Sierra Rutile Project Area 1 – Environmental, Social and Health Impact Assessment: Mine Closure Plan

Report Prepared for

Sierra Rutile Limited

Sierra Rutile Limited

Report Number: 515234/ Mine Closure Plan

Report Prepared by

srk consulting

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List of abbreviations

BTP	British Titan Products
CDC	Community Development Committee
CET	Coarse electrostatic tailings
CMCP	Conceptual Mine Closure Plan
CRL	Consolidated Rutile Limited
DHMT	District Health Management Teams
EHS	Environmental, health, and safety
EIA	Environmental Impact Assessment
EPA	Environment Protection Agency
EPA-SL	Environmental Protection Agency of Sierra Leone
ESHIA	Environmental, Social and Health Impact Assessment
ESHMP	Environmental, Social and Health Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
EU	European Union
EVD	Ebola Virus Disease
$FeTiO_3$	Titanium-iron oxide mineral
FET	Fine electrostatic tailings
FPP	Feed Preparation Plant
GIIP	Good international industry practice
GOSL	Government of Sierra Leone
HHS	Household Survey
HMC	Heavy Mineral Concentrate
HSEC	Health, Safety, Environment and Community
IoE	Index of Erosion
IT	Ilmenite tailings
ITNs	Insecticide-treated bed nets
LoM	Life of Mine
LRBCS	Land Rehabilitation and Biodiversity Conservation Strategy
masl	meters above sea level
mbc	Meters below collar
MCP	Mine Closure Plan
MSP	Mineral Separation Plant
NCD	Non-Communicable Diseases
NMA	National Minerals Agency
PAH	Poly-Aromatic Hydrocarbon
PAG	Potentially acid generating
PCB	Polychlorinated Biphenyls

PCO	Present Closure Obligation
PPG	Pittsburgh Plate Glass
RHIA	Rapid Health Impact Assessment
RoM	Run of Mine
RRA	Rapid Rural Assessment
SCC	Species of Conservation
SIA	Social Impact Assessment
SLEP (MM) Reg. 2013	Sierra Leone's Environmental Protection (Mines and Minerals) Regulations 2013
SML	Sherbro Minerals
SFT	Sulfide flotation tailings
SRK	SRK Consulting (South Africa) (Pty) Limited
SRL	Sierra Rutile Limited
SRCE	Standardised Reclamation Cost Estimator
TiO_2	Titanium Dioxide
TOC	Total Organic Content
TSMF	Tropical and Subtropical Moist Forests
TSS	Total Suspended Solid
TT	Total tailings
WBS	Work Breakdown Structure
WHO	World Health Organization

1 Introduction

Sierra Rutile Limited (SRL) is an existing mining operation located in the Bonthe and Moyamba Districts of the Southern Province of Sierra Leone (Figure 1-1). The mine has been in operation for over 50 years and produces rutile, ilmenite and zircon rich concentrate.

In 2015 the Environmental Protection Agency of Sierra Leone (EPA-SL) issued a notification to SRL (reference number EPA-SUHA.96/214/a/HNRM), instructing SRL to undertake an Environmental, Social and Health Impact Assessment (ESHIA) and develop an Environmental, Social and Health Management Plan (ESHMP) for their current and proposed dry and wet mining activities including the proposed expansion areas within Area 1. This included the Gangama and Lanti Deposits and other deposits within SRL's current operations in Sierra Rutile Area 1 (SR Area 1).

1.1 Purpose of this report

This Mine Closure Plan (MCP) has been prepared to assist SRL in the implementation of appropriate environmental and social management measures during operations of the SR Area 1. The aim of this document is to demonstrate how closure of the SR Area 1 operations will be completed in a manner that meets the applicable legislative requirements, Iluka Resources Limited (Iluka) and SRL environmental management standards and Good International Industry Practice (GIIP).

This report has been written in accordance with the *Environment Protection Agency (EPA) Act 2008 (Act No. 11 of 2008)* as amended, and the *Sierra Leone Environmental Protection (Mines and Minerals) Regulations 2013 (Statutory Instrument No. 10 of 2013)* (SLEP (MM) Reg. 2013). The report structure has been informed by the Ninth Schedule of Regulation 16(A), 33 (7)) reflected in SLEP (MM) Reg. 2013, which prescribe the format for a MCP. As this application is submitted for an existing operation and at the request of the EPA-SL, this process is being undertaken under the requirements for a Category A project. Ongoing data collection during operations will provide information to fill current gaps, with the knowledge base in the plan improving with every subsequent revision and re-submission of the plan, which the regulations require to occur on a two-year cycle. The MCP has been developed to be site specific and to address the particular risks associated with SR Area 1.

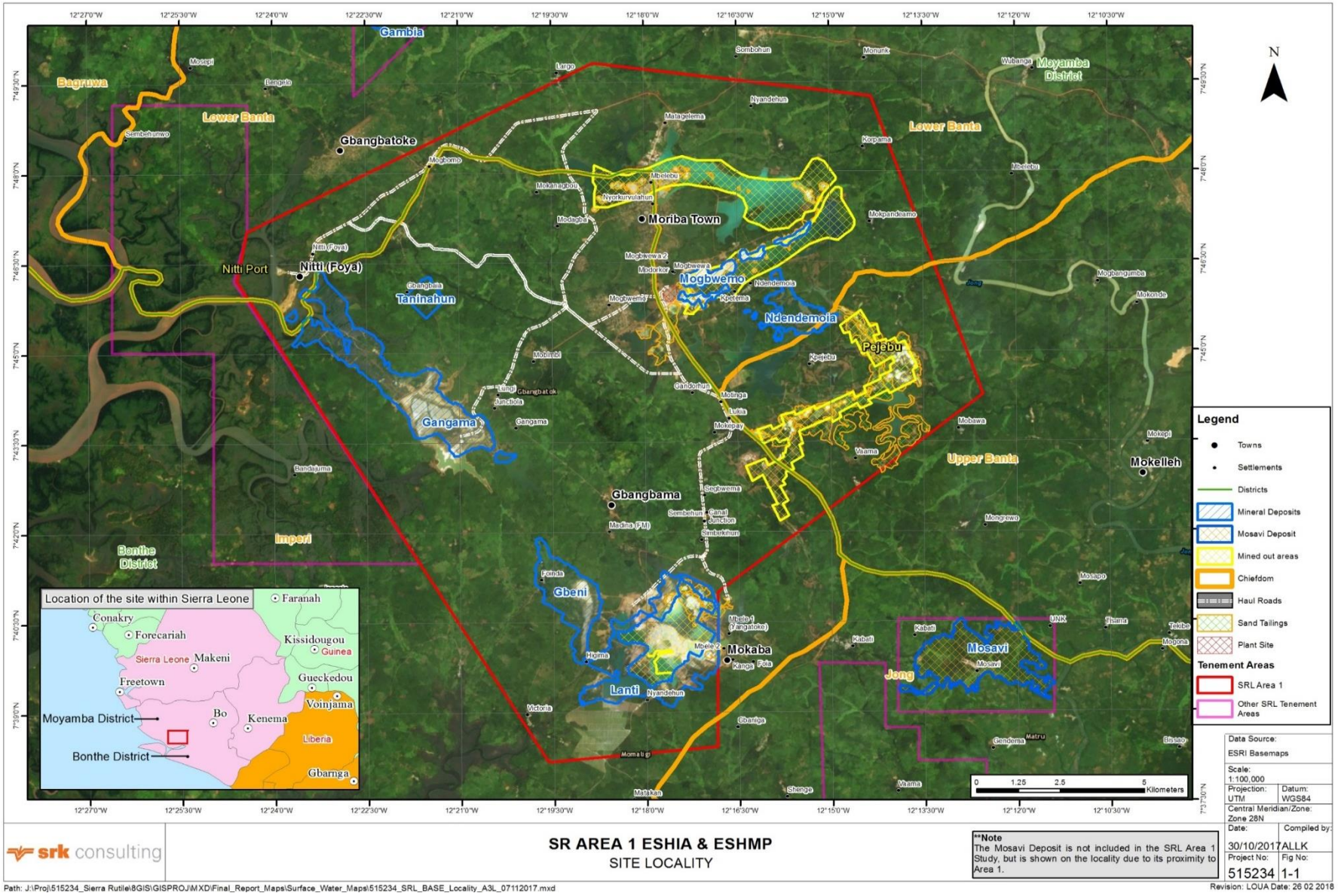

Figure 1-1: SR Area 1 site location

2 Project overview

This section provides a brief overview of the mining and processing activities at the operation, with a more detailed description provided below.

SRL's core product is natural rutile, with ilmenite and zircon by-products. Currently, SRL's primary operations consist of: Lanti mining operations (both wet and dry mining); processing operations (floating and land based concentrators); Gangama dry mining operation (dry mining and land based concentrator); Mineral Separation Plant (MSP); and the transport and export of product through the Nitti Port facilities. In addition, the mine maintains an extensive network of ponds and has power generation facilities, accommodation, offices, a clinic and roads (Figure 2-1).

2.1 Land description and tenure

The SR Area 1 operation is located in the Moyamba and Bonthe Districts in the Southern Province of Sierra Leone (Figure 1-1). It is situated 30 km inland from the Atlantic Ocean, 135 km south east of Freetown. The mine operates in four chiefdoms, namely; the Imperi, Jong, Upper Banta and Lower Banta Chiefdoms. Moriba Town is the largest town within SR Area 1. The deposits within SR Area 1 are alluvial in nature and located around the Gbangbama Hills and the Moyamba Hills.

Although SRL is the largest mining operation in the region, Vimetco operates a bauxite mine to the east of SR Area 1 approximately 15 km from the MSP to the south-western extent of Vimetco's current disturbance.

2.2 Regulatory approvals

By an agreement dated February 4, 1972 (*the Principal Agreement*) as amended by an agreement dated May 23, 1975 (*the Supplemental Agreement*), the Government of Sierra Leone (GOSL) and SRL agreed on terms and conditions for the exploration and development of deposits of titanium-bearing and associated minerals.

In pursuance of such agreements, the GOSL and SRL entered into three mining leases and dredging licences, which grant SRL the right to mine titanium-bearing and associated minerals within the designated areas. These agreements were revised and supplemented in November 1989 with the *Sierra Rutile Agreement (Ratification) Act, 1989*.

The agreements were again ratified and confirmed in March 2002 by the *Sierra Rutile Agreement (Ratification) Act, 2002* (Sierra Rutile Act). The mining leases referred to in the Sierra Rutile Act have now been re-designated by the GOSL as Licence No 2134 of 1984 and the additional lease areas issued in 1991. The term of the mining lease granted to SRL is 33 years from the date of commencement of mining operations. The lease expires on the 23 January 2039, however there is an option to extend for a further 15 years.

SRL currently holds seven mining leases covering 559 km^2 with a total of 16 deposits identified. SRL's Area 1 Mine Lease Area (SR Area 1) covers an area of approximately 290 km^2.

The SRL operation with SR Area 1 has an existing Environmental Licence (reference number EPA-SL030) and has undertaken two previous Environmental and Social Impact Assessment (ESIA) studies for their operations in 2001 and an update in 2012, respectively. When these studies where undertaken, the primary mining process was dredge mining although limited dry mining was undertaken and borrow pits were excavated for construction materials. During 2013 SRL commenced a distinct open pit mining operation (referred to hereafter as dry mining) as an auxiliary method of ore extraction in conjunction with wet mining. In 2016, a second dry mining operation was commissioned.

It is anticipated that, over time, dredge mining will cease and dry mining would be the primary mining method employed.

2.3 Site activities

The following section details the mining, processing and support activities associated with SR Area 1. In addition to the activities described below, SRL rents warehousing facilities and office space in Freetown.

2.3.1 SRL mining history

The presence of titanium-bearing mineral sands was first discovered in south western Sierra Leone in the early 1920s by an exploration geologist for Gold Coast Geological Survey. It was only until the 1950s that British Titan Products (BTP) began exploring the Gangama and Lanti-Teso-Gbeni Deposits and in 1957, BTP, together with Pittsburgh Plate Glass (PPG), re-drilled the Lanti Deposit and subsequently confirmed reserve estimates. BTP and PPG formed Sherbro Minerals (SML) in 1961, with PPG having majority share of 80 %. A recession in the rutile market delayed the development of the Deposits until 1967, when SML started mining operations at the Mogbwemo Deposit. While early mining was mainly confined to the Mogbwemo Deposit, SML also dredged the area currently known as Titan Reservoir, and conducted dry mining in the Old Gandorhun area near the village of Mogbwemo. SML was affected by poor production due to technical difficulties associated with the suction dredge and resulted in the liquidation of the Company in 1971.

Nord Resources Corporation (Nord) and Armco Steel acquired SRL's mining and exploration interests and formed SRL in November 1971. Following further exploration, a new feasibility study was completed in 1977. Construction began on a new bucket line dredge, which is now referred to as Dredge D1. The SRL operation started production at Mogbwemo in March 1979. The mine temporally closed in 1982, but from 1983 to 1995 the mine operated continuously and profitably under Nord's management, and generated up to 154,000 tonnes per annum (tpa) of rutile. Average annual SRL production for the five years between 1990 and 1994 was 148,360 t rutile and 58,650 t of ilmenite.

In addition to the Mogbwemo Deposit, SRL mined several other deposits during the late 1980s and early 1990s. The Bamba Belebu Deposit was mined from August 1986 through August 1989. The Pejebu (North) Deposit was mined from September 1989 through March 1990, and the Pejebu (South) Deposit was mined from March 1990 to February 1992. A dry mining method was used at the Mokula Deposit from September 1989 to March 1990. The ore from the Mokula Deposit was transported and dumped for reclamation by the Neumann dredge during the mining of the Pejebu (North) Deposit. Mining of the Lanti North Deposit was performed from 1992 to 1995.

In 1993, Nord sold 50 % of SRL to Consolidated Rutile Limited (CRL) of Australia and the decision was made to expand the facilities to a two-dredge operation. The second dredge was under construction when operations were suspended in January 1995 for security reasons associated with the civil war. The mine was shut down and placed on care and maintenance. In January 1995, the Revolutionary Union Front (RUF), an anti-government military group, overran the Sierra Rutile Mine and resulted in a complete shutdown of the mine and the destruction of much of the mine equipment and infrastructure.

Between 1999 and 2004, SRL changed ownership and in 2004 the European Union (EU) gave a grant of €25 million to GOSL on condition that the full amount was loaned to SRL to restart its mining operations. The refurbishment programme that started in 2005 was funded by the GOSL loan and cash from the shareholder.

SRL became an AIM-listed company in August 2005 and Dredge D1 resumed mining operations in the Lanti North Deposit in February 2006 after an 11-year shutdown. Thereafter, construction of

Dredge D2 resumed. Dredge D2 started mining the Gangama Deposit in January 2008 and operated until 25 July 2008, when the dredge capsized during normal operation.

Between 2007 and 2011, the shareholding of SRL changed and with Pala Investments Limited investing in September 2010 and ultimately increasing its stake to 54 %. In 2016, Iluka completed the acquisition of SRL by means of a merger, making SRL a wholly owned subsidiary.

2.3.2 SRL mining product

SRL's core product is natural rutile, with ilmenite and zircon by-products. Rutile is a mineral composed primarily of titanium dioxide (TiO_2), ilmenite is a titanium-iron oxide mineral ($FeTiO_3$) and zircon is a mineral composed primarily of zirconium silicate ($ZrSiO_4$). Both rutile and ilmenite are feedstock in the production of titanium dioxide, a white pigment used in the production of paints, paper, plastics and pharmaceuticals. Other important markets for natural rutile include welding, where it is used in both electrodes and flux cored wire applications, and titanium sponge production. Zircon is used in the decorative ceramics industry as well as use as a refractory material.

Other feedstocks for the pigment industry include ilmenite, synthetic rutile, leucoxene and titanium slag. Different feedstocks are processed by either the chloride or the sulphate process. TiO_2 pigment is preferred due to its attractive characteristics of high brightness and opacity, which far surpass any substitutes. The natural rutile produced by SRL has a titanium dioxide content of over 95 % with low levels of impurities. It is considered to be a premium product within the rutile market due to a number of favourable physical and chemical characteristics over other supplies of natural rutile.

2.3.3 Current mining operation

Mining, scrubbing and screening is undertaken on-board the Lanti dredge, with mineral concentrate produced on board the floating Wet Concentrator Plant (WCP). The dry mines produce Run of Mine (ROM) ore for their respective land-based WCPs, where de-sliming and primary heavy mineral concentration takes place. The separation of mineral concentrate into the various products takes place at the MSP. Products are then transported from the MSP to Nitti Port where it is barged approximately 37 km to ships awaiting offshore in the Sherbro River Estuary. Figure 2-1 provides a simplified process flow of the SRL mining operations.

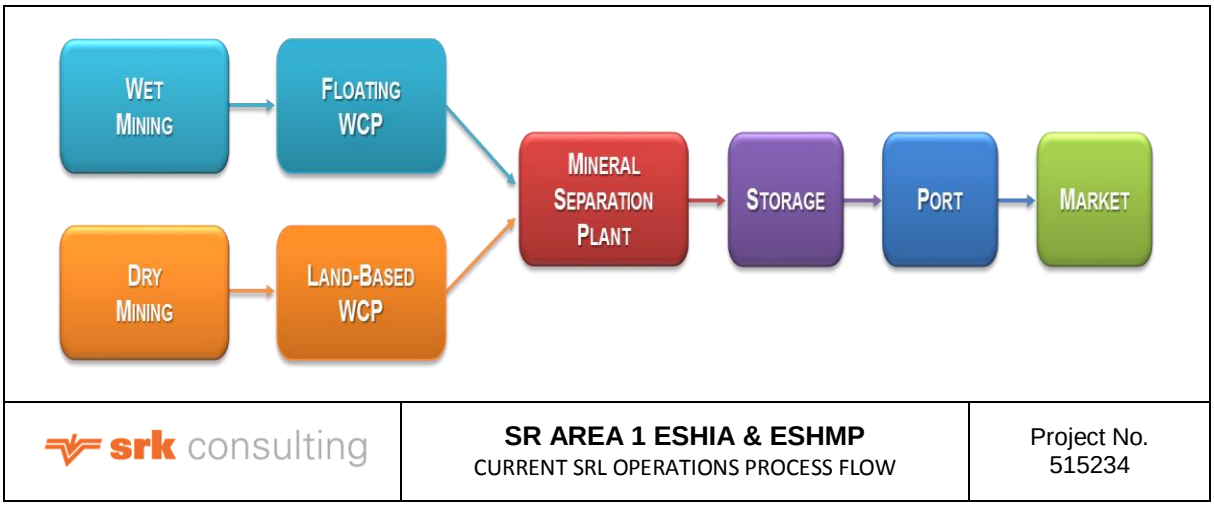

Figure 2-1: Simplified process flow of the current SRL operations

Wet mining

Wet (dredge) mining involves the removal of vegetation, excavation of the pit and flooding of the open pit with rainwater or water pumped from previous mine sites. The dredge plant excavates using an electric bucket line dredge, which collects and feeds the materials to a floating WCP.

The dredge scrubs and screens the ore, after which it is pumped to the floating WCP. De-sliming removes clay from the ore. The de-sliming process occurs in two stages. Gravity then separates the heavier minerals from the lighter minerals. The resultant Heavy Mineral Concentrate (HMC) contains up to 60 % recoverable rutile. The concentrate then goes to two separate cyclone towers: one for low sulfur ore and a second one for high sulfur ore. No chemicals are used in the process.

Waste material produced by the floating WCP comprise sands which are deposited in a sand stacking area and slimes (fine material), which is deposited back into constructed slimes paddocks. Presently there is one dredge (D1) operating at the Lanti wet mining deposit. Figure 2-2 provides an aerial overview of the Lanti wet mining area, while Figure 2-3 provides pictures of wet mining operations

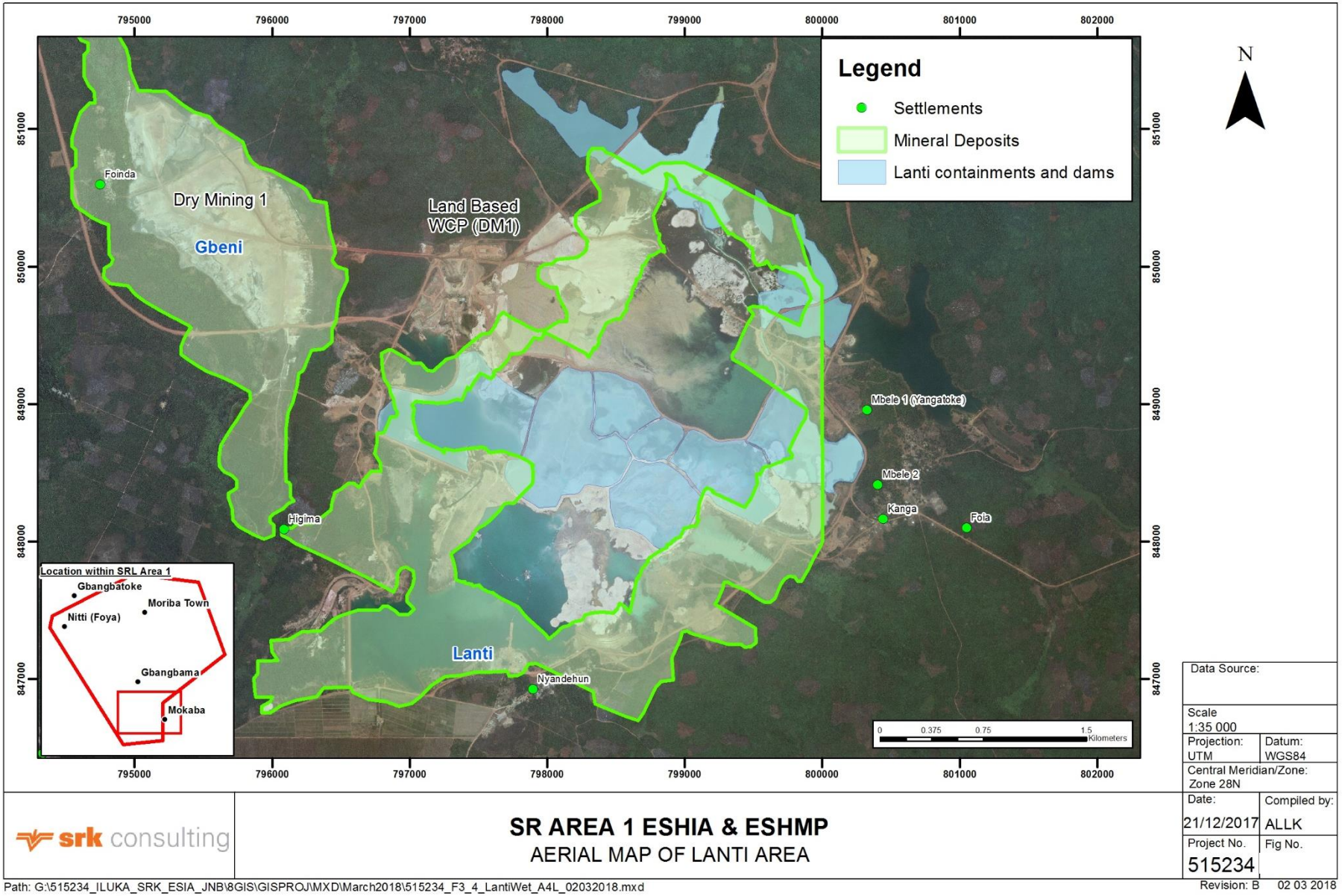

Figure 2-2: Aerial overview of wet mining area

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LANTI WET MINING OPERATIONS

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Figure 2-3: Lanti wet mining operations

Dry mining

SRL has historically undertaken limited dry mining of small isolated deposits in fringe areas outside the larger economic deposits where dredge mining is used. The material was excavated and hauled to the nearest operating dredge pond where it was stockpiled in the dredge ponds to be processed with the dredged material (CEMMATS, 2012). However dry mining is appropriate for some ore bodies and is therefore currently being undertaken at two dry mining areas: Lanti at the Gbeni Deposit and Gangama.

As opposed to wet mining, dry mining involves the excavation of ore (ROM) in a dry environment. A conventional load and haul method delivers ore from Gbeni and Gangama deposits into two benefication and land-based WCPs, known as the Lanti Plant (DM1) and the Gangama Plant (DM2).

The ROM feed is stockpiled at the land-based WCP's where a grader tips the ROM feed into a 150 t hopper, and the material is then passed onto an apron feeder, which discharges onto a vibrating grizzly feeder. The grizzly feeder separates the undersize material which discharges into a primary scrubber. Material leaving the primary scrubber is discharged onto a double deck screen. The oversize material from both decks is combined and conveyed to tailings disposal. The undersize material is pumped to the de-sliming and effluent disposal section, where it is fed to cluster cyclones. The overflow from the primary and secondary cyclones flow to the final effluent sump together with sand tailings from the spiral modules. The overflow gravitates to the water dam. The underflow from the de-sliming cyclones collects in the spirals feed sump where it is diluted before being pumped to the spirals module. Sand tailings and slimes tailings are co-disposed, while HMC is dewatered and stockpiled for transportation to the MSP for further processing.

The sand tailings are classified into coarse and fine material and dealt with separately. The <1.6 mm material is produced from the land-based WCPs tails, while the coarse material comprises of screen oversize +1.6 mm – 200 mm. Fine material is pumped to a cyclone stacker, where it is stacked. The cyclones separate finer fractions from the coarse fractions to build sand beaches. The material is spread and moved with dozers. The recovery of process water is enhanced through the use of these cyclones. Oversize (+200 mm) material originating from the grizzly is discharged into an oversize bunker for removal by front end loader. Coarse material is transported by conveyors and dispersed by a spreader conveyor.

Figure 2-4 provides an aerial overview of the Lanti dry mining area, Figure 2-5 an aerial overview of Gangama dry mining area and Figure 2-6 demonstrate pictures of the dry mining operations.

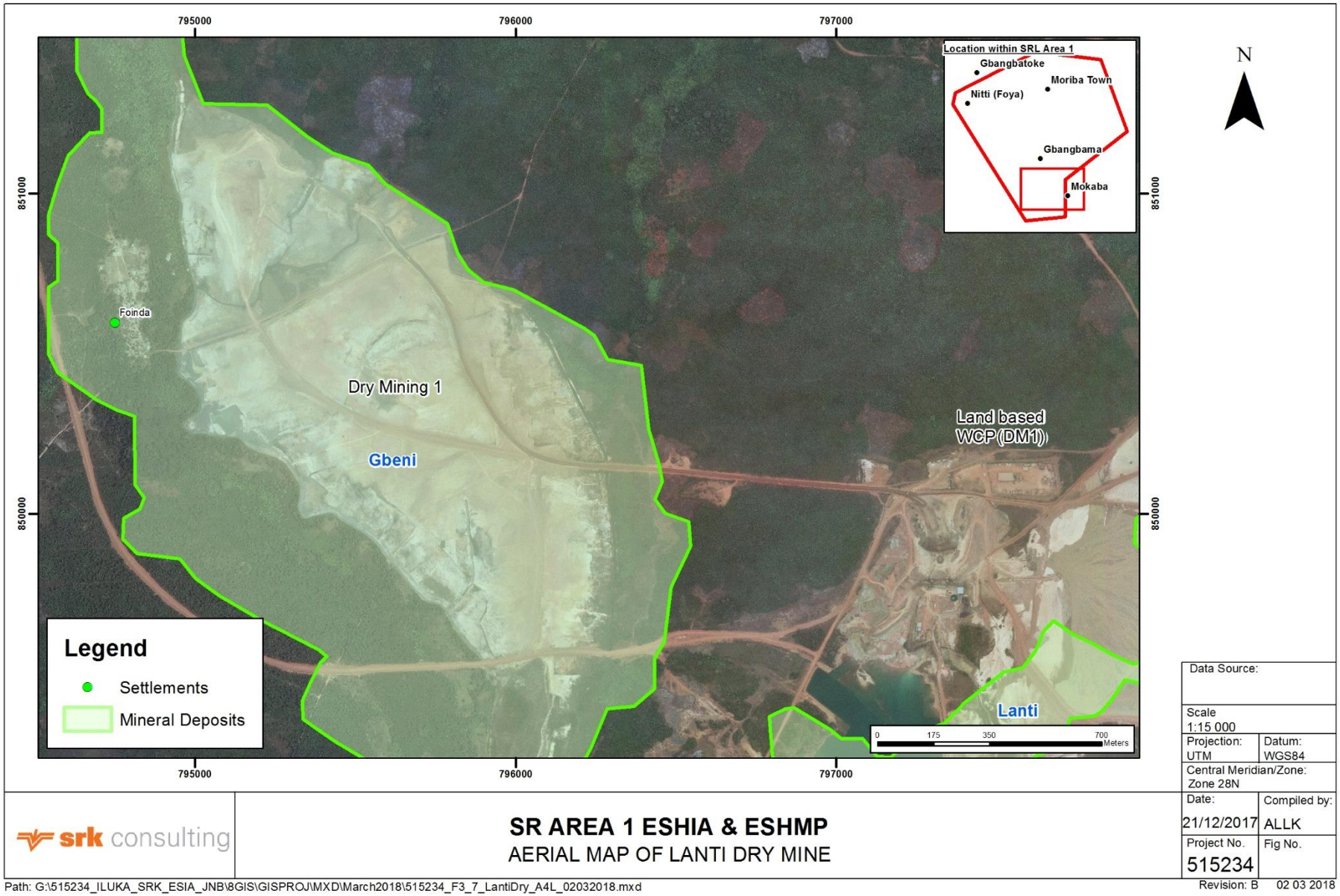


Figure 2-4: Aerial overview of Lanti dry mining area

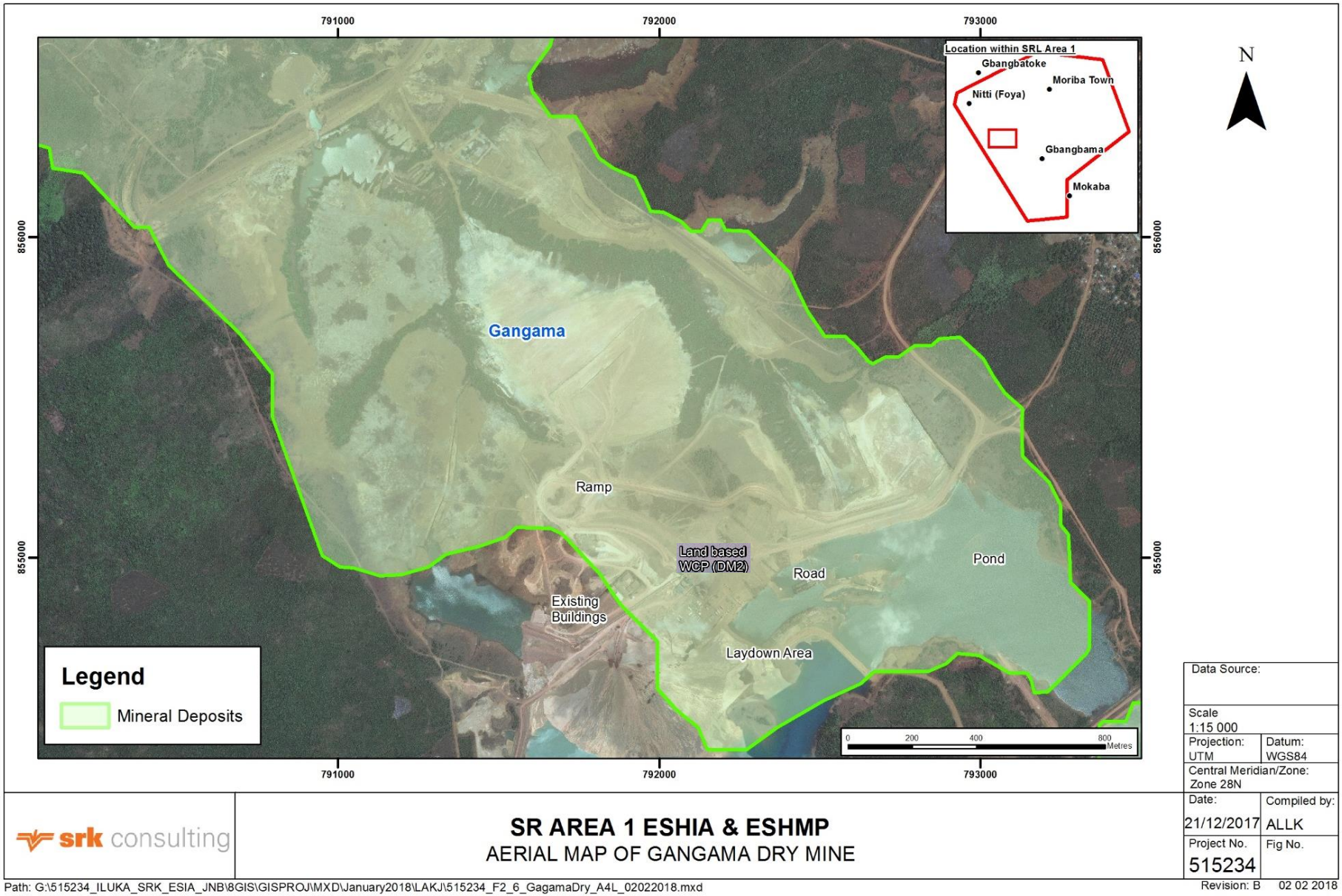
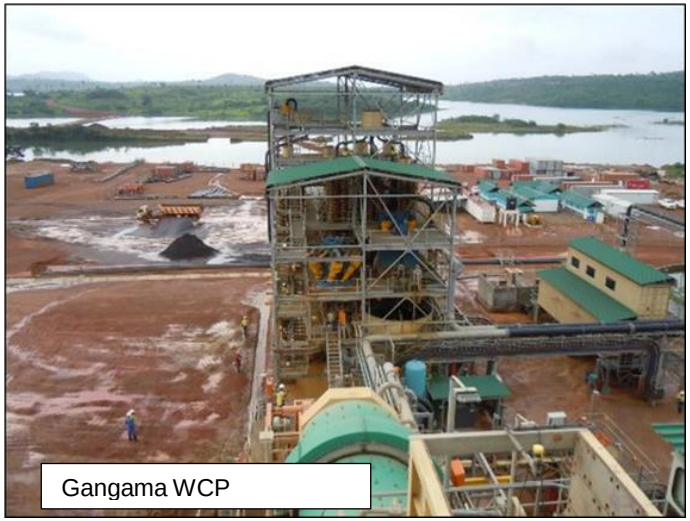


Figure 2-5: Aerial overview of Gangama dry mining area



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LANTI AND GANGAMA DRY MINING OPERATIONS

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Figure 2-6: Lanti (top row) and Gangama (bottom row) dry mining operations

The construction of Gangama Dry Mine commenced in April 2015 and was commissioned in May 2016. The concentrator plant at Gangama was constructed adjacent to areas used for the construction of the capsized D2 dredge. The following infrastructure and facilities were constructed:

- WCP;
- Offices and workshop;
- Power distribution;
- Water distribution and management;
- Tailings disposal facilities; and
- Roads (including ramp).

2.3.4 Mineral processing

Further processing occurs at the MSP situated at the western end of the former Mogbwemo Dredge Pond and south of Moriba Town (Figure 2-7). The MSP includes the Feed Preparation Plant and the Dry Plant, as well as mining offices, laboratory, power plant, warehouse, vehicle maintenance buildings and machine shops.

Feed Preparation Plant

Trucks transport the HMC from the Lanti wet, Lanti dry and Gangama plants to the MSP. Here the feed is loaded by front-end loaders onto a conveyor belt from where it is screened, scrubbed, de-slimed and separated using gravity methods.

Hydro-sizers are used to separate coarse and fine materials. The fine fraction is sent to a flotation plant where sulfur is removed by washing and scrubbing with chemicals that include soda ash (sodium bicarbonate - $NaHCO_3$), flotation oil (Almag oil / mineral oil – naphthenic oil and antioxidant), dowfroth 250 (propylene oxide methanol adduct - $C_7H_{16}O_3$) and potassium amyl xanthate ($C_6H_{11}KOS_2$). The resultant rutile rich feed, containing approximately 95 % heavy minerals, then goes to the dry plant. The sulfur tailings go to the Sulfide Flotation Tailings (SFT) pond (Figure 2-8).

Dry Plant

The main processes at the dry plant are drying, sizing and electrostatic separation. The electrostatic process deflects non-conductors (zircon and silica) and separates them from conductors (rutile, hematite and ilmenite) in the product stream. The fine and coarse tailings from the electrostatic separation process discharges separately to the Fine Electrostatic Tailings (FET) and Coarse Electrostatic Tailings (CET) ponds (Figure 2-8).

The conductors (rutile, hematite and ilmenite) undergo electromagnetic separation where the non-magnetic rutile separates from the magnetic hematite and ilmenite. The final rutile product contains approximately 95 % titanium dioxide (TiO_2). The products are stored in separate stockpiles per varying grades for transport to Nitti Port.

Ilmenite Tailings (IT) discharges to the IT pond. The rest of the tailings consisting of a mixture of various streams (slimes, ilmenite etc.), discharge to the Total Tailings (TT) pond (Figure 2-8).

2.3.5 Nitti Port

The port facilities are located at Nitti, approximately 4 km south of Gbangbatoke (Figure 2-9). The port facilities include an office building, other support (e.g. generator building) and storage buildings, product storage silos, product storage domes, loading facilities, Marine Fuel Oil storage tanks including 2,500 tonne IGR storage, barges and two push boats, with a third grounded near the jetty. There are four defunct rutile storage silos with capacity of 750 Mt each and two product storage domes each with a capacity of 12,000 metric tonnes for the storage of rutile and ilmenite respectively. The rutile and ilmenite concentrate product material is stored in the domes and silos.

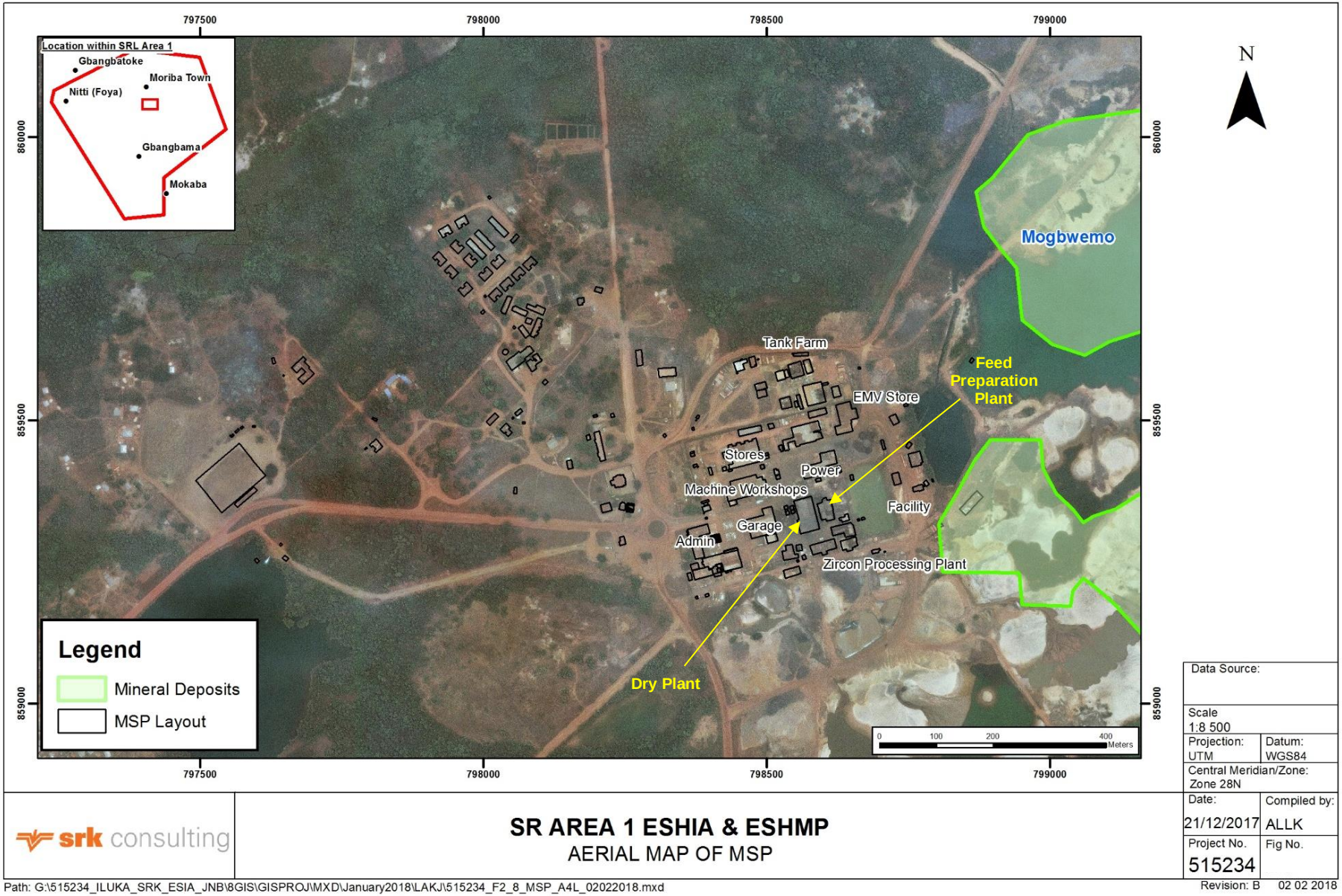

Figure 2-7: Aerial overview of Mineral Separation Plant

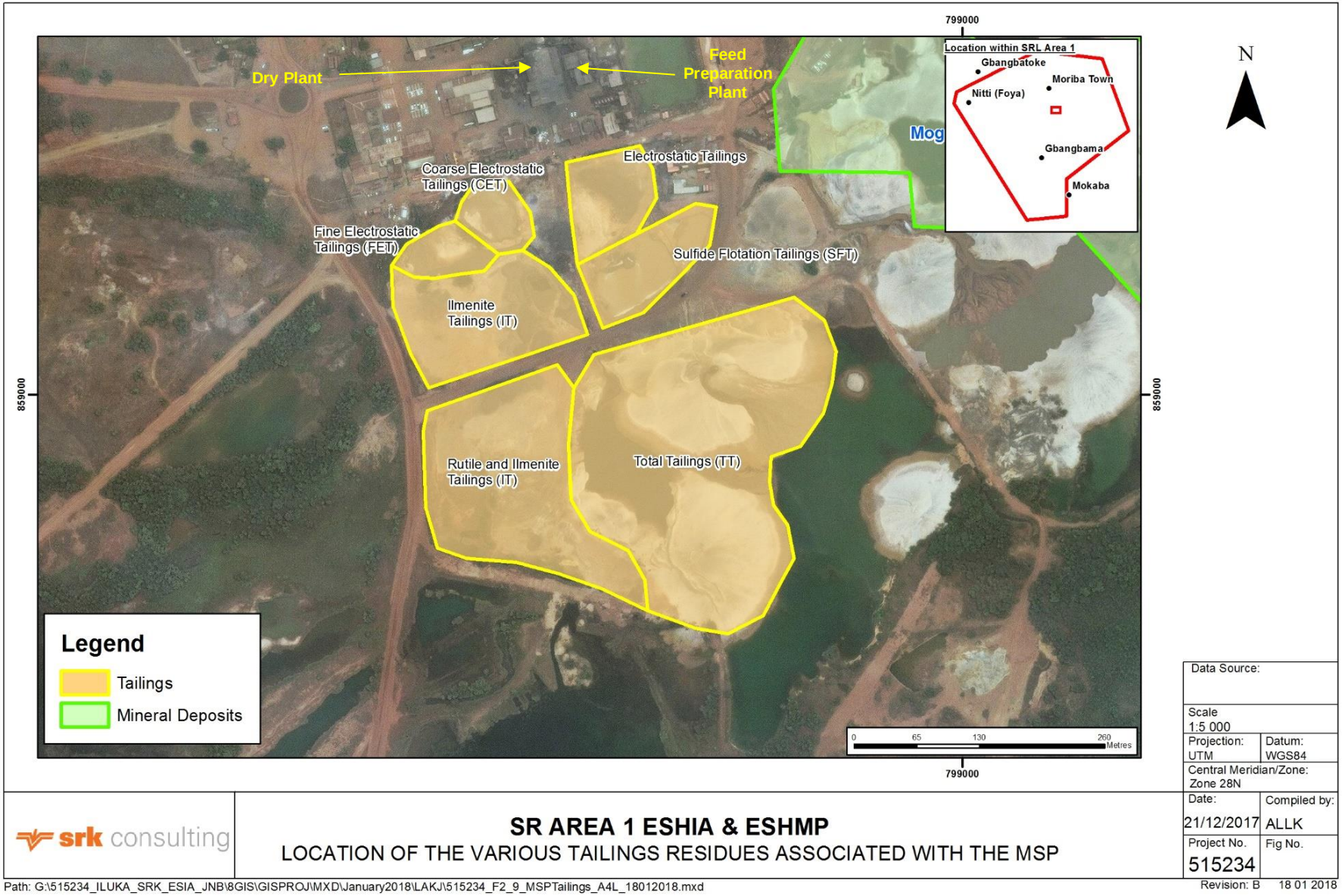

Figure 2-8: Aerial overview of MSP tailings facilities

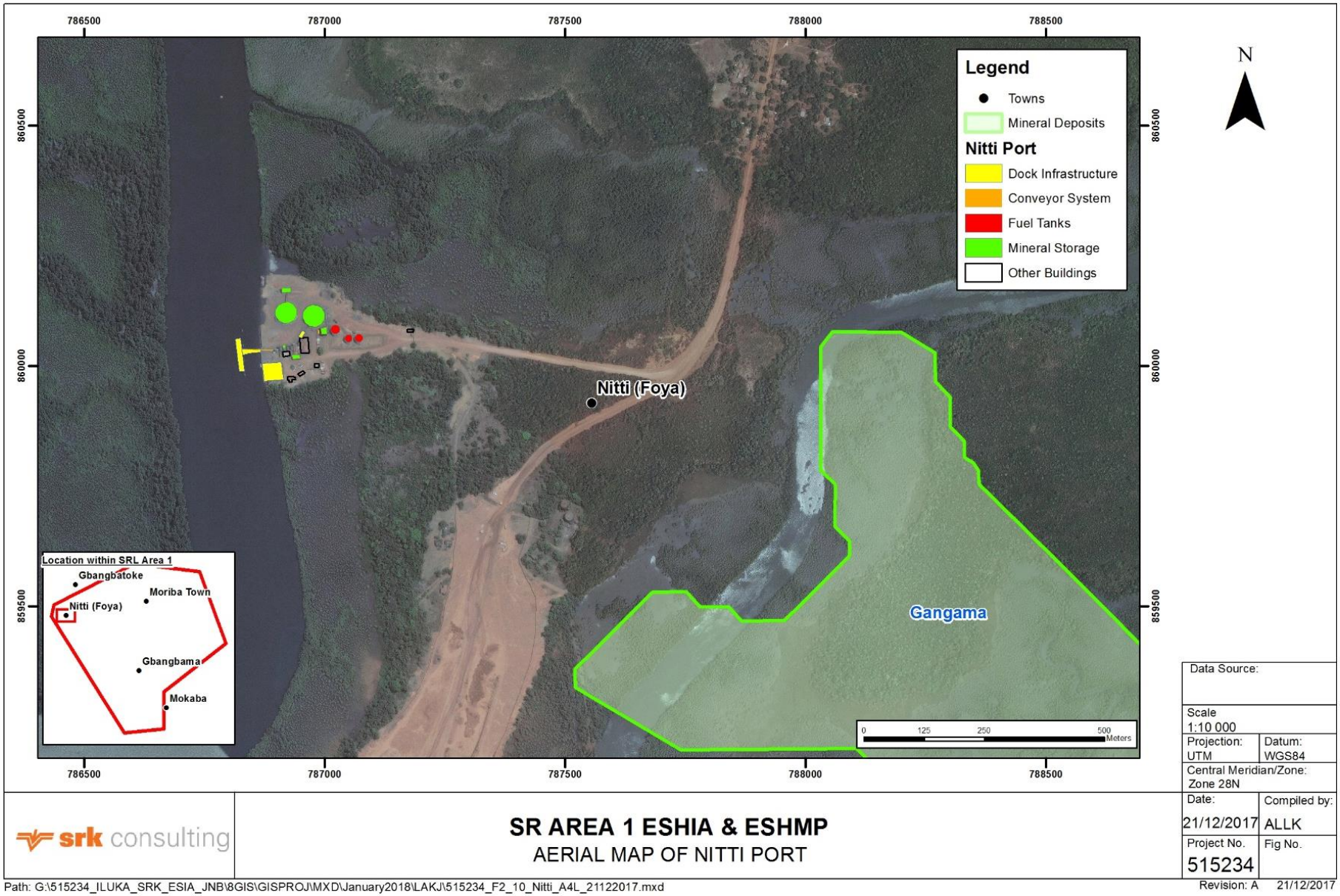

Figure 2-9: Aerial overview of Nitti Port

The product is then loaded onto barges from the storage silos and domes. Product that is stored in the domes and/or stockpiles requires the operation of a front-end loader and the combination of a tipping bin, feeder conveyors to discharge product onto the dispatch conveyor to barges. The final handling of bulk-shipped products is by barge from Nitti Port to transfer buoys in the Sherbro River Estuary (approximately 37 km from Nitti Port) and then onto ocean-going vessels (Figure 2-10).

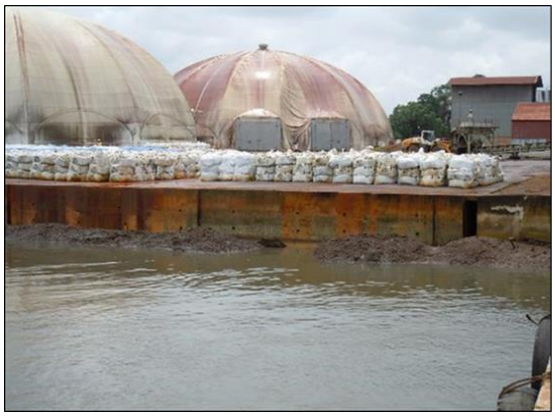

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Figure 2-10: Nitti Port product stockpile storage domes and product one tonne bags (left) and loading of barges (right)

2.3.6 Roads

SRL maintains an extensive network of gravel roads within SR Area 1. These roads are utilised by SRL to haul product and materials between various operations and for mine personnel to access areas within the SR Area 1. These roads are also used by the communities for movement between settlements and to commute to major settlements outside of the SR Area 1.

The main haul roads connect Lanti Dredge D1, Lanti Dry (DM1) and Gangama Dry Mining (DM2) to the MSP stockpile area, where the HMC is transported. Product from the MSP is hauled to Nitti Port via road. There are also access roads that connect the main camp areas to the SRL operational areas and access roads between operational areas. There are roads that connect historical mining areas to current operational areas. All roads within the SR Area 1 are used by the public but are maintained by SRL as the majority of roads are public roads that have been upgraded by SRL to haul roads.

2.3.7 Electricity and power supply

SRL has an existing power supply system that is an entirely stand-alone or “island” system without any interconnection to other systems. System voltage levels (46 kV, 13.2 kV, and 4.16 kV) and frequency (60 Hz) are based on the United States of America (USA) standard rather than European practices, as is the norm elsewhere in Africa.

The current SRL power supply system consists of Powerhouse 2 (PH2) and various distribution and transmission equipment. The PH2 was commissioned in January 2009 which replaced the previous Powerhouse 1 (PH1) and is the only electrical power source serving the operation.

The PH1 was first constructed in the early 1970s to serve the operation prior to the establishment of PH2. With the exception of its 4.16 kV switchboard, the powerhouse has been decommissioned and stripped. The original switchboard associated with PH1 still forms part of the SRL distribution network and remains in service.

A single, 10 MVA rated, 46 kV overhead transmission line distributes electricity from PH2 to an outdoor step-down substation at Shimbek. From the substation, a 9 km long 13.2 kV overhead transmission line supplies electricity to the floating plants. A second 10 MVA rated overhead transmission line, approximately 10 km in length, ends at Gangama where it supplies power to the Gangama dry plant (DM2).

The SRL network also includes two separate 4.16 kV systems. The first of these is directly connected from the PH2 4.16 kV switchboard and includes electricity supply services to the main plant site and offices. The second is the Mobimbi accommodation camp 4.16 kV system, which is supplied from a 13.2/4.16 kV step down transformer, connected off the Gangama 13.2 kV line.

2.3.8 Potable water supply

SRL has an existing water treatment plant with an output capacity of about 950 ℓ per minute, treating water supplied from the Mogbwemo Domestic Reservoir. Water is treated with chlorine, soda ash and aluminium sulphate used as coagulant, before filtration to produce potable water up to WHO drinking water quality standard. The potable water is then pumped to the mine offices and camp areas and stored in a 130,000 ℓ tank to provide piped water for the mine camp houses, dormitories, the MSP and offices.

2.3.9 Mine camps, buildings and other facilities

Mobimbi mine camp was developed by SRL for employees and is located approximately 4 km southwest of the MSP. The camp consists of housing, mess facilities, gym, laundry and a swimming pool and houses management employees. South Spur, forming a part of the Mobimbi housing complex, is located to the south of Mobimbi and is mainly used for contractors. The combined area of Mobimbi and South Spur is approximately 205 ha. The mine has an additional camp located adjacent to the MSP area (Kpanguma) and houses senior SRL staff. The three on-site camps can accommodate 440 people. Kpanguma houses senior staff, Mobimbi houses Management, South Spur houses contractors.

2.3.10 Waste management

Solid waste is disposed of as part of existing Waste Management Plan (an updated Waste Management Plan is included in Appendix L2). Domestic waste comprises waste streams such as packaging, plastic, paper products and glass, which is disposed of at the SRL waste dump located near the MSP. All waste streams generated from work areas are collected and segregated. SRL plan to upgrade the waste management facilities at SR Area 1. All reusable and recyclable waste streams such as metals, plastic containers and timber are cleaned by end users under the supervision of Environmental, Health and Safety (EHS) officers and stored separately. Waste oils and greases are collected in separate receptacles provided in all areas where these are generated and are subsequently removed and taken to the SRL powerhouse as a feedstock to the power generation units. Incinerator units are used for the combustion of biomedical waste generated from the clinic. Sewage (both black and grey water) is generally disposed of in septic tanks at operational areas and camps.

2.4 Current workforce

As of August 2017, SRL employs 1,871 people, of which the 93 % are Sierra Leonean nationals. There are 93 Sierra Leoneans in management positions, 156 senior staff members and 1,583 general staff members. The remaining workforce consist of 39 expatriates. Table 2-1 provides a further breakdown of the workforce currently employed by SRL.

SRL utilises the services of contractor companies that provide services such as security, fleet maintenance, corporate services, shipping, warehouse and camp management. These contractors employ a combined total of 725 Sierra Leonean nationals and 18 expatriates. Table 2-2 provides a breakdown of the employment statics for SRL's contractors.

Table 2-1: Current workforce breakdown for the SRL operation (August 2017)

Position	Staff numbers
Number of expatriates employed	
Senior management	11
Middle management	4
Professionals	24
Total expatriates	**39**
Number of Sierra Leoneans employed	
Management staff	
Senior management	5
Middle management	18
Professionals	70
Total management – national	**93**
Senior staff	156
General staff	1,583
Total general and senior staff - national	**1,739**
Total of staff combined	**1,871**

Table 2-2: Breakdown of contractors used by SRL (August 2017)

Item	Quantity
No of companies	**6**
All Terrain Services	
Beowulf	
Afrilogue	
CET	
AYS / VOLVO	
Frontier Afrique	
Expatriates employed by all contractors	**18**
Sierra Leonean citizens	**725**
Breakdown of Sierra Leonean citizens employed by all contractors	
Senior management	7
Supervisors	35
Below supervisors	683

2.5 Progressive rehabilitation status

In November 2006, SRL formed a partnership with the Darwin's Initiative of United Kingdom (UK) to develop a sustainable strategy to rehabilitate mined-out land. The aim of the three-year Darwin project was to support novel and practical conservation strategies in Sierra Leone's mining industry. The main objective of this project was to develop practical methods for successful reclamation and conservation in the mining industries of developing countries that both conserve biodiversity and enhance community livelihoods. While there were short term successes in demonstrating techniques that allowed for the establishment of covers with a potential post closure use, administrative issues resulted in the termination of the project at the end of 2009.

During 2010 SRL developed a Land Rehabilitation and Biodiversity Conservation Strategy (LRBCS) (SRL EHS Department, 2010). The LRBCS states that SRL started land rehabilitation programs in the 1990s and with a total of 81 hectares (ha) of land rehabilitated. These re-vegetated lands are now a source of fuel-wood for some communities close to these areas.

Although there was some effort in rehabilitating disturbed land, this was apparently undertaken without a formal plan, leading to the development of SRL's LRBCS which aimed to "*sustainably apply practical and cost effective solutions to rehabilitate disturbed lands through the use of best experiences, whilst integrating the priorities of project-affected communities with a vision to sustainably expand the scope of rehabilitation activities to rehabilitate mined-out land to alternative but productive land use and also conserve biodiversity*". The LRBCS was supported by the Land Disturbance Inventory which was completed in October 2011 and identified an area of 4,600 ha disturbed by mining activities and requiring rehabilitation.

The LRBCS resulted in approximately 142 hectares per year (ha/yr) of land rehabilitated between 2012 and 2015:

- During 2012 to 2014: 426 ha of the areas at the Pejebu mined out sand tailings and borrow pits were rehabilitated, disturbed from 1992-1993; and
- During 2015: 142 ha at the Mogbwemo mined out sand tailings was rehabilitated, mined from 1979-1986.

The approach used to rehabilitate the above areas was to use a selection of tree species suitable for various uses that have been established in these areas. These species include crop trees (cashew), exotic timber trees (various acacia and eucalyptus species, teak and pine) local timber trees, medicinal trees (neem, tamarind), and exotic trees for fodder and soil improvement (mother of cocoa). The trees were established by digging a 1x1x1 m hole into the sand tailings, filling it with topsoil (compost has also been trialled), applying mineral fertiliser and planting the tree. Trees were then hand watered through the dry season. Plant spacing was initially wide (9×9 m grid of trees) but with infill planting in later years, and transplanting of elephant grass into rehabilitation, the spacing has reduced to a 3×3 m grid. The increased density aimed to quickly close the canopy and maximise litter fall to increase the organic matter content of the sandy tailings.

Following the 2016 acquisition of SRL by Iluka, a review of the past rehabilitation practices was conducted to identify whether the approach was suitable for the areas still requiring rehabilitation, or whether changes to the approach are required. In summary it was determined that:

- The rehabilitation currently established on sand tailings at SRL appears primarily limited by water availability during the dry season and secondarily by the nutrient retention capacity, both limitations being a result of the physical properties of the sandy tailings. These sandy tailings are unlikely to improve substantially over time, even with leaf litter and organic matter accumulation, given their primary physical properties. Hence the current rehabilitation would be unlikely to sustain subsistence agriculture, the ultimate objective of the rehabilitation effort;
- Erosion of the steep slopes of the rehabilitated sand tailings slopes is visible and likely contributes to poor growth of trees on these sloping areas;

- Wildfire fuelled by grasses established beneath the trees is a problem for establishing rehabilitation. In areas of high human traffic such as near the main road, elephant grass has not been established to reduce the fire risk that grass growth fuels;
- Slimes appear well structured and when dry should be ripped and planted (planting as per current practice);
- Borrow pit rehabilitation, apart from needing contouring to reduce slope angles for safety reasons would be improved if ripped when dry. This is within the context that the Ferralsols that predominate in the borrow pit area are inherently stable and not prone to erosion and therefore contouring to reduce slope is not required.

3 Closure obligations and commitments

The design of the MCP considers a number of interrelated components. Among these are legal and other obligations. The combination of these aspects, provide the key considerations used in the development of the plan.

3.1 Legal and other obligations

3.1.1 Legislation

The ESHIA details the applicable legislation that governs the environmental, social and health aspects of SR Area 1. This section provides a brief summary of this legislation but focusses on the legislation that will influence closure and rehabilitation of SR Area 1.

The EPA-SL are the custodians of environmental law within Sierra Leone. The EPA-SL is housed within the President's Office and is the main government agency in charge of all issues concerning the environment. The following Acts and regulations form the basis of the environmental regulatory framework in Sierra Leone that is applicable to SR Area 1:

- *Sierra Rutile Agreement (Ratification) Act, 2002*;
- *Mines and Minerals Act, 2009*;
- *Environmental Protection Act, 2008*; and
- *Sierra Leone Environmental Protection (Mines and Minerals) Regulations 2013*.

Based on the applicable laws and regulations it is required that any company or persons wanting to undertake any mining related activities will be requested by the EPA-SL to submit an environmental licence project screening application. Once the project has been categorised by the EPA-SL the specific environmental and social impact assessment and management undertakings will be determined. This opinion is informed by the relevant Acts and regulations as detailed in the sections below.

Sierra Rutile Agreement (Ratification) Act, 2002

SRL is governed by *The Sierra Rutile Agreement (Ratification) Act, 2002* and refers to the *Mines and Minerals Act 1994* (amended by *The Mines and Minerals Amendment Act, 1999*) as applicable. If there are conflicts between the two Acts, the Agreement Act will take preference. The Sierra Rutile Act addresses policies, development, operations and financial matters related to mining within the SRL mining area, including environmental and social matters such as surface land usage and rent, community relocation, hydrology, hydrogeology and water quality matters. The Act sets out a number of statutory obligations for SRL in relation to the occupation of surface land and compensation of landowners or occupiers. The Act also requires that a closure plan be developed and implemented at the operations.

Mines and Minerals Act, 2009

The key provisions of the Mines and Minerals Act relate to mineral rights and access to surface rights (including compensation for land owners), radioactive materials, protection of the environment,

community development, health and safety and transparency in the extractives industry. An environmental impact assessment (EIA) has to fulfil the requirements of this Act and the *Environmental Protection Act, 2008*. The Minister for Mineral Resources and the National Minerals Agency (NMA) are the current relevant authorities for enforcing the Act.

General and specific provisions for varying mining activities are provided in Part XV – Protection of the Environment of the Act (§131 – 137). The majority of Part XV is applicable for mining right holders seeking a small or large-scale mining licence. There are however certain sections that apply to all mining licence holders. The sections relevant to this plan are:

- §136 (1)-(6), provides a potential need for rehabilitation of damaged areas and the associated financial provision requirements;
- §137 (1)-(7), sets out possible directives served by the Minister that may require a former mineral holder to meet the obligations (or part thereof) set out in the mining right;
- §105 (2)(i)(v) provides the mechanism for the application to include "proposals for the progressive reclamation and rehabilitation of land disturbed by mining and for the minimisation of the effects of mining on surface water and ground water and on adjoining or neighbouring lands."

Environmental Protection Agency Act, 2008 and EIA regulations

The *Environmental Protection Act, 2008* (EPA Act), which repeals the EPA Act of 2000, outlines the functions of the EPA-SL and the environmental impact assessment and management requirements. The Act specifies in §24 (1) the requirement for an environmental licence (valid for 12 months and eligible for renewal on application) for specific listed activities in the First Schedule, through an environmental impact assessment process. In the Second Schedule the Act sets out the criteria for determining whether an EIA is necessary. Schedule Three specifies the required contents of an EIA. The Act also outlines fines for offences, inspections by the EPA-SL, the prohibition of the import, storage, disposal and release of hazardous and toxic substances. A clause covering financing requirements for rehabilitation is included.

The Environmental and Social (Mines and Mining) regulations, 2013

The Sierra *Leone Environmental Protection (Mines and Mining) Regulations, 2013* (SLEP (MM) Reg.2013), were drafted under the EPA Act and apply to corporates or individuals applying for or having been issued exploration or mineral rights under the *Mining and Minerals Act, 2009*. All persons or industries which undertake or have cause to undertake any extractive industries project will likely be subject to its provisions.

The regulations raise the standard of environmental management required by mining operations and align favourably with the principles of good international industry practice. Key international environmental management principles form the basis of the regulations, including sustainability, access to information, public participation and consultation, the precautionary principle, protection of affected communities, access to information, corporate social responsibility, adoption of environmental best practice and the polluter pays principle.

Historically in Sierra Leone, mining companies would have established company or operation specific Acts that would be comprised of varying environmental and social commitments relevant for that operation. This was necessitated due to an absence of legislation dealing with environmental and social protection and management. The GOSL, through the EPA-SL, is now in a position to implement these regulations as the primary means of environmental and social governance for the mining sector within the country, superseding company specific Acts.

Of particular relevance for closure are the following:

- §12 The project categorisation process The Regulations categorise projects into four categories, A, B, C and D based on their level of impact, with category 'A' being the most rigorous and category

'D' the least. Each category has a prescribed level of assessment (EIA and social impact assessment (SIA), ESIA, Code of Practice) and required management instruments (MCP, Environmental Management Plan (EMP), Social Management Plan (SMP) – including grievance mechanism, public communications plan, Community Development Agreement, Resettlement Management Plan) for each;

- Schedule Two provides the prescriptive form for project screening application;
- Schedule Three provides the methodology for a project characterisation to be employed by the authorities;
- Prescriptive structure and tables of contents of the EIA and SIA reports, the ESIA, the Code of Practice, the EMP and SMP reports, and the MCP are provided in the relevant schedules;
- § 28 requires that for category A and B projects the holder of a mineral right is required to establish costs for a restoration plan, including progressive restoration proposals and costs associated with the MCP prior to commencement of works and to provide financial assurance to the full value of the restoration, rehabilitation and remedial works associated within the MCP to the satisfaction of the Board. Estimates shall be revised annually, and the financial assurance revised accordingly;
- §29 lists the acceptable forms of financial assurance which includes a surety bond, a trust fund, an insurance policy, a cash deposit or annuities, or a combination of any of these;
- §30 states that an environmental licence may be suspended for failure to comply with financial assurance provisions;
- § 32 (1) requires that at mine closure the mine area should be left in a condition free of any adverse physical, chemical and biological effects, with no long term adverse environmental risks. § 32 (2) requires that a mineral right holder shall leave the area of operations in a condition that facilitates future sustainable land use and ensures that rehabilitation does not become a burden to the community after the mining activities are over. §32 (3), states that "a mineral right holder's obligations and liabilities shall continue until a closure certificate has been delivered;
- § 33 requires that a mine closure plan should be produced which shall include "all technical and legal measures that need to be implemented by the holder of a mineral right in order to rehabilitate the areas disturbed by its operations and to eliminate actual or potential risks to the environment and to public health and safety. For category A and B projects a MCP must be developed in accordance with §33 (1) (3) and the standards set out in the Ninth Schedule. Category C projects will need to include a conceptual mine closure plan in the ESIA (§33 (2) (4)). The detailed MCP and financial assurance shall be submitted for approval to the authorities at least six months before the proposed commencement of the project. The plan will be reviewed and updated every two years or whenever there are changes to the project which necessitates an update (§33(8));
- §34, requires the mineral right holder to undertake progressive mine closure;
- §35 provides a mechanism to enforce adherence by the holder to implementing requirements of the closure plan, which includes punitive measures and in the case of repeat offences, cancelation of the mining licence;
- §36 describes the process of asset management at the end of the life of mine;
- §37 describes the process required around the closure management of fresh water dams;
- §38(1), allows for the local community or authority to request that certain facilities, such as roads, buildings, water wells, or other, that can be beneficial to the local community after the termination of the mining activities be excluded from the mine closure plan. In which case, the local community or the district authority, as appropriate, shall take the responsibility for the maintenance of such facilities as well as for their closure should it be required;
- §39 describes the biennial review requirement; and
- §40 (2), requires that monitoring and reporting be undertaken for a minimum of three years after final closure. The authority may insist on a longer period if necessary.

3.1.2 International environmental and social principles, policies and standards

Whilst seeking primarily to comply with Sierra Leonean legislation, international environmental and social policies, standards and guidelines provide an overarching framework for the SRL ESHIA. A number of the key international policies, standards and guidelines are presented below. The GOSL is also signatory to several international conventions and agreements, which are described in detail in the ESHIA and listed below:

- Equator Principles*:* The principles provide a framework for an accepted international approach to the management of social and environmental issues. The intention is to ensure that projects are developed in a site-specific manner that is socially responsible and reflects sound environmental management practices;
- International Finance Corporation (IFC) Performance Standards*:* The IFC Performance Standards are an international benchmark for identifying and managing environmental and social risk;
- World Bank Environmental, Health and Safety (EHS) guideline*:* The EHS guidelines are technical reference documents with general and industry-specific examples of GIIP; and
- International Council on Mining and Metals (ICMM): Member companies of the ICMM are committed to measuring their sustainable development performance in terms of 10 principles approved in May 2003.

3.1.3 Constructive obligations

A constructive obligation is an obligation that derives from an entity's actions where[1]:

- (a) by an established pattern of past practice, published policies or a sufficiently specific current statement, the entity has indicated to other parties that it will accept particular responsibilities; and
- (b) as a result, the entity has created a valid expectation in those parties that they can reasonably rely on it to discharge those responsibilities.

In addition to complying with international and national regulations and standards, Iluka, SRL's parent company, has its own of policies, standards, procedures and guidelines, which according to the definition above, result in the creation of constructive obligations. As SRL falls under Iluka governance framework, SRL is required by Iluka to adhere to the policies, frameworks, standards and procedures summarised below.

Iluka Corporate Policies, Framework, standards and procedures

All Iluka Group standards and procedures provide auditable criteria, against which compliance can be measured. These structures define commitments, directions and intentions. They provide emphasis, set direction and are equivalent to organisational law; driving decision making within the business. These policies, standards and procedures are described in detail in the ESHIA. Those that influence closure activities are discussed below, as the existence of these policies, framework, standards and procedures create constructive obligations that SRL has to address at closure.

- Iluka Health, Safety, Environment and Community (HSEC) Management System Framework: amongst other requirements, this Framework requires the efficient use of resources, in particular energy, water and land, and effective plans for the cessation of operations and rehabilitation of disturbed areas; and
- Iluka Health, Safety, Environment and Community Policy 2017: The HSEC policy provides a declaration on the importance Iluka places on conducting its business safely, without detrimental health effects and with regard to the community and the value of the natural environment. Iluka HSEC policy commits the company to operate in a sustainable manner by targeting high levels of performance and pursuing leading practice in the areas of health, safety, environment and community reflecting the company's values of Commitment, Integrity and Responsibility.

Iluka Group standards

These standards specify uniform mandatory performance requirements that govern decisions and behaviour in support of the Iluka policies. They describe what shall be done. They provide a basis for verifying compliance through audits and assessments. Iluka has 14 Group standards as discussed in the ESHIA, with Standard 8 relating to closure:

[1] International Accounting Standard 37.14 (IAS 37.14) requires that an entity must recognise a provision if, and only if: a present obligation (legal or constructive) has arisen as a result of a past event (the obligating event), payment is probable ('more likely than not'), and. the amount can be estimated reliably

- Standard 8: Rehabilitation and Closure: closure of sites and operations is planned and implemented with due consideration of residual risk to Iluka and other stakeholders. Rehabilitation efforts are aligned with accepted leading practice, applicable legislation and undertaken in a socially and environmentally responsible manner.

3.1.4 Obligations arising from ESIA and ESMP

An update of the 2001 ESIA and Environmental and Social Management Plan (ESMP) was prepared by CEMMATS Group Ltd (Sierra Leone) in 2012 to fulfil new legislative requirements in Sierra Leone as recommended by the EPA-SL (CEMMATS, 2012). Volume 1 contained the updated ESIA, Volume 2 the updated Environmental and Social Action Plan (ESAP) and Volume 3 the Environmental Audit. The 2012 reports are based largely on the 2001 ESIA Knight Piésold studies. The 2012 ESIA and ESMP addressed closure of the operation and presented closure management activities that SR Area 1 was to adhere to. The 2012 ESIA and ESMP will be replaced by the 2018 ESHIA and ESHMP, with the MCP documented in both the ESHIA and ESHMP. The following briefly summarises the obligations that arose from the 2012 Mine Reclamation and Closure Plan (CEMMATS, 2012):

- Reclamation of dredge ponds involves draining the ponds to their final water elevation, assessing the long-term stability of remaining slopes and regraded highwalls, and providing for access control and fish stocking;
- The canal walls of the dredge canals and adjacent spoil materials will be shaped down to a gradient to a 2.0H to 1.0V gradient. Reclamation will include backfilling the canal with the adjacent excavated materials, grading and shaping, soil amendments and seeding;
- The reclamation of tailings piles includes those at the dredging operations, the total tailings facility and the chemical tailings facility. Tailings will be reclaimed primarily to agricultural use. Tailings piles will be regraded but will not be ripped due to their sandy nature. Topsoil material (150 mm) will then be placed over areas where the minimum 2.0H to 1.0V slope is achievable. For most tailings piles, soil material will be placed over tailings to establish a plant growth medium;
- Dry mining pit walls will be pulled back so that slopes are no steeper than 2.0H to 1.0V. The reclamation of dry mined and borrow areas will include the addition of soil amendments and revegetation;
- Existing roads that will not be used as part of future operations will be reclaimed during mine operations. Roads requiring closure will be ripped to remove compaction. Once ripped, roads will be regraded to blend with the local topography, limit erosion, and promote natural drainage. Culverts will be removed where necessary and the disturbed area regraded to allow for unobstructed drainage. Water bars, or small berms, approximately 25 cm tall, will be built as needed along regraded road surfaces to reduce overland flow. In addition to the roads, trails on SR Area 1 must also be reclaimed. Only minor scarification, regrading, and revegetation will be required to return trails to their natural topography and to provide proper drainage. The areas will have seedbeds prepared and will subsequently be seeded. Application of mulch will follow seeding. As required, storm water controls, slope reductions, or armouring will be used to control storm water and erosion;
- The Domestic Waste Facility will include a compacted soil cover (600 mm) as part of final closure. The final closure of the Hazardous Waste Facility will also require a soil cover that will be vegetated and shaped to promote drainage of surface run-off; and
- Closure of SR Area 1 will include the decommissioning, demolition and disposal of the land plant and ancillary facilities. The land plant will be completely demolished and removed at the end of mining operations. The dredges and wet plant will also be dismantled and removed. At Nitti, harbour facilities will be demolished at the end of mining unless the harbour is required to support regional development.

4 Project environmental and social aspects

The following descriptions of environmental conditions have been extracted and adapted from the ESHIA as well as the specialist reports that support the ESHIA, as referenced below (note: each of the specialist studies is appended to the ESHIA). These descriptions should be updated in future revisions of the MCP using on-going monitoring data to reflect any changes in environmental conditions throughout operations that may affect closure. The purpose of this section is not to provide an exhaustive description of environmental conditions, rather the purpose is to provide sufficient contextual information to understand potential mining impacts and closure risks that require mitigation during rehabilitation and closure. Furthermore, the purpose of this section is to highlight where relevant, how the mine affects the environment and how the environment affects the mine.

4.1 Climate and meteorology

ESHIA Specialist Study Reference: Air Quality Impact Assessment (AQIA) (SRK, 2018(1)) (Appendix A) and Surface Water Study (SRK 2018(4)) (Appendix G).

The climate of SR Area 1 is one that experiences a distinct wet season and a distinct dry season, where rainfall is more than twice evaporation. Although, the rainfall is twice evaporation, little to no rain falls during the dry season, which lead to a moisture deficit during the dry season when vegetation must rely on soil water storage.

The climate is that typical of the tropics being hot and moist during summer and dry in winter. The average rainfall is estimated to be around 2,800 mm/year. The wet season typically begins in May and ends in November, with the highest average monthly rainfall reading of 651 mm in August. The dry season, beginning in December and ending in April, is characterised by low rainfall. The average rainfall during the dry season varies from a minimum of 6 mm in January to a maximum of 97 mm in April. The annual average A Pan evaporation rate is slightly in excess of 1,100 mm/year, with the highest evaporation rates occurring during the dry season.

The average temperatures from the Weatherbase site (range 25.3 - 28.1 °C) were comparable to Lanti mine site data. Average maximum temperatures reached 33.4°C and minimum temperatures 19.8 °C. Relative humidity ranged from 68.6 - 87.4 %, with higher humidity measured during the wet season and lower humidity measured in the dry season.

4.2 Topography and geology

ESHIA Specialist Study References: Soils and Land Capability Assessment (ESS 2018) (Appendix K) and Hydrogeology Study (Graell 2018) (Appendix F).

4.2.1 Topography

The SR Area 1 consists of a series of prominent hills and slight undulations with an elevation range of 0.9 meters above sea level (masl) along the mangroves, to 322 masl with the highest point being at Gbangbama Hill. The existing dredge ponds and rutile deposits are situated around the Imperi Hills region on the western and south-western extent, with the Lanti and Gangama expansion situated within the alluvial plains and mangrove swamps to the north west.

The hills in the region have relatively steep slope angles and form prominent features in the landscape. The majority of the area adjacent to the hills comprises undulating, broad expansive fluvial plains, becoming increasingly flat towards the mangrove swamp areas.

4.2.2 Geology

The local geology is described as Tertiary aged alluvial deposits overlying the Precambrian high-grade quartzo-feldspathic-garnet gneiss (charnockite). The SR Area 1 heavy mineral sands placer deposits are hosted in the Bullom sediments which were deposited following a Tertiary marine regression with seas levels some 100 m below current levels. Mechanical and chemical weathering liberated heavy minerals from the underlying Kasila Group which were deposited in pre-incised channels.

Estuarine and marine unconsolidated sediments are located to the west of the major watershed located within the centre of SR Area 1. In contrast, alluvial and elluvial sediments were deposited sub-aerially to the north-east of the watershed. Several cyclic sequences comprising poorly sorted clastic gravels overlain by sands and clayey silts are preserved. Hard lateritic inclusions are common but are generally associated with the upper portions of the sequence.

The heavy minerals are generally angular and display little evidence of transport over long distances or extensive reworking. Grades rapidly decrease downstream with sand replacing the argillaceous material within the matrix.

4.3 Soils quality

ESHIA Specialist Study Reference: Soils and Land Capability Assessment (ESS 2018) (Appendix K).

The soils of the area are typical of tropical soils and those associated with estuarine environments. Whilst the soils generally have adequate water holding capacity to supply plant requirements during the dry season, the soils are highly leached and as a result tend to be deficient in adsorbed nutrients. In the context of this MCP, native soils will not necessarily be used as a growth medium as there are mine residues that will provide this ecosystem function. Topsoils will be used as an inoculum to the growth medium, to assist in return of plant propagules, nutrient cycling between the soils and vegetation and in some instances the formation of rhizobial relationships.

The soils in the area can be broadly categorised into three dominant reference groups, each group reflecting similar physical and chemical characteristics. The dominant soils groupings include:

- Fluvisols - accommodate genetically young soils in fluvial, lacustrine or marine deposits. The Fluvisols mapped are confined almost exclusively to the colluvial accumulation of transported soils within the alluvial plains;
- Ferralsols - represent the classical, deeply weathered, red or yellow soils of the humid tropics and have diffuse horizon boundaries, a clay assemblage dominated by low-activity clays (mainly kaolinite) and a high content of sesquioxides; and
- Gleysols - comprise soils saturated with groundwater for long enough periods to develop reducing conditions resulting in gleyic properties, including underwater and tidal soils. This pattern is essentially made up of reddish, brownish or yellowish colours at aggregate surfaces and/or in the upper soil layers, in combination with greyish/bluish colours inside the aggregates and/or deeper in the soil. These soils were confined almost exclusively to the mangrove swamplands in the northwest of the study area.

These different soils types are generally found in the four topographic zones of the area which includes:

- The marshes and swamplands associated with the coastal plains – Gleysols and saturated Gleycutanic materials;
- The sandy and silty clay loams and fluvial derived alluvial/colluvial deposits associated with the lower slopes and alluvial plains (Fluvisols);
- The in-situ derived ferricretes/laterites and shallow plinthic soils on the lower midslopes; and
- The ridge or crest slope and shallow to deep soils on saprolitic crystalline bed rock.

There are no indications of any toxic elements that are likely to limit natural plant growth in the soils mapped within the mining areas. It is however evident from previous studies (CEMMATS 2012) that with the dystrophic leaching conditions the exchangeable cation sites are largely occupied by exchangeable aluminium, iron and protons (H+) derived from natural organic acids associated with decaying organic matter. When exposed and wet, the hydrolysis of aluminium and the equilibration with exchangeable iron and protons results in low pH conditions with a high buffering capacity.

In general, soil pH values tend to decrease with increasing annual rainfall amounts and better drainage (Rose et al. 1979). The better-drained soils exhibited lower pH values (paste), relative to the more poorly drained soils developed in the mangroves/swampy areas.

In terms of the essential nutrients required for plant growth, the soils are considered poor, with less than adequate supplies of potassium, calcium, magnesium and phosphate.

The potential for soil to retain and supply nutrients was assessed by measuring the Total Exchange Capacity (TEC) and Cation Exchange Capacity (CEC) of the soils (CEC is the total capacity of a soil to hold exchangeable cations. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification). Generally, the TEC / CEC values for the soils mapped in the area are moderate to low, with the values being somewhat reduced due to the generally low clay percentages and the highly leached nature of the soils. Typically, a soil rich in humus will have a CEC of 300 me/100g (>30 me/%), while a soil low in organic matter and clay may have a CEC of 1-5 me/100g (<5 me/%).

The average Index of Erosion (IOE) for the majority of the soils likely to be impacted (Fluvisols) fall within the moderate to erodible category. The low clay content and lack of meaningful structure rendering these soils moderately erodible to erodible. This rating is influenced by the moderate organic matter content and undulating to flat terrain, which reduces the index of erosion to moderate.

The steeper slopes associated with the more resistant Ferralsols are the exception, with resistant to highly resistant erodibility indices, albeit that the potential for an increase in erodibility index will occur if vegetation is removed or the soils are disturbed.

4.4 Geochemistry

ESHIA Specialist Study Reference: Geochemistry Characterisation of Selected Residues report (i.e. geochemistry study) (SRK 2018(2) (Appendix E).

By virtue of the footprint covered by mine residues, these materials are the largest component of the rehabilitation and closure activities. As the geochemistry of these materials may influence vegetation establishment and long-term water quality, there is a requirement to understand the geochemical - characteristics in the event that specific closure actions are required to potentially mitigate geochemical impacts.

Recent and historical geochemical characterisations have focussed on primary and secondary tailings as these materials occupy a significant proportion of the mining landscape. No geochemical information exists on the geochemistry of the material remaining in the pits and dredge ponds after mining has been undertaken.

The primary process tailings are Non-Acid Forming (NAF) and there are no detectable sulfide minerals that could potentially generate acidity in the primary process tailings.

Sulfide Flotation Tailings (SFT) are Acid Generating and have the potential to stay acidic in the long term if exposed to oxidizing conditions and these tailings contain acid generating sulfide minerals, marcasite and pyrite. Total Tailings (TT) and Ilmenite Tailings (IT) also contain sulfides and are potentially acid generating. Fine Electrostatic Tailings (FET) and Coarse Electrostatic Tailings (CET) are NAF.

The leachates from primary process tailings are acidic (pH <6.0) and characterised by low salinity (EC <3.3 mS/m). All the measured parameters in the leachate are within the Sierra Leone's Environmental Protection (Mines and Minerals) Regulations 2013 (SLEP (MM) Reg. 2013) "limit at any moment" effluent quality for mining and metallurgic operations, except pH.

The parameters that exceed the background surface water levels in the leachate of the primary process tailings include the following:

- pH (<6.0), conductivity (>0.98 mS/m), aluminium (>0.02 mg/l), copper (>0.007 mg/l), manganese (>0.015 mg/l) and nickel (>0.002 mg/l) and sulfate (>2.3 mg/l); and
- Aluminium (>0.06 mg/l), chloride (>1.7 mg/l) and calcium (>2.0 mg/l), nitrate as N (>0.31 mg/l in Lanti tailings.

The leachates from secondary process tailings are acidic (pH <5.7) and characterised by low salinity (EC < 7.8 mS/m). All the measured parameters in the leachate are within the SLEP (MM) Reg. 2013 "limit at any moment" except pH.

The parameters that exceed the background surface water levels in the leachate from the secondary process tailings include pH (<6.0), Al (>0.06 mg/l), Ca (>2.0 mg/l), Cu (>0.007 mg/l), Mn (>0.015 mg/l), Ni (>0.002 mg/l), SO_4 (>2.3 mg/l) and TDS (>35 mg/l).

The implication of the findings of the geochemistry study are as follows:

- As the primary process tailings are currently slightly acidic, but inherently NAF and non-saline, the bulk of this material is considered to be geochemically unreactive.
- The secondary process tailings, specifically SFT, TT and IT, are PAG, acidic and non-saline and are likely to present a risk of increased acidity when exposed to oxidising conditions. The low pH of the tailings supernatant and seepage is likely to present a risk to the already slightly acidic environment and add to the overall acidity of the surface and groundwater system.

4.5 Radiation

ESHIA Specialist Study Reference: Radiological Assessment and Gap Analysis report (i.e. radiation study) (SRL 2018) (Appendix I)

The ore deposits contain minerals with elevated concentrations of radionuclides of the uranium and thorium decay chains (NORM). The uranium and thorium radionuclides and their decay products are concentrated in the monazite and zircon minerals. As the monazite and zircon minerals are progressively concentrated through mining and upgrading processes, the uranium and thorium concentrations of some process streams will increase.

The enhanced radionuclide concentrations in ore bodies; mining; and processing operations will result in the radiation exposure of workers and, possibly, members of the public. Potential exposure pathways for workers and members of the public include external gamma; radon inhalation; dust inhalation; and inadvertent soil ingestion. Members of the public could additionally be exposed to potential dose from water ingestion and other secondary pathways.

To quantify the risk, modelling was undertaken to determine the effective radiation dose rate to the various organisms and these values are then compared to a screening dose rate of 10 μGy/h. A dose to an organism less than the screening level value, implies that there is no increased risk to the environment.

The results from the current evaluation demonstrate that modelled dose rates for all fauna species exposed to process materials at SR Area 1 are below the threshold dose rate of 10 μGy/h. For mine residues (slimes tailings, HMC, MSP tailings and MSP products), flora species (with the exception of trees) are above the screening dose level. Based on Derived Concentration Reference Levels (DCRLs), flora species potentially only show effects of reduced reproductive success at levels of 10 – 100 mGy/day (equivalent to 417 to 4,170 μGy/h). Preliminary DCRL's are set at 1 – 10 mGy/day (equivalent to 42 to 417 μGy/h), but at these levels, no effects to populations have yet been proven. For the above-mentioned residues Lichen and Bryophyte (the most sensitive organisms) dose rates are in excess of 42 μGy/h, but still well below 417 μGy/h. The activity concentration levels contained within mine sand tailings, or areas contaminated with HMC, MSP tailings or products should not have a significant effect on fauna and flora populations present.

Available analysis was used to estimate potential doses to workers and members of the public from relevant pathways of exposure. In the absence of suitable environmental data, conservative assumptions about occupancy factors; inhalation rates; dust concentrations in air; dust particle size etc., were used to estimate radiation dose.

The dose assessment determined that the largest contributing exposure pathway for workers is from external gamma, followed by dust inhalation. Inadvertent soil ingestion dose as well as radon inhalation dose was shown to be negligible contributors to total dose. All doses calculated for the workforce is an order of magnitude below the annual dose limit of 20 mSv/y, and in line with doses measured at Iluka Australian operations. The estimated total dose for members of the public on roads or in villages close to dry mining; wet mining; WCP; MSP; tailings; and Nitti Port is below the public exposure limit of 1 mSv/y.

Potential exposure of the public from ingestion of surface or groundwater, is not expected to be significant, but would nonetheless need on-going monitoring.

Information from the radiation investigation currently indicates that there are no specific measures required at closure to limit potential radiation impacts.

4.6 Hydrology

ESHIA Specialist Study Reference: Surface Water Study (SRK 2018(4) (Appendix G)).

SR Area 1 lies in between east Teso River and west of Jong (Taia River), which are among some of the major rivers in Sierra Leone. The mining area catchment/surface river system drains in three different directions:

- The MSP catchment system which is east of the SR Area 1 lease boundary, consists of three of the catchment river systems (Kopa, Tikote, and Kokpoi Streams), which flow east into the Jong River;
- The Lanti catchment system includes the Gbeni and Lanti streams. Gbeni stream is located on the southern portion of the SR Area 1 and it flows to the south west before joining the Lanti stream to form Teso Creek. The Teso Creek flows into the Sherbro River which eventually flows into the sea. The Teso Creek is influenced by tidal action; and
- The Gangama catchment river system, is located east of SR Area 1. The catchment drains in Gbangbaia Creek which flows into Bagru Creek. The Bagru Creek flows to Sherbro River which then flows into the sea.

The water quality data was captured during three sampling sessions conducted by SRL in July, August and October 2017. A summary of the water quality assessment indicates the following:

- There is a generally a low pH, and little mineral content for buffering. Therefore, there can be an expectation of mineralisation and solubilisation of some metals, including aluminium from the resident soils, which may occur naturally, and not necessarily directly caused by SRL operations;
- Mogbwemo Domestic Pond, although used by the local community as a domestic source of water, did not meet the drinking water quality guidelines in July and August due to the low pH (4.2 – 4.7) and elevated aluminium concentrations. The quality improved slightly in October with a drop in aluminium concentrations to within drinking water quality guideline limits. The pH was not measured in October;
- The water discharging from the MSP tailings, through to the Mogbwemo Dredge Pond is impacted by the mining activities. The pH is below the legislative limits and aluminium concentrations exceed the drinking water standard limits. The concentration of determinants appears to decrease at surface water locations further away from the MSP area;
- The impact from mining activities is far less obvious downstream of Bamba / Belebu Pond, as only slightly acidic (pH 5.8) conditions were noted in August at SW14. This is expected as there is no active mining occurring in this catchment;
- At the old mining areas of Pejebu, the dam and dredge pond water quality is comparable to the background water quality, except the acidity that exceeds the legislative limits (pH of 4.5 at the dredge pond and pH 5.9 at the dam). The quality does not comply with the legislation limits due to the low pH but is within the drinking water quality guideline limits. This point is a recipient of the MSP effluent;
- The surface water quality is within the legislative limits at Lanti, except pH that exceeded the limits in August. The determinants elevated above background levels include TSS, turbidity, sulfate, nitrate, manganese, nickel, selenium and zinc. Aluminium concentrations are elevated relative to the drinking water guideline limits and the pH is also below the drinking water guidelines limit;
- At Gangama operations, the quality of G5 dam, upstream of the Gangama operations, water is comparable to the background water quality except nitrate concentrations that are slightly elevated relative to the background levels. Further down gradient from the Plant area, the water quality appears to be impact by mining activities indicated by acidity (pH of 5.8) and elevated dissolved aluminium content.

The influence that selected MSP tails have on water quality indicates that rehabilitation and closure measures are required to limit the influence these residues have on the hydrological environment, with these measures discussed in Section 8.2.11. No specific measures to manage water quality associated with other residues are currently indicated.

4.7 Hydrogeology

ESHIA Specialist Study Reference: Hydrogeology Study (Graell 2018) (Appendix F).

The geology underlying SR Area 1 has been described as Tertiary to Recent sediments overlying the gneissic basement of the Kasila Group. Drilling during this investigation has shown that the groundwater occurrence within the fresh basement is limited to isolated fractures and the yield is generally very low. For this reason, this is considered to be the effective base of the hydrogeological regime within SR Area 1.

Although laterite is extensive with an average thickness of 4.29 m, it has been removed during dry mining in Gangama and Gbeni. This material is generally confined to the unsaturated zone above the groundwater level and therefore does not form part of the hydrostratigraphy. Nonetheless, the laterite distribution does influence the groundwater recharge across SR Area 1.

Since there has been limited transportation of the Tertiary to Recent sediments, they tend to be clayey silts and silty clays similar in characteristic to the weathered basement. For this reason, the unconsolidated material including the weathered basement is grouped together as one hydrostratigraphic unit. The base of this unit ranges from 9 m to 34 m below surface with an average depth of 23.44 m. Bullom sediments in the coastal strip tend to have a higher permeability.

The highest groundwater yields besides the Bullom sediments are found at the weathered/fresh basement contact zone. This is considered to be a separate hydrostratigraphic unit which has a thickness of approximately 2 m to 3 m.

The effective hydrostratigraphy for SR Area 1 may therefore be summarized as follows:

- Unconsolidated Tertiary and Recent sediments, Bullom strata and weathered basement;
- The contact zone between the weathered and fresh basement;

Preliminary observed groundwater levels within the monitoring boreholes drilled during this investigation range from 2 meters below collar (mbc) to 12 mbc with an average depth of 7.20 mbc. The shallower groundwater levels are concentrated within the Gangama and Gbeni dry mining areas. This may be a function of the removal of ore that has already taken place. However, this could also be attributed to the location of the deposits within topographic lows - which would typically be groundwater discharge zones.

There is a very good correlation (0.98) between the topography and groundwater levels. At this stage it would appear that mining has not significantly altered the expected ambient groundwater gradients.

According to Knight Piesold (2008), most surface water sources, including the historical dredge ponds, are used by local community members for a variety of domestic purposes including for drinking water. Shallow groundwater wells are also used by local community members for water supply purposes. Deeper boreholes that have been drilled by Non-governmental Organisations (NGOs) were also evident during the site visit as part of this investigation. All the boreholes observed during the site visit as part of this investigation were equipped with hand pumps.

Groundwater sampling has not been undertaken at the time of writing this report. The historical monitoring data is therefore considered by Graell to be sufficient for the preliminary assessment at present.

Based on the current information, the groundwater pH rises in response to rainfall, drops in response to rainfall or shows a delayed drop in response to rainfall. It is anticipated that the groundwater pH variation is dependent on the rate of rainfall recharge across SR Area 1 and the location of the specific monitoring point relative to geological conditions and mining infrastructure.

The groundwater total dissolve solids (TDS) range from 5.56 mg/l to 77.9 mg/l which is considered to be good quality. Similar to pH, the TDS shows a variable response to rainfall where the TDS either increases, decreases or shows a delayed response to rainfall. It is anticipated that this variable response is due to either the dilution and/or mobilisation of soluble salts. Interestingly the pH trends seem to lag behind the TDS trends at some individual monitoring points. This suggests that pH variations may be in response to TDS fluctuations rather than vice versa.

The slightly too moderately acidic groundwater with the associated low TDS concentrations are attributed to the heavily leached soils which are typical of humid tropical climates. Bacteriological analyses indicate severe contamination which is attributed primarily due to human defecation.

Currently SRL do not anticipate that there are specific impacts on groundwater that will require the implementation of closure actions.

4.8 Land use capability

ESHIA Specialist Study Reference: Soils and Land Capability Assessment (ESS 2018) (Appendix K).

The land capabilities range from moderate to low intensity (carrying capacity) grazing or subsistence farming land, with poor or no commercial potential, to land with a natural conservation or wilderness status. The depth of most of the soils is well within the conditions suitable for arable land capability. However, the poor nutrient status, excess iron and moderate to poor water holding capabilities, reduce the rating of all of these sites to a moderate conservation status or low potential subsistence arable status.

4.9 Air quality

ESHIA Specialist Study Reference: Air Quality Impact Assessment (AQIA) (SRK, 2018(1)) (Appendix A).

SR Area 1 experiences two sources of air emissions, namely those that can be attributed to existing mining operations and non-mining sources. The majority of the mining emissions are related to operational activities and SRL anticipates that the emission will largely cease at the end of life. There will however, be surfaces from which dust can be generated (mine residues, exposed/cleared footprints, roads etc.) which will require closure measures to control dust generation.

4.10 Terrestrial, aquatic and wetland biodiversity

ESHIA Specialist Study Reference: Terrestrial, Aquatic and Wetland Ecological Studies (STS 2018) (Appendix B).

The study was confined to areas that will be disturbed by the additional mining that is being planned as part of the on-going development and extraction of the heavy minerals in SR Area 1. As no baseline exists for other areas given that assessments were not conducted prior to when mining commenced, SRL assumes that the characteristics described for SR Area 1 are analogous for those in areas already disturbed.

4.10.1 Regional biodiversity setting

Terrestrial Eco-regions

The majority of SR Area 1 occurs within the Guinean Mangroves (AT1403) terrestrial ecoregion, while the remaining portion of the study area occurs within the Western Guinean Lowland Forests (AT0130) (WWF, 2001).

The Guinean Mangrove is a vulnerable terrestrial ecoregion, encompassing approximately 14,000 km^2. This ecoregion is influenced by a large tidal range and high inputs of freshwater, containing stands that are more than 25 m in height and extend as far as 160 km inland. As the best developed mangroves in western Africa, this ecoregion provides important habitat for migratory birds and endangered species

The Western Guinean Lowland Forest is a critically endangered terrestrial ecoregion, encompassing approximately 128,000 km^2. The Western Guinean Lowland Forest contains the western most rainforest on the African continent. The flora and fauna are distinctive, with larger numbers of narrowly endemic species than in the contiguous Eastern Guinean Lowland Forest ecoregion to the east (WWF, 2001).

Aquatic Eco-regions

SR Area 1 is located within the Northern Upper Guinea Aquatic Ecoregion (reference number 511) according to the WWF Freshwater Ecoregions of the World classification[2]. This ecoregion is defined by the basins of the Coliba (Tominé and Komba), Kogon, Tinguilinta, Fatala, Konkouré, Kolenté, Kaba and Mongo Rivers and is characterized by a rich aquatic fauna with high endemism among fish, molluscs, amphibians, and crabs (Lévêque, 1997).

Biomes

The majority of SR Area 1 falls within the mangroves biome while the remaining portion is situated within the tropical and subtropical moist broadleaf forests biome. Mangroves occur in the waterlogged, salty soils of sheltered tropical and subtropical shores. They are subject to the twice-daily ebb and flow of tides, fortnightly spring and neap tides, and seasonal weather fluctuations. They stretch from the intertidal zone up to the high-tide mark.

Tropical and Subtropical Moist Forests (TSMF) are characterised by low variability in annual temperature and high levels of rainfall (>2,000 mm annually). Forest composition is dominated by semi-evergreen and evergreen deciduous tree species. These trees number in the thousands and contribute to the highest levels of species diversity in any terrestrial major habitat type.

4.10.2 Biodiversity features in SR Area 1

Habitats

Five habitat units are identified within the SR Area 1, with these being:

- Degraded Forest, which historically consisted of Moist Semi-Deciduous Forest which has been degraded by extensive, long term, slash-and-burn subsistence agriculture;
- A few remaining ridges which are associated with more intact remnant Moist Semi-Deciduous Forest;
- Watercourses associated with historic dredge ponds where bankside vegetation has re-established as well as systems downstream of the dredge ponds;
- Watercourses not affected by mining or decant, and mangrove areas; and
- Transformed habitat associated with villages, active agricultural fields, borrow pits, active dredge ponds and mining areas and associated infrastructure.

The degraded Forest and transformed habitat are the dominant habitats in and around SR Area 1.

Alien floral species in SR Area 1 were mostly associated with villages, agricultural and mining disturbances, where in some instances they were completely dominant.

[2] Reference: WWF Freshwater Ecoregions of the World (FEOW): http://www.feow.org/ecoregions/details/511

Historic dredge ponds are utilised as an aquaculture resource by the community. In this regard, alien species were introduced to some of these ponds as part of an active aquaculture program. Overall the aquatic resources in SR Area 1 presented with a fair prevalence and diversity of fish species. Of the taxa identified, the conservation status of all are classified as Least Concern.

4.10.3 Estuarine environment

ESHIA Specialist Study Reference: Draft Estuarine Study (Anchor 2018).

Although there are no specific remedial measures anticipated for the estuarine environments, there are areas at Nitti Port where mangroves have been impacted by sedimentation. However, the estuarine environment provides a large component of the ecosystem services utilised by communities associated with the SR Area 1.

Water quality

Sechii depth, a measure of the distance that light is able to penetrate through the water column, varied from 24-121 cm in the wet season but was considerably higher (i.e. indicative of clearer waters) in the dry season (50-198 cm). There were no clear patterns with distance downstream in either season, with peak Sechii depth often recorded at stations mid-way between the top and bottom. Total Suspended Solids (TSS) differed strongly between the wet and dry season being considerably elevated in the latter season. Anchor is of the opinion that the higher TSS levels in the dry season are linked to elevated phytoplankton abundance. The relationship between Sechii depth and TSS was poor but that between Sechii depth and Chlorophyll-a (Chl-a) concentration was much better, suggesting that phytoplankton were making a greater contribution to light attenuation than the inorganic material (sediment). All physiochemical measurements were within what can be considered “normal” limits and are likely to be typical of conditions in the study area.

Primary productivity

Chlorophyll-a (Chl-a) concentration at many stations were high compared to those reported in the literature for other West African estuaries. Higher values mostly associated with marine influence, suggests that phytoplankton blooms are developing in the wider areas of the estuary in the vicinity of Sherbro Island where nutrient levels, light penetration and retention support phytoplankton growth. During the dry season there was likely a greater water retention time in the upper creeks due to decreased flow through of fresh water and a greater tidal influence allowing longer residence time for phytoplankton. The increased retention times in conjunction with greater water clarity (increased Sechii disk depths) would have increased primary production and resulted in phytoplankton blooms and the elevated Chl-a values.

Sediment quality

Intertidal sediments in the study area are composed mostly of silt (i.e. extremely fine sediment) but included some coarser material (coarse, medium, fine and very fine sand) as well. Sub-tidal sediments were generally coarser, most likely as a result of more intense scouring in the channel.

Trace metal concentrations in sub-tidal sediment samples were generally low, and none exceeded commonly accepted levels of serious concern. The concentrations of three trace metals (arsenic (As), chromium (Cr) and nickel (Ni)) in sub-tidal sediment samples did exceed the level where toxicity may begin to be observed in sensitive species (National Oceanic and Atmospheric Administration (NOAA) Effects Range Low guideline, Long & Morgan 1990, Long *et al.* 1995) at some stations, but there were

no clear spatial patterns that suggest anthropogenic[3] pollutant sources. Poly-Aromatic Hydrocarbon (PAH)[4] concentrations were below the laboratory detection limits in all sub-tidal sediment samples.

Fish

The diversity of fish sampled during these surveys is lower than that reported in other fish surveys in the region. Fish samples collected from creeks potentially adversely impacted by mining activities in SR Area 1 (Gbangbaia, Kangama and Teso Creeks) did not have markedly different diversity or abundance from samples collected in the Bagru, Telo and Motevo Creeks and Sherbro Island that are unlikely to be impacted by mining.

Based on these two fish surveys it appears that the estuarine fish community in terms of diversity and composition is typical of a "normal" West Africa estuary, however, the relatively low number of fish caught, the small size of individuals (relative to the reported maximum sizes) and the relatively low mean trophic level of the fish community, does indicate anthropogenic impacts. It is suspected that the constant high levels of fishing effort by artisanal and commercial fishers using both long lines and gill nets is having a significant impact on the estuarine fish stocks.

Human use

Extensive fishing activity or evidence of fishing was observed in all the creeks surveyed during this study. This suggests that most of this fishing is of a subsistence nature, although it was observed that fishers sold their catch for cash when the opportunity arose. Mangrove trees are harvested for wood poles used to provide moorings for boats at villages and to create barriers across the upper reaches of the creeks (probably also in-house construction although this was not investigated). The estuaries and rivers themselves serve as an important access route for the transport of people, goods and produce.

4.11 Socio economic

ESHIA Specialist Study Reference: Social Impact Assessment (SIA) (SRK 2018(3)) (SRK 2017(3)) (Appendix J).

The social baseline is a collection and review of socio-demographic, socio-economic, socio-cultural, land use and institutional information in order to develop an appropriate understanding of the existing social context. The findings of the baseline collection indicate:

- Approximately 4,000 households resided within SR Area 1. The household survey recorded a sample of 2,960 household members in 560 households in total, resulting in an average household size of 5.2 persons per household. This figure correlates with the Population and Household Census (PHC) (2015), which showed average household sizes in Moyamba and Bonthe Districts as 5.1 and 6.2 respectively;
- Assuming an average household size of 5.2 persons per household, the population estimate in the SR Area 1 is 20,800. This brings the population density to 71 people per km², excluding the areas taken up by mining related activities (20,800 persons / 290 km²);
- The Districts of Sierra Leone are divided into 149 Chiefdoms (52 of which are in the Southern Province). Paramount Chiefs, who are elected by Chiefdom Councillors, govern Chiefdoms. Paramount Chiefs are in place for the remainder of their lives unless disputed. Those living in the Chiefdoms elect Chiefdom Councillors. General administration, law enforcement and local economic development are the responsibility of the Paramount Chief and their council, as are land rights and land custodianship. Chiefdoms are broken down into sections and then villages, which are governed by Section Chiefs and Town Chiefs respectively (CEMMATS, 2012);

3 Environmental pollution and pollutants originating in human activity.

4 Polycyclic Aromatic Hydrocarbons (PAHs) are hydrocarbons—organic compounds containing only carbon and hydrogen—that are composed of multiple aromatic rings (organic rings in which the electrons are delocalized).

- According to CEMMATS (2012), housing in the study area consisted of a mixture of traditional structures and buildings that were more modern. Raffia palm, grass, mud and bamboo were key components of less formal structures. Sun-dried bricks, cement brick, mud and sticks were options used for walls, and corrugated iron walls were observed in the built-up areas;
- Information provided by the Ministry of Education Science and Technology in Bonthe and Moyamba Districts showed a significant difference between the enrolment of boys and girls at various levels of education (2017);
- The household surveys (HHS) and rapid rural appraisal (RRA) (SRK, 2017a and 2017b) found that agriculture was the most important livelihood activity in most villages (barring villages closest to the ocean and mining ponds, where fishing activities were more common). Over 30 crops are cultivated with groundnuts, cassava, maize and peppers, cassava (33 %) was named as the most important livelihood crop, followed by groundnuts (24 %) and maize (10 %);
- In addition to mining related income, villages obtain income from subsistence farming and remittances from family members working elsewhere;
- Besides mining (SRL and Vimetco), other key employers in SR Area 1 included stone mining, the Sierra Tropical Pineapple farm and the African Lion Agriculture Oil Palm plantations;
- The majority of participants in the HHS (SRK, 2017a) inherited their land from family members. The majority owned their land with a title deed or a receipt;
- The most cited reasons for occupying specific land was inheritance (43 %), followed by only land available (24 %) and proximity to job opportunities (10 %);
- Slash and burn agriculture was the most common land use practice in SR Area 1. Crop rotation with periods of fallow was common, with a cycle of approximately 15 years;
- Palm wine and palm oil are made from oil palms, while raffia palm fronds are used for thatching of roofs. Traditional weave baskets are used in mining ponds, streams, rivers and most importantly, estuaries to fish, while fish traps, fishing rods, and hooks were set up in deeper waterbodies;
- Forested areas, “swamps” (mangroves) and freshwater resources that the study area communities rely on for a number of ecosystem services, were said to be in varying states of damage and reduced functionality;
- The collection of firewood, as well as the creation of charcoal, was another observed ecosystem-based service being utilised in a number of villages;
- General tree harvesting and reduced access to areas with tree coverage may underpin a reported community concern regarding reduced opportunity for the hunting and logging activities required for both subsistence and income;
- An economy based on local markets seems important to communities in the study area, allowing them to buy and sell produce and goods. The presence of SRL was reported to be central to trade and business in the area, because it encouraged buyers and sellers to SR Area 1;
- Wood was the preferred means of generating energy for cooking, while batteries were the most cited means of generating energy for lighting. Few people use energy for warmth due to the tropical climate;
- Roads in SR Area 1 were observed to be in good condition between the SRL offices and mine infrastructure. However, the roads between villages, towns and outer lying agricultural land and swamps were in varying conditions, often poor;
- The cost of transport was described as expensive, and as such, many chose to walk or used bicycles and motorbikes as means of transport;
- Access to potable water in the study area is low. The majority of households sourced their potable water from both non-mechanical and mechanical wells. In a number of instances, wells were shallow and hand dug, and were therefore often dry during the dry season due to their inadequate depth;
- Access to sanitation in the study area is limited, and largely, participants use their own pit latrine and the bush for latrines; and
- In terms of refuse disposal, the majority of participants claimed to have their own waste disposal area, with some making use of community waste pits, dumping their refuse elsewhere or burning it.

4.12 Community health environment

ESHIA Specialist Study Reference: Draft Rapid Health Assessment Report (SHAPE 2018) (Appendix D)

Years of conflict and the recent EVD epidemic have had a major impact on the health sector in Sierra Leone. Life expectancy at birth stands at 50.1, increasing by 11 years between 2000 and 2012, but still below the African average of 58 years and much lower than the global average of 70 years.

Communicable diseases are the leading cause of disease burden nationally of which malaria is the single biggest killer, accounting for 38 % of all hospital admissions. Tuberculosis (TB) is another significant public health problem, with an estimated three new infections per 1,000 people each year. The national HIV prevalence rate stands at 1.5 % (2013 statistic). Sierra Leone was severely hit by the most widespread Ebola Virus Disease (EVD) epidemic in history, where a total of 8,706 people were infected and 3,590 died.

The country is estimated to have the world's highest maternal mortality ratio, at 1,360 maternal deaths per 100,000 live births in 2015. Child mortality is also high, with over 150 of every 1,000 children dying before the age of five years. Malnutrition is widespread with almost one third of under-five children having stunted growth. Non-Communicable Diseases (NCDs) and injuries are increasing in significance, with cardiovascular diseases, cancer, diabetes and chronic respiratory disease, as well as injuries increasingly responsible for premature death and disability contributing to a double burden of communicable and NCD.

According to the Moyamba District Council, the top ten diseases/illnesses in the District are malaria, diarrhoeal diseases, skin diseases, hypertension, pneumonia, anaemia, intestinal worms, rheumatism, ear infection and onchocerciasis. The cause for these conditions has been attributed to a suitable habitat for mosquitoes to breed in, poor sanitation services and weak hygiene, lack of access to potable water, poor dietary habits and poor health prevention practices.

Poor housing and crowding in Moriba Town and Mogbwemo were cited as a key predisposing factor for communicable diseases in SR Area 1. Acute respiratory infection was consistently listed among the top three morbidities affecting young children presenting at the local health facilities. Measles outbreaks occur in the study area and the Moyamba District Health Management Teams (DHMT) reported that cases are seasonal and largely attributable to suboptimal coverage of measles vaccine (80 % in 2016).

TB was mentioned as an important concern and Moyamba DHMTs reported that cases of TB are increasing in the District with most of the cases co-infected with HIV. It was reported that mining areas are becoming hotspots for HIV and TB co-infections. This was of concern as only twelve facilities in Moyamba District have the capacity to diagnose and treat TB. The Bonthe DMHT reported that the District indicators on TB case detection were lagging and not meeting public health targets. Despite these deficiencies most cases of TB were considered to be co-infections with HIV. The SRL clinic reported that not many cases of TB were seen, however those that were, are generally co-infected with HIV.

Malaria was reported as the number one cause of morbidity in SR Area 1. The high burden of malaria was attributed to low utilisation of Insecticide-treated bed nets (ITNs) and environmental risk factors (occurrence of pools of stagnant water, artificial ponds and heavy vegetation). Typically, Malaria cases were reported to be higher during and after the rainy season (April to December). Communities along the rivers retire early and sleep under ITNs due to a type of nuisance fly that bites. Malaria rates are generally lower in the District as a result (a reported 26 % prevalence in the District). The SRL clinic reported that the community does not like using ITNs for sleeping under due to the heat, and that they are often used inappropriately (fishing and gardening).

In 2016, Bonthe District had the highest maternal mortality rate nationally, but this had improved in 2017. There are currently nine doctors in the District, which is an improvement to the pre-EVD period where one or two used to be the norm. This is attributed to support from WHO and others.

Healthcare services in and around SR Area 1 were inadequate. The biggest facility (the community health centre in Moriba Town) was too small and offered limited services to cater for the healthcare needs of the growing population. Community health officers also play an important role, especially in hard to reach areas, with these staff having been trained with the support of the United Nations Children's Fund. The staff are volunteers for now but there is a plan to try to pay them in the future. They are selected based on literacy, status in community and skills.

The SRL clinic receives and stabilizes all emergency cases that are brought to them, irrespective of SRL's involvement. Cases are referred (generally to Serabu) and the on-going cost of non-SRL related cases, are not the responsibility of SRL.

5 Stakeholder concerns relating to closure

ESHIA Specialist Study Reference: Issues and Response Report (SRK 2017(3)) (Appendix J).

Stakeholder comments related to mine closure and post closure land use that were raised during the scoping phase public participation process in 2017 are documented in Table 5-1. Stakeholders will have further opportunity to comment during the stakeholder engagement process associated with the impacted assessment phase in 2018.

Table 5-1: Stakeholder engagement process - Extract from the Issues and Responses Report

Comments, issues, suggestions raised by stakeholders	Stakeholder Name	Organisation or Village or Chiefdom	Date	Source of comment: (meeting or written)	Response by SRK ESHIA and SRL Project Team or Others as appropriate including reference where concern is addressed in the ESHIA as appropriate
General project related issues					
The Paramount Chief noted that there are legacy issues and that mined out areas have not been rehabilitated. Iluka should be aware that they have inherited both assets and liabilities, and must clarify their obligations in terms of the liabilities. Will the current owners of SRL continue to provide benefits to the local governance authority, like to previous owners did? He looks forward to a new beginning with Iluka.	Paramount Chief Alie Badara Sheriff III	Kabati, Jong	19 June 2017	Community meeting: Jong-Kabati	Surface rent will be paid as per legal requirements. A Community Development Agreement has been put in place to enable benefits for all Primary Host Communities. SRL is committed to conducting its business in an environmentally and socially responsible manner.
There should be stronger collaboration between the company and the District Agriculture Department in the crop assessments in the area.	Mary Mansaray	District Agricultural Officer for Bonthe District, Ministry of Agriculture Forestry and Food Security, Jong	19 June 2017	Community meeting: Jong-Kabati	SRL is already collaborating with the District Agriculture Department and will continue to build and strengthen relationships with them.
They allege that SRL has destroyed their land.	Koroma Moses	Foinda, Imperi	June 2017	Written comment (Comment form)	SRL recognises the importance of arable land and is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable.
	Mohammed Sannoh	Sannola, Imperi	June 2017	Written comment (Comment form)	
He/she alleges that SRL has destroyed people's land and houses.	Momoh Gbouma	Foinda, Imperi	June 2017	Written comment (Comment form)	
Claimed that SRL destroyed his land and asked that the company provide him with land.	Abu Gbouma	Foinda, Imperi	June 2017	Written comment (Comment form)	
She claims that the company destroyed her land and the crops, which they plant for their survival.	Regina Kpanabom	Mbelleh Yangatoke	June 2017	Written comment (Comment form)	
ESHIA related issues and information					
EPA-SL advised that they wish to see progressive rehabilitation take place at the mine.	Madam H Jallow	Executive Chairperson, Environmental Protection Agency	20 June 2017	EPA Offices, Freetown	SRL is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable
He appreciates the consultation meeting, as it is meaningful and highlights the many aspects that will be involved in the ESIA. The ESIA investigations should consider: • The problem of loss of land and agriculture in mining activities; • Cemeteries, traditional sacred sites and secret society bush; • Loss of livelihoods; • Noise and dust from machines; • SRL's plans to mitigate impacts.	Rev Anthony Pessima	Kabati, Jong	17 June 2017	Community meeting: Bagruwa-Sembehun	Positive and negative impacts will be assessed in the ESHIA, including options to increase positive impacts and minimise negative impacts. The ESHIA will assess impacts on air quality, biodiversity, community health, geochemistry, ground and surface water, mine closure, noise, radiation and socio-economics, and soils and land use. Please refer to Chapter 6, Section 6.3 of the ESHIA Report for details of the assessment of environmental, social and health impacts associated with the activities of the project. Chapter 7, Section 7.4 outlines the mitigation and management measures to ensure that social, health and environmental impacts, risks and liabilities identified during the ESHIA are effectively managed during the various phases of the project.
Soils and land capability					
Does SRL plan to replenish the degraded soils?	Paramount Chief Alie Badara Sheriff III	Kabati, Jong	19 June 2017	Community meeting: Jong-Kabati	SRK undertook a soils specialist study as part the ESHIA and ESHMP to determine the necessary management measures related to soils, including rehabilitation. Please refer to Chapter 6, Section 6.3 5 of the ESHIA Report for details of the assessment of soil impacts associated with the activities of the project. Chapter 7, Section 7.4, Tables 7.2, 7.3 and 7.4 contain specific mitigation and management measures to ensure that the social, health and environmental (including soil) impacts, risks and liabilities identified during the ESHIA are effectively managed during the various phases of the project.
Said that conditions are poor for farming on available land.	Ibrahim Sesay	Mogbewa II, Lower Banta	June 2017	Written comment (Comment form)	

Comments, issues, suggestions raised by stakeholders	Stakeholder Name	Organisation or Village or Chiefdom	Date	Source of comment: (meeting or written)	Response by SRK ESHIA and SRL Project Team or Others as appropriate including reference where concern is addressed in the ESHIA as appropriate
Land degradation will take place whether mining is wet or dry. The SRL rehabilitated lands have never regained their fertility to support agriculture in the area. What are SRL's plans to return fertility to the soils in the area?	Sulaiman Sengeh	Principal, Centennial Secondary School, Jong	19 June 2017	Community meeting: Jong-Kabati	SRL is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable
Topsoil typically contains concentration of rutile and ilmenite, so these soils have historically been mined rather than set aside for reclamation purposes and this practice has continued to date as part of renewed operations and has resulted too in continuous in the loss of these soils for future reclamation. It was expected from SRL that these impacts will be mitigated by the planned post-mining land use plan in order to lower the water levels and even drain them completely but that was not the case. It did not happen to the best wishes of the local communities. Also topsoil deposits that were not mined are still inundated as a result of the massive flooding in the project area. This inundation associated with dredge mining has over the years resulted in increased siltation as the turbid or muddy water in the ponds settles after mining. In fact, as I'm writing these comments, there is no effective soil management structure in place that will help mitigate the impacts to soil that has been inundated by water for the past fifty (50) years. As a result, there is no timely reclamation and stabilization based on reports, and has resulted to a great loss of topsoil through erosion. There is also no construction of sediment control ponds as was planned. Now there are exotic species in the project area. All the relocated villages and other resident communities have no reasonable amount of farmlands and have no easy access to sufficient local building materials as a result of the massive inundation and flooding of water. It is also a serious loss of potential farmlands.	Thomas B M Sabbah	Moriba Town, Imperi	23 June 2017	Written comment (Email)	SRK undertook a soils specialist study as part the ESHIA and ESHMP to determine the necessary management measures related to soils, including rehabilitation. Please refer to Chapter 6, Section 6.3 5 of the ESHIA Report for details of the assessment of soil impacts associated with the activities of the project. Chapter 7, Section 7.4, Tables 7.2, 7.3 and 7.4 contain specific mitigation and management measures to ensure that the social, health and environmental (including soil) impacts, risks and liabilities identified during the ESHIA are effectively managed during the various phases of the project.
Dry mining has destroyed the highly productive lands for farming, so available adjacent land is now congested.	Kadiatu Gbouma	Foinda, Imperi	June 2017	Written comment (Comment form)	
	Ambulai Ngegba	Fobu, Imperi	June 2017		
Dry mining has destroyed all the productive land, so farming is congested where land is available.	Momoh Gbouma	Foinda, Imperi	June 2017		
Biodiversity / natural resources					
The Paramount Chief is concerned about the loss of biodiversity due to mining activities.	Paramount Chief Alie Badara Sheriff III	Kabati, Jong	19 June 2017	Community meeting: Jong-Kabati	SRL appointed biodiversity experts to undertake specialist studies as part of the ESHIA. The studies investigated how the mine could possibly affect plants and animals – both on land and in the rivers and estuaries. These specialists also recommended management measures to minimise SRL's impact on plants and animals. Please refer to Chapter 6, Sections 6.3 2, 6.3.3 and 6.3.4 of the ESHIA Report for details of the assessment, respectively of aquatic biodiversity, terrestrial biodiversity and marine and estuarine resource impacts, associated with the activities of the project. Chapter 7, Section 7.4, Tables 7.2, 7.3 and 7.4 contain specific mitigation and management measures to ensure that the social, health and environmental (including aquatic, terrestrial and marine and estuarine biodiversity) impacts, risks and liabilities identified during the ESHIA are effectively managed during the various phases of the project.
Are there plans to reforest areas were trees have been felled?	Mary Mansaray	District Agricultural Officer for Bonthe District, Ministry of Agriculture Forestry and Food Security, Jong	19 June 2017	Community meeting: Jong-Kabati	Although planting of trees has been an ongoing part of the existing rehabilitation practices, the rehabilitation plan is currently being reviewed to ensure improvement.

Comments, issues, suggestions raised by stakeholders	Stakeholder Name	Organisation or Village or Chiefdom	Date	Source of comment: (meeting or written)	Response by SRK ESHIA and SRL Project Team or Others as appropriate including reference where concern is addressed in the ESHIA as appropriate
The bulk of the biodiversity and biomass of the project area is contained in the forest resources. Forests provide habitat for a whole variety of fauna ranging from micro-organisms to wild life and big game. So when these are completely cleared, valuable species of plants and animals including IUCN classified endangered species, simply disappear if appropriate measures are not taken to preserve stock. It has been observed that SRL is not following this industry best practice for the past years as a matter of routine in preserving topsoil and plants even though concerns had been raised by the local communities in this direction. As a result, there is now immense loss of biodiversity as well as previous habitat in the project area. There is a complete soil nutrient depletion. What will happen to the affected communities when SRL might have pulled out? Question yet remained unanswered. Terrestrial: The major terrestrial units include closed High moist fragmented forest and forest re-growth. High fragmented forest is mostly found in clusters in the lowlands, along streams and river courses around settlement and residual areas – e.g. Gangama/Mobambay Hills and Lanti forests. All were aged farmlands but had been completely destroyed by the project mining operations with no mitigation to alleviate the suffering of the poor people.	Thomas B M Sabbah	Moriba Town, Imperi	23 June 2017	Written comment (Email)	SRL appointed biodiversity experts to undertake specialist studies as part of the ESHIA. The studies investigated how the mine could possibly affect plants and animals – both on land and in the rivers and estuaries. These specialists also recommended management measures to minimise SRL's impact on plants and animals. Please refer to Chapter 6, Sections 6.3 2, 6.3.3 and 6.3.4 of the ESHIA Report for details of the biodiversity impact assessment, associated with the activities of the project.
Closure and rehabilitation					
What plans are there for rehabilitation of the land, and the land use options post mining?	Alhaji Paramount Chief Robert Coker Seilolo Papapwe III	Sembehun, Bagruwa	17 June 2017	Community meeting: Bagruwa-Sembehun	SRL is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable.
Land used for mining activities must be rehabilitated for agriculture activities.	Ramatu Kafala	Tissana, Jong	June 2017	Written comment (Comment form)	
A Mine Reclamation and Closure Plan (MRCP) was developed to outline the general closure and reclamation programs for the project area. The plan includes descriptions of surface preparation, soil material placement, seeding and planting. One of the key issues affecting the local communities in the project area is the overall shortage of agricultural land and the shortage is due to over utilization and degradation of the farmlands. Another contributing factor is in part of land take, flooding and slow pace of reclamation to date. The area said to be rehabilitated is a mere joke by comparison because it not properly done. Dry Mining and Borrow Pits: These are still visible in the project area and not reclaimed and they represent a potential safety and stability hazard. There are no soil amendments, proper re-vegetation – e.g. dry mined out area at Foinda/Higima, and other mined out areas in the Project concession area.	Thomas B M Sabbah	Moriba Town, Imperi	23 June 2017	Written comment (Email)	A conceptual closure specialist study was undertaken as part of the ESHIA, and a Mine Closure Plan has been prepared. Please refer to Section 9 and Appendix L4 (SRK 2018(6)) of the ESHIA Report. The MCP aims to demonstrate how closure of the SR Area 1 operations will be completed in a manner that meets the applicable legislative requirements, Iluka and SRL environmental management standards and good international industry practice. The MCP has been developed to be site specific and to address the particular risks associated with SR Area 1.
Environmental management					
SRL mining activities result in many negative impacts within the communities. How will SRL manage these in future?	Kortu E Stevens	Sectional Youth Leader, Gbangbatoke	15 June 2017	Community meeting: Lower Banta-Ndendemoia	SRL recognises that there are legacy issues and commits to acting in an environmentally and socially responsible manner. SRL's Environment, Health and Safety Department is responsible for addressing all environmental issues. The EPA-SL regularly monitors this department. Iluka is committed to implementing international standards of health, safety, environmental and community practices at all of its operations, including SRL and therefore current management systems will be improved to meet these high standards.
SRL has operated for 60 years with nothing for the community to show. In his view dredge mining is preferred over dry mining, as the latter drives away animals, and creates open pits that pose a safety risk to people and animals. He believes that SRL will not rehabilitate the open pits created during dry mining.	J P Lahai	Chairman, Landowners Association, Retired Civil Servant, Upper Banta	15 June 2017	Community meeting: Upper Banta-Motinga	SRL is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable. SRL is committed to ensuring that all land affected by their operations, is appropriately remediated.
He introduced himself as the intermediary between government, the company and community. He clarified that dry mining is better than wet mining. He said that from his engagement with the SRL CEO, all pits will be filled in progressively	Chief Sylvester Goba	Jong Chiefdom	15 June 2017	Community meeting: Upper Banta-Motinga	The best applicable rehabilitation practices will be planned for in the revised rehabilitation plan and will be implemented on a pre-determined rehabilitation schedule.

Comments, issues, suggestions raised by stakeholders	Stakeholder Name	Organisation or Village or Chiefdom	Date	Source of comment: (meeting or written)	Response by SRK ESHIA and SRL Project Team or Others as appropriate including reference where concern is addressed in the ESHIA as appropriate
Socio–economic issues					
Mining has destructive impacts on land and communities e.g., people's farming activities. Land clearing contributes to shortage of bush meat, water quality affects etc. SRL should contribute to restoring livelihoods, supporting education and maintaining roads. The host communities must benefit from the mining too.	Walter S B Margai	Town Chief, Gbangbatoke	15 June 2017	Community meeting: Lower Banta-Ndendemoia	SRL recognises that there are legacy issues and commits to acting in an environmentally and socially responsible manner. SRL has a Community Development Agreement (CDA) in place to enable benefits for all Primary Host Communities comprising the chiefdoms of Upper Banta, Lower Banta, Imperri, Jong and Bagruwa. The objective of the CDA is to provide a framework for the implementation of the SRL's community development obligations in accordance with the Mines and Minerals Act 2009 and the Sierra Rutile Agreement (Ratification) Act 2002. The agreement guides how SRL decides on and implements community development projects, in consultation with their communities. Furthermore, a detailed Social Impact Assessment was undertaken by SRK as part of this ESHIA process. Information provided to SRK by community members during the household surveys, conducted as part of the Social Impact Assessment, also informs SRL's planning process.
It is with a considered view that mining projects may have both beneficial and adverse impacts on the socio-economic fabric of the area where the activities are conducted. But as required by Law, the SRL Company was to enter into written agreement with the local communities that owned the land for surface rent which should be paid to them annually. It is also required by Law to pay adequate and reasonable compensation for assets including crop and land acquired for its mining and ancillary activities. And lastly, as expected, the land should be restored nearly to its original state once their mining operation ceases in the area. This progressive reclamation of mined out lands is highly required by Law. The socio-economic status in this regard is in relation to likely movement of job seekers at this existing time of mining operations that will in turn increase stress on the social services and public utilities such as water supply and food in the area. And that is why there is always this major concern expressed by local residents that their farmlands are adversely affected by the operations of SRL mine to the extent that their agricultural activities in the area had become less productive. Prior to commencement of SRL mining operation, each of the relocated villages under reference used to have sites of traditional cultural importance. The common sites were ancestral cemeteries, the Poro/Bondo society bushes and the shrines. Few villages amongst others used to have caves. These were often protected and preserved and also used as sites for social/religious ceremonies, particularly at the society bushes, shrine bushes and caves. The mining activities of SRL have completely cleared all these bushes and none is left as a monument for the future generation. The cultural heritage of the local people is no more. The customs and traditions of the local communities are flouted with impunity and this is contrary to Section 10A (IV) of the SRL Agreement. What a pity.	Thomas B M Sabbah	Moriba Town, Imperi	23 June 2017	Written comment (Email)	
We do not have sufficient land for cultivation as the mine has taken our farmlands. During the negotiations with the mine 50 years ago, prices were very low and now the cost of living is very high. I appeal to SRL and the government to increase the increment on the Nitti surface rent to improve the living conditions of our people. My family members need an increment of 60 million Leones per year since we have extended family members who are attending primary, secondary schools and universities.	Walter Tennyson, Sandy Bah Kelly	Gbangbama, Imperi	June 2017	Written comment (Comment form)	SRL is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable. SRL adheres to the relevant Sierra Leone Government Policies.
The rehabilitation employment process has taken about five years. Only three youths were employed as casuals. Not even ten percent (10 %) of land owners benefited from it. We ask that SRL properly rehabilitate relocated villages, because we have never seen a good example of rehabilitation.	Michael M Dauda	Kpejebu, Upper Banta	June 2017	Written comment (Comment form)	SRL recognises the importance of arable land and is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable.
Resettlement, compensation and livelihood related issues					
Our plantations/crops have been destroyed and we don't have anywhere else to plant. We are asking SRL to provide us with land.	Korema Ibrahim, Sorba Wulu	Foinda, Imperi	June 2017	Written comment (Comment form)	SRL recognises the importance of arable land and is currently working to improve the rehabilitation plan in order to restore mined out areas as soon as practicable.
Agricultural support					
Concerned that farmers are losing their lands and asked whether there is provision in terms of support for agriculture, especially mechanised agriculture for the long term.	Mary Mansaray	District Agricultural Officer for Bonthe District, Ministry of Agriculture Forestry and Food Security, Jong	19 June 2017	Community meeting: Jong-Kabati	SRL is in the process of establishing a comprehensive Community Development Agreement. The associated agreement has been negotiated between SRL and the Bonthe and Moyamba District Councils. The agreement will guide how decisions are made to select potential community development projects and how they are implemented, in consultation with the communities.

Comments, issues, suggestions raised by stakeholders	Stakeholder Name	Organisation or Village or Chiefdom	Date	Source of comment: (meeting or written)	Response by SRK ESHIA and SRL Project Team or Others as appropriate including reference where concern is addressed in the ESHIA as appropriate
Agriculture is the backbone of any community. Request therefore that SRL pay special attention to agricultural activities. We would like SRL to support small holder farmers in the following ways: • Mechanical cultivation (Rice, Cassava and maize); • Afforestation through the collaboration with the Ministry of Agriculture, Forestry and Food Security (MAFFS) and Livestock Farming; • Strong collaboration between SRL and MAFFS in the areas of assessment, crop compensation, support to farmers and afforestation to retain the soil again.	Mary Mansaray	District Agricultural Officer for Bonthe District, Ministry of Agriculture Forestry and Food Security, Jong	June 2017	Written comment (Comment form)	Furthermore, the detailed Social Impact Assessment being undertaken by SRK, as part of this ESHIA process, will provide information to inform SRL's planning process.
Request to create an agricultural project for the people in the community.	Bagaie Toraray	Sloic Mattru Extension, Mossavie, Jong	June 2017	Written comment (Comment form)	
Require assistance with land rehabilitation.	Sulaiman Sengeh	Jong	June 2017	Written comment (Comment form)	

6 Post closure land use and closure objectives

6.1 Post closure land use

The practice of returning a pre-mining land use during closure has evolved over the last 10 to 15 years and GIIP is to develop a closure plan where post closure land use allows the land to be used sustainably by stakeholders and ecological components, within the constraints imposed by the environment, recognising that post closure uses will often mimic pre-mining uses or the uses on land adjacent to the mining areas. This approach is recognised in SLEP (MM) Reg. 2013 in § 32 (2) which requires that a mineral right holder shall leave the area of operations in a condition that facilitates future sustainable land use and ensures that rehabilitation does not become a burden to the community after the mining activities are over.

Given that there are a variety of potential landforms that exist at the end of LoM on which rehabilitation and land capability restoration would be required, SRL undertook a workshop during September 2017, to determine the land capability and land use suitability of the different landforms. This exercise was undertaken with the following context:

- That the majority of the agricultural activities that are undertaken within the SR Area 1 are subsistence level activities where households, families or in some instances communities have small farms that are operated using slash and burn techniques;
- That there are pressures on productive land as a result of population growth, influx and the disturbance of areas by mining activities; and
- In addition to the agricultural activities, existing ecosystems are utilised for the collection of firewood, as well as the creation of charcoal, and to a limited extent fabrication of timber products (furniture and structures).

The landforms that are likely to exist at end of LoM, are:

- Footprints where demolition activities have been undertaken;
- Roads;
- Borrow pits primarily excavated for the construction of the dams at the various ponds, but also excavated for other construction activities;
- Dredge canal;
- Ponds with retaining engineered earthen dam walls;
- Sand from both dredge mining as well as sand from the dry mining primary concentrating process that segregated during gravitational classification following deposition;
- Slimes typically from dredge mining and disposed of in dedicated slimes paddocks. There may however, also be slimes that segregate from the dry mining tailings by gravitational classification, with these concentrated near the centre of the sub aqueously disposed tailings;
- A co-disposed sand/slimes mix typically from dry mining disposal where incomplete classification has occurred;
- MSP tailings; and
- Dry mining pits.

For purposes of planning, it was possible to group the above land forms into five broad categories:

- Sand tailings – consisting of the coarse tailings fraction from both wet and dry mining;
- Co-disposed tailings;
- Slimes – consisting of the fine tailings from both wet and dry mining;
- In situ – consisting of footprint on which demolition had been undertaken, roads, borrow pits, dredge canal, dams, floor of dry mining pits; and
- Ponds – body of water remaining behind the dams.

The purpose of the workshop was to list all possible land uses (listed vertically in a matrix - Table 6-1) and then qualitatively assign the ease to which the land use could be implemented on the different landforms (documented horizontally in a matrix), taking cognisance of the rehabilitation that would be required to achieve the land use. The potential land uses were divided into 5 broad categories of potential activities, as reflected in Table 6-1 . These categories were further divided into a number of sub-types of activities. For example, within the category “subsistence agriculture” some of the sub-types of subsistence agricultural activities included the cultivation of annual crops, the cultivation of raffia palm, the cultivation of rice etc.

As stated the ease to which the land use could be implemented was qualitatively assessed, with the following categories used:

- High – few impediments to adopting the land use on the landform;
- Moderate – some impediments to adopting the land use on the landform; and
- Low – many impediments to adopting the land use on the landform.

In addition to listing the ease of implementing land uses on the landforms, the advantages and disadvantage of the different land uses on the various landforms as determined by the workshop participants.

Table 6-1: Suitability of adoption of different land use options on the LoM Landforms

Post Closure Land Use		Advantages	Disadvantages	Ease of implementation of land use on landform				
				Sand Tailings	Co Disposed Tailings	Slimes	In situ materials*	Ponds
Type	**Sub-type**							
Forestry	Exotic Eucalypts (timber, charcoal)	Fast growing, easy propagation, soil tolerant, regenerate, high timber biomass	Fire, invasive	Moderate	High	High	High	Low
	Exotic Acacia (charcoal, timber)	Fast, easy propagation	Leaves slow degrading, invasive	High	High	Moderate	High	Low
	Native - fast growing (charcoal)	Easy propagation	Soil sensitive	Low	Moderate	Moderate	High	Low
	Native - slow growing (timber)	Generally easy propagation	Soil sensitive	Low	Moderate	Moderate	High	Low
	Native - Medicinal	Easy propagation	Soil sensitive	Low	Moderate	Moderate	High	Low
Subsistence agriculture	Fruit trees (paw paw, cashew, mango)	Easy propagation	Only needed near home as used for personal consumption	Low	Moderate	Moderate	High	Low
	Annual crops (cassava, okra, corn, peanut)	Easy propagation, desirable product, scalable production	Soil sensitive, landform sensitive	Low	Moderate to High		High	Low
	Palm (oil and raffia palm for oil, wine, roofing, fencing)	Perennial	Time until production, soil sensitive, productivity/ha variable	Low	Moderate	Moderate	High	Low
	Rice	Known technology, constructible landform, soil structure insensitive, but requires specific hydrological conditions	Water requirements, acid soil sensitive	Moderate	High	High	High	Low
	Hunting (e.g. “Cutting grass” (rat), duiker)	Culturally important	Declining forest habitat, over exploitation	Low	Moderate	Moderate	High	Low
	Livestock (goats)	Local trade, adaptable, insensitive to vegetation, low maintenance	Vegetation impacts if overstocked, require a baseline primary productivity which is unlikely to be present in the oligotrophic lakes	Low	Moderate	Moderate	High	Low
Settlement	Villages	Sand tailings suitable, landscape can be optimised	Landform stability, water requirement	High	High	High	High	Low
	Town	Sand tailings suitable, landscape can be optimised, limited productivity requirement	Landform stability, water requirement	High	High	Low	High	Low
	Ponds	Domestic reliance (washing, fishing, drinking etc.)	Water quality, drowning, flooding, disease	High	High	High	n/a	High
	Infrastructure (dam wall, roads, social amenities, recreational facilities)	Landscape can be optimised, culturally desirable, space consuming	Maintenance responsibilities and requirement for a third party to take responsibility	Moderate	High	Moderate	High	Low
Conservation	Degraded forest	Easy to rehabilitate	Productive and deep soils	Low	Moderate	Moderate	High	Low
	Remnant forest	Regulatory support, compatible with current camp site	Difficult to rehabilitate, difficult to protect, require productive and deep soils that may be limited	n/a	n/a	n/a	n/a	Low
	Mangrove	Easy rehabilitation, soil insensitive	Hydrological sensitivity - must be tidal	High	High	High	High	Low
	Waterways	Required for catchment management, easy rehabilitation, ecotone values	Soil sensitive, ecotone sensitivity	Low	Moderate	High	n/a	High
Aquaculture	Artisanal fishing -freshwater	Culturally important, low infrastructure requirements	Drowning, water quality, over exploitation	Low	Low	3	n/a	High
	Swamp vegetation (reeds, cutting grass etc.) dwelling construction, food	High demand, controllable by landscape design	Landform-hydrology sensitive	Cannot be achieved	Moderate	High	High	Moderate

* In situ material includes dry mining pits; borrow pits; dredge canals; roads; footprints where demolition activities have been undertaken.

This process identified that there would be no mechanism to control post closure land use once rehabilitated land has been returned to land owners. Land owners would ultimately determine the land use, with it being likely that there could be a succession of uses in time, and that various owners could utilise the adjacent land blocks differently. Consequently, instead of planning to implement specific land uses, SRL should undertake rehabilitation in a manner which would minimise land capability constraints. The requirement for land capability restoration, allowing a succession of post closure land uses, informed the overall closure objective (Section 6.2).

Recognising the land use limitations identified in Table 6-1, prescriptions for landform modification will be developed, as discussed in Section 8.2.8. It is intended that these modifications will reduce the identified land capability limitations, thus allowing land owners to utilise the rehabilitated area in their preferred manner.

Although SRL will rehabilitate the different land forms to a land capability capable of supporting a range of post closure land uses as far as practical, there are limitations, as discussed below:

- Current planning is to drain all ponds to a level at which stability risks to the retaining dams are acceptable in the long term. The reduced pond footprints will still retain water and these features will therefore remain permanent in the landscape. The post closure land use of these ponds may therefore be associated with aquaculture, but this will not be the primary reason to maintain those ponds;
- Given the seasonal rainfall, it is likely that the water level in the ponds will fluctuate. The effect of these fluctuations will be to alternatively expose and saturate the fringe around the ponds potentially creating an ecotone at the transition between the water body and dry ground. The post closure land use of these ecotones will therefore be limited to activities that include species that can tolerate periods of saturation and drying;
- The establishment of swamp vegetation and the services that this ecosystem provides will only be possible in areas that are saturated for the majority of the year;
- Mangrove formation and the use of the ecosystem services provided by the mangroves will be limited to estuarine areas;
- Geotechnical testing has not been conducted on the slimes to determine whether it will be sufficiently stable to support settlement, however, observations indicate that during the dry season significant surface cracks form, indicating potential instability. Therefore, use of these areas for settlements should be avoided; and
- It is not SRL's intention to establish an ecosystem similar to that which exists in the remnant forests associated with the accommodation camp. However, any rehabilitation activities undertaken in the camp will be with the intention of preserving the existing species as well as creating land capacity that will support the reestablishment of species in the areas cleared for structures.

Using information from the matrix, a number of possible land use on the different landforms were identified, recognizing that landform modification would be required to achieve the desired land capability to sustain the land use or succession of land uses. The landform modifications are discussed in detail in Section 8, however, Table 6-2 below documents the existing landform, the key mitigation measures and the potential post closure land uses.

Table 6-2: Land capability and associated land use of the various land forms

Existing Landform	Key Mitigation measures	Potential uses
Sand	Addition of slimes	Forestry, agriculture, settlements
Slimes	Removal of paddocks	Forestry, agriculture
Poorly segregated dry tailings	Reshaping and planting	Forestry, agriculture, settlements
MSP tailings	Reprocessing	
Ponds with retaining dam walls	Water level lowering	Aquaculture
Dry mining pits	Reshaping and ripping	Forestry, agriculture, settlements
Borrow pits	Reshaping and ripping	
Dredge canals	Reshaping	
Roads	Ripping	
Footprints post demolition	Ripping and planting	

To ensure a variety of potential post closure land uses will be possible, landform restoration will be completed utilising the key mitigation measures stated above. Once completed, native forestry species will be established using a variety of species with economic and environmental value. The rehabilitated areas will be maintained until the species are established and available for subsistence purposes. Thereafter, SRL will relinquish the rehabilitated area to the land owner, for the land owner to utilise as per the owner's needs.

6.2 Closure objectives

The overall closure objective for SR Area 1 is to implement remedial measures in a manner that the land capability of the rehabilitated areas is capable of sustaining a variety of post closure land uses, where the residual post closure risks are acceptable to SRL and SRL's stakeholder. The sub-objectives to support this objective are:

- Ensure safety and health of all stakeholders during closure and post closure, and that communities using SR Area 1 after closure are not exposed to unacceptable risks;
- Utilise closure methodologies that relinquish areas in a self-sustaining condition with little or no need for ongoing care and maintenance;
- Understand and address community concerns regarding closure;
- Comply with mine closure permitting and regulatory requirements;
- Obtain documented confirmation of meeting all closure requirements; and
- Physically and chemically stabilise remaining structures to minimise residual risks.

7 Land forms

SLEP (MM) Reg. 2013 requires the “presentation of final land forms in map and graphic (3D) formats”. Currently, although topographic survey is available, there is not sufficient information to generate meaningful final land capability maps or three-dimensional drawings of post closure land capability. Figure 7-1, indicates the landforms of the areas above water level and the area expected to be exposed by lowering the water level in the ponds. However, there is uncertainty as to what landform will be exposed when the water level is lowered. Therefore, even preliminary maps are unlikely to represent the closed condition. These maps and drawings will be generated in future iterations of the MCP.

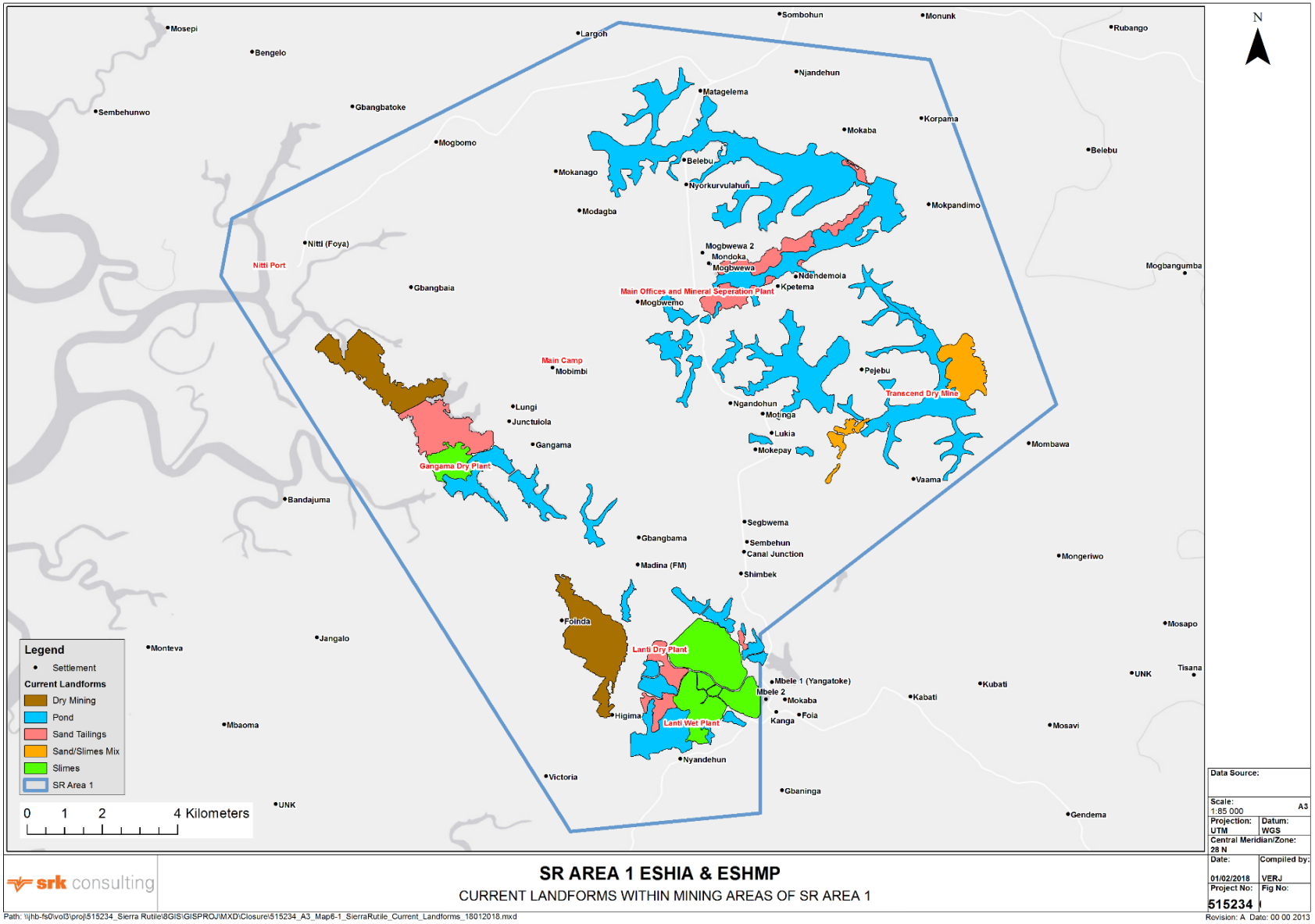


Figure 7-1: Current landforms within mining areas in SR Area 1

8 Risk assessment and management of closure issues

8.1 Risk assessment

The Ninth Schedule of the SLEP (MM) Reg. 2013 requires that a risk assessment is conducted to support the MCP, with the stated purpose of the assessment being to:

- Ensure early identification of potential-risks;
- Develop acceptable and realistic criteria to measure performance;
- Ensure orderly, timely and-cost-effective closure outcomes;
- Reduce uncertainty in terms of the scale of closure costs; and
- Ensure application of continual improvements in remedial technology, the enhancement of the final design and management of drainage, erosion and seepage controls.

A risk assessment was therefore undertaken by SRL to identify potential risks which require mitigation at the end of LoM. As the regulations do not specify a method for the risk assessment, with one of the stated purposes of the risk assessment being to identify potential risks, a qualitative risk assessment was undertaken as part of the closure planning process. This was undertaken as a risk workshop held at SRK House in September 2017 and attended by SRL, SRK, Iluka, SAS and Graell representatives with the focus being on risk identification, as opposed to risk quantification. As the primary purpose of the workshop was to identify risk, the approach taken was to describe the risks in terms of unwanted events, the cause of the unwanted events and the potential impact of the unwanted events if unmitigated.

Although the focus of the workshop was on risk identification, the unwanted events were categorised into low, medium and high risk based on the workshop participants perception of the probability and consequence of the unwanted event occurring.

The risk assessment was undertaken within the context of the current environment, assuming that no specific closure measures were implemented at the various aspects of SR Area 1. Of particular importance to the identification of the unwanted event and how this manifest as a potential risk was the following contextual information that was available from site knowledge as well as the various specialist investigations undertaken in support of the ESHIA:

- There is a distinct wet and dry season in the region;
- As discussed further in Section 8.2.8, the geotechnical properties of sand tailings are such that the water retention potential of the sand is insufficient to support vegetation cover, particularly in the dry season;
- Geotechnical testing has not been conducted on the slimes to determine whether it will be sufficiently stable to support settlement, however, observations indicate that during the dry season significant surface cracks form, indicating potential localised instability;
- Surface water quality is influenced by mining residues with this typically manifesting as pH values outside legislative limits. Turbidity may also exceed limits, particularly when active deposition is being undertaken. The greatest impact is however associated with the MSP where effluent from the secondary process tailings has elevated salts, metals and low pH in the waterbodies connected to the tailings deposition, although the influence of tailings decreases with distance;
- Pyrite and/or marcasite associated with the fine tailings which when exposed either during deposition or by water level fluctuations, releases acidity. The sulfides oxide rapidly if exposed to the atmosphere and are depleted within approximately 3 years, which then limits acidity generation. Geochemically the coarse residues are unreactive and unlikely to generate acidity, although they may potentially leach Al, Cu, Fe, K, Mn, SO_4 and Zn;
- The historical mining ponds have altered the groundwater levels, flow patterns and baseflow seepage in the immediate vicinity of the ponds, however, it is anticipated that this will be limited to the valleys adjacent to the mining ponds. It is possible that the elevated water levels within the mining ponds have also locally raised the groundwater levels which are being accessed by the

immediately adjacent community boreholes. Since the groundwater tends to mimic the topography within SR Area 1, more distant community boreholes will be unaffected. The groundwater gradients are expected to recover to their ambient levels, especially if the post mining topography reflects the pre-mining conditions and diverted rivers are reinstated. The lowering of the mining pond levels will also assist in this regard;

- Water within the ponds is retained by constructed dams across the valley downstream of the water bodies, with there being a total of 35 retaining dams associated with the SR Area 1. The long-term stability of these facilities is uncertain and retaining the dams in the current configuration in the post closure landscape may require an indefinite maintenance regime;
- The RRA and HHS indicated a perception that there are constraints to land available to use for subsistence agricultural purposes. As indicated in Section 6.1, there is link between community livelihood and agricultural activities, with there being an apparent need in the region for additional land for agricultural purposes; and
- The primary productivity of the mining ponds is not sufficient to maintain significant aquaculture activities.

The outcomes of the risk assessment are presented in Table 8-1, with this table documenting the aspect where the unwanted event occurs, the cause of the unwanted event and the resultant impact that would require addressing at closure.

Table 8-1: Outcomes of the risk assessment

Risk No	Aspect	Unwanted event	Cause of unwanted event	Resultant risk	Rating
1a	Subsistence fishing	Eutrophication of lakes	Lack of formal sewage treatment in the villages, with sewage potentially flushing into the ponds	Loss of livelihood on those reliant on aquaculture if mass fish mortalities occur	Low
				Water quality may deteriorate to the point where quality is no longer fit for consumptions for those who utilise the ponds as primary drinking water source	Low
1b				Loss of ecosystem complexity as less tolerant species are effected, leading to less diverse communities that in turn become less resilient to changes	Low
1c		Low pH water in specific ponds	Oxidation of pyrite/marcasite in the fine fraction of primary tailing and in the SFT, with the discharge of leachate into ponds	Sensitive taxa are impacted in ponds, leading to loss of ecosystem complexity and resilience	Low
2a	Retaining dams associated with the various ponds	Failure of retaining dam leading to a release of pond water or retained tailings into the downstream environment, which in some cases are fresh water courses or estuaries	Lack of maintenance and seepage in excess of design specification through wall base	Loss of human and animal life	High
				Damage or loss of subsistence agricultural land	
				Damage to downstream structures	
2b				Sedimentation of water courses or estuaries leading to loss of capacity to support biodiversity	
3a	Rehabilitation of sand	Vegetation does not survive the dry season	Low water retention in sands with inherent low fines fraction with there being insufficient retained moisture to sustain plants through the dry season	Failure to establish land capability capable of supporting a succession of post closure land uses. Not addressing the water and nutrient retention potential could result in multiple attempts at vegetation establishment on the same area incurring unnecessary costs	High
3b		Alien invasive species	Demand for utilisable land not achieved by rehabilitation leading to establishment of alien species on low land capability areas	Nodes of alien species communities may become established accelerating recruitment into native vegetation (irrespective of whether it is disturbed by mining activities) or onto subsistence agricultural areas	Medium
3c		Failure of communities to establish and rehabilitated areas to be dominated by a limited number of species	Dominance by species that contain volatile substances increasing flammablility	Bush fire spreading and impact on subsidence agriculture and native vegetation	Low
3d		Biological activity in rehabilitated areas does not occur at a rate sufficient to cycle nutrients, making them available for plant utilisation	Biological activity in stockpiled soils may have been impacted by stockpiling activities with the result that the activity of inoculating the soils with topsoil does not provide the appropriate microbial community to colonise the growth medium and allow nutrient cycling	Insufficient nutrient cycling in soils leading to reduced vegetation vigour	High
3e					
4	Post closure land management practices	Early exploitation of rehabilitated areas	Land pressures and demand	Unsuccessful revegetation	High
5a	Slimes	Lack of consolidation of slimes in slime paddocks	Geotechnical properties of slimes	Instability of the substrate limiting establishment of a post closure land capability that can support a succession of land uses	Medium
5b		Exposure of slimes to the atmosphere resulting in the oxidation of pyrite in the slimes leading to the acidity in the substrate being lower than required for optimal growth, limiting vegetation establishment on reclaimed land	Lowering of water levels, exposing pyrite in slimes to atmospheric oxygen and commencement of oxidation reactions	Unsuccessful revegetation	Medium
6	Groundwater	Decrease in phreatic surface in aquifers	Draining of ponds	Potential local loss of community water supply	Medium
7a	Surface water	Unmanaged water flows may inundate rehabilitated areas, impacting on land capability thereby limiting subsequent potential to utilise the land post closure	Insufficient planning of water management in the post closure environment	Land capability restoration not possible	Medium
7b					
8	Geotechnical settlement	Cracking of dwellings constructed on rehabilitated areas	Inhomogeneous substrate and or plastic sediments resulting in differential consolidation, impacting on structures stability	Structural damage, possible health and safety of community affected	High
9a	Infrastructure	Theft from abandoned structures	Unguarded structures and illegal access	SRL asset loss	Low
9b		Community health and safety impacted	Illegal access and unfamiliarity of with safety requirements	Injury or fatality	High

Risk No	Aspect	Unwanted event	Cause of unwanted event	Resultant risk	Rating
9c		Degradation of remaining structures	Structures transferred to a third party who does not maintain the structures. Scheduling of demolition activities poorly planned and structures awaiting demolition not being maintained	Potential failure and impacts on health and safety of community	Medium
9d		Exposure to Naturally Occurring Radioactive Material (NORM)	Illegal access to areas where NORM has concentrated and where rehabilitation has not been implemented	Impacts on health and safety of the community	Low
10a	Community	Stakeholders disputing approach of land capability restoration and establishment of native species that potentially have a beneficial use for the community thereby requiring a change in approach to rehabilitation or lack of approval of final closure plan	Stakeholder engagement not appropriately undertaken	A delaying in obtaining closure approvals, potentially including relinquishment	Medium
10b			Expected cessation of surface rent payments	A delaying in obtaining closure approvals, potentially including relinquishment and community loss of livelihood	Low
10c		Loss of direct and indirect economic benefits/income post mining	Closure of mining operations	Loss of livelihood	High
10d		Loss of health services	Closure of SRL clinic	Untreated health issues	High

8.2 Closure management

This MCP is based on the best available information at the time of preparation. Some aspects of the environment and operational conditions will need to be investigated further during operations as input to a final MCP.

8.2.1 Vegetation establishment

In line with the SRL's overall closure objective of implementing remedial measures in a manner that the land capability of the rehabilitated areas is capable of sustaining a variety of post closure land uses, a variety of techniques will be utilised to prepare the substrate to be vegetated, to have the capability of supporting a variety of post closure land uses and supporting the associated vegetation covers. However, as stated in Section 6.1, although the rehabilitated lands will generally have the land capability to support a variety of land uses, it is SRL's intention to establish a range of woody species on rehabilitated lands as the basis for commencement of subsistence agriculture. Once the rehabilitated lands are relinquished, the land users can then establish alternative vegetation if required.

As indicated in Section 2.5 historical revegetation has been undertaken by excavating a hole into the substrate being rehabilitated, filling the hole with topsoil obtained from stockpile and then hand planting tree species. Additional to the above has been the hand watering of each individual tree during the dry season for communities established on sand tailings.

The current planting practice (referred to as SRL revegetation strategy in Section 8) will be modified to ensure optimal use of scarce topsoil resources. With improvement in the underlying soils, topsoil will be used as a source of propagules and an inoculum of microbes, rather than as a growth medium. Consequently, shallower holes (300mm) will be excavated for planting. Excessive hand watering has been required due to poor soils and planting too close to the commencement of the dry season. Improved scheduling of rehabilitation activities (along with soils improvements) will reduce the amount of hand water undertaken.

SRL have developed community management nurseries at Mondorkor and Njagbahun (CEMATS, 2012) to provide species to be utilised during revegetation activities. These nurseries will be upgraded by SRL and managed to produce the species required for rehabilitation activities during the closure period.

8.2.2 Wet mining, primary and secondary processing infrastructure and all ancillary infrastructure

Regulation 38 of the SLEP (MM) Reg. 2013 makes provision for communities to retain certain facilities, such as roads, buildings, water wells, or other, that can be beneficial to the local community after the termination of the mining activities. In these cases, the local community or the local authority, as appropriate, shall take the responsibility for the maintenance of such facilities as well as for their closure should it be required. Although there is infrastructure associated with the SR Area 1 that can have a benefit to the community if managed by a third party, no applications, to SRL's knowledge, have been lodged to exclude items from the MCP. Therefore, for purposes of the current MCP, SRL intends to implement decommissioning and closure activities to remove all infrastructure associated with mining and processing as well as any ancillary infrastructure (accommodation, offices, Nitti Port, etc.). Future engagements relating to structure retention and transfer of liability to a third party will be undertaken as appropriate.

All land based infrastructure (concentrating and processing plants, Nitti Port, accommodation facilities, administrative buildings, sewage plant, etc.) will be decommissioned using a combination of mechanical plant to break down structures after salvageable equipment has been removed, using conventional demolition methodologies.

Current planning is that a platform will be excavated at a suitable position on the shore of the last Lanti mining pond and this platform allowed to fill to design capacity. The Lanti dredge and primary concentrator (Wet Plant) will then be floated onto the platform, where after the water in the platform will removed, allowing the equipment to settle onto dry ground. Decommissioning of the equipment can then be undertaken on dry land and equipment and scrap stripped from the structure.

As the Gangama Solondo dredge has capsized (Section 2.3.1) the above approach of preparing a platform and then floating the dredge onto the platform cannot be used. There are two possible options on how to decommission Solondo Dredge. One option is the removal of the dam and lowering of the water level around Solondo Dredge, thereby allowing equipment and scrap to be stripped. If the water level does not subside sufficiently, option two is to construct a paddock around Solondo Dredge, using material with geotechnical properties suitable to limit ingress into the paddock. This will then be pumped dry, allowing decommissioning activities to commence. The approach will be determined in future revisions of the MCP and will be done within the context that the pond in which the Solondo Dredge resides is likely to be used for tailings storage in the future.

Material inventories will be managed near the end of operations to minimise any surplus materials at closure. Fuel, lubricants and other materials needed to support the closure activities will be utilised during the closure period, with these storage areas closed once product requirements have ceased on completion of closure.

Where practicable, equipment and materials with value not needed for post-closure operations will be sold and removed from SR Area 1. Similarly, any scrap with value will be separated for ultimate removal from SR Area 1. Existing salvage yards or a facility designated for this purpose during the closure period will be used for the temporary storage of the equipment. Preliminary assessment by SRL indicates that radioactive scale on equipment or scrap is not expected, however radiation surveys will be undertaken during the demolition process to ensure any materials with elevated radiation are segregated and managed in accordance with the appropriate SRL's Plan. The exception is the density gauges (sealed radiation sources) that are integral to some of the plant process monitoring equipment. These will be separated from any equipment removed during decommissioning and either returned to the supplier or shipped to a facility licenced for the handling and disposal of sealed sources. All no-value equipment, scrap and building rubble will be disposed of in a facility on SR Area 1, as will be described in SRL Waste Management Plan to guide closure activities.

A decontamination plan will be developed to manage the removal of contamination (i.e. hydrocarbons, NORM, etc.) of equipment, scrap, rubble and residual mining or processing material in pipes, tanks, reaction vessels, cyclones etc. prior to disposal.

A soil contamination investigation will be conducted on completion of demolition activities, particularly in remaining open excavations. The purpose of this is to identify areas of possible contamination and design and implement appropriate remedial measures to ensure that the soil completion criteria (Section 9) are achieved.

Excavations remaining following demolition and foundation and slab removal, and those where contamination remediation has been undertaken will be filled with a combination of sand and slimes to ground level prior to the establishment of vegetation.

Specific decommissioning activities will include:

- All power and water services to be disconnected and certified as safe prior to commencement of any demolition works;
- Salvageable equipment will be removed and transported to a centralised facility prior to the commencement of demolition;

- All fittings, fixtures and equipment within buildings will be dismantled and removed to designated Existing salvage yards or a facility designated for this purpose during the closure period will be used for the temporary storage of the equipment;
- All above ground electrical, water and other service infrastructure and equipment will be removed and placed in designated temporary salvage yards prior to removal from SR Area 1 or disposed if of no economic value;
- Electrical, water and other services that are more than 400 mm below ground surface will remain;
- All pipes and structures deeper than 400 mm need to be sealed to prevent possible ingress and ponding of water;
- Concrete slabs and footings will be broken and buried in situ;
- All concrete below 500 mm depth will remain underground with the invert of all structures broken/sealed to prevent possible ingress and ponding of water;
- Soils beneath the plant, storage tanks and chemical storage areas will be sampled. Any contaminated soils found will be removed for disposal;
- All subsurface cavities such as reinforced concrete tunnels under stockpiles will be backfilled; and
- All telecommunication towers and dishes will be dismantled and removed.

The yard areas (e.g. platforms created for buildings, laydown areas, salvage yard, and other disturbed areas) will be closed and regraded if necessary to control storm water runoff and erosion. Compacted areas will be ripped to mitigate the effects of traffic. Vegetation will be established using the SRL revegetation strategy.

Measures that will be conducted specifically at the Nitti Port area in addition to the above demolition activities include:

- Removal of jetty structures from the waterbody;
- Salvage of the sunken push-boat;
- Surface scarification to remove spilled product, prior to ripping of the footprint;
- Manual removal of the sediments and product that has runoff into the mangroves on the northern side of the port and reestablishment of vegetation by planting mangrove species; and
- Conducting a radiation survey to determine whether there are any additional remedial measures required at the material handling and stockpile areas.

As mentioned in Section 2.3, SRL operates a warehouse facility in Freetown, where bagged zircon concentrate is currently stored. No remedial measures will be required at this facility, other than to remove any residual bags back to SR Area 1, if necessary.

8.2.3 Roads, laydowns and parking areas

Mine roads that are not needed for closure and post-closure uses (e.g. security and monitoring) or use by communities will be closed. The mines roads retained will be resized for post-closure use by regrading and ripping to a width that is appropriate for anticipated post-closure traffic – nominally 30 % of current width for haul roads. Closure actions for the removal of roads, parking areas and laydowns include:

- Removal of all signage, fencing, shade structures, traffic barriers, etc.;
- All ‘hard top’ surfaces will be ripped and bitumen or other hard standing in parking areas removed along with any culverts and concrete structures. This material will be disposed of as will be described in SRL Waste Management Plan to guide closure activities;
- Any safety berms of material stockpiled along the road edges will be graded back onto the area being rehabilitated prior to vegetation establishment;
- All potentially contaminated soils are to be identified and demarcated for remediation; and
- Once surface preparation has been undertaken by ripping, natural vegetation will be allowed to re-establish.

Where roads are to be retained for closure, post closure and community uses, the following will be undertaken:

- Removal of all signage and traffic barriers that are not needed by statutory requirements for the safe use of the road;
- SRL do not intend re-engineering water course crossings along the alignment of the retained roads, unless the current infrastructure impinges on the sustainability of the road. A survey will be undertaken to determine crossing requirements and where necessary upgrades will be constructed. However, where the current culverts are sufficient, the width of the stretch of road leading and existing the crossing will be retained to limit the impacts that road rehabilitation could have on the crossings;
- Where there are no requirements for safety berms along the road edge, the approach will be to rehabilitate from one edge to reduce road width. Where safety or water management berms are required, rehabilitation will be undertaken on both edges to reduce the width and will in addition to the actions below, include reconstruction of the berms;
- The width being rehabilitated will be ripped;
- All potentially contaminated soils are to be identified and demarcated for remediation; and
- Once surface preparation has been undertaken by ripping, natural vegetation will be allowed to re-establish.

8.2.4 Borrow pits

The pits that have been used to provide construction material for the dam walls and roads were excavated leaving unsafe highwalls in addition to an exposed footprint. SRL estimates that the borrow pits cover an area of approximately 310 ha throughout SR Area 1.5 m. The flat surfaces of the borrow pits could be used for a variety of agricultural or forestry related land uses. The closure actions that will be implemented at the borrow pits are:

- Highwalls will be reshaped to a profile of 1V:2H either by dozing from the crest, or using an excavator at the base of the highwall. Reshaping will be undertaken so that as much of the topsoil as possible from the cut area at the highwall crest is spread as the final layer of the reshaped surface;
- The base of the borrow pits will be ripped; and
- Vegetation will be established on the reshaped wall and borrow pit base using the SRL revegetation strategy.

8.2.5 Dredge canal

A canal was historically used to transfer the dredge and floating concentrator between the northern and southern ore bodies in Area 1. The canal was constructed by widening and deepening existing drainage lines or, where relevant, was purposes built. The canal is approximately 10 m deep and 50 m wide with almost vertical sides, with the material removed from the canals stacked adjacent to the canals. Observations on site indicate that while the slopes of the stacked material were not engineered and are in some instance staked with slopes of 1V:2H, natural vegetation has established on this material. Given the cover and biomass on the stacked material, SRL do not intend reshaping the slopes on the premise that these slopes are already stable. Furthermore, observation on site indicate that the base of the canal is generally well vegetated and in some instances, being used for a variety of agriculture activities, such as rice.

The closure actions that will be undertaken at the dredge canal are:

- The near vertical canal walls will be reshaped to a gradient of 1V:2H by dozing from the crest or using an excavator at the base; depending on the wall heights. Reshaping will be undertaken so that as much of the topsoil as possible from the cut area at the highwall crest is spread as the final layer of the reshaped surface; and
- Vegetation will be established on the reshaped wall and borrow pit base using the SRL revegetation strategy.

8.2.6 Mining and tailings ponds

There are a variety of ponds associated with SR Area 1. These include the historical dredge ponds, the active ponds associated with current dredge mining at Lanti and the tailings ponds associated with dry mining activities (Lanti and Gangama). Water within the ponds is retained by constructed walls across the valley downstream of the water bodies, with there being a total of 35 retaining dams associated with the SR Area 1.

Although the ponds are used for a variety of domestic and aquaculture activities, the ponds occupy an area in excess of 2,300 ha, some of which were used for agricultural activities prior to the commencement of mining. The removal of the ponds, or a portion of the ponds, would therefore potentially expose footprint which could be used for a variety of agricultural or forestry related post closure land uses, once land capability has been restored. A reduced footprint will change the waterline to waterbody ratio increasing the proportion of fringing vegetation, possibly assisting to mitigate the current oligotrophic status of the dams, potentially improving their ability to support fish populations. The fringing vegetation may also provide a suitable habitat to establish species that thrive in hydromorphic conditions for which there is a community use, for example raffia palms for roofing material.

An additional driver for the reduction in pond area is the stability risks associated with the retaining dam walls. During operations, stability is monitored and remedial measures implemented where necessary, however, at closure and post closure, the sustainability of the dams has yet to be determined. As there are significant environmental, social, health and safety risks associated with dam wall failure, SRL is of the opinion that the current dams should not be retained in the post closure landscape. While stability analyses have not been undertaken on the dams to determine post closure sustainability, SRL is of the opinion that reducing dam height and reshaping if necessary, has the potential to result in an engineered structure that is durable after operations have ceased.

In order to lower the dams, the water level in the ponds will require release. This will be undertaken in a controlled manner to limit the impacts that the released water on downstream structures, recognising that pond levels fluctuate significantly between the wet and the dry season. Current planning is that water levels will be reduced by the annual progressive extension of the respective spillways in the dry season, to the dry season pond water level. The new spillway level created each year will then allow water entering the ponds in the subsequent wet season to spill in a controlled manner. Spillway lowering will continue until the desired final height of the dams is achieved. Thereafter, the material above the final height can be removed and placed either as material at the base of the dam to provide additional stability or to be used to improve the nutrient and water holding properties of sand tailings as discussed below. In addition to lowering the dam wall heights, sand tailings will be disposed on the upstream surface of the dams to displace water from the dams, thereby limiting contact of water and the dams.

There is an expectation that the lowering of the water level in the ponds will expose highwalls where the dredge removed ore. These highwalls are expected to be near vertical and will require reshaping as they represent a safety risk to those accessing the SR Area 1.

Currently there is no information on the surface morphology below water level. This information is required in additional to dam stability analyses to determine the final dam height. Furthermore, bathymetry will allow more detailed planning on highwall reshaping requirements and sand reshaping requirements. The closure actions for the ponds are:

- Undertake a bathymetry survey of ponds to determine subaqueous morphology;
- Undertake stability analyses of all dams and determine optimal closure configuration of these structures;

- Commence with a program of lowering the water levels in the ponds through spillway expansion on an annual basis in the dry season. Each resultant spillway should be engineered to contain the flood event specific to each dam, without impinging on the dam's stability in the following wet season. Once the final spillway level has been achieved, engineer the final spillway to contain the 24-hour - Probable Maximum Precipitation (PMP) event assuming maximum water level at the peak of the wet season;
- Progressively remove the material in the dam above the spillway level. If required, the surplus material above spillway level can then be deposited on the downstream side of the dam to enhance stability. If not required, the surplus can be used to improve the plant nutrient and water holding properties of the sand tailings exposed by water level lowering;
- Once the final dam configuration has been reached, establish vegetation on the residual dam using the SRL revegetation strategy; and
- Once final water level is achieved, reshape the dredge ponds highwalls to a gradient sustainable for the specific soil form. SRL expects the reshaped highwalls to mostly consist of in situ material onto which vegetation can be directly established using the SRL revegetation strategy.

8.2.7 Dry mining pits

Dry mining operations are being undertaken at both Lanti (Gbeni) and Gangama by excavators and haulage trucks where ore is removed from the pit and hauled to the primary concentrating plant. The use of the load and haul method will continue at Gangama, however, during December 2017 an in-pit mining unit was constructed at Gbeni where the mining occurs to the base of the ore deposit within a box cut. Ore is pushed towards a hopper by dozers where it is then pumped to the processing plant. Once sufficient pit room has been formed, tailings deposition will occur behind the box cut as the mining face progressively advances.

Various trenches have been constructed within both mining pits to dewater the voids ahead of mining. Various diversion channels are associated with the mining areas to separate the contact water from rainfall runoff. A stream diversion is associated with the Lanti dry mining area and a second one is to be constructed on the eastern boundary of the Gbeni pit. The mining process results in an undulating pit floor surrounded by pit highwalls (at a gradient of approximately 1V:1.5H), with the various drainage trenches excavated into the floor.

Currently saline intrusion is likely to be a factor if dry mining is undertaken in close proximity to the estuary in the northern extremity of the Gangama deposit, as there is uncertainty as to whether the area is underlain by Bullom sediments which are more transmissive than the Tertiary to Recent sediments. While this could change the groundwater quality in the vicinity of the pit, the more significant impact could be associated with how the intrusion influences the ability of SRL to establish vegetation and provide a land capability with a variety of post closure land uses, although there is the potential that the area could revert to mangrove. As the extent and influence of the saline intrusion has not yet been determined, no specific closure measures are included in this MCP to restore land capability or groundwater quality in the areas possibly subject to intrusion.

The closure measures that will be implemented at the dry mining area include:

- Reshaping of the remaining pit walls, either above virgin ground or above backfilled tailings as required to reduce the overall slope to one that is sustainable post closure. Reshaping will be undertaken so that as much of the topsoil as possible from the cut area at the highwall crest is spread as the final layer of the reshaped surface;
- Establishment of vegetation on the reshaped highwalls using SRL revegetation strategy;
- Rehabilitation of pit floors consisting of basement material will include the following activities:
    - Reshaping, where practical, to limit water ponding, which could potentially limit the establishment of a post closure land capability that would support a variety of post closure land uses;
    - Backfilling of trenches excavated to dewater ahead of mining activities. Backfilling will be undertaken using either the material excavated from the trenches if available or a combination

of material stripped during the lowering of the pond's dams and a slimes/sand mix depending on what material is available proximate to where it is required; and

- Vegetation will be established using SRL revegetation strategy.

- Rehabilitation of pit floors where tailings have been deposited will be rehabilitated as described in Section 8.2.8, Section 8.2.9 and Section 8.2.10; and
- An assessment will be made ahead of closure on post closure water management requirements. This will be used to assess whether the diversion canals, river diversion, berms, etc. are required in the landscape. Those that are not required will be decommissioned, backfilled and vegetation established. If practical, pre-mining flow directions will be re-established.

8.2.8 Sand tailings

There are a number of sources of sand tailings associated with SR Area 1. These include the sand deposited during primary processing of dredge mined material, including sand tailings deposited outside of the pond footprint as well as those potentially exposed through the lowering of the dams and draining of the mining ponds. There are also likely to be sand tailings associated with dry mining residue deposition. While the coarse and fine tailings generated during primary processing of dry mining material are co-disposed into a single facility, gravitational classification leads to particle separation.

Sand tailings consist of relatively uniform material of large particle size, which results in a poor capacity to retain water and nutrients. As a result, these materials are not suitable to sustain vegetation in the dry periods in their current form. This is exacerbated by the climatic conditions where there is a distinct wet and dry season, with the soils required to store water for plant utilisation during the dry season, potentially to a depth in excess of 2 m.

According to Hillel (1982 in Hattingh and Viljoen, 2006) soil water is important from an ecological perspective, meeting a number of ecological roles. Soil water is required for nutrient transport, it is a component utilised during photosynthesis and provides turgor to the plant. Soil water is also important in soil formation processes and is a component of weathering, humus enrichment, mobilisation and transport). The water retention properties are a function of the soil structure which is related to the manner in which irregularly shaped mineral and organic particles are arranged in relation to each other. Particle arrangement results in the formation of pores, which are the voids in which water is stored in soils. Sandy materials have numerous pores, but an overall low total pore space while fine material has a large total pore space. The ideal mixture is somewhere between these two extremes (Hattingh and Viljoen, 2006).

Although the sand tailings have poor physical properties for plant growth, there are a variety of materials that could be added to improve their texture, particularly increasing the fines content to a level at which there is sufficient water retention to support plant growth during the dry season. Given that there are large quantities of fine material in the form of slimes, separated from the sand during primary concentration, the slime could be added to the sand to improve soil texture and water retention capacity. In addition to slimes, the material removed from the dams could be used to improve texture, if the removed material is not used to stabilise the remaining wall.

The ideal reconstituted soil matrix will require determination from geotechnical testing, particularly size distribution, on the sand tailings. However, given that the geotechnical information available on the *in situ* soils in areas undisturbed by mining (ESS, 2017) indicate a clay percentage between 9 and 21 % (excluding the gleysol sample), SRL is currently of the opinion that adding 15 % slimes to the sand tailings to a depth of 2 m would provide sufficient water retention capacity in the reconstituted sand tailings to support vegetation growth, however this is subject to modelling studies currently underway.

The above-water sand tailings have an undulating morphology with steep slopes in some areas. SRL expects that this similar morphology will be reflected in the subaqueous sand tailings, given that the

sand tailings have a relatively high angle of repose, even underwater. SRL therefore, expects that reshaping of both the surface tailings and those exposed by the lowering of the pond levels will be required during closure. The subaqueous morphology will however, only be determined by undertaking a bathymetric survey or draining the ponds.

The closure actions on all sand tailings include:

- Undertaking the necessary geotechnical investigations to determine the optimal reconstituted soil matrix and perform field trials to demonstrate the mix has the potential to support vegetation;
- Reshaping of slopes to a maximum gradient of 1V:5H where relevant using dozers. Reshaping will also be undertaken to re-establish drainage patterns are far as possible, taking into consideration the erosion potential that runoff may have on rehabilitated areas;
- Slimes or material from dams will be transported to the sand tailings under rehabilitation and worked into the upper 2 m of the sand profile so that an average fines percentage of 15 % is achieved. The technique of blending the fines material into the profile has not yet been determined and will require trialling in the SR Area 1 to obtain an efficient way of mixing the materials to obtain the required distribution of fines. Methods of transporting the slimes to the sand tailings will also require investigation. Options currently include load and haul, or slurrying and pumping; and
- Once SRL is satisfied that the required blend of 85:15 of sand:slimes material has been achieved, vegetation will be established on the sand tailings.

The 2017 geochemical assessment (SRK 2017(2)) on primary tailings indicates that the primary tailings are inert and leachate quality complies with SLEP (MM) Reg. 2013 requirements, although there may be instances where Al, Cu, Fe, K, Mn, SO_4 and Zn leach in concentrations above background water quality. The current water quality database is not indicating that this is a significant impact, albeit that this database is still being developed to show seasonal fluctuations. As no significant impact is being recorded, no specific remedial measures are included in this plan to limit leaching and potential downstream impacts.

8.2.9 Slimes

Slimes deposited in the slimes paddocks exhibit localised cracking during the dry season, potentially indicating a surface instability associated with the slimes surface. There is currently no data to indicate the extent of the cracking or the depth to which drying occurs. Visual evidence suggests that the fine fraction associated with the slimes provides sufficient water holding capacity for vegetation to survive through the dry season. SRL therefore, do not intend to implement closure actions to enhance the water and nutrient holding characteristics of the slimes and are of the opinion that the slimes will provide a land capability on which a number of post closure land uses can be undertaken.

Given the absence of data on the textural properties of the slime, the long-term stability of slimes in paddocks is uncertain. Should the paddocks be stable, SRL will construct decants in the paddock walls to limit water impounding on the paddocks after closure. The intention is to remove surface water accumulations from the paddocks, which could limit post closure land use. This is within the context that the slimes have low permeability, but are not expected to be at saturation if standing water is removed. Slime deposited sub-aqueously, and particularly those co-disposed during dry mining are not artificially contained within paddocks, and therefore no measures to drain surface water from these deposits is expected.

Anecdotal evidence suggests that slimes that have been deposited sub-aqueously, which are subsequently exposed to the atmosphere do not initially support plant growth. This is believed to be due to the oxidation of pyrite and/or marcasite associated with this fraction, with acidity being the limiting product of oxidation. Further anecdotal evidence suggests that the effects of acidity are short term (under 5 years) and the available sulfides are rapidly oxidised and leached from the fines, where after vegetation can be established on the slimes. The vegetation limiting effect of oxidation is normally observed in ponds, where the level has dropped exposing the slimes as opposed to the slime

paddocks associated with dredge mining. Further studies will be undertaken to determine the factors that influence reaction kinetics in the different slimes impoundments (paddock versus ponds),. As SRL expects slimes to be exposed during the draining of the ponds, and with these slimes oxidising on exposure, SRL intends mixing a quantity of lime into the exposed slimes prior to establishing vegetation, with the lime projected to buffer the effects of acidity. Laboratory testing, numerical modelling and field trials will be required to determine the optimal mixing depth as well as the optimal mixing ratio.

SRL assumes that the surface of the slimes will be more even than sand surfaces and therefore do not expect that there will be a significant requirement to reshape slimes exposed by the lowering of the pond water levels. The exception being areas where slimes are mined for mixing with sand tailings to enhance the nutrient and water holding properties.

The closure actions for the slimes are:

- Undertake the necessary geotechnical investigations on slimes and stability analyses on the slimes paddocks;
- Remove slimes for addition to sand tailings to enhance nutrient and water holding properties and then reshape excavation areas to be free draining;
- Determine liming requirements through laboratory testing and numerical geochemical modelling and perform field trials on materials where sulfide oxidation is anticipated to limit vegetation establishment;
- Where stability is not compromised, the slimes paddocks will be breached, and engineered drainage structures constructed to limit water accumulation on the surface. The drainage structures will be constructed to drain the 24 hour – PMP;
- Slimes in paddocks and those exposed by lowering of pond water levels will be allowed to dry until SLR determines that the surface is sufficiently consolidated, to allow mechanical plant access. Although significant reshaping of slopes is not anticipated, minor reshaping may be required to enhance runoff and limit erosion. This will be undertaken by dozer as necessary;
- Lime will be blended into the slimes where sulfide oxidation and resultant acidity is anticipated to limit vegetation establishment, at the concentration and depth determined by the investigations and field trials; and
- Establish vegetation using the SRL revegetation strategy.

8.2.10 Co-disposed Tailings

Tailings from primary processing of dry mining ores consist of fine and coarse residues co-disposed sub-aqueously. As stated above, gravitational classification is likely to separate the material into a coarse and a fine fraction. However, it is expected that there will be a transition zone between the coarse and fine fractions. The implication of this size distribution is that some parts of the tailings will have a higher water retention potential that the coarse fraction and no textural adjustments will be required ahead of revegetation. The sand/slime mix in the transition zone is likely to have an angle of repose less steep than the coarse fraction, but steeper than slimes and there may be a requirement to undertake reshaping activities to reduce the slopes associated with the transition material.

Although the slimes fraction of the transitional material has the potential to contain pyrite and/or marcasite, it is not anticipated that the acidity arising from oxidation of sulfide in the poorly segregated dry mining tailings, will limit vegetation establishment. Therefore, no lime will be added to this material prior to revegetation.

The closure actions for the transitional material are:

- Reshape the transitional material where necessary; and
- Establish vegetation using the SRL revegetation strategy.

8.2.11 MSP tailings and stockpiles

The various MSP processes generate a number of residue streams at different stages as the material flow through the plant. Hydro-sizers are used to separate coarse and fine materials. The fine fraction is sent to a circuit where sulfur is removed by flotation. The resultant rutile rich feed is then pumped to the dry plant. The sulfur tailings are pumped to the SFT pond. The main processes at the dry plant are drying, sizing and electrostatic and magnetic separation. The electrostatic process deflects non-conductors (zircon and silica) and separates them from conductors (rutile, hematite and ilmenite) in the product stream. Previously, the fine and coarse tailings from the electrostatic separation process discharged separately to the FET and CET ponds. At present, both streams are combined and discharged into a combined Coarse and Fine electrostatic tails pond. The conductors (rutile, hematite and ilmenite) undergo magnetic separation where the non-magnetic rutile separates from the magnetic hematite and ilmenite. IT discharges to the IT storage area. The rest of the tailings consisting of silica quartz and slimes, discharge to the TT pond (gravity tails pond). In addition to the residues mentioned above, there are a number of stockpiles located within the plants and other areas that are processed, to recover economic value. These stockpiles include:

- Ilmenite feed;
- Dry mill spillage;
- Ilmenite plant feed;
- HMC wet plant (low sulfur);
- HMC wet plant (high garnet);
- HMC wet plant (scrapings);
- DM 1 tower; and
- DM 2 tower;

SRL intends to reprocess the stockpiles to extract residual value. If reprocessing does not occur prior to closure, it should form part of the closure activities. There is currently no economic value in the TT and SFT and these facilities will be closed as described below.

The closure actions for stockpiles and tailing facilities with residual value include:

- Material in stockpiles and tailings facilities will be excavated if necessary and loaded for haulage to the Lanti dry plant. Hauled material will be blended with ore if available or with sand tailings to obtain the correct densities for primary processing. Mineral from the processing will be recovered and the residues will be disposed of as tailings. Where blending of stockpiles and tailings is not necessary, these materials will be directly processed in the MSP;
- Once the stockpiles are removed, the footprints below the stockpiles will also be excavated and transported for reprocessing. The depth of the excavation will be determined after the material has been removed. If the removal of the stockpile, tailings and material in the footprint results in a depression in the landscape, this will be filled with a mixture of sand and slimes to obtain a topography that will limit water ponding; and
- Vegetation will be established using the SRL revegetation strategy.

The TT will remain in situ in the pond and the following will be undertaken:

- The TT pond will be reshaped to a more uniform shape to promote runoff and to limit ponding;
- It is anticipated that the water retention potential will be insufficient to sustain vegetation growth however, this will be confirmed with tests. If testing indicates that the TT cannot sustain vegetation, then alternative uses for the material will be investigated particularly given the proximity of the residue to Mogbwemo town; and
- Vegetation will then be established using the SRL revegetation strategy.

SRL assumes that the sulfides in the SFT are fine grained and liable to oxidise rapidly when exposed to the atmosphere. There are therefore two closure options. The first is to construct an engineered facility where the SFT can be disposed of below the regional groundwater level and then place low

permeability covers, likely of laterite to limit atmospheric influence, particularly oxygen and water ingress. An alternative, which still requires trialling, is to excavate the SFT and transport the tailings to a hardstand in the plant, where the tailings can be subjected to natural oxidation under the prevailing climatic conditions. SRL anticipated that the leachate generated from this process can be managed within existing water management circuits. There may however, be a need to add lime to limit the leachates effect on the pH of water within the circuit, given that water around the mine are generally poorly buffered. Once SRL can demonstrate that the residual sulfide will not generate significant acidity, the depleted tailings will be transported to an adjacent sand or slimes pile for disposal. There may be a need to undertake leaching in a number of phases to leach the full volume of the material that has been stockpiled in the SFT. Potential contamination in the SFT footprint will be determined, and if necessary will be excavated for treatment which could include leaching and/or treating with lime. The resultant excavation will be backfilled with sand and slimes and revegetated using the SRL revegetation strategy.

In addition to the residues mentioned above, there is an accumulation of plant screening material located to the north of the MSP. This material is removed from screens by front end loader and then disposed in the dedicated area, resulting in stockpile side slopes at the angle of repose (approximately 35°). Initially screening indicates that this material may have elevated gamma radiation. The following closure measures will be undertaken on the plant screening material:

- Reshaping to a profile where erosion of covers is not likely to significantly impact the cover or mobilise the gamma containing plant screening material. Reshaping will be undertaken within the context that there are space constraints at the toe and may involve pioneering benches onto the dump and depositing to the south of the facility away from the wetland;
- Covering with material excavated from the dam walls or material suitable of sustaining plant growth during the dry season, with the cover designed to limit exposure to gamma radiation if this is determined to be a risk; and
- Establishment of vegetation using the SRL revegetation strategy.

8.2.12 Waste management facilities

SRL is currently updating the Waste Management Plan as part of this ESHIA. However, it should be noted that a separate ESHIA is presently underway for the design and construction of an engineered landfill facility at Mokula. During this ESHIA process, the Waste Management Plan's practices will be aligned to the availability of this new facility. This plan will determine what facilities exist at the end of LoM. Closure activities will be implemented at the waste disposal sites to result in a stable landform with low potential to generate leachate. These are anticipated to include covering with predominantly slimes material and then establishing vegetation.

The Waste Management Plan will also address the handling of waste generated during closure.

8.2.13 Water management

Prior to closure a water management plan will be developed to identify which water management structures are required at closure and which can be decommissioned. Ditches, canals and trenches not required will be backfilled. Bunds not required will be flattened by redistributing the material across the footprint adjacent to the bunds. Vegetation will then be established using the SRL revegetation strategy.

As closure approaches and more data is available, SRL will prepare a SR Area 1 site wide closure water management plan which will consider flow across rehabilitated areas and the potential erosion impact that rainfall can have on the rehabilitated areas. The post closure plan will be developed to minimise these impacts and enhance the sustainability of the rehabilitated areas under different post closure land uses, within the context that SRL can only advise post closure land uses, not regulate the use to which areas of different land capabilities are utilised.

8.2.14 Remediation of contaminated soil

Soil contamination is potentially associated with hydrocarbons, most likely in areas where product is stored or in areas where refuelling and maintenance activities are undertaken. While there is no confirmation of contamination, contaminants may also be associated with historical exploration activities and laboratory activities if assay reagents have not been appropriately managed. Should these contaminants have leached through the soil, to the underlying aquifer, groundwater contamination may have resulted. A soil contamination assessment and where necessary supporting groundwater assessment will be undertaken prior to closure to determine where areas of contamination exist on the mine.

Management of contamination at closure will be determined once the assessments have been undertaken. However, the general principles will be:

- Soils contaminated with hydrocarbons, will be excavated and then treated at a bioremediation facility to be established at SRL;
- Chemical contamination is likely to be addressed using a combination of in situ remediation, where possible, or excavation with disposal being undertaken according to SRL waste management plan; and
- Where groundwater has been impacted, appropriate remedial measures will be developed based on the nature and the extent of contamination, if source removal is not adequate to address impacts.

In addition to the above there may be areas where minerals containing NORM have been either stored or spilt. Where possible the primary source of the NORM will be removed when the minerals are removed and the underlying soils will be assessed to determine whether remedial actions are required. Radiation will be managed as per the SRL Occupational Health and Safety Plan (see Appendix L5 of the ESHIA) and proposed control measures in the radiation study (see Appendix I of the ESHIA).

8.2.15 Management of potentially hazardous material

To date, no asbestos survey has been conducted at the mine. This will be undertaken ahead of the commencement of demolition and fibrous material will be managed according to SRL Waste Management Plan.

Electrical equipment has not been surveyed to determine the presence of Polychlorinated Biphenyls (PCB) in dielectric or coolant fluids. This survey will be undertaken prior to the decommissioning of the electrical equipment and the demolition or removal from SR Area 1. PCB detected in the generation and transmission equipment will be managed according to SRL Waste Management Plan.

8.2.16 Social closure

Closure objective

The overall closure objective for SR Area 1 is to implement remedial measures in a manner that the land capability of the rehabilitated areas can sustain a variety of post closure land uses, where the residual post closure risks are acceptable to SRL and SRL's stakeholders. SRL will therefore undertake landform modification and establish an initial crop of native species for use as woodlots.

The objective of the social closure component is to manage social post closure risks and to mitigate identified closure impacts as far as possible. It is not possible for SRL to fully mitigate the consequences of closure, but optimum outcomes will be sought within the framework of a viable social closure plan.

Closure stakeholders

Consultation with local stakeholders on the impact of mine closure and the development of a final mine closure plan will be important in the five years leading up to closure. The aim of stakeholder engagement in the social closure process are to provide sufficient and accessible information to stakeholders in an objective manner which will assist them to understand and respond to changes brought about by closure of SRL operations.

A broad classification of the affected closure stakeholders is presented below, divided into internal and external stakeholder categories:

- Internal stakeholders:
  - Procured contractors;
  - Permanent employees; and
  - Labour unions.
- External stakeholders:
  - Local and host communities;
  - Community Development Committee (CDC);
  - Business and commerce;
  - Community-based organisations (CBOs) / special interest group representatives;
  - Educational institutions;
  - Environmental and conservation organisations;
  - Health institutions;
  - Landowner Associations;
  - Local Government;
  - Media;
  - Member of Parliament;
  - Mining and industry;
  - National Government;
  - Non-governmental organisations (NGOs);
  - Land owners (leasers); and
  - Traditional leadership (Paramount Chiefs, Chiefdom Committee, Section Chiefs, Town Chiefs).

Stakeholder issues that arise in anticipation of and during closure will be managed proactively and follow a structured approach where stakeholders can raise their concerns and get the required feedback in a timeous manner. A grievance mechanism (as outlined in the Stakeholder Engagement Plan) is required according to the IFC Performance Standards 1, 2 and 4.

Social closure risks

Through an integrated specialist closure risk workshop, nine social risks relevant to the project were identified (Table 8-1). The potential medium to high risks that were identified include:

- Infrastructure aspects
  - Illegal access to structures and unfamiliarity with safety requirements could result in injuries or fatalities to trespassers; and
  - Degradation of structures awaiting demolition could pose health and safety risks to the communities.
- Community aspects
  - Loss of direct and indirect economic benefits / income and therefore loss of livelihoods;
  - Untreated health issues as a result of loss of health services at the SRL clinic; and

- A delay in obtaining closure approvals, potentially including relinquishment due to stakeholders disputing the approach of land capability restoration.

Social impacts of closure

Apart from the medium and high risks listed in the previous section, the Social Impact Assessment (SRK ESHIA, 2018) identified positive operational impacts that will cease as a result of mine closure with these identified and discussed in the Social Impact Assessment (SRK, 2018(3)).

The impact of *increased government income due to payment of taxes and royalties ceasing* cannot be mitigated through action by SRL, and are therefore not addressed as part of social closure planning. Also, contribution to national and regional economic growth ceasing, SRL no longer contributing to improved local economies and loss of lease payment income as a result of mining activities cannot be managed through direct intervention by SRL, but the closure management measures identified in this plan may indirectly reduce the negative impacts identified.

Conceptual social closure plan

Table 8-2 summarises the positive and negative social closure impacts and management measures, as informed by the social closure risks and the social impacts, with the management measures in Table 8-2 referring to the Social Closure (SC) measures documented in Table 8-3. The management plans will be updated regularly as indicated in Table 8-3, based on the results of further social closure risk and impact assessments, which will be undertaken in future revisions of the MCP.

Table 8-2: Social impacts of closure and related management measures

Stakeholder group	Impacts	Management measures
Employees and dependents	Loss of direct and indirect income and benefits.	Refer to SC1, SC3, SC7.
	Loss of access to SRL clinic.	Refer to SC6, SC7.
Local businesses	Loss of local procurement opportunities.	Refer to SC2, SC4, SC5, SC6, SC7.
Communities	Access to previously restricted land for agriculture (+).	Refer to SC4, SC5, SC7.
	Access to previously restricted land for cultural resources and sites (+).	Refer to SC4, SC5, SC7.
	SRL no longer contributing to local economics.	Refer to SC1-SC7.
	Health and safety impacts due to illegal access to and degradation of structures.	Refer to SC6, SC7.
Landowners	Loss of lease payment income.	Refer to SC1-SC7

Table 8-3: Conceptual social closure framework

Planning components	3 - 5 years before closure	2 – 3 years before closure	1-2 years	Post closure
SC1: Severance Plan (employees and contractors)				
• Profile of employees; • Legal compliance of severance options; • Phased severance options; • Identify benefit replacement options; and • Budget for severance.	• Develop the Severance Plan; and • Implement the Severance Plan.	• Monitor the implementation of Severance Plan; • Update the Severance Plan based on monitoring results; and • Continue to implement the Severance Plan.	• Monitor the implementation of Severance Plan; • Update the Severance Plan based on monitoring results; • Continue to implement the Severance Plan in preparation for final closure; and • Monitor implementation upon closure.	• Evaluation of implementation of the Severance Plan.
SC2: Business Continuity Plan (external stakeholders in the mine supply chain, or strongly dependent on mine activities)				
• Identify and implement appropriate information sharing and business advice inputs; • Identify businesses most vulnerable to mine closure and implement appropriate advice and support; • Develop and agree transitional arrangements with businesses operating from mine-owned assets; • Identify and discuss opportunities for businesses to use mine assets after closure; • Assess possibilities for enhancing benefits of lease income; and • Budget for business support.	• Implement the existing Business Continuity Plan; and • Include closure-specific business support in the existing Business Continuity Plan.	• Monitor implementation to date; • Update the closure-specific Business Continuity Plan based on monitoring results; and • Continue to implement the closure-specific Business Continuity Plan.	• Continue to implement the closure-specific Business Continuity Plan in preparation for final closure; and • Monitor implementation upon closure.	• Evaluation of implementation of the Business Continuity Plan.
SC3: Counselling and Capacity Building Plan (employees and long-term local contractors)				
• Profile of employees; • Capacity building plan and	• Develop the Counselling and	• Monitor implementation to date;	• Monitor the implementation to date;	• Evaluation of implementation of the

Planning components		3 - 5 years before closure	2 – 3 years before closure	1-2 years	Post closure
• Counselling plan and implementation to include: ○ Retirement planning; ○ Money management; ○ Small business development and management; ○ Debt management; ○ Life skills counselling; and ○ Psychological counselling.	implementation to include: ○ Skills enhancement; ○ Skills transfer; and ○ Development and training. • Budget for counselling and capacity building.	Capacity Building Plan; and • Implement the Counselling and Capacity Building Plan.	• Update the Counselling and Capacity Building Plan; and • Continue to implement the Counselling and Capacity Building Plan.	• Update the Counselling and Capacity Building Plan in preparation for final closure; • Continue to implement the Counselling and Capacity Building Plan; and • Monitor implementation upon closure.	Counselling and Capacity Building Plan.
SC4: Community Development Plan through the CDC, with initial support from SRL					
• Develop the Community Development Plan as agreed with the CDC. Consider the following: ○ Support training institutions to improve vocational training access and employability; ○ Support an NGO to facilitate breeding cane rat ("cutting grass") and rabbits as sources of bush meat; ○ Explore the implementation of improved / modernised fishing and aquaculture opportunities with relevant NGOs; ○ Support the development of agricultural training courses in co-operation with relevant NGOs; ○ Identify areas to be protected from exploitation for livelihoods needs; ○ Support an NGO to protect medicinal plants, setting up / supporting expansions where medicinal plants can be grown / sold / possibly take medicinal products into the western pharmaceutical market; ○ Support an NGO to develop hydroponic / aquaponics systems (either at household /		• Address economic development in the context of closure planning in the Community Development Plan; and • Implement closure specific economic development.	• Continue to implement closure specific economic development initiatives; and • Monitor effectiveness of implementation and adapt interventions where required.	• Evaluation of implementation of the Community Development Plan; and • Upon closure, SRL exits CDC.	• Social monitoring on community development/livelihoods indicators to develop a picture of post closure development legacy

Planning components	3 - 5 years before closure	2 – 3 years before closure	1-2 years	Post closure
village level) for improved crop yields as part of closure planning; and ○ Support growth of Raffia palm groves as identified by rehabilitation team.				
SC5: Land Transfer and Land Capability Information Document				
• Outline the remedial measures that will be implemented to ensure that rehabilitated land is capable of sustaining a variety of post closure land uses: ○ Refer to CDC; ○ Refer to business support; and ○ Refer to ESHIA Mine Closure Plan (2018): Land rehabilitation and land use optimisation.	• Develop a Land Transfer and Land Capability Information Document for distribution.	• Distribute the Land Transfer and Land Capability Information Document.	• Develop a final updated Land Transfer and Land Capability Information Document; and • Distribute the finale updated Land Transfer and Land Capability Information Document	• Evaluation of satisfaction with adherence to MCP.
SC6: Asset Handover Plan				
• Identify opportunities for businesses to use mine assets after closure; • Inventory of transferable assets; • Information on the management of transferrable assets; • Engage with third parties relating to structure retention and transfer of liability to a third party as appropriate, including the clinic and roads maintained by SRL; • Legal arrangements for asset transfer; • Capacity building for asset management as necessary; • Asset transfer engagement (within broader Stakeholder Engagement Plan); and • Decommissioning plan for assets where applicable.	• Develop the Asset Handover Plan; and • Implement the Asset Handover Plan.	• Update the Asset Handover Plan; and • Continue to implement the Asset Handover Plan.	• Finalise handover; and • SRL exits.	

Planning components	3 - 5 years before closure	2 – 3 years before closure	1-2 years	Post closure
SC7: Closure engagement as part of the Stakeholder Engagement Plan				
Closure engagement will address engagement related to SC1-6, and will include: • Employees; • Communities; • Local government; • Contractors; • Local business; • Local service providers; • Regulators; and • Non-Profit Organisations, NGOs, civil society. Engagement content will vary by stakeholder grouping, taking into account the extent of impact on specific stakeholder groups and the potential for groups of stakeholders to support or supplement closure mitigation measures.	• Implement closure engagement as per the Stakeholder Engagement Plan.	• Monitor engagement; • Monitor closure engagement; • Update closure engagement; and • Continue to implement the closure engagement as per the Stakeholder Engagement Plan.	• Final closure engagement as per the Stakeholder Engagement Plan.	• Implement engagement where required, for example related to implementation of management measures in response to evaluation results.

Social closure monitoring and evaluation

Monitoring and evaluation will be executed for each plan, as indicated in Table 8-3.

Monitoring

Detailed monitoring plans will be developed to assist with determining:

- Progress with activities – what has been done and what has not been done;
- The nature and causes of problems and the options for the solution of problems;
- The effectiveness of the human and financial resources deployed for the implementation of the project / programme; and
- Whether the project / programme is producing the required results.

Evaluation

Evaluation will focus on the impacts or effects of the implemented plans at the end of closure. It will aim to establish whether the original goals and objectives have been achieved and if they were relevant. Evaluation is undertaken against baseline information, on the basis of which progress (or lack of it) can be objectively demonstrated. Evaluation will assess:

- Successes and failures of the work carried out;
- The results of the work: Were the goals and objectives achieved? What impacts flowed from the implementation of the project / programme? and
- Areas where additional intervention is still required, and nature of these interventions required.

Social closure success criteria

Monitoring and evaluation will be guided by the following social success criteria per planning phase:

Table 8-4: Social closure success criteria

Focus area of mitigation	3 - 5 years before closure	2 – 3 years before closure	1-2 years
Employee related risk	The Severance Plan is approved by SRL management and has been communicated to employees.	The Severance Plan has been implemented as intended.	Monitoring indicates an acceptable level of residual risk.
	The Counselling and Capacity Building Plan is approved by management and has been communicated to employees.	The Counselling and Capacity Building Plan has been implemented as intended. At least 50 % of employees has partaken in counselling and capacity building activities.	Monitoring indicates an acceptable level of residual risk.
Local business risk	The Business Continuity Plan has been updated to include closure planning and has been approved by SRL management and accepted by businesses.	The Business Continuity Plan has been implemented as intended, with approximately 50 % of businesses having benefited from the plan.	Monitoring indicates an acceptable level of residual risk.
Community related risks	Support for community development is achieved.	All community development projects commenced and at various stages of implementation, as per the plan.	Monitoring indicates an acceptable level of residual risk.

Focus area of mitigation	3 - 5 years before closure	2 – 3 years before closure	1-2 years
	Land Transfer and Land Capability Document approved by SRL management, and engagement plan for communication with external stakeholders are in place.	Land Transfer and Land Capability Document communicated to relevant stakeholders as per the Stakeholder Engagement Plan. Rehabilitation activities are in line with the Land Transfer and Land Capability Document.	Monitoring indicates an acceptable level of residual risk.
	Asset Handover Plan approved by SRL management.	All agreements as per the Asset Handover Plan are in place.	Monitoring indicates an acceptable level of residual risk.
Stakeholder engagement risks	Closure stakeholder engagement executed as per the Stakeholder Engagement Plan.	All grievances related to closure closed out.	All engagement required to close-out evaluation results executed.

8.2.17 Care and maintenance

This section outlines procedures and other contingency arrangements that are necessary in the event of a temporary cessation of operations, with the placement of SRL on care and maintenance before the end of the LoM.

The primary goals during care and maintenance are to:

- Limit degradation of the environment;
- Maintain protection of public health and safety; and
- Protect and maintain the existing infrastructure to ensure that it is ready for start-up on short notice.

In the event that SRL operations is placed in care and maintenance, an environmental, social, legal and safety review will be undertaken to determine areas of exposure which may result in unacceptable risk to SRL. The outcome of the review will be used to develop a detailed care and maintenance plan. Until such time as the review is completed, the following contingency arrangements will be implemented:

- Water management infrastructure - the structures will be maintained to allow free drainage and to ensure that water level in the ponds is managed so that dam stability is not compromised. Management will include the removal of accumulated sediments as well as erosion repairs that may be required;
- Primary and secondary process plants – pipelines, reaction vessels, spirals etc. will be drained to adjacent ponds. Process chemical inventory will be stored in areas with secondary containment. Conveyor belts will be cleared, and stockpiled ore depleted;
- Dry mining areas – haul roads and other access points to the pit will be barricaded where practicable;
- Infrastructure – non-essential infrastructure such as workshops, offices etc. will be secured against theft; and
- Roads - all uncapped roads managed by SRL will be routinely watered in the dry season to minimise dust.

9 Completion criteria

Following the execution of the closure management plan, it is necessary to have measurable criteria against which to assess the effectiveness of the plan and its implementation. These criteria will assist SRL in identifying when the standard of closure achieved is sufficient to relinquish responsibility for a specific area. Additional completion criteria will be developed once additional studies and consultations have been completed, with completion criteria reviewed and refined with subsequent biennial submissions of the MCP.

These criteria have been determined to demonstrate that the closure objective of implementing remedial measures in a manner that the land capability of the rehabilitated areas is capable of sustaining a variety of post closure land uses, where the residual post closure risks are acceptable to SRL and SRL's stakeholder, has been achieved. The completion criteria therefore have been developed to demonstrate that the risks identified with a ranking of high (Section 8.1) have specifically been addressed. Furthermore, the completion criteria have been developed within the context that the overriding philosophy of closure is to establish land capability with a wide range of land uses, followed by the establishment of vegetation typically found in woodlots. It is thus not proposed to re-establish land use (although the various land uses can be used on the land capability returned) nor to re-establish biodiversity on rehabilitated lands.

Given the scale of SR Area 1, SRL anticipates that closure will be undertaken over a 10-year period. Thereafter, SRL will enter into a five-year post closure period, where the main activity will be monitoring to collect the necessary data to demonstrate that completion criteria have been achieved. Where necessary and where data indicates that completion criteria will not be achieved, maintenance will be undertaken and if the data indicates requirement, a change in closure action may be implemented.

The completion criteria, risk addressed and specific closure objective achieved are documented in Table 9-1.

Table 9-1: Preliminary completion criteria required for SR Area 1 relinquishment

Aspect	Completion criteria	Risk No.	Applicable closure objective addressed[1]	Evidence
General	Surface topography with slopes, on average, at their design angle	9b	Physically and chemically stabilise remaining structures to minimise residual risks Utilise closure methodologies that relinquish areas in a self-sustaining condition with little or no need for ongoing care and maintenance	Topographic surveys
	Woodlot vegetation established on land with a capability to sustain these species. Where woodlots are not established, land capability commensurate with expected post closure use Vegetation sustained for at least 5 years after planting with a mortality similar to that in areas undisturbed by mining	3d, 4,		Photographic and record of vegetation mortality
	Waste generated during the decommissioning and demolition activities is safely disposed of as per Waste Management Plan	Note 2	Physically and chemically stabilise remaining structures to minimise residual risks Ensure safety and health of all stakeholders during closure and post closure, and that communities using SR Area 1 after closure are not exposed to unacceptable risks	Waste placed in waste management facility and not in ad hoc uncontrolled piles
	All retained infrastructure are safe and stable			Professional certification of stability at point of transfer
Sand tailings	Sand matrix reconstituted to sustain plant growth in the dry season. Textural composition to typically be as per design specification across optimal mixing depth.	3d, 4,	Utilise closure methodologies that relinquish areas in a self-sustaining condition with little or no need for ongoing care and maintenance	Textural data on areas where sand tailings were rehabilitated
	Vegetation density and mortality to be comparable with growth on areas not disturbed by mining activities over a 5-year period			Vegetation specialist report comparing rehabilitated areas with appropriate reference sites
Slimes and poorly segregated dry mining tailings mix	Woodlot vegetation established on land with a capability to sustain these species. Where woodlots are not established, land capability commensurate with expected post closure use.	3d, 4, 8	Utilise closure methodologies that relinquish areas in a self-sustaining condition with little or no need for ongoing care and maintenance	Photographic and record of vegetation mortality
	Vegetation density and mortality to be comparable with growth on areas not disturbed by mining activities over a 5-year period			Vegetation specialist report comparing rehabilitated areas with appropriate reference sites
Dams	Stability analyses undertaken and dams certified as being structurally stable	2a, 2b	Physically and chemically stabilise remaining structures to minimise residual risks	Geotechnical reports
	Seepage through the walls within the design specification for each individual dam, the design specification developed for the reshaped dam following the lowering of the pond water level	2a, 2b	Physically and chemically stabilise remaining structures to minimise residual risks	Piezometer data

Aspect	Completion criteria	Risk No.	Applicable closure objective addressed[1]	Evidence
Water courses	Downstream water quality comparable with upstream quality	1c	Utilise closure methodologies that relinquish areas in a self-sustaining condition with little or no need for ongoing care and maintenance	Water quality database
	Aquatic biodiversity conditions comparable to those of reference sites	1c		Biomonitoring database
	Reinstated water course	7		Design reports
Groundwater	Alternative water sources identified where phreatic surface drop has reduced borehole/well yields below community requirement	1c		Alternative water source
	Water quality comparable with background quality			Water quality database
Social	Refer to Table 8-4	10c, 10d	Refer to Table 8-4	

Note 1 – overriding objective for all completion criteria are: Understand and address community concerns regarding closure; Comply with mine closure permitting and regulatory requirements and obtain documented confirmation of meeting all closure requirements. Note 2 – no specific risk mitigated but this is GIIP

10 Financial provision

The estimate of liability has been prepared using an Excel based model known as the Standardised Reclamation Cost Estimator (SRCE, version 2.0). The SRCE utilises standardised reclamation calculation methods, data and procedures to estimate the cost of reclaiming a mine. The methods of calculation used in the model are based on first-principle approaches for volume and distance calculations, and productivity estimation, with productivity calculations largely derived from published sources such as the Caterpillar Performance Handbook (ed. 46).

The SRCE was used for the calculation of the Present Closure Obligation (PCO) for SRL, in accordance with requirements of the International Financial Reporting Standards (IFRS).

10.1 Model assumption

Only small equipment would be used for closure activities as this is the equipment available on site. The SRCE model has the ability to define the equipment availability for the different categories of plant typically used during closure and rehabilitation activities. As the equipment at the mine is old and there are likely to be periods during the rainy season when productivity is impacted, equipment availability of 45 minutes/hour was used. Operator skills were set as low. This is not a reflection on the SRL operators, but a means of influencing the operability of plant to account for equipment age and interruptions to production during the rainy season. Speed on SR Area 1 was limited in the model to 50 km. The speed, availability and operator skill all influence equipment productivity.

The second overriding assumption in the model is that a specific land use will not be implemented at any of the areas where rehabilitation is being undertaken. Rather, a wide range of possible post closure land uses and the approach at closure should be to establish land capabilities that will support these wide land use ranges. The implication of this is that sand tailings will require structural modification to increase the fines content to enhance water holding capacity to support plant growth. While this can theoretically be achieved in a number of ways, the practical approach in the SRL context is to mix slimes into the top 2,000 mm of sand tailings to achieve an overall 15 % slimes content. SRK has assumed that the sand/slimes and the slimes has sufficient fine fraction to support plant growth that no additional fines fraction addition is required.

The third overriding assumption is that all haul distances – other than the hauling of residual product from the Freetown warehouse back to the MSP are 2,000m. This has the largest implication where topsoil or slimes are hauled for use as cover material. The 2,000m has been chosen as there currently is insufficient data resolution to refine the actual haul distances. The topsoil haul distances may be underestimated given the limited stockpiles on SR Area 1. Equally the slimes haul distances may be an over estimate as there may be slimes sources for blending with tailings within a smaller radius of the site.

Specific assumptions that influence the quantum of the closure liability are:

- Planting will be undertaken in all areas using the SRL revegetation strategy;
- Dams will be reduced to 50 % of their current height, exposing footprint with the draining of the ponds;
- Sand tailings require additions of slimes or material removed from the dams to achieve a fines content of 15 % through the upper 2 m of the sand. For calculation purposes, and allowance has been made that 20 % of the exposed sand surface will require reshaping and 10 % of the poorly segregated dry mining tailings will require reshaping;
- Dredge canals will be rehabilitated by reshaping sidewalls;
- Lime will be added to the slimes footprints and mixed by ripping prior to vegetation establishment;
- Dry mining pit highwalls will be reshaped;

- Borrow pit walls will be reshaped and the entire exposed footprint will be ripped ahead of planting;
- Stockpiles and MSP tailings (excluding Total Tailings and Sulfide Flotation Tailings) and will require hauling to the Lanti dry plant for blending. Processing costs based on current costs were included in the estimate;
- A provision was made for the transport of SFT to the MSP for leaching and then after leaching, placement on the TT;
- Demolition costs were based on the physical dimensions of structures (land based) or on the tons of material in structure (water based). A provision was made to haul rubble to landfill;
- Power lines and pipelines to be removed;
- Surface water monitoring: 18 samples will be collected monthly for a period of 15 years (10 years closure and five years post closure);
- Groundwater monitoring: 10 samples will be collected quarterly for a period of 15 years (10 years closure and five years post closure);
- Surface rent will be payable over only the disturbed area through the closure and post closure period, with the surface rent rate increasing by 3 % per annum from a base rate of USD15.14/a. As a block of land becomes available the year after vegetation is established, it will be possible to discharge the requirement of surface rent on this area, although SRL will continue to monitor and maintain the area through closure and post closure;
- Security will be required during closure however, the security complement will decrease as closure approaches;
- Lease payments will continue for the 10-year closure period;
- Provisions have been made for:
  - Salvage of the Nitti Port push boat;
  - Handling costs for removal of radiation sources; and
  - Sealing of exploration boreholes.
- A human resource complement will be required during the closure period – however no retrenchment, redeployment costs are included in the PCO; and
- Camp operating costs will be incurred as accommodation will be required for operations personnel.

The estimate of the closure liability at the end of 2017 is presented in Table 10-1. Iluka's closure provision applies an additional contingency to this liability estimate to allow for uncertainty in the estimation process.

Table 10-1: Estimate of the closure liability

Activities	Cost (USD)
Rehabilitation Earthworks	
Overburden	29 687
Other Waste	140 852
Earthmoving	7 072 408
Recontouring	4 768 825
Topsoil	862 540
Slime Final Cartage	7 882 455
Deep Ripping	2 186 714
Contaminated Materials	2 126 336
Sub Total	***25 069 817***
Site Support	
General	3 376 828
Security	2 239 907
Surveying	960 000
Rehab Labour Allocation	3 704 710
Sub Total	***10 281 445***
Infrastructure removal	
Infrastructure Moves	10 000
Pumps and Piping	117 200
Mining Unit	173 365
Concentrator/Processing Plant	2 051 944
Electrical Services	1 109 003
Ancillary Infrastructure	798 215
Bores	50 000
Sub Total	***4 309 727***
Revegetation Works	
Native Establishment	3 851 431
Sub Total	***3 851 431***
Rehabilitation Planning	
Rehabilitation/Closure Plans	475 000
Sub Total	***475 000***
Environmental Monitoring	
Groundwater Monitoring	132 948
Surface Water Monitoring	479 556
Sub Total	***612 504***
Land Management	
Landowner Expenses	6 740 639
Sub Total	***6 740 639***
Grand Total	**51 340 562**

11 Closure implementation

The purpose of implementing closure actions is to reduce closure risk to an acceptable residual risk timeously. As stated in Section 9, SRL anticipates that 10 years will be required to implement the closure management plan, followed by a five-year post closure period. A detailed schedule has not been determined, however, an initial high-level indication of timing is presented in Table 11-1 and based on the current estimates of LoM (with these potentially subject to change depending on mine planning activities):

- Lanti Wet (18 months) – LoM 2019;
- Lanti Dry (including Gbeni) (six years) – LoM 2024; and
- Gangama Dry (four years) – LoM 2022.

As there are currently a number of knowledge gaps relating to the closure plan for the mining areas, SRL will focus on rehabilitating borrow pits in 2018 and 2019, while the various investigations are undertaken to collect data to further inform closure activities. The areas of focus during this period will be:

- Determining the optimal reconstituted soil matrix for the sand tailings and commence with field trials;
- Determine lime requirements for slimes;
- Determine the geotechnical stability of the dams; and
- Determine the morphology of the mining and tailings ponds through bathymetry. Aside from being necessary for understanding reshaping and rehabilitation requirements, this data is required to determine post closure water management.

Table 11-1: High level implementation plan

	2018	2019	2020	2021	2022	2023	2024	Clos. Yr. 1	Clos. Yr. 2	Clos. Yr. 3	Clos. Yr. 4	Clos. Yr. 5	Clos. Yr. 6	Clos. Yr. 7	Clos. Yr. 8	Clos. Yr. 9	Clos. Yr. 10	Post Clos. Yr. 1	Post Clos. Yr. 2	Post Clos. Yr. 3	Post Clos. Yr. 4	Post Clos. Yr. 5
Rehabilitation of borrow pits																						
Further investigations to support closure																						
Field Trials																						
Rehabilitation of above water residues																						
Draining of ponds and removal of dams																						
Rehabilitation of tailings above water level																						
Processing of MSP stockpiles and tailings																						
Leaching of SFT																						
Decommissioning of dredge and primary concentrator																						
Decommissioning of land plants																						
Rehabilitation of dry mining footprints																						
Decommissioning of MSP																						
Decommissioning of roads																						
Decommissioning of ancillary infrastructure																						
Rehabilitation of final drained pond footprints																						
Monitoring and maintenance																						

Colour Key:

Activities that can be undertaken concurrently with operations

Activities that will be undertaken at the end of LoM

12 Monitoring and maintenance

The objective of the closure and post-closure monitoring program will be to track the recovery of the SR Area 1 towards the long-term post-closure land capability goals, in accordance with the overall closure objectives. The monitoring program will be designed to collect information to demonstrate that the completion criteria have been achieved. The closure monitoring program will be informed by information obtained from the operational monitoring programs considered in the ESHMP. The operational monitoring plans will be revised in the first year of the closure period to reflect the post-closure monitoring requirements. The monitoring required during the closure and post-closure period is summarised below:

- Surface water – monthly monitoring against parameters as required by the SLEP (MM) Reg. 2013 and informed by operational information. Sampled monthly during the 10 year closure and a five year post-closure period;
- Groundwater – Quality monitoring of aquifers against the parameters as required by the SLEP (MM) Reg. 2013 and informed by operational information. Aquifer recovery will also be monitored during the collection of water samples. Sampled monthly during the 10 year closure and a five year post-closure period;
- Aquatic and terrestrial biodiversity – continuation of operational monitoring requirements. Sampled bi-annually during closure and post closure;
- Vegetation establishment – basal cover, indigenous species recruitment and species diversity;
- Soil properties – where soil matrix reconstitution is required, once off sampling of each prepared site will be undertaken to obtain sufficient data to demonstrate that the optimal matrix and mixing depth has been achieved at the 95 % percentile level; and
- On completion of lowering of the dam, piezometric water level in the dams will continue to provide sufficient data to inform the closure stability analyses.

Annual reports will be prepared to document the results of the monitoring during the closure and post-closure phases. These reports will provide important information required to manage the on-going closure activities, with the data and reports being used to:

- Provide recommendations for improving subsequent reclamation activities;
- Indicate where rehabilitation and closure activities have not been successful, requiring a potential change in design criteria;
- Provide information where maintenance or a change in approach is required during the post-closure period; and
- Indicate if completion criteria have been achieved.

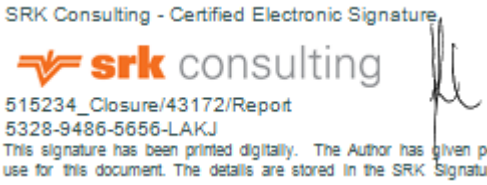
SRK anticipates that the majority of maintenance activities required in the post closure period, will involve establishing individual trees where the mortality has led to a loss of individuals above that specified for completion criteria. Reestablishment will include determining the cause of mortality, if on a large scale, and treatment of the cause of the mortality if related to physical conditions within SRL's ability to correct. Given that the majority of rehabilitation activities will be undertaken in relative flat areas, significant erosion repair is not anticipated. Should monitoring indicate that there is a proliferation of undesirable alien vegetation in the areas revegetated that is different to those in analogue conditions unaffected by mining, the operational eradication program will be extended.

13 Data management

Documentation including all reports, data, records and inspections will be retained by SRL during the mine closure process. All information will be retained for a period of ten years, post finalisation of closure at a location to be determined at mine closure. Administration of these records will be determined at the appropriate time. The details of storage have not been finalised however any information relevant to mine closure and post closure monitoring will be available to authorities as may be required.

Annual reporting of post closure performance of rehabilitation works will be completed and submitted to relevant authorities. These annual reports will be completed to the standard applicable to the relevant authorities at the time of closure.

Prepared by



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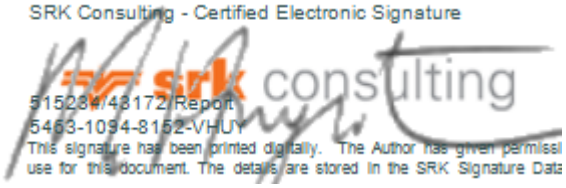

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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