Sierra Rutile Area 1: Final Environmental, Social and Health Impact Assessment and Management Plan

Report Prepared for

Sierra Rutile Limited

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Report Number 515234/ESHIA/ESHMP

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Executive Summary

Sierra Rutile Limited (SRL) is an existing mining operation located in the Bonthe and Moyamba Districts of the Southern Province of Sierra Leone. The mine has been in operation for over 50 years and produces rutile, ilmenite and zircon rich concentrate. SRL currently holds seven mining leases covering 559 km^2 with a total of 16 mineral deposits identified. SRL's Area 1 Mine Lease Area (SR Area 1) covers an area of 290 km^2.

The SRL operation 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. The primary mining process was dredge mining (referred to hereafter as wet mining). In 2013, SRL commenced a distinct open cast 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.

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 them 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 SR Area 1. This included the Gangama and Lanti deposits and other deposits within SRL's current operations in SR Area 1.

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by SRL in 2016 to undertake a scoping site visit and to develop a scoping report that met the Sierra Leonean legal requirements. The scoping report (SRK, 2017e) was submitted to, and accepted by, the EPA-SL on 16 October 2017. Subsequent to this initial appointment Iluka Resources Limited (Iluka) acquired the SRL operation and requested SRK to prepare an ESHIA and an ESHMP in accordance with the EPA-SL's requirements (EPA-SUHA.96/214/a/HNRM, 2015) as well as Iluka's corporate policies, which are aligned with Good International Industry Practice (GIIP). This report constitutes the final ESHIA and ESHMP.

Governance Framework

The legal and policy framework for this project highlights the relevant policies, directives and guidelines applicable to the ESHIA and ESHMP. The ESHIA and ESHMP report has been developed in accordance with the laws and regulations of Sierra Leone, including international treaties and agreements, Iluka's corporate policies and standards and GIIP requirements including the Equator Principles and the IFC 2012 Performance Standards. The ESHIA also takes account of GIIP guidelines such as those from the International Council on Mining and Metals (ICMM), Extractive Industries Transparency Initiative (EITI), and the International Labour Organization Guidelines on Occupational Safety and Health Management Systems.

Project Location and Setting

The SR Area 1 operation is located in the Moyamba and Bonthe Districts in the Southern Province of Sierra Leone. It is situated 30 km inland from the Atlantic Ocean, 135 km south east of Freetown, and 65 km south west of Bo (geodesic distances). 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.

Project Description

The Principal Agreement (4 February 1972), as amended 23 May 1975, between the Government of Sierra Leone (GOSL) and SRL, sets out terms and conditions for the exploration and development of deposits of titanium-bearing and associated minerals for three mining leases and dredging licences. 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 have been re-designated by the GOSL as Licence No. 2,134 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 23 January 2039, however there is an option to extend for a further 15 years.

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 mine ponds and has power generation facilities, accommodation, offices, a clinic and roads.

A summary of the mining operations and process is provided in Table 3-2. For an in-depth description of the mining processes and mineral processing, refer to Section 3.4 in the ESHIA.

Table-1: **Summary of mining operations and processes including associated timeframes**

Type of operation	Large-scale open cast (dry mining) and dredge mining (wet mining)
Type of orebody	Rutile, ilmenite and zircon
Deposit groups (current and planned)	• Lanti Wet • Lanti Dry (including Gbeni) • Gangama Dry
Current mining operations (LOM)	• Lanti Wet (18 months) • Lanti Dry (including Gbeni) (6 years) • Gangama Dry (4 years)
Historical dredge areas (ponds)	• Bamba / Belebu • Mogbwemo • Pejebu • Motinga 1 and 2 • Mosama
Current operational activities	• Site clearing • Dredging • Dam construction • Ore extraction (earth moving) • Primary mineral processing • Secondary mineral processing • Tailings management • Transporting and storage of ore and product • Port handling and shipping • Access road building and maintenance • Waste management • Power generation facility and transmission of power • Potable water services • Mine offices, workshops, storage, accommodation and associated facilities • Rehabilitation

As at August 2017, SRL employed 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. 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 22 provides an overview of proposed changes to operational processes and methods at the various mining operation sites. Refer to Section 3.8 for a detailed description of the proposed future changes.

Table 2: Proposed future changes operational processes

Operational Area	Proposed amendments to operational process
Lanti wet mine and floating wet concentrator plant	No proposed additions or amendments to the current process.
Lanti dry mine and land-based wet concentrator plant	It is proposed to modify the current load and haul mining method by constructing an in-pit Dry Mobile Mining Unit, followed by an ex-pit scrubber, before ore is pumped to the current concentrator. Lanti dry mine currently has a nameplate capacity of 500 tph, and the intent is to increase throughput to 1,000 tph. This proposal will see the establishment of the following infrastructure within the existing footprint: • In-pit Dry Mobile Mining Unit; • Ex-pit scrubber; • Additional tailings containment facilities; • Potential extensions to or new borrow pits; and • Potential extensions to roads.
Gangama dry mine and land-based wet concentrator plant	The current load and haul method used at the Gangama Deposit will continue. However, capacity is proposed to be increased from 500 tph to 1,000 tph by increasing the haul and load effort. This proposal will however, see the establishment of the following within the existing footprint: • Additional tailings containment facilities; • Potential extensions to or new borrow pits; and • Potential extensions to roads.
MSP and complex	There is a proposed plan to upgrade the MSP on the existing location to improve the plant's performance and health and safety standards.
Nitti Port	There are no proposed additions or amendments to the current layout and processes at Nitti Port.

ESHIA Process

The ESHIA is being undertaken in a phased approach that meets the requirements of the Sierra Leonean law and aligns with GIIP requirements for Environmental Impact Assessment. Broadly, this includes the following phases: scoping; drafting of the ESHIA, finalisation of the ESHIA, decision-making and public consultation phases. During the scoping phase, the scopes of work for the specialist studies were finalised and terms of reference for their appointment developed. In addition, the Communication and Public Participation Plan was updated to reflect the new process. The EPA-SL approved the Scoping Report on 16 October 2017. A draft ESHIA has been prepared based on the findings of a number of specialist studies dealing with the biophysical and socio-economic and health environments of the study area. Mitigation measures for identified environmental, social and health impacts are presented in an ESHMP as well as a number of standalone management plans.

The Final ESHIA (this report) has been updated with responses to the stakeholder issues raised regarding the project where relevant.

Public Consultation and Disclosure

Stakeholder consultation and disclosure is an integral part of the ESHIA process. It provides stakeholders with the opportunity to raise concerns and questions about the proposed project, giving them the opportunity to provide input into the planning and design. These meetings are also important as potential impacts and mitigation measures are discussed. For a list of stakeholders consulted, refer to Section 5.2

Between 15 and 21 June 2017 a first round of engagement meetings was held with stakeholders groups in the Imperi, Lower Banta, Upper Banta and Jong Chiefdoms. Government agencies were consulted in Freetown. Approximately 1,329 stakeholders representing various sectors of society, including host communities in the study area and beyond, attended the information sharing meetings in June 2017. All comments, concerns, questions and suggestions raised by stakeholders during the information sharing meetings are recorded in an Issues and Response Report.

The intention is to host a second round of stakeholder meetings to feed back the Draft ESHIA findings to stakeholders. A Non-Technical Summary and the Issue and Responses Report (IRR) will be circulated during the stakeholder engagement process. Stakeholders will be afforded an opportunity to review the Draft ESHIA and provide comment on the findings and proposed measures for managing negative impacts and enhancing benefits. An IRR was prepared and submitted to the EPA in August 2018.

Description of the environmental and social context of the study area

Physical environment

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. Most of the area adjacent to the hills comprises undulating, broad expansive fluvial plains, becoming increasingly flat towards the mangrove swamp areas.

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.

Soils

Four topographic zones were identified across SR Area 1. These include 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 midslopes and the ridge or crest slope and shallow to deep soils on saprolitic crystalline bed rock. Soils indicate an above average organic matter content, generally low clay percentages for all but the gleyed materials within the mangroves and swamplands, with limited structure and textural variation. The soil structure and clay texture (saturated silty clay loams) varied in the tidal mangrove swamplands in the north-west of the study area.

Climate

Sierra Leone is located in West Africa, between the Tropic of Cancer and the Equator. 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 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. The average monthly temperatures ranged between 25.3 °C - 27.9 °C, with the maximum reaching 33.4 °C and minimum reaching 22.7 °C. Daily temperatures during the rainy season are up to 5 °C lower than in the dry season.

Air Quality

The baseline air quality (SRK, 2018(1)), as indicated through the available monitoring data, is a result of mine related activities, with contributions from the villages and surrounding activities, resulting in an existing cumulative impact. Dust fallout monitoring is currently being undertaken at SRL and began in July 2017. As the monitoring period falls in the wet season, the majority of dust fallout concentrations were below the Residential Area standard of 600 mg/m^2/day at the villages, except at SRLDM02 (September and November 2017) and Mogbwemo Village (November 2017). The Non-residential Area standard was not exceeded during the monitoring period. Dust fallout is expected to increase during the dry season. 24-hour PM_{10} concentrations exceeded the World Bank (WB)/ IFC Environmental, Health and Safety (EHS) Guideline value of 50 µg/m^3, 16 times during the monitoring period from 29 July 2017 to 31 December 2017. The average 24-hour PM_{10} concentrations also showed one exceedances of the WB / IFC EHS Guideline value, in December 2017.

24-hour $PM_{2.5}$ concentrations exceeded the WB / IFC EHS Guideline value of 25µg/m^3, 31 times during the monitoring period from 29 July 2017 to 31 December 2017. The average 24-hour $PM_{2.5}$ concentrations also showed one exceedances of the WB / IFC EHS Guideline value in December 2017. A comparison of the PM_{10} and $PM_{2.5}$ data shows that $PM_{2.5}$ concentrations are at an average of 83% of PM_{10} concentrations. Hence the majority of PM_{10} is made up of particulates that are less than 2.5 microns. SO_2 and NO_2 monitoring indicated concentrations that were below the applicable WB / IFC EHS Guideline values for the month of July 2017.

Surface Water

SR Area 1 lies between the Teso River in the east and Jong (Taia River) in the west, two major rivers in Sierra Leone. The mining area catchment / surface river system drains in three different directions as described below for the MSP, Lanti and Gangama mining areas. The MSP catchment system located to the east of the SR Area 1 lease boundary, consists of three of catchment river systems (i.e. Kopa, Tikote, and Kokpoi), which flow east into the Jong River. The Lanti catchment system consists of four catchments, and includes the Gbeni and Lanti streams. Gbeni stream is located on the southern portion of the SR Area 1 and flows 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. The Gangama catchment river system (i.e. Gbangbaia Creek, Jangalo Creek and Gbangbatoke-S1, S11 and S12A) is located to the east of the SR Area 1. The catchment drains into Gbangbaia Creek, which flows into Bagru Creek. The Bagru Creek flows into the Sherbro River, which then flows into the sea.

The surface water study (SRK, 2018(4)) indicates that the pH is generally low, and there is little mineral content for buffering. There is therefore 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. Whilst mining would usually be expected to impact surface water quality by disturbing the soils and ore bodies, ongoing monitoring will better assist to assess natural influences on water quality versus mine related influences. A low pH in surface water samples with low mineral and salt content may be a natural reflection of the dissolution of carbon dioxide from the atmosphere, respiration of aquatic life forms and dissolution of natural soil humic acids. It does not necessarily infer that there is a direct detrimental impact of mining activities where not supported by significant changes in the ionic balance of the water.

The water discharging from the MSP tailings, through to the Mogbwemo Dredge Pond is impacted by the mining activities. In July and August, the pH (4.2 – 4.7) was below the legislative limits and aluminium concentrations exceeded the drinking water standard limits. The concentration of determinants appears to decrease at surface water locations further away from the MSP area. A slightly acidic pH in surface water samples does not imply that the water quality is not fit- for-use, for domestic use or supporting aquatic life, particularly associated with weak acids such as carbonic acid from carbon dioxide. The quality improved slightly in October with a drop in aluminium concentrations to within drinking water quality guideline limits.

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 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 impacted by mining activities indicated by acidity (pH of 5.8) and elevated dissolved aluminium content. Nitti Port surface water has elevated aluminium, chloride and magnesium concentrations relative to the background levels and consequently increased salinity (EC and TDS). Aluminium concentrations exceed the drinking guidelines limits.

Groundwater

The hydrogeological investigation (Graell 2018) was conducted in phases commencing with an initial site visit to assess on-site conditions. Refer to Section 4.7 where the phases and methodology are detailed.

The groundwater occurrence within the fresh basement is limited to isolated fractures and the yield is generally very low, and is the effective base of the hydrogeological regime within SR Area 1. The highest groundwater yields besides the Bullom sediments, are found at the weathered / fresh basement contact zone. This is a separate hydrostratigraphic unit which has a thickness of approximately 2 m to 3 m. Groundwater levels are not currently measured in the SR Area 1 community boreholes. Preliminary observed groundwater levels in 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.

Groundwater gradients currently mimic the topography suggesting a limited influence of mining to date. Rainfall recharge has been simulated by SRK to be in the order of 0.17% - 2.6% Mean Annual Precipitation (MAP) for the various catchments across SR Area 1. The poorly sorted unconsolidated sediments and weathered bedrock tend to have a low transmissivity (0.12 m^2/day – 6 m^2/day) whereas the weathered/fractured basement contact has a wider transmissivity range (6 m^2/day – 200 m^2/day) depending on the nature of the contact at a specific location. The Bullom sediments have the highest transmissivity, which is estimated to be in the order of 300 m^2/day. Given the low permeability of the ore deposit, the groundwater ingress volumes into the dry mining operations should be manageable and dewatering may be achieved through the use of trenches which are connected to sumps at the lowest elevation. Substantially higher groundwater ingress volumes are anticipated should the dry mining operations encounter Bullom sediments such as at Foinda village at Gbeni and in the northern extent of the Gangama deposit.

The ambient groundwater quality is slightly to moderately acidic (pH 4.38) with low Total Dissolved Solids (TDS) (5.56 mg/l to 77.9 mg/l) as excepted in heavily leached environments in humid tropical climates. Community boreholes indicate extensive bacteriological contamination which is attributed to human impacts. With the exception of pH and aluminium, historical sampling has shown that the water quality within SR Area 1 generally falls within the World Health Organisation (WHO) drinking water standards and the Republic of Sierra Leone effluent standards. Although the active Lanti mining pond has a lower pH and higher TDS than the historical mining ponds, the water quality is expected to improve post mining.

Noise

Ambient noise in SR Area 1 has evolved in character and level from a former rural district to what is now characteristic of a mining district interspersed with rural villages. The results of the 2017 noise baseline survey (Acusolv, 2018) show that ambient noise levels in the villages vary around 55 dBA during the day and around 45 dBA at night. Apart from truck noise in villages intercepted by haul roads, current daytime and night-time noise accrues predominantly from natural sounds and community activity noises. Sources of natural sounds include rain, wind, birds, insects and amphibia. Community activities creating noise include local traffic, trade, work, living, leisure, speech communication, children having fun and the sounds of radios and music being played. Local traffic comprises predominantly of motor cycles used for private and public (taxi) transport. Although noisy, the traffic volumes of motor cycles in villages are generally low and mostly confined to a single road running through the centre of a village.

Radiation

There are two main sources of radiation exposure in mineral sands mining and processing at SRL: man-made sources, i.e. density gauges, which are used in various processes of the operation to determine slurry densities; and naturally occurring radioactive materials (NORM) in the ore, products and tailings (SRL, 2018).

Various Cesium (Cs-137) density gauges are used at the dredge; dry mining units (Lanti and Gangama); and the MSP for process optimization purposes. Additional sources are stored in a licensed bunker facility for future use / re-use, or for future disposal. Sources are classified into five categories: Category 1 sources are potentially the most dangerous and Category 5 sources are the most unlikely to be dangerous. Individual sources at SR Area 1 are either Category 4 or Category 5

sources, which are the lowest activity sources in industry. Two types of risks are considered, the risk in handling and being close to a source, and the risk associated with radioactive material being dispersed from a source.

Deposits of mineral sands containing heavy or dense minerals originate from erosion and weathering of rocks and occur as a result of the concentrating effects of wind, ocean currents and wave action. These deposits are enriched through such geological processes in the naturally occurring radionuclides of the uranium and thorium decay chains. The radioactivity is primarily associated with specific minerals within the deposit (e.g. especially monazite and to a lesser extent, zircon). The potential radiation hazard increases with the concentration of these minerals in various products and tailings streams. Radioactivity in the mineral sands products, especially zircon, can also occur due to incorporation of elemental thorium and uranium into the crystal lattice of the mineral at the time of formation. The amount of monazite in the minerals sands ore typically determines the level of radiation protection that may be necessary. In the deposits within the project area, monazite only occurs in low concentrations (typically <1%). Although the monazite content is relatively low, there exists the potential for exposure significantly in excess of average background levels in mine operations where the mineral sands are extracted and concentrated. Of particular significance from a radiation management perspective is the production of a monazite-rich mineral stream, as in the MSP, and its subsequent disposal in the mine pits.

The typical mineral assemblage of the ore in SR Area 1 deposits consist predominantly of rutile (TiO_2), followed by ilmenite ($FeTiO_3$), and zircon ($ZrSiO_4$) respectively. The orebodies in general have an activity concentration of less than 1 Becquerel per gram (Bq/g) uranium and thorium, thereby not classified as requiring Regulation as per the International Atomic Energy Agency (IAEA) Safety Report Series 49 – Assessing the need for radiation protection measures in work involving mineral sand raw materials standards (2006).

IAEA Safety Standards Series RS-G-1.7 - Application of the Concepts of Exclusion, Exemption and Clearance (2004), sets exclusion levels for naturally occurring radioactivity in bulk materials at 1 Bq/g head-of-chain activity for the uranium and thorium decay chain radionuclides. These values are at the upper end of the world-wide distribution for naturally occurring radioactivity in soils. The activity concentration of 1 Bq/g is currently the internationally-accepted level for defining the scope of Regulation for naturally occurring materials containing uranium or thorium. Ores or mineral concentrates with head-of-chain uranium or thorium activity concentrations less than 1 Bq/g would generally be considered inherently safe (IAEA 2004).

Geochemistry

The mineralogy of the primary process tailings consists predominantly of inert or resistant quartz that does not contribute to either acidity or alkalinity. The geochemistry study (SRK 2018(2)) notes that the reactive minerals in primary tailings include kaolinite [$Al_4(OH)_8(Si_4O_{10})$] and gibbsite ($Al(OH)_3$). Kaolinite is an aluminosilicate mineral that dissolves to some extent in ASS, and therefore acts as a neutralising agent in the tailings. Gangama dry mining and Lanti dry mining tailings contain gibbsite ($Al(OH)_3$), a low solubility secondary mineral, which can also contribute to Neutralisation Potential (NP). Gibbsite does not occur in the Lanti dredge mine tailings in detectable quantities but occurs in detectable quantities in the Lanti dry mining tailings.

The reactive minerals in secondary process tailings include marcasite and pyrite in Sulfide Flotation Tailings (SFT), goethite in Total Tailings (TT) and Coarse Electrostatic Tailings (CET) and almandine in CET, TT, Ilmenite Tailings (IT) and Fine Electrostatic Tailings (FET).

The primary process tailings are Non-Acid Forming (NAF). This is consistent with the mineralogy results that showed that there are no detectable sulfide minerals that could potentially generate acidity in the primary process tailings. SFT are Acid Generating (AG) and have the potential to stay acidic in

the long term if exposed to oxidizing conditions. This is consistent with the mineralogy results that indicated the presence of acid generating sulfide minerals, marcasite and pyrite. TT and IT also contain sulfides and are Potentially Acid Generating (PAG). FET and 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 legislative requirements. 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 Sierra Leone legislative requirements. 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), SO4 (>2.3 mg/l) and TDS (>35 mg/l).

Biological Environment

Terrestrial Ecology

Most of SR Area 1 occurs within the Guinean Mangroves (AT1403) terrestrial ecoregion, while the remaining portion of SR Area 1 occurs within the Western Guinean Lowland Forests (AT0130). The field assessments (STS, 2018) identified five habitat units. Despite an Invertebrate Habitat Assessment (IHAS) classification score that indicate habitat conditions are fair and adequate to sustain a diverse macro-invertebrate community, the SASS score (a measure of diversity and overall integrity) is very low. Decant from the mine ponds resulting in turbid conditions, impacts water quality and instream flow, which is likely to negatively affect macro-invertebrate diversity. However, despite these factors the Average Score Per Taxon (ASPT) score was relatively high. These observations indicate that diversity is affected to a greater degree compared to sensitivity and thus habitat impacts on the system are considered more significant than water quality impacts. Habitat impacts as indicated by the application of the Index of Habitat Integrity (IHI) data (high flow assessment in July 2017 only) are more significant, with instream habitat considered moderately modified and riparian habitat largely modified. The fish community is diverse. During the dry season survey no fish were captured and no fishermen were present which likely indicates a low abundance of fish under low flow conditions. Harvesting by the local community highlights the importance of the fish in the mangroves and the river systems of the area.

The majority of the medicinal species in the area are all considered to be common to the region and were encountered throughout SR Area 1, especially within the degraded forest areas. It is understood that some species no longer occur within SR Area 1 because of habitat degradation. Alien floral species in SR Area 1 were mostly associated with villages, agricultural and mining disturbances, where in some instances they were completely dominant. 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 present a fair prevalence and diversity of fish species. Of the taxa identified, the conservation status of all are classified as of Least Concern.

Habitat suitability for maintaining a diverse macro-invertebrate community in SR Area 1 varied from adequate to excellent at the time of assessment. However, despite suitable available habitat, macro-invertebrate diversity was generally lower than expected, but with a high prevalence of sensitive taxa. Diatom community results also presented with lower classifications, indicating some impact on systems affected by dewatering of historic and active dredge ponds. However, diatom species composition in SR Area 1 does not necessarily imply impacts from mining only, but rather from all anthropogenic activities resulting in nutrient, electrolyte and organic material input, which includes activities not associated with mining. There is evidence that the aquatic systems reach a state of equilibrium with the older historic dredge ponds over time.

The drainage features of the area consist of both systems with channelled flow, mostly the larger systems, as well as systems with more diffuse flow, mostly smaller systems flowing beneath riparian trees. The naturally occurring wetland and mangrove swamp systems identified in the vicinity of the SR Area 1 are generally deemed in a largely natural to moderately modified condition. Impounded systems, largely modified due to the extent and severity of impacts associated with historical dredge ponds on these systems. All groups are considered of moderate to very high ecological importance and sensitivity, and all are deemed to provide essential goods and services to the surrounding communities along with important ecological functions.

Estuarine Ecology

The estuarine ecological survey (Anchor, 2018) focussed on estuarine habitats bet ween SRL's Area 1 operation and the coast in the vicinity of Sherbro Island. A total of 27 sites were sampled on the Gbangbaia, Kangama, Teso and Motevo Creeks, along the Bagru River and the northern shore of Sherbro Island near the mouth of the Bagru River in the wet season (2017). These sites were sampled again in the dry season (2018) together with an additional four sites on Teso Creek and two sites in Telo Creek.

In situ water quality measurements and water and sub-tidal sediment were collected at all sites in the wet and dry seasons. Intertidal sediment and macrofauna samples, vegetation transects and fish samples were collected at alternate sites (2-3 samples per creek). Oysters were collected at all sites where they were present (this was the case for many more sites in the wet compared with the dry season); the tissue was removed and was analysed for trace metal content. Bird counts, observations of other wildlife and human use of natural resources was noted and recorded at all times during the field survey. Water temperature across all sampling sites varied between 26.3 and 28.2°C (wet season) and 26.3 to 29.1°C (dry season). No evidence of vertical stratification was evident in the temperature data from any of the sampling sites. pH showed little variation across the various survey sites, ranging from slightly acidic (6.68) to slightly alkaline (8.20) in the wet season, and was slightly more alkaline in the dry season (6.86-8.66).

Mangrove habitat lost to mining activities is currently estimated to be 1.25 km^2 or 0.18 % of the mangrove forest area in the Sherbro River Estuary with a total 3 km^2 or 0.44 % to be lost with future mining plans in the Kangama area. Eight mangroves species were identified during the wet and dry season field surveys. These species are typical of West African mangrove ecosystems. The sites surveyed were predominately composed of Rhizophora racemosa which is characteristic of the zone closest to the river channels. A. marina occurred in small clumps in places and was likely due to a change to topography or sediment characteristics of that specific site.

The surveys of the estuaries downstream of the SR Area 1 mining area indicated an estuarine fish community dominated by marine species that contributed 39 of the 55 species, whilst more freshwater species (10) were recorded than strictly estuarine species (6). During the wet season survey, the marine guild was also dominant in terms of fish abundance (69 %) but the freshwater group contributed a significant 28% numerically to the total catch. The dry season survey saw a shift in relative abundance, with the marine guild contributing 90% to the total catch and a substantial reduction in the numerical contribution of freshwater taxa to just 7 % of the total catch. The estuarine fish community was dominated by carnivorous and omnivorous species with only one species classified as herbivorous (the phytoplanktivorous Bonga shad). Most species present in the wet season fish community were first level predators consuming mainly benthic invertebrates, zooplankton, macro-crustaceans and insects; or second level generalist predators consuming mainly fish, shrimps and crabs.

In all, 20 species of water birds were recorded during the wet season survey and more than double this (50) during the dry season. Numbers of birds recorded was highest in Bagru and Sherbro Creeks

in both seasons and is believed to be linked to the much greater sand and mudflat habitat available in these two counting areas (preferred feeding area for many water birds). Species that were highlighted as being particularly important (in terms of the numbers recorded) included Common redshank, Gull-billed tern, Lesser crested tern, Little tern and African skimmer.

Although no mammals were encountered in the mangroves during the 2018 wet season survey, several mammal tracks were evident in some of mangrove transects. Otter and monkey tracks were abundant in the Motevo and Bagru Transects and a single feline track was further noted in the Motevo Transect. The otter track is likely to be that of Aonyx capensis as this species has previously been recorded in Sierra Leone estuaries. The monkey tracks, possibly from several different species, were observed indicating their use of the mangroves for refuge and food resources.

Extensive fishing activity or evidence of fishing was observed in all the creeks surveyed during this study. Gill net fishing was practised throughout the study area, but the highest densities of fishers were encountered near the mouth of Bagru Creek transects in the lee of Sherbro Island, and in the lower stretches of Motevo Creek transect. These gill nets mostly target pelagic species such as Clupeids (sardinellas) and mullets, although bentho-pelagic sciaenids (croakers) and polynemidae (threadfins) were also present in the gill net catches. The estuaries and rivers themselves serve as an important access route for the transport of people, goods and produce. Observed fishing effort during the dry season survey was substantially lower than that seen during the wet season survey and individual vessel catches were greater in the former season.

Socio-economic Environment

Sierra Leone is divided into four regions (Northern, Eastern, Southern Provinces and the Western Area), which are then further divided into twelve Districts. In the Southern Province, there are four Districts, including Bo, Moyamba, Bonthe and Pujehun. The socio-economic study (SRK, 2018(3)) presents data for the Bonthe and Moyamba Districts where SR Area 1 is located. It also focuses on demographic indicators, community and social organisation, housing, education, economy and livelihoods, land ownership and use and cultural heritage.

Gross Domestic Product (GDP) in Sierra Leone had experienced strong growth of on average 8 % per year between 2003 and 2014, albeit off a low base. Growth was well above average in 2012 (15.2 %) and 2013 (20.7 %). Total SRL expenditure on workforce and goods and services was US$70.2 million in 2016, of which US$56.5 million were spent on goods and services (US$19 million of this was spent on goods and services in Sierra Leone). It is therefore assumed that US$13.7 million was spent on payroll. The 2016 SRL expenditure is equivalent to 1.8% of Sierra Leone's GDP. SRL's total economic contribution in 2016, considering indirect and induced effects, was reported as US$109.5 million, equivalent to 2.8% of GDP, which is highly significant for a single operation.

Sierra Leone had an estimated population of 7 million in 2015, of which, 20 % were living in the Southern Province (smallest number). It is estimated that a total of 4,000 households reside within SR Area 1. The household survey (HHS) recorded 2,960 household members in 560 households in total, resulting in an average household size of 5.2 persons per household.

Population growth and increased migration was focused in Moriba Town and its surrounding villages. Other towns experiencing growth included Mokaba, Gbangbaia, Gbangbama and Madina. Overall, 41 % of household survey participants reported that they had experienced people moving into the household between August 2016 and August 2017. In the same period, 35 % reported that they had experienced people moving out of the household. Main reasons cited for movement into and out of a household were related to seeking jobs and family matters.

In general, enrolment in the four Senior Secondary Schools drops for both groups (girls and boys) for progressively higher levels, but the drop is much more pronounced among girls. The limited number of girls completing school are rooted in economic and social factors, including the involvement of

young girls in subsistence agricultural activities at home, as well as early pregnancy and child bearing. There was a strong link between education and employment status evident in the household survey data. Of the males no longer going to school, 14 % had a Junior Secondary School education, and 13 % a Senior Secondary School education. Only 5 % had completed vocational training, and 3 % had a degree or a post-graduate degree. Similarly, 13 % of females had a Junior Secondary School, but only 7 % of females had a Senior Secondary School education. Only 2 % had completed vocational training, and 1.2 % had a degree or a postgraduate qualification.

Housing consists of a mixture of traditional buildings and buildings that were more modern. Households that were relocated during previous / historic mine expansion projects had rectangular structures, made of mud or cement brick walls and fibre concrete roofs. These houses were also usually found in the larger towns and villages. Raffia palm, grass, mud and bamboo were key components of structures. Sundried bricks, cement brick, mud and sticks were options used for walls, and corrugated iron walls were observed in the built-up areas. Where mud was used, erosion of the walls was evident due to heavy rains in the wet season. Roofs consisted of corrugated iron, palm leaves, and grass thatch. Soil and concrete floors were observed, some of these floors tiled. The majority of participants in the HHS inherited their land from family members. The majority owned their land with a title deed or a receipt. Some household survey participants owned their land with no proof, rented or were using / occupying the land illegally. The most cited reasons for occupying specific land were inheriting (43 %), followed by only land available (24 %) and close to job opportunities (10 %). A minority of participants suggested that a large number of people in the study area were tenants and not outright landowners.

Most households reportedly sourced their potable water from communal taps, non-mechanical wells and mechanical well. 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. When wells are dry, alternative water sources include the mine ponds, swamps, natural ponds and river water. In addition, a minority of participants were sourcing their water from rivers, dams or unprotected springs. Rain water is only available during the wet season and collected in containers, rather than in storage tanks. Approximately two thirds of households agreed that they had access to sufficient water.

In the study area, Mobimbi and Kpanguma are supplied with electricity from the SRL power plant. Wood was the preferred means of generating energy for cooking for 107 household survey participants, while batteries were the most cited means of generating energy for light. Few participants used wood as the major source of energy for warming.

Ownership and use of sanitation facilities was highest in the urban settlements (Moriba Town, Mogbwemo, and Matagelema) and lowest in the more rural villages. Access to sanitation was reportedly limited, and largely, and household survey participants claimed to use their own ventilated improved pit latrine (78 participants) and the bush (32 participants) for latrines. For ablutions, people were mostly observed to be bathing in hand-made structures using buckets outside of their homes and in both mining ponds and fresh water streams.

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. The SRL clinic reported that not many cases of TB were seen, however those that were, are generally co-infected with HIV. It was reported by key stakeholders that influx management was handled well during the EVD outbreak as new arrivals (or harbouring of people) in the area were immediately noted, with reports of a few suspected cases (or known contacts under surveillance) detected and sent back to areas where they were under monitoring.

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. 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 are inadequate. The biggest facility (the community health centre in Moriba Town) is 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. While the country had embarked on the process of rebuilding and rehabilitating its health system, following a decade-long civil, the vulnerability in the health sector was exposed during the 2014-2016 EVD epidemic. This highlighted many gaps in service delivery, and the lack of preparedness to respond to disease outbreaks. Post-EVD, the country has embarked on another recovery plan and review of various health policies and plans.

Impact Assessment

Based on the qualitative and quantitative baseline data, a number of potential environmental, social and health impacts were identified. These impacts were assessed using a standardized methodology to ascertain their level of significance (i.e. High, Medium or Low) and whether they are negative (-) or positive (+) (Table 5).

The significance of each identified impact was initially rated before management measures were considered. After the identification and consideration of practical, fit-for-purpose management measures, the significance of the impacts were re-assessed.

A summary of the potential impacts that were awarded a high or medium significance prior to management measures being considered are presented in Table 2. The full impact assessment findings are presented in Section 6 of the ESHIA. The respective management measures for these impacts are also represented in Table 5 and form part of the comprehensive ESHMP (Section 7 of the ESHIA). The ESHMP will be implemented by SRL staff through its existing management system.

Table 2: **Summary of potential high and medium impacts for the project and the associated environmental management measures**

Impact	Mitigation measure	Significance before management	Significance after management
ENVIRONMENTAL IMPACTS			
AIR QUALITY			
Dust emissions during the operational phase	• Pave or treat road surfaces for ore delivery within the processing plant site to suppress dust entrained by vehicles • Use dust suppression techniques such as wet suppression or chemical suppression (must be environmentally friendly and non-polluting), to reduce dust on roads • Attend to dust control when loading trucks by minimising drop heights and prevention of over loading • When stockpiling ore, the design specification of equipment should be considered to determine a suitable drop height to control the fall of materials which will reduce dust emissions • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors	High (-)	Low (-)
Dust emissions during the expansion phase	• Pave or treat road surfaces for ore delivery within the processing plant site to suppress dust entrained by vehicles • Use dust suppression techniques such as wet suppression or chemical suppression (must be environmentally friendly and non-polluting) to reduce dust on roads that exhibit an increase of dust emitted from the entrainment of dust • Attend to dust control when loading trucks by minimising drop heights and prevention of over loading • Limit load size to reduce spillage and cover final product loads with tarpaulins where needed • When stockpiling ore, the design specification of equipment should be considered to determine a suitable drop height to control the fall of materials which will reduce dust emissions • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors	High (-)	Medium (-)

Impact	Mitigation measure	Significance before management	Significance after management
Dust and gas emissions during the Decommissioning and Closure Phase	• Demolish all infrastructure and establish vegetation on the footprint exposed by demolition activities • SRL will continue with the planting practice (referred to as SRL planting method) on all the areas to be rehabilitated during closure • Borrow pits will be rehabilitated by reshaping the high walls and then establishing vegetation on the reshaped walls and borrow pit base • Slimes dams will be rehabilitated by the establishment of vegetation. As these have been exposed to wetting and drying cycles, there is no need to include lime prior to vegetation establishment • SRL MSP tails will be rehabilitated in situ, if they are not processed during operations or at the end of LoM	Medium (-)	Medium (+)
BIODIVERSITY: AQUATIC RESOURCES			
Loss of habitat, biota and ecosystem services due to mining activities at the current wet mining operation	• Active dredging areas must be cordoned off, with specific reference to containing the sand and tailings which are by-products of the active dredging process • Infrastructure should cross wetlands and rivers at right angles, with design of crossings allowing retention of wetland and riparian zone soil conditions • Engage with the host community and clearly communicate schedules for planned pit wall lowering and changes in decant rates that may occur, so that stakeholders know when to expect elevated water levels	Medium (-)	Medium (-)
Loss of habitat, biota and ecosystem services due to handling and shipping at Nitti Port	• Operational footprints must be minimised, and strict controls of edge effects implemented • Dedicated fuel storage and facilities used to refuel vehicles must be secured, with procedures in place to clean up any fuel spillages • Procedures must be in place for cleaning up any spillages of product	Medium (-)	Medium (-)
Loss of habitat, biota and ecosystem services due to construction and operation activities associated with dry mining at Lanti and Gangama	• Stream diversion structures should be as short as possible. In addition, stream diversion structures should be designed to ensure they are geomorphologically stable and are not prone to excessive erosion • Erosion management and sediment controls should make use of measures such as the use of rock packing and revegetation of profiled slopes • Erosion management and sediment controls such as the use of rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented where relevant from the outset of dry mining activities • An Alien and Invasive Plant Control Plan (AIPCP) must be implemented • Engage the host community and clearly communicate schedules for the respective phases of the mine, also with reference to future plans for closure and rehabilitation	Medium (-)	Medium (-)

Impact	Mitigation measure	Significance before management	Significance after management
BIODIVERSITY: TERRESTRIAL RESOURCES			
Loss of faunal and floral habitat, species diversity and SCC due to current wet mining operations	• Only clear vegetation and flood areas where necessary, avoid unnecessary vegetation clearing • As far as possible utilise existing roads, if not feasible, construct roads where possible in areas that have already been disturbed, and not within sensitive habitat • Throughout the operational phase, management and control of alien plant species is to be exercised • Educate drivers with regard to species conservation, and encourage them to not unnecessarily drive over faunal species • Investigate the feasibility of developing a nursery utilising indigenous species and implement trials for rehabilitation to determine rehabilitation success • The species composition can include medicinal and timber species as indicated in the floral ecological assessment, which will lessen the pressure on these species due to habitat destruction and utilisation by host communities • Develop a Biodiversity Action Plan containing objectives to improve agricultural efficiency by host communities, improving current rehabilitation strategies and actively managing alien and invasive floral communities within SR Area 1	High (-)	Medium (-)
Loss of faunal and floral habitat, species diversity and SCC caused by construction and operation activities associated with dry mining at Lanti and Gangama	• Avoid unnecessary vegetation clearing • Wherever feasible, construct roads in areas that have already been disturbed and not within sensitive habitat • Manage and control of alien plant species throughout the operational and rehabilitation phases • Educate drivers with regards to species conservation, and encourage them to not unnecessarily drive over faunal species • Investigate the feasibility of developing a nursery utilising indigenous species and implement trials for rehabilitation to determine rehabilitation success; • The species composition of vegetation used in rehabilitation should include medicinal and timber species • Develop a Biodiversity Action Plan containing objectives to improve agricultural efficiency by host communities, improve current rehabilitation strategies and actively managing alien and invasive floral communities within the study area	High (-)	Medium (-)
BIODIVERSITY: MARINE AND ESTUARINE RESOURCES			
Modification of remaining estuarine habitat	• Ensure vegetation clearing and overburden stripping is conducted during the dry season to limit erosion sediment loads flowing into the lower reaches of the mangrove ecosystem • Remove and store overburden in such a way that it is not washed into the mangrove creeks during the wet season	High (-)	Medium (-)

Impact	Mitigation measure	Significance before management	Significance after management
	• Ensure there is adequate stormwater management to prevent erosion from the newly exposed mining areas and transport of sediment into the lower reaches of the mangrove channels • Maintain and regularly service all equipment so as to minimise the risks of hydrocarbon spills • Develop and implement a comprehensive water quality monitoring programme that includes sites where it enters the estuarine system and at stations in the vicinity of Nitti Port and along the ore transport route • Develop and implement and Emergency Response and Contingency Plan which includes spill management and clean-up procedures to prevent and or remediate pollution incidents		
Fragmentation of habitats and alteration of ecosystem functioning	• Ensure that fresh water flow into each of the mangrove creeks does not drop below 60 % of the natural base flow, especially during the dry season • Design and manage diversion channels and outlets so as to allow migration of biota both upstream and downstream • Create diversion channels that by-pass active mining pits and maintain the connection between estuarine and freshwater habitats • Lower pond retaining walls during the closure phase at end of mine life	High (-)	Medium (-)
Changes in the community composition and distribution of estuarine biota	• As far as possible limit footprint of mining operations in estuarine habitat (channel and mangrove). If possible do not mine the channel and maintain a buffer of mangrove vegetation • Develop and implement a comprehensive water quality monitoring programme that includes sites where it enters the estuarine system and at stations in the vicinity of Nitti Port and along the ore transport route • Develop and implement and Emergency Response and Contingency Plan which includes spill management and clean-up procedures to prevent and or remediate pollution incidents • Ensure that fresh water flow into each of the mangrove creeks does not drop below 60 % of the natural base flow, especially during the dry season; • Design and manage diversion channels and outlets so as to allow migration of biota both upstream and downstream	High (-)	Medium (-)

Impact	Mitigation measure	Significance before management	Significance after management
Impacts on livelihoods and / or loss or alteration of ecosystem services	• As far as possible limit footprint of mining operations in estuarine habitat (channel and mangrove). If possible do not mine the channel and maintain a buffer of mangrove vegetation • Rehabilitate mined out areas once the operational phase has been completed, this will require infilling of mined out areas with overburden as far as possible, restoration of estuary channel profiles, removal of barriers to tidal flows and replanting of mangrove species in the affected areas • Ensure that fresh water flow into each of the mangrove creeks does not drop below 60 % of the natural base flow, especially during the dry season • Design and manage diversion channels and outlets so as to allow migration of biota both upstream and downstream • Create diversion channels that by-pass active mining pits and maintain the connection between estuarine and freshwater habitats	High (-)	Medium (-)
Direct loss of estuarine habitat and biota within the mining footprint	• As far as possible limit footprint of mining operations in estuarine habitat (channel and mangrove). If possible do not mine the channel and maintain a buffer of mangrove vegetation • Rehabilitate mined out areas once the operational phase has been completed, this will require infilling of mined out areas with overburden as far as possible, restoration of estuary channel profiles, removal of barriers to tidal flows and replanting of mangrove species in the affected areas • Rehabilitation will be a fairly intensive and complex process with mangrove propagules having to be germinated and cared for in advance of the rehabilitation measures	High (-)	Medium (-)
SOILS			
Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinization	• Minimize the disturbed footprint as far as practically possible • Timeously replace soils and undertake concurrent rehabilitation where possible as part of the Soil Management Plan • Regular cleaning and maintenance (good housekeeping) of vehicles, erosion control by water and dust and on-going adherence to social and labour commitments to the loss of eco system services • Implement the Mine Closure Plan to support the proposed project as and when appropriate • Install suitable erosion control infrastructure as needed	High (-)	Medium (-)

Impact	Mitigation measure	Significance before management	Significance after management
NOISE			
General rise in ambient noise levels due to ore transportation	• Minimize the extent of the project footprint • Control dust emissions to minimize impacts to biodiversity • Prior to disturbance, identify species of value (conservation, medicinal, economic, cultural etc.) and develop an action plan to salvage where feasible. • Develop and implement a system to train and educate employees and contractors on the importance and preservation of biodiversity • Install culverts beneath internal haul road crossing of the paleo channel to allow surface flow • Implement the Closure and Rehabilitation Plan • Seek and develop opportunities to offset loss of terrestrial habitat, such as reforestation using indigenous species.	Medium (-)	Medium
SURFACE WATER			
Construction of dams and ponds attenuate flood peaks resulting in changes in seasonal flooding patterns which effect sediment loading, sediment deposition on floodplains, fish ecosystems and host communities / residents	• Investigate the removal of the dams to allow the natural functioning of the ecosystems in accordance with the Mine Closure Plan • SRL should review the reservoir hydrology and spillway design depending on the Mine Closure Plan recommendations regarding the dams	High (-)	High (-)
Decrease in water quality downstream of the Gangama and Gbeni operations due to inadequate stormwater management	• Formalise and size the river diversion as per the Storm Water Management Plan (SWMP) where the Gbeni East Trench is located • Ensure the correct sizing of the Gbeni West Trench as per the SWMP; and • Construct silt traps as per the SWMP	Medium (-)	Low (-)
Insufficient water necessary for mining and processing at Lanti and MSP operations	• Update water balance with dam volumes, actual water volumes used in the plant and during mining (long term data) • Provide data on current make-up water requirements • If ponds are to be removed from MSP area, ensure an alternate water supply to guarantee continuation of mineral processing activities	Medium (-)	Low (-)
GROUNDWATER			
Seepage from MSP tailings and dams raising groundwater levels	Since the raised groundwater levels are localized and in close proximity to the Mogbwemo Dredge Pond, no mitigation measures are proposed	Medium (-)	Medium (-)

Impact	Mitigation measure	Significance before management	Significance after management
MSP secondary processed tails acid generation contaminating groundwater (operational and decommissioning phase)	• Acid generating material is identified and either disposed of sub aqueously or isolated from the receiving environment through appropriate rehabilitation measures • Radioactive material should be identified and isolated from the receiving environment through appropriate rehabilitation measures	Medium (-)	Medium (-)
Lanti mining pond water may lead to groundwater contamination	Provide alternative water supply if the Lanti mining pond has affected the water quality in the community boreholes in the immediate vicinity to the point where they cannot be used	Medium (-)	Low (-)
Nitti Port hydrocarbon spillage contaminating groundwater	Mitigation measures should be identified by specific experts in this field	High (-)	Medium (-)
Failure of the historical and Lanti mining pond walls as a result of groundwater seepage (operational and decommissioning phase)	• In the current mine closure plan, the water levels within the mining ponds will be lowered to reduce maintenance and risk of wall failure • Tailings should be deposited downstream of the mining pond walls to ensure greater stability	High (-)	Medium (-)
RADIATION			
Impact on social and biophysical receiving environments based on radiation exposure	• Radiation will be monitored and analysed (detail provided in Section 6.9.3) • Conduct a ERICA assessment (biota modelling) once processing materials have been characterized in terms of full radionuclide analysis • Update and implement the radiation management plan based on findings from the baseline monitoring and ERICA assessment	Medium (-)	Medium (-)
SOCIAL IMPACTS			
SOCIO-ECONOMIC			
Loss of (or loss of access to) land, crops and livelihood resources in project footprint areas due to mining activities	• Limit project footprint to minimise physical and/or economic displacement • As intended, design and implementation of GIIP Resettlement Action Plans (RAP), inclusive of livelihood restoration measures for all new physical displacement	High (-)	Medium (+)
Host community disruption due to influx of non-local job seekers, employees and business owners.	• Preparation and implementation of a code of practice to guide the management and onsite behaviour of construction and operational teams. • Procurement of goods and services should continue to be only done through a formal process • Apply approach to recruitment as set out in the relevant national legislation • Continue to communicate the recruitment policy and process regularly to local people and contractors	Medium (-)	Low (+)

Impact	Mitigation measure	Significance before management	Significance after management
	• Inform local communities about the construction and operation timeframes and the Grievance Management Procedure • Opportunities to educate and upskill local people to an employable level are explored by SRL and will be implemented once a feasible option(s) had been identified • Engage regularly with the Paramount Chiefs to manage and monitor influx and housing / site allocations		
Contribution to national and regional economic growth due to investment	• Procure goods and services from local or national suppliers as far as possible • Procure ancillary services for goods purchased overseas, such as installation, customisation and maintenance, from national companies as far as possible • Local employment to remain a focus area	Medium (+)	Medium (+)
Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL investment, resulting in better quality of life	• Education provision to local business and government on the maintenance of roads provided by SRL • Continue to provide infrastructure maintenance for existing SRL infrastructure • Implement regular briefing sessions with relevant Paramount Chiefs and sectoral ministries represented by local government	Low (+)	Medium (+)
Dissatisfaction over perceived preferences in development investment and engagement	• Active participation in the CDC, and mentoring and support for this initiative • Promote and support participatory community development planning • Ensure adequate application and access to the Grievance Management Procedure as well as short response turnaround times • Pursue joint social services and infrastructure expansions and programmes with NGOs (with a focus on education) through the CDC • Production and dissemination of information on development investments and activities, based on monitoring and evaluation results and reports	Medium (-)	Medium (+)
HEALTH			
Transmission of communicable diseases from workforce to the host community due to influx and general hygiene	• Develop a communicable disease strategy (HIV, TB etc.) and plan that includes employees, contractors and visitors. The strategy should include elements that reduce the risk for local introduction of communicable disease • Develop an outbreak preparedness and response plan that includes business resilience elements. This should include cooperation with the DHMTs • Develop an influx management plan • Develop a monitoring system as part of the CHMMP to monitor specific health indicators	Medium (-)	Low (-)
Increased burden of disease associated with malaria due to modification of the environment (including	• Perform a malaria indicator study to determine the local burden of disease; • Conduct a baseline entomology study to determine the presence of disease transmitting mosquitoes and other vectors, their behaviours and what controls could be effective	High (-)	Medium (+)

Impact	Mitigation measure	Significance before management	Significance after management
current mining activities such as mine dredge ponds and in-migration of work-seekers)	• Develop an influx management plan that may consider environmental management and health systems strengthening in collaboration with the DHMT • Develop an integrated workplace malaria and vector control programme that has a focus on environmental management, integrated vector control, bite prevention, behaviour management and effective case management within the workplace		
Increased risk of sexually-transmitted diseases and high risk sexual practices due to current and future mining activities	• As part of the proposed communicable disease strategy and plan, review the HIV Policy and plan to ensure it is meeting the potential risks and the needs of the project • Develop HIV and sexually transmitted infection (STI) prevention strategies and interventions for transport workers, especially long-distance truck drivers • Work with contracted transport companies to reduce the number of trucks that overnight in the immediate area around host communities such as Moriba Town, Mogbewa, Mogbwemo and Mataglema. Administrative controls should support the driving in and delivery of loads to limit the amount of time that trucks spend in the Project area where this is possible • Develop a contractor management plan to support these strategies in the contracted workforce, with effective enforcement and monitoring to track compliance as relevant • Develop an influx management plan • As part of the Community Health Management and Monitoring Plan (CHMMP), develop a monitoring system for specific health indicators related to STIs and HIV	High (-)	Medium (-)
Emergence and spread of veterinary medicine and Zoonotic diseases due to inadequate camp and waste facilities	• Consider conducting studies with the Lassa Fever Research Centre (in Kenema) to determine the presence of the reservoir host in the general host community, accommodation camps and around land-fill / waste disposal sites. If the species is present, it would be beneficial to conduct further studies to determine if rodents are carrying the virus • Implement rodent controls in accommodation camps, work and landfill areas; • Develop an influx management plan • Continue to support the DHMT(s) with outbreak preparedness and response as a strategic intervention • Implement effective camp facility management to prevent rodents from gaining access to accommodation, kitchens and food / water storage areas • Implement effective waste management practices in all accommodation, work areas and landfills to reduce the risk for pests being attracted or proliferating in these locations	High (-)	Low (-)

Cumulative impacts were also identified. Cumulative impacts result from the successive, incremental, and / or combined effects of an action, project, or activity when added to other existing, planned, and / or reasonably anticipated future ones (IFC, 2013).

The key natural and social external influences and stresses that may impact on the valued biophysical and social components (VECs) that are located in the area of influence are air quality, noise, land use, biodiversity, surface water, social and economic impacts. In addition to the existing SR Area 1 operations, there are other past, present and future developments by multiple stakeholders that might have caused, area causing, or may cause impacts.

The management of cumulative impacts will depend on the context in which the development is occurring (i.e. the impacts from other projects and natural drivers that affect the VECs) and the characteristics of the SR Area 1 operation. As cumulative impacts result from the actions of multiple stakeholders, the responsibility for their management is collective. For instance, social influx cannot be managed by SRL alone, but requires the involvement of a number of stakeholders including government, traditional leaders and civil society.

In the context of the SR Area 1 existing activities and expansion, most negative cumulative impacts can be mitigated through proactive project design and management. Project-specific impacts identified in the ESHIA need to carefully managed to control the cumulative effects of the project.

Environmental, Social and Health Management Plan

The purpose of the ESHMP is to ensure that environmental, social and health impacts identified during the ESHIA process are effectively managed during the various project phases. The ESHMP specifies the mitigation and management measures to which SRL is committed, and shows how the Project will mobilise organisational capacity and resources to implement these measures. The ESHMP also shows how mitigation and management measures will be scheduled.

Best practice principles require that every reasonable effort be made to reduce and preferably to prevent negative impacts, while enhancing positive benefits, especially within the environment and communities most directly affected by SRL's current and proposed activities in SR Area 1. These principles are guiding in the ESHIA process.

The ESHMP covers information on the management and / or mitigation measures that will be taken into consideration to address impacts in respect of:

- **Operational phase:** Historical and current dredge mining operations and associated infrastructure (i.e. included in the 2012 ESIA and approved via Environmental Licence number EPA-SL030);
- **Expansion phase:** Construction, initial operational and expansion of the Lanti and Gangama dry mining operations (2013 onwards), including:
    - Site and vegetation clearing, grubbing, establishment of layout area, contractors camp, widening of existing haul roads, dry mining, scrubbers, expansion of tailings storage facilities, borrows pits and trucking of ore (haul roads)
- **Decommissioning phase, closure and post closure phase.**

It is necessary to highlight that the ESHMP is a living document that will be periodically reviewed and updated by SRL.

SRL is responsible for ensuring adherence to the management and mitigation measures detailed in the ESHMP and the relevant approvals. SRL's management, employees and contractors are all bound by the ESHMP and SRL's Health, Safety, Environment and Community (HSEC) Management System and must use these document as a guide to avoid, minimise and manage environmental, health and social impacts.

In addition, the following stand-alone management plans have been developed and are included in the list of appendices:

- Chemical Management Plan;
- Waste Management Plan;
- Tailings Management Plan;
- Mine Closure Plan;
- Occupation Health and Safety Plan;
- Emergency Response and Contingency Plan;
- Community Development Action Plan; and
- Communication and Public Participation Plan.

An environmental and social monitoring plan has also been prepared (Section 8).

Closure principles and financial provision

As part of the ESHIA process, a Mine Closure Plan was prepared (SRK 2018(6)). This section of the ESHIA has been informed by the Mine Closure Plan.

The aim of the Mine Closure Plan is 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 HSEC management standards and GIIP. The Mine Closure Plan has been developed to be site specific and to address the particular risks associated with SR Area 1.

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 stakeholders.

Table of Contents

Executive Summary ii
Disclaimer xlii
List of Abbreviations xliii
1 Introduction 1
1.1 Background to project 1
1.2 Geographical setting 1
1.3 SRL compliance to date 3
1.4 Purpose of the report 4
1.5 ESHIA and ESHMP objectives 4
1.6 ESHIA process and schedule 5
1.6.1 Approach to the scoping phase 6
1.6.2 Approach to the ESHIA and ESHMP process 7
1.7 Particulars of the applicant for an environmental licence 7
1.8 Information on the environmental firm engaged to work on the ESHIA 8
1.9 Assumptions and limitations 9
2 Legal and GIIP framework 11
2.1 National regulatory framework 11
2.1.1 *Sierra Rutile Agreement (Ratification) Act*, 2002 11
2.1.2 *Mines and Minerals Act, 2009* 13
2.1.3 Sierra Leone Mining Sector Reform: A strategic environmental and social assessment, 2008 15
2.1.4 *Environment Protection Agency Act, 2008* and *EIA Regulations* 15
2.1.5 The *Environmental and Social (Mines and Mining) Regulations, 2013* 15
2.2 International environmental and social principles, policies and standards 21
2.2.1 Equator Principles 21
2.2.2 International Finance Corporation Performance Standards 21
2.2.3 International Council on Mining and Metals 22
2.2.4 Other benchmarks, guidelines and reference materials 22
2.2.5 International conventions 24
2.3 Corporate Policies, Framework and Standards 24
2.3.1 Iluka Health, Safety, Environment and Community Management System Framework 24
2.3.2 Iluka Health, Safety, Environment and Community Policy 2017 24
2.3.3 Iluka Group standards 25
3 Description of the project 27
3.1 General information on the project 27
3.2 SRL mining history 28
3.3 SRL mining product 29

3.4 Current mining operation....29
3.4.1 Wet mining....32
3.4.2 Dry mining....36
3.4.3 Mineral processing....41
3.4.4 Nitti Port....41
3.4.5 Roads....46
3.4.6 Mining vehicles....46
3.4.7 Electricity and power supply....46
3.4.8 Potable water supply....47
3.4.9 Mine camps, buildings and other facilities....47
3.4.10 Waste management....47
3.5 Current workforce....47
3.6 Total investment and financial sources....49
3.7 Mining rights....49
3.8 Proposed additions to the SRL mining operations....49
4 Environmental and Social Baseline....51
4.1 Climate and meteorology....51
4.1.1 General description of climate in Sierra Leone....51
4.1.2 General description of regional climate....52
4.1.3 Climate conditions at the project site....52
4.2 Topography and geology....66
4.2.1 Topography....66
4.2.2 Geology....68
4.3 Soil quality....69
4.3.1 Soils characterisation....70
4.3.2 Soil classification and site evaluation....71
4.3.3 Laboratory analysis....73
4.3.4 Soil erodibility and compaction....74
4.4 Geochemistry....75
4.4.1 Mineralogy....75
4.4.2 Elemental composition....76
4.4.3 Acid generating characteristics....76
4.4.4 Leachate quality....77
4.5 Radiation....77
4.5.1 Sources of radiation at SRL operations....78
4.5.2 Dose assessment methodology....83
4.5.3 Radiation dose assessment....89
4.5.4 Transport of radioactive material....105
4.6 Hydrology....106
4.6.1 Water resources....106
4.6.2 Floodline Determination....111

4.6.3 Stormwater Management....114
4.6.4 Water Balance....114
4.6.5 Water Quality....121
4.7 Hydrogeology....129
4.7.1 Monitoring borehole drilling....129
4.7.2 Hydrostratigraphy....132
4.7.3 Observed groundwater levels....132
4.7.4 Aquifer parameters....134
4.7.5 Groundwater users....138
4.7.6 Hydrochemistry....140
Borehole Hydrochemistry....140
Detailed Historical Water Analyses....145
4.7.7 SR Area 1 mining influence on groundwater....147
4.8 Land use capability....151
4.8.1 Arable potential land....152
4.8.2 Sub arable / subsistence / grazing land capability....152
4.8.3 Wilderness / conservation land....152
4.8.4 Wetland areas....152
4.9 Air quality....155
4.9.1 Existing sources of air emissions....155
4.9.2 Ambient air quality standards and guidelines....156
4.9.3 Ambient air quality data....158
4.9.4 Potential sensitive receptors....168
4.10 Noise quality....171
4.10.1 Sources of noise....171
4.10.2 Noise standards and guidelines....174
4.10.3 Existing ambient noise levels....176
4.10.4 Baseline reference ambient levels....179
4.11 Terrestrial, aquatic and wetland biodiversity....180
4.11.1 Regional biodiversity setting....180
4.11.2 Biodiversity features in SR Area 1....181
4.12 Estuarine environment....207
4.12.1 Methodology....207
4.12.2 Estuarine water quality....211
4.12.3 Estuarine sediment quality....214
4.12.4 Biomonitoring....218
4.12.5 Vegetation....220
4.12.6 Fish....221
4.12.7 Birds, reptiles and mammals....224
4.12.8 Human use....229
4.13 Socio-economic environment....231

4.13.1 Methodology....231
4.13.2 National and regional context....232
4.13.3 Socio-economic conditions of the SR Area 1....234
4.14 Community health environment....250
4.14.1 Methodology....250
4.14.2 National and regional context....251
4.14.3 Study area findings....253
5 Public Participation....265
5.1 Results of Public Participation during Scoping Phase....265
5.2 Stakeholder identification....265
5.3 Public participation process during the Scoping Phase....266
5.3.1 Project notification / announcement....266
5.3.2 Information sharing and issue gathering meetings....266
5.3.3 Opportunities for comment....269
5.3.4 Issues and Response Report....269
5.4 Key issues raised by stakeholders during scoping....269
5.4.1 Legacy issues....270
5.4.2 Company related issues....270
5.4.3 ESHIA and environment related issues....270
5.4.4 Socio-economic issues....270
5.5 Public participation during the Impact Assessment Phase....271
5.5.1 Announcing opportunity to comment on the Draft ESHIA findings....271
5.5.2 Availability of the Draft ESHIA findings for public comment....271
5.5.3 Feedback meetings on Draft ESHIA findings....272
5.5.4 Submission of comments from stakeholders on the findings....272
5.5.5 Issues and Response Report....272
5.6 Public participation activities after the decision-making phase....272
6 Environmental, Social and Health Impacts....273
6.6 Cumulative impact assessment....410
6.6.1 Objectives for assessing cumulative impacts....410
6.6.2 Rationale for consideration of cumulative impacts....410
6.6.3 Identification of valued biophysical and social components....410
6.6.4 Natural and social external influences and stresses and impacts....411
6.6.5 Key past, present and future developments with the Sierra Rutile region....412
6.6.6 Management of cumulative impacts....413
6.6.7 Cumulative impact mapping....413
7 Environmental, Social and Health Management Plan....416
7.1 Introduction....416
7.2 Roles and responsibilities....417
7.3 Structure of the ESHMP....422

7.4 Impact Mitigation and Management....422
7.5 Checking and Corrective Actions....447
7.5.1 Inspections....447
7.5.2 Internal and external audits....447
7.5.3 Corrective action....447
7.5.4 Reporting....447
7.5.5 Management review....448
7.5.6 Liaison....448
8 Environmental and social monitoring....449
9 Closure principles, land use and financial provision....456
10 Project alternatives....464
10.1 Introduction....464
10.2 Location alternatives....464
10.2.1 Mine lease....464
10.2.2 Location of land-based concentrators and associated infrastructure....464
10.3 Activity alternatives (alternative mining methods)....464
10.4 Land use options after mine closure....465
10.5 The no-go option....466
11 Conclusion....467
12 References....469
Appendices....474
Appendix A: Air Quality Impact Assessment Report....475
Appendix B: Biodiversity - Terrestrial, Aquatic and Wetland Ecological Report....476
Appendix C: Biodiversity - Estuarine and Marine Report....477
Appendix D: Community Health Impact Assessment Report....478
Appendix E: Geochemistry Characterisation of Selected Residues....479
Appendix F: Groundwater Report....480
Appendix G: Surface Water Report....481
Appendix H: Noise Report....482
Appendix I: Radiation Report....483
Appendix J: Socio-economic Report....484
Appendix K: Soils and Land Use Capability Report....485
Appendix L: Management Plans....486
Appendix L1: Chemical Management Plan....487
Appendix L2: Waste Management Plan....488
Appendix L3: Tailings Management Plan....489
Appendix L4: Mine Closure Plan....490
Appendix L5: Occupational Health and Safety Plan....491

Appendix L6: Emergency Response and ContingencyPlan 492
Appendix L7: Community Development Action Plan 493
Appendix L8: Communication and Public Participation Plan 494
Appendix M: Photos of Stakeholder Meetings 495
Appendix N: Attendance Registers 496
Appendix O: Maps 497

List of Tables

Table-1: Summary of mining operations and processes including associated timeframes iii
Table 2: Summary of potential high and medium impacts for the project and the associated environmental management measures xv
Table 1-1: Information on the environmental licence applicant 7
Table 1-2: Information on the environmental firm engaged to undertake work 8
Table 1-3: Core project team members and key responsibilities 8
Table 1-4: Project specialist study leads 9
Table 2-1: Summary of schedules provided in the Regulations 19
Table 3-1: Summary of the site area 27
Table 3-2: Summary of mining operations and processes including associated timeframes 31
Table 3-3: List of heavy duty vehicles used at various mining operations 46
Table 3-4: Current workforce breakdown for the SRL operation (August 2017) 48
Table 3-5: Breakdown of contractors used by SRL (August 2017) 48
Table 3-6: Proposed future changes operational processes 50
Table 4-1: Reference to the location of specialist studies in the appendix 51
Table 4-2: Comparison between on-site rainfall and Lakes Environmental data 53
Table 4-3: Intensity Duration Frequency (IFD) estimates for SRL (mm) 55
Table 4-4: Storm design and rainfall depths (mm) 55
Table 4-5: Comparison of Lakes Environmental and on-site temperature and humidity data 57
Table 4-6: Monthly evaporation (mm) - Torma Bum 61
Table 4-7: Monthly class A-pan and class S-pan (mm) 61
Table 4-8: Categories of sources 78
Table 4-9: SRL Radiation Licenses 79
Table 4-10: Typical mineral assemblage of the SRL ore 81
Table 4-11: Typical mineral assemblage of SRL HMC 81
Table 4-12: Radionuclide concentrations in heavy mineral sand Australian operations 82
Table 4-13: Dose limits for Occupational Exposed Persons and the public (IAEA 2011) 84
Table 4-14: Pathways of exposure for workers from operational sections at SR Area 1 85
Table 4-15: Pathways of exposure for the public from operational sections at SR Area 1 86
Table 4-16: Estimated occupational doeses for workers 89
Table 4-17: Dose assessment for workers at the mines and WCPs 92
Table 4-18: Dose assessment for workers from the MSP 95
Table 4-19: Dose assessment for workers at Tailings Storage 99
Table 4-20: Dose assessment for workers through potential exposure pathways at Nitti Port 101
Table 4-21: Estimated doses to members of the public 102
Table 4-22: Mean Annual Runoff at each river system 109
Table 4-23: Mean Annual Runoff into and out of the dams / ponds 110
Table 4-24: Surface water monitoring points 121
Table 4-25: Surface water quality analysis 125
Table 4-26: SR Area 1 monitoring borehole drilling 131

Table 4-27: SR Area 1 pump testing results 136
Table 4-28: SR Area 1 village / community boreholes 138
Table 4-29: Simplified criteria for land capability classification and rating 151
Table 4-30: Air quality guidelines and standards for PM_{10} 156
Table 4-31: Air quality guidelines and standards for $PM_{2.5}$ 157
Table 4-32: Ambient air quality guidelines and standards for SO_2 157
Table 4-33: Ambient air quality guidelines and standards for NO_2 158
Table 4-34: NEM: AQA, 2004 acceptable dust fallout standards 158
Table 4-35: Dust, gas and particulate matter monitoring locations and weather stations 159
Table 4-36: Dust fallout for August to November 2017 161
Table 4-37: Monthly average 24-hour PM_{10} concentrations 163
Table 4-38: Monthly average 24-hour $PM_{2.5}$ concentrations 165
Table 4-39: 24-hr SO_2 concentrations 168
Table 4-40: 1-hr NO_2 concentrations 168
Table 4-41: Villages in close proximity to the mine 169
Table 4-42: Current noise generating construction activities 171
Table 4-43: Current noise-generating operation activities and equipment 171
Table 4-44: WB / IFC EHS Guideline - noise level guidelines 175
Table 4-45: Summary of the Degraded Forest habitat type 181
Table 4-46: Summary of the ridges and remnant Semi-deciduous Moist Forest habitat type 182
Table 4-47: Summary of the unaltered watercourses (including mangroves) habitat type 183
Table 4-48: Summary of the altered watercourses habitat type 184
Table 4-49: Summary of the transformed areas habitat type 185
Table 4-50: Floral SCC identified during the assessment 185
Table 4-51: Potential faunal species of conservational concern found within SR Area 1 186
Table 4-52: Traditional medicinal plants identified during the field assessment 187
Table 4-53: Exotic or invasive species identified during the assessment 188
Table 4-54: List of fish species identified during the assessment 189
Table 4-55: Description of biomonitoring reference sites 191
Table 4-56: Summary of results for the macro-invertebrate integrity assessment 195
Table 4-57: Summary of the results of the assessments applied to the wetland systems for Group 1 197
Table 4-58: Summary of the results of the assessments applied to the wetland systems for Group 2 198
Table 4-59: Summary of the results of the assessments applied to the wetland systems for Group 3 199
Table 4-60: Summary of the results of the assessments applied to the wetland systems Group 4 200
Table 4-61: Sample log showing sampling activities undertaken at each sampling station 210
Table 4-62: Concentration of trace metals (mg/kg) in subtidal sediment samples collected from 27 estuary sampling stations in the 2017 wet and 2018 dry surveys. Values highlighted in red font exceed the Effects Range Low (ERL) NOAA guidelines. 216
Table 4-63: Concentrations of trace metals in oyster tissue collected at different sites in the estuaries of the study area 219
Table 4-64: List of bird species recorded on the estuary 226
Table 4-65: Summary of data gathering methods 232

Table 4-66: Key National and Provincial social indicators 232
Table 4-67: Key District and Chiefdom social indicators - Bonthe 233
Table 4-68: Key district and chiefdom social indicators - Moyamba 234
Table 4-69: Main source of water 247
Table 4-70: High level opinion on Quality of Life in the study area 249
Table 4-71: Source of baseline health data 251
Table 4-72: Coverage of malaria control interventions in Bonthe and Moyamba Districts, 2013 255
Table 4-73: Summary of nutritional indicators in Bonthe and Moyamba Districts 258
Table 4-74: Immunisation coverage (%) in Bonthe and Moyamba Districts, 2013 vs. 2015 264
Table 5-1: Details of information sharing meetings held during the Scoping Phase 268
Table 6-1: Key elements in the evaluation of impact significance 275
Table 6-2: Characteristics used to describe impacts and impact consequence 276
Table 6-3: Method for rating the significance of impacts 277
Table 6-4: Impact significance rating and mitigation measures for the Impact 279
Table 6-5: Impact AQ-1 – Dust emissions during the operational phase 281
Table 6-6: Impact AQ-2 – Increased emissions from the powerplant 282
Table 6-7: Impact AQ-3 – Increased emissions from the dryers at the SRL MSP 283
Table 6-8: Impact AQ-4 – Increased emissions from the medical incinerators 284
Table 6-9: Impact AQ-5 – Dust emissions during the expansion phase 286
Table 6-10: Impact AQ-6 – Impact of dust and gas emissions during the Decommissioning and Closure Phase 288
Table 6-11: Impact AQ-7 – Impact of dust and gas emissions during the Post Closure Phase 289
Table 6-12: Impact BDA-1 – Loss of habitat, biota and ecosystem services due to mining activities at the current wet mining operation 291
Table 6-13: Impact BDA-2 – Loss of habitat, biota and ecosystem services due to the MSP and haul roads 292
Table 6-14: Impact BDA-3 – Loss of habitat, biota and ecosystem services due to handling and shipping at Nitti Port 293
Table 6-15: Impact BDA-4 – Loss of habitat, biota and ecosystem services due to construction and operation activities associated with dry mining at Lanti and Gangama 294
Table 6-16: Impact BDA-5 – Loss of habitat, biota and ecosystem services due to lowering of dredge ponds during decommissioning / closure and rehabilitation 296
Table 6-17: Impact BDA 6 - Loss of habitat, biota and ecoservices resulting from decommissioning of plant and unneeded haul roads 297
Table 6-18: Impact BDA-7- Loss of habitat, biota and ecosystem services due to earthworks associated with rehabilitation efforts 298
Table 6-19: Impact BDA-8 - Loss of habitat, biota and ecosystem services due to lowering of dredge pond decant post closure 300
Table 6-20: Impact BDT-1 - Loss of faunal and floral habitat, species diversity and SCC due to current wet mining operations 303
Table 6-21: Impact BDT-2 – Loss of faunal and floral habitat, species diversity and SCC due to ancillary human impacts 304
Table 6-22: Impact BDT-3 - Loss of faunal and floral habitat, species diversity and SCC caused by construction and operation activities associated with dry mining at Lanti and Gangama 306

Table 6-23: Impact BDT-4 – Loss of faunal and floral habitat, species diversity and SCC due to lowering of dredge pond decants.....307

Table 6-24: Impact BDT-5 – Loss of faunal and floral habitat, species diversity and SCC due to decommissioning / rehabilitation of active dry mining areas, plant and haul roads.....308

Table 6-25: Loss of faunal and floral habitat, species diversity and SCC due to inefficient rehabilitation and alien and invasive plant proliferation.....309

Table 6-26: Impact BDME-1 – Modification of remaining estuarine habitat.....312

Table 6-27: Impact BDME-2 – Fragmentation of habitats and alteration of ecosystem functioning 313

Table 6-28: Impact BDME-3 – Changes in the community composition and distribution of estuarine biota.....315

Table 6-29: Impact BDME -4 – Impacts on livelihoods and / or loss or alteration of ecosystem services .317

Table 6-30: Impact BDME -5 – Direct loss of estuarine habitat and biota within the mining footprint.....319

Table 6-31: Impact S-1 – Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinization.....321

Table 6-32: Impact S-2 – Net loss of soil volumes and utilisation potential due to change in material status (physical and chemical) and loss of nutrient base 323

Table 6-33: Impact N-1 – General rise in ambient noise levels due to current mining activities 325

Table 6-34: Impact N-2 – General rise in ambient noise levels due to the construction and operation of the Lanti and Gangama dry mining operations 326

Table 6-35: Impact N-3 – General rise in ambient noise levels due to transport and haul road operations.....327

Table 6-36: Impact SWSS-1 - Construction of dams and ponds attenuate flood peaks resulting in changes in seasonal flooding patterns which effect sediment loading, sediment deposition on floodplains, fish ecosystems and host communities / residents.....330

Table 6-37: Impact SWSS-2 - Increase in flooding in the pit due to lack of stormwater diversion from the Gbeni operations causing an impact on operations.....331

Table 6-38: Impact SWSS-3 - Decrease in water quality downstream of the Gangama and Gbeni operations due to inadequate stormwater management.....331

Table 6-39: Impact SWSS-4 - Dam walls being overtopped or failing as a result of freeboard requirements not being sufficient and a large flood event occurs.....332

Table 6-40: Impact SWSS-5 - Insufficient water necessary for mining and processing at Lanti and MSP operations.....333

Table 6-41: Impact SWSS-6 - Excess water release may affect downstream users from Gangama operation 334

Table 6-42: SWSS-7 - Discharge of acidic water from the MSP and Lanti operation leading to reduction in pH and increased acidity resulting in acidic, soft and corrosive water affecting the natural water system 335

Table 6-43: SWSS-8 - Potential use of acidic, soft and corrosive water at Lanti WCP resulting in corrosion and damage of metallic structures, equipment and pipes.....336

Table 6-44: Impact GW-1 – Elevated historical mining pond levels may increase the available drawdown in community boreholes 338

Table 6-45: Impact GW-2 – Seepage from MSP tailings and dams raising groundwater levels 339

Table 6-46: Impact GW-3 – MSP hydrocarbon and sewage spills contaminating groundwater.....340

Table 6-47: Impact GW-4 – MSP secondary processed tails acid generation contaminating groundwater (operational and decommissioning phase).....341

Table 6-48: Impact GW-5 – Elevated Lanti mining pond levels may increase the available drawdown in community boreholes 342

Table 6-49: Impact GW-6 – Lanti dredge hydrocarbon and sewage spills contaminating groundwater 343

Table 6-50: Impact GW-7 – Lanti mining pond water may lead to groundwater contamination 344
Table 6-51: Impact GW-8 – Nitti Port hydrocarbon spillage contaminating groundwater.....345
Table 6-52: Impact GW-9 – Waste disposal site leachate contaminating groundwater (operational and decommissioning phase).....346
Table 6-53: Impact GW-10 – Raised historical mining pond levels altering groundwater baseflow distribution to surface water systems.....347
Table 6-54: Impact GW-11 – Lanti mining pond retarding groundwater baseflow to surface water systems 348
Table 6-55: Impact GW-12 – Seepage of poor quality groundwater through the lanti mining pond wall and weathered aquifer discharging into the surface water systems.....349
Table 6-56: Impact GW-13 – Failure of the historical and Lanti mining pond walls as a result of groundwater seepage (operational and decommissioning phase) 350
Table 6-57: Impact GW-14 – Gbeni and Gangama dry mining dewatering leading to lowered groundwater levels 351
Table 6-58: Impact GW-15 – Gangama dry mining groundwater ingress adjacent to the estuary 352
Table 6-59: Impact GW-16 – Gbeni and Gangama dry mining hydrocarbons contaminating groundwater.....353
Table 6-60: Impact GW-17 – Gbeni and Gangama dry mining sulfide exposure contaminating groundwater (operational and decommissioning phase).....354
Table 6-61: Impact GW-18 – Gangama dry mining saline intrusion contaminating groundwater (operational and decommissioning phase) 355
Table 6-62: Impact GW-19 – Gbeni and Gangama dry mining slope failure as a result of groundwater seepage.....356
Table 6-63: Impact GW-20 – Gbeni and Gangama dry mining saturation due to groundwater ingress 357
Table 6-64: Impact GW-21 – Suspended solids from the Gbeni and Gangama dry mining dewatering volumes contaminating surface water.....358
Table 6-65: Impact GW-22 – Lowered historical mining pond levels may reduce the available drawdown in community boreholes.....359
Table 6-66: Impact GW-23 – Lowered historical mining pond levels may expose sulfides leading to groundwater acidification.....360
Table 6-67: Impact GW-24 – Decommissioning the MSP tailings and dams will lower groundwater levels beneath the tailings disposal area 361
Table 6-68: Impact GW-25 – Lowered Lanti mining pond levels may reduce the available drawdown in community boreholes.....362
Table 6-69: Impact GW-26 – Lowered Lanti mining pond level may expose sulfides leading to groundwater acidification.....363
Table 6-70: Impact GW-27 – Gbeni and Gangama dry mining groundwater gradients recover post mining.....364
Table 6-71: Impact GW-28 – Lowered historical mining pond levels altering groundwater baseflow distribution to surface water systems.....365
Table 6-72: Impact RI-1 – Impact on social and biophysical receiving environments based on radiation exposure.....367
Table 6-73: Impact H-1 - Transmission of communicable diseases from workforce to the host community due to influx and general hygiene.....370
Table 6-74: Impact H-2 – Increased burden of disease associated with malaria due to modification of the environment.....371
Table 6-75: Impact H-3 – Risk of outbreak of arbo-viral diseases due to influx and opening of transport corridors.....372

Table 6-76: Impact H-4 – Effects on human health as a result of changes in the biophysical environment incurred by current and future mining activities 374

Table 6-77: Impact H-5 – Increased risk of sexually-transmitted diseases and high risk sexual practices due to current and future mining activities 376

Table 6-78: Impact H-6 – Food and nutrition-related issues due to influx and land use change 377

Table 6-79: Impact H-7 – Increase in non-communicable diseases as a result of life style and demographic changes 378

Table 6-80: Impact H-8 – Emergence and spread of veterinary medicine and Zoonotic diseases due to inadequate camp and waste facilities 379

Table 6-81: HS-1 - Increased crime as a result of the influx of job seekers, employees and business owners. 383

Table 6-82: Impact HS-2 – Instances of drowning due to mine ponds, resulting in mental health stress on next of kin and the broader host community. 384

Table 6-83: Impact HS-3 – Increased traffic and activities resulting in irritation relating to dust, and noise 385

Table 6-84: Impact HS-4 – Altered movement patterns to access services, fields, natural resources and villages resulting in dissatisfaction and frustration. 386

Table 6-85: Impact PP-1: Host community disruption due to influx of non-local job seekers, employees and business owners 387

Table 6-86: PP-2: Increased pressure on infrastructure and social services due to influx, impacting on quality of life. 388

Table 6-87: Impact LR-1 – Loss of (or loss of access to) land, crops and livelihood resources in project footprint areas due to mining activities 390

Table 6-88: Impact LR-2: Loss (or loss of access to) cultural resources and sites due to mining activities restricting / encompassing land. 391

Table 6-89: Impact LR-3: Increase in fishing and aquaculture opportunities as a result of mine ponds (existing and non-rehabilitated). 392

Table 6-90: Impact LR-4: Perceived decrease quality of drinking water and perceived unsuitability of mine pond water for drinking, resulting in perceived lack of access to drinking water 393

Table 6-91: Impact LR-5: Increased access to domestic water due to existence of mine ponds. 394

Table 6-92: Economic multipliers for different sectors in Sierra Leone 396

Table 6-93: Impact EW-1 – Contribution to national and regional economic growth due to investment 396

Table 6-94: Impact EW-2 – Increased government income due to payment of taxes and royalties 397

Table 6-95: Impact EW-3 – Continued employment and income opportunities as a result of ongoing and expanded operations by SRL. 400

Table 6-96: Impact EW-4 – Opportunities for local business due to procurement by SRL. 402

Table 6-97: Impact EW-5 – Lease payment income for land owners as a result of mining activities. 403

Table 6-98: Impact SS-1 – Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL investment, resulting in better quality of life. 404

Table 6-99: Impact SD-1 – Dissatisfaction over limited jobs due to high unemployment and poverty in the study area. 405

Table 6-100: Impact SD-2 – Distrust in leadership due to corruption (or unfair advantage), or perceptions thereof 406

Table 6-101: Impact SD-3 – Dissatisfaction over perceived procurement inequities. 407

Table 6-102: Impact SD-4 – Dissatisfaction over perceived preferences in development investment and engagement. 408

Table 6-103: Impact SD-5 – Disproportionate impacts on vulnerable groups due to their status in the host community / study area. 409

Table 6-104: Past, existing and future activities....413
Table 7-1: Key responsibilities and reporting lines for SR Area 1 operations....419
Table 7-2: Operational phase: Historical and current wet mining operations and associated infrastructure....424
Table 7-3: Expansion phase: Construction, initial operational and expansion of the Lanti and Gangama dry mining operations....436
Table 7-4: Decommissioning / Closure Phase / Post Closure Phase....443
Table 8-1: Monitoring plan....450
Table 9-1: Suitability of adoption of different land use options on the LoM Landforms....459
Table 9-2: Land capability and associated land use of the various land forms....461
Table 9-3: Estimate of the closure liability....463

List of Figures

Figure 1-1: SR Area 1 general site locality map....2
Figure 1-2: High-level diagram of the ESHIA process....6
Figure 3-1: Simplified process flow of the current SRL operations....29
Figure 3-2: Diagram showing current mining operations and processes....30
Figure 3-3: Simplified process flow of the wet mining operation....33
Figure 3-4: Aerial overview of wet mining area....34
Figure 3-5: Lanti wet mining operations....35
Figure 3-6: Simplified process flow of the dry mining operations....37
Figure 3-7: Aerial overview of Lanti dry mining area....38
Figure 3-8: Aerial overview of Gangama dry mine....39
Figure 3-9: Lanti (top row) and Gangama (bottom row) dry mining operations....40
Figure 3-10: Nitti Port product stockpile storage domes and product one tonne bags (left) and loading of barges (right)....42
Figure 3-11: Aerial overview of MSP....43
Figure 3-12: Location of various tailings residues associated with the MSP....44
Figure 3-13: Aerial overview of Nitti Port....45
Figure 4-1: Comparison between Lakes Environmental and on-site rainfall data....54
Figure 4-2: Average monthly temperature and humidity patterns for Lanti mine site for a 3-year period....58
Figure 4-3: Average monthly temperature and humidity patterns for Mogbwemo for a 112-year period....59
Figure 4-4: Lakes Environmental average monthly temperature and humidity patterns for the site for a 3-year period....60
Figure 4-5: All hours, day time and night time wind roses from Lakes Environmental....63
Figure 4-6: Lakes Environmental seasonal wind roses....64
Figure 4-7: Lakes Environmental wind class frequency distribution....65
Figure 4-8: Relief map for SR Area 1 and surrounding landscape....67
Figure 4-9: Regional geological map (ESS 2018)....69
Figure 4-10: Dominant soils in dry mining areas of SR Area 1 (ESS 2018)....72
Figure 4-11: Photographs of a gauge storage facility (left) and a density gauge in opertation (right)....80

Figure 4-12: Urnaium (U) and Thorium (Th) levels in process streams (SRL 2018) 83
Figure 4-13: Dry (DM1 and DM2) and wet (Dredge D1) mining operations and WCPs (SRL 2018) 91
Figure 4-14: Mineral Separation Plant (MSP) (SRL 2018) 94
Figure 4-15: Zircon bagging at the MSP and storage at D3 (SRL 2018) 97
Figure 4-16: Tailings Storage Area (SRL 2018) 97
Figure 4-17: Tailings Storage Area flow diagram (SRL 2018) 98
Figure 4-18: Nitti Port product storage and shipment 100
Figure 4-19: Gamma screening level surveys of Area 1 (SRL 2018) 104
Figure 4-20: SR Area 1 river systems and major catchment areas 108
Figure 4-21: Floodline map for the Gbeni and downstream of L4 Lanti operations 112
Figure 4-22: Floodline map for the Gangama operations and the Nitti Port 113
Figure 4-23: Lanti DM1 containments and dams 115
Figure 4-24: Gangama DM2 tailings and water storage facilities 116
Figure 4-25: Lanti DM1 – water balance 118
Figure 4-26: Gangama DM2 – water balance 119
Figure 4-27: MSP – water balance 120
Figure 4-28: Surface water monitoring network 122
Figure 4-29: Surface Water Quality - pH 127
Figure 4-30: Surface Water Quality – Electrical Conductivity 128
Figure 4-31: SR Area 1 monitoring borehole drilling locations (Graell 2018) 130
Figure 4-32: SR Area 1 Depth to groundwater (MBC) (Graell 2018) 133
Figure 4-33: SR Area 1 Topography vs Groundwater Level (mamsl) (Graell 2018) 134
Figure 4-34: SR Area 1 blow yields (l/sec) (Graell 2018) 135
Figure 4-35: SR Area 1 Transmissivity distribution (m²/day) (Graell 2018) 137
Figure 4-36: SR Area 1 village / community boreholes (Graell 2018) 139
Figure 4-37: Goundwater pH response to rainfall (Graell 2018) 142
Figure 4-38: Goundwater TDS response to rainfall (Graell 2018) 143
Figure 4-39: Groundwater TDS response vs pH (Graell 2018) 144
Figure 4-40: SR Area 1 Piper diagram (Graell 2018) 146
Figure 4-41: Land capability in the dry mining areas SR Area 1 (ESS 2018) 154
Figure 4-42: Dust and gas monitoring locations (SRK, 2018(1)) 160
Figure 4-43: Dust fallout results for August 2017 to November 2017 (SRK, 2018(1)) 162
Figure 4-44: PM_{10} concentrations for the period July 2017 to December 2017 (SRK, 2018(1)) 164
Figure 4-45: $PM_{2.5}$ concentrations for the period July 2017 to December 2017 (SRK, 2018(1)) 166
Figure 4-46: Comparison of PM_{10} and $PM_{2.5}$ concentrations (SRK, 2018(1)) 167
Figure 4-47: Location of villages (SRK, 2018(1)) 170
Figure 4-48: MSP dry plant noise emission characteristics 172
Figure 4-49: Lanti dredge noise emission characteristics 172
Figure 4-50: Lanti floating concentrator noise emission characteristics 173
Figure 4-51: Lanti dry mining feed preparation plant noise emission characteristics 173
Figure 4-52: Lanti dry mining spiral plant noise emission characteristics 174

Figure 4-53: Gangama dry mining feed preparation plant noise emission characteristics 174
Figure 4-54: Existing ambient noise levels measured in the SR Area 1 survey in 2017 (paired values L_{Day}/L_{Night} dBA are daytime and night time levels) (Acusolv 2018).....178
Figure 4-55: Existing ambient noise profile for SR Area 1 (Acusolve 2018) 179
Figure 4-56: Species from aquatic assessment (STS 2018).....190
Figure 4-57: Location of aquatic ecological assessment study sites (STS 2018) 192
Figure 4-58: Photographic documentation of aquatic sampling sites SR1 and SR3.....193
Figure 4-59: Photographic documentation of aquatic sampling sites SR4 and SR5.....194
Figure 4-60: Conceptual illustration of the freshwater resource PES – western portion of SR Area 1 (STS 2018) 201
Figure 4-61: Conceptual illustration of the freshwater resource PES – eastern portion of SR Area 1 (STS 2018) 202
Figure 4-62: Conceptual illustration of the freshwater resource PES – southern portion of SR Area 1 (STS 2018) 203
Figure 4-63: Conceptual illustration of the freshwater resource EIS - western portion of SR Area 1 (STS 2018) 204
Figure 4-64: Conceptual illustration of the freshwater resource EIS - eastern portion of SR Area 1 (STS 2018) 205
Figure 4-65: Conceptual illustration of the freshwater resource EIS - southern portion of SR Area 1 (STS 2018) 206
Figure 4-66: Map of SR Area 1 and downstream estuarine and marine habitats where the ecological surveys were undertaken (Anchor 2018) 208
Figure 4-67: Map of SR Area 1 and downstream estuarine and marine habitats showing individual sampling stations for both wet and dry seasons (Anchor 2018).....209
Figure 4-68: Temperature (°C), salinity (PSU) and pH in surface and bottom at each sampling site during the wet season (left) and dry season (right) (Anchor 2018) 213
Figure 4-69: Total Suspended Solids (TSS) at each sampling station in the wet and dry season (Anchor 2018) 214
Figure 4-70: Trace metal content in subtidal sediment samples taken in the 2017 wet and 2018 dry surveys as well as showing sediment quality guidelines (ERL: Effects Range Low). 217
Figure 4-71: Examples of benthic invertebrate macrofauna found in sub-tidal grab and intertidal core samples (Anchor 2018) 221
Figure 4-72: Fish species recorded during the wet season field survey conducted during 2017 in the estuarine creeks draining SR Area 1 (Anchor 2018).....223
Figure 4-73: Bird counting areas (shading) and vessel tracks during the wet season (white lines) and dry season (yellow lines) (Anchor 2018).....225
Figure 4-74 Mammal tracks in mangrove transects (Anchor 2018).....228
Figure 4-75: Fishing activities (Anchor 2018).....230
Figure 4-76: Oyster shell midden showing extensive and long-term harvesting of oysters from the estuaries of the study area (Anchor, 2018) 231
Figure 4-77: Chiefdom structure.....236
Figure 4-78: Population growth hotspots in SR Area 1.....237
Figure 4-79: Income characteristics of SR Area 1.....242
Figure 4-80: Ecosystem service activities.....246
Figure 4-81: Sanitation types 248
Figure 4-82: Broad cause of disease burden in Sierra Leone, 2012[19] 252

Figure 6-1: Local procurement in different economic sectors 401
Figure 6-2: Cumulative imapact mapping 415
Figure 7-1: Key elements of an HSEC Management System 417
Figure 7-2: Organisational structure for SRL management 418

Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd (SRK) by Sierra Rutile Limited (SRL), as well as based on scientific data collection, analysis and interpretation undertaken by SRK and its specialist scientists. SRK has exercised all due care in reviewing and verifying supplied information, and collected primary data. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied, and collected data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate. SRK is an independent consulting firm with no financial interest in SRL, nor its parent company Iluka Resources.

List of Abbreviations

AG	Acid Generating
ADF	Agricultural Development Fund
AIDS	Acquired Immune Deficiency Syndrome
ARI	Acute Respiratory Infections
ARPANSA	Austrialian Radiation Protection and Nuclear Safety Agency
AIPCP	Alien and Invasive Plant (AIP) Control Plan
ALARA	As low as reasonable achievable
AQIA	Air Quality Impact Assessment - specialist study for SR Area 1 (SRK, 2018(1))
ASS	Acid Sulfate Soils
ASPT	Average Score Per Taxon
AWC	Available Water Capacity (i.e. of a soil)
BCC	Behaviour Change Communication
BDA	Biodiversity Aquatic Resoures
BDME	Biordiversity Marine and Estuarine
BDT	Biodiverity Terrestrial Resources
Bq/g	Becquerel per gram
BID	Background Information Document
BLC	British Land Classification
BTP	British Titan Products
CAD	Community Affairs Department
CADAM	Community Advocacy and Development Movement
CBO	Community Based Organisation
CDA	Community Development Agreement
CEM	Community Empowerment Movement
CDP	Communty Development Plan
CDC	Community Development Committee
CEC	Cation Exchange Capacity
CET	Coarse Electrostatic Tailings
CH_4	Methane
CIA	Cumulative Impact Assessment
CO_2	Carbon Dioxide
CPPP	Communication and Public Participation Plan
CRL	Consolidated Rutile Limited
DCF	Dose Conversion Factor
DCRL	Derived Consideration Reference Level
dB (A)	Decibels (A Scale)
DHMT	District Health Management Teams

DM1	Lanti Plant (land-based Wet Concentrator Plant) – also referred to as "Lanti Dry Mining Plant".
DM2	Gangama Plant (land-based Wet Concentrator Plant) – also referred to as "Gangama Dry Mining Plant".
DO	Dissolved Oxygen
EAP	Environmental Assessment Practitioner
EHA	Environmental Health Area (as per the IFC)
EHS	Environment Health and Safety
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative (2016)
EIS	Ecological Importance and Sensitivity
EMP	Environmental Management Plan
EP	Equator Principles - guidelines adopted by Equator Principles Financial Institutions (EPFIs)
EPIII	Equator Principles updated for the third time in 2012
EPA Act	*Environmental Protection Act* (Act No. 11 of 2008)
EPA-SL	Environmental Protection Agency of Sierra Leone
EPFIs	Equator Principles Financial Institutions
ERICA	Environmental Risk from Ionizing Contaminants Assessment
ESAP	Environmental and Social Action Plan
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
EVD	Ebola Virus Disease
EU	European Union
$FeTiO_3$	Titanium – iron Oxide
FET	Fine Electrostatic Tailings
GDP	Gross Domestic Product
GIIP	Good International Industry Practice
GOSL	Government of Sierra Leone
GST	Goods and Service Tax
HFO	Heavy Fuel Oil
HHS	House Hold Survey
HIV	Human Immunodeficiency Virus
HMC	Heavy Mineral Concentrate
HSEC	Health, Safety, Environment and Community
HTT	High Tension Tailings
Hz	Hertz
IT	Ilmenite Tailings
ITN	Insecticide-treated bed Nets
ICRP	International Commission on Radiological Protection

IDP	Internally Displaced Persons
IEC	Information, Education and Communication
IAEA	International Atomic Energy Agency
ICMM	International Council on Mining and Metals
ICPMS	Inductively Coupled Plasma Mass Spectrometry
IFC	International Finance Corporation
IFC 2012	IFC Performance Standards and Guideline Notes
IFD	Intensity Frequency Duration
IMF	International Monetary Fund
IMDG	International Maritime Dangerous Goods
IOE	Index of Erosion
IHAS	Invertebrate Habitat Assessment
ILO	International Labour Organisation
IRR	Issues and Response Report
ISO	International Organisational for Standardisation
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
km	Kilometer
km/hr	Kilometers per Hour
kV	Kilovolt
LOM	Life of Mine
MAR	Mean Annual Runoff
masl	Meters above sea level
l/sec	Litres per second (pumping rate)
mcb	Meters below collar
MDC	Moyamba District Census
MET	Medium Electrostatic Tails
MLCPE	Ministry of Lands, Country Planning and the Environment
mm	Milimeters
MSP	Mineral Separation Plant
m/s	Meters per second
mSv/y	milli Sieverts per year
MPA	Marine Protected Area
Mt	Million Tonnes
NGO	Non-Governmental Organisation
NMA	National Minerals Agency
NMCP	National Malaria Control Programme
NSRPA	Government of Sierra Leone Ministry of Energy Nuclear Safety and Radiation Authority
NOAA	National Oceanic and Atmospheric Administration
NORM	Naturally Occurring Radioactive Material

NP	Neutralisation Potential
NAF	Non-Acid Forming
NAS	National HIV / AIDS Secretariat
NO_2	Nitrogen Dioxide
NMJD	Network Movement for Justice and Development
OEM	Original Equipment Manufacturer
OSH	Occupational Safety and Health
OSHAS	Occupational Safety and Health Assessment Series
PAG	Potentially Acid Generating
PCO	Present Closure Obligation
PCU	Practical Salinity Units
PES	Present Ecological Status
PHC	Population Housing Consensus (2015)
PH1	Powerhouse 1
PH2	Powerhouse 2
PM	Particulate Matter
POC	Probability of Occurrence
PPG	Public and Publicly Guaranteed
PSU	Practical Salinity Units
RAP	Resettlement Action Plan
RHIA	Rapid Health Impact Assessment
ROM	Run of Mine
RMP	Radiation Management Plan
rpm	Revolutions per minute
RRA	Rapid Rural Appraisal
RUF	Revolutionary Union Front
SASS	South African Scoring System
SCC	Species of Conservation Concern
SESA	Strategic Environmental and Social Assessment
SIA	Social Impact Assessment
SLDHS	Sierra Leone Demographic and Health Survey
SLEP (MM) Reg. 2013	*Sierra Leone's Environmental Protection (Mines and Minerals) Regulations 2013*
SML	Sherbro Minerals Limited
SO_2	Sulfur Dioxide
SWMP	Stormwater Management Plan
STI	Sexually Transmitted Diseases
SRK	SRK Consulting (South Africa) (Pty) Ltd
SRCE	Standardised Reclamation Cost Estimator
SR Area 1	Sierra Rutile Mine Lease Area 1
SRE	Sherbo River Estuary

SRL	Sierra Rutile Limited
SFT	Sulfide Flotation Tailings
t	Tonnes
TB	Tuberculosis
TEC	Total Exchange Capacity
TFR	Total Fertility Rate
Th	Thorium
TSS	Total Suspended Solids
TiO_2	Titanium Dioxide
TT	Total Tailings
TOC	Total Organic Content
tpa	Tonnes Per Annum
TSF	Tailings Storage Facility
U	Uranium
UNICEF	United Nations International Children's Emergency Fund
VECs	Valued Environmetal and Social Components
VOC	Volatile Organic Compound
WB / IFC EHS Guideline	World Bank Group International Finance Corporation 2007. Environmental Health and Safety (EHS) Guidelines
WCP	Wet Concentrator Plant
WHO	World Health Organisation
WWF	World Wildlife Fund
$ZrSiO_4$	Zirconium Silicate

1 Introduction

1.1 Background to project

Sierra Rutile Limited (SRL) is an existing mining operation located in the Bonthe and Moyamba Districts of the Southern Province of Sierra Leone. The mine has been in operation for over 50 years and produces rutile, ilmenite and zircon rich concentrate. SRL currently holds seven mining leases covering 559 km^2 with a total of 16 mineral deposits identified. SRL's Area 1 Mine Lease Area (SR Area 1) covers an area of 290 km^2.

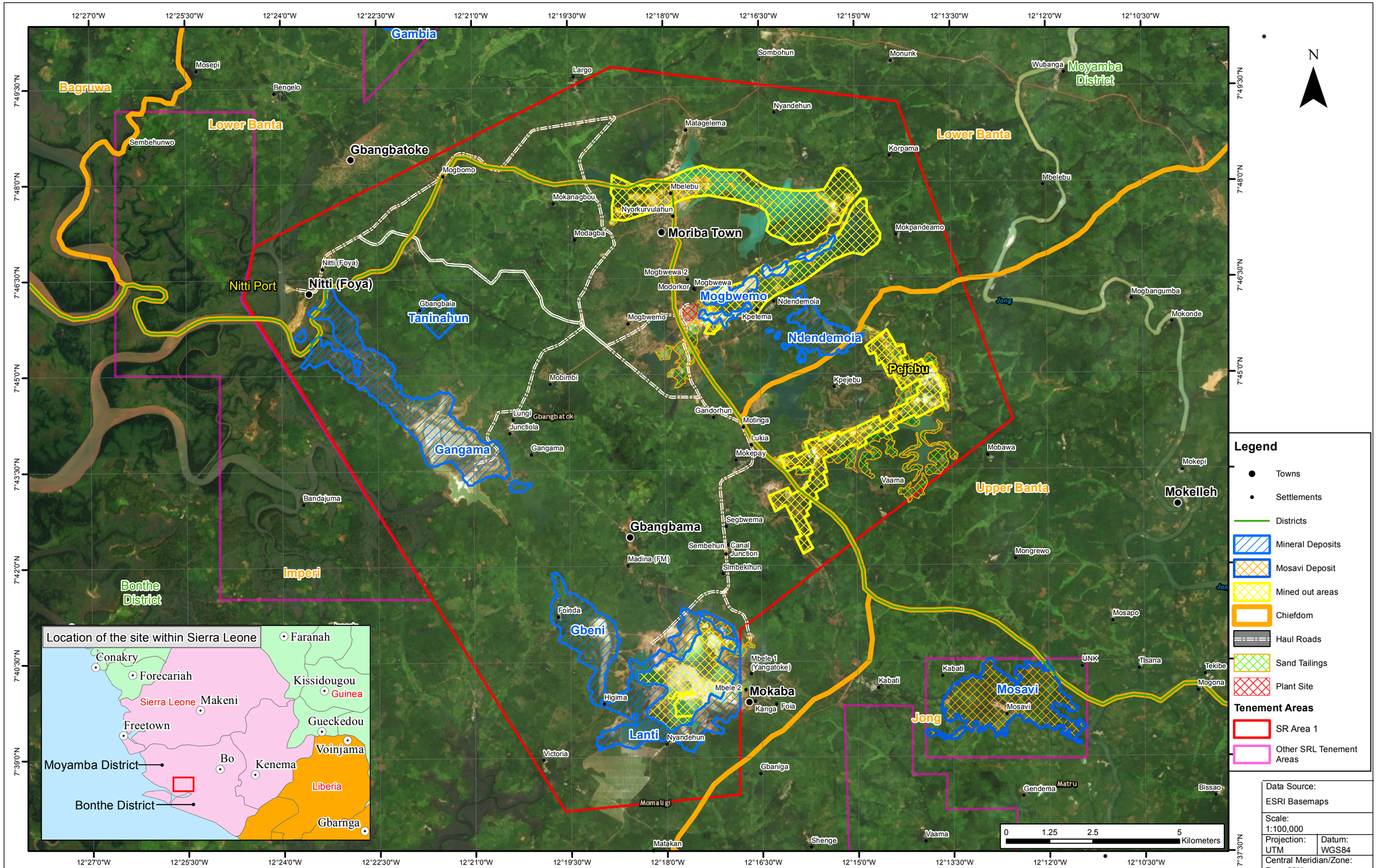
The SRL operation SR Area 1 has an existing Environmental Licence (reference number EPA-SL030) and has undertaken two previous Environmental and Social Impact Assessment (ESIA) studies for their operations in 2001 and an update in 2012 respectively. When these studies where undertaken, the primary mining process was dredge mining (referred to hereafter as wet mining). During 2013 SRL commenced a distinct open cast 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.

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 them 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 SR Area 1. This included the Gangama and Lanti deposits and other deposits within SRL's current operations in SR Area 1.

SRK Consulting (South Africa) (Pty) Ltd (SRK) was appointed by SRL in 2016 to undertake a scoping site visit and to develop a scoping report that met the Sierra Leonean legal requirements. The scoping report (SRK, 2017e) was submitted to, and accepted by, the EPA-SL on 16 October 2017. Subsequent to this initial appointment Iluka Resources Limited (Iluka) acquired the SRL operation, and requested that an ESHIA and an ESHMP be conducted in accordance with the EPA-SL's requirements (EPA-SUHA.96/214/a/HNRM, 2015) as well as Iluka's corporate policies, which are aligned with Good International Industry Practice (GIIP). This report constitutes the final 2018 ESHIA and ESHMP.

1.2 Geographical setting

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, and 65 km south west of Bo (geodesic distances). 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.



Legend

- Towns
- Settlements
- Districts
- Mineral Deposits
- Mosavi Deposit
- Mined out areas
- Chiefdom
- Haul Roads
- Sand Tailings
- Plant Site

Tenement Areas

- SR Area 1
- Other SRL Tenement Areas

Data Source: ESRI Basemaps	
Scale: 1:100,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 30/10/2017	Compiled by: ALLK
Project No: 515234	Fig No: 1-1

srk consulting

SR AREA 1 ESHIA & ESHMP

SR AREA 1 GENERAL LOCALITY MAP

**Note
The Mosavi Deposit is not included in the SRL Area 1 Study, but is shown on the locality due to its proximity to Area 1.

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F1_1_SRL_SiteLocality_A3L_14032018.mxd

Revision: LOUA Date: 14 03 2018

1.3 SRL compliance to date

A number of environmental and social studies that inform environmental and social management at SRL have been conducted since 2000, including:

- An ESIA (Volume 1) and Environmental and Social Management Plan (ESMP) (Volume 2) was prepared by Knight Piésold and Co. (USA) (referred as Knight Piésold) in 2001 (Knight Piésold and Co. 2001), to fulfil the national environmental regulatory requirements of Sierra Leone as well as the international standards at the time, including the Performance Standards for Environmental and Social Sustainability of the International Finance Corporation (IFC) dated 2012 (IFC 2012). The ESMP comprised a Public Consultation and Disclosure Plan, a Resettlement Action Plan (RAP) for Foinda Village, Initial Community Development Plan (CDP), Waste Management Plan, Emergency Response and Contingency Plan, and Mine Reclamation and Closure Plan;
- Knight Piésold prepared a Waste Characterisation Report in 2008. This report was based on a limited number of samples taken during 2006 of various process waste streams at the SRL operation. The report was prepared to assist SRL personnel with nominal compliance with its waste characterisation programme as set out in the 2001 ESIA;
- A 2008 Water Monitoring Report evaluated the water quality of process waters being discharged to the environment. Prepared by Knight Piésold, this report was based on the results of water monitoring conducted during the early 1990s, the 2001 ESIA study as well as additional surface water monitoring undertaken in August 2006. Surface water monitoring was conducted of existing water sources, including mine process water and water from domestic supply reservoirs and sources. No ground water sampling was undertaken. The Environmental and Social Action Plan (ESAP) prepared in 2001 provided for an on-going water monitoring programme to compile a consistent and comprehensive water baseline;
- An update of ESIA and 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 ESAP and Volume 3 the environmental audit. The 2012 reports are based largely on the 2001 Knight Piésold studies, with certain updates presented in specific areas. Additional baseline information was presented, and several management plans were updated. The ESIA and ESMP focused primarily on the wet mining process; and
- In 2012, SRK was commissioned by SRL to undertake a review and gap analysis of the 2001 ESAP. The objective of the study was to:
    - Determine compliance across operations against the requirements set out in the ESAP;
    - Determine how SRL's ESAP compares to current applicable mining and environmental legislation in Sierra Leone; and
    - Determine how SRL's ESAP aligns with GIIP, including the Equator Principles (EP, 2013) and the updated IFC 2012 Performance Standards.

A follow up audit was conducted by SRK in 2013. Both reports set out immediate and medium to long term actions and recommendations to address identified gaps.

Following the release of the audit findings, SRK was appointed to undertake immediate, short and medium-term actions to address gaps in the existing ESAP with a view to meeting new national legal requirements and moving towards international good practice. This included the following:

- Providing the operation with a tool for assessing the environmental and social requirements in project life cycle phases;
- Description of lessons learned from previous resettlement activities;
- A Water Management Plan was compiled;
- A Closure Liability Assessment was undertaken;
- A draft update of the Communication and Public Participation Plan was completed; and
- A scope of work for the update of the ESHIA and ESHMP was compiled.

In 2015, SRK prepared a status report that provided options to integrated environmental and social considerations into the feasibility study and planning of the Gangama Dry Mine. Subsequent to this,

SRK developed an environmental and social construction management plan for the development of the Gangama dry mining process plant.

Social and environmental priorities and mine site procedures have been managed and implemented through the existing ESAP since its completion in 2001 and will be updated and applied to the new project activities in the 2018 ESHIA.

1.4 Purpose of the report

SRL has an existing environmental licence and has undertaken two previous ESIA studies. Therefore, the purpose of this 2018 ESHIA and ESHMP process and report is to present:

- An updated environmental, social and health baseline;
- An updated environmental, social and health impact assessment which considers the following broad project phases:
    - Operational phase: Historical and current dredge mining operations and associated infrastructure (i.e. included in the 2012 ESIA and approved via Environmental Licence number EPA-SL030);
    - Expansion phase: Construction, initial operational and expansion of the Lanti and Gangama dry mining operations (2013 onwards), including: site and vegetation clearing, grubbing, establishment of layout area, contractors camp, widening of existing haul roads, dry mining, scrubbers, expansion of Tailings Storage Facility (TSF), borrows pits and trucking of ore (haul roads);
    - Decommissioning, closure and post closure phase;
- Propose appropriate mitigation and management measures; and
- Provide an action plan for completing baseline monitoring.

The ESHIA and ESHMP is undertaken to ensure that the environmental and social consequences of the project are fully understood, and impacts are adequately managed. The ESHIA and ESHMP recognises that SRL is an existing operation, however it will cover all phases of the SRL operation; the construction, operation, closure and post closure (including on-going rehabilitation) phases. This updated ESHIA and ESHMP also takes new baseline information into consideration that was not previously addressed, such as the marine and estuarine studies, and includes a rapid health impact assessment. The 2018 ESHIA and ESHMP also presents updated social findings as an in-depth social survey was undertaken as part of this process.

This report has been written in accordance with the *Environment Protection Agency Act*, *2008* (Act No. 11 of 2008) (EPA Act) as amended, and the *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 Seventh Schedule of Regulation 15(1) reflected in the SLEP (MM) Reg. 2013, which provides the mechanism and prescribed format for an ESIA Report. 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.

1.5 ESHIA and ESHMP objectives

The objectives of the 2018 ESHIA and ESHMP process are to:

- Identify environmental, social and community health issues and concerns that need to be addressed at the SRL operation;
- Identify national, international and corporate management requirements which the operation must satisfy;
- Gather and evaluate baseline information to characterise the affected environment and communities;
- Undertake consultation with stakeholders and promote full disclosure of information and transparency with regards to the process;

- Identify, define and evaluate environmental, social and health impacts so that potentially significant impacts can be adequately addressed;
- Apply Iluka's Health, Safety, Environment and Community (HSEC) Policy and approach to set out key management and monitoring objectives for the life cycle of the operation, which can be further developed and implemented by SRL;
- Assess and provide feedback on project alternatives; and
- Promote environmental and social sustainability.

1.6 ESHIA process and schedule

The ESHIA is being undertaken in a phased approach that meets the requirements of the Sierra Leonean law and aligns with GIIP for Environmental Impact Assessment (EIA). Broadly this includes the following phases: scoping, draft ESHIA / ESHMP, final ESHIA / ESHMP, decision making and public consultation phases.

Below is a high-level sequential overview of the program to undertake this ESHIA (a schematic of this process is provided in Figure 1-2):

- Project initiation site visit;
- Scoping report and plan for the ESHIA study;
- Submission and acceptance of scoping report by relevant authorities;
- Finalise scope of work for specialist studies;
- Update Communication and Public Participation Plan (CPPP);
- First round of public participation;
- Conduct specialist studies;
- Draft ESHIA and ESHMP;
- Draft report submission to EPA-SL;
- Second round of public participation in the form of the Public Disclosure process;
- Update and finalise ESHIA and ESHMP; and
- Final submission to EPA-SL.

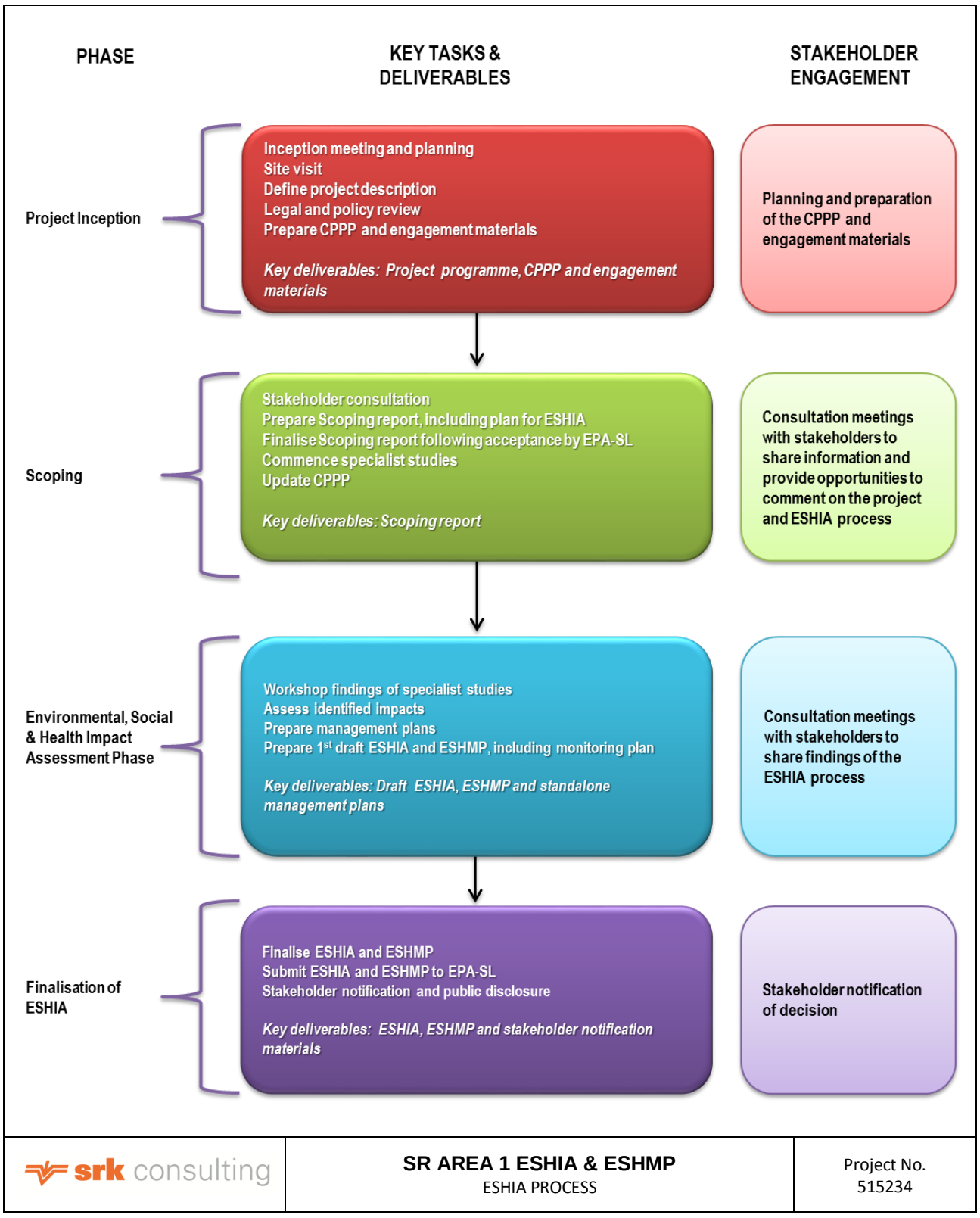


Figure 1-2: High-level diagram of the ESHIA process

1.6.1 Approach to the scoping phase

Building on SRL's 2012 ESIA and ESMP and current public and community engagement, the scoping phase was primarily focused on providing the authorities with a program of work for the ESHIA during 2017 for submission to the EPA-SL in March 2018 (i.e. to be referred to as the 2018 ESHIA and ESHMP). The scoping phase included a site visit by SRK to build on information gathered since SRK's

visits in 2013 and 2016, taking account of new mine processes and expansion areas in SR Area 1. It also allowed the ESHIA team to consult stakeholders in SR Area 1 study area.

During this phase, the scopes of work for the specialist studies were finalised and terms of reference for their appointment developed. In addition, the Communication and Public Participation Plan was updated to reflect the new process (Appendix L9). The EPA-SL approved the Scoping Report on 16 October 2017.

1.6.2 Approach to the ESHIA and ESHMP process

The plan of study for the ESHIA and ESHMP is set out below. The rationale for the different levels of specialist studies for the various environmental and social components, is taken from the issues raised historically and during the initial engagement for the 2018 ESHIA by the public and community, the expected severity of impacts and the level of confidence required in the impact assessment. The level of information and time required to develop adequate, practical management and mitigation measures, was also a consideration in determining the terms of reference of specialist studies. Within this phase, the impact assessment and management plan will run concurrently with public participation activities. During the ESHIA phase, the following has been undertaken:

- Specialists conducted and completed their respective specialist baseline investigations and assessments;
- An integration workshop was held with specialists to identify all potential environmental and social impacts and integrate specialist studies;
- Stakeholder engagement materials were prepared (such as Background Information Documents (BID), advertisements, notification letters, site notices), and public meetings, focus group discussions and consultation with affected communities undertaken; and
- The ESHIA report compiled, and management measures and commitments workshopped with SRL.

Going forward, the following will take place:

- The Draft ESHIA report will be submitted to the relevant authorities;
- The Draft ESHIA report will be made available for public review and comment as part of the Public Consultation and Disclosure Process; and
- The public comments, has been submitted to authorities.

1.7 Particulars of the applicant for an environmental licence

SRL, a wholly owned subsidiary of Iluka, is the applicant for an environmental licence under the EPA Act. Table 1-1 provides the applicant's details as required by the SLEP (MM) Reg. 2013.

Table 1-1: Information on the environmental licence applicant

Name	Sierra Rutile Limited
Identity documentation / registration	SLE290316SIERR1600061
Legal representative	Basma and Macaulay
Address	30 Siaka Stevens Street 2nd Floor, Access Bank Building Freetown Sierra Leone
Telephone number	+23276801416
Email Address	sierrarutile.limited@sierra-rutile.com

1.8 Information on the environmental firm engaged to work on the ESHIA

SRL appointed SRK to conduct the ESHIA and ESHMP. Information relating to SRK is provided in Table 1-2.

Table 1-2: Information on the environmental firm engaged to undertake work

Name	SRK Consulting South Africa (Pty) Ltd
Identity documentation / registration	1995.012890.07 (RSA company registration)
Registration with the Agency	N/A
Legal representative	Mr Vis Reddy
Address	265 Oxford Road, Illovo, Johannesburg, South Africa PO Box 55291, Northlands, 2115, South Africa
Telephone number	+27 11 441 1111
Email Address	johannesburg@srk.co.za
Environmental Assessment Practitioner	Mr. Marius van Huyssteen, BSc(Hons) Geography and Environmental Management, Certified Environmental Practitioner (EAP)

The core project team undertaking this assessment is provided in Table 1-3. The team is supported by relevant specialists undertaking environmental and social studies that informed the ESHIA and key local resources, including a local environmental consultant registered with the EPA-SL.

Table 1-3: Core project team members and key responsibilities

Team role	Team member	Responsibilities
Project partner	Darryll Kilian	Oversight of the project Quality assurance
Project manager	Marius van Huyssteen	Overall project planning and management Client liaison Technical review
Project coordinators	Paul Jorgensen Natasha Anamuthoo	Project execution Management of specialist studies Preparation of reports
Stakeholder engagement advisor	Vassie Maharaj	Public consultation advisory and management
ESHIA and ESHMP local support	Osman Lahai Ralph Bona – Scoping phase only Braima Koroma – Environmental Impact Assessment phase	Public consultation, translator and ESHIA / ESHMP support

The scope of work required for the specialist studies were developed during the Scoping phase of the project. A list of specialists is provided in Table 1-4.

Table 1-4: Project specialist study leads

Specialist study	Proposed SRK team and project specialist
Air quality	Dhiren Naidoo, SRK Consulting, South Africa
Biodiversity - terrestrial and freshwater	Stephen van Staden, STS Environmental, South Africa
Biodiversity - estuarine and marine	Dr Barry Clark, Anchor Environmental, South Africa
Community health	Dr Mark Divall, Shape Consulting, South Africa
Geochemistry	Dr Levi Ochieng, SRK Consulting, South Africa
Groundwater	Rainer Krantz, Graell Limited, Mauritius
Surface water	Peter Shepherd, SRK Consulting, South Africa
Noise	Dr Ben van Zyl, Acusolv, South Africa
Radiation	Clasina Roodt, Sierra Rutile Limited, Sierra Leone
Socio-economic	Anita Bron, SRK Consulting, South Africa
Soils and land use capability	Ian Jones, Earth Science Solutions, South Africa

A Mine Closure Plan was also developed as specialist report by Mr. James Lake of SRK Consulting, South Africa.

1.9 Assumptions and limitations

The following assumptions and limitations have been identified with regards to ESHIA and ESHMP:

- All the technical and spatial data, project description and information provided by SRL to the Environmental Assessment Practitioner (EAP) and specialists, reflects the current mining operations and proposed activities at SR Area 1;
- The ESHIA and ESHMP contains the latest project description, and subsequent material changes will need to be dealt with appropriately via measures including those contained in the ESHMP and the associated standalone management plans;
- The EAP and specialists have identified all possible impacts based on available information, research and site investigations and these have been assessed and rated accordingly using a standardised impact assessment methodology;
- All specialist modelling undertaken for the ESHIA and ESHMP process is predictive modelling largely based on quantitative data;
- All assumptions, limitations and uncertainties presented in the specialist studies appended to the ESHIA and ESHMP are applicable;
- Sierra Leone legislation is applied where applicable. In instances where no Sierra Leone legal requirements are available, relevant IFC 2012 Performance Standards, as well as other applicable standards[2] were applied;
- The public participation process has been sufficiently effective in identifying the critical issues that needed to be addressed through specialist investigations and / or by the EAP. Specialist input has thus been appropriately scoped to investigate the critical issues;
- The public participation process provided ample opportunity for stakeholders to express any issues and concerns. It has thus been effective in identifying critical issues that the specialist investigations and / or EAP needed to address;
- The public participation process has sought to involve key stakeholders, including government officials, traditional leaderships, Non-Governmental Organisations (NGOs), Community Based Organisations (CBOs) and community members. It is assumed that where participation has been sought from the organisational representative/s, that these parties have the authority to comment on behalf of their organisation;

[2] Other standards are referenced in the specialist sections where thay are applicable, including Australian, South African and US EPA standards, as well as WB / IFC EHS and WHO Guidelines where relevant.

- All comments received from the authorities are included and considered in the ESHIA and ESHMP;
- A monitoring and evaluation system, including auditing, will be established, in line with this ESHMP, to track the implementation of specific management measures to avoid, minimise and mitigate impacts. Corrective action will be undertaken to address shortcomings and / or non-performances;
- Monitoring for the project will be undertaken on an ongoing basis as required to determine the validity and accuracy of impact predictions. Any exceedances of parameters or complaints from stakeholders will be investigated and remedied by SRL when required to do so;
- All mining activities potentially impacting on the biophysical, socio-economic and community health environments will be undertaken in accordance with national legislation, GIIP standards and guidelines and SRL corporate policies, standards and procedures;
- The ESHMP is a living document which will evolve over the life of the project. The plans will be updated in response to environmental, social and health impact management requirements by SRL and / or its appointees; and
- SRL is committed to continue to engage with stakeholders on an ongoing basis in line with the Stakeholder Engagement Plan and the grievance management procedure developed by SRL.

2 Legal and GIIP framework

This section provides an overview of the governance framework applicable to the ESHIA and ESHMP and falls within the context of legal requirements and guidelines including:

- The laws and regulations of Sierra Leone including international treaties and agreements;
- Iluka's policies and standards;
- The EPs, including the policies, guidelines and procedures of the IFC 2012 Performance Standards, the World Bank Group Environmental, Health and Safety (EHS) Guideline, including sector specific guidelines were applicable;
- GIIP guidelines such as those from the International Council on Mining and Metals (ICMM) Voluntary Principles on Human Rights Extractive Industries Transparency Initiative, 2016 (EITI) and the International Federation of Chemical, Energy, Mine and General Workers' Union; and
- Any other benchmarks, guidelines and reference materials, including Voluntary Principles on Security and Human Rights, Extractive Industries Transparencies Initiative and the International Labour Organization Guidelines on Occupational Safety and Health Management Systems.

The scope of the ESHIA and ESHMP outlined in this report was developed in accordance with the abovementioned requirements and each one is described in further detail below.

2.1 National regulatory framework

The EPA-SL is 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 EPA-SL was established in 2009 with the goal of creating and enforcing a strict regulatory framework for environmental Regulation in Sierra Leone. It has the mandate to coordinate, monitor and evaluate the implementation of national environmental policies, programmes and projects, including issuing EIA licences. The following Acts and Regulations form the basis of the environmental regulatory framework in Sierra Leone that is applicable to this project:

- *Sierra Rutile Agreement (Ratification) Act*, 2002 (Sierra Rutile Act);
- *Mines and Minerals Act*, 2009;
- *Environment Protection Agency Act*, *2008 (EPA Act)*; and
- *Environmental and Social Regulations for Mining, 2013* (SLEP (MM) Reg. 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.

2.1.1 *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* (Amendment Act)) as applicable. If there are conflicts between the two Acts, the Amendment 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 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 specific requirements are discussed further below.

Clause 2 (a)

The provisions of the Mines and Minerals Act (as amended) relating to mining leases and dredging licences shall apply to SRL's mining leases and additional mining leases except to the extent that they are inconsistent with the express or any implied terms and conditions of the agreement, in which event the provisions of the 2002 agreement shall prevail. The latest *Mines and Minerals Act* is the *Mines and Minerals Act, 2009*. Other relevant legislation is the First Amendment Agreement dated 4 February 2004 and Second Amendment Agreement dated 30 April 2012.

Clause 2 (b)

SRL has the right to occupy and utilise permanently and temporarily such parts of the surface land, whether Government of Sierra Leone (GOSL) -owned or otherwise, that are necessary or useful to its mining operations. It deals with the right to erect necessary equipment, plant, machinery and buildings for the purpose of mining, conducting mining operations, etc. It also deals with paying compensation to owners or occupiers of the land and resettlement of local population if absolutely essential. The agreement also contains provisions for indemnification of the Company by the GOSL in respect of claims made by owners / occupiers of the mining lease area against the Company. There are also provisions for payments of mining and surface rents, crop compensation, royalties and income tax.

Clause 6 (a)(1)

This clause states: "The Company shall pay to the Government annually in advance mining rent under each mining lease and additional mining lease for each square mile or part thereof embraced within the mining lease area commencing with the financial year ending December 31, 1989 and for each subsequent financial year end at the rate of US dollars (US$) 400 for the first year increasing annually thereafter at a cumulative rate of 5% per annum."

Clause 6 (a)(2)

The clause states: "The Company shall pay to the Government annually in advance a Surface Rent under the Mining Lease for all land occupied or used there under, for the purposes enumerated in Section 35 (1) of the Mines and Minerals Act at the rate of US $4 per acre per annum. Beginning January 1, 2003, the rate shall increase to US$ 10 (ten) per acre per annum, such rate increasing in respect of each subsequent year at the rate of 3% per annum

Surface rent is distributed equally to the land "owner", Paramount Chief and Native Administration." Surface rent is no longer distributed using the formula in Clause 6(a)(2). It is presently distributed according to section of the *Mines and Minerals Act, 2009* (i.e. 50% landowner, 15% Paramount Chief, 15% District Council, 10% Chiefdom Administration and 10% Constituency Development Fund).

The Act does not address the arrangements to be made for the cessation of surface rent payments and the return of rehabilitated land to communities at the end of mining operations. SRL will have to work jointly with the GOSL and affected stakeholders to develop an appropriate and fair strategy for this to occur. This strategy will have to address the issue of reversion of land rights, cut off dates for surface rent payments and any special considerations relating to a significant change in land use from slash and burn agriculture to a permanent pond.

Clause 10 (b) (1)

The clause states "The Company shall endeavour to make satisfactory arrangements for payment of a fair and reasonable compensation for any prospective damage to any crops, buildings, trees or works therein. The Government shall negotiate on behalf of the landowners or occupiers with the Company to assess the compensation to be paid. The landowners or occupiers shall have the right to participate in the negotiations."

Clause 10 (b) 2 (iii-v)

This clause states “iii. The compensation payable by the Company pursuant to this clause shall be based on the estimated monetary amount (or fair market value) of the damage to be done to the crops, buildings, trees or works on the land. Any compensation with reference to the fact that the owner will be deprived of the use and occupancy of the land is included in and covered by the surface rent payable pursuant to clause 6 (a) (2) hereof.

iv. The Company shall not unduly disturb and interfere with the living conditions of the local population settled within the mining lease area.

v. If at any point the resettlement of the local population appears to be absolutely essential, the Company shall move with utmost caution, with the consent of the government and in consultation with local authorities in persuading the local population to resettle and provide a fully adequate resettlement programme in accordance of the directions of the responsible minister.”

2.1.2 *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 EIA must fulfil the requirements of this Act and the EPA Act. The Minister for Mineral Resources and the National Minerals Agency (NMA) are the current relevant authorities for enforcing the Act.

General provisions for environmental protection

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 this part in the Act is applicable for mining licence holders seeking a small or large-scale mining licence. There are however certain sections that apply to all mining licence holders. The relevant sections are as follows:

- §132 (1), which requires the mining licence holder to exercise duty of care to protect the environment and minimise pollution, and states “a holder of a mineral right is subject to all laws of Sierra Leone concerning the protection of the environment” (§132 (2));
- §133 (1), which states “In addition to any requirements set out in the Environment Protection Agency Act, an EIA prepared by a small-scale or large-scale mining licence applicant shall be based on environmental baseline assessment work, and shall contain the types of information and analysis reflecting international mining best practice”. §133 (1)(a) and §133 (1)(b)(i)-(xiv) provide the required detail and work to be undertaken to meet this requirement. It is likely that the mining authorities would utilise the SLEP (MM) Reg. 2013 as the guiding document to meet these requirements;
- §133 (2), makes provision for the need to undertake public consultation and the submission of updated Environmental Management Plans (EMPs) should there be material changes to the mining operation;
- §133 (3), states that any “EIA and environmental management programme submitted by a mining licence applicant or a mining licence holder shall be considered non-confidential and shall be made available to the public at the Mining Cadastre Office”;
- §134 (1), requires any mining licence holder to prepare and submit in triplicate, an Environmental Management Programme Report each calendar year after the first year in which commercial production first occurs. The contents of the report must cover all items listed in §133 (1)(b). The report needs outline if the environmental program is being achieved (§134 (2)), a copy provided to the EPA-SL (§134 (3)) and made available to the public (§134 (4));
- §135 (1), prohibits the diversion of a water course unless it forms part of an approved environmental management program;
- §136 (1)-(6), provides a potential need for rehabilitation of damaged areas and the associated financial provision requirements; and
- §137 (1)-(7), sets out possible directives served by the Minister that may require a former mining licence holder to meet the obligations (or part thereof) set out in the mining right.

General provisions for land acquisition

The Act gives effect to the following general provisions regarding surface rights and land acquisition:

- §32(1)(b), states that "The holder of a mineral right shall not exercise any of his rights, under the mineral right-except with the written consent of the owner or lawful occupier or his duly authorised agent, in respect of -
  (i) any land dedicated as a place of burial or which is a place of religious or other cultural significance
  (ii) any land which is the site of, or which is within two hundred metres or such greater distance as may be prescribed, of any inhabited, occupied or temporarily unoccupied house or building
  (iii) any land which is within fifty metres or such greater distance as may be prescribed, of land which has been cleared or ploughed or otherwise bonafide prepared for the growing of, or upon which there are agricultural crops
  (iv) any land which is the site of, or within one hundred metres or such greater distance as may be prescribed, any cattle dip, tank, dam, or other body of water"
- §33 (1), states that "Owners and lawful occupiers may continue to graze stock or cultivate the surface as long as it does not interfere with the proper use of the land specified by the mining right";
- §33 (4), states "It is prohibited to create unprotected pits or other hazards likely to endanger stock, crops or any lawful activity";
- §34, states that "In the case of large scale mining licences, the holder must obtain a land lease or other right to use the land from the onwer or lawful occupier of the land. Rents may be payable as specified in §34(a)";
- §35 (1), states "Where there are disturbances or damages to the rights of the occupier during the course of excercising any mining rights (for example to crops, trees and buildings), the holder of the right must pay fair and reasonable compensation for such damages. It is assumed this applies to both exploration and large scale mining licences"; and
- §36, states that "For large scale mining licences, the Minister may compulsorily acquire private land if it is satified the holder has taken all reasonable steps to acquire land on reasonable terms with the owner and the land is ncessary for mining or ancillary purposes. In cases of compulsory land acquisition the holder of an exploration licence must make payment of compensation to the person or persons concerned (§37). In instances where the whereabouts of the person or persons concerned or any of them are unknown, the holder of a licence must give such undertakings concerning the payment of compensation as required by the Minister".

Should there be a potential for resettlement resulting from any of the above activities, §38 states, "the holder of the right must arrange for relocation of the rightful occupiers to a suitable alternative site, based on their preferences, and taking their economic, social and cultural well-being into consideration". Ultimately, the resettlement process must lead to the improvement in the social and economic conditions of the occupiers, and must be carried out in accordance with the relevant planning laws. The cost for the resettlement should be borne by the holder of the right.

Large-scale mining licence

The Act sets out the following environmental requirements for granting of a large-scale mining licence in Part XII:

- §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" Additionally, a statement of the "effects of the mining operations on the environment and on the local population and proposals for mitigation, compensation and resettlement measures" (§105 (2)(i)(vi)). Additionally, the provision of details and results of stakeholder consultation (§105 (2)(l)).
- §105 (2)(s), states that "the Minister may require the application to be accompanied by and EIA licence" (under §131 (2));
- Under §108 (3), "no large-scale mining licence shall be granted to an applicant unless the application is accompanied by an EIA Licence as may be required by the Minister under §131 (2)";

- §112, sets out the requirements for a renewal of a large-scale mining licence, with environmental considerations provided in §112 (2)(a)(v);
- §113, provides provision for amendments to the mining licence, including the environmental management programme (§113 (1)(c) and (§113 (3)); and
- §115, sets out the obligations of holders of a large-scale mining licences. Specifically, §115 (1)(a) "develop and mine the mineral deposits covered by the licence in accordance with the approved programme of mining operations and the environmental management programme".

2.1.3 Sierra Leone Mining Sector Reform: A strategic environmental and social assessment, 2008

The Strategic Environmental and Social Assessment (SESA) of the mining sector in Sierra Leone was undertaken in response to the GOSL's request for assistance in developing its Minerals Policy. The aim of SESA is to help meet long term country development by integrating environmental and social considerations in mining sector reforms. It also provides a summary of the findings of the SESA process and makes recommendations on the Policy, institutional and governance changes required to address environmental and social priorities in reform of the Sierra Leone mining sector.

2.1.4 *Environment Protection Agency Act, 2008* and *EIA Regulations*

The *Environment Protection Agency Act*, *2008*, which repeals the EPA Act of 2000, outlines the functions of the EPA-SL and the EIA 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 EIA 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.

Although exploration activities are not specifically stated, the First Schedule does list extractive industries as projects requiring an EIA. Extractive industries are not defined in the Act, however if a conservative broad definition is taken by the EPA-SL, exploration activities is likely to be considered as an extractive industry.

Guidelines on EIA procedures were published by the Ministry of Lands, Country Planning and the Environment (MLCPE) in July 1999. They were then re-issued by the MLCPE in July 2002. The original intent of the guidelines was to facilitate implementation of the EIA provisions in the repealed Environment Protection Act, 2000. To date, they are still considered by the MCLPE to be valid for the EIA provisions in the new EPA Act, 2008.

2.1.5 The *Environmental and Social (Mines and Mining) Regulations, 2013*

The 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 who 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 GIIP. 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, corporate social responsibility, adoption of environmental best practice and the polluter pays principle.

Historically in Sierra Leone, mining companies would operate under a specific Act 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 a mining licence holder are the following:

- §3 (2)(a) – (m) Application of principles and accountability to be applied by the EPA-SL or other authorities;
- §4(1) states the need for a person or company to apply for an EIA licence, "no person shall undertake or cause to be undertaken any mining project; including … exploration … specified in the first schedule of the Act, and for which an EIA Licence is required, unless that person obtains an EIA Licence issued by the Agency". While the First Schedule of the Act does not specifically state exploration as a listed activity, this Regulation now infers that an exploration project will be required to obtain an EIA Licence;
- §5 (a) – (e) provides the legal responsibilities of a mining licence holder. The Regulations define mineral rights as a "means to explore for or to mine minerals by the hold of a valid … exploration licence…issued under the *Mines and Minerals Act, 2009*" therefore a holder of such rights is required to consider the following responsibilities:
  - §5 (a) provides a link to the *Mines and Minerals Act, 2009* (§132 (1)), in that every mining licence holder shall carry on their operations in a manner that is "reasonably practicable[3]" in order to minimise, manage and mitigate any environmental impact resulting from their operations;
  - §5 (b) requires the mining licence holder to comply to any international human rights instruments that Sierra Leone is party to with respect to host communities;
  - §5 (c) requires open and transparent consultation and negations if displaced and affected communities;
  - §5 (d) requirements for a Community Liaison Committee to be formulated, and
  - §5 (e) provides the outline for the preparation of any resettlement management plans of known or potential involuntary displacement.
- §11 Project screening applications, with Schedule Two providing a prescriptive form for project screening;
- §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 SIA, ESIA, Code of Practice) and required management instruments (Mine Closure Plan, EMP, Social Management Plan – including grievance mechanism, Communication and Public Participation Plan, Community Development Agreement, Resettlement Management Plan) as may be applicable, for each. 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 Mine Closure Plan are provided in the relevant schedules; and
- Monitoring, auditing and reporting - annual reporting on social and environmental performance to the Authority (§25 and §26), including an annual update of the EMP and SMP based on project changes (§24); quarterly reporting on emissions and effluents in relation to specific environmental quality standards. Environmental quality standards specified thus far are generic and few are provided at this stage.

The *Mines and Minerals Act, 2009*, requires any person or organisation that is in possession of a mining right licence (or seeks to renew their licence) to provide details on environmental impacts. While the Act does not provide information on the required details, the mining authority might refer the applicant to the project screening requirements outlined in these Regulations.

[3] Reasonably practical is not defined in the Regulations and could result in ambiguity, therefore it would be important to define the limitations of the term reasonably practical with the Agency.

Obligations of an Environmental Licence Holder

Part V (§24 - §31) of the Regulations provide the obligations that an environmental licence holder must meet. These are as follows:

- §24 (1), requires "the [environmental licence] holder to review and update (if necessary) the contents of the ESMPs on the anniversary of commencement of works";
- §25 and §26 requires the mining licence holder to submit separate annual environmental and social reports;
- §27 requires the evidence of environmental and social monitoring and needs to accompany the environmental and social management plans; and
- §28, requires "the [mining licence] holder undertaking category A or B projects to provide financial assurance for itemised costs associated with the Mine Closure Plan, these costs are to be revised on an annual basis".

Public Participation

As outlined above, public consultation and participation is a fundamental obligation of the environmental licence holder in terms of the Regulations. In terms of §3(2)(h)(ii), participation should be guided by the following rules:

- "All information shall be transparent and honest;
- There shall be no discrimination;
- Cultural diversity shall be respected;
- Information shall be communicated in the language commonly used by affected parties, and be clear and simple to understand;
- Local needs and circumstances shall be taken into consideration;
- All sectors and interest of society shall be well represented including women, elderly and youth; and
- Joint problem-solving shall be promoted through continuous dialogue and local traditions."

§3(2)(i) states that public consultation of key stakeholders should start from the earliest stages of a mining project throughout the mining operations and mine closure, with the following rules being applied:

- Host communities shall have the right to receive and access public information in a timely and transparent manner;
- Host communities shall have the right to participate responsibly in decision making processes pertaining to mining projects that affect their interest, provided that the claims are not frivolous or vexatious;
- Host communities shall have the right to receive copies of the SMP at no cost and the applicant shall raise awareness within the community about the contents of the plan;
- Host communities shall have the right to monitor the implementation of the provisions contained in the SMP, provided that such monitoring shall in no way impede the applicant from fulfilling its obligations under these Regulations; and
- Host communities shall have the right to denounce any matter concerning the violation of their civil and human rights.

Requirements for a Community Liaison Committee and Resettlement Management Committee are also stipulated in the Regulation in as far as this applies to a particular project.

Mine Closure and Mine Closure Planning Obligations

Part VI (§32 - §41) of the Regulations provide the obligations that an environmental licence holder must meet with regards to mine closure planning. These obligations are as follows:

- §32 (3), states that "a mineral right holder's obligations and liabilities shall continue until a closure certificate has been delivered";

- For category A and B projects a Mine Closure Plan 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 Mine Closure Plan 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 mining licence holder to undertake progressive mine closure;
- §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; 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.

Environmental standards

Part VII (§42 - §54) of the Regulations provide the obligations that an environmental licence holder must meet with regards to environmental standards. These obligations are as follows:

- §42 (1), gives effect to the establishment and §42 (2) the enforcement of environmental quality standards and parameters;
- §43 (1), provides the obligation for the mining licence holder to ensure that they meet the prescribed effluent and emission quality standards. If standards have not been established or require updating, §43 (2) allows the [EPA-SL] board to establish effluent and emission quality standards in accordance to the §12 (h) and (t) of the EPA Act;
- §45, prevents the discharge of any toxic and hazardous substance into the air or waters of Sierra Leone as imposed by §58 (5) of the EPA Act;
- §46, states that if the natural quality of water used in mining activities already exceeds the minimum effluent standards, the effluent discharged from such operations shall not have a lower quality than the water taken from its natural source;
- §47, sets out the “effluent international quality standards for mining and metallurgic operations”;
- §49, sets out the “quality standards for arsenic, lead, particulate matter, sulphur dioxide”;
- §50 (1), allows the authority to establish standards for other effluent and emission parameters not included in these Regulations;
- §50 (2), requires the mining licence holder to technically demonstrate that effluent discharges and emissions from operations for parameters not yet regulated do not cause negative effects to public health, safety and the environment;
- §51, requires that the relevant environmental instruments (e.g. EIA, ESIA or EMP) set out the proposed monitoring and control stations and determine the frequency of sampling (in conjunction with §53, which give effect to the establishment of official monitoring guidelines); and
- §52 requires the mining licence holder to undertake quarterly monitoring, where Category A and B projects will present a quarterly report to the authorities and retain monitoring information for five years.

Monitoring and inspection, enforcement, grievance management and incident reporting

Part VIII (§55- §60) sets out the monitoring and inspection requirements undertaken by the authorities, including Regulations on auditing. Part IX (§61- §66) provides Regulations to ensure enforcement (in part these Regulations are in accordance to §53 - §56 of the EPA Act).

Notably §61 requires the mining licence holder to develop a formal grievance mechanism and designate a grievance officer early in the project lifecycle process.

Additionally, the mining licence holder must allow the authorised authorities to enter the project premises and provide assistance where relevant (§65 (1)). §65 (2) requires the mine’s environmental officer to report any major incident that could, or is giving rise to adverse environmental impact or

social impact to the authorities within 24 hours and submit a detailed report within 10 working days from which the incident took place.

Administration of an environmental licence

§67(2) states that the Minerals Advisory Board shall not consider an application for a mining right or permit unless the applicant submits an environmental licence that has been granted under these Regulations. Additionally, the environmental licence shall be valid for a period of 12 months or for a period as determined by the authorities (§69 (1)), and may be renewed in accordance with §31 of the Act.

Schedules under these Regulations

The Regulations contain 18 schedules that are relevant for the mining licence holders that are undertaking an environmental licence application process. These are summarised in Table 2-1.

Table 2-1: Summary of schedules provided in the Regulations

Schedule	Title	Description	Applicable Project Category or authority or person
1	Public Participation and Consultation	Provides the procedural requirements for public participation and consultation per project category as per §3 (2)(h).	A, B, C, D
2	Project Screening Application	Provides the required forms and tables to be completed by the applicant to determine the category of a project. The information presented in these tables will be used by the EPA-SL to determine which environmental and social impact and management measures will need to be utilised by the application as per §11 (5).	A, B, C, D
3	Project Screening Criteria	The EPA-SL will determine the project category based on the information presented in the screening application and the criteria provided in this schedule. Included in this schedule are determining criteria that will result in the mandatory need for an environmental assessment. All other cases will be determined using other criteria reflected in the schedule. These criteria meet the requirements outlined in §11 (6) and §12 (2).	To be used by the EPA-SL
4	Preparation of a Scoping Report	The content of the scoping report for category A and B projects is provided in this schedule. A generic table of contents is provided and typically will consist of a 20 – 60-page document. (§14 (1) and §15).	A, B
5	EIA Standards for Category A and B Projects	This schedule provides a generic terms of reference for undertaking an EIA. Included are the general provisions and content that an EIA report must contain and stipulates that this be supported by a non-technical summary. (§15 (1) (a)).	A, B
6	SIA Standards	This schedule provides a generic terms of reference for undertaking an SIA. Included are the general provisions and content that an SIA report must contain and is supported by a non-technical summary (§15 (1) (b)).	A, B (however the principles provide will apply to C and D projects too)
7	ESIA Standards	An ESIA is considered to be a simplified form of environmental, social and health impact assessment. Included in this schedule is the required content of the report (should not exceed 100 pages (including appendices)). (§15 (1) (c)).	C

Schedule	Title	Description	Applicable Project Category or authority or person
8	Environmental Code of Practice	This schedule sets out the provisions and content of an environmental code of practice (§15 (1) (d) and §55 (2)).	D
9	Mine Closure Plan Standards	This schedule provides the objectives, principles, level of detail, public consultation needs and approaches to mine closure. Included is a table that outlines the Mine Closure Plan information requirements in relation to the anticipated life of mine. A generic table of contents is also provided (§16 (1) (a)(d) and §33).	A, B C (conceptual Mine Closure Plan)
10	EMP Standards	The schedule provides details on what should be included into an EMP, including the objectives, programme of environmental works and a recommended table of contents. (§16 (1)(b)).	A, B
11	Social Management Plan Standards	The schedule provides details on what should be included into a social management plan, including the objectives and a recommended table of contents. (§16 (1)(b)).	A, B (if required)
12	CDA and Plan Standards	A CDP needs to be developed and an agreement reached with the host community. The findings of the EIA, SIA or ESIA need to be incorporated into the CDP. This schedule sets out the content of the CDP and agreement. (§16 (1)(c)(iii) and §139 (1).	All small and large-scale mining licence holders
13	Consent for the Use of Land for Mining Purposes	Consent must be obtained from the Chiefdom Mining Allocation Committee or the land's rightful occupiers or owners before mining activities can commence on the relevant land. This schedule provides the standard form that must be completed by the applicant. (§17 (1)).	All applicants for a mining right
14	Confirmation of local community Participation in Sustainable Development	Throughout the process there needs to be clear and transparent engagement with local communities. Included in this is the requirement for local community participation and sustainable development. This schedule provides the required form that needs to be completed. (§18 (1)(c)).	All applicants for an environmental licence
15	Application form for Environmental Licence	After undertaking and developing the required environmental and social impact and management measures the applicant needs to submit a form to the authorities for an environmental licence. This schedule provides the required form that needs to be submitted. (§17 (3) §18(3) and §19).	All applicants for an environmental licence
16	Financial Assurance Mechanism Standards	This schedule provides the financial assurance mechanisms and standards to be utilised for a specific project. Included in the schedule is information on early scoping, the level of assurance, timing, types of funding, accessibility, funding providers and review procedures, funding release mechanisms, public involvement requirements and responsible agency. (§28 (1) and §29(1)(2)).	All applicants for an environmental licence
17	Care and Maintenance Programme Standards	Should a mine need to be closed permanently or temporarily due to unforeseen circumstances, then a care and maintenance programme may need to be implemented. This schedule sets out the contents and requirements for such a programme. (§31(2)).	Any mining licence holder

Schedule	Title	Description	Applicable Project Category or authority or person
18	Roster of Independent Auditors	The Agency will establish and maintain a roster of environmental and social consultants that can undertake the full range of audits in the mining and minerals sector. This schedule provides the mechanism to establish this roster and the related requirements for the Agency. (§59 (3)).	EPA-SL

2.2 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 2018 ESHIA / ESHMP. A number of the key international policies, standards and guidelines used in this ESHIA / ESHMP are presented below. The GOSL is also signatory to several international conventions and agreements.

2.2.1 Equator Principles

The Equator Principles Financial Institutions (EPFIs) have adopted a set of guidelines, known as the EP, published in 2003 and revised in 2006 and update in 2012. EP III was adopted in 2012.

The principles provide a framework for an accepted international approach to the management of social and environmental issues. They were developed by a number of leading financial institutions, including the IFC, to provide an approach to determine, assess and manage environmental and social risk in project financing. The intention is to ensure that projects are developed in a site-specific manner that is socially responsible and reflects sound environmental management practices. The principles apply to all new projects seeking project finance from EPFIs with total project costs of US$10 million or more. While SRL is not currently seeking funding from EPFI's, the principles, sentiments and approaches included in the EPs and IFC 2012 Performance Standards are still relevant to the operation. To provide guidance on how the broad-based EPs can be made specific to this project, reference is made to IFC 2012 Performance Standards and Guideline Notes, which are generally considered to represent GIIP.

2.2.2 International Finance Corporation Performance Standards

The IFC 2012 Performance Standards are an international benchmark for identifying and managing environmental and social risk, and has been adopted by many organizations as a key component of their environmental and social risk management.

There are eight IFC Performance Standards in total, seven of which are relevant to the SR Area 1 operations, namely:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labor and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Performance Standard 8: Cultural Heritage.

2.2.3 International Council on Mining and Metals

Sustainable development principles

The ICMM has adopted the Brundtland Commission's definition of sustainable development: "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". In the mining and metals sector, this means that investments should be financially profitable, technically appropriate, environmentally sound and socially responsible.

Member companies of the ICMM are committed to measuring their sustainable development performance in terms of 10 principles approved in May 2003. The principles, listed below, form an important part of the ICMM's sustainable development framework:

- Principle 1: Implement and maintain ethical business practices and sound systems of corporate governance;
- Principle 2: Integrate sustainable development considerations within the corporate decision-making process;
- Principle 3: Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities;
- Principle 4: Implement risk management strategies based on valid data and sound science;
- Principle 5: Seek continual improvement of our health and safety performance;
- Principle 6: Seek continual improvement of our environmental performance;
- Principle 7: Contribute to conservation of biodiversity and integrated approaches to land use planning;
- Principle 8: Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products;
- Principle 9: Contribute to the social, economic and institutional development of the communities in which we operate; and
- Principle 10: Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

2.2.4 Other benchmarks, guidelines and reference materials

Extractive Industries Transparency Initiative

The EITI is a coalition of governments, companies, civil society organisations that attended a conference in London in June 2003, hosted by the United Kingdom Government. A Statement of Principles to increase transparency of payments and revenues in the extractive sector was agreed. The aim of this initiative is to strengthen governance by improving transparency and accountability in the extractive industries sector. The EITI promotes improved governance in resource-rich countries through the verification and full publication of company payments and government revenue. The Sierra Leone government voted to join EITI in November 2008 with the last report being generated in 2013.

International Labour Organization (ILO) Guidelines on Occupational Safety and Health Management Systems

In 2001, the ILO published ILO-OSH 2001, also titled "*Guidelines on Occupational Safety and Health Management Systems"* to assist organizations with introducing Occupational Safety and Health (OSH) management systems. These guidelines encourage continual improvement in employee health and safety, achieved via a constant process of settling policy, organizational development, planning and implementation, evaluation, and action for improvement, all supported by constant auditing to determine the success of OHS actions. The ILO management system was created to assist employers to keep pace with rapidly shifting and competitive industrial environments. The ILO recognizes that national legislation is essential, but that it is sometimes insufficient on its own to address the challenges faced by industry, and therefore elected to ensure free and open distribution of administrative tools in the form of occupational health and safety management system guidance for

everyone. This open access forum is intended to provide the tools for industry to create safe and healthy working environments and foster positive safety cultures within the organizations.

Occupational Health Safety Assessment Series (OHSAS) 18000

OHSAS 18000 is an international occupational health and safety management system specification. OHSAS 18000 comprises two parts, OHSAS 18001 and 18002 and embraces a number of other publications. OHSAS 18000 is the internationally recognized assessment specification for occupational health and safety management systems. This management system operates on the basis of policy, planning, implementation and operation, checking and corrective action, management review, and continual improvement.

International Organisation for Standardisation (ISO) 14001

ISO 14001 sets out the criteria for an environmental management system. It does not state requirements for environmental performance, but maps out a framework that a company or organization can follow to set up an effective environmental management system. It can be used by any organization that wants to improve resource efficiency, reduce waste and drive down costs. Using ISO 14001 can provide assurance to company management and employees as well as external stakeholders that environmental impacts are being measured and improved. ISO 14001 can also be integrated with other management functions and assists companies in meeting their environmental and economic goals. ISO 14001, as with other ISO 14000 standards, is voluntary, with its main aim to assist companies in continually improving their environmental performance, whilst complying with any applicable legislation. Organizations are responsible for setting their own targets and performance measures, with the standard serving to assist them in meeting objectives and goals and the subsequent monitoring and measurement of these. ISO 9001 Quality Management Systems and ISO 14001 Environmental Management System can work in tandem with OHSAS 18001 / 18002 to complement each other and form a better overall system. Each component of the system is specific, auditable, and accreditable by a third party after review.

International Organisational for Standardization (ISO) 26000

ISO 26000 in contrast with most ISO standards, does not aim at certification. The objective of ISO 26000 is to *"provide harmonized, globally relevant guidance based on international consensus among expert representatives of the main stakeholder groups and so encourage the implementation of social responsibility worldwide. The guidance in ISO 26000 draws on best practice developed by existing public and private sector initiatives and is intended to be useful to organizations large and small in both these sectors*"

ISO 26000 defines social responsibility as the *"responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behaviour that contributes to sustainable development, including health and the welfare of society takes into account the expectations of stakeholders, is in compliance with applicable law and consistent with international norms of behaviour and is integrated throughout the organization and practised in its relationships"*. ISO 26000 deals with a wide range of issues and has identified seven "core subjects":

- Organizational governance;
- Human rights;
- Labour practices;
- The environment;
- Fair operating practices;
- Consumer issues and
- Community involvement; and
- Development.

Although it is not meant to become a certification standard nor to be used as a standard-setting document, nothing in the text prevents countries from adopting national standards based on ISO 26000 that could become certifiable.

2.2.5 International conventions

Sierra Leone is also signatory to a number of international conventions that would need to be considered by the project, namely:

- The International Labour Organization Conventions;
- Declaration on Rights of the Indigenous Peoples;
- Stockholm Convention on Persistent Organic Pollutants;
- Basel Convention on the Control of trans-boundary movements of hazardous waste and their disposal; and
- International Covenant on Economic, Social and Cultural Rights.

2.3 Corporate Policies, Framework and Standards

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. All 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. Below is a description of the Iluka framework, policies, standards and procedures.

2.3.1 Iluka Health, Safety, Environment and Community Management System Framework

The Health, Safety, Environmental and Community (HSEC) Management System framework defines the requirements, processes and tools to assist with achieving Iluka's sustainability objectives which are:

- High levels of performance aimed at sustainable outcomes;
- Sound governance, planning, control and risk management systems; and
- Positive and enduring legacies with mutually beneficial outcomes.

The HSEC Management System Framework comprises of the following key areas:

- Environment – conducting activities such that adverse impacts on existing and potential environmental values are minimised. This includes the efficient use of resources, in particular energy, water and land, and effective plans for the cessation of operations and rehabilitation of disturbed areas;
- Health – identifying, assessing and monitoring health hazards;
- Safety – managing personal and operational safety risks; and
- Community – engaging our communities and ensure their views form part of our decision-making process.

The system covers the lifecycle of Iluka activities from exploration, planning and project development, through to operation, closure and rehabilitation.

2.3.2 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. The main aspects of the HSEC Policy are to:

- Assess and manage environment, workforce and community risks associated with Iluka's activities;
- Comply with all legislative requirements, which are recognise as the minimum standard to achieve;
- Set clear, achievable and measurable performance targets;
- Seek to continuously improve performance;
- Maintain a HSEC management system covering all areas of the business;
- Provide appropriate training to staff; protect the health and safety of the people by identifying and taking appropriate action to mitigate workplace fatalities, injuries and illnesses;
- Acknowledge the cultures, customs and values of people in communities where we operate;
- Engage early in open, inclusive and meaningful communication and incorporate stakeholder views in the decision-making processes;
- Seek to make a positive difference to the social and economic development of the areas in which the Company operates;
- Develop effective plans for the cessation of operations and rehabilitation of disturbed areas;
- Use resources efficiently, in particular energy, water and land; and
- Maintain a product stewardship approach towards the use of the Company's products.

The HSEC Policy aligns with Iluka's overarching commitment to deliver high levels of health, safety, environment and communities performance while providing a commitment to ensure that health, safety, environment and communities standards reflect the relevant leading practise.

2.3.3 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 below:

- Standard 1: Risk and hazard management: environment, workforce and community risks associated with Iluka operations are assessed and managed. Controls are implemented, communicated and monitored for their suitability and effectiveness. Planned and unplanned changes are managed effectively;
- Standard 2: Social Performance: activities are conducted in such a way that social risks to the business and social impacts on communities are identified, assessed and controlled, and engagement with stakeholders is conducted in a meaningful, transparent, collaborative and consistent manner;
- Standard 3: Training and Awareness: employees and contractors are appropriately trained and are competent to perform work;
- Standard 4: Contractor Management: contractor selection, engagement and management are systematically conducted to ensure alignment and conformance with Iluka's policies and objectives. Contractor capability and performance are regularly monitored to identify opportunities for continual improvement;
- Standard 5: Design, Construction and Operations: management of HSEC risk is integrated in the design, construction, commissioning, operations and decommissioning of sites, plant and equipment;
- Standard 6: Process Safety: a systematic approach to process hazard management is implemented, ensuring necessary preventive controls and defences are installed and maintained to prevent catastrophic release, fire, and explosion. Process integrity is effectively managed by the application of robust design, engineering, operating and maintenance systems;
- Standard 7: Environmental Management: are conducted in such a way that adverse impacts on existing and potential environmental values are understood and minimised;
- 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;

- Standard 9: Carbon and Energy: maintain and report complete, accurate and transparent energy use and greenhouse gas emissions data. Identify, assess and prioritise emissions minimisation opportunities, including improved efficiency in energy use;
- Standard 10: Radiation Management: risks with the potential to result in adverse outcomes during exploration, pre-feasibility, operations and closure are appropriately managed to levels as low as reasonably achievable;
- Standard 11: Workplace Health and Hygiene: employees and contractors are assessed for their fitness to work. Health hazards within Iluka workplaces and the communities in which we operate are identified and effectively managed. Health promotion initiatives are undertaken to actively encourage safe and healthy lifestyles;
- Standard 12: Incident Reporting and Investigation: HSEC near hits and incidents are reported and appropriately investigated to establish root cause and identify contributing factors. Preventive and corrective actions are implemented to prevent recurrence and share learnings;
- Standard 13: Emergency and Crisis Preparedness: identified risks with the potential to result in emergency and crisis situations are appropriately managed. Iluka's capability to respond to such events is developed, documented, maintained and verified; and
- Standard 14: Audit and Assurance: Iluka's management system is effective in managing sustainability performance, has been successfully implemented and progress is measured to drive continual improvement.

3 Description of the project

3.1 General information on the project

The SRL operation is located in the Moyamba and Bonthe District in the Southern Province of Sierra Leone. It is situated 30 km inland from the Atlantic Ocean and 135 km south east (geodesic distance) of Freetown (Figure 1-1). SRL has undertaken dry and wet mining activities to extract rutile deposits intermittently since 1967.

SRL holds mining leases covering a land area of 559 km^2, with a total of 16 mineral deposits identified. These deposits, alluvial in nature, are mainly located around the Gbangbama Hills and the Moyamba Hills. SRL's mining leases cover one of the world's largest known rutile deposit. A summary of the site area is provided in Table 3-1.

Table 3-1: Summary of the site area

Location	Moyamba and Bonthe Districts, Southern Province, Sierra Leone
Centre point GPS co-ordinates	7.766421 -12.294057
Distance to closest major settlement	65 km south west of Bo and 135 km south east of Freetown (geodesic distances)
Area of mining lease(s)	290 km^2 (SR Area 1 only)

In addition to the general site locality map for SR Area 1 (Figure 1-1), SLEP (MM) Reg. 2013 prescribes that the following mapping information is to be provided:

- Location map (1:25,000) depicting the following:
  - Study area and area of influence;
  - Topography and relief;
  - Access roads;
  - Urban areas and areas of urban expansion;
  - Populated rural areas;
  - Agriculture areas, cultivated areas, and areas with agricultural potential;
  - Protected areas; and
  - Water bodies, wetlands, forests.
- Land use map (1:500 or 1:1,000) depicting the following:
  - Water supply and sewerage network;
  - Electric power supply network;
  - Site facilities layout (comprises any construction or works that modifies the preoperational landscape such as tunnels, open pits, plants, buildings, camps, roads, waste rock dumps, tailing channels, tailing dams, slag deposits, mineral transportation, etc.);
  - Land owned by the applicant; and
  - Land owned by third parties.
- Geology map.

With available spatial data, SRK has endeavoured to satisfy the above requirements by producing a series of maps which are included in Appendix O.

3.2 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 shareholders.

SRL became an AIM-listed company in August 2005 and Dredge D1 resumed mining operations in Lanti North 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 to port during normal operation.

Between 2007 and 2011, the shareholding of SRL changed and Pala Investments Limited acquired a 54 % share. In 2016, Iluka completed the acquisition of SRL by means of a merger, making SRL a wholly owned subsidiary.

3.3 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.

3.4 Current mining operation

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 (Figure 1-1). In addition, the mine maintains an extensive network of ponds and has power generation facilities, accommodation, offices, a clinic and roads.

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 WCP's, 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 3-1 provides a simplified process flow of the SRL mining operations, Figure 3-2 presents a pictorial representation of the current mining operation and processes, and a summary is provided in Table 3-2.

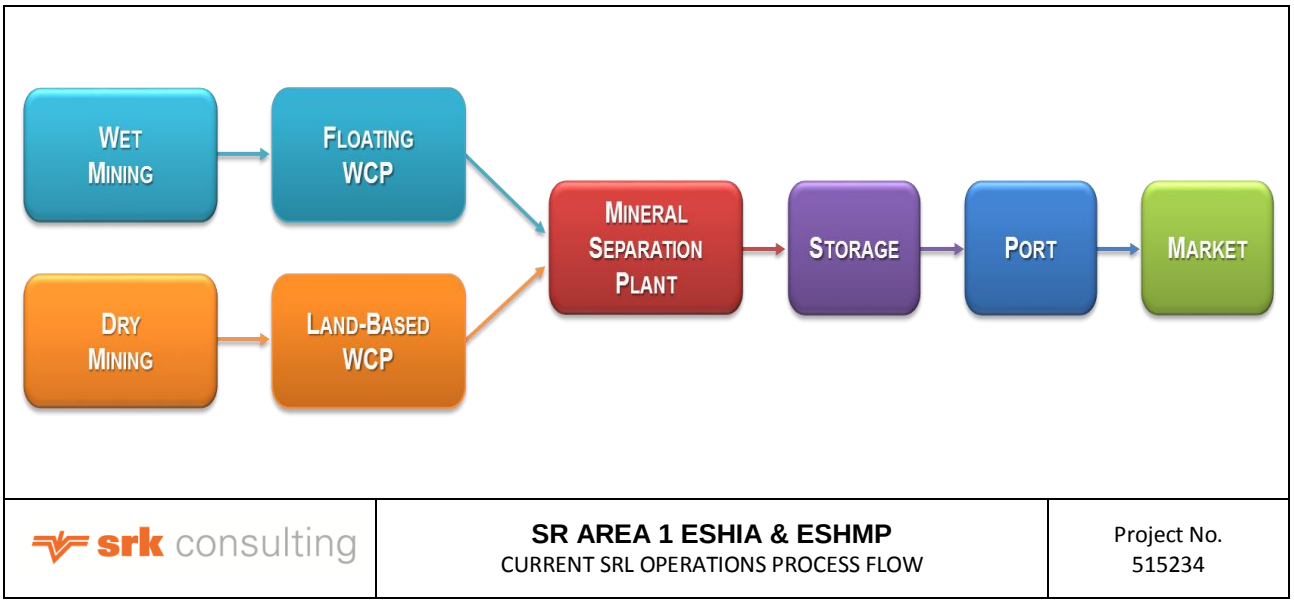


Figure 3-1: Simplified process flow of the current SRL operations

srk consulting	SR AREA 1 ESHIA & ESHMP CURRENT SRL MINING OPERATIONS & PROCESSES	Project No. 515234

Figure 3-2: Diagram showing current mining operations and processes

Table 3-2: Summary of mining operations and processes including associated timeframes

Type of operation	Large scale open cast (dry mining) and dredge mining (wet mining)
Type of orebody	Rutile, ilmenite and zircon
Deposit groups (current and planned)	• Lanti Wet; • Lanti Dry (including Gbeni); and • Gangama Dry.
Current mining operations (LOM)	• Lanti Wet (18 months); • Lanti Dry (including Gbeni) (6 years); and • Gangama Dry (4 years).
Historical dredge areas (ponds)	• Bamba / Belebu; • Mogbwemo; • Pejebu; • Motinga 1 and 2; and • Mosama.
Current operational activities	• Site clearing; • Dredging; • Dam construction; • Ore extraction (earth moving); • Primary mineral processing; • Secondary mineral processing; • Tailings management; • Transporting and storage of ore and product; • Port handling and shipping; • Access road building and maintenance; • Waste management; • Power generation facility and transmission of power; • Potable water services; • Mine offices, workshops, storage, accommodation and associated facilities; and • Rehabilitation.

3.4.1 Wet mining

Wet 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 wet concentrator plant. 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.

The slimes (clay materials) is pumped to a containment pond and the sand is pumped to a sand stacking area.

Presently there is one dredge (D1) operating at the Lanti wet mining Deposit.

A simplified process flow is provided in Figure 3-3. Figure 3-4 provides an aerial overview of the wet mining area, while Figure 3-5 provides pictures of wet mining operations.

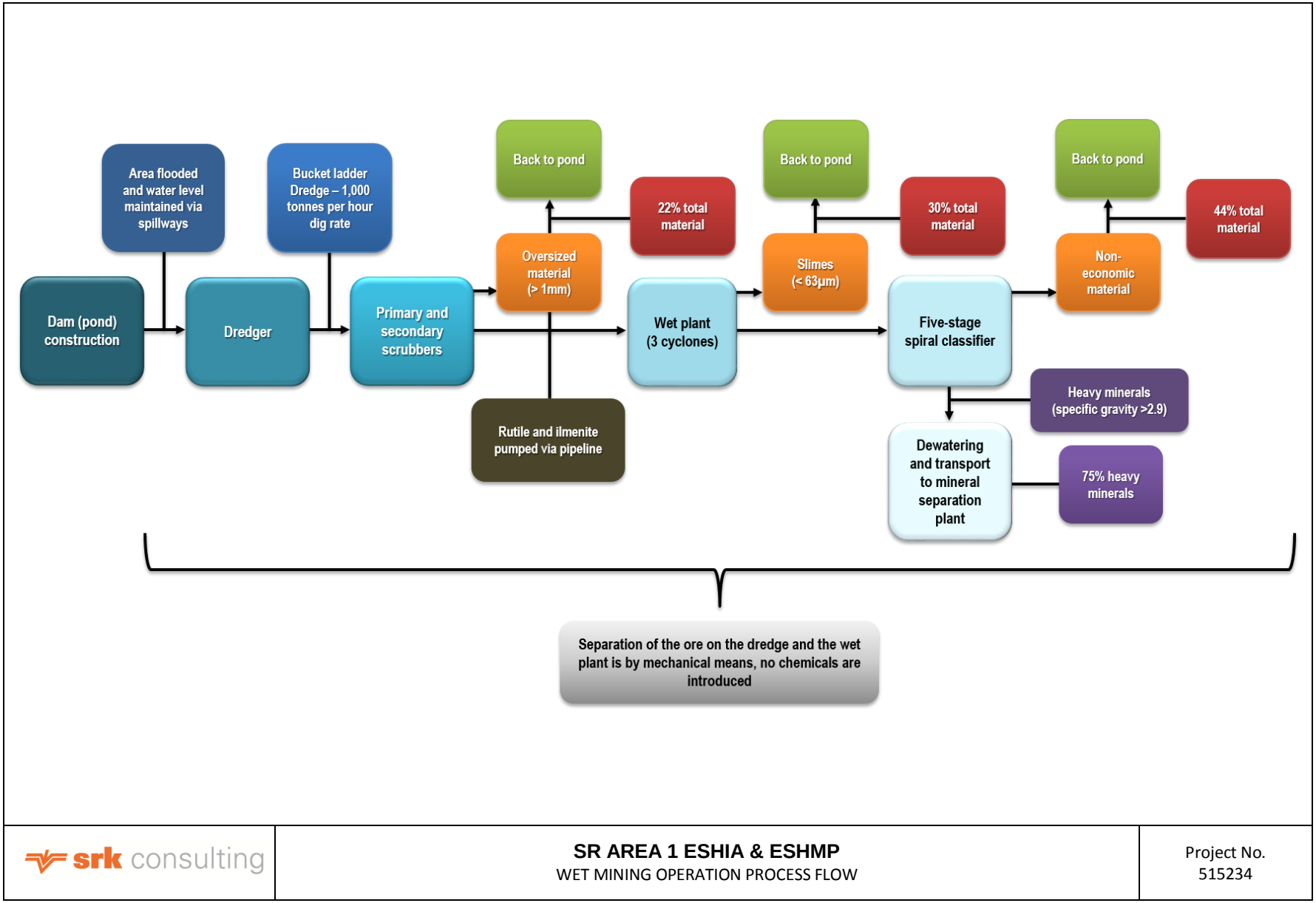
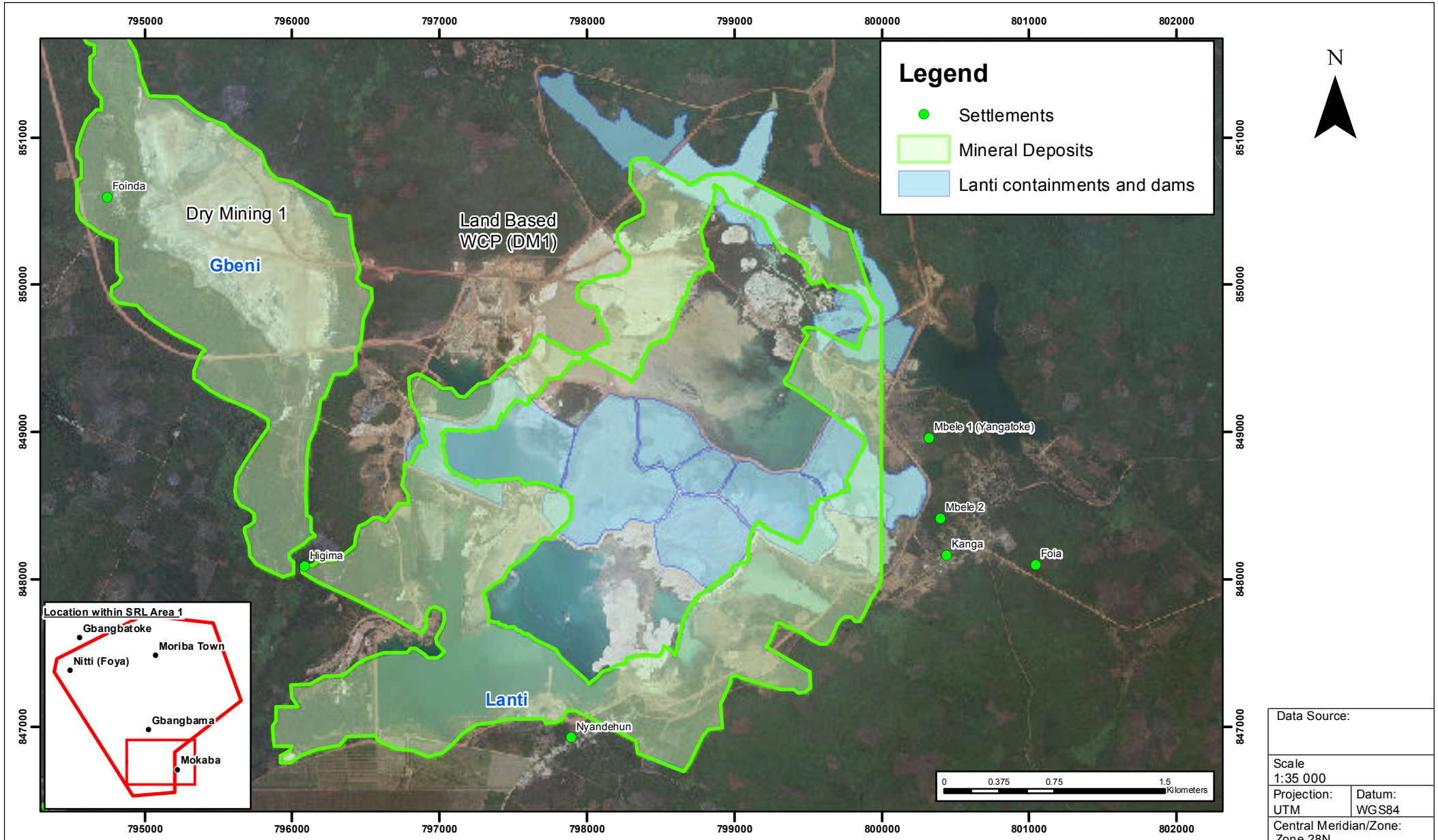


Figure 3-3: Simplified process flow of the wet mining operation



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Central Meridian/Zone: Zone 28N	
Date: 21/12/2017	Compiled by: ALLK
Project No. 515234	Fig No. 3-4

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SR AREA 1 ESHIA & ESHMP

AERIAL OVERVIEW OF WET MINING AREA

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SR AREA 1 ESHIA & ESHMP
LANTI WET MINING OPERATIONS

Project No.
515234

Figure 3-5: Lanti wet mining operations

3.4.2 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). Currently there are two dry mining areas namely: Lanti (which includes 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 beneficiation and land-based WCP's, 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 WCP's 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 3-6 provides a simplified process flow of the dry mining operations. Figure 3-7 provides an aerial overview of the Lanti dry mining area, Figure 3-8 an aerial overview of Gangama dry mining area and Figure 3-9 presents photographs of the dry mining operations.

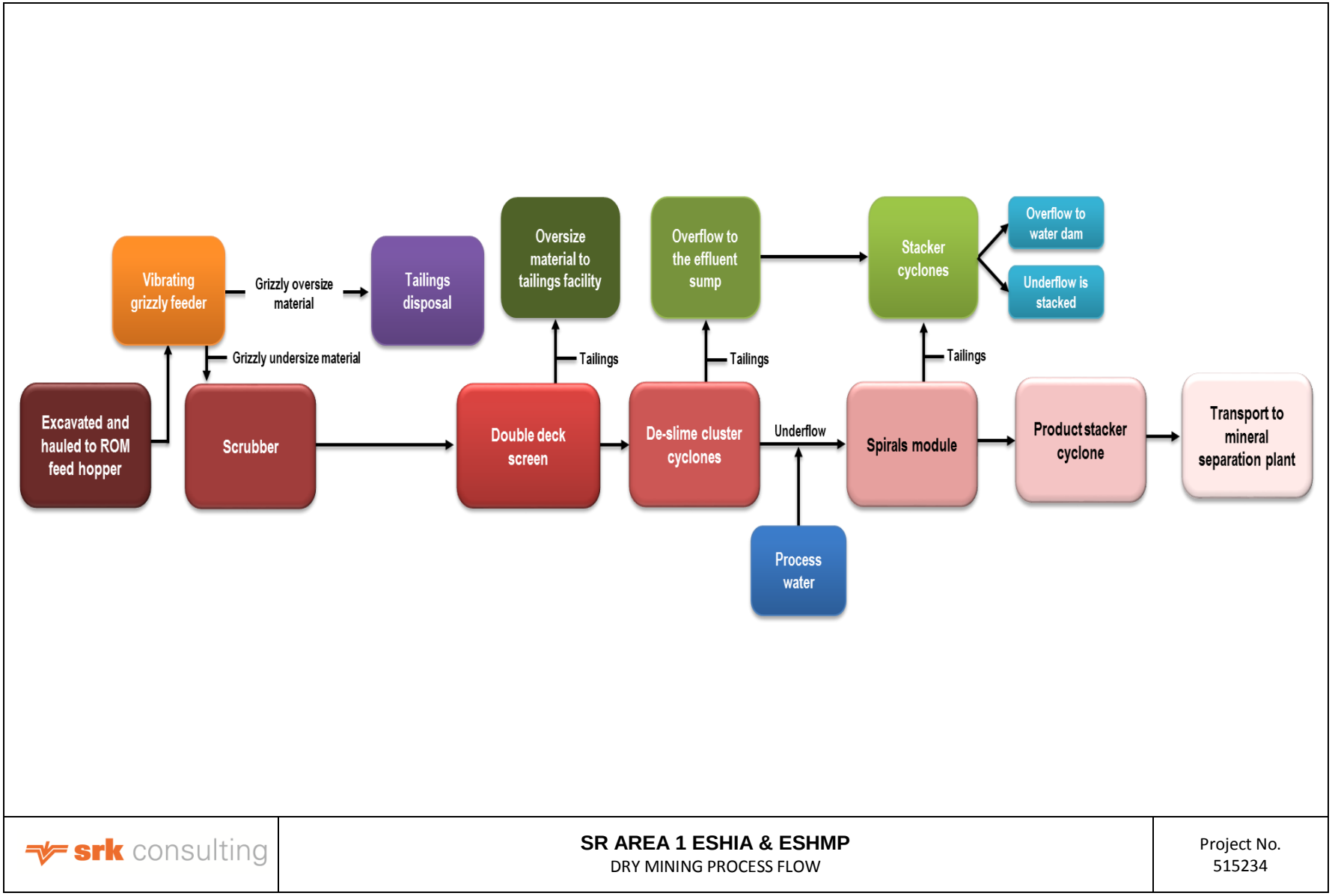
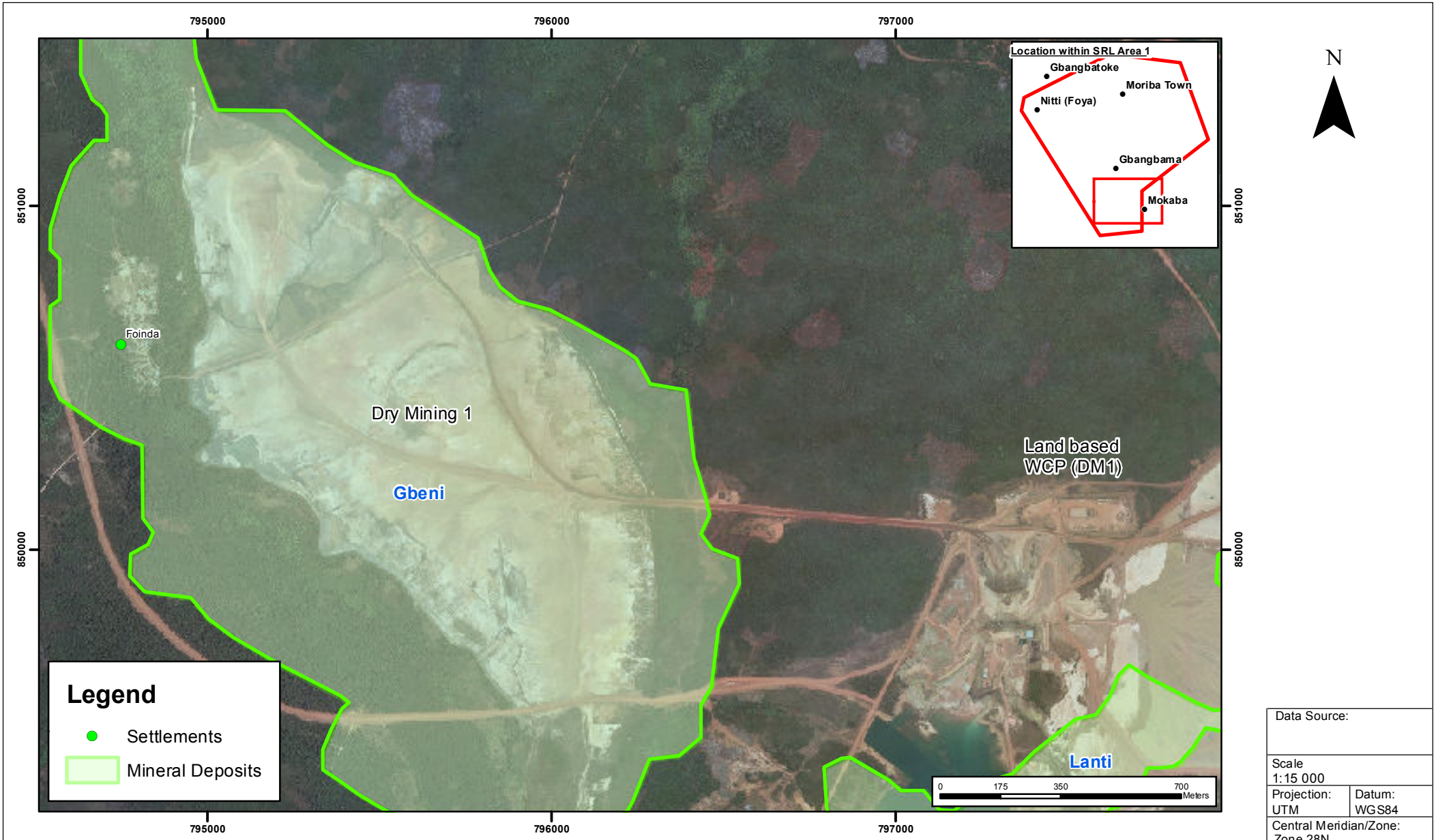


Figure 3-6: Simplified process flow of the dry mining operations



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Project No. 515234	Fig No. 3-7

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SR AREA 1 ESHIA & ESHMP

AERIAL OVERVIEW OF LANTI DRY MINING AREA

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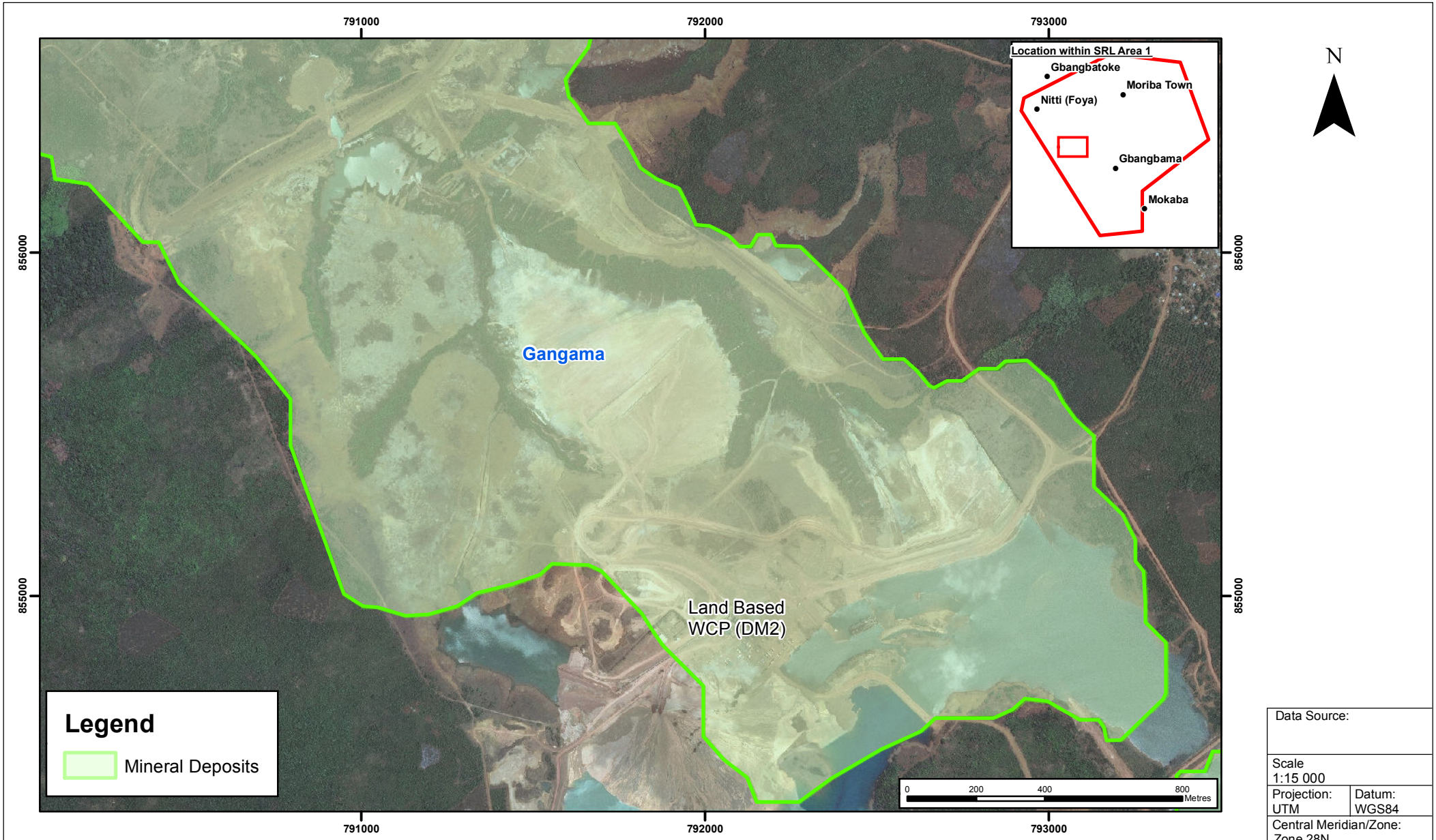

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Date: 21/12/2017	Compiled by: ALLK
Project No. 515234	Fig No. 3-8

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SR AREA 1 ESHIA & ESHMP

AERIAL OVERVIEW OF GANGAMA DRY MINE

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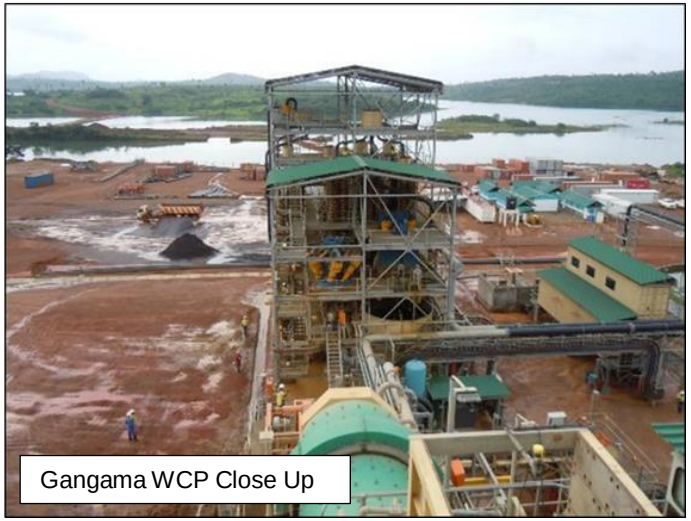

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SR AREA 1 ESHIA & ESHMP
LANTI AND GANGAMA DRY MINING OPERATIONS

Project No.
515234

Figure 3-9: Lanti (top row) and Gangama (bottom row) dry mining operations

Since undertaking an ESIA in 2012, SRL has constructed and commissioned the Gangama dry mine and its associated concentrator plant. Hence the operations at Gangama are not covered under the 2012 ESIA and are included in this update. 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:

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

3.4.3 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 3-11). 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 3-12).

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 3-12).

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 ilmenite contains approximately 60% TiO_2 and zircon concentrate at least 20% ZrO_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 3-12).

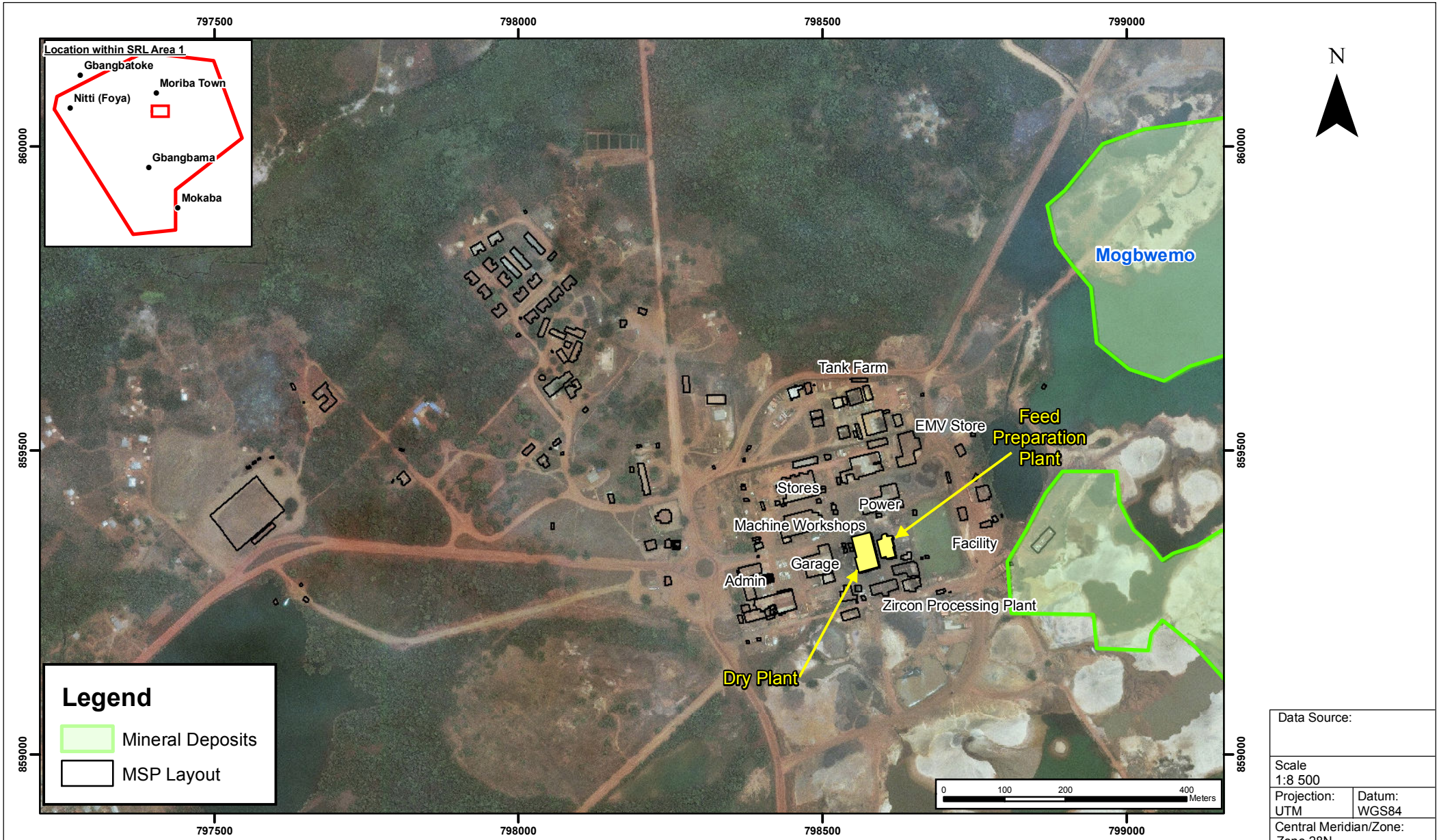
3.4.4 Nitti Port

The port facilities are located at Nitti, approximately 4 km south of Gbangbatoke (Figure 3-13). The port facilities include an office building, generator building, and storage buildings, product storage

silos, product storage domes, loading facilities, Marine Fuel Oil storage tanks, barges and two push boats. 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 ton storing rutile and ilmenite respectively. The rutile and ilmenite rich concentrate product materials are received from the MSP and stored in the domes and silos.

The product is the loaded onto barges from the storage silos and domes. All bulk-shipped products are dispatched through a common dispatch conveyor. The dispatch conveyor runs below the silos and the product is discharged directly onto the conveyor. 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 and 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 vessels (Figure 3-10).

Figure 3-10: Nitti Port product stockpile storage domes and product one tonne bags (left) and loading of barges (right)



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Date: 21/12/2017	Compiled by: ALLK
Project No. 515234	Fig No. 3-11

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SR AREA 1 ESHIA & ESHMP

AERIAL OVERVIEW OF MSP

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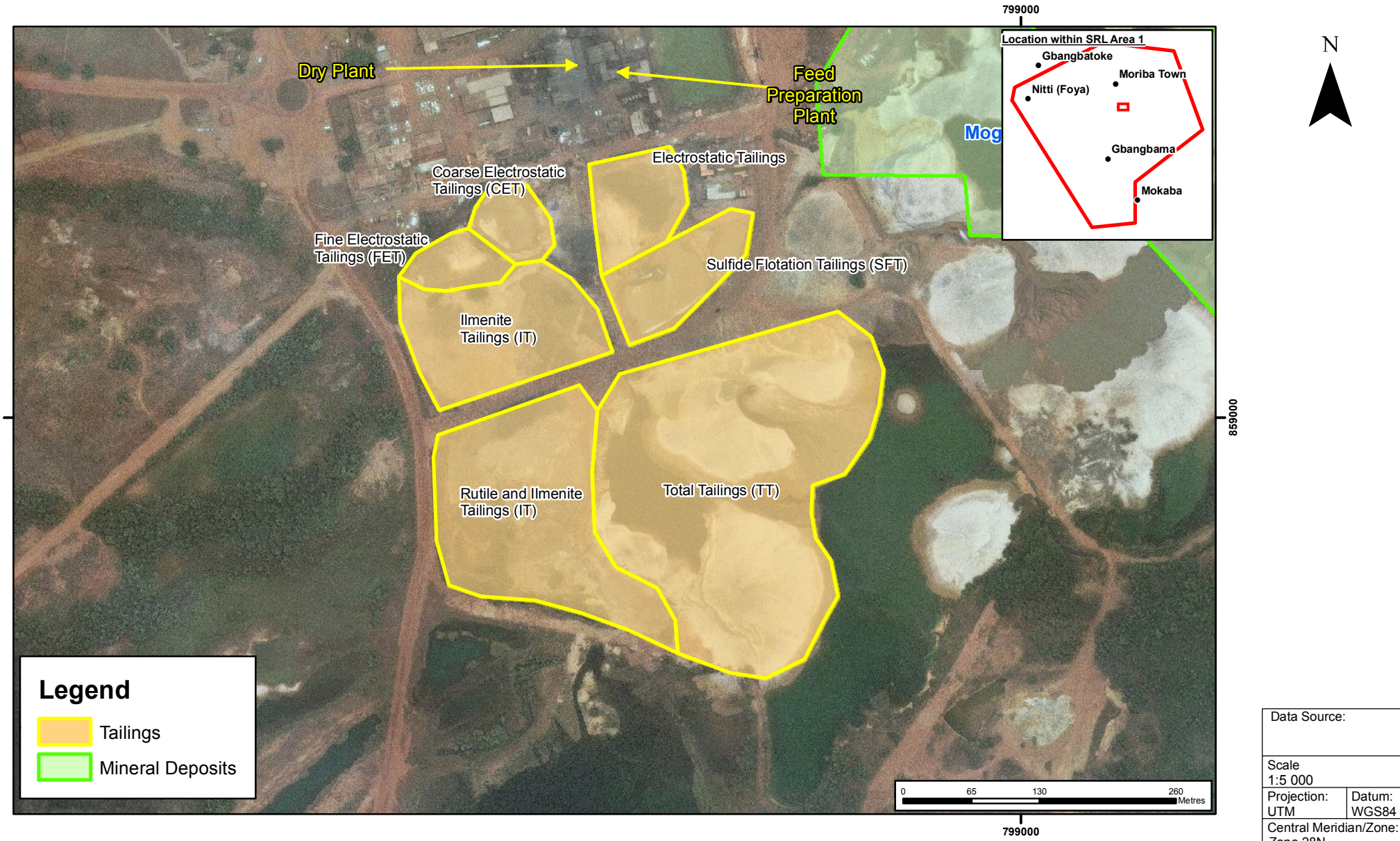

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SR AREA 1 ESHIA & ESHMP

LOCATION OF THE VARIOUS TAILINGS RESIDUES ASSOCIATED WITH THE MSP

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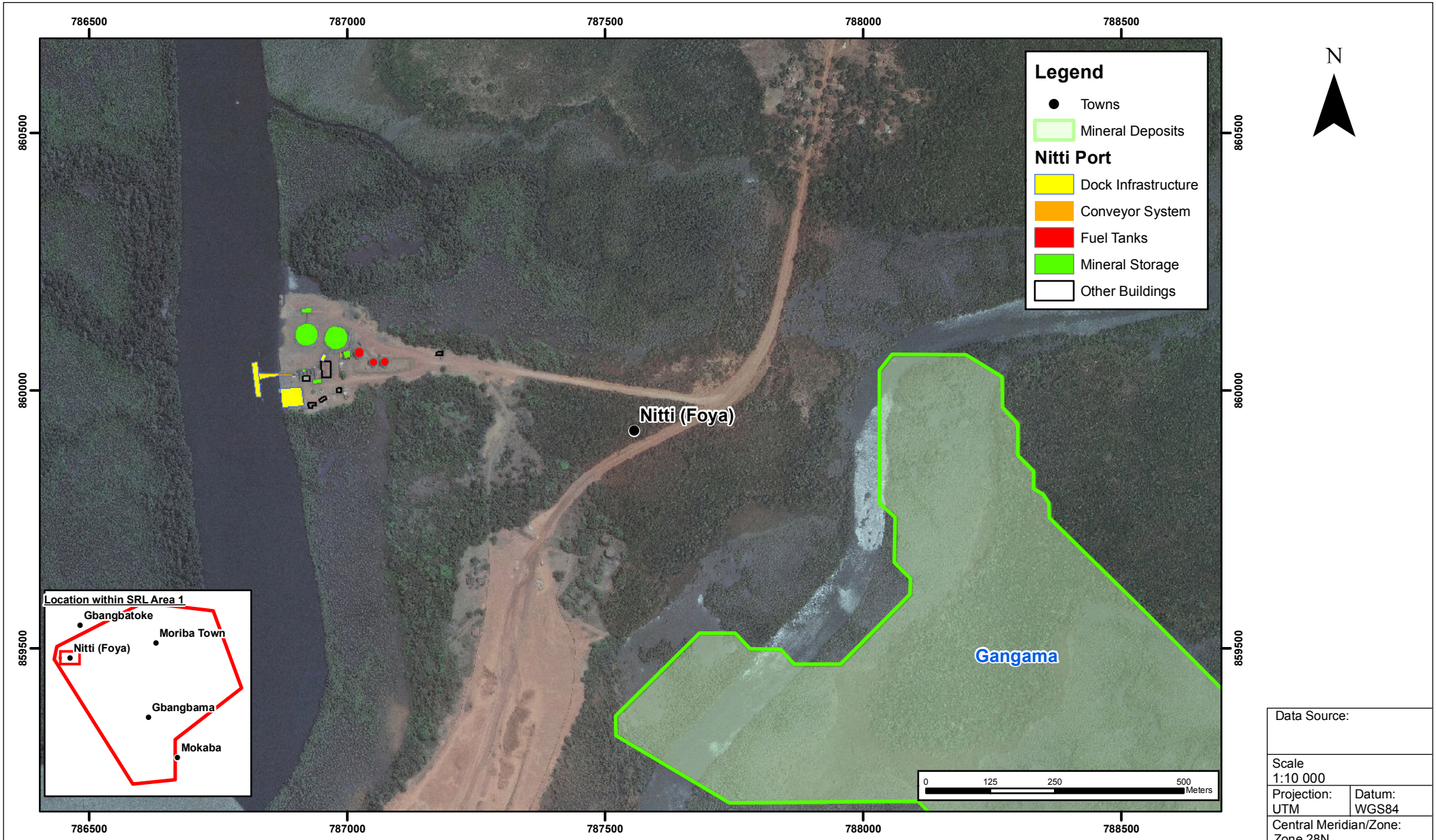

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Date: 21/12/2017	Compiled by: ALLK
Project No. 515234	Fig No. 3-13

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SR AREA 1 ESHIA & ESHMP

AERIAL OVERVIEW OF NITTI PORT

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3.4.5 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.

3.4.6 Mining vehicles

SRL operates various heavy-duty vehicles at their mining operations. These vehicles are primarily used to excavate and move ROM ore / feed to the concentrator plants, as well as to assist with maintenance and rehabilitation. A summary of the various vehicles used is provided in Table 3-3.

Table 3-3: **List of heavy duty vehicles used at various mining operations**

Operational area	Equipment list
Gangama concentrator plant	• 2x Volvo L220H (Weight 30 t, 4.6 m³ bucket capacity)
Gangama pit	• 2x Volvo 750D (Weight 75 t, with 5 m³ bucket, one on standby) • 1x Dressta TD-15M (Weight 20 t, Blade capacity 6 m³) • 5x Volvo A40F (Weight 40 t, 39 t carrying capacity)
Lanti concentrator plant	• 5 x Volvo L220H (Weight 30 t, 4.6 m³ bucket capacity)
Gbeni pit (Lanti dry mine)	• 2x Volvo 750D (Weight 75 t, with 5 m³ bucket, one on standby) • 1x Dressta TD-15M (Weight 20 t, Blade capacity 6 m³) • 1x Dressta TD-20M (Weight 27 t, Blade capacity 14 m³) • 5x Volvo A40F (Weight 40 t, 39 t carrying capacity) • 1x Caterpillar D9 (Weight 49 t, Blade capacity 18 m³)
Mining services / Tailings wall building	• 2x Volvo A40F (Weight 40 t, 39 t carrying capacity) • 2x Dressta TD-15M (Weight 20 t, Blade capacity 6 m³) • 2x Dressta TD-20M (Weight 27 t, Blade capacity 14 m³)
Site Drainage	• 1x Volvo 380D (Weight 38 t, 2.3 m³ bucket capacity)
Road Maintenance	• 3x Volvo G990 (Weight 22 t) • 3x Mercedes Benz
Rehabilitation	• 1x Dressta TD-15M (Weight 20 t, Blade capacity 6 m³)

3.4.7 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, 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 the Powerhouse 2 (PH2), associated switchboard, and 46 kV, 13.2 kV and 4.16 kV systems. 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 plant consists of four Caterpillar / Mak 16CM32, Marine Fuel Oil fuelled medium speed (720 rpm) generator sets, each nominally rated at 6.8 MW and generating 4.16 kV at 60 Hz. As such, there is an installed capacity of 27.2 MW. As part of the PH2 package, a new 3,150 A rated switchboard was developed and now serves as part of the main electrical power distribution centre for the operations.

The PH1, the original, diesel fuelled power plant, 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 PH1 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 (i.e. floating dredger and floating WCP). 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.

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.

3.4.8 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 World Health Organisation (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.

3.4.9 Mine camps, buildings and other facilities

SRL provides housing to specific groups of employees. There are two accommodation camps:

- Mobimbi camp:
  - This camp is for management employees;
  - It is located on Mobimbi Hill, approximately 4 km south west of the MSP;
  - The camp consists of housing, mess facilities, a gym, laundry and a swimming pool;
  - South Spur, which forms part of the Mobimbi housing complex, is located to the south of Mobimbi;
  - The combined area of Mobimbi and South Spur is approximately 205 ha.
- Kpanguma camp:
  - This camp is for senior staff;
  - It is located near the SRL clinic in proximity to the plant area.

In total, that above on-site camps can accommodate 440 people.

3.4.10 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.

3.5 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 3-4 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 3-5 provides a breakdown of the employment statics for SRL's contractors.

Table 3-4: 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 3-5: 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

3.6 Total investment and financial sources

On 7 December 2016, SRL merged with Iuka, to become a wholly owned subsidiary of Iluka. The skills and experience of SRL personnel, combined with Iluka's operational and technical expertise, are expected to enhance operational performance. Iluka expects to invest at least US$ 60 million over the next two years (2017 - 2018) on improvements to the SRL operation and plans to progress a number of expansion opportunities available to the Company. At the time of the merger the final consideration for SRL equity was AUS$375 million, with Iluka assuming SRL's net debt of AUS$ 80 million.

3.7 Mining rights

By an agreement dated 4 February 1972 (the Principal Agreement) as amended by an agreement dated 23 May 1975 (the Supplemental Agreement), the 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. 2,134 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 23 January 2039, however there is an option to extend for a further 15 years.

3.8 Proposed additions to the SRL mining operations

The SRL operation intends to amend their current operations by implementing a more cost-effective mining method as well as by doubling the throughput of Lanti and Gangama dry mining operations from 500 tonnes per hour (tph) to 1,000 tph and increasing the throughput capacity of the MSP from 175 ktpa to up to 300 ktpa of rutile. The latter expansion is driven by capacity constraints as well as environmental, occupational health and safety related considerations. The primary change in the dry mining process involves the installation of an in-pit Dry Mobile Mining Unit at the Lanti dry mine. This will replace the existing load and haul method at Lanti dry mine and result in efficiency improvements. Ore will then be pumped as slurry via pipeline up to the land-based Wet Concentrator Plants (WCP) at Lanti. This reduces the need for haulage, stockpiling and reclaiming that is currently undertaken at the dry mining areas. All operational expansions will be undertaken within the existing operations footprint in areas that are already impacted from mining operations.

Table 3-6 provides an overview of proposed changes to operational processes and methods at the various mining operation sites.

Table 3-6: Proposed future changes operational processes

Operational Area	Proposed amendments to operational process
Lanti wet mine and floating wet concentrator plant	No proposed additions or amendments to the current process.
Lanti dry mine and land-based wet concentrator plant	It is proposed to modify the current truck and shovel method by constructing an in-pit Dry Mobile Mining Unit, followed by an ex-pit scrubber, before ore is pumped to the current concentrator. Lanti dry mine currently has a nameplate capacity of 500 tph, and the intent is to increase throughput to 1,000 tph. This proposal will see the establishment of the following infrastructure within the existing footprint: • In-pit Dry Mobile Mining Unit; • Ex-pit scrubber; • Additional tailings containment facilities; • Potential extensions to or new borrow pits; and • Potential extensions to roads.
Gangama dry mine and land-based wet concentrator plant	The current load and haul method used at the Gangama Deposit will continue. However, capacity will be increased from 500 tph to 1,000 tph by increasing the haul and load effort. This proposal will however, see the establishment of the following within the existing footprint: • Additional tailings containment facilities; • Potential extensions to or new borrow pits; and • Potential extensions to roads.
MSP and complex	There is a proposed plan to upgrade the MSP on the existing location to improve the plant's performance and health and safety standards. This potential future activity does not form part of the 2018 ESHIA scope.
Nitti Port	There are no proposed additions or amendments to the current layout and processes at Nitti Port.

4 Environmental and Social Baseline

This section describes the existing characteristics of the environment in SR Area 1 and area of influence. The study area has been mined over the past 50 years thereby subsequently altering the receiving environment. As such, the baseline descriptions reflect the current status quo, taking into account the historical and current mining operations.

The environmental and social baseline has been updated from the previous 2001 and 2012 ESIAs using data derived from specialist studies undertaken for the 2018 ESHIA and ESHMP. Specialist studies comprising fieldwork investigations and laboratory analysis were undertaken from June 2017 to February 2018.

Specialist's reports are included as appendices to this ESHIA. Table 4-1 provides a reference to the location of the respective specialist studies.

Table 4-1: Reference to the location of specialist studies in the appendix

Specialist study	Appendix reference
Air Quality Impact Assessment	Appendix A
Biodiversity - Terrestrial, Aquatic and Wetland Ecological Studies	Appendix B
Biodiversity - Estuarine Study	Appendix C
Community health - Rapid Health Impact Assessment	Appendix D
Geochemistry Characterisation of Selected Residues	Appendix E
Groundwater – Hydrogeological Study	Appendix F
Surface Water Study	Appendix G
Noise Study	Appendix H
Radiological Assessment and Gap Analysis	Appendix I
Social Impact Assessment	Appendix J
Soils and Land Capability Assessment	Appendix K

Note: A Mine Closure Plan was also undertaken as a specialist study and it is attached as Appendix L4.

4.1 Climate and meteorology

The content of this section is adapted from the specialist Air Quality Impact Assessment (AQIA) (SRK, 2018(1)) (Appendix A) and Surface Water Study (SRK, 2018(4)) (Appendix G).

4.1.1 General description of climate in Sierra Leone

Sierra Leone is located in West Africa, between the Tropic of Cancer and the Equator. The climate in Sierra Leone is tropical, with a wet season from May to October and a dry season from November to April.

The Inter-Tropical Convergence Zone (ITCZ) has a major influence on the climate of Sierra Leone. Throughout the year the ITCZ remains in the northern hemisphere in the eastern Pacific and Atlantic regions. Over Africa, the ITCZ migrates from the southern to the northern hemisphere between January and July (Tyson and Preston-Whyte, 2000). The hot weather during this period, heats the air in the ITCZ, increasing its humidity and making it buoyant. As the buoyant air rises as a result of the trade winds from the south west, it expands and cools, producing rainfall over Sierra Leone and surrounding regions. As the ITCZ moves south during September, the wet season draws to a close.

The winds that originate during the dry season (winter), known as the Harmattan winds, consist of the north east trade winds. These winds bring no precipitation apart from the occasional very light rain. The Harmattan winds transport dust from the Sahara Desert and usually blow from late November to mid-March. Average wind speeds in Sierra Leone are generally low.

There is little seasonal variation in mean air temperatures, with slightly hotter conditions in April and May. Altitude influences temperature as well as other weather variables, with temperatures generally decreasing with altitude.

4.1.2 General description of regional climate

According to the Koppen Climate Classification System (Arnfield, 2017), the SR Area 1 is classified as a Category "A" climate type, which is characteristically hot and moist during summer and cool and dry in winter. The region / site also falls into the subcategory "Am" which represents a tropical monsoon climate i.e. wet summers and dry winters. The ITCZ influences the climate in the summer period bringing rain and during winter, the trade winds dominate bringing a drier climate. Average temperatures associated with this classification are usually greater than 18 ºC. Rainfall is usually above 1,500 mm.

4.1.3 Climate conditions at the project site

Climate data for the SR Area 1 has been collected and reviewed from on-site weather stations (MSP and Lanti Dry Mine), and Weatherbase for the Mogbwemo village. The Mogbwemo village is located adjacent to the SRL MSP. Two additional weather stations were installed during the SRK site visit in July 2017, at Nitti Port and Gangama Dry Mine. The data for these weather stations are not presented in this report as only one month's data has been collected. Modelled meteorological data from Lakes Environmental for the SR Area 1 is also presented in this section.

Rainfall

Rainfall is an important parameter with respect to air quality. During the wet season, air pollution, and more specifically in this case, dust particles, are removed from the atmosphere. Dust emissions are suppressed due to increases in soil moisture content and increased vegetation cover during the wet season. During the cooler dry and hot dry seasons, dust emission levels are generally higher.

Rainfall data obtained from the SRL MSP site for the period January 2001 to May 2017 were assessed. The average annual rainfall measured at the MSP was 2,827 mm, with the majority of rainfall falling from May to November. In comparison, low rainfall was measured during December to April. The weather station installed at the Lanti Mine Site measured rainfall from January 2001 to December 2007 and from August 2014 to August 2017. It should be noted that 10 months of wet season data was missing during the latter period (August 2014 to August 2017) due to unknown reasons. However due to the long-term data downloaded from the weather station this will not be an issue. The average annual rainfall for this period was 2,933 mm. Similarly, to the rainfall obtained from the MSP site, the majority of rainfall is measured from May to November, with low rainfall measured from December to April.

Rainfall data for the Mogbwemo area was sourced from Weatherbase. The average annual rainfall measured at Mogbwemo is 3,098 mm, which is slightly higher than at the weather stations located on the mine site.

In comparison to the measured rainfall data, the average annual rainfall from Lakes Environmental (for the SR Area 1) is considerably higher at 4,274 mm for the period January 2014 to December 2016. As with the measured data, the majority of rainfall occurs from May to November.

The average monthly rainfall for the on-site data and Lakes Environmental is presented in Table 4-2 and Figure 4-1. Similar trends are observed between the datasets.

Table 4-2: Comparison between on-site rainfall and Lakes Environmental data

Month	SRL MSP Site	Lanti Mine Site	Mogbwemo Village	Lakes Environmental
Units	**mm**	**mm**	**mm**	**mm**
January	6.5	3.7	3.8	74.4
February	10.6	27.6	15.4	30.6
March	50.2	44.9	28	18.0
April	92.7	139.4	85.7	140.1
May	240.5	199.0	285.8	405.0
June	375.6	396.4	408.7	569.9
July	515.1	556.8	651.6	567.0
August	636.6	686.4	690.3	754.2
September	450.2	443.5	448.3	732.5
October	278.2	271.9	328.3	543.5
November	146.8	154.0	121.7	373.4
December	24.0	9.7	30.1	64.8
Total	**2,827**	**2,933**	**3,098**	**4,274**

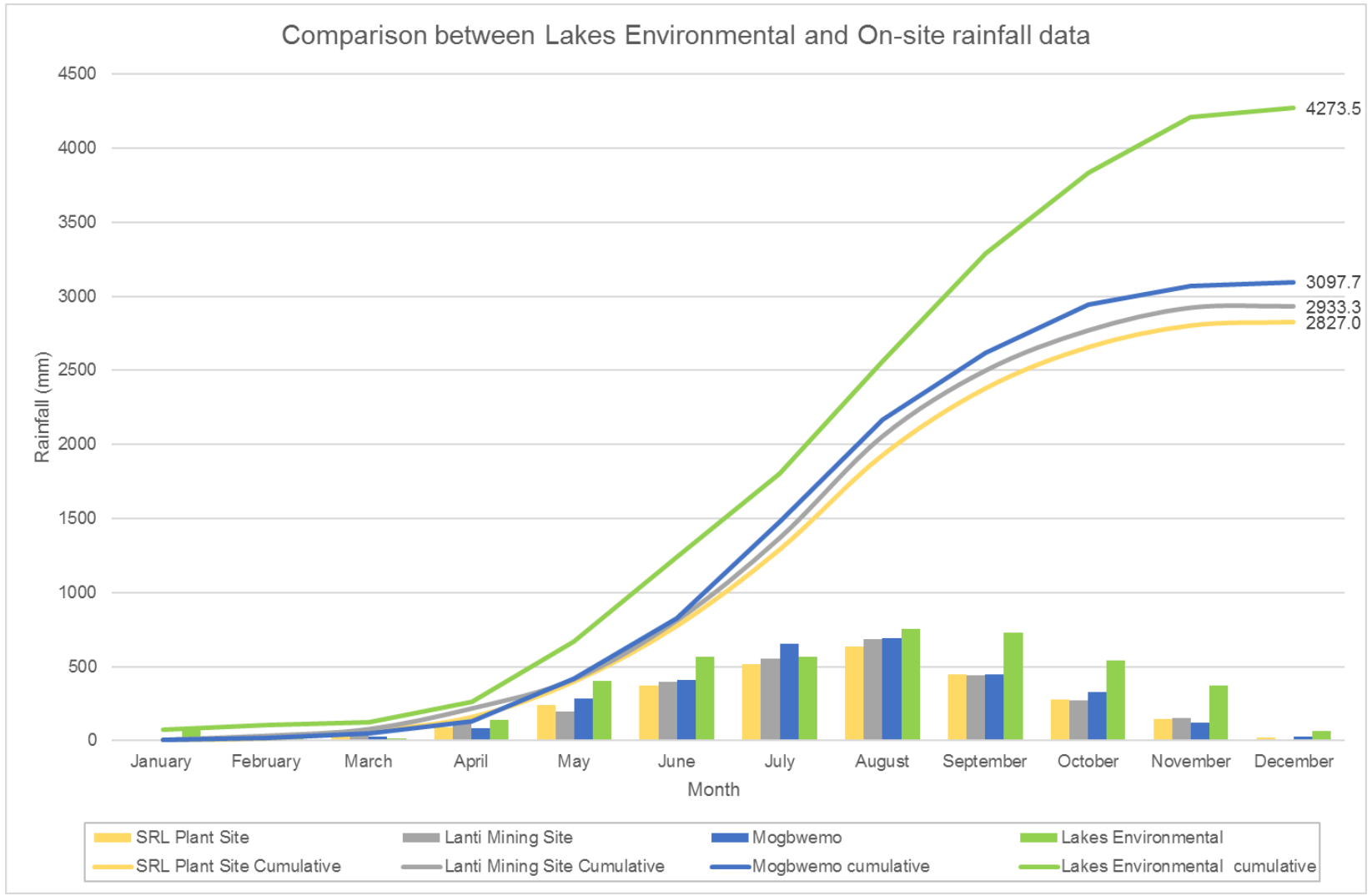


Figure 4-1: Comparison between Lakes Environmental and on-site rainfall data

Storm rainfall

The storm rainfall depths for SRL were obtained from the Intensity Frequency Duration (IFD) study (Golder Technical Memorandum, 2017). The MSP site data was specifically used because the IFD curves can only be calculated using data observed for more than 10 years.

The IFD curves for different recurrence intervals and estimate design rainfall is presented in Table 4-3. These curves were calculated for the following periods of rainfall: 5 minutes, 10 minutes, 30 minutes, 45 minutes, 1 hour, 2 hours, 4 hours, 6 hours, 8 hours, 10 hours, 16 hours, 20 hours, 4 days, 5 days, 6 days and 7 days.

The rainfall design is presented in Table 4-4.

Table 4-3: Intensity Duration Frequency (IFD) estimates for SRL (mm)

Duration (minutes)	Average Recurrence Intervals (ARI) (mm)							Duration (hours)
	1:1	1:2	1:5	1:10	1:20	1:50	1:100	
180	69.6	106.8	138.6	159.9	180.6	207.6	228.0	3
360	90.6	128.4	168.0	189.6	222.0	262.8	294.0	6
720	106.8	152.4	189.6	214.8	247.2	294.0	336.0	12
1,440	120.0	168.0	211.2	235.2	268.8	314.4	362.4	24
2,160	129.6	183.6	230.4	255.6	284.4	324.0	370.8	36
2,880	139.2	196.8	244.8	273.6	297.6	336.0	374.4	48
4,320	151.2	208.8	259.2	288.0	309.6	338.4	381.6	72

Table 4-4: Storm design and rainfall depths (mm)

Return Period (Years) / Rainfall Period		1:2	1:5	1:10	1:20	1:50	1:100
5	minutes	2	4	14	44	80	81
10	minutes	13	46	46	74	110	116
15	minutes	27	46	64	94	128	138
30	minutes	50	72	90	118	152	170
45	minutes	62	87	105	135	170	190
1	hour	72	98	116	146	182	200
1.5	hours	83	111	129	159	196	216
2	hours	94	124	142	172	210	232
4	hours	116	150	170	200	238	266
6	hours	128	168	189	222	263	294
8	hours	138	176	198	227	264	298
10	hour	144	184	208	236	274	308
12	hours	154	189	214	247	294	336
16	hours	160	178	203	239	297	337
20	hours	167	210	236	262	300	338
24	hours	168	211	235	269	314	362
1	day	184	230	256	284	324	371
2	days	197	245	274	298	336	374
3	days	209	259	288	310	338	382

Return Period (Years) / Rainfall Period		1:2	1:5	1:10	1:20	1:50	1:100
4	days	216	268	302	320	363	408
5	days	226	270	307	330	372	424
6	days	230	284	312	340	376	432
7	days	234	289	318	344	385	438

Temperature and humidity

Similar to rainfall, temperature and humidity data were sourced from the on-site weather station at Lanti mine site, from Weatherbase and Lakes Environmental. The monthly average, average maximum and average minimum temperatures and average humidity are presented in Table 4-5 and Figure 4-2 to Figure 4-4.

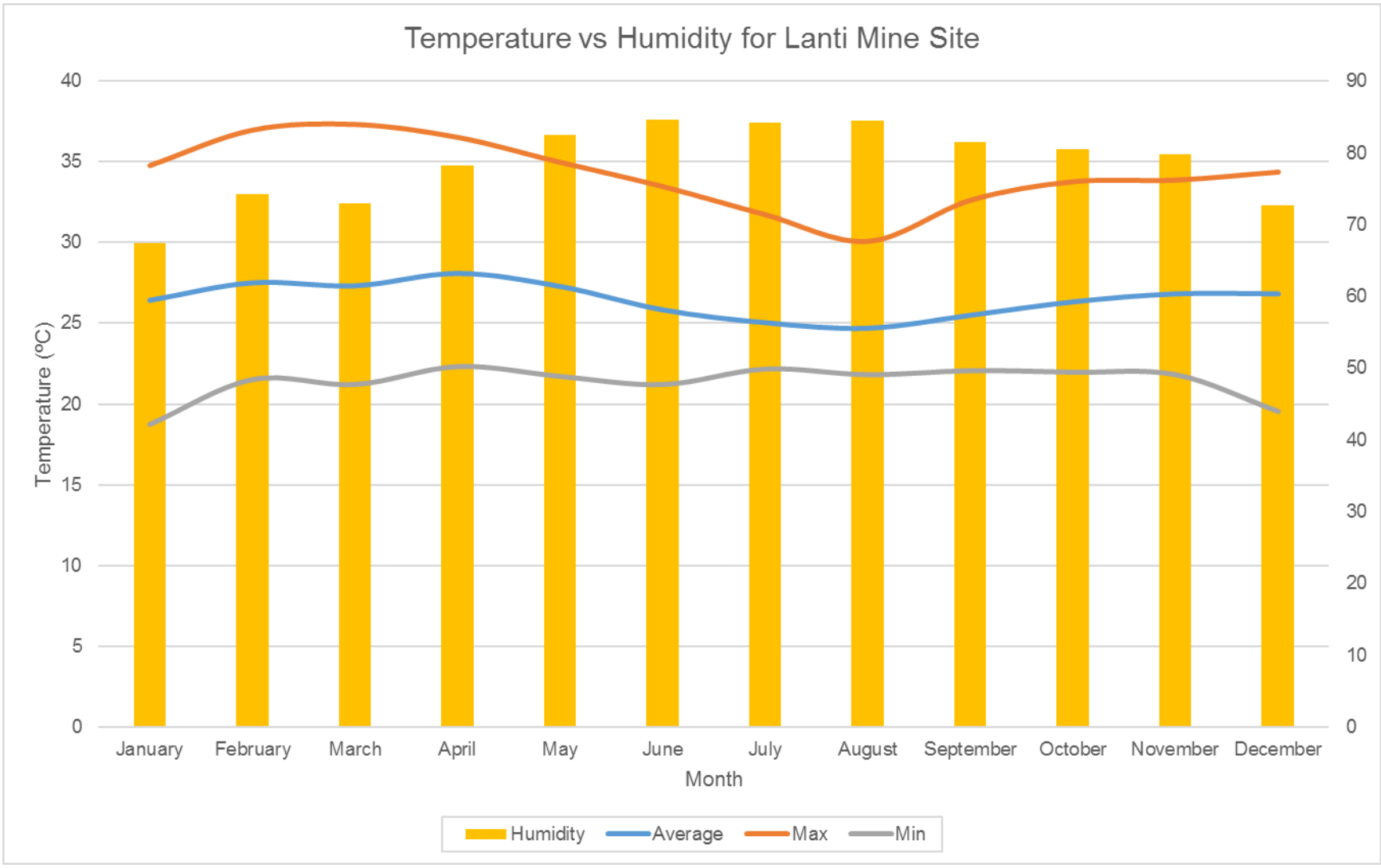
The data obtained from the Lanti mine site indicates average temperatures ranging from 24.7 - 28.1 °C, with maximum temperatures reaching 37.3 °C and minimum temperatures 18.8 °C. Relative humidity ranged from 67.4 - 84.6 %, with higher humidity measured during the wet season and lower humidity measured in 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.

The average temperatures for the Lakes Environmental dataset ranged from 25.2 - 28.2 °C, with a maximum of 36.7 °C and minimum of 16.6 °C. Humidity ranged from 72.1 - 91.5 % during the period from January 2014 to December 2016. The various datasets are comparable, with the slight differences in relative humidity between the datasets not considered significant.

Table 4-5: Comparison of Lakes Environmental and on-site temperature and humidity data

Month	Lanti Mine Site				Mogbwemo Village				Lakes Environmental			
	Average	Max	Min	Humidity	Average	Ave. Max	Ave. Min	Humidity	Average	Max	Min	Humidity
	°C	°C	°C	%	°C	°C	°C	%	°C	°C	°C	%
January	26.4	34.8	18.8	67.4	25.7	31.2	19.8	70.3	25.9	34.9	17.4	78.3
February	27.5	37.0	21.5	74.3	27.3	32.9	21.1	71.0	26.7	36.4	18.7	76.3
March	27.3	37.3	21.2	72.9	27.9	33.4	21.8	68.6	27.5	37.1	19.7	72.1
April	28.1	36.5	22.3	78.3	28.1	32.8	22.6	70.4	28.2	36.7	21.5	75.5
May	27.3	35.0	21.7	82.5	27.3	31.6	22.7	79.9	27.5	34.9	22.8	84.6
June	25.8	33.5	21.2	84.6	26.4	30.1	22.3	82.6	26.3	32.3	22.3	88.1
July	25.0	31.7	22.2	84.2	25.4	28.3	22.0	86.8	25.5	29.9	21.0	89.6
August	24.7	30.1	21.8	84.5	25.3	28.2	21.9	87.4	25.2	30.0	21.0	90.3
September	25.5	32.6	22.1	81.5	25.9	29.4	22.1	84.8	25.3	29.8	21.4	91.5
October	26.3	33.8	22.0	80.5	26.5	30.3	22.1	81.6	25.7	30.5	21.9	91.5
November	26.8	33.9	21.8	79.8	26.7	30.9	22.0	79.6	25.9	31.7	21.4	90.2
December	26.8	34.4	19.6	72.6	26.1	31.0	20.6	75.7	25.6	33.8	16.6	78.3



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SR AREA 1 ESHIA & ESHMP
AVERAGE MONTHLY TEMPERATURE AND HUMIDTY PATTERNS – LANTI MINE SITE (3-YEAR PERIOD)

Project No.
515234

Figure 4-2: Average monthly temperature and humidity patterns for Lanti mine site for a 3-year period

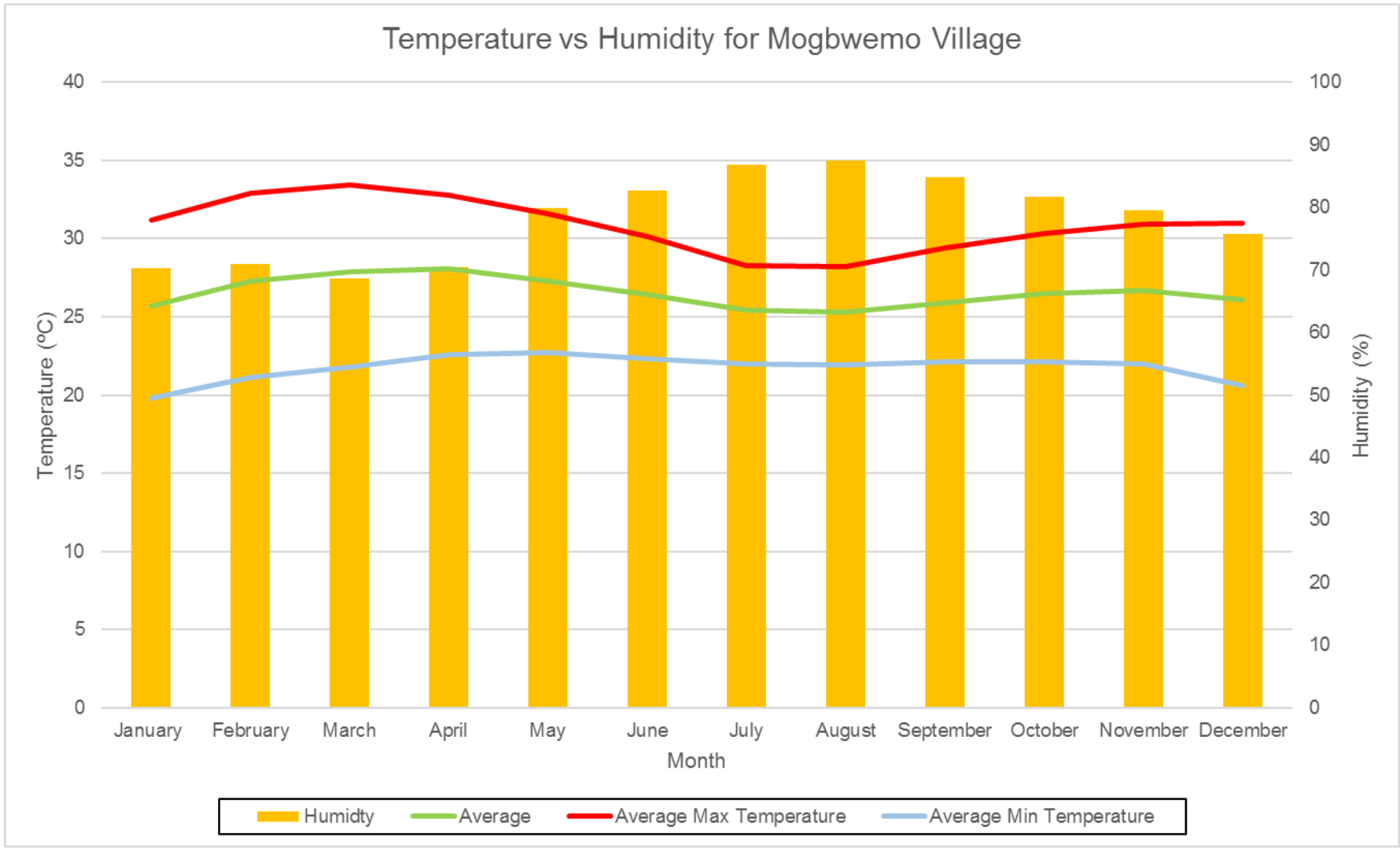

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Figure 4-3: Average monthly temperature and humidity patterns for Mogbwemo for a 112-year period

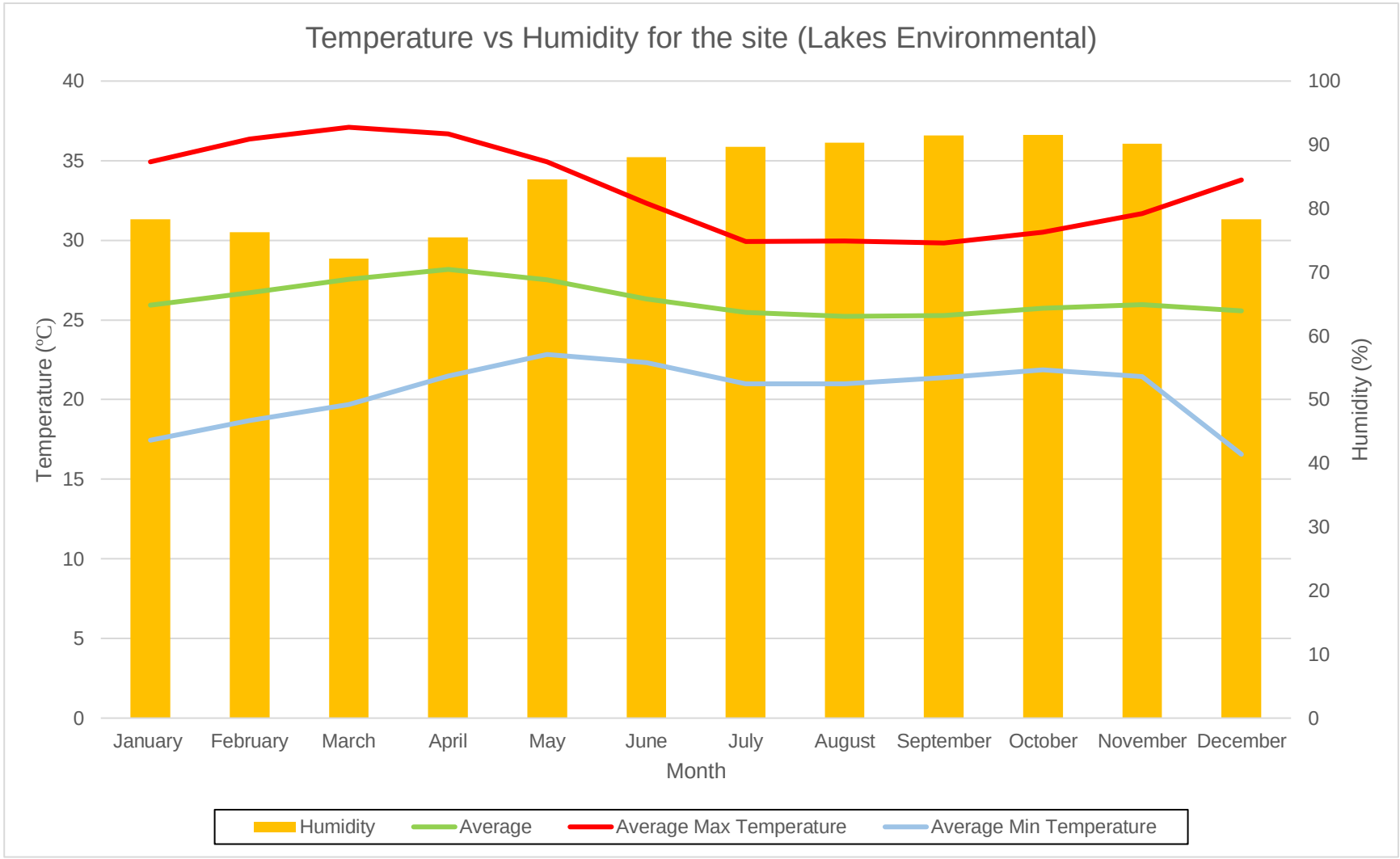

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Figure 4-4: Lakes Environmental average monthly temperature and humidity patterns for the site for a 3-year period

Evaporation

The mean annual evaporation (class A-pan) data was calculated using the 1966 Torma Bum evaporation station measurements. Albeit incomplete, the pan evaporation data was used to interpolate the Torma Bum data and reconcile the missing figures. Original and reconciled monthly A-pan evaporation figures from Torma Bum evaporation station were used in the water resource rainfall-runoff model and are presented in Table 4-6 and Table 4-7 below. The A-pan evaporation data was converted to S-pan evaporation data. A-Pan evaporation is measured using a circular tank which is filled with water and then the drop in depth is converted to a loss in evaporation. The difference between the A-pan and S-Pan data is that the A-Pan is situated above ground while the S-Pan is situated below the ground

Table 4-6: Monthly evaporation (mm) - Torma Bum

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A-pan (mm)	-	114	135	122	109	91	-	-	-	84	84	101	
Piche (mm)	78	106	124	90	71	45	40	32	39	43	51	53	772

Table 4-7: Monthly class A-pan and class S-pan (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A-pan (mm)	84	114	135	122	109	91	72	54	56	84	86	101	1108
S-pan (mm)	58	84	102	91	80	64	47	31	33	58	59	73	779
Distribution (%)	7.3	11.2	13.6	12.1	10.4	8.2	5.9	3.8	4.0	7.0	7.3	9.1	100

Wind speed

The wind field for an area is an important parameter with respect to air quality and winds can generate dust emissions, as well as influence the dispersion of an emissions plume. The degree to which winds can influence dispersion depends on the wind speed. Higher wind speeds result in longer travel distance and dilution of the pollutants and lower, more stable wind conditions result in shorter travel distance and build-up of pollutant levels (especially gases) over a smaller area.

Lakes Environmental data

Hourly meteorological data for the period January 2014 to December 2016 was acquired from Lakes Environmental[4].

The wind roses for all hours, day and night time for the SR Area 1 are presented in Figure 4-5. The prevailing winds in the SR Area 1 are relatively constant throughout the year. Winds are predominantly from the south west and west-south west during the day (Figure 4-5b) and earlier (18h00-23h00) parts of the night (Figure 4-5c). Winds during the latter part of the night (Figure 4-5d) are of lower speed and prevalent from all directions with the highest frequency of winds blowing from the north east.

The average wind speed for all hours for the SR Area 1, is 2.64 m/s with maximum speeds less than 8.8 m/s and with calms (<0.5 m/s) of 2.97 %. The average wind speeds for day time (06h00 - 18h00) during the year is 3.31 m/s with calms of 1.68 %. The average wind speed during the earlier parts of

[4] Note: The Sierra Leone Meteorological Office was not contacted for additional information as the air quality specialist had site data and modelled meteorological data.

the night (18h00 - 23h00) is 2.79 m/s with calms of 2.71 %. The average wind speed decreases during the latter parts of the night to 1.42 m/s with calms prevailing 5.11 % of the time.

Wind roses were also created for two distinct seasons, i.e. wet season (May to October) and dry season (November to April) (Figure 4-6). The prevailing wind directions during the dry season are from the west-south west and south west with lower occurrences from the west and north east. The influence of the Harmattan winds from the north east is observed during the dry season. However, during the wet season the prevailing wind direction is from south west with a lower occurrence from the west-south west, south-south west and south. The highest average wind speeds of 2.73 m/s occur during the wet season with calms prevailing 3.93 % of the time. The lowest average wind speed occurs during the dry season with an average wind speed of 2.56 m/s with calm conditions prevailing 1.99 % of the time. The winds during the wet season average 2.83 m/s with calms of 6.66 %.

The wind class frequency distribution, presented in Figure 4-7, shows that 91.8 % of wind speeds are below 5.7 m/s (low to moderate) with 8.2 % of winds above 5.7 m/s.

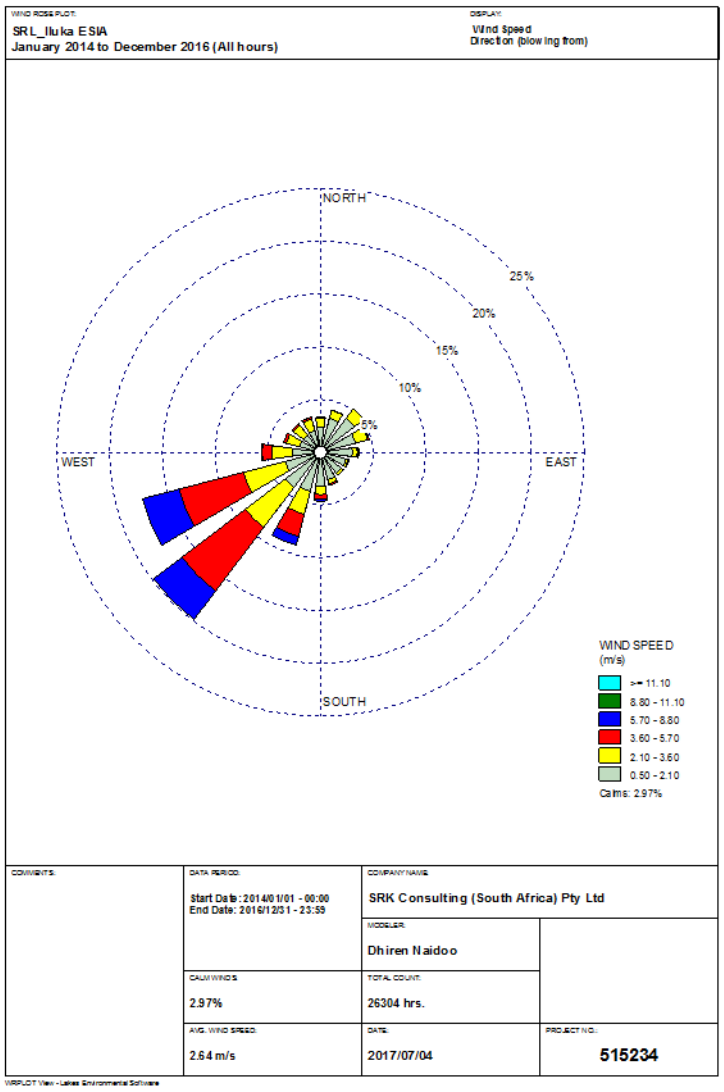

Figure 4-5a: January 2014 to December 2016 (All hours)

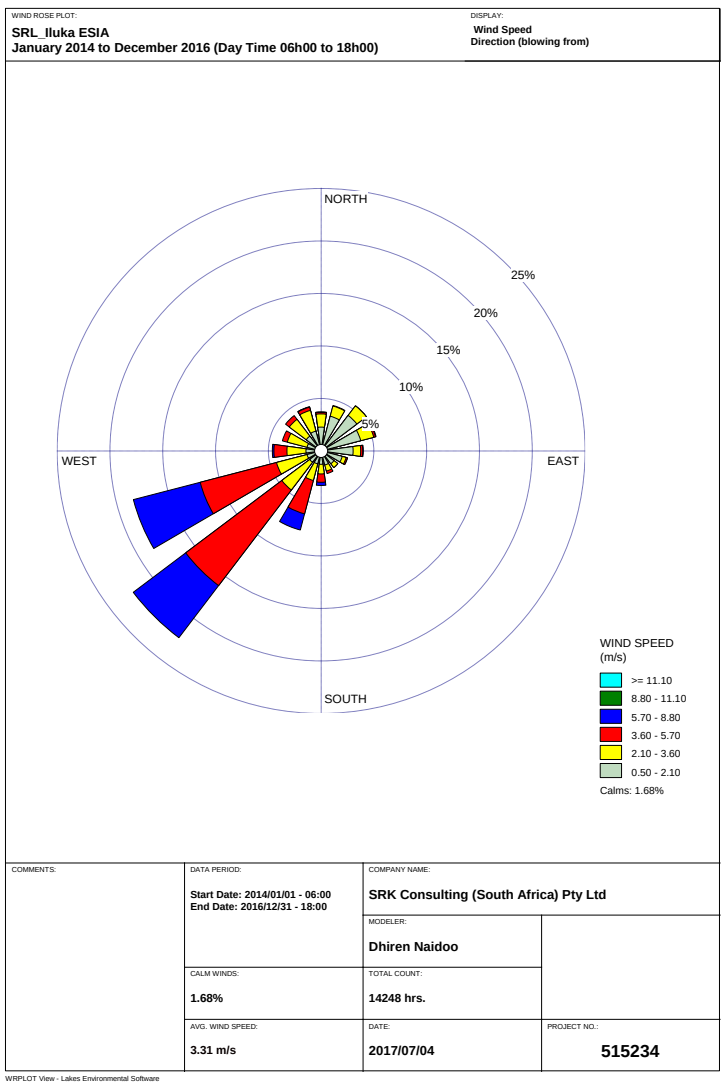

Figure 4-5b: January 2014 to December 2016 (Day Time 06h00-18h00)

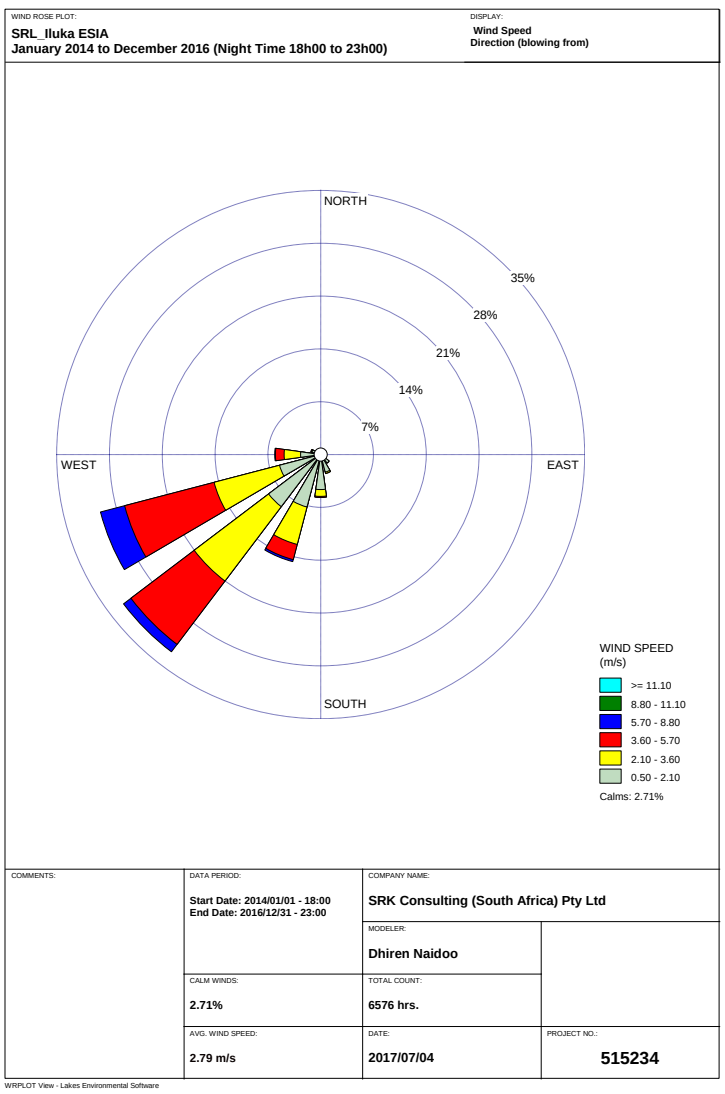

Figure 4-5c: January 2014 to December 2016 (Night Time 18h00-23h00)

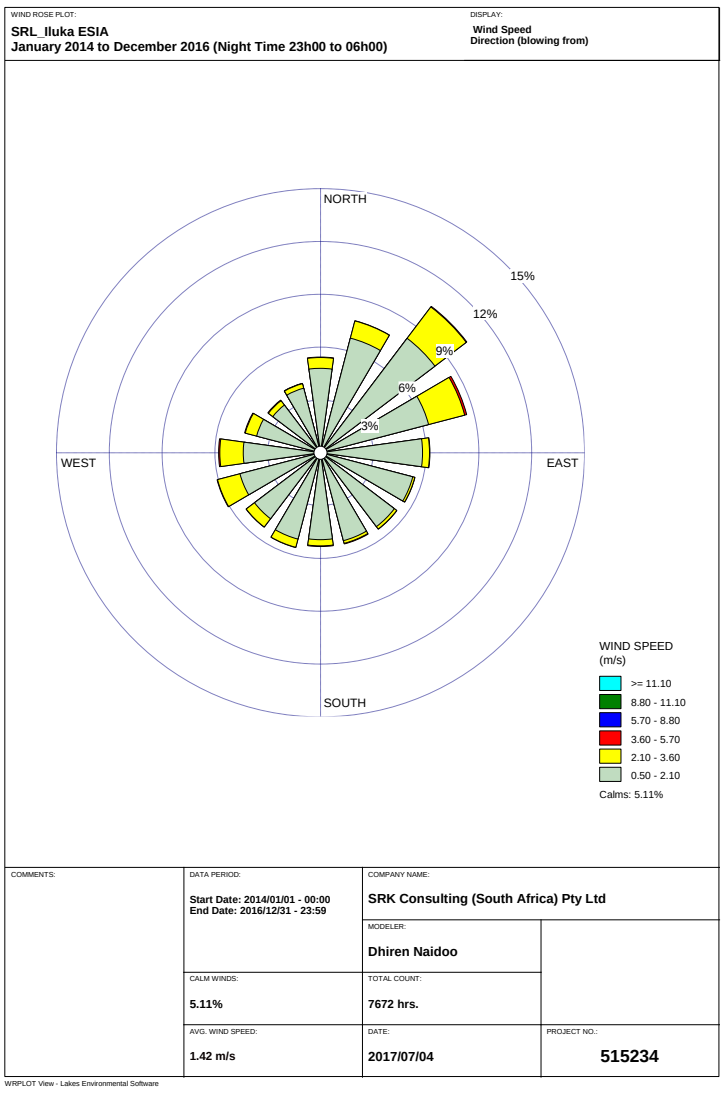

Figure 4-5d: January 2014 to December 2016 (Night Time 00h00-06h00)

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Figure 4-5: All hours, day time and night time wind roses from Lakes Environmental

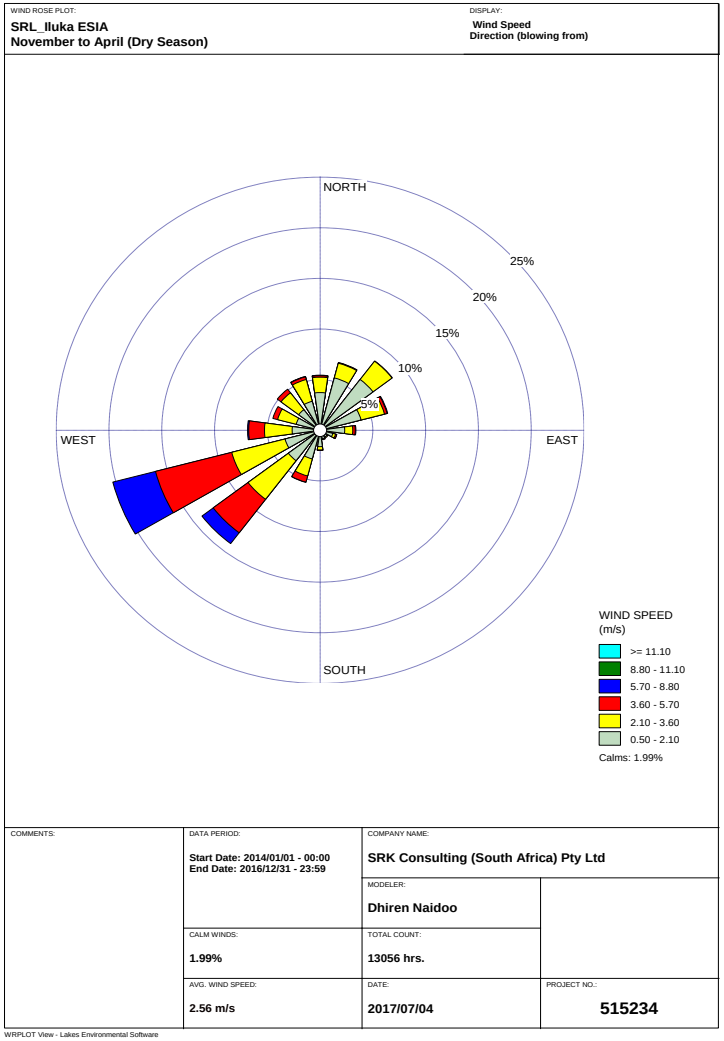

Figure 4-6a: Dry season (November to April)

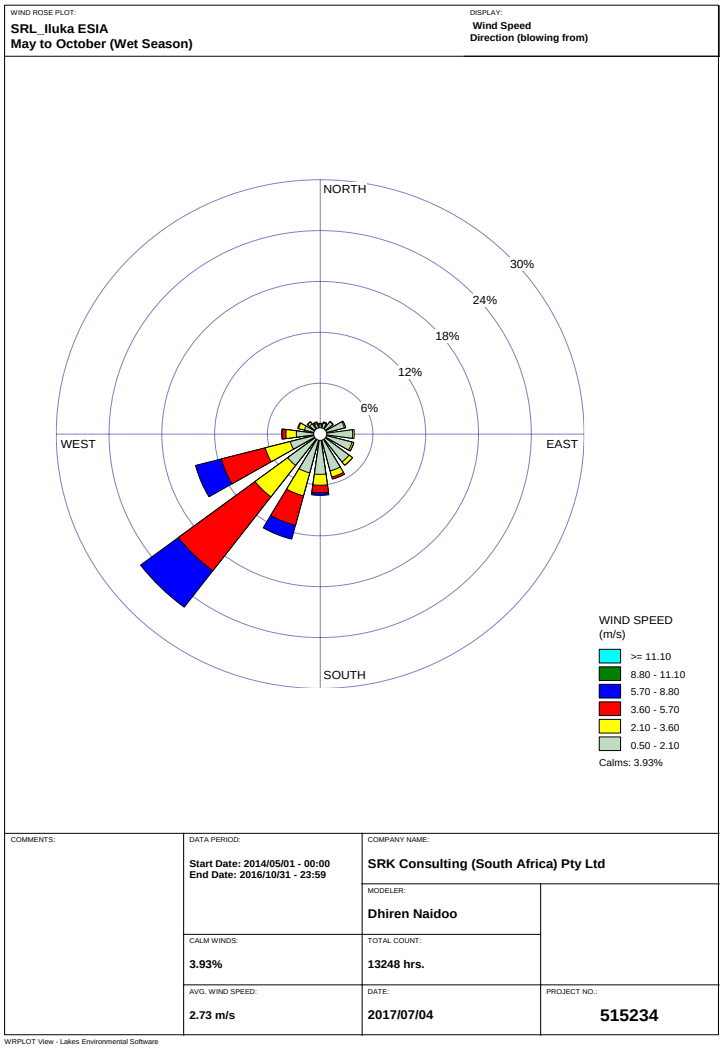

Figure 4-6b: Wet season (May to October)

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LAKES ENVIRONMENTAL SEASONAL WIND ROSES

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Figure 4-6: Lakes Environmental seasonal wind roses

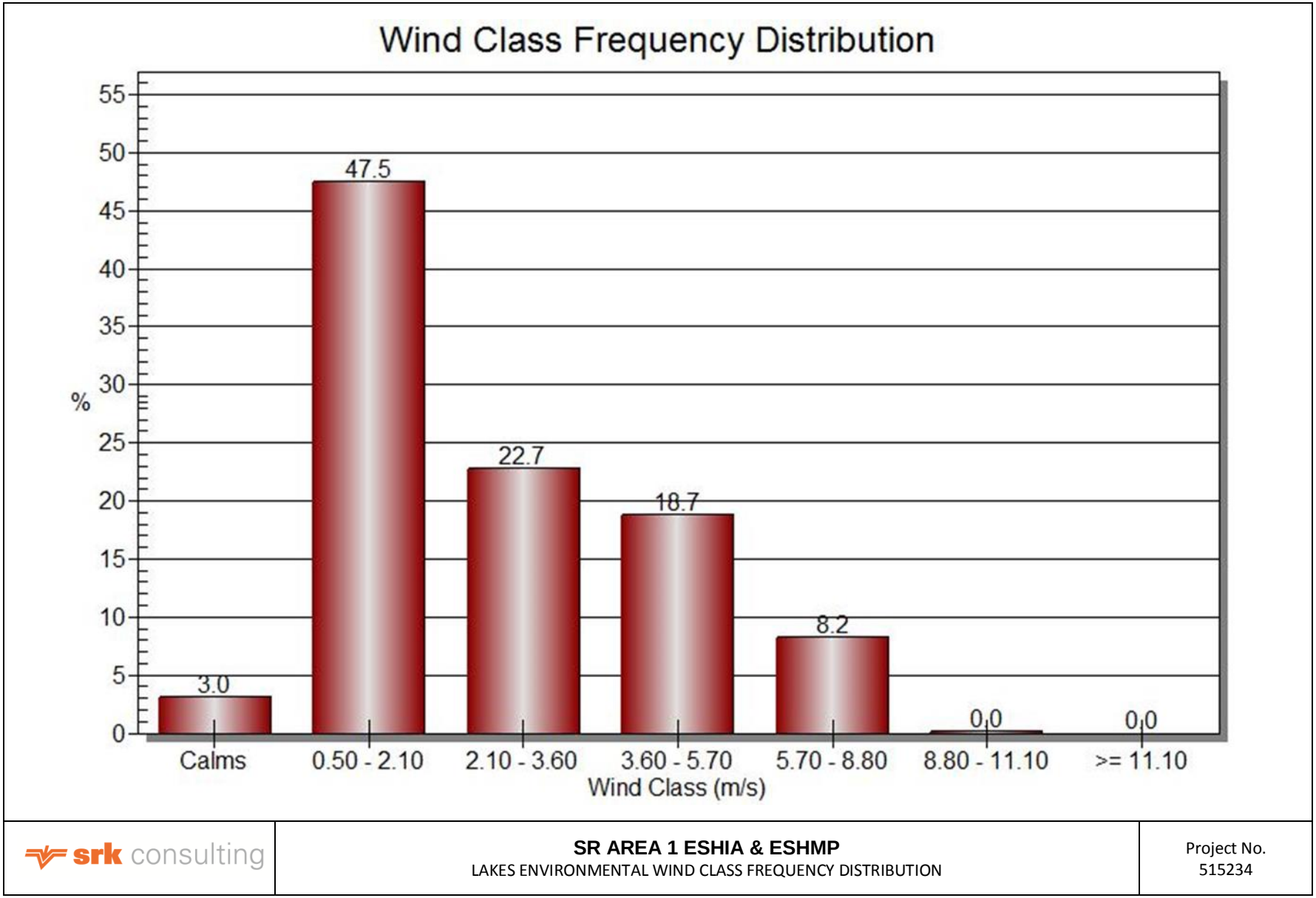


Figure 4-7: Lakes Environmental wind class frequency distribution

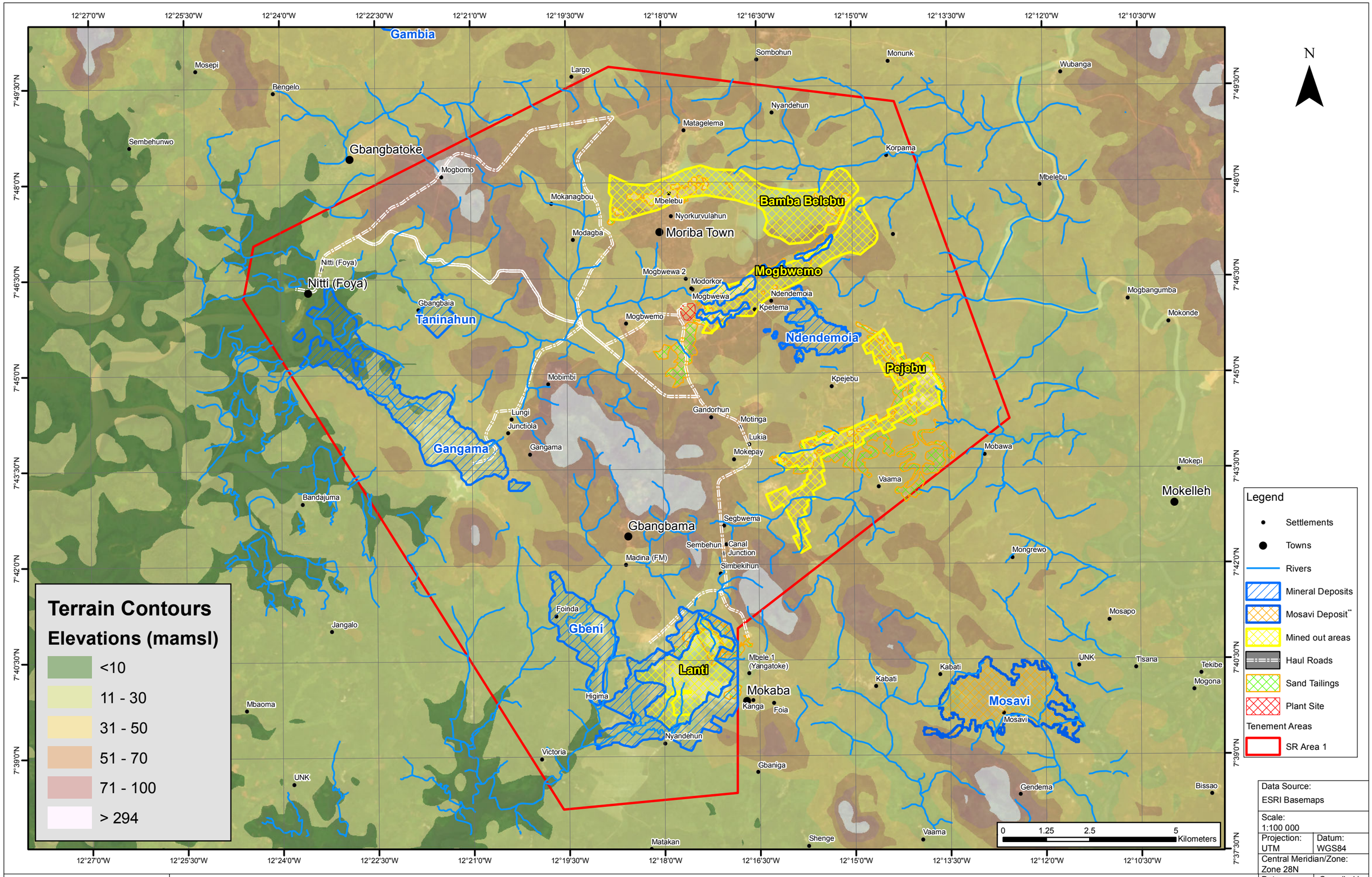
4.2 Topography and geology

The content of this section is adapted from the specialist Soils and Land Capability Assessment (ESS 2018) (Appendix K).

4.2.1 Topography

The topography of 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 areas adjacent to the hills comprise undulating, broad expansive fluvial plains, becoming increasingly flat towards the mangrove swamp areas.



Data Source:	ESRI Basemaps
Scale:	1:100 000
Projection: UTM	Datum: WGS84
Central Meridian/Zone:	Zone 28N
Date:	Compiled by:
21/09/2017	ALLK
Project No:	Fig No:
515234	4-8

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SR AREA 1 ESHIA & ESHMP

RELIEF MAP FOR SR AREA 1 AND SURROUNDING LANDSCAPE

Path: G:\519230_AECI_BB_PERF_MON_2017\8GIS\GISPROJ\MXD\515234_F4_8_SRL_TopoMap_A3L_23022018.mxd

Revision: A Date: 23 02 2018

4.2.2 Geology

Knowledge of the overall geomorphology and the regional and local geology in particular is helpful in better understanding the origin of the soils and their associated land capability, the extrapolation and use of site-specific information (soil and core sampling and logging undertaken by the mine geologists) being invaluable.

The lithological sequence and generally similar geological structures that define the mining areas and the depositional environment that characterises the emplacement and genesis of the mineral deposit, all have an influence on the soil formation and characteristics.

Regionally, the geology comprises two tectonic-stratigraphic units, the stable Precambrian West African Craton that forms the majority of the eastern side of the country, and comprises elements of an orogenic belt that was deformed during the Pan-African tectono-thermal event, and a 20 – 40 km wide coastal strip to the west comprising Pleistocene to Recent sediments (Figure 4-9).

The origin of the heavy mineral deposits at SRL are proximal alluvial placers in origin, with the primary source of mineralisation derived from the quartzo-feldspathic gneisses of the Precambrian (2.1 ba) Kasila Group (refer to Figure 4-9). The heavy mineral suite is hosted within the Bullom Group, the onset of which marked the end of the late Tertiary marine regression.

Sea levels at this time were approximately 100 m below the present levels, exposing the basement rocks of the Kasila Group to erosion. Mechanical and chemical degradation of the Kasila gneisses to form kaolinite and other clay minerals, subsequently liberated the heavy minerals where they were eroded and deposited into pre-incised channel systems. It is these systems that have been mined and identified for further exploration.

The earliest drainage pattern probably followed the regional structural fabric, draining to the Jong River in the south east. A secondary drainage pattern, orientated to the north-north east was superimposed over the basement fabric, while the current day drainage is the result of a marine transgression and the Bullom sedimentation during the Cenozoic uplift.

Surface geology in the project area consists of laterite derived from weathered bedrock exposed in the Gbangbama and Imperi Hills. The local bedrock is a Precambrian aged high-grade quartzo-feldspathic-garnet gneiss (charnockites) with accessory rutile, ilmenite, zircon, and monazite.

Concentrations of these heavy resistate accessory minerals in the laterites and associated clay soils surrounding the hills, constitute the ore bodies that are being mined by SRL within the alluvial deposits. The mineral assemblage reported in SRL gravity concentrates is typical for titanium-rich placers of similar origin.

The alluvial-laterite / bedrock contact is often marked by a sharp change in slope, often at the swamp / upland interface. The alluvial deposits, found mainly in or near the tidal creek areas, have been protected from erosion by the general rise in sea level and burial by the marine sediments. Valley walls of more resistant but weathered gneiss also protect the alluvium and heavy laterisation of the alluvium, giving rise to massive iron cemented sands.

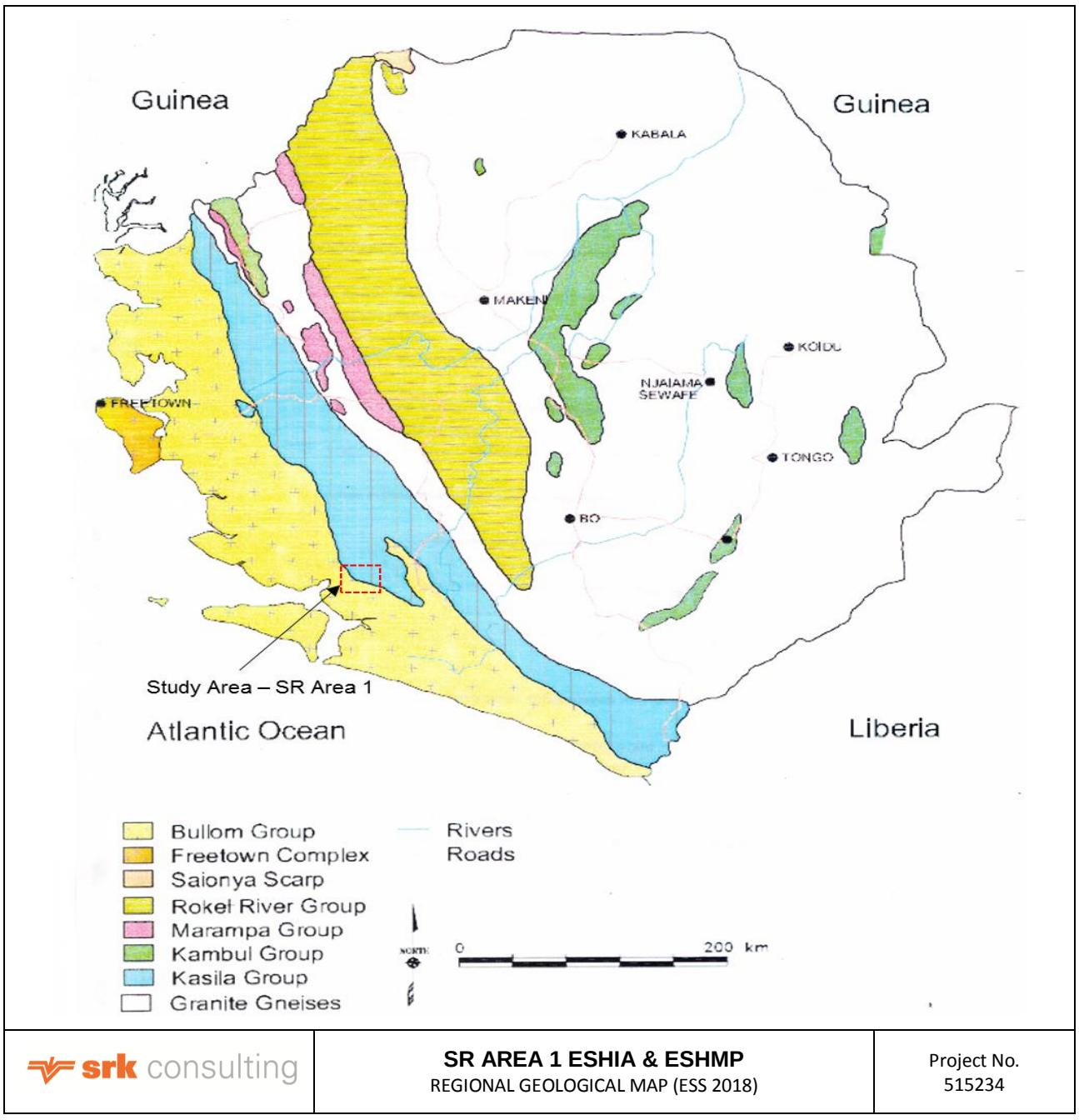


Figure 4-9: Regional geological map (ESS 2018)

4.3 Soil quality

The content of this section is adapted from the specialist Soils and Land Capability Assessment (ESS 2018) (Appendix K).

The geology (parent materials), climate and topography (slope and attitude) are some of the drivers for soil formation and contribute to the variation in soil forms across the SR Area 1. Climate (rainfall) and the effects of mechanical weathering (erosion) have a significant influence on the weathering, transportation and depositional processes, while the geology has an influence on the soil chemistry and structural characteristics.

The climate is typically described as a tropical environment comprising hot and humid conditions with high rainfall during the wet season. The high rainfall is significant to the erosion and depositional conditions that effect pedogenisis.

Four topographic zones were identified across the area of study (SR Area 1). These include:

- 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 midslopes; and
- The ridge or crest slope and shallow to deep soils on saprolitic crystalline bed rock.

4.3.1 Soils characterisation

Based on the field studies (ESS 2018) and assimilation of the historic soil studies and assessments, the soils can be broadly categorised into three dominant reference groups, each group reflecting similar physical and chemical characteristics. The dominant soils groupings include:

Fluvisols

Fluvisols accommodate genetically young soils in fluvial, lacustrine or marine deposits. Despite their name, Fluvisols are not restricted to river sediments (Latin *fluvius*, river); they also occur in lacustrine and marine deposits. Many Fluvisols correlate with Alluvial Soils, Stratified Alluvium, Stratic Rudosols, Fluvents or Auenböden. The Fluvisols mapped are confined almost exclusively to the colluvial accumulation of transported soils within the alluvial plains.

Ferralsols

Ferralsols represent the classical, deeply weathered, red or yellow soils of the humid tropics. These soils have diffuse horizon boundaries, a clay assemblage dominated by low-activity clays (mainly kaolinite) and a high content of sesquioxides.

Ferralsols are also known as Oxisols, Laterites or Hard Plinthite, are associated with strongly weathered material on old, stable geomorphic surfaces, and develop faster in material weathered from basic rock than from siliceous material. This soil group is typically found on level to undulating land of Pleistocene age or older, and are less common on younger, easily weathering rocks.

The deep and intensive weathering results in a residual concentration of resistant primary minerals (e.g. quartz) along with sesquioxides and kaolinite. This mineralogy and the relatively low pH explain the stable microstructure (pseudo-sand) and yellowish (goethite) or reddish (hematite) soil colours.

Gleysols

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.

Gleysols with a thionic horizon or hypersulfidic material (acid sulphate soils) are common in these reducing environments as reported in the studies undertaken by Knights Piésold 2001. Redox processes may also be caused by up-moving gases, like CO_2 or CH_4. Gley or gleycutanic soils with clear signs of groundwater influence are derived from the Russian - gley (a mucky mass) (a soil name introduced by G.N. Vysotskiy in 1905). These soils cover a wide range of unconsolidated materials, mainly fluvial, marine and lacustrine sediments that are found in bottom lands and low lying topographic positions in landscapes with a high groundwater table, tidal zones, shallow lakes or sea shores. These soils were confined almost exclusively to the mangrove swamplands in the north west of SR Area 1.

4.3.2 Soil classification and site evaluation

The soils and land capability specialist (ESS 2018) undertook the site assessment and soil mapping of the dry mining areas within SR Area 1.

The soil structure of the interfluves returned apedel to single grained friable loamy sands, with occasional weak crumby laminated structure and well defined peds, with better than average permeability and moderate to poor water holding characteristics. These soils are for the most part well drained and returned effective rooting to depths of between 650 mm and 900 mm. These soils are of the more productive soils in the area, albeit that the highly leached nature and associated poor nutrient levels render these soils of a low potential grazing / sub arable (subsistence) to poor arable land capability.

The Fluvisols that dominate these areas are derived from the crystalline rocks of the more mountainous hinterland (Kasila Group and Granite Gneisses) to the east of the SR Area 1 (Figure 4-10).

In contrast, the marshlands and tidal zone (Gangama) comprises moderately shallow to shallow saturated gleycutanic and gleyed profiles (Gleysols), a significant area of hydromorphic and wet-based soils that occupy the tidal zone and mangrove swamp lands. The anaerobic conditions and tidal nature of this environment renders these sites of low productivity and of a wetland status in terms of their land capability rating. These soils range from shallow saturated sandy clays and gley's, to moderately deep silty clay loams on a hard plinthic "C" horizon.

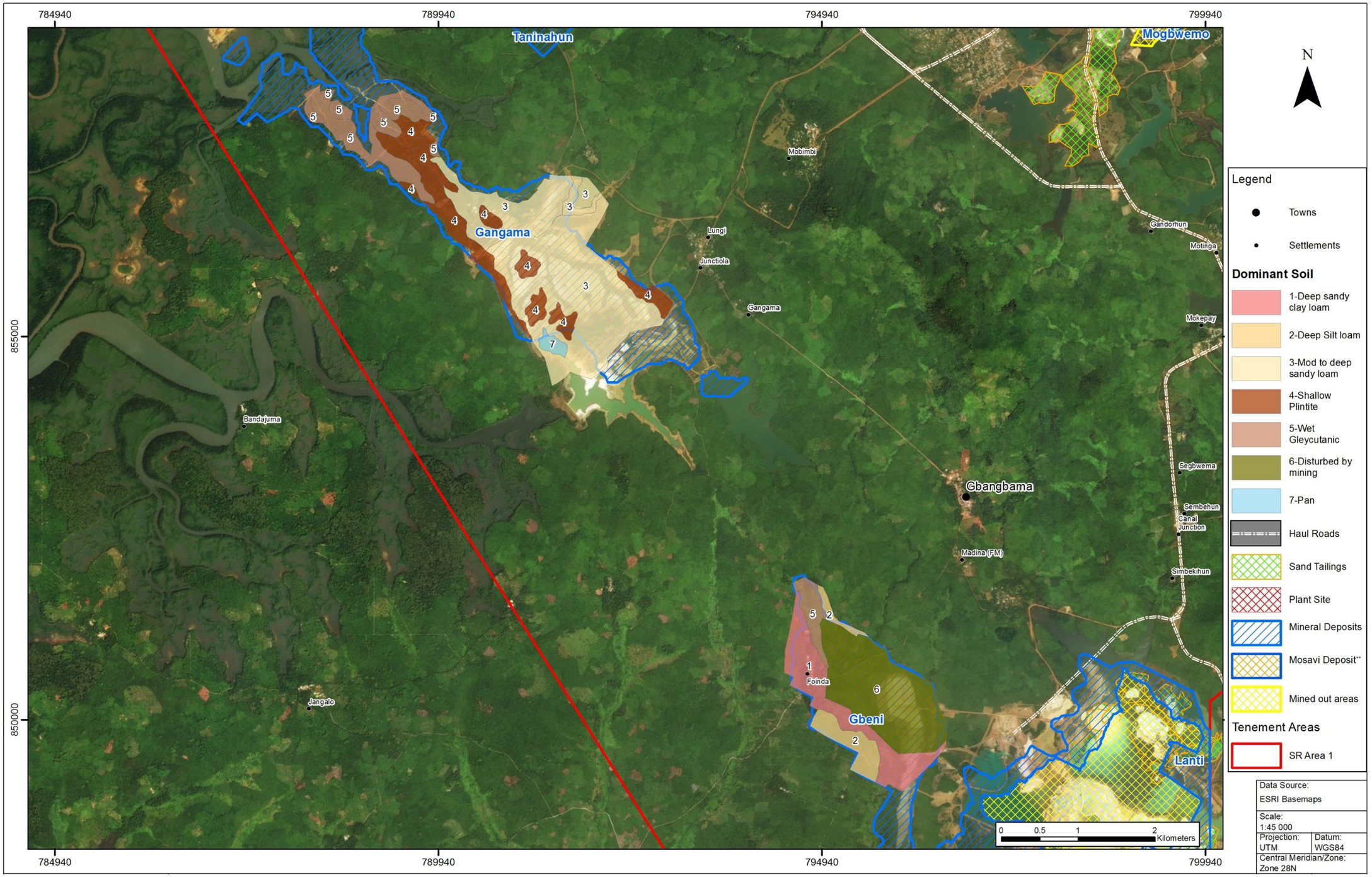
Inland of the coastal plains the soils are representative of in-situ processes and comprise for the most part shallow rooting depths on deeply weathered sandy loam of varying colour and structure underlain by on a hard plinthic base ("C" horizon). This zone is characterised by soils with a more variable texture and structure and comprises more gravelly sandy loams and silty sand loams with highly variable rooting depths (200 mm to over 1,200 mm). The soil water holding capability is at best moderate to poor 80 mm/m-100 mm/m. These soils are generally red brown to yellow or orange / red in colour and show little evidence of redoximorphic characteristics within the profile. Mapping on these sites was limited, the mining areas associated almost exclusively with the alluvial flood plains, tidal zone and low lying colluvial depositional sites.

Across the catena the soils grade inland from the coastal swamp lands to the colluvial / alluvial derived sandy loams and silty clay loams associated with the fluvial / riverine areas and on upslope through the Ferralsols and shallower rooted soils associated with the lateritic sub base and steeper hill slopes.

The interfluves and shallow wide-open valleys that characterise the south and central portions of the proposed mining include the Lanti, Gbandei, Gbeni, Bondavei and Gangama South dry mining deposits, which contrast with the mangroves and marshland environment in the north-western portion of Gangama. The soils of these areas are generally characterised by deeper and sandier Fluvisols returning clay fractions between 8 % and 16 % and a significant sand fraction (upwards of 65 % to 75 %).

The differing soil groupings (dominant forms) are depicted in Figure 4-10. This system groups the soils based on their physical and chemical similarities, a system that helps in the formulating of a meaningful soil utilisation and management plan for the materials that are to be disturbed.

In addition, the sensitivity or vulnerability of a site to being disturbed, uses the physical and to some extent chemical attributes of the soils as a measure. The sensitivity / vulnerability rating is a tool used to better understand the potential impact that an activity might have on the site, and assists in the development of the soil utilisation plan (stripping depths, stockpiling methods and general mitigation of impacts).



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SR AREA 1 ESHIA & ESHMP
DOMINANT SOILS (ESS 2018)

Project No. 515234

Figure 4-10: Dominant soils in dry mining areas of SR Area 1 (ESS 2018)

4.3.3 Laboratory analysis

As part of the Soils and Land Capability Assessment (ESS 2018), a number of soil samples were taken as part of the site assessment and analysed for chemical and physical parameters at an accredited laboratory. Samples were taken from a number of auger point observations, the "A" horizon and the "B2/1" horizon, collectively regarded as the "utilisable" portion of the soil profile, while bulk density and physical parameters were assessed from representative samples taken for selective test pits.

Information obtained from the laboratory results includes, the soil chemistry as well as soil texture, and nutrient status, information that is needed when considering how the materials will react to being disturbed, stockpiled and stored, and how productively they can be used during rehabilitation.

These information sets combined with the field observations (soil depths, topographic slope, altitude, ground roughness and geology) to compile a baseline of information. The specialist study (Appendix K) provides greater detail in terms of presentation of the laboratory results and their interpretations, however, for purposes of this report, the outcomes are summarised in the subsections that follow.

Physical characteristics

From the analytical results, the physical soil characteristics include:

- Topsoil clay percentages ranging from as low as 4 % on the alluvial derived sands, to more than 15 % on the sandy loams, with a weak correlation with their position in the landscape / topography. The wet-based and in places saturated Gleysols returned higher clay percentages, a distinguishing aspect that is significant;
- Subsoil clay content ranges from less than 8 % on the Fluvisols and alluvial derived stratified alluvium, to as high as 48 % on the clay rich Gleysols;
- Moderate to high infiltration / permeability rates, are associated with the sandy loams and well sorted alluvial / colluvial materials, which form the present-day cover materials to the lower slopes and riverine environs upslope of the mashes and mangroves; and
- The wetlands and swamplands, which predominate within the tidal zone downslope of the coastal plains and fluvial riverine environment returned a range of hydromorphic soils with a higher silt and clay content. The sensitivity of this zone is important to a range of ecological aspects and ecosystem services.

In summary, field observations and laboratory analysis results returned better than average organic matter content, generally low clay percentages for all but the gleyed materials within the mangroves and swamplands, with limited structure and textural variation. The contrast in soil structure and clay texture (saturated silty clay loams) of the tidal mangrove swamplands in the north-west, will influence the management recommendations for soil storage and utilisation during the operation and rehabilitation.

Chemical characterisitcs

From the analytical results, the soil chemical characteristics include:

- The chemistry of the soils reflects the weathered product of the underlying (in-situ) geology (Ferralsols) and / or transported materials of the upslope environs from which they are derived (Fluvisols and Gleysols). The physical and chemical characteristics of the materials are shown in Table 3.3.3a of the specialist study (Appendix K), and typify the acidic characteristics and low fertility of soils that evolve in tropical areas of high rainfall. The highly leached status of all exchangeable cation bases (e.g. calcium, sodium, potassium, and magnesium) and nutrients (Birkeland, 1984 and Langmuir, 1997) evident in the results;
- The fluvial zone returned chemistry that is indicative of the highly leached and better sorted transported materials, and reflects the pedogenetic character and structure of younger deposited materials with less pronounced lamellae and ped formation. These soils are nutrient poor, lower in clay mineralisation, have generally more sand, higher infiltration rates and permeability, as well

as lower water holding capabilities. These are important factors when considering the utilisation potential of the soil for rehabilitation; and

- In contrast the Ferralsols are rich in iron, returning red and yellow orange coloured soils with a distinctive ferricrete / laterite forming a hard, resistant gravel to the base of the soil profile. The inherent structure is more pronounced with an apedel to weak crumby structure and stronger ped formation, a distinguishing characteristic. These soils are generally shallower in rooting depth (<600 mm) and while they have slightly higher clay content (field observations), the relatively low clay percentages and poor nutrient stores are supportive of the dystrophic leaching status.

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 (Al^{3+} or $Al(OH)^{2+}$), 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/%).

Availble Water Capacity

In addition to a soil being able to retain a nutrient pool it also needs to retain water if it is going to be of use as a growing medium.

Available Water Capacity (AWC) of a soil is a function of the water which lands on the surface and infiltrates into the soil and is retained within the pore spaces, and the excess water that drains through the soil and is lost down profile into the groundwater environment.

The vadose water (water in the unsaturated soil profile) available to plants is held in the profile on the clay surfaces and taken up by the plants as needed. The percentage and types of clay determine the ease with which the soil water can be taken up by a plant.

The AWC has been based on the soil texture and clay percentages obtained from the soils analysis, and expressed as a function of utilisable soil depth. This measure along with the soil depth and nutrient availability are important considerations when debating and considering how much soil is needed for sustainable rehabilitation, the retention of soil water being one of the critical aspects in rehabilitation.

4.3.4 Soil erodibility and compaction

The physical attributes of the soils (structure and texture) coupled with the poor nutrient stores, the low clay content, the climate (high rainfall) and the generally flat to undulating topography (all but the hills and elevated ridges) result in an erosion index of moderate. This is tempered somewhat by the natural vegetative over of tropical bush and grasses to an index of Low.

Erodibility is defined as the vulnerability or susceptibility of a soil to erode. It is a function of both the physical and chemical characteristics of a material, the topographic slope as well as the treatment of the soil.

The resistance to, or ease of erosion of a soil, is expressed by an erodibility factor ("K"), which is determined from soil texture / clay content, permeability, organic matter content and soil structure. The Soil Erodibility Nomograph (Wischmeier *et al*, 1971) is used to calculate the "K" value.

The Index of Erosion (IOE) can be determined by multiplying the "K" value by the "slope" (measured as a percentage). Erosion problems may be experienced when the IOE is greater than 2.

The average IOE for the majority of the soils that are 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 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.

The vulnerability of the "B" horizon (refer to Table 2.3a of the specialist study, Appendix K) to erosion once the topsoil and / or vegetation is removed, must not be under estimated when undertaking activities likely to disturb these soils.

4.4 Geochemistry

The content of this section is adapted from the specialist Geochemistry Characterisation of Selected Residues report (i.e. geochemistry study) (SRK, 2018(2)) which is attached as Appendix E.

For the above geochemistry study, SRK undertook the sampling of the tailings from 18 June 2017 to 23 June 2017 during the wet season (May – October). The sampling focussed on Area 1 (Gangama and Lanti) tailings that include primary process tailings and secondary process tailings. The primary process tailings are the tailings generated during the primary preparation (feed preparation and concentrator) at the two mining areas before the concentrates go for secondary processing at the MSP. The secondary process tailings are the tailings generated at the MSP following feed preparation and mineral separation.

4.4.1 Mineralogy

The primary process tailings consist of predominantly inert or resistant quartz that does not contribute to either acidity or alkalinity (SRK, 2018(2)).

The reactive minerals in primary tailings include kaolinite [$Al_4(OH)_8(Si_4O_{10})$] and gibbsite ($Al(OH)_3$). Kaolinite occurs in all the analysed primary process tailings samples. Kaolinite is an aluminosilicate mineral that dissolves to some extent in Acid Sulfate Soils (ASS) and therefore acts as a neutralising agent in the tailings.

Gangama dry mining and Lanti dry mining tailings contain gibbsite ($Al(OH)_3$), a low solubility secondary mineral, which can also contribute to Neutralisation Potential (NP).

Gibbsite does not occur in the Lanti dredge mine tailings in detectable quantities but occurs in detectable quantities in the Lanti dry mining tailings.

The precipitation of gibbsite in the tailings was confirmed by running a PHREEQC[5] check using 25 % water extract data at a paste pH of 5.6.

The reactive minerals in secondary process tailings include marcasite and pyrite in SFT, goethite in Total Tailings (TT) and Coarse Electrostatic Tailings (CET) and almandine in CET, TT, Ilmenite Tailings (IT) and Fine Electrostatic Tailings (FET). Marcasite and pyrite are likely to contribute to acidity in SFT when exposed to oxidising conditions. Goethite, a pseudomorph of marcasite and pyrite may contribute to NP in TT and CET at pH range of 3.0 – 3.7. Almandine, a fast weathering aluminosilicate mineral, may contribute to the NP in CET, TT, IT and FET. In addition, monazite, a radioactive phosphate mineral, occurs in CET, FET, IT and TT.

In addition, monazite, a radioactive phosphate mineral containing cerium, occurs in CET, FET, IT and TT.

4.4.2 Elemental composition

Total metal analysis of the tailings was undertaken to identify elements that are present at concentrations that may be of environmental concern with respect to water quality.

The appropriate media to compare the concentrations of the elements in the tailings is the total elemental concentration of the ore material from which the tailings are generated to determine enrichment relative to the ore given that there is no physical or chemical alteration of the materials. However, elemental concentration data of the ore material was unavailable and the elemental concentrations of the tailings have been compared to the average crustal abundance (Forstescue, 1992). Although the average crustal abundance data do not necessarily account for mineralisation present in the ore body, in the absence of ore data, the use of crustal abunbace data is an industry accepted approach of identifying enrichment and is commonly applied in ESIA studies.

Elements that are significantly enriched (i.e. GAI ≥3) in the primary process tailings include silver (<0.40 – 0.81 mg/kg), boron (240 – 590 mg/kg), cadmium (0.78 – 1.4 mg/kg) and selenium (22 – 41 mg/kg).

Elements that are significantly enriched (i.e. GAI ≥3) in the secondary process tailings include silver (<0.40 – 28 mg/kg), boron (370 – 1,290 mg/kg), cadmium (<0.10 – 1.4 mg/kg), cobalt (16 – 443 mg/kg), lead (<0.10 – 194 mg/kg), selenium (<3.0 – 91 mg/kg), titanium (0.29 – 33 %) and zirconium (114 – 4,000 mg/kg).

However, significant enrichment does not necessarily imply that the element represents an environmental risk although the enriched element in the tailings may leach into surface water and groundwater depending on site conditions. The risk that these enriched elements present is a function of the environmental mobility of the element, assessed by leach tests.

4.4.3 Acid generating characteristics

The primary process tailings are Non-Acid Forming (NAF). This is consistent with the mineralogy results that showed that there are no detectable sulfide minerals that could potentially generate acidity in the primary process tailings.

[5] PHREEQC is a computer program written in the C programming language that is designed to perform a wide variety of aqueous geochemical calculations [Source: https://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc.v1/html/phqc_2.htm; accessed 13 February 2018]

SFT are Acid Generating (AG) and have the potential to stay acidic in the long term if exposed to oxidizing conditions. This is consistent with the mineralogy results that indicated the presence of acid generating sulfide minerals, marcasite and pyrite. TT and IT also contain sulfides and are Potentially Acid Generating (PAG). FET and CET are NAF.

4.4.4 Leachate quality

To determine the leachable major and trace constituents, short-term leach tests were conducted on solid samples. The leachates from the solid samples and supernatant from the slurry samples were analysed for major and trace constituents.

The leachate and supernatant qualities were assessed against:

- Sierra Leone's SLEP (MM) Reg. 2013 which stipulates the "limit at any moment" effluent quality for mining and metallurgic operations; and
- Background surface water quality (average concentrations for July, August and October 2017) from surface water monitoring point SW6, located a distance away from the mining activities and representing the least affected surface water monitoring point within SR Area 1 (Figure 4-28))

The background surface water quality is within the WHO limits and the SLEP (MM) Reg. 2013 which are more stringent than the WHO limits except the mercury limit (SLEP (MM) Reg. 2013, 0.002 mg/l and WHO, 0.0005 mg/l).

The leachates from primary process tailings are acidic (pH < 5.9) and characterised by low salinity (EC < 3.3 mS/m). All the measured parameters in the leachate are within the *SLEP (MM) Reg. 2013* "limit at any moment" effluent quality 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 also 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" effluent quality 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).

4.5 Radiation

The content of this section is adapted from the specialist Radiological Assessment and Gap Analysis report (i.e. radiation study) (SRL 2018) which is attached as Appendix I.

This section describes the radiological assessment and gap analysis for SR Area 1, which is based on a review of historic data, naturally occurring radioactive materials (NORM) in the ore, products and tailings and man-made radioactive sources (density gauges) (SRL 2018). Commenced in 2017, the study comprised an assessment of potential radiation pathways, including dose estimations for the workforce and members of the public, and provided recommendations for a further phase of studies to improve the understanding and management of any radiological impacts.

4.5.1 Sources of radiation at SRL operations

There are two main sources of radiation exposure in mineral sands mining and processing at SRL: man-made sources, i.e. density gauges, which are used in various processes of the operation to determine slurry densities; and naturally occurring radioactive materials (NORM) in the ore, products and tailings.

Man-made radiation: sealed radioactive sources

Various Cesium (Cs-137) density gauges are used at the dredge; dry mining units (Lanti and Gangama); and the MSP for process optimization purposes. Additional sources are stored in a licensed bunker facility for future use / re-use, or for future disposal (Figure 4-11a). Sources are classified into five categories: Category 1 sources are potentially the most dangerous and Category 5 sources are the most unlikely to be dangerous. Two types of risks are considered, the risk in handling and being close to a source, and the risk associated with radioactive material being dispersed from a source. It would be highly unlikely for a Category 1 source to contaminate a public water supply to dangerous levels, even if the radioactive material were highly soluble in water. It would be virtually impossible for a source in Caterogy 2 to 5 to contaminate a public water supply to dangerous levels.

Individual sources at SR Area 1 are either Category 4 or Category 5 sources, which are the lowest activity sources in industry (Figure 4-11b).

Table 4-8: Categories of sources

Category	Risk in being close to an individual source	Risk in the event that the radioactive material in the source is dispersed by fire or explosion
1	**Extremely dangerous to the person:** This source, if not safely managed or securely protected, would be likely to cause permanent injury to a person who handled it or who was otherwise in contact with it for more than a few minutes. It would probably be fatal to be close to this amount of unshielded radioactive material for a period in the range of a few minutes to an hour.	This amount of radioactive material, if dispersed, could possibly, although it would be unlikely, permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a few hundred metres away, but contaminated areas would need to be cleaned up in accordance with international standards. For large sources the area to be cleaned up could be a square kilometre or more.
2	**Very dangerous to the person:** This source, if not safely managed or securely protected, could cause permanent injury to a person who handled it or who was otherwise in contact with it for a short time (minutes to hours). It could possibly be fatal to be close to this amount of unshielded radioactive material for a period of hours to days.	This amount of radioactive material, if dispersed, could possibly, although it would be very unlikely, permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a hundred metres or so away, but contaminated areas would need to be cleaned up in accordance with international standards. The area to be cleaned up would probably not exceed a square kilometre.
3	**Dangerous to the person:** This source, if not safely managed or securely protected, could cause permanent injury to a person who handled it or who was otherwise in contact with it for some hours. It could possibly, although it would be unlikely, be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks.	This amount of radioactive material, if dispersed, could possibly, although it would be extremely unlikely, permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a few metres away, but contaminated areas would need to be cleaned up in accordance with international standards. The area to be cleaned up would probably not exceed a small fraction of a square kilometre.

Category	Risk in being close to an individual source	Risk in the event that the radioactive material in the source is dispersed by fire or explosion
4	**Unlikely to be dangerous to the person:** It is very unlikely that anyone would be permanently injured by this source. However, this amount of unshielded radioactive material, if not safely managed or securely protected, could possibly, although it would be unlikely, temporarily injure someone who handled it or who was otherwise in contact with it for many hours, or who was close to it for a period of many weeks.	This amount of radioactive material, if dispersed, could not permanently injure persons.
5	**Most unlikely to be dangerous to the person:** No one could be permanently injured by this source.	This amount of radioactive material, if dispersed, could not permanently injure anyone.

SRL has a Radiation Management Plan (RMP) for sealed radioactive sources (September 2017) detailing the requirements for the safe storage; transport and use of portable and fixed industrial gauges. The purpose of the RMP is to ensure that all practices involving radiation gauges at SRL are conducted as safely as possible and in compliance with the Sierra Leone *Nuclear Safety and Radiation Protection Act 2012*. Compliance with the RMP ensures that the radiation doses to all employees, contractors and visitors are managed appropriately and below the prescribed statutory limits and are as low as reasonable achievable (ALARA). It also ensures that the number of people exposed to radiation, and the likelihood of unexpected exposure to radiation, are minimised.

The GOSL Ministry of Energy Nuclear Safety and Radiation Authority (NSRPA) have issued two Certificates of Registration (licences) for the possession and use of density gauges (Appendix 3 of the Radiation Specialist report).

Table 4-9: SRL Radiation Licenses

Certificates of Registration		
Certificate No	**Provision**	**Validity Period**
APN-USE-0026/16	Authorization for possession and use	12 Months
APN-POS-001/16	Authorization for possession	12 Months

Detailed in these licences, the Licensee is directed to:

- Ensure that any personnel, who subsequently may be engaged to operate, install or otherwise deal with the density gauge, have approved training;
- Comply with the *Nuclear Safety and Radiation Protection Act 2012*;
- Provide prior written notification to the NSRPA of any intension to sell, relocate, install or dispose of the density gauges;
- Provide prior written notification to the NSRPA of plans to modify the structure of the premise in any way that may significantly impact on radiation protection and safety; and
- Ensure that the installation, service or maintenance of the density gauge on the premises is performed only by personnel authorised by the regulatory authority.

Regular inspections are conducted by the NSRPA to ascertain compliance to license conditions.

Figure 4-11(a): Gauge storage facility SR Area 1

Figure 4-11 (b): Density gauges in operation

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Figure 4-11: Photographs of a gauge storage facility (left) and a density gauge in opertation (right)

Naturally Occurring Radioactive Material (NORM)

Deposits of mineral sands containing heavy or dense minerals originate from erosion and weathering of rocks and occur as a result of the concentrating effects of wind, ocean currents and wave action. These deposits are enriched through such geological processes in the naturally occurring radionuclides of the uranium and thorium decay chains. The radioactivity is primarily associated with specific minerals within the deposit (e.g. especially monazite and to a lesser extent, zircon). The potential radiation hazard increases with the concentration of these minerals in various products and tailings streams.

Radioactivity in the mineral sands products, especially zircon, can also occur due to incorporation of elemental thorium and uranium into the crystal lattice of the mineral at the time of formation. The amount of monazite in the minerals sands ore typically determines the level of radiation protection that may be necessary. In the deposits within the project area, monazite only occurs in low concentrations (typically <1%). Although the monazite content is relatively low, there exists the potential for exposure significantly in excess of average background levels in mine operations where the mineral sands are extracted and concentrated. Of particular significance from a radiation management perspective is the production of a monazite-rich mineral stream, as in the MSP, and its subsequent disposal in the mine pits.

Radioactive decay of uranium and thorium gives rise to a number of decay products (Appendix 4) as the original atoms change from one element to another as they decay through the emission of radiation, ultimately ending in a stable final atom. In most mineral sands deposits, the uranium and thorium decay chains are in secular equilibrium, which means that the radioactive decay product has the same activity concentration as the parent. If the deposits are subject to chemical treatment processes, then some radionuclides, for example radium, may be separated from their parent radionuclide, thereby disrupting the state of equilibrium. However, such processes are not common in mineral sands processing and the radioactivity contained in the mineral grain remains intact and the chemical availability of radionuclides with respect to water solubility, plant uptake and metabolic behaviour following inhalation or ingestion does not alter from the natural state.

SRL Ore

The typical mineral assemblage of the ore in SR Area 1 deposits, as summarized in Table 4-10, consist predominantly of rutile (TiO_2), followed by ilmenite ($FeTiO_3$), and zircon ($ZrSiO_4$) respectively. The orebodies in general have an activity concentration of less than 1 Becquerel per gram (Bq/g) uranium and thorium, thereby not classified as requiring Regulation per International Atomic Energy Agency (IAEA) Safety Report Series 49 – Assessing the need for radiation protection measures in work involving mineral sand raw materials standards (2006): "The following values of activity concentration are specified in the Standards as being values below which it is usually unnecessary to regulate, irrespective of the quantity of material or whether it is in its natural state or has been subject to some form of processing:

- 1 Bq/g for uranium and thorium series radionuclides; and
- 10 Bq/g for potassium (40 K)".

IAEA Safety Standards Series RS-G-1.7 - Application of the Concepts of Exclusion, Exemption and Clearance (2004), sets exclusion levels for naturally occurring radioactivity in bulk materials at 1 Bq/g head-of-chain activity for the uranium and thorium decay chain radionuclides. These values are at the upper end of the world-wide distribution for naturally occurring radioactivity in soils. The activity concentration of 1 Bq/g is currently the internationally-accepted level for defining the scope of Regulation for naturally occurring materials containing uranium or thorium.

Ores or mineral concentrates with head-of-chain uranium or thorium activity concentrations less than 1 Bq/g would generally be considered inherently safe (IAEA 2004).

Table 4-10: Typical mineral assemblage of the SRL ore

Mineral assemblage of ore	Typical Abundance (wt%)	Activity Concentration (Bq/g) of constituents (2016 average)
Heavy Mineral Content (HMC)	3 – 5	1.42
Rutile (TiO_2)	1 – 2	0.42
Zircon ($ZrSiO_4$)	~ 0.1	12.18
Ilmenite ($FeTiO_3$)	~ 0.2 – 0.3	1.04
wt% = Weight Percentage		

Heavy Mineral Concentrate

The typical mineral assemblage of HMC produced during primary upgrading of ore at SR Area 1 is summarized in Table 4-11.

Table 4-11: Typical mineral assemblage of SRL HMC

Mineral Assemblage of HMC	Typical Abundance (wt%)
Rutile (TiO_2)	41 – 63
Ilmenite ($FeTiO_3$)	15 – 26
Zircon ($ZrSiO_4$)	3 – 4
Others including: Garnet $(Ca, Fe, Mg, Mn)_3(Al, Fe, Mn, Cr, Ti, V)_2(SiO4)_3$; Monazite $(Ce,La,Nd,Th,Y)PO_4$); Iron Oxides (Hematite, Goethite, etc.); Pyrite / marcasite (FeS_2); and Corundum (Al_2O_3)	7 – 25
wt% = Weight Percentage	

As can be seen from Table 4-11, SRL HMC consists predominantly of rutile, followed by ilmenite and zircon respectively.

SRL products and tailings

Where specific data on the radionuclide content of SRL heavy mineral products is not available, the information from other published data for heavy minerals from other sources may be used to indicate the potential activities in the various process streams. The data in Table 4-12 presents the typical radionuclide content of various heavy minerals extracted from mineral sands Australian operations (Iluka 2005; UPT 1996; WACME 2000).

Table 4-12: Radionuclide concentrations in heavy mineral sand Australian operations

Mineral	Typical mass concentrations (ppm)		Typical activity concentration (Bq/g)[a]	
	Uranium (U)	Thorium (Th)	Uranium[b]	Thorium[b]
Ilmenite	10-20	50-480	0.12-0.25	0.2-2
Rutile	40-90	40-60	0.5-1.1	0.15-0.25
Zircon	100-300	120-280	1.2-4.0	0.5-1.1
Monazite	1,000-3,000	50,000-70,000	12-40	200-300
Note: (a) Calculated activities using mass / activity relationships of 1 ppm U = 12.4/1,000 Bq/g and 1 ppm Th = 4.07/1000 Bq/g. (b) Expected: uranium (U-238) and thorium (Th-232) in secular equilibrium with decay products in unprocessed minerals.				

Most of the radioactivity associated with heavy minerals is, in particular, due to the presence of significant levels of uranium and thorium in monazite. The content of uranium and thorium in monazite is considerably higher than that of the other minerals. Therefore, in considering the distribution of radioactivity throughout the mining and processing of mineral sands, it is appropriate to focus on the partitioning of monazite at various stages of processing.

In the SR Area 1 operations, monazite is mainly associated with the zircon-rich product; followed by electrostatic tailings; ilmenite tails and ilmenite concentrate respectively and this is reflected in the activity concentrations (Bq/g) as illustrated in Figure 4-12. It has to be noted that the zircon cleaning circuit at the MSP has previously been de-commissioned and the currently produced zircon product therefore contains monazite to a large degree.

Figure 4-12 illustrates the uranium and thorium concentrations in ore, intermediate product (HMC); final products; and tailings streams at SR Area 1.

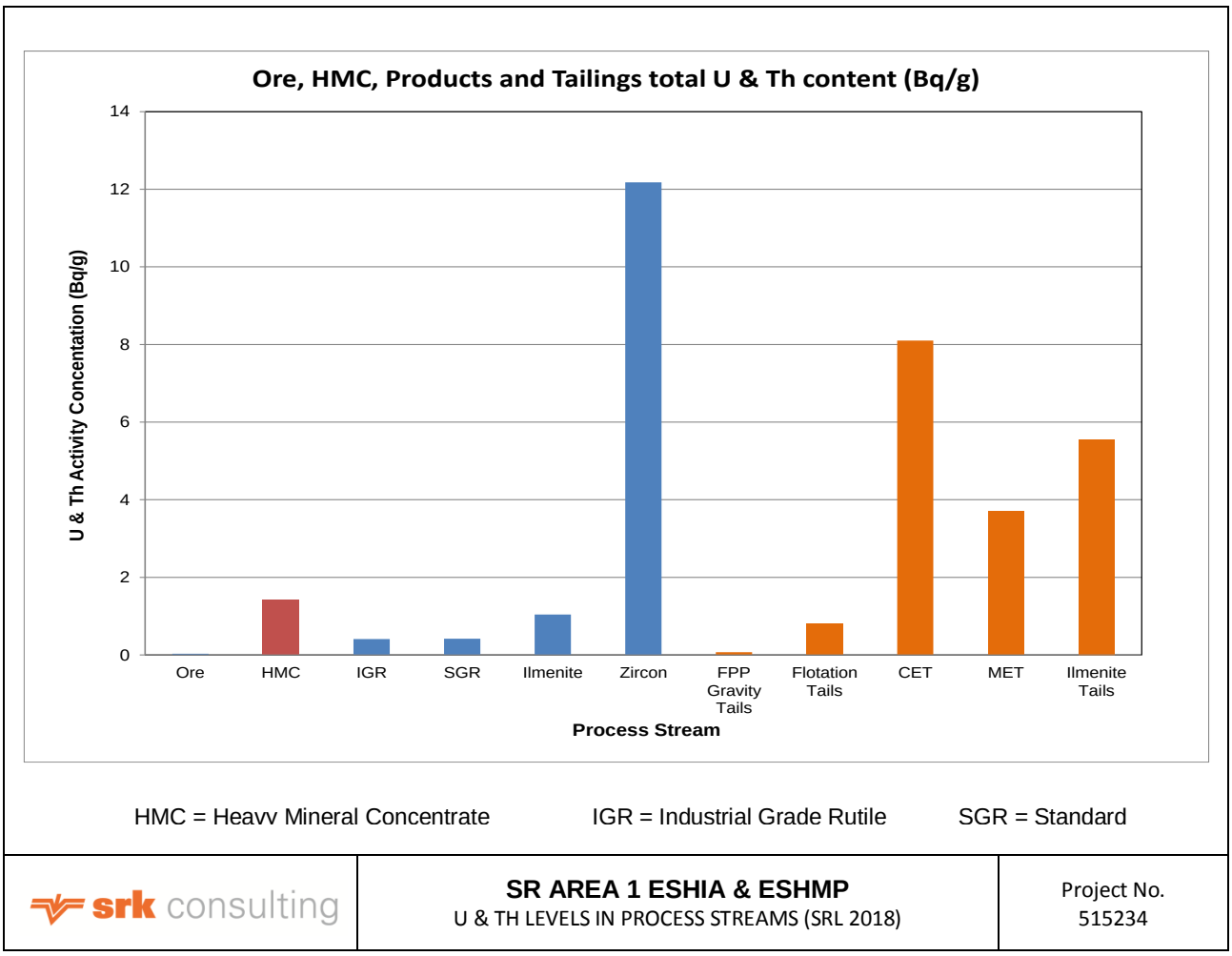


Figure 4-12: Urnaium (U) and Thorium (Th) levels in process streams (SRL 2018)

4.5.2 Dose assessment methodology

An overview of the dose limitation system

The dose limits recommended by the IAEA are set down in the Basic Safety Standards of the IAEA (2011; Table 4-13). The exposure of individuals must be restricted so that both the total effective dose and the total equivalent dose to relevant organs or tissues do not exceed any of the relevant dose limit specified below.

Occupational exposure

- An effective dose of 20 milli Sieverts per year (mSv/y) averaged over five consecutive years, and of 50 mSv in any single year;
- An equivalent dose to the lens of the eye of 20 mSv per year averaged over 5 consecutive years and of 50 mSv in any single year; and
- An equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

Public exposure

- An effective dose of less than 1 mSv in a year;
- An equivalent dose to the lens of the eye of 15 mSv in a year; and
- An equivalent dose to the extremities (hands and feet) or the skin of 50 mSv in a year.

The occupational dose limit of 20 mSv/y, would apply to those workers who are exposed as a result of working directly with radiation or radioactive materials i.e. occupationally exposed persons. This limit is the sum of all exposures, both from external radiation and the intake of radioactive materials.

Table 4-13: Dose limits for Occupational Exposed Persons and the public (IAEA 2011)

Application	Dose Limit: Occupational Exposed Person	Dose Limit: Members of the Public
Effective dose	20 mSv per year averaged over a period of 5 consecutive calendar years [1,2,3]	1 mSv in a year[4]
Equivalent dose to:		
a) Lens of the eye	20 mSv per year averaged over a period of 5 consecutive calendar years [1,2,3]	15 mSv in a year
b) Skin[5]	500 mSv in a year	50 mSv in a year
c) The hands and feet	500 mSv in a year	No limit specified
The limits apply to the sum of the relevant doses from external exposure in the specified period and the committed dose from intakes in the same period. In this Note, committed dose means the dose of radiation, arising from the intake of radioactive material accumulated by the body over 50 years following the intake (except in the case if intakes by children, where it is the dose accumulated until the age of 70)		
Any dose resulting from medical diagnosis should not be taken into account		
Any dose attributable to normal naturally occurring background levels of radiation should not be taken into account.		
Note 1: With the further provision that the effective dose must not exceed 50 mSv in a single year		
Note 2: When a female employee declares a pregnancy, the embryo or fetus should be afforded the same level of protection as a member of the public		
Note 3: When, in exceptional circumstances, a temporary change in the dose limit requirements is approved by the Authority, one of the following conditions applies: a) The effective dose limit must not exceed 50 mSv per year for the period, that must not exceed 5 years, for which the temporary change is approved, and b) The period for which the 20 mSv per year average applies must not exceed 10 consecutive years and the effective dose must not exceed 50 mSv in any single year		
Note 4: In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1 mSv per year		
Note 5: The equivalent dose limit for the skin applies to the dose averaged over any 1 square centimeter of skin, regardless of the total area exposed.		

Potential Exposure Pathways

The mining and processing of heavy mineral ores has the potential to cause elevated radiation exposures of both workers and members of the public during operations and from the management of waste arising from production. Therefore, depending on the level of potential exposures in the industry, certain radiation control measures may be required to provide for an adequate degree of protection for both employees and the public. Appendix 9 provides an introduction to ionizing radiation and pathways of exposure.

In general, radiation hazards to workers arise in the mining and processing of heavy minerals through three principal pathways, namely external irradiation, inhalation and ingestion. The specific potential exposures are, as follows:

- External exposure from the ore body during mining of ores or during separation of heavy minerals, or from stockpiled ore, mineral concentrates, or tailings;
- External exposure during transport of ore or mineral concentrates;
- Internal exposure from the inhalation of dusts containing elevated levels of radioactivity;
- Internal exposure from the inhalation of radon gas released from minerals during mining or processing operations or from stockpiled materials; and

- Direct ingestion of material during handling of ores and heavy mineral concentrates and products.

Potential exposure pathways to members of the public include off-site releases of dusts or radon gas, contamination of food and water supplies due to the migration of radionuclides from the mine site during mining operations or following the disposal of mining tailings (by-products). Radioactivity associated with the various heavy minerals or tailings may also have the potential to be dispersed in the environment during processing operations.

Table 4-14 and Table 4-15 summarize the potential relevant pathways of exposure arising from mining and processing activities at SR Area 1, which could have an impact on workers and members of the public respectively.

Table 4-14: Pathways of exposure for workers from operational sections at SR Area 1

Operational Area	Process Streams	Worker Dose Assessment	
		Relevant Pathways	Occupancy
Dry mining operations (Lanti DM1 and Gangama DM2) and respective WCPs	Mineral sands ore Oversize material HMC Sand tailings -63 micron Slimes tailings	External gamma	2,000 h/y @
		Dust inhalation (only HMC)*	2,000 h/y @
		Inadvertent soil ingestion	N/A (consumption rate as per footnote ^)
Dredge mining operations (Lanti D1) and floating WCP	Mineral sands ore Oversize material HMC Sand tailings -63 micron Slimes tailings	External gamma (some shielding from water will occur as the process is wet)	2,000 h/y @
		Dust inhalation (HMC as stockpiled on shore)*	2,000 h/y @
		Inadvertent soil ingestion	N/A (consumption rate as per footnote ^)
MSP and tailings storage area	HMC IGR SGR Ilmenite product Zircon product FPP gravity tails FPP flotation tails CET MET / FET Ilmenite tails	External gamma	2,000 h/y @ (MSP) 1,000 # h/y (50% tailings area)
		Dust inhalation	2,000 h/y @
		Inadvertent soil ingestion dose	N/A (consumption rate as per footnote ^)
Nitti Port (product storage and shipment)	IGR SGR Ilmenite product Zircon product	External gamma	2,000 h/y @
		Dust inhalation	2,000 h/y @
		Inadvertent soil ingestion dose	N/A (consumption rate as per footnote ^)

* In the WCP, the HMC stockpile is not entirely dry and dust inhalation dose from this stockpile would therefore be an over-estimate

@ A worker gamma and dust inhalation exposure time of 2,000 hours / year (h/y) is assumed: (365 days/y – 52 Sundays – 52 Saturdays – 11 holidays) x 8 h/day = 2,000 h/y as per internationally accepted value used for worker occupancy

^ Worker soil consumption rate =100 mg/day (ICRP 72); (Ozkaynak et al 2011)

The general workforce at SRL does not work within the tailings storage area. A security guard is stationed at the gate, some distance away from actual stockpiles. Dozer, FEL and truck drivers occasionally in the area are being shielded from external gamma dose to a large extent by their equipment. A reduced occupancy of 1,000 h/y (50 % of worker occupancy) was thereby selected for worker gamma dose in the area.

HMC = Heavy Mineral Concentrate IGR = Industrial Grade Rutile SGR = Standard Grade Rutile
FPP = Feed Preparation Plant CET = Coarse Electrostatic Tails MET = Medium Electrostatic Tails

Table 4-15: Pathways of exposure for the public from operational sections at SR Area 1

Operational Area	Process Streams	Worker Dose Assessment	
		Relevant Pathways	**Occupancy**
Dry mining operations (Lanti DM1 and Gangama DM2) and respective WCPs	Mineral sands ore Oversize material HMC Sand tailings -63 micron Slimes tailings	The closest communities to DM1 or DM2 is approximately 500 m removed and not close enough to incur a direct gamma dose; and the WCP is a secure area with no access for members of the public	N/A
		Dust inhalation possible for road users and communities in the vicinity	876 h/y (10 %) @
		Communities not located close enough to DM1 or DM2 to incur a direct soil ingestion dose; and the WCP is a secure area with no access for members of the public	N/A
Dredge mining operations (Lanti D1) and floating WCP	HMC -63 micron Slimes tailings	Gamma dose for public possible from unsecured HMC stockpile (road users) and slimes tailings in TSF	876 h/y (10 %) @
		Dust inhalation possible for road users and communities in the vicinity	876 h/y (10 %) @
		Soil ingestion^ dose for public possible from unsecured HMC stockpile (road users) and slimes tailings in TSF	N/A (consumption rate as per footnote ^)
MSP and tailings storage area	HMC IGR SGR Ilmenite product Zircon product FPP gravity tails FPP flotation tails CET MET / FET Ilmenite tails	The MSP and tailings storage areas are secure areas with no access to members of the public to incur external gamma dose	N/A
		Some communities in vicinity of the MSP and tailings storage area (Mogbwemo and KPetema) can incur dust inhalation dose	876 h/y (10 %) @
		The MSP and Tailings Storage areas are secure areas with no access to members of the public to incur external gamma dose	N/A
Nitti Port (product storage and shipment)	IGR SGR Ilmenite product Zircon product	Nitti Port is a secure area with no access to members of the public to incur a gamma dose	N/A
		Foya village is in the vicinity of Nitti Port. Members of the public can thereby potentially receive dust inhalation doses	876 h/y (10 %) @
		Nitti Port is a secure area with no access to members of the public to incur a soil ingestion dose	N/A
* In the WCP, the HMC stockpile is not entirely dry and dust inhalation dose from this stockpile would therefore be an over-estimate			

Operational Area	Process Streams	Worker Dose Assessment	
		Relevant Pathways	Occupancy
^ Inadvertent soil ingestion for adults = 100 mg/day (ICRP 72; Ozkaynak et al 2011); Inadvertent soil ingestion for children = 200 mg/day (Ozkaynak et al 2011; Stanek and Calabrese 1995b)			
@ A public exposure of 876 h/y (10 % occupancy: 10/100 x 365 days/y x 24 h/day) is assumed for members of the public using roads in close proximity to sources of radiation			
HMC = Heavy Mineral Concentrate	IGR = Industrial Grade Rutile	SGR = Standard Grade Rutile	
FPP = Feed Preparation Plant	CET = Coarse Electrostatic Tails	MET = Medium Electrostatic Tails	
TSF = Tailings Storage Facility			

Radon (Rn-222) is an inert gas produced when radium (Ra-226) decays by alpha emission. Radium is in turn a decay product of the uranium decay series. The potential levels of radon gases in mineral sand mining and separation will depend on the rate at which radon emanates or is released from the ore or mineral product and the level of ventilation in the area where these materials are handled, produced or stockpiled.

The emanation of radon from heavy minerals has been found to be very low (KER 1988). In the open, any radon released from an ore body, or a stockpile, will be rapidly diluted in the atmosphere and dispersed. Therefore, it is likely that in open pit mining and associated processing, the radon levels will be comparable to ambient levels and this exposure pathway will not be significant.

Other potential pathways, such as surface or groundwater contamination, are not considered to be of significance as long-term migration of radionuclides from chemically un-altered tailings and other residues disposed of to a mine pit is expected to be minimal. Physical methods are used to separate the heavy minerals in the ore and any mineral tailings returned to pit will not have undergone chemical treatment. Therefore, the monazite will not be altered chemically and there will not be any change in the solubility of uranium and thorium, or the other radioactive elements in the decay series.

It is also known that the radionuclide constituents are highly inert and bound strongly in the mineral structure, when not chemically altered, and it can be concluded that the potential for migration of radioactivity to surface or ground water in the area would be the same as would be with the presence of the ore deposits. Over the long-term any local movement of radionuclides through the groundwater aquifer would be very slow.

The only tailings stream with potential chemical alteration would be the FPP sulfide tailings, containing sulfide minerals, marcasite and pyrite, as this material is acid generating which has the potential to stay acidic in the long term if exposed to oxidizing conditions. From the SRL Water Monitoring Report (Knight Piésold, 2008), it was shown that the supernatant discharge from the coarse sulfide plant tailings outlet pipe into the sulfide plant tailings holding area had radioactivity levels that exceeded the WHO Guidelines (2008) for gross alpha and gross beta. Process / surface water locations downstream of the Mogbwemo Dredge Pond however did not exceed WHO Guidelines, indicating a minimal impact from these discharge sources.

The ESHIA geochemistry characterisation study (SRK, 2018(2)) noted that while the previous studies assessed tailings leachates quality against the WHO Guidelines and indicated that aluminium (Al), manganese (Mn), nickel (Ni), cadmium (Cd) and uranium (U) exceeded the guideline limits. The SRK (2017b) study assessed the current tailings leachate quality against SLEP (MM) Reg. 2013 “limit at any moment” effluent quality for mining and metallurgic operations and background surface water levels. The findings indicated that all the measured parameters in the leachate from both the primary and secondary process tailings are within the Regulations “limit at any moment” except pH:

- As the primary process tailings are expected to be typically non-acid forming, slightly acidic and non-saline, the bulk of this material is considered to be geochemically unreactive. Due to the low acid sulphate soil and metal leaching (ASS/ML) risk, no special ASS/ML management

requirements are recommended except continuation with operational monitoring and testing to detect any unexpected changes that may occur during mining (SRK, 2018(2)); and

- The secondary process tailings, specifically sulfide flotation tailings (SFT), total tailings (TT) and ilmenite tailings (IT), are potentially acid generating (PAG), acidic and non-saline and are likely to present a risk of increased acidity when exposed to oxidising conditions. These materials should continue to be deposited sub-aqueously as is currently done to limit exposure to oxygen. It is recommended that sufficient depth of water cover over the potentially acid generating (PAG) tailings be ensured to prevent re-suspension of tailings by wind or wave action to minimise exposure to potential oxidising conditions (SRK, 2018(2)).

It is further noted that drinking water is provided by SRL for workers, and that members of the public extract water for drinking purposes from wells in their villages and not from surface water sources. Some villages are also supplied with drinking water from SRL. The location of drinking water wells for the public is far removed from the MSP or tailings storage facility, as the closest community (Mogbwemo) is approximately 500 m from the MSP. Even though members of the public make use of surface water bodies for swimming and bathing, the amount of water accidentally ingested would be minimal. Swimming or bathing by members of the public does not occur in close proximity to the MSP or tailings storage area.

Surface and groundwater monitoring will be included as part of the overall environmental monitoring program. There may be some seasonal and regional variations, and these variations must be taken into account in assessing the possible long-term impacts of mining or mineral processing on the surface and groundwater conditions in the area.

Potential Exposure Groups

The following groups of individuals may be exposed to radiation resulting from the SR Area 1 operations:

- Workers at the mining operations;
- Drivers and operators of the mining equipment;
- Workers at the WCPs, MSP and Nitti Port;
- Workers at the mine site involved in the rehabilitation and MSP tailings disposal operations;
- Visitors to the operations;
- Contractors; and
- Members of the public who live close to the mining and processing operations, or export facilities and product haulage road.

Dose conversion factors and calculations of dose from potential exposure pathways

Effective dose calculations for individual exposure pathways are dependent on dose conversion factors (DCFs), which are updated by international protection agencies (i.e. ICRP) following outcomes of human and environmental impact studies. Dose conversion factors used, and dose calculations for expected pathways of exposure in the current radiation risk assessment are detailed in Appendix 6 of the Radiation specialist report.

Limited data is available on the SRL uranium and thorium content of the ore and tailings streams. Routine in-house XRF analysis is done on products and some of the tailings materials but currently, a quality control bench-marking exercise is underway to validate the accuracy of in-house analysis. Initial results from this program have indicated that in-house analysis is biased towards the higher end. Previous studies aimed at characterizing tailings materials have also only evaluated gross alpha (α) and gross beta (β) content; did not analyze for uranium or thorium directly; and did not quantify full decay chain (Appendix 4 of the radiation specialist report attached as Appendix I) radionuclide

analysis. To date, no full decay chain radionuclide analysis are available on any of the process streams.

An overview of the radiological characteristics of the ore and processing streams is given in Appendix 1 of the radiation specialist report attached as Appendix I (those available from analysis). Material radionuclide concentrations were used to estimate potential doses to workers and members of the public from various pathways of exposure. Assumptions about occupancy factors; inhalation rates; dust concentrations in air; particle size of dust etc. leads to the estimates of radiation dose summarized in Section 5 of the radiation specialist report (Appendix I).

Gamma measurements taken during the assessment evaluation

Gamma dose rate screening surveys across the SR Area 1 operations; roads; and Nitti Port were undertaken by personnel trained in the use of the RS-125 and RS-220 Super Spectrometers, suitable for measurement of environmental gamma dose rates. An additional survey was conducted to determine background gamma dose (to be subtracted from estimated doses to workers and members of the public) at an area selected for this purpose. Gamma dose rate measurements adjacent to HMC and oversize stockpiles were also conducted as indicative of dose and for estimation of radionuclide content of these materials. Instrument specifications are detailed in Appendix 7 of the radiation specialist report (Appendix I). Background dose from various sources that individuals are exposed to during everyday living is detailed in Appendix 8 of the radiation specialist report (Appendix I).

4.5.3 Radiation dose assessment

Flow-sheets and dose estimation per operational section

Figure 4-13 to Figure 4-17 display the flow-sheet layout of individual sections of mining and processing at SR Area 1 and indicates feed, intermediates, products and tailings streams. Table 4-16 to Table 4-21 summarizes the dose assessment detailed results for each operational area for workers and a summary for members of the public.

Radiation Dose Assessment for Workers

Using the material analysis data in Appendix 1 (Table B) of the radiation specialist report (Appendix I) and making assumptions about occupancy factors; dust concentrations; and particle size of dust in air, leads to the following estimates of radiation doses, as summarised in Table 4-16. Calculations used for dose estimations are given in Appendix 6 of the radiation specialist report (Appendix I).

Table 4-16: Estimated occupational doeses for workers

Exposure Pathways	Exposure Time (h/y)	Annual Effective Dose (mSv/y)
Dry Mining operations (Lanti DM1 and Gangama DM2) and WCPs		
External Gamma (combined materials – reconstructed ore)	2,000 h/y	0.09
External Gamma (HMC only)		1.66
Dust Inhalation (combined materials – reconstructed ore)	2,000 h/y	0.009
Dust Inhalation (only HMC)*		0.163
Inadvertent Soil Ingestion (combined materials – reconstructed ore)	N/A (consumption rate as per footnote ^)	$4.2x10^{-5}$
Inadvertent Soil Ingestion (only HMC)		$7.5x10^{-4}$
Dredge Mining operations (D1) and floating WCP		
External Gamma (some shielding from water will occur as the process is wet)	2,000 h/y	0.09 ~

Exposure Pathways	Exposure Time (h/y)	Annual Effective Dose (mSv/y)
External Gamma (HMC only)		1.66
Dust Inhalation (HMC as stockpiled is on shore)*	2,000 h/y	0.163
Inadvertent Soil Ingestion (combined materials – reconstructed ore)		$4.2x10^{-5}$
Inadvertent Soil Ingestion (only HMC)	N/A (consumption rate as per footnote ^)	$7.5x10^{-4}$
External Gamma (some shielding from water will occur as the process is wet)		0.09 ˜
MSP and tailings storage area		
External Gamma (combined materials – reconstructed HMC)+	2,000 h/y (MSP)	1.47
External Gamma (combined tailings)	1,000# h/y (Tailings area)	1.10
Dust Inhalation (combined materials – reconstructed HMC)	2,000 h/y	0.14
Dust Inhalation (combined tailings)		0.21
Inadvertent Soil Ingestion (combined materials – reconstructed HMC)	N/A (consumption rate as per footnote ^)	0.0007
Inadvertent Soil Ingestion (combined tailings)		0.0011
Nitti Port		
External Gamma	2,000 h/y	0.74
Dust Inhalation	2,000 h/y	0.07
Inadvertent Soil Ingestion	N/A (consumption rate as per footnote ^)	0.0003

* In the WCP, the HMC stockpile is not entirely dry and dust inhalation dose from this stockpile would therefore be an over-estimate

˜ Overestimate of gamma dose on the dredge and floating WCP as all materials are wet and would be shielded. Largest exposures at dredge would be from density gauges and not NORM

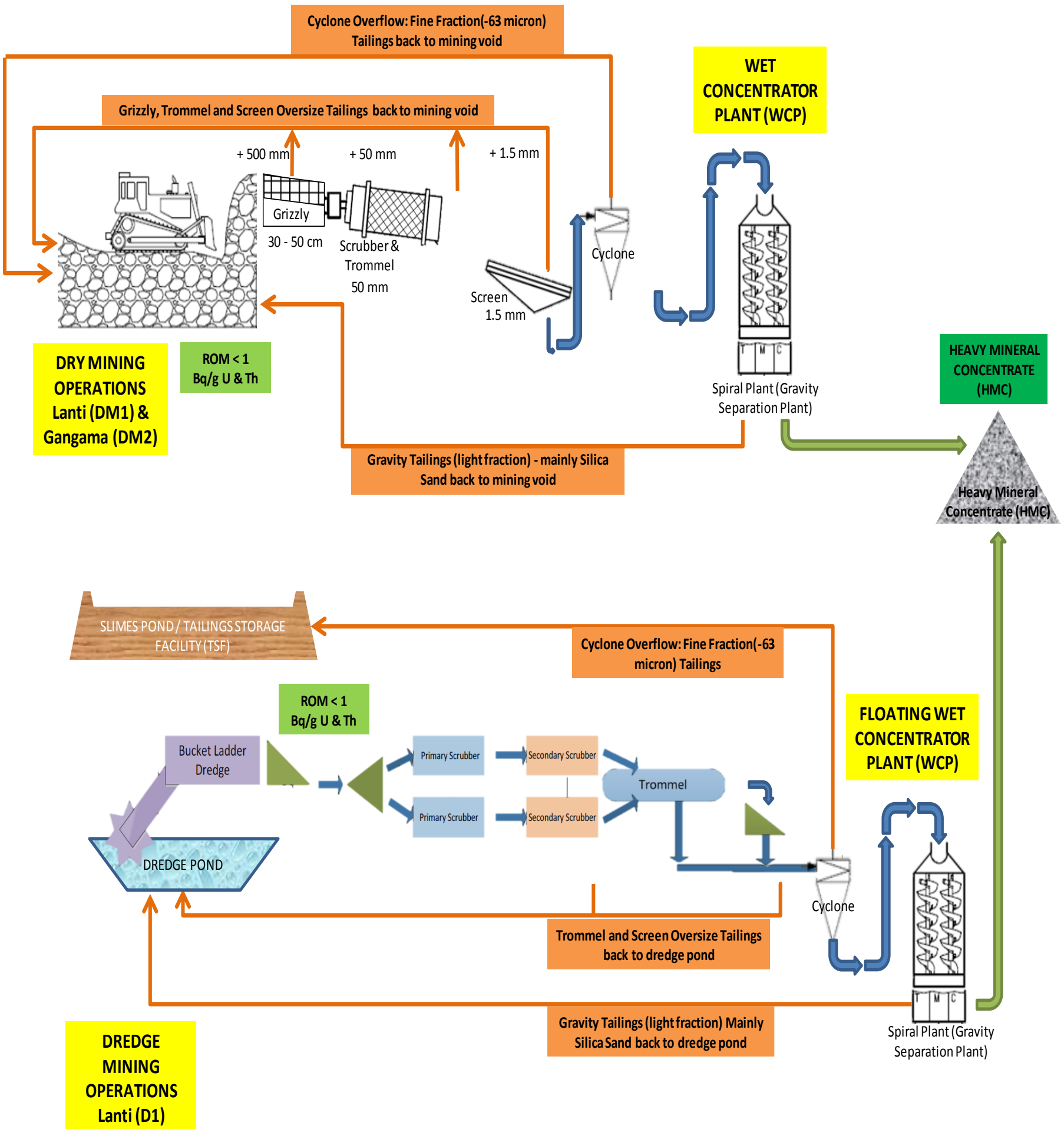
^ Worker soil consumption rate =100 mg/day (ICRP 72); (Ozkaynak et al 2011)

@ Reconstructed ore = recombined activity concentration of ore as made up from the streams into which it is sub-divided at the MUP and WCP, i.e. recombining of oversize + minus 63 micron slimes + gravity sand tailings + HMC (combined per mass ratio)

+ Reconstructed HMC = recombined activity concentration of HMC as made up from the streams into which it is sub-divided at the FPP and MSP, i.e. recombining of FPP gravity tails + Sulfide flotation tails + HTT + ilmenite tails + IGR + SGR + ilmenite product + zircon product (combined per mass ratio)

#The general workforce at SRL does not work within the tailings storage area. A security guard is stationed at the gate, some distance away from actual stockpiles. Dozer, FEL and truck drivers occasionally in the area are being shielded from external gamma dose to a large extent by their equipment. A reduced occupancy of 1,000 h/y was thereby selected for worker gamma dose in the area.

These dose estimates are based on very conservative parameters, especially for exposure times for each pathway. Dust inhalation doses is further conservative in that a dust loading of 1 mg/m^3 was assumed for calculation purposes and the initial air quality modeling data for the ESHIA (SRK, 2017a) indicated the maximum $PM_{2.5}$ dust loading to be 0.013 mg/ m^3 which is tenfold lower than the assumed value. This dust monitoring was however conducted during the wet season, and additional monitoring during the dry season is required.



srk consulting	SR AREA 1 ESHIA & ESHMP DRY AND WET MINING OPERATIONS AND WCPS (SRL 2018)	Project No. 515234

Figure 4-13: Dry (DM1 and DM2) and wet (Dredge D1) mining operations and WCPs (SRL 2018)

Table 4-17: Dose assessment for workers at the mines and WCPs

Operational Area	Process Streams	Worker Dose Assessment		
		Relevant Pathways	Annual Dose (mSv/y)	Exposure Time (h/y)
Background gamma (0.06 µSv/h)			**0.12**	2,000 h/y
Dry mining operations (Lanti DM1 and Gangama DM2); dredge mining operations (D1) and wet concentrator plants (WCPs)	Mineral sand ore	External Gamma	0.04	2,000 h/y
	Primary oversize / secondary oversize		0.03	
	Co-disposed tailing (sand and slimes)		0.02	
	-53 um Fraction (thickener underflow)		0.70	
	Heavy Mineral Concentrate (HMC)		1.66	
	RS-220 measure oversize		0.009	
	RS-220 measure HMC		0.42	
	Reconstructed mineral sand ore		0.09	
	Mineral sand ore (only dry mine)	Dust Inhalation	0.004	2,000 h/y
	Primary oversize / secondary oversize (only dry mine)		0.003	
	HMC (dry mines and dredge)		0.163	
	Reconstructed mineral sand ore (only dry mine)		0.009	
	Mineral sand ore	Inadvertent Soil Ingestion	0.000021	N/A (consumption rate as per footnote ^)
	Primary oversize / secondary oversize		0.0000135	
	Co-disposed tailing (sand and slimes)		0.00000792	
	-53 um Fraction (thickener underflow)		0.000385	
	HMC		0.000749	
	Reconstructed mineral sand ore		0.0000419	
	Annual Effective Dose (all pathways) – inclusive of background and derived from reconstructed ore		**0.099**	
	Maximum Annual Effective Dose (all pathways) – inclusive of background and derived from exposure to HMC only		**1.82**	

Annual Dose (mSv/y) = External Gamma Dose (mSv/y) + Dust Inhalation Dose (mSv/y) + Soil Ingestion Dose (mSv/y)

For the WCP, the Reconstructed mineral sand ore should be the combined products and tailings within the WCP, the Estimated Annual Dose = Annual dose from Reconstructed ore

Annual Dose (mSv/y) = Average External Gamma Dose from different materials + Average Dust Inhalation Dose from different materials + Average Soil Ingestion Dose from different materials

Maximum Annual Dose (mSv/y) = Max External Gamma Dose from an individual material + Max Dust Inhalation Dose from an individual material + Max Soil Ingestion Dose from an individual material

^ Inadvertent soil ingestion for workers = 100 mg/day (ICRP 72; Ozkaynak et al 2011);

The largest contributing exposure pathway for workers at mining operations is from external gamma when compared to other pathways of exposure. The maximum potential dose that a worker could receive at the WCP is 1.66 mSv/y (excluding background), under the assumption that the individual would stand next to a stockpile of HMC for 2,000 h/y; inhale only HMC dust; and ingest only HMC material. This dose would be an over-estimate, as HMC constitutes only 4 % of the total material treated through the mine and WCP.

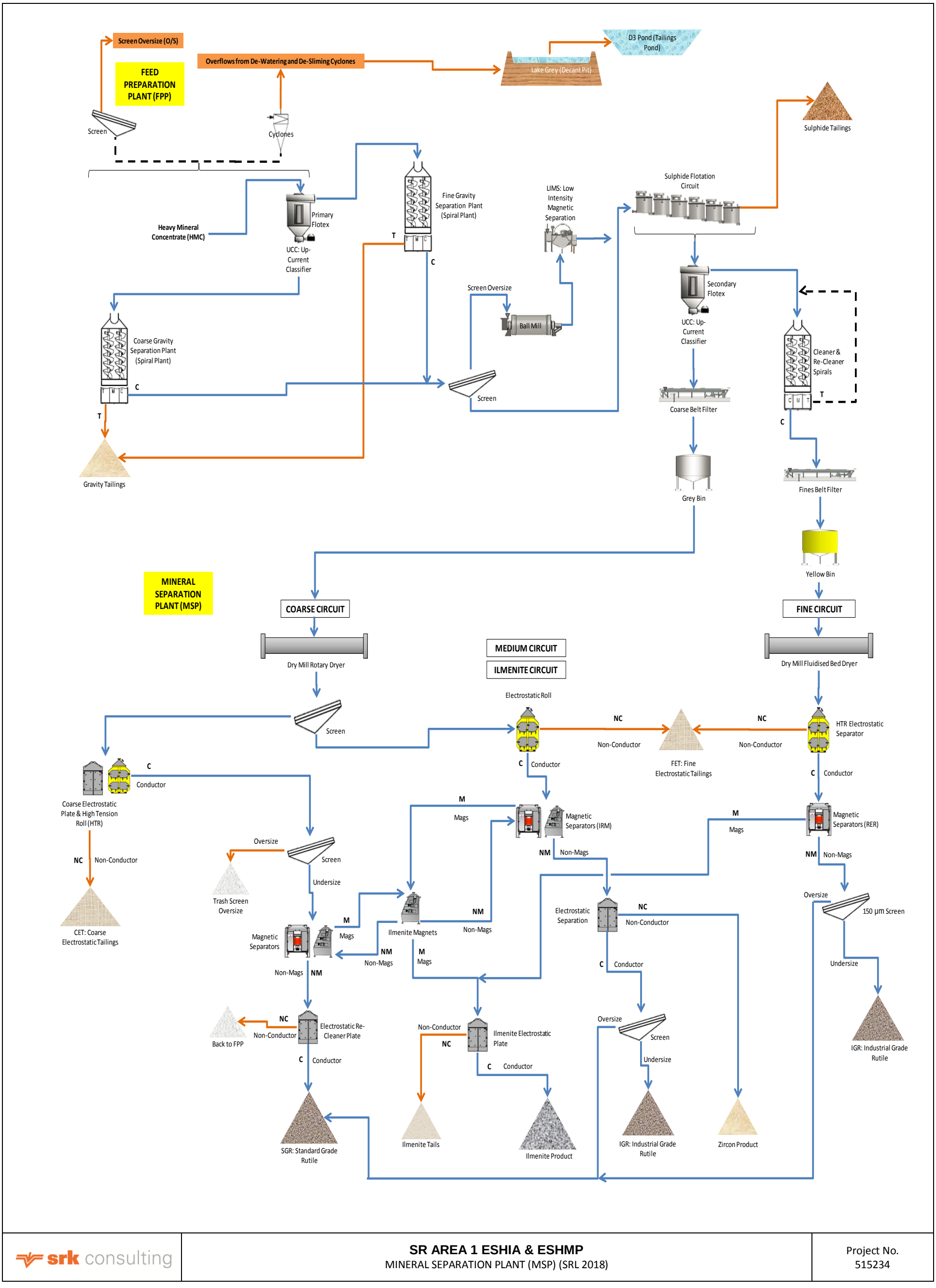


Figure 4-14: Mineral Separation Plant (MSP) (SRL 2018)

Table 4-18: Dose assessment for workers from the MSP

Operational Area	Worker Dose Assessment			
	Process Streams	Relevant Pathways	Annual Dose (mSv/y)	Exposure Time (h/y)
Background gamma (0.06 µSv/h)			**0.12**	2,000 h/y
MSP	Heavy Mineral Concentrate (HMC)	External Gamma	1.66	2,000 h/y
	Feed Preparation Plant (FPP) gravity tails		0.08	
	Flotation circuit tails (Sulfide tails)		0.97	
	Coarse Electrostatic Tails (CET)		10.28	
	Medium Electrostatic Tails (MET)		4.44	
	Ilmenite Tails (IT)		7.08	
	Industrial Grade Rutile (IGR) product		0.44	
	Standard Grade Rutile (SGR) product		0.45	
	Ilmenite product (IP)		1.25	
	Zircon product		15.02	
	Reconstructed combined HMC feed		1.47	
	Heavy Mineral Concentrate (HMC)	Dust Inhalation	0.16	2,000 h/y
	Feed Preparation Plant (FPP) gravity tails		0.01	
	Flotation circuit tails (Sulfide tails)		0.09	
	Coarse Electrostatic Tails (CET)		0.94	
	Medium Electrostatic Tails (MET)		0.42	
	Ilmenite Tails (IT)		0.64	
	Industrial Grade Rutile (IGR) product		0.05	
	Standard Grade Rutile (SGR) product		0.05	
	Ilmenite product (IP)		0.12	
	Zircon product		1.41	
	Reconstructed combined HMC Feed		0.14	
	Heavy Mineral Concentrate (HMC)	Inadvertent Soil Ingestion	0.0007	N/A (consumption rate as per footnote ^)
	Feed Preparation Plant (FPP) gravity tails		0.0000	
	Flotation circuit tails (Sulfide Tails)		0.0005	

Operational Area	Worker Dose Assessment			
	Process Streams	**Relevant Pathways**	**Annual Dose (mSv/y)**	**Exposure Time (h/y)**
	Coarse Electrostatic Tails (CET)		0.0054	
	Medium Electrostatic Tails (MET)		0.0022	
	Ilmenite Tails (IT)		0.0038	
	Industrial Grade Rutile (IGR) product		0.0002	
	Standard Grade Rutile (SGR) product		0.0002	
	Ilmenite product (IP)		0.0006	
	Zircon product		0.0075	
	Reconstructed Combined HMC Feed		0.0007	
	Annual Effective Dose (all pathways) – inclusive of background and derived from Reconstructed HMC		**1.61**	
	Maximum Annual Effective Dose (all pathways): – inclusive of background and derived from exposure to Zircon product only		**16.44**	
Annual Dose (mSv/y) = External Gamma Dose (mSv/y) + Dust Inhalation Dose (mSv/y) + Soil Ingestion Dose (mSv/y)				
Since HMC should be the combined products and tailings within the MSP, the Estimated Annual Dose = Annual dose from HMC				
Annual Dose (mSv/y) = Average External Gamma Dose from different materials + Average Dust Inhalation Dose from different materials + Average Soil Ingestion Dose from different materials				
Maximum Annual Dose (mSv/y) = Max External Gamma Dose from an individual material + Max Dust Inhalation Dose from an individual + Max Dust Inhalation Dose from an individual				
^ Inadvertent soil ingestion for adults = 100 mg/day (ICRP 72; Ozkaynak et al 2011)				

The largest calculated contributing exposure pathway for workers at the MSP is from external gamma, followed by dust inhalation. It was further shown that the largest dose from an individual material would be incurred from exposure to zircon product, followed by CET and ilmenite tails respectively.

The maximum potential dose for workers at the MSP is 16.32 mSv/y (excluding background), under the assumption that an individual would stand next to an open stockpile of zircon product for 2,000 h/y; inhale only zircon dust; and ingest only zircon material. This dose would be an over-estimate, as zircon product constitutes only 0.5 % (2016 average) of the total material treated through the MSP. This exposure scenario is also not realistic, as the zircon product is bagged within the MSP directly from the product chute (Figure 4-15) and then stored in an area of the plant with controlled access to workers. Dust liberation and soil ingestion pathways of exposure from zircon product is mitigated through product containment (within bags) and through the compulsory use of dust masks within the area. Gamma exposure is mitigated through limiting the access to the zircon storage area.

Zircon Bagging at MSP

Storage at D3

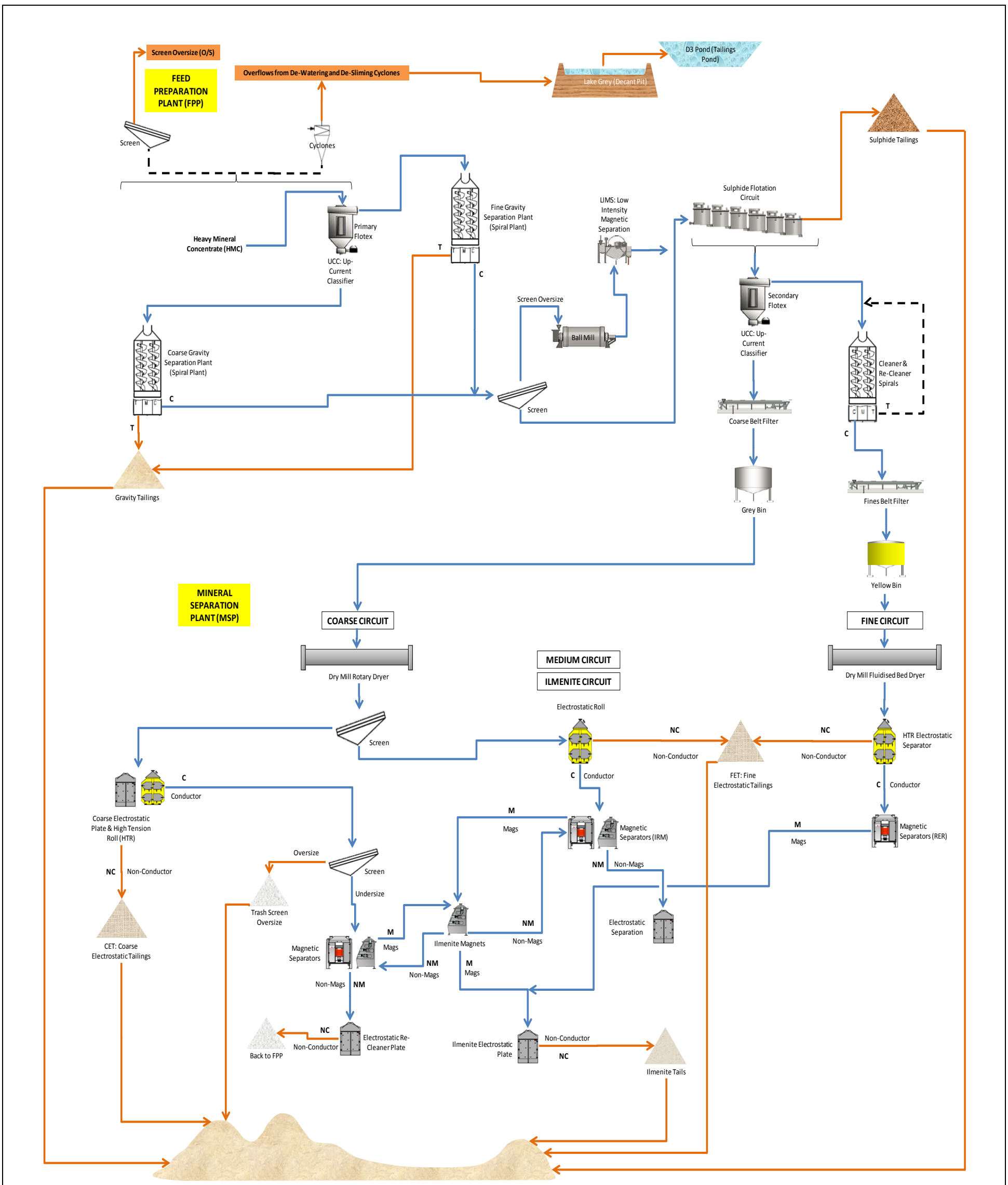
srk consulting	**SR AREA 1 ESHIA & ESHMP** ZIRCON BAGGING AT MSP & STORAGE AT D3 (SRL 2018)	Project No. 515234

Figure 4-15: Zircon bagging at the MSP and storage at D3 (SRL 2018)

The estimated annual dose for workers at the MSP is 1.49 mSv/y (excluding background), and is consistent with radiation doses of Iluka Australian operations, which record annual doses of workers at the MSP, from all exposure pathways, of below 5 mSv/y. The current personal gamma monitoring program conducted at SRL, through measurement of external gamma dose through thermoluminescent dosimeters (TLD badges), has to date not identified any over-exposures for this area.

srk consulting	**SR AREA 1 ESHIA & ESHMP** TAILINGS STORAGE AREA (SRL 2018)	Project No. 515234

Figure 4-16: Tailings Storage Area (SRL 2018)



srk consulting	SR AREA 1 ESHIA & ESHMP TAILINGS STORAGE AREA FLOW DIAGRAM (SRL 2018)	Project No. 515234

Figure 4-17: Tailings Storage Area flow diagram (SRL 2018)

During 2015 and 2016, some of the tailings areas were re-worked to further extract recoverable heavy minerals which were then added to HMC originating from the active mining areas and used as feed to the MSP.

In addition to this, the high-tension tailings (HTT; a combination of CET, MET and FET) are sporadically sold dependent upon market demand. This resulted in a marked reduction of the total tailings tonnage currently stored in the tailings storage area adjacent to the MSP. It also resulted in a reduced total material activity concentration (Bq/g U and Th) as the HTT material has an elevated level of uranium and thorium above the remainder of the tailings streams. The dose assessment for workers (Table 4-19), and for members of the public (Table 4-21), is therefore conservative when based on exposures to the reconstructed combined tailings material.

Table 4-19: Dose assessment for workers at Tailings Storage

Operational Area	Worker Dose Assessment			
	Process Streams	Relevant Pathways	Annual Dose (mSv/y)	Exposure Time (h/y)
Background gamma (0.06 µSv/h)			**0.12**	2,000 h/y
Tailings Storage Area adjacent to the MSP	Feed Preparation Plant (FPP) gravity tails	External Gamma	0.04	1,000 h/y (50 %)
	Flotation circuit tails (Sulfide tails)		0.48	
	Coarse Electrostatic Tails (CET)		5.14	
	Medium Electrostatic Tails (MET)		2.22	
	Ilmenite tails (IT)		3.54	
	Reconstructed Combined MSP tailings		1.10	
	Feed Preparation Plant (FPP) gravity tails	Dust Inhalation	0.01	2,000 h/y
	Flotation circuit tails (Sulfide tails)		0.09	
	Coarse Electrostatic Tails (CET)		0.94	
	Medium Electrostatic Tails (MET)		0.42	
	Ilmenite tails (IT)		0.64	
	Reconstructed Combined MSP tailings		0.21	
	Feed Preparation Plant (FPP) gravity tails	Inadvertent Soil Ingestion	0.00004	N/A (consumption rate as per footnote ^)
	Flotation circuit tails (Sulfide tails)		0.0005	
	Coarse Electrostatic Tails (CET)		0.0054	
	Medium Electrostatic Tails (MET)		0.0022	
	Ilmenite tails (IT)		0.0038	
	Reconstructed Combined MSP tailings		0.0011	

Operational Area	Worker Dose Assessment			
	Process Streams	Relevant Pathways	Annual Dose (mSv/y)	Exposure Time (h/y)
	Annual Effective Dose (all pathways) – inclusive of Background and derived from Combined MSP tails		**1.31**	
	Maximum Annual Effective Dose (all pathways) – inclusive of Background and derived from exposure to CET only		**6.09**	
Annual Dose (mSv/y) = External Gamma Dose (mSv/y) + Dust Inhalation Dose (mSv/y) + Soil Ingestion Dose (mSv/y)				
Worker occupancy for gamma exposure assumed 1,000 h/y (50 % of worker occupancy) as the only individuals exposed is the security guard (some distance away from active tails stockpiles); FEL; Dozer; and Truck Drivers (equipment shielding from gamma radiation).				
Worker estimated annual dose calculated from gamma exposure, dust inhalation and soil ingestion originating from "Reconstructed Combined MSP tailings"				
Maximum Annual Dose (mSv/y) = Max External Gamma Dose from an individual material + Max Dust Inhalation Dose from an individual material + Max Soil Ingestion Dose from an individual material				
^ Inadvertent soil ingestion for adults = 100 mg/day (ICRP 72; Ozkaynak et al 2011)				

The largest calculated contributing exposure pathway for workers at the tailings storage facility is from external gamma, followed by dust inhalation. It was further shown that the largest dose from an individual material would be incurred from exposure to CET, followed by ilmenite tails and medium / fine electrostatic (MET and FET) tails respectively.

The maximum potential dose for workers at the tailings storage facility is 5.97 mSv/y (excluding background), under the assumption that an individual would stand next to a stockpile of CET for 1,000 h/y; inhale only CET dust for 2,000 h/y; and ingest only CET material. This dose would be an over-estimate, as CET constitutes only 2.8 % (2016 average) of the total tailings material stored in the area. It has to be noted that the only individuals exposed to gamma radiation at the tailings storage area are the security guards, which are some distance away from the tailings stockpiles; FEL and dozer operators; and truck drivers. Mobile equipment operators would have some shielding provided by the machinery.

The estimated annual dose for workers at the tailings storage facility is 1.19 mSv/y (excluding background). The current personal gamma monitoring program (TLD badges) conducted for security guards at the tailings storage area, has to date not identified any over-exposures.

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Figure 4-18: Nitti Port product storage and shipment

Table 4-20: Dose assessment for workers through potential exposure pathways at Nitti Port

Operations Evaluated	Process Streams	Worker Dose Assessment		
		Relevant Pathways	Annual Dose (mSv/y)	Exposure Time (h/y)
Background gamma (0.06 µSv/h)			**0.12**	2,000 h/y
Nitti Port (Product storage and shipment)	Industrial Grade Rutile (IGR) product	**External Gamma**	0.44	2,000 h/y
	Standard Grade Rutile (SGR) product		0.45	
	Ilmenite product (IP)		1.25	
	Zircon product		15.02	
	Reconstructed Combined MSP products		0.74	
	Industrial Grade Rutile (IGR) product	**Dust Inhalation**	0.05	2,000 h/y
	Standard Grade Rutile (SGR) product		0.05	
	Ilmenite product (IP)		0.12	
	Zircon product		1.41	
	Reconstructed Combined MSP products		0.07	
	Industrial Grade Rutile (IGR) product	**Inadvertent Soil Ingestion**	0.0002	N/A (consumption rate as per footnote ^)
	Standard Grade Rutile (SGR) product		0.0002	
	Ilmenite product (IP)		0.0006	
	Zircon product		0.0075	
	Reconstructed Combined MSP products		0.0003	
	Annual Effective Dose (all pathways) – inclusive of: Background and derived from Combined Products		**0.81**	
	Maximum Annual Effective Dose (all pathways) – inclusive of: Background and derived from exposure to Zircon product only		**16.44**	
Annual Dose (mSv/y) = External Gamma Dose (mSv/y) + Dust Inhalation Dose (mSv/y) + Soil Ingestion Dose (mSv/y)				
Worker estimated annual dose calculated from gamma exposure, dust inhalation and soil ingestion originating from "Reconstructed Combined MSP Tailings"				
Maximum Annual Dose (mSv/y) = Max External Gamma Dose from an individual material + Max Dust Inhalation Dose from an individual material + Max Soil Ingestion Dose from an individual material				
^ Inadvertent soil ingestion for adults = 100 mg/day (ICRP 72; Ozkaynak et al 2011)				

The largest calculated contributing exposure pathway for workers at Nitti Port is from external gamma, followed by dust inhalation. It was further shown that the largest dose from an individual material would be incurred from exposure to zircon product, followed by ilmenite. The maximum estimated dose for workers at Nitti Port is 16.3 mSv/y (excluding background), under the assumption that an individual would stand next to an open stockpile of zircon product for 2,000 h/y; inhale only zircon dust; and ingest only zircon material. This dose would be an over-estimate, as zircon product constitutes only 0.7 % (2016 average) of the MSP products and is only transported to Nitti Port when shipments are

due (i.e. not permanently stored at the port). The estimated annual dose for workers at Nitti Port is 0.69 mSv/y (excluding background), as calculated from exposure to reconstructed MSP products.

Radiation Dose Assessment for members of the public

Using the material data in Appendix 1 of the radiation study (Appendix I) and making assumptions about occupancy factors, dust concentrations and particle size of dust loads to the estimates of radiation doses for members of the public is summarised in Table 4-21.

Table 4-21: Estimated doses to members of the public

Exposure Pathways	Exposure Time (h/y)	Age Group	Annual Effective Dose (mSv/y)
Dry Mining operations (Lanti DM1 and Gangama DM2) and WCPs			
Closest community about 500 m from dry mining plants, thereby not close enough to incur a direct gamma dose and the WCP is a secured area with no access for the public	N/A		
Dust inhalation possible for road users and communities in the vicinity (combined materials – mineral sand ore)	876 h/y (10 %) @	Adult	0.003
		15 years	0.003
		10 years	0.002
		5 years	0.002
		1 year	0.001
Closest community about 500 m from dry mining plants, thereby not close enough to incur a direct soil ingestion dose and the WCP is a secured area with no access for the public	N/A		
Dredge Mining operations (D1) and floating WCP			
Gamma dose for public possible from HMC stockpile (road users on foot), but direct access to the stockpile now restricted	876 h/y (10 %) @	0.73	
Gamma dose for public possible from unsecured slimes tailings in TSF (road users on foot)		0.31	
Dust inhalation possible for road users and communities in the vicinity of HMC stockpile	876 h/y (10 %) @	Adult	0.051
		15 years	0.049
		10 years	0.040
		5 years	0.029
		1 year	0.022
Dust inhalation possible for road users and communities in the vicinity of slimes tailings in TSF		Adult	0.019
		15 years	0.019
		10 years	0.015
		5 years	0.011
		1 year	0.008
Soil ingestion dose for public possible from unsecured HMC stockpile (road users on foot), but direct access to the stockpile now restricted	N/A (consumption rate as per footnote ^)	Adult	0.0009
		15 years	0.0019
		10 years	0.0022
		5 years	0.0027
		1 year	0.0035
Soil ingestion dose for public possible from unsecured in vicinity of slimes tailings in TSF (road users on foot)		Adult	0.0004
		15 years	0.0009

Exposure Pathways	Exposure Time (h/y)	Age Group	Annual Effective Dose (mSv/y)
		10 years	0.0011
		5 years	0.0013
		1 year	0.0017
MSP and Tailings Storage Area			
The MSP and tailings storage areas are secure areas with no access to members of the public to incur external gamma dose	N/A		
Some communities in vicinity of the MSP (Mogbwemo and Kpetema) can incur dust inhalation dose from combined material (reconstructed HMC). Closest community approximately 500m from MSP	876 h/y (10 %) [@]	Adult	0.0008
		15 years	0.0018
		10 years	0.0021
		5 years	0.0025
		1 year	0.0033
Some communities in vicinity of the tailings storage area (Mogbwemo and KPetema) can incur dust inhalation dose from combined tailings. Closest community approximately 500m from MSP		Adult	0.064
		15 years	0.061
		10 years	0.050
		5 years	0.036
		1 year	0.028
The MSP and tailings storage areas are secure areas with no access to members of the public to incur soil ingestion dose	N/A		
Nitti Port			
Nitti Port is a secure area with no access to members of the public to incur a gamma dose	N/A		
Foya is the only village in the vicinity of Nitti Port, but at a distance in excess of 1 km. Members of the public can thereby potentially receive dust inhalation doses from combined products	876 h/y (10 %) [@]	Adult	0.0004
		15 years	0.0008
		10 years	0.0010
		5 years	0.0012
		1 year	0.0015
Nitti Port is a secure area with no access to members of the public to incur a soil ingestion dose	N/A		
* In the WCP, the HMC stockpile is not entirely dry and dust inhalation dose from this stockpile would therefore be an over-estimate			
[@] A public exposure of 876 h/y (10 % occupancy: 10/100 x 365 days/y x 24 h/day) is assumed for members of the public using roads in close proximity to sources of radiation			
[^] Inadvertent soil ingestion for adults = 100 mg/day (ICRP 72; Ozkaynak et al 2011); Inadvertent soil ingestion for children = 200 mg/day (Ozkaynak et al 2011; Stanek and Calabrese 1995b)			

The highest calculated dose that a member of the public could receive from any of the operations evaluated, is from external gamma exposure to HMC. This dose rate, when added to dust and soil ingestion doses, is still below the public dose limit of 1 mSv/y.

It is therefore concluded that no high radiation exposure risk to members of the public exist for mining and processing activities at SR Area 1.

Gamma screening level surveys

During 2017, gamma screening level surveys were conducted of the SRL operational areas, roads and storage facilities (e.g. Nitti Port). Measurements were conducted with the RS-125 Serial No 2711

and RS-220 Serial No 6327. From the surveys it was shown that areas with the highest gamma radiation exposure are the MSP; the tailings storage area; and Nitti Port. This confirms the outcome of the radiation dose assessment for the workforce (Figure 4-19).

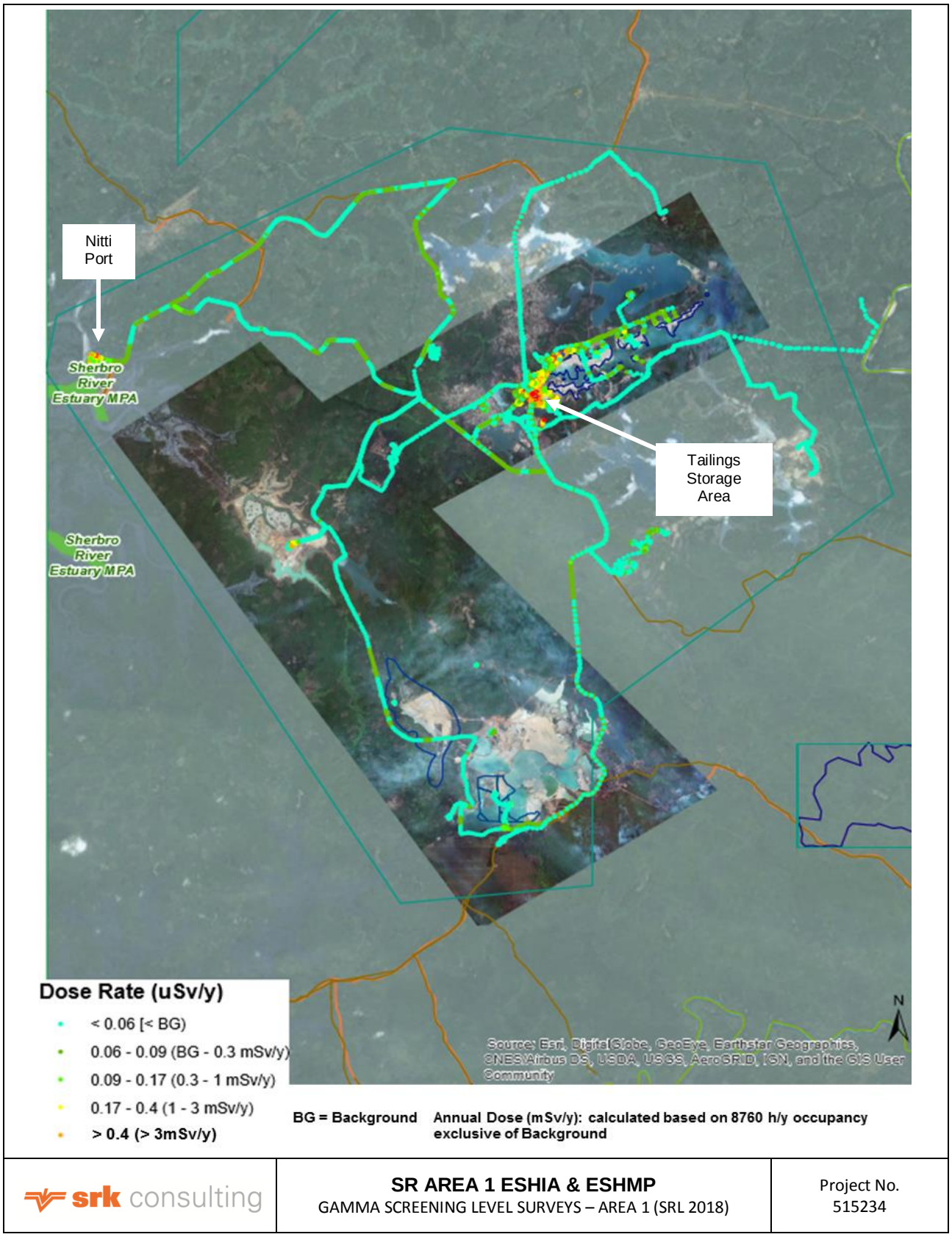


Figure 4-19: Gamma screening level surveys of Area 1 (SRL 2018)

Radiation Dose Assessment for fauna and flora

Just as ionizing radiation affects humans, it may affect other living organisms. This may lead to effects in the environment, impacting individuals, populations, species and whole ecosystems. Such effects, which arise from the biological effects of ionizing radiation in wildlife, are referred to as environmental effects.

Environmental effects may include:

- Increase morbidity (or reduce fitness) of individuals within populations;
- Increase mortality; and
- Reduce reproduction success (reduced number of offspring caused by reduced fertility or other factors).

To protect people, dose or dose rate limits may be specified and dose reduction strategies implemented, so as to remove the risk of acute effects. With regards to wildlife, the objective is to prevent or reduce the frequency of deleterious radiation effects, such as those that cause morbidity, early mortality or reduce reproductive success to a level where they would have a negligible impact of the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities and ecosystems (ICRP, 2008).

More recently, there has been increasing awareness of the potential vulnerability of the environment and the need to be able to demonstrate that it is protected against the effects of industrial pollutants, including radionuclides, for example the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) publication: Fundamentals for Protection of Ionizing Radiation (2014).

Plants and animals may be exposed to ionising radiation in the environment from different sources, and under different types of exposure situations. In all of these, factors affecting the doses received will vary enormously.

Various assessment tools are available for the radiological assessment of the environment. One of the readily available assessment tools is called ERICA (Environmental Risk from Ionizing Contaminants Assessment) that predicts the risk to reference animals and plants from ionizing radiation. The initial or Tier 1 ERICA assessment is used for screening out sites or materials giving rise to negligible risk of the populations of non-human species being affected by the presence of the ionizing radiation, i.e. radionuclide activity concentrations present (terrestrial, marine and freshwater environments) that could not result in dose to non-human species above the screening value of 10 µGy per hour. This screening value is the dose rate assumed to be environmentally safe.

The pragmatic approach to determine actual risk to biota would be to consider the existing databases (FASSET, ERICA, UNSCEAR, ICRP and PROTECT) on effects in terms of bands of dose within which certain effects have been noted, or might be expected, and then to select a band to serve as what is termed a ‘derived consideration reference level’ (DCRL). A DCRL can therefore be considered as a band of dose rate within which there is likely to be some chance of deleterious effects of ionizing radiation occurring to individuals of that type of species.

It is proposed to conduct such an ERICA assessment for SRL once all processing materials have been characterized in terms of full radionuclide analysis.

4.5.4 Transport of radioactive material

HMC is hauled from Lanti (dry mine and dredge) and Gangama (dry mine) to the MSP and non-commercial tailings are back-loaded to the mine for final disposal into mine voids. Some of the high-tension tailings (HTT) are sold and transported to Nitti Port, but some might be discarded along with other tailings streams into the mining voids. MSP products are hauled to Nitti Port for loading onto barges and eventually onto ocean going vessels.

The transport of radioactive materials is controlled by the IAEA Safety Requirements - Regulations for the Safe Transport of Radioactive Material (2012), and the International Maritime Dangerous Goods Code 2016 (IMDG Code). This includes the transport of ores and concentrates which contain natural thorium and uranium radionuclides with a specific activity exceeding 10 Bq/g.

For the purposes of transport, some of these materials may be exempt from the requirements of the IAEA Transport Regulations (2012), and the IMDG Code. The exempt concentrations for both uranium and thorium are 1 Bq/g. However, there is an additional clause that applies to the transport of materials containing natural uranium and thorium, where processing of the material is not for extraction of the radioactive elements. Under this criterion, heavy mineral sand products or tailings may be exempt from the transport Regulations if they have an activity concentration of thorium and uranium of less than 10 Bq/g.

As per Appendix 1, only two products have activity concentrations potentially in excess of 10 Bq/g and these are the zircon product and the electrostatic tails (CET, MET and FET also known as HTT). Currently, these two products are combined in ratios as to result in material activity concentrations below 10 Bq/g for transport purposes.

In the potential event that zircon or HTT are classified as radioactive for the purposes of transport, SRL shall ensure that radioactive classification, packaging, labelling and placarding of trucks comply with the IAEA Transport Regulations. The Radiation Management Plan for transport will be adhered to in respect of the following:

- All reasonable steps are taken to stow and secure any package in a freight container or on a vehicle;
- Any radiation monitoring or personal dose assessment requirements as outlined in the RMP are complied with; and
- The NSRPA are notified immediately of any accident involving the transport vehicle and loss of containment of radioactive materials.

4.6 Hydrology

The content of this section is adapted from the specialist Surface Water Study (SRK, 2018(4)) which is attached as Appendix G.

This section describes the surface water baseline for SR Area 1, which is based on a review of historic data, surface water monitoring and analyses. Commenced in 2017, the study investigated the baseline surface water conditions identifying mining and non-mining discharge sources.

4.6.1 Water resources

The surface water resources at the mine have been significantly changed from natural flow conditions. The historical mining areas are now largely ponded areas and the outflows into the natural river systems are via spillways from these impoundments. These dams are not ideal and in order to identify what the current flow regime and the potential impact of removing the dams will have on the water resources a runoff model was prepared. Runoff for the current situation was modelled and then a simulation of what the flows in the river could be if the dams were removed (or reduced in size) was undertaken.

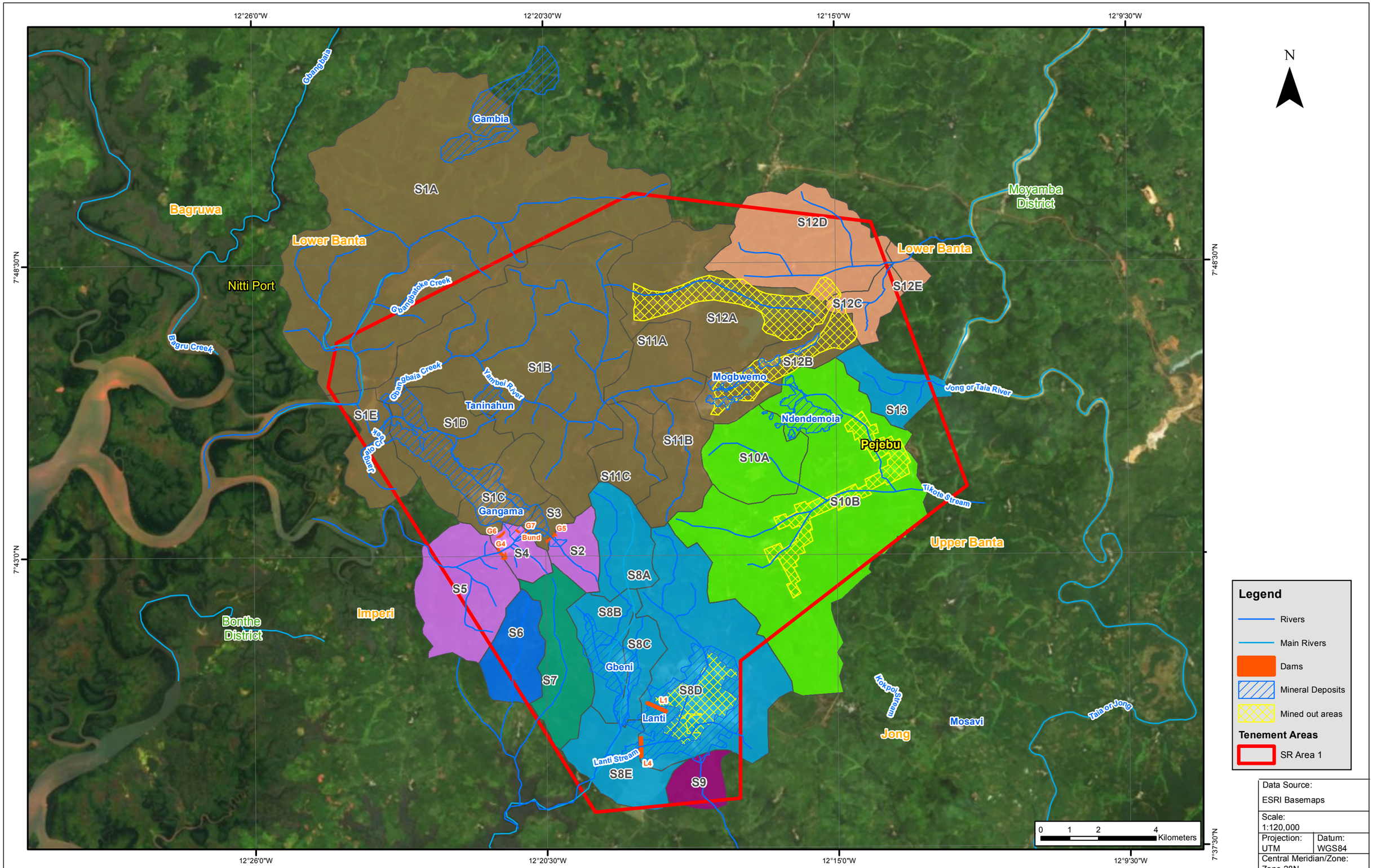
Surface water hydrology

SR Area 1 lies in between the 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 as described below for the MSP, Lanti and Gangama mining areas (Figure 4-20).

The MSP catchment system (i.e. S12D, S12C, S12E S13, S10A, S10B) located to the east of the SR Area 1 lease boundary, consists of three of catchment river systems (i.e. Kopa, Tikote, and Kokpoi stream), which flow east into the Jong River.

The Lanti catchment system consists of catchments S6, S7 and S8A to S8E, and includes the Gbeni and Lanti streams (Figure 4-20). Gbeni stream is located on the southern portion of the SR Area 1 and flows 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.

The Gangama catchment river system (i.e. Gbangbaia Creek, Jangalo Creek and Gbangbatoke-S1, S11 and S12A) is located to the east of the SR Area 1. The catchment drains into Gbangbaia Creek, which flows into Bagru Creek. The Bagru Creek flows into the Sherbro River, which then flows into the sea.



Legend

- Rivers
- Main Rivers
- Dams
- Mineral Deposits
- Mined out areas

Tenement Areas

- SR Area 1

Data Source: ESRI Basemaps	
Scale: 1:120,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	

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SR AREA 1 ESHIA & ESHMP

SR AREA 1 RIVER SYSTEMS AND MAJOR CATCHMENT AREAS

Date: 20/12/2017	Compiled by: SETI
Project No: 515234	Fig No: 4-20

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_1_SRL_RiverSystemsMap_A3L_14032018.mxd

Revision: LOUA Date: 14 03 2018

Flow results

The flow results for the various watercourses is presented in Table 4-22. The flow values in Table 4-22 represent the Mean Annual Runoff (MAR) generated from rainfall after taking catchment evaporation, dam evaporation and mining activities into account. Any abstractions from the river (including the environmental water requirements), irrigation, afforestation and alien vegetation are excluded from the results.

Table 4-22: Mean Annual Runoff at each river system

Site	Cumulative catchment (km^2)	Mean Annual Runoff (Mm^3)
S1, S11 and S12A	187.0	51.97
S2, S3, S4 and S5	20.2	4.26
S6	6.2	1.32
S7	8.7	1.86
S8	51.9	12.41
S9	3.3	0.70
S10 and S12B	65.3	12.97
S12	21.5	4.59
S13	5.0	1.07

The flows into and out of each dam / pond are outlined in Table 4-23. For example, the table shows that flow out of Titan Pond is 1.54 Mm^3 per annum, which is only 3 % of the entire catchment runoff given the small size of the pond. Removing the pond will cause an increase in the river runoff. The same flow behaviour, referred to above, is observed in the river systems with removal of all the dams.

The greatest variation in the flows in the rivers will be the daily changes rather than a monthly total. If the dams are not present the runoff will immediately discharge along the river and will not be retained in the dams. This results in a more variable flow in the rivers than is currently experienced below the dams. During the dry season, currently there is little or no flow. However this situation will change if the dams / ponds are removed as there will be a consistent baseflow in the rivers.

Table 4-23: Mean Annual Runoff into and out of the dams / ponds

River system	Dam/pond name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAR into the dam (Mm^3)	MAR out of the dam (Mm^3)
S1, S11 and S12A	Titan (S11B)	0.15	0.12	0.1	0.08	0.06	0.05	0.05	0.09	0.21	0.25	0.22	0.19	1.56	1.54
	Bamba Belebu Pond (S12A)	0.44	0.35	0.28	0.22	0.17	0.15	0.14	0.27	0.6	0.72	0.65	0.54	4.53	4.26
S2, S3, S4 and S5	G5 (S2)	0.07	0.06	0.05	0.04	0.03	0.02	0.02	0.04	0.1	0.12	0.11	0.09	0.75	0.73
	G7 (S3)	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.02	0.05	0.06	0.05	0.04	0.36	0.35
	G4 (S4)	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.03	0.07	0.09	0.08	0.07	0.56	0.53
S8	Lanti	0.14	0.11	0.09	0.07	0.05	0.04	0.04	0.08	0.18	0.22	0.2	0.16	1.39	1.11
S10 and S12B	Motinga	0.17	0.14	0.11	0.09	0.07	0.06	0.06	0.1	0.23	0.28	0.25	0.21	1.76	1.66
	Mogbwemo	0.16	0.13	0.1	0.08	0.06	0.05	0.05	0.1	0.22	0.27	0.24	0.2	1.68	0.68
	Pejebu	0.95	0.77	0.61	0.47	0.37	0.32	0.31	0.58	1.29	1.56	1.4	1.16	9.8	9.72

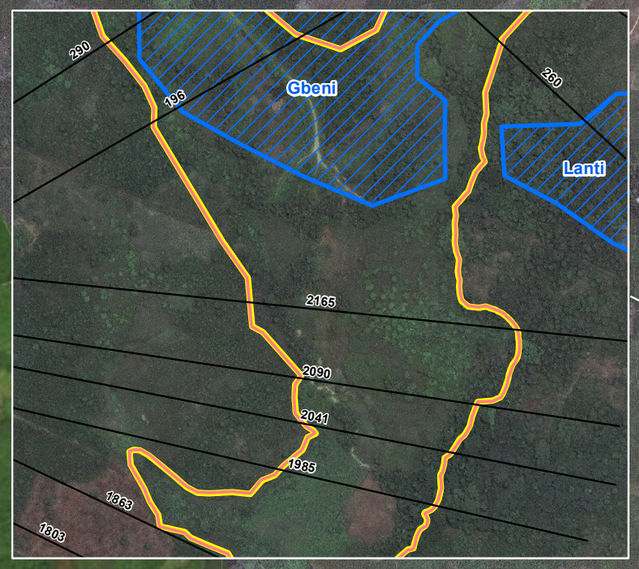
4.6.2 Floodline Determination

In order to ensure that the mine infrastructure is not impacted on by the rivers, a floodline analysis was conducted for the rivers that could potentially impact the mine workings. Floodlines determination for the watercourses in the historical mining areas were not undertaken as the river flow paths have been altered and are now predominantly dams / ponds. Floodlines in the dam areas are controlled by the spillway dimensions and these dams occupy the bulk of these catchments and thus negates any significant flooding potential. The floods into the dams are significantly attenuated and hence floodlines for these dam areas have been excluded from this study.

The results of the floodline determination are shown in Figure 4-21 and Figure 4-22.

12°21'0"W
12°19'30"W
12°18'0"W
12°16'30"W
7°42'0"N
7°40'30"N
7°39'0"N

Sembehun
Canal Junction
Simbekihun
Madina (FM)
Foinda
Higima
Victoria
Nyandehun
Mbele 1 (Yangatoke)
Mbele 2
Mokaba
Kanga
Foia
Gbaniga
Gbeni
Lanti



N

0 0.5 1 2 Kilometers

Legend

- Towns
- Settlements
- 1:100 year Floodline
- 1:50 year Floodline
- Cross Sections
- Mineral Deposits
- Mined out areas
- Haul Roads
- Sand Tailings

Data Source: ESRI Basemaps	
Scale: 1:30,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 07/12/2017	Compiled by: SETI
Project No: 515234	Fig No: 4-21

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SR AREA 1 ESHIA & ESHMP

FLOODLINE MAP FOR THE GBENI AND DOWNSTREAM OF L4 OPERATIONS

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_21_Lanti_FloodlineMap_A3L_14032018.mxd

Revision: LOUA Date: 14 03 2018

12°25'30"W 12°24'0"W 12°22'30"W 12°21'0"W 12°19'30"W

7°48'0"N 7°46'30"N 7°45'0"N

Gbangbatoke

Nitti (Foya)

Nitti (Foya)

Gbangbaia

Taninahun

Gangama

Mobimbi

N

0 0.5 1 2 Kilometers

Legend

- Towns
- Settlements
- Cross Sections
- 1:100 year Floodline
- 1:50 year Floodline
- Districts
- Mineral Deposits
- Mined out areas
- Chiefdom
- Haul Roads
- Sand Tailings

Data Source: ESRI Basemaps	
Scale: 1:33,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 14/12/2017	Compiled by: SETI
Project No: 515234	Fig No: 4-22

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SR AREA 1 ESHIA & ESHMP

FLOODLINE MAP FOR THE GANGAMA OPERATIONS AND THE NITTI PORT

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_22_Gangama_FloodlineMap_A3L_14032018.mxd

Revision: LOUA Date: 14 03 2018

4.6.3 Stormwater Management

The objectives of the Stormwater Management Plan (SWMP) are to provide a practical and executable plan for the management of stormwater on site, the effective management and separation of natural run-off and mine impacted water and to facilitate compliance with domestic legislation and international norms and standards.

Due to the high rainfall in Sierra Leone, a robust stormwater system is essential for the sustainability of the mine. A SWMP was developed as one option for the mine to implement. The areas where stormwater management systems have been developed are as follows:

- MSP;
- Dry Mining Plant 1 (DM1), located at the Lanti operation;
- Dry Mining Plant 2 (DM2), located at the Gangama operation;
- Gbeni operations; and
- Nitti Port.

Presently SRL is managing stormwater as follows:

- Stormwater diversion berms and channels redirect natural water away from new mining areas;
- Natural water holding dams and attenuation dams in the low-lying topographical areas;
- Mine impacted water collection berms redirect water to the appropriate containment facility (dredging ponds); and
- Silt traps are used to collect sediment before discharge.

The details of the SWMP are contained in Section 7 of the specialist Surface Water study (Appendix G).

4.6.4 Water Balance

The water balance will be able to simulate the water use at the Mine, simulate the main inputs and outputs of water in the system and simulate water use during average, wet and dry periods. The daily water balance for the MSP, Lanti operations (DM1) (Figure 4-23) and Gangama operations (DM2) (Figure 4-24) was designed using the Goldsim Monte Carlo simulation software.

Water balance results

A schematic flow diagram of the process water reticulation system for SR Area 1 (Figure 4-25 to Figure 4-27) was included in the data received from SRL and was used for the design of the water balance. Water requirements for DM1 were provided by the mine for June 2017 and were used as an average in the water balance calculation. The water requirements were provided for the DM2 and MSP and were used to determine the input water requirements. These are the requirements that the various plants have of the water quality and volume of the water coming into the plant as process water.

12°18'40"W
12°17'30"W
12°16'20"W
7°41'20"N
7°40'10"N
N
CP1
CP1
CP2
CP7
CP3
DM1
Gbeni
CP7A
CP4
CP6
CP7B
CP9A
CP8A
CP11B
CP5
L1
CP9B
Mbele 1 (Yangatoke)
Mbele 2
CP11A
CP12
Kanga
Mokaba
Foia
Higima
Lanti
CP13
CP13
Trench
L4
Nyandehun
0 0.25 0.5 1 Kilometers

Legend

- Towns
- Settlements
- Road Network
- DM1 Pump station bund
- Lanti Trench
- EMV Workshop
- Dams
- CP 7A and 7B
- Lanti Containments and Dams
- Dry mining plant
- C3 Dam
- Mineral Deposits
- Mined out areas
- Haul Roads
- Sand Tailings

Data Source: ESRI Basemaps	
Scale: 1:20,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 30/10/2017	Compiled by: LOUA
Project No: 515234	Fig No: 4-23

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SR AREA 1 ESHIA & ESHMP

LANTI DM1 CONTAINMENTS AND DAMS

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_23__Lanti_D1_containments_and_Dams_A3L_14032018.mxd

Revision: B Date: 14 03 2018

12°22'30"W 12°21'40"W 12°20'50"W 12°20'0"W

7°44'10"N

7°43'20"N

N

Gangama

Coffer Dam

G1

DM2

Bund

G7

G6

G5

G4

Lungi

Junctiola

Gangama

0 150 300 600 Metres

Legend

- Towns
- Settlements
- Water reticulation
- Road Network
- Gangama Dams
- Pits
- Mineral Deposits
- Haul Roads

Data Source: ESRI Basemaps	
Scale: 1:15,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	

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SR AREA 1 ESHIA & ESHMP

GANGAMA DM2 TAILINGS AND WATER STORAGE FACILITIES

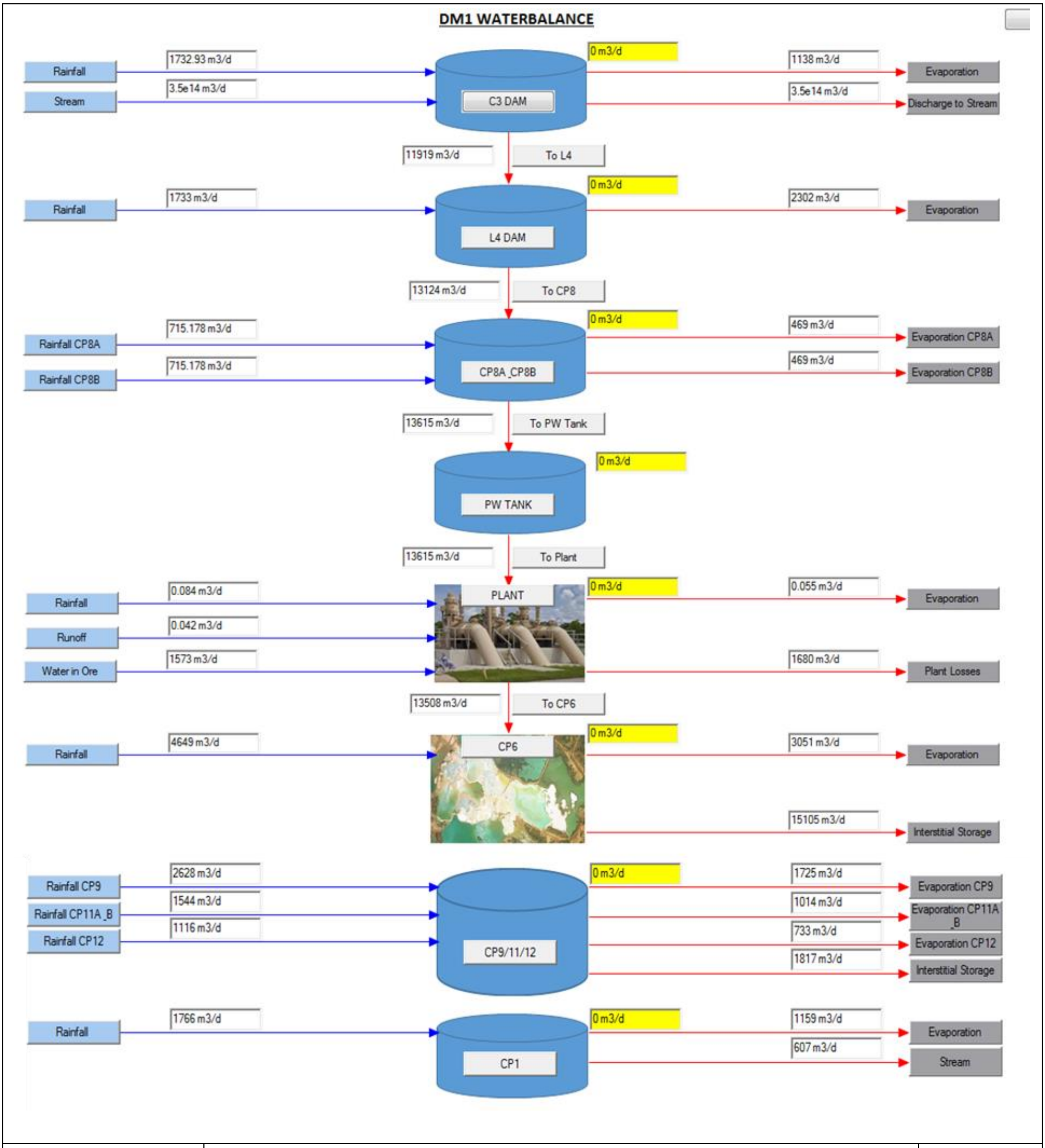
Date: 30/10/2017	Compiled by: FOWL
Project No: 515234	Fig No: 4-24

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_24_Tailings_and_Water_Storage_Facilities_A3L_14032017.mxd

Revision: LOUA Date: 14 03 2018

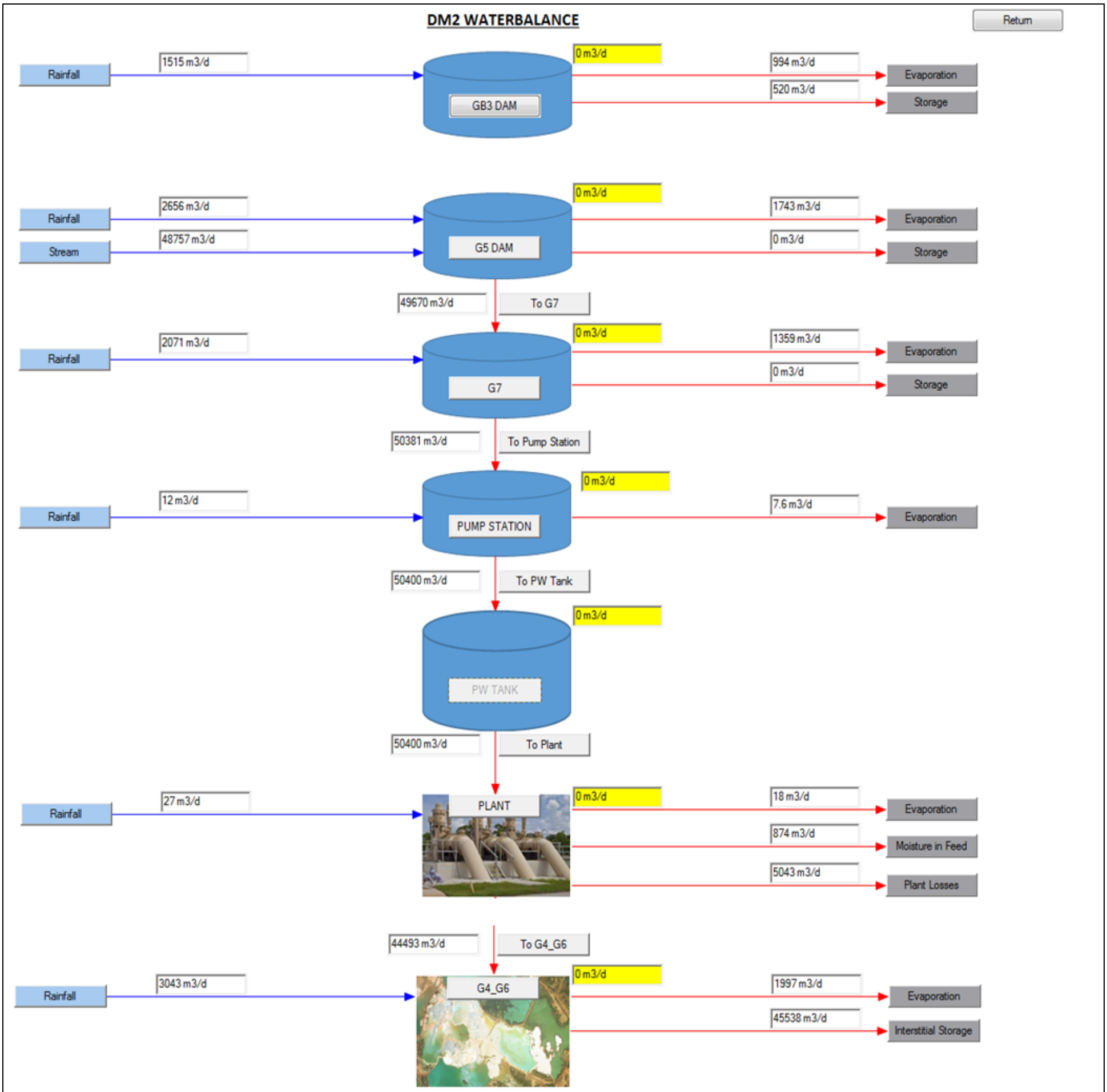
The schematic diagrams presented in Figure 4-25 to Figure 4-27 show the flow of water to and from the three sites with the approximate quantities, in cubic metres per day (m^3/d), on average (for the year and / or monthly average). The relevant inputs, including rainfall and water pumped from the streams, are shown on the left-hand-side. The diagram illustrates the circulating flow of water through the system. The values on the right of the schematic represent outputs, including consumption, evaporation and other losses.

The water balances depict the water volume demands at each facility, the amount of water being utilised in the mining process and where the storages, shortfalls and excesses are in the systems. Water balances aid in the efficient water management practice.



srk consulting	SR AREA 1 ESHIA & ESHMP LANTI DM1 WATER BALANCE	Project No. 515234

Figure 4-25: Lanti DM1 – water balance



srk consulting	SR AREA 1 ESHIA & ESHMP GANGAMA DM2 WATER BALANCE	Project No. 515234

Figure 4-26: Gangama DM2 – water balance

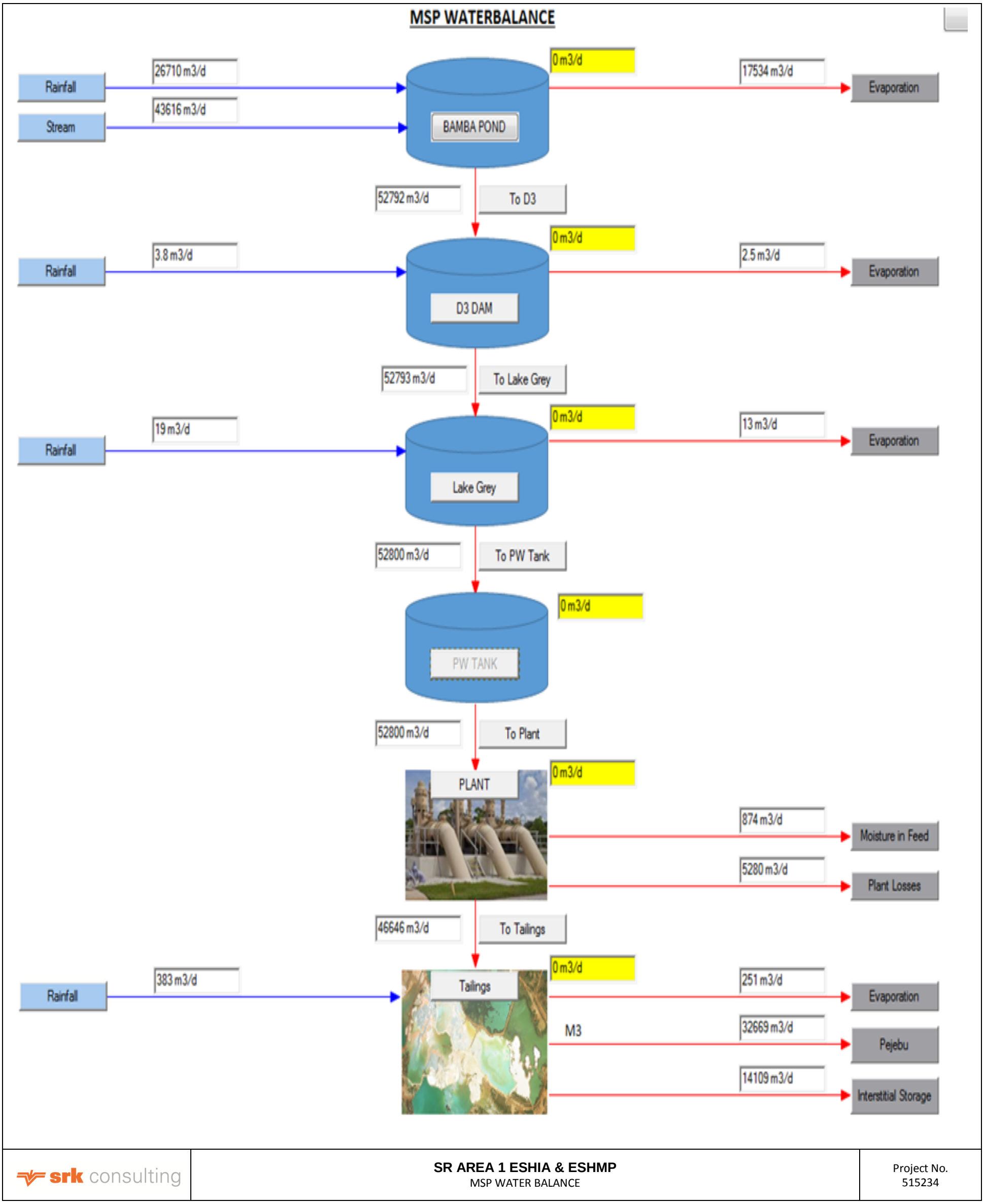


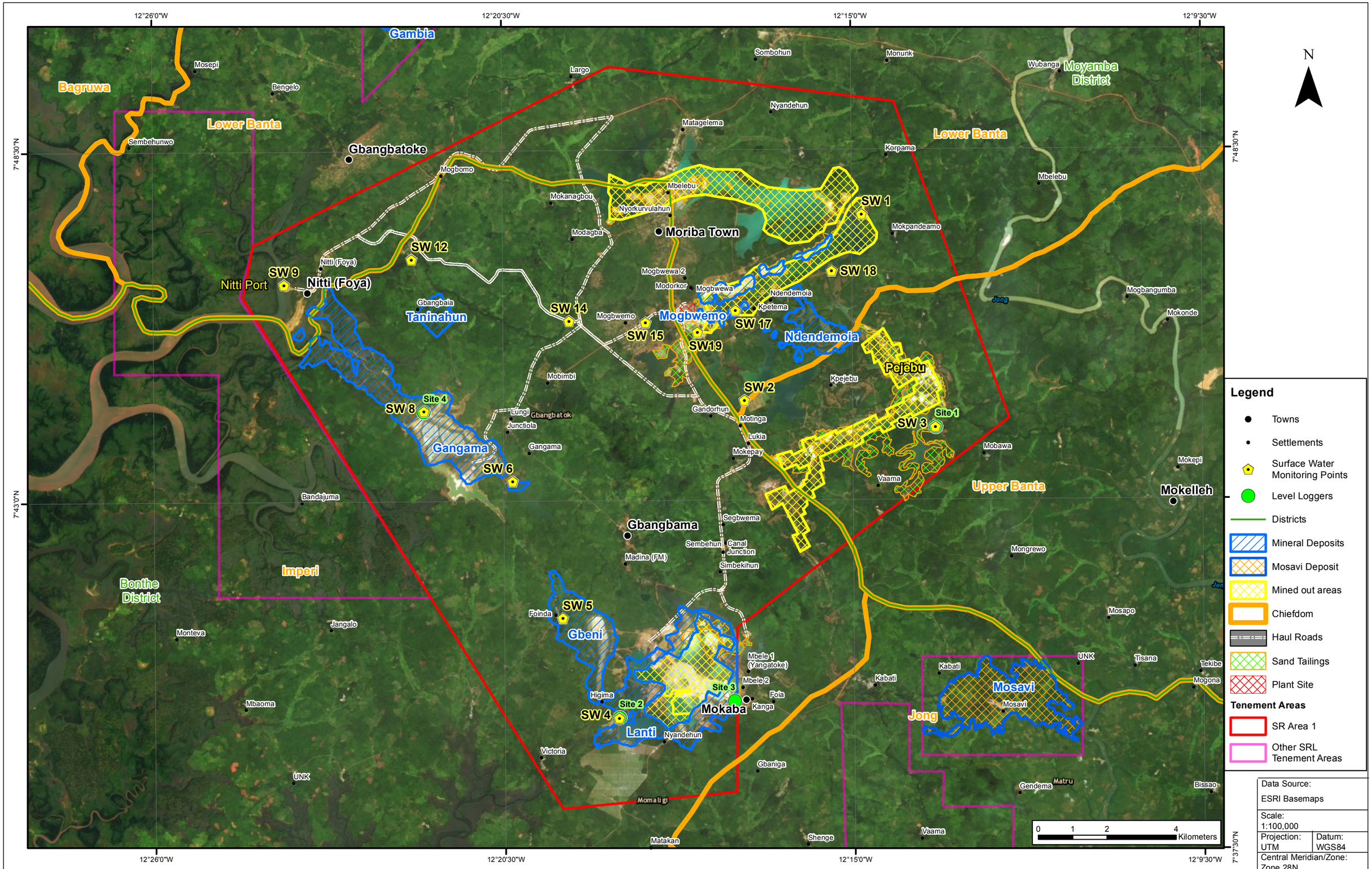
Figure 4-27: MSP – water balance

4.6.5 Water Quality

The surface water monitoring network is summarised in Table 4-27 and shown in Figure 4-28. These sites were chosen to monitor the effects of mining and the processing plants on the quality of surface water within the Area 1.

Table 4-24: Surface water monitoring points

Surface Water Monitoring Points (see Figure 4-28)	
Name	**Area of Interest**
SW 1	Mogbwemo Dredge Pond effluent. This point was selected as it is the furthest point from the MSP in Mogbwemo Dredge Pond to identify potential buffering in the pond.
SW 2	Motinga Pond. This point was selected as it is the point near the pineapple plantation.
SW 3	Pejebu Dredge Pond effluent. This point was selected as it is one of the points that discharges from the mine area into the Tikote Stream.
SW 4	Lanti North Dredge Pond effluent. This point was selected as it is one of the points that discharges from the mine area into the Lanti Stream.
SW 5	This point is situated to the west of the Gbeni pit in the west natural water diversion trench. This point was chosen as it describes the water quality of the upstream flow.
SW 6	G5 Dam upstream of the Gangama operations. This is the background point selected for the study.
SW 8	Gangama north downstream of the dry mining below the breached G1 wall. This point was selected as it is one of the points that discharges from the mine area into the unnamed stream.
SW 9	This point is located alongside the jetty at Nitti Port.
SW 12	This point is located downstream of the discharge point from the Bamba / Belebu Dredge Pond near the Gbangbaia village.
SW 14	This point is located downstream of the discharge point from the Bamba / Belebu Dredge Pond. This stream is not impacted by the MSP.
SW 15	Mogbwemo Domestic Pond. This point can only be potentially impacted from the historical mining that took place when the Motinga and Titan Ponds were mined 40 years ago.
SW 17	Mogbwemo Dredge Pond near MSP upstream of Kpetema bund.
SW 18	Mogbwemo Domestic Pond discharge to Pejebu Pond into the M3 channel.
SW 19	Discharge from MSP tailings into channel



Legend

- Towns
- Settlements
- Surface Water Monitoring Points
- Level Loggers
- Districts
- Mineral Deposits
- Mosavi Deposit
- Mined out areas
- Chiefdom
- Haul Roads
- Sand Tailings
- Plant Site

Tenement Areas

- SR Area 1
- Other SRL Tenement Areas

Data Source: ESRI Basemaps	
Scale: 1:100,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 23/02/2018	Compiled by: SETI
Project No: 515234	Fig No: 4-28

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SR AREA 1 ESHIA & ESHMP

SURFACE WATER MONITORING NETWORK

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_28_SurfaceWaterMonitoring_A3L_15032018.mxd

Revision: LOUA Date: 15 03 2018

The water quality data was captured during three sampling sessions conducted by SRL in July, August and October 2017. The water samples were analysed by Exova Jones Environmental Laboratory, an accredited laboratory in the United Kingdom.

The samples were analysed for a suite of physical and chemical determinants which are summarised in Table 4-25 relative to the guideline limits required by the Sierra Leone legislation as well as the guideline limits for domestic water use. The water quality parameters that exceed guideline limits are highlighted in Table 4-25. The pH and the EC concentrations for the monitoring points (August dataset) are shown in Figure 4-29 and Figure 4-30 respectively. These are two parameters that are important in water chemistry, are good indicators of general water chemistry and are both out of range of the background water quality average (SW 6).

The background surface water quality for the area is taken as the sample collected at the monitoring point SW 6. This point is upstream of any mining activities, but is in a man-made dam and therefore possibly represents the least affected surface water monitoring point within the SR Area 1. The water quality is compared to the average background water quality value, average for July, August and September (orange text) and to the guidelines as detailed in Table 4-25.

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. Whilst mining would usually be expected to impact surface water quality by disturbing the soils and ore bodies, on-going monitoring will better assist to assess natural influences on water quality versus mine related influences;
- It should be noted that a low pH of surface water samples with low mineral and salt content may be a natural reflection of the dissolution of carbon dioxide from the atmosphere, respiration of aquatic life forms and dissolution of natural soil humic acids etc. It does not necessarily infer that there is a direct detrimental impact of mining activities where not supported by significant changes in the ionic balance of the water;
- A slightly acidic pH of surface water samples similarly does not imply that the water quality is not fit-for-use, for domestic use or supporting aquatic life, particularly associated with weak acids such as carbonic acid from carbon dioxide. Future water quality monitoring should consider the specific concentration limits recommended in guidelines for water uses. This should also consider the context of the water use, which should be supported by aquatic biomonitoring, and understanding of the practical risk that the water quality parameters may pose, if any, to human health and the environment, in the context of the 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 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; and
- Nitti Port surface water has elevated aluminium, chloride and magnesium concentrations relative to the background levels and consequently increased salinity (EC and TDS). Aluminium concentrations exceed the drinking guidelines limits.

Table 4-25: Surface water quality analysis

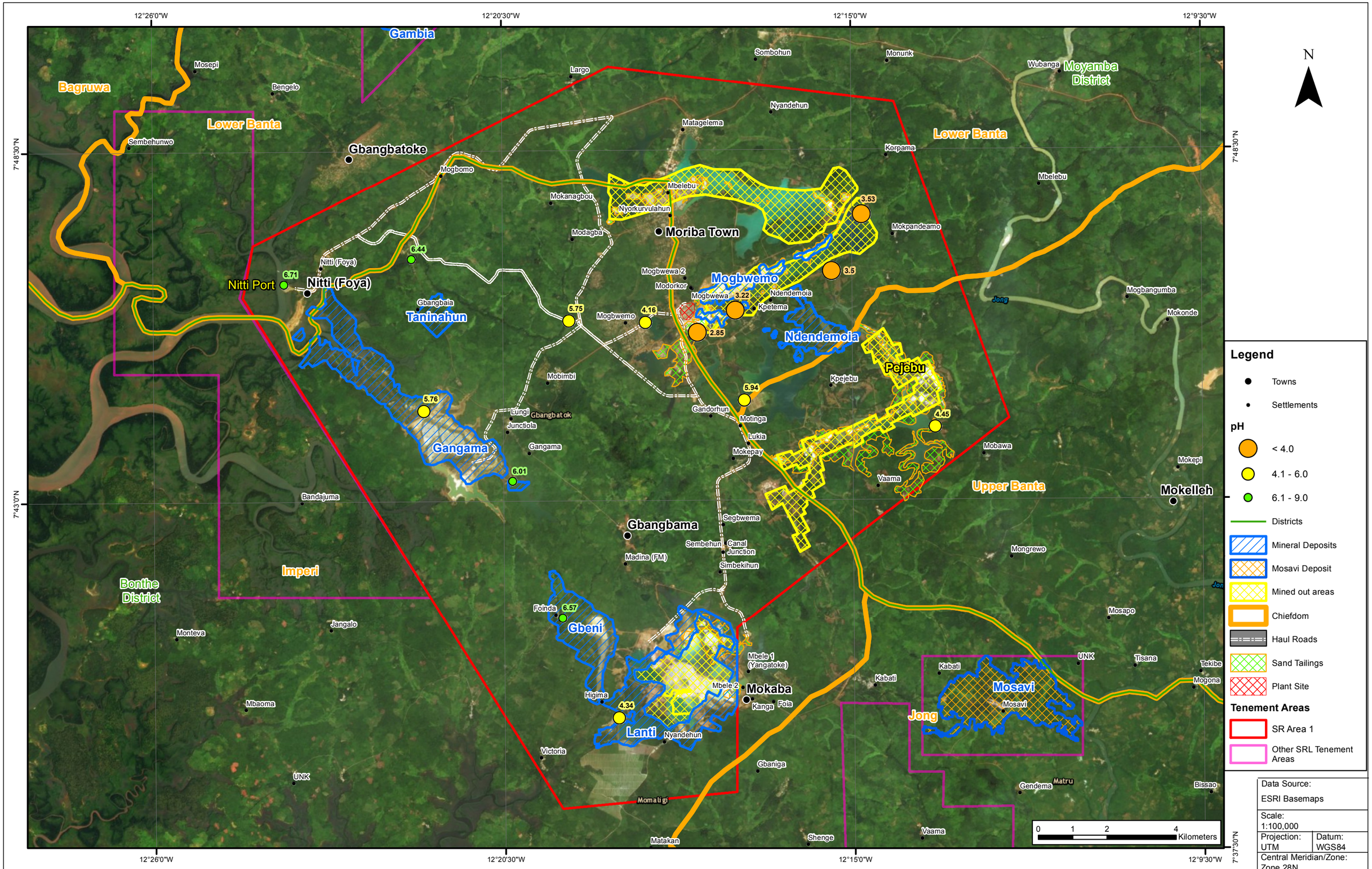
Parameter: Analyses in mg/ℓ (Unless specified otherwise)	Units	SANS 241:2015 (Standard Limits for Potable Water)	Applicable		LOD	SW 6 - Baseline				SW 1			SW 2			SW 3			SW 4			SW 5			SW 8		
			Sierra Leone	World Bank Guidelines		Jul	Aug	Oct	Average	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct
			Environmental and Social Regulations for Mining 2013	Mining (IFC EHS) 2007																							
pH – Value at 25°C *	S.U.	5 - 9.7	6 - 9	6 - 9	0.010	6.3	6.0		6.2	3.7	3.5	3.7	6.3	5.9		4.5	4.5		4.2	4.3		6.9	6.6		6.3	5.8	
Electrical Conductivity in mS/m at 25°C	mS/m	170			0.500	0.95	1.01	0.97	0.98	13.69	12.52	11.13	0.86	1.15	0.81	3.14	2.40	2.32	4.58	3.18	3.94	2.45	1.82	1.48	1.40	1.51	1.27
Total Dissolved Solids at 180°C *	mg/l	1200			35.000	35.00	35.00		35.00	35.00	57.00	39.00	35.00	35.00		35.00	35.00		35.00	35.00		35.00	35.00		35.00	35.00	
Colour in PtCo Units *	mg/l Pt-Co	15																									
Turbidity in N.T.U	NTU	1			0.100	1.50	1.50		1.50	1.30	0.70	0.30	1.70	2.50		1.00	1.00		0.90	1.50		6.70	7.80		7.10	13.60	
Chloride as Cl	mg/l	300			0.300	1.80	1.50	1.80	1.70	2.00	1.60	1.60	6.80	1.60	1.70	1.80	1.50	1.80	2.10	1.60	1.80	2.20	1.70	1.90	1.90	1.50	1.90
Sulphate as SO4	mg/l	500			0.500	2.40	2.20		2.30	24.00	24.50	18.70	8.90	2.30		6.70	5.70		9.00	6.90		2.50	2.40		2.80	3.20	
Fluoride as F	mg/l	1.5			0.300	< 0.300	< 0.300	< 0.300	0.30	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300
Nitrate as N	mg/l	11			0.050	0.23	0.38		0.31	0.27	< 0.050	0.25	1.11	0.41		0.23	0.38		0.23	0.38		0.25	0.41		0.38	0.70	
Calcium as Ca	---	---			0.200		2.00	2.00	2.00		2.00	2.00		2.00	2.00		2.00	2.00		2.00	2.00		2.00	2.00		2.00	2.00
Magnesium as Mg	---	---			0.100		1.00	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00
Aluminium as Al	mg/l	0.3			0.020		0.09	0.04	0.06		0.90	0.72		0.14	0.06		0.12	0.12		0.13	0.17		0.65	0.34		0.34	0.42
Antimony as Sb*	mg/l	0.02			0.002		< 0.002	< 0.002	0.002		< 0.002	0.01		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	0.00
Arsenic as As*	mg/l	0.01	0.1	0.1	0.003		0.00	0.00	0.003		0.00	0.003		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00
Cadmium as Cd	mg/l	0.003	0.05	0.05	0.001		< 0.001	< 0.001	0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001
Total Chromium as Cr	mg/l	0.05		0.1	0.002		< 0.002	< 0.002	0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		0.00	< 0.002		< 0.002	0.00
Copper as Cu	mg/l	2	0.6	0.3	0.007		< 0.007	< 0.007	0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007
Iron as Fe	mg/l	2	2	2	0.020		0.43	0.67	0.55		0.12	0.16		0.40	0.29		0.21	0.12		0.06	0.02		1.12	0.44		0.49	1.24
Lead as Pb	mg/l	0.01	0.2	0.2	0.005		0.01	0.01	0.005		0.005	0.01		0.01	0.01		0.01	0.01		0.01	0.01		0.01	0.01		0.01	0.01
Manganese as Mn	mg/l	0.4			0.002		0.01	0.02	0.015		0.13	0.12		0.01	0.01		0.03	0.04		0.03	0.04		0.05	0.05		0.05	0.05
Nickel as Ni	mg/l	0.07		0.5	0.002		0.00	0.00	0.002		0.01	0.01		0.00	0.00		0.00	0.00		0.01	0.01		0.00	0.00		0.00	0.00
Selenium as Se*	mg/l	0.04			0.003		0.00	0.00	0.003		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.01		0.00	0.00		0.00	0.00
Zinc as Zn	mg/l	5	1.5	0.5	0.003		0.00	0.00	0.003		0.01	0.01		0.01	0.00		0.00	0.00		0.01	0.00		0.00	0.00		0.00	0.00
Total Suspended Solids (TSS)	mg/l		50	50	10.000	< 10.000	< 10.000		10.000	< 10.000	< 10.000	< 10.000	< 10.000	< 10.000		< 10.000	< 10.000		< 10.000	< 10.000		< 10.000	14.000		< 10.000	12.000	
Mercury (total)	mg/l		0.002	0.002	0.001		< 0.001	< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001
Chemical Oxygen Demand (COD)	mg/l			150	9	19	< 9	< 9	12	< 9	< 9	14	14	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	16	< 9	< 9	16	< 9	< 9

Parameter: Analyses in mg/ℓ (Unless specified otherwise)	Units	SANS 241:2015 (Standard Limits for Potable Water)	Applicable		LOD	SW 6 - Baseline				SW 9			SW 12			SW 14			SW 15			SW 17			SW 18		SW 19	
			Sierra Leone Environmental and Social Regulations for Mining 2013	World Bank Guidelines Mining (IFC EHS) 2007		Jul	Aug	Oct	Average	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct	Jul	Aug	Oct	Aug	Oct	Aug	Oct
pH – Value at 25°C *	S.U.	5 - 9.7	6 - 9	6 - 9	0.010	6.3	6.0		6.2	7.1	6.7		6.5	6.4		6.0	5.8		4.7	4.2		3.4	3.2		3.5		2.9	
Electrical Conductivity in mS/m at 25°C	mS/m	170			0.500	0.95	1.01	0.97	0.98	128.10	43.00	109.20	1.05	20.73	1.94	1.95	1.60	1.63	2.78	4.02	3.43	21.80	23.50	22.10	12.46	16.29	51.40	66.00
Total Dissolved Solids at 180°C *	mg/l	1200			35.000	35.00	35.00		35.00	692.00	245.00		35.00	102.00		35.00	35.00		48.00	66.00		62.00	55.00		35.00		117.00	
Colour in PtCo Units *	mg/l Pt-Co	15																										
Turbidity in N.T.U	NTU	1			0.100	1.50	1.50		1.50	46.40	36.10		0.40	2.90		1.10	3.00		1.90	1.40		0.20	3.10		10.60		4.20	
Chloride as Cl	mg/l	300			0.300	1.80	1.50	1.80	1.70	365.20	110.50	295.40	2.10	49.70	2.50	2.10	1.60	1.80	2.20	1.50	1.80	2.00	1.60	2.20	1.60	1.70	1.50	1.60
Sulphate as SO4	mg/l	500			0.500	2.40	2.20		2.30	43.70	15.10		1.80	10.50		5.30	3.90		6.50	8.60		36.20	41.10		22.90		88.80	
Fluoride as F	mg/l	1.5			0.300	< 0.300	< 0.300	< 0.300	0.30	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300	< 0.300
Nitrate as N	mg/l	11			0.050	0.23	0.38		0.31	0.23	< 0.050		0.23	0.45		0.25	0.38		0.23	0.38		0.23	0.38		< 0.050		0.38	
Calcium as Ca	---	---			0.200		2.00	2.00	2.00		2.90	6.80		2.00	2.00		2.00	2.00		2.00	2.00		2.00	2.00	2.00	2.00	2.00	2.00
Magnesium as Mg	---	---			0.100		1.00	1.00	1.00		8.20	23.90		3.80	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00
Aluminium as Al	mg/l	0.3			0.020		0.09	0.04	0.06		2.64	0.66		0.15	0.21		0.13	0.14		0.31	0.24		1.04	1.21	0.62	0.91	2.14	3.63
Antimony as Sb*	mg/l	0.02			0.002		< 0.002	< 0.002	0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	0.00	< 0.002	< 0.002	< 0.002	0.00
Arsenic as As*	mg/l	0.01	0.1	0.1	0.003		0.00	0.00	0.003		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
Cadmium as Cd	mg/l	0.003	0.05	0.05	0.001		< 0.001	< 0.001	0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Total Chromium as Cr	mg/l	0.05		0.1	0.002		< 0.002	< 0.002	0.002		0.00	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	< 0.002		< 0.002	0.00	< 0.002	< 0.002	< 0.002	0.00
Copper as Cu	mg/l	2	0.6	0.3	0.007		< 0.007	< 0.007	0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007		< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Iron as Fe	mg/l	2	2	2	0.020		0.43	0.67	0.55		1.79	0.50		0.40	0.70		0.36	0.36		0.13	0.06		0.32	0.51	0.17	0.31	2.84	5.23
Lead as Pb	mg/l	0.01	0.2	0.2	0.005		0.01	0.01	0.005		0.01	0.01		0.01	0.01		0.01	0.01		0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01
Manganese as Mn	mg/l	0.4			0.002		0.01	0.02	0.015		0.02	0.01		0.02	0.01		0.05	0.07		0.08	0.07		0.10	0.12	0.09	0.12	0.23	0.44
Nickel as Ni	mg/l	0.07		0.5	0.002		0.00	0.00	0.002		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.01	0.02	0.01	0.01	0.01	0.02
Selenium as Se*	mg/l	0.04			0.003		0.00	0.00	0.003		0.00	0.01		0.00	0.01		0.00	0.00		0.00	0.01		0.00	0.00	0.00	0.00	0.00	0.00
Zinc as Zn	mg/l	5	1.5	0.5	0.003		0.00	0.00	0.003		0.01	0.00		0.00	0.00		0.01	0.00		0.01	0.00		0.02	0.02	0.01	0.02	0.02	0.03
Total Suspended Solids (TSS)	mg/l		50	50	10.000	< 10.000	< 10.000		10.000	60.000	41.000		< 10.000	< 10.000		22.000	< 10.000		< 10.000	< 10.000		< 10.000	< 10.000		20.000		27.000	
Mercury (total)	mg/l		0.002	0.002	0.001		< 0.001	< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Chemical Oxygen Demand (COD)	mg/l			150	9	19	< 9	< 9	12	23	< 9	< 9	13	< 9	< 9	10	< 9	< 9	12	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9

*unfiltered

LEGEND

	Drinking Water/WHO 2017#SANS 2015
	Environmental and Social Regulations for Mining 2013
	Mining (IFC EHS) 2007
123	Exceeding the Background WQ (SW 6 Average)



Legend

- Towns
- Settlements

pH

- < 4.0
- 4.1 - 6.0
- 6.1 - 9.0
- Districts
- Mineral Deposits
- Mosavi Deposit
- Mined out areas
- Chiefdom
- Haul Roads
- Sand Tailings
- Plant Site

Tenement Areas

- SR Area 1
- Other SRL Tenement Areas

Data Source: ESRI Basemaps	
Scale: 1:100,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	

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SR AREA 1 ESHIA & ESHMP

SURFACE WATER QUALITY - pH

Date: 12/12/2017	Compiled by: SETI
Project No: 515234	Fig No: 4-29

Path: J:\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Final_Report_Maps\ENVIRO_SummaryReport\March2018\515234_F4_29_SurfaceWater_pH_A3L_15032018.mxd

Revision: LOUA Date: 15 03 2018

12°26'0"W 12°20'30"W 12°15'0"W 12°9'30"W

7°48'30"N 7°43'0"N 7°37'30"N

N

Gambia
Bagruwa
Lower Banta
Upper Banta
Moyamba District
Bonthe District
Imperi
Jong

Mosepi
Bengelo
Sembehunwo
Gbangbatoke
Largo
Sombohun
Monunk
Wubanga
Nyandehun
Matagelema
Korpama
Mbelebu
Mogbomo
Mokanagbou
Nyorkurvulahun
Modagba
Moriba Town
Mokpandeamo
Nitti (Foya)
Nitti Port
Gbangbaia
Taninahun
Mogbwewa 2
Modorkor
Mogbwemo
Mogbwewa
Ndendemoia
Kpetema
Mogbangumba
Mokonde
Mobimbi
Kpejebu
Pejebu
Lungi
Gbangbatok
Junctiola
Gangama
Gandorhun
Motinga
Lukia
Mokepay
Mobawa
Mokepi
Vaama
Mokelleh
Bandajuma
Segbwema
Gbangbama
Sembehun
Canal Junction
Madina (FM)
Simbekihun
Mongrewo
Fotinda
Gbeni
Mbele 1 (Yangatoke)
Mbele 2
Mokaba
Higima
Kanga
Foia
Lanti
Nyandehun
Victoria
Gbaniga
Kabati
Mosavi
UNK
Tisana
Tekibe
Mogona
Mosapo
Monteva
Jangalo
Mbaoma
UNK
Momaligi
Matakan
Shenge
Gendema
Matru
Bissao

125.2
124.6
207.3
430
235
514
40.2
16
11.5
24
15.1
10.1
18.2
31.8

0 1.25 2.5 5 Kilometers

Legend

- Towns
- Settlements

EC uS/cm

- < 100
- 100 - 300
- > 300
- Districts
- Mineral Deposits
- Mosavi Deposit
- Mined out areas
- Chiefdom
- Haul Roads
- Sand Tailings
- Plant Site

Tenement Areas

- SR Area 1
- Other SRL Tenement Areas

Data Source: ESRI Basemaps	
Scale: 1:100,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 11/12/2017	Compiled by: SETI
Project No: 515234	Fig No: 4-30

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SR AREA 1 ESHIA & ESHMP

SURFACE WATER QUALITY - ELECTRICAL CONDUCTIVITY

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Revision: LOUA Date: 15 03 2018

4.7 Hydrogeology

The content of this section is adapted from the specialist Hydrogeology Study (Greall 2018) (Appendix F). The hydrogeological investigation was conducted in phases commencing with an initial site visit to assess on-site conditions. A total of 19 additional boreholes were drilled SR Area 1, with some emphasis on the dry mining areas to support future dewatering efforts. The monitoring boreholes were subjected to a constant rate test followed by recovery. Groundwater sampling and groundwater modelling will be undertaken throughout 2018 and the results will be included in an undated hydrogeological report.

4.7.1 Monitoring borehole drilling

A total of 19 monitoring boreholes were drilled during the course of the hydrogeological investigation (Figure 4-31). The sites were selected to evaluate ambient groundwater conditions away from the mining operations and the impact of the historical mining ponds on the groundwater regime. Some emphasis was also placed on the Gangama and Gbeni dry mining deposits with the installation of borehole pairs to monitor the groundwater levels within the orebody and the underlying weathered / fresh basement contact respectively.

Boreholes monitoring ambient groundwater conditions are located on the northern and south eastern boundary of SR Area 1 distant from any historical, current or planned mining operations. The boreholes monitoring the historical mining ponds are located on the watersheds immediately adjacent to these features so that any groundwater fluctuations in response to the mining pond levels may be determined. Borehole pairs drilled in the Gangama and Gbeni dry mining deposits monitor the groundwater response within the orebody and the underlying weathered / fractured basement contact to dewatering.

Given the generally low yield / water strikes within the unconsolidated sediments, the boreholes were generally screened throughout from 3 m below surface to the fresh basement. In the dry mining areas, the shallow boreholes that were drilled into the orebody were screened throughout whereas the deeper boreholes drilled into the weathered / fresh basement contact were only screened across this zone with the remainder of the hole constructed with plain casing to surface. A gravel pack was installed across the screened casing while a concrete seal was installed across the solid casing to surface.

The details of the boreholes drilled during this investigation are presented in Table 4-26. Hole depths range from 9 m to 40 m with an average depth of 24 m. The hydrogeological characteristics of the drill holes will be described in the following sections.

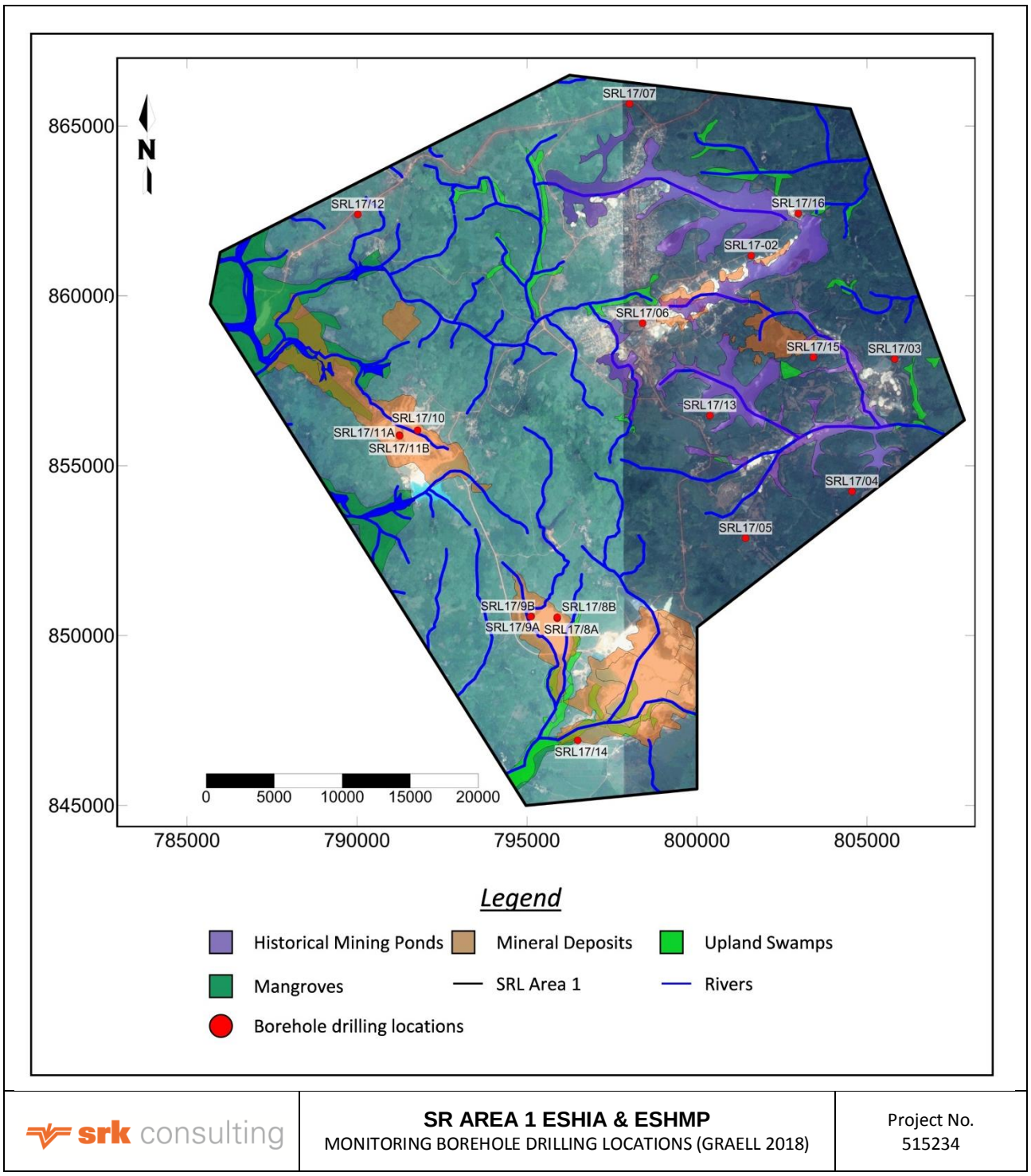


Figure 4-31: SR Area 1 monitoring borehole drilling locations (Graell 2018)

Table 4-26: SR Area 1 monitoring borehole drilling

X	Y	Z	BH-ID	Depth (m)	GW (mbc)	GW (mamsl)	Laterite Thickness (m)	Weathering Depth (m)	Blow Yield l/sec
802009	867469		SRL17-01	28	12.00		5	21	0.72
801595	861180	52.48	SRL17-02	30	11.40	40.58	5	28	4.00
805814	858139	44.92	SRL17/03	25	9.81	34.61	2	9	
804557	854242	38.78	SRL17/04	40	4.89	33.39	10	34	
801426	852866	44.34	SRL17/05	20	7.05	36.79	5	20	2.50
798398	859191	52.71	SRL17/06	23			8	20	20.00
798013	865651	56.02	SRL17/07	35	8.61	46.91	6	30	5.50
795886	850511	21.00	SRL17/8A	9	2.00	18.50	0		
795887	850536	20.95	SRL17/8B	25	3.78	16.67	0	20	2.00
795123	850565	14.00	SRL17/9A	12	3.45	10.05	1		
795106	850559	13.95	SRL17/9B	28	3.48	9.97	4	25	1.86
791782	856043	11.16	SRL17/10	20	5.40	5.26	0	20	10.00
791250	855902	11.72	SRL17/11A	15	6.43	4.79	0		0.50
791255	855877	11.64	SRL17/11B	27	6.16	4.98	0	27	6.00
790024	862395	74.75	SRL17/12	15	9.68	64.57	3	12	
800377	856477	50.00	SRL17/13	25	9.49	40.01	8	25	4.50
796494	846914	13.11	SRL17/14	34			0	34	32.00
803421	858193	40.22	SRL17/15	30	6.71	33.01	3	30	1.75
802975	862423	49.50	SRL17/16	20	12.03	36.97	0	20	2.50

Meters below collar (mbc)

4.7.2 Hydrostratigraphy

The geology underlying the site 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 surface and therefore does not form part of the hydrostratigraphy. Nonetheless, the laterite distribution does influence the groundwater recharge across the study area.

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. However, these areas would be assigned different hydrogeological characteristics in any subsequent groundwater modelling rather than defining them as a separate hydrostratigraphic unit for the purpose of this investigation.

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.

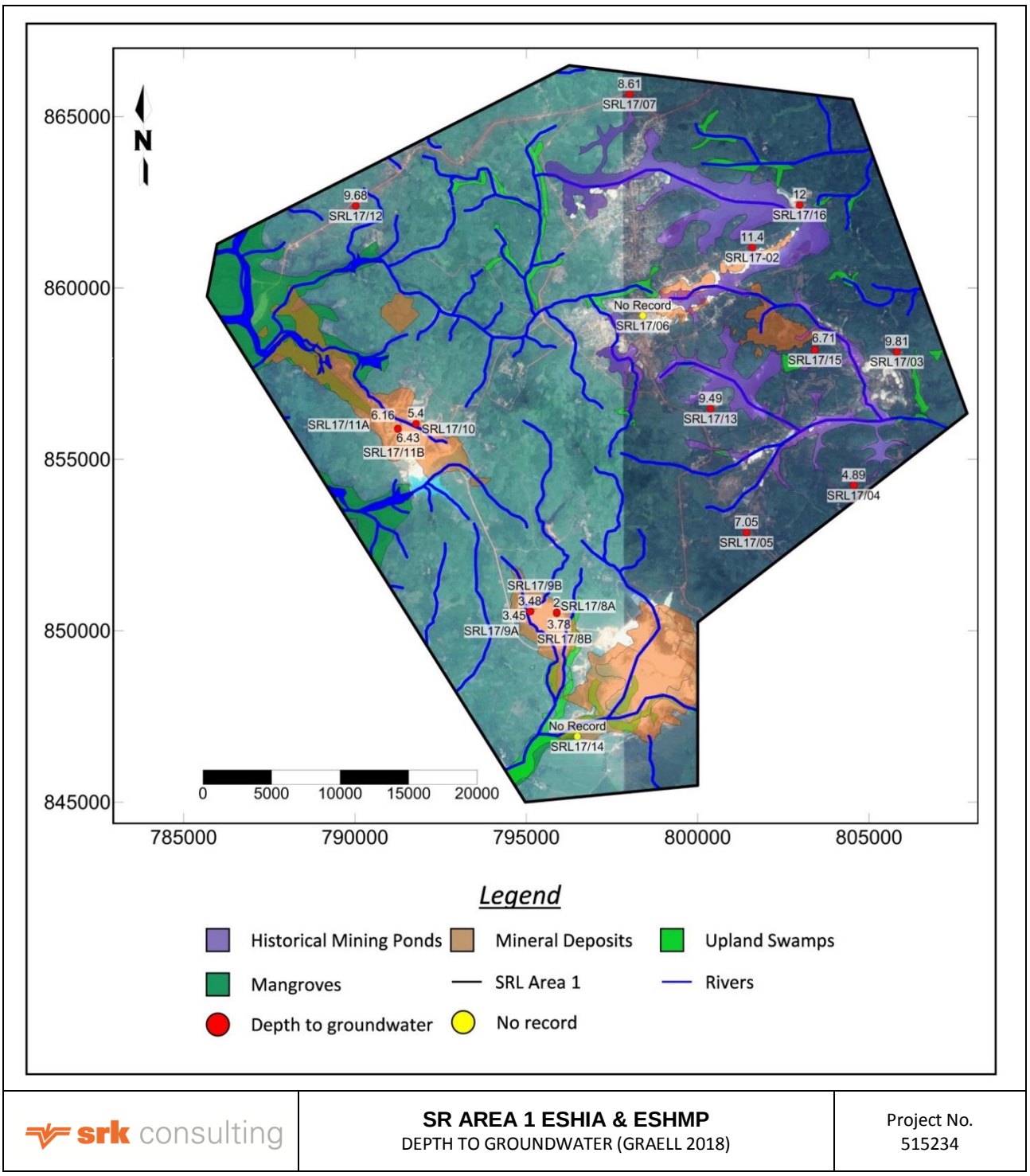
The effective hydrostratigraphy for SR Area 1 may therefore be summarized as follows:

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

4.7.3 Observed groundwater levels

Groundwater levels are not currently measured in the SR Area 1 community boreholes. Preliminary observed groundwater levels in the monitoring boreholes drilled during this investigation range from 2 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 as shown in Figure 4-32. 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.

Groundwater gradients tend to mimic the topography under ambient conditions. The potential influence of the historical mining ponds and current mining operations on the groundwater gradients has been investigated by plotting the topography against groundwater levels as shown in Figure 4-33. 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. However, this may change in the future as dry mining deepens below the regional groundwater levels. It is also important to note that borehole SRL17/02 has a similar groundwater elevation to that of the surrounding historical mining ponds. It is possible that the groundwater levels may lower in response to the lowering of the historical mining pond water levels as part of any closure plan.



srk consulting	**SR AREA 1 ESHIA & ESHMP** DEPTH TO GROUNDWATER (GRAELL 2018)	Project No. 515234

Figure 4-32: SR Area 1 Depth to groundwater (MBC) (Graell 2018)

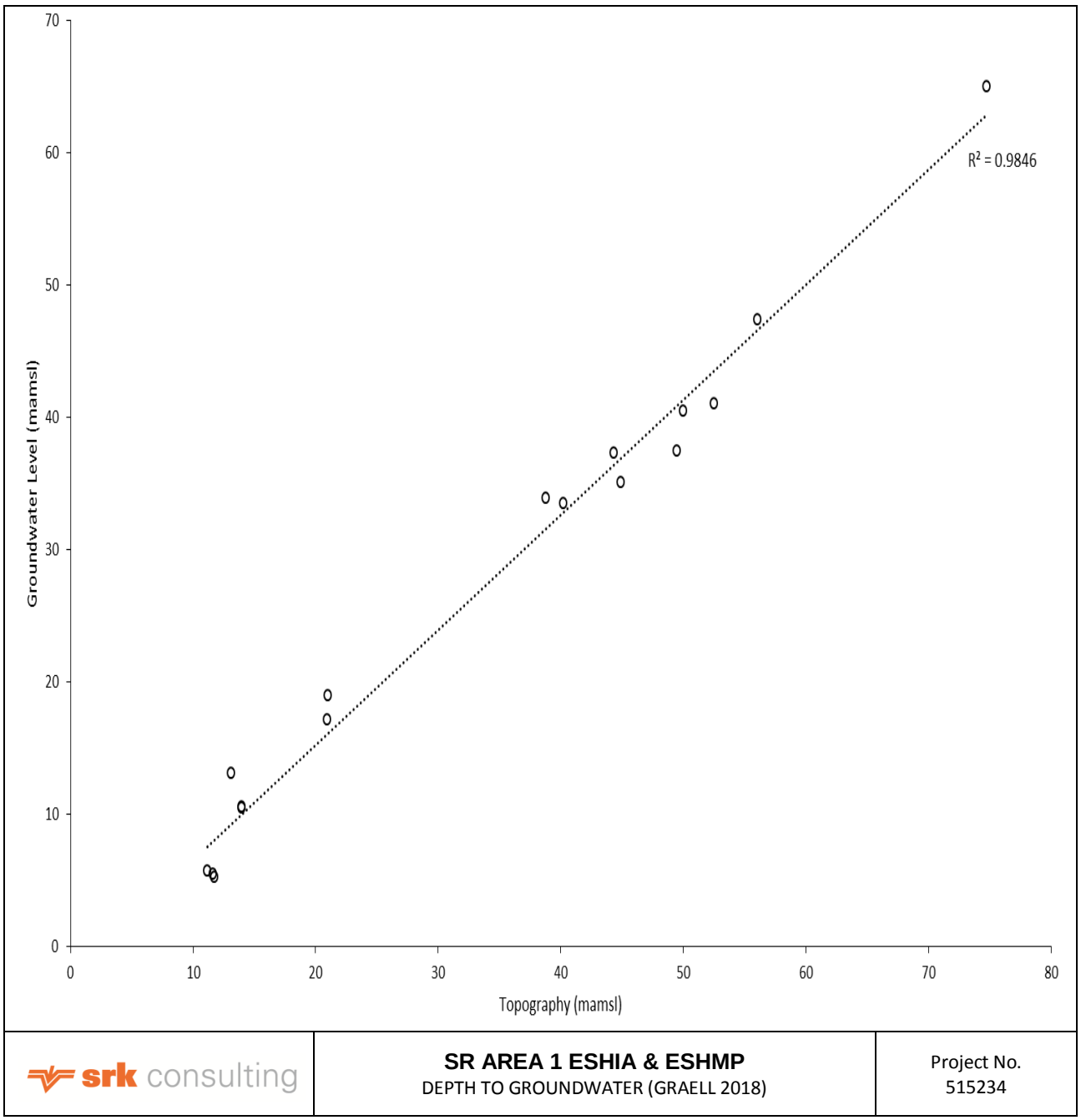


Figure 4-33: SR Area 1 Topography vs Groundwater Level (mamsl) (Graell 2018)

4.7.4 Aquifer parameters

Borehole blow yields provide an indication of the permeability distribution across SR Area 1 as displayed in Figure 4-34. It can be seen that the majority of the blow yields range from 0.5 l/sec to 6 l/sec with an average of 2.9 l/sec. Exceptions include SRL17/06 (20 l/sec), SRL17/10 (10 l/sec) and SRL17/14 (32 l/sec). The latter borehole is associated with the Bullom sediments. Lower blow yields in the dry mining areas are attributed to the clayey silty nature of the ore deposit.

Pump tests have been undertaken on the majority of the monitoring boreholes drilled during this investigation as shown in Table 4-27. The three exceptional boreholes SRL17/06, SRL17/10 and SRL17/14 could not be pump tested since the yield exceeded the pump capacity. The decision whether to pump test these holes in future will be undertaken once the groundwater modelling has been completed during 2018.

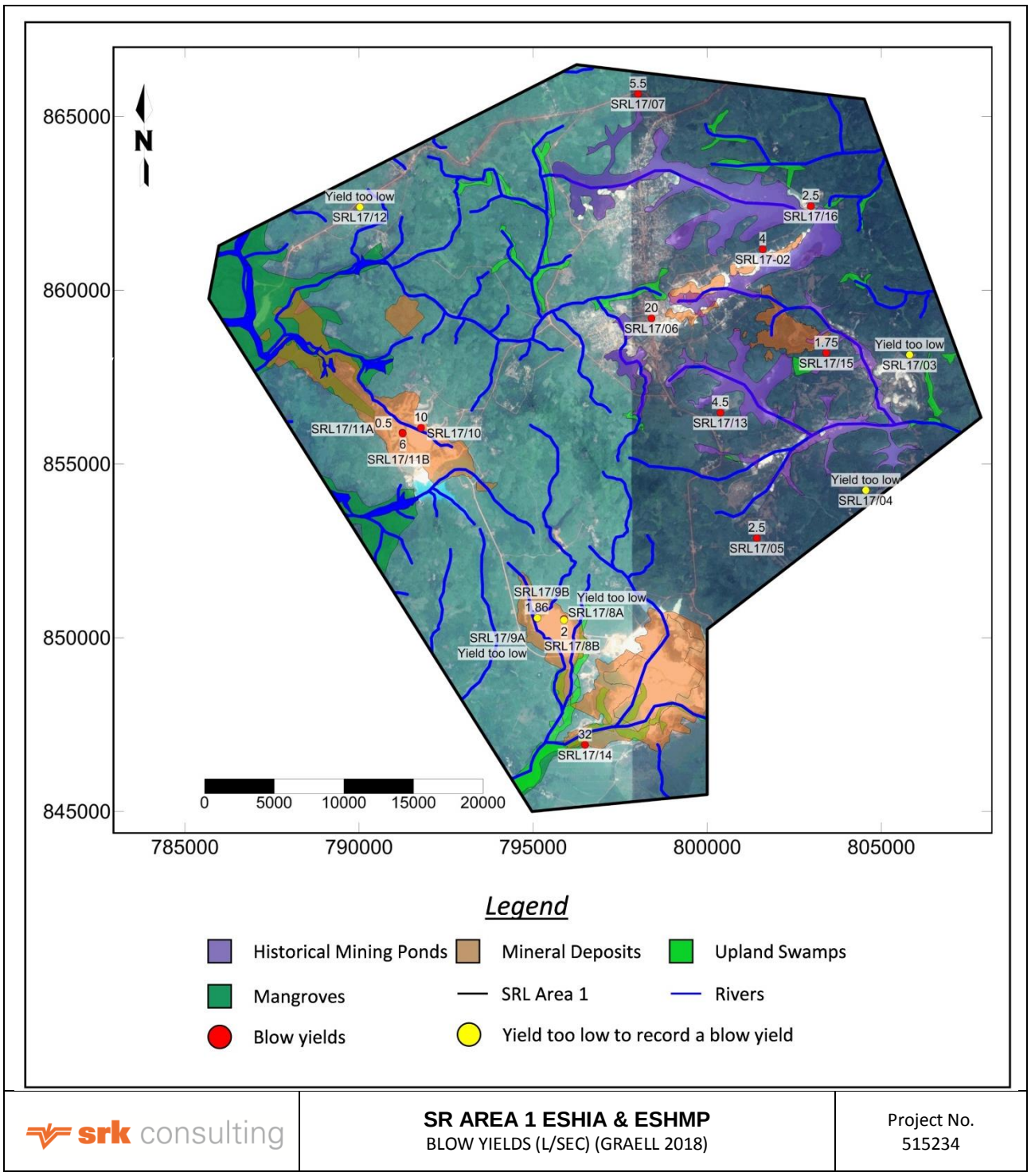


Figure 4-34: SR Area 1 blow yields (l/sec) (Graell 2018)

Table 4-27: SR Area 1 pump testing results

Borehole (BH)-ID	Pumping Duration (min)	Pumping Rate (l/sec)	Pumping T (m^2/day)	Recovery T (m^2/day)	Slug Test K (m/day)
SRL17-01	120	0.45	4	3	
SRL17-02	120	1.82	17	17	
SRL17/03	70	0.15	0.12	0.23	
SRL17/04	180	0.93	2	1	
SRL17/05	120	1.38	7	6	
SRL17/06	BH yield too high				
SRL17/07	120	1.84	214	154	
SRL17/8A					0.02
SRL17/8B	180	0.79	6	6	
SRL17/9A					0.09
SRL17/9B	180	0.79	5	5	
SRL17/10	BH yield too high				
SRL17/11A	120	0.27	50	10	
SRL17/11B	180	1.91	18	18	
SRL17/12	7	0.24	0.82	3	
SRL17/13	180	3.24	20	30	
SRL17/14	BH yield too high				
SRL17/15	180	1.2	6	6	
SRL17/16	180	1.22	17	18	

Table 4-27 shows a general correlation between the constant rate and recovery pumping tests. Exceptions include SRL17/07, SRL17/11A and SRL17/13. The relatively high transmissivity for SRL17/11A is attributed to vertical leakage from the underlying weathered / fresh basement contact. Boreholes SRL17/8A and SRL17/9A were slug tested since their yields were too low for pump testing purposes.

The transmissivity for the boreholes that were pump tested ranges between 0.12 m^2/day and 214 m^2/day. The distribution of the average transmissivity per borehole as shown in Figure 4-35, is variable across the site. This is to be expected given that the major aquifer besides the Bullom strata is the weathered / fresh basement contact.

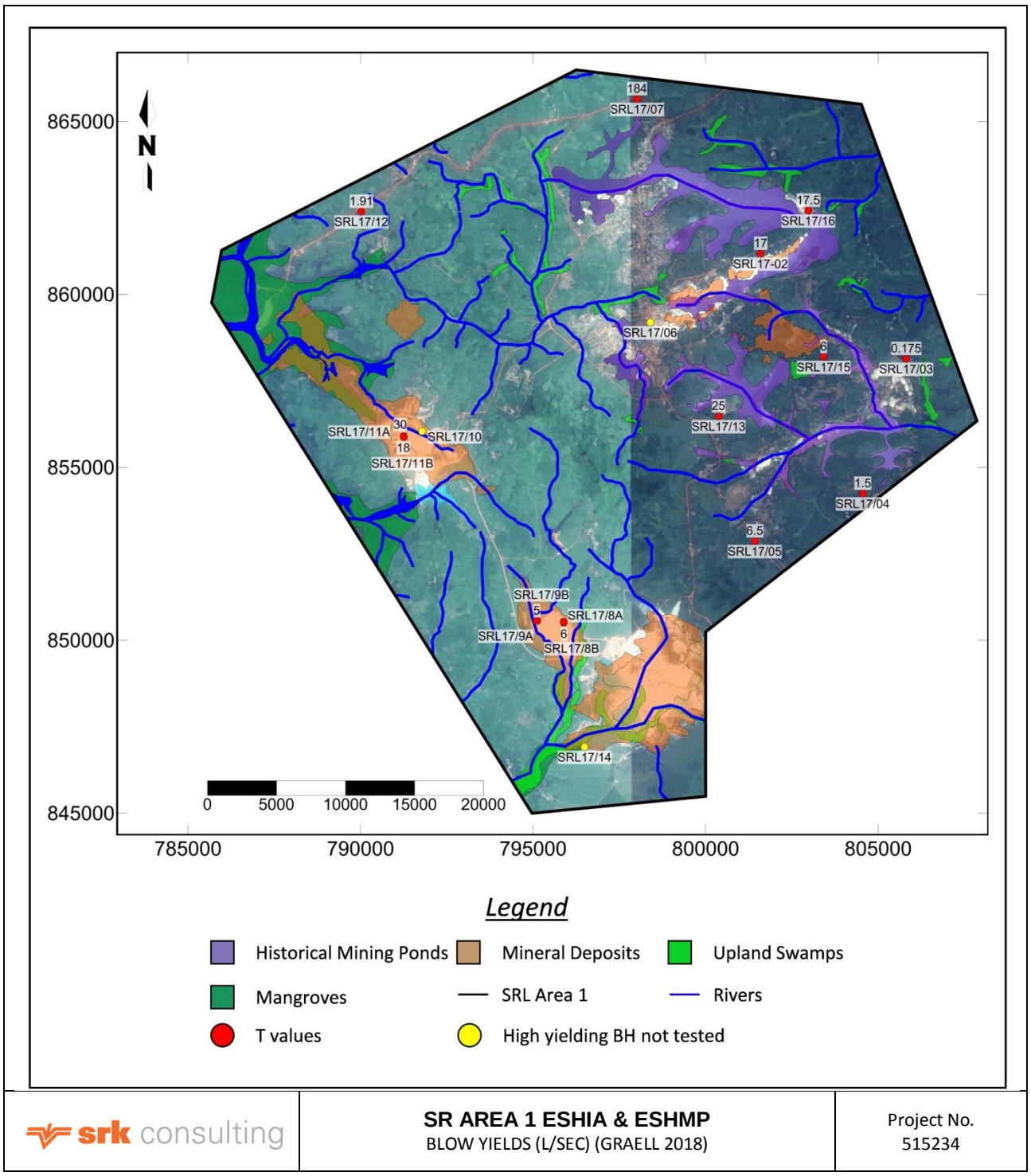


Figure 4-35: SR Area 1 Transmissivity distribution (m²/day) (Graell 2018)

SRK has undertaken surface water modelling for SR Area 1 (SRK, 2018(4)). These simulations indicate that the effective rainfall recharge to groundwater is in the order of 0.17 % - 2.61% of MAP. Recharge values below 1 % are lower than normally expected. However, this is attributed to the high intensity of the rainfall which promotes runoff and the laterite distribution which also reduces infiltration. The surface water simulated baseflow values will be compared to the groundwater model once this has been constructed.

4.7.5 Groundwater users

According to Knight Piésold (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. This was confirmed during the site visit as part of this investigation undertaken by Graell in July 2017. Shallow groundwater wells are also used by local community members for water supply purposes. Deeper boreholes that have been drilled by NGOs were also evident during the site visit as part of this investigation. SRK (2013) has listed a number of village / community boreholes as part of the proposed monitoring plan outlined in that document as shown in Table 4-28. Hole depths, borehole yields and rest water levels are not available at present. All the boreholes observed during the site visit as part of this investigation were equipped with hand pumps.

Table 4-28: SR Area 1 village / community boreholes

X	Y	Location
797612.0	861989.0	Moriba Village Well
805471.4	858440.3	Mondorkor Village Well
800666.0	848504.0	Mokaba Village Well
798159.0	847050.0	Nyandehun Village Well
797355.0	851445.0	Yangatoke Village Well
793299.0	856337.0	Junctiola Village Well
791924.0	857435.0	Semabu Village Well
790525.0	861322.0	Gbangbama Village Well
796662.0	859280.0	Mogbwemo Village Well 2
797069.9	858955.1	Mogbwemo Village Well
798640.0	860073.0	Mogbewa Village

The locations of the village / community boreholes are shown in Figure 4-36. It is possible that groundwater levels may lower in response to the lowering of the historical mining pond water levels as part of the current SR Area 1 Mine Closure Plan. It is therefore important that the groundwater abstraction points are comprehensively identified before any adjustments to the mining pond water levels are undertaken. This includes determining the current groundwater levels where possible.

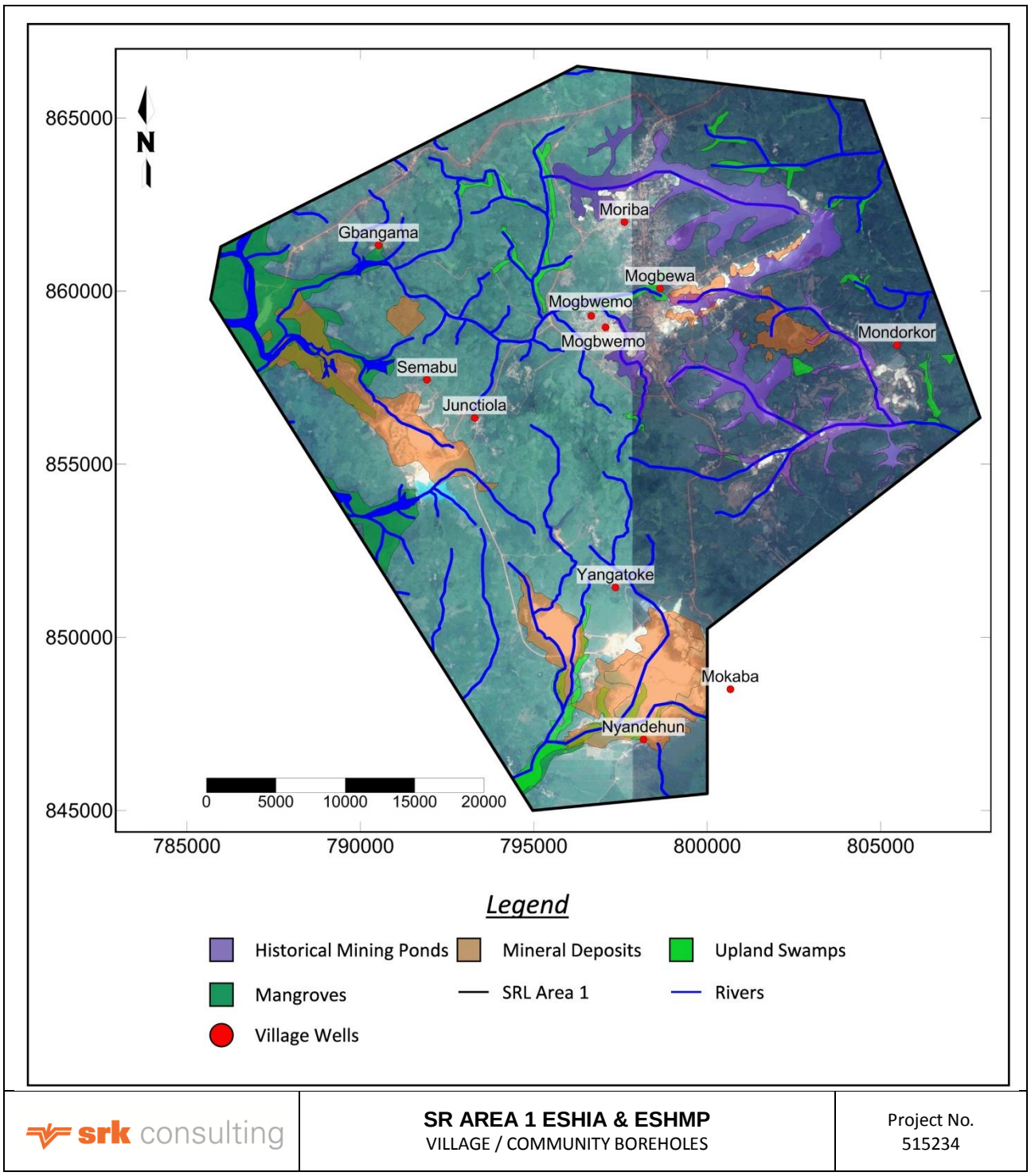


Figure 4-36: SR Area 1 village / community boreholes (Graell 2018)

4.7.6 Hydrochemistry

Groundwater sampling will be undertaken as part of this investigation during 2018 to substantiate the findings of the historical water quality monitoring results from Knight Piésold (2008) and SRK (2013). However, in the absence of current monitoring data, these historic results are discussed as a preliminary assessment. The historic water quality analyses will be evaluated within the context of the SLEP (MM) Reg. 2013, as well as against the WHO (2017) drinking water standards.

Potential Contamination Sources

SRK (2013) identified a number of potential contaminant sources within the SR Area 1 operations as follows.

MSP:

- Power plant;
- Domestic waste site;
- Fuel Depot (MFO and diesel), underground storage tanks and oil traps;
- Workshops, cleaning bays and old sewage works, and
- Tailings streams including the SFT, CET, FET, and Total Tailings (TT).

The geochemistry speicaist study (SRK, 2018(2)) identified marcasite and pyrite in the SFT. These reactive minerals are likely to contribute to acidity when exposed to oxidising conditions.

Historical Mining Ponds:

A site visit report by SRK in 2013 (SRK, 2013) indicated that the historical mining pond water quality had improved in comparison to the pH and EC of the active Lanti mining pond. An exception was the Mogbwemo Dredge Pond, which is located immediately adjacent to the MSP and the associated secondary tailings disposal area. According to SRK, 2013, it is anticipated that microbiological analysis would confirm high heterotrophic and total and faecal coliform counts for these water bodies.

Lanti Wet Mining:

SRK (2013) indicates that the active Lanti mining pond is characterized by a pH in the order of 4 and a TDS of 60 mg/l. Elevated concentrations of Al, Cu, Fe, K, Mn, SO_4 and Zn in the leachate from the primary process tailings relative to background surface water levels are expected (SRK, 2018(2)). Hydrocarbon and lubricant spills also represent a potential source of contamination.

Gangama and Gbeni Dry Mining:

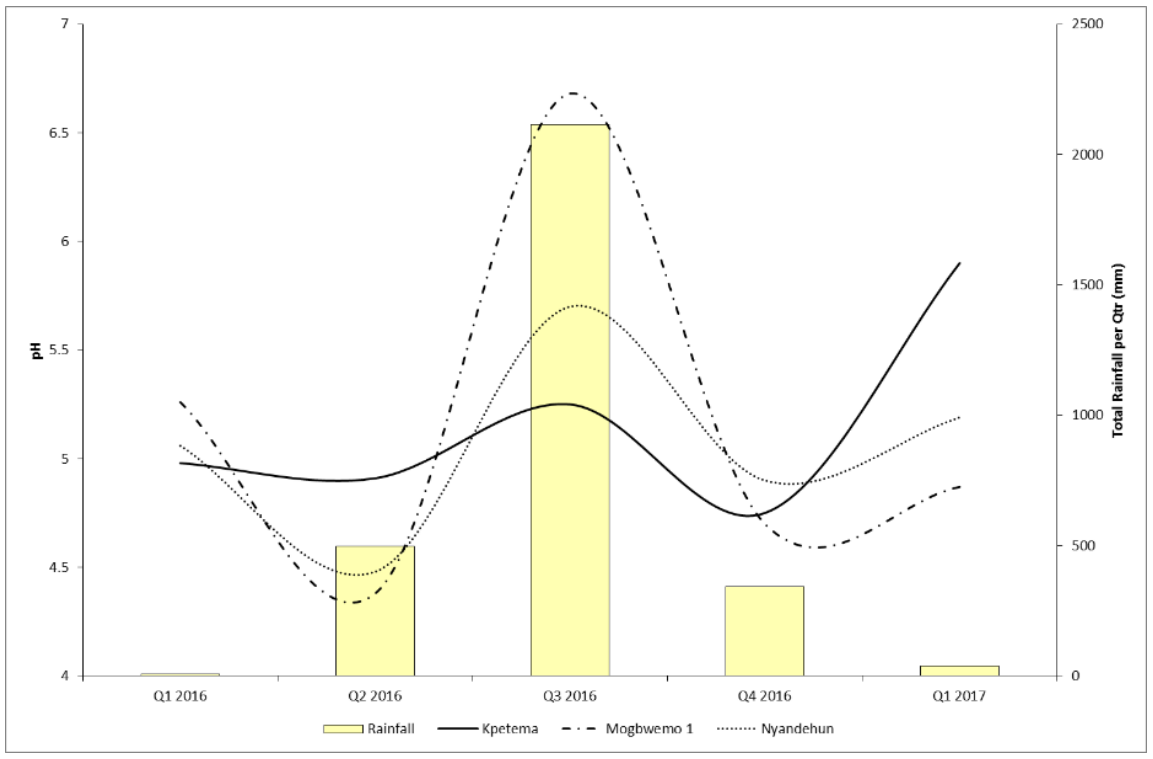
According to SRK, 2018(2), the primary tailings are relatively inert and should not require any additional remedial measures. However, potentially elevated concentrations of Al, Cu, Fe, K, Mn, SO_4 and Zn in the leachate from the primary process tailings relative to background surface water levels are expected. Hydrocarbon and lubricant spills also represent a potential source of contamination. The potential for suspended solids to be discharged into the surface water systems from any pit dewatering due to groundwater ingress is a possibility.

Borehole Hydrochemistry

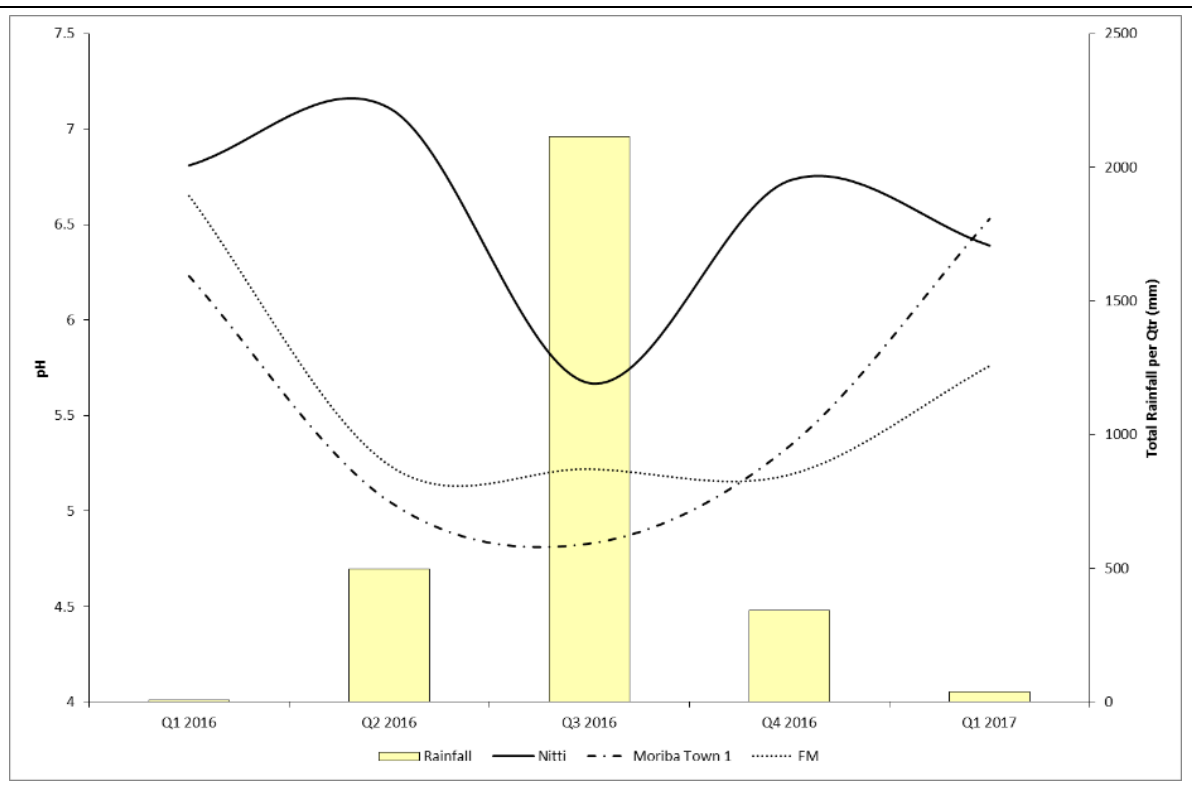
The historical groundwater monitoring provided by SRL for 2016 and the first quarter of 2017 has been limited to the measurement of pH, EC, turbidity and bacteriological analysis. Measured pH ranges from 4.38 to 7.15 and varies in response to rainfall as shown by the examples in Figure 4-37. Based on 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, as well as the location of the specific monitoring point relative to geological conditions and mining infrastructure.

According to the WHO (2007), a direct relationship between human health and the pH of drinking water is impossible to ascertain, because pH is so closely associated with other aspects of water quality, and acids and alkalis are weak and usually very dilute. However, because pH can affect the degree of corrosion of metals as well as disinfection efficiency, any effect on health is likely to be indirect and due to increased ingestion of metals from plumbing and pipes or inadequate disinfection. According to WHO (2007), it is not considered necessary to propose a health-based guideline value for pH. Any assessment regarding the suitability of water for drinking should consider the quality holistically and not just pH in isolation.

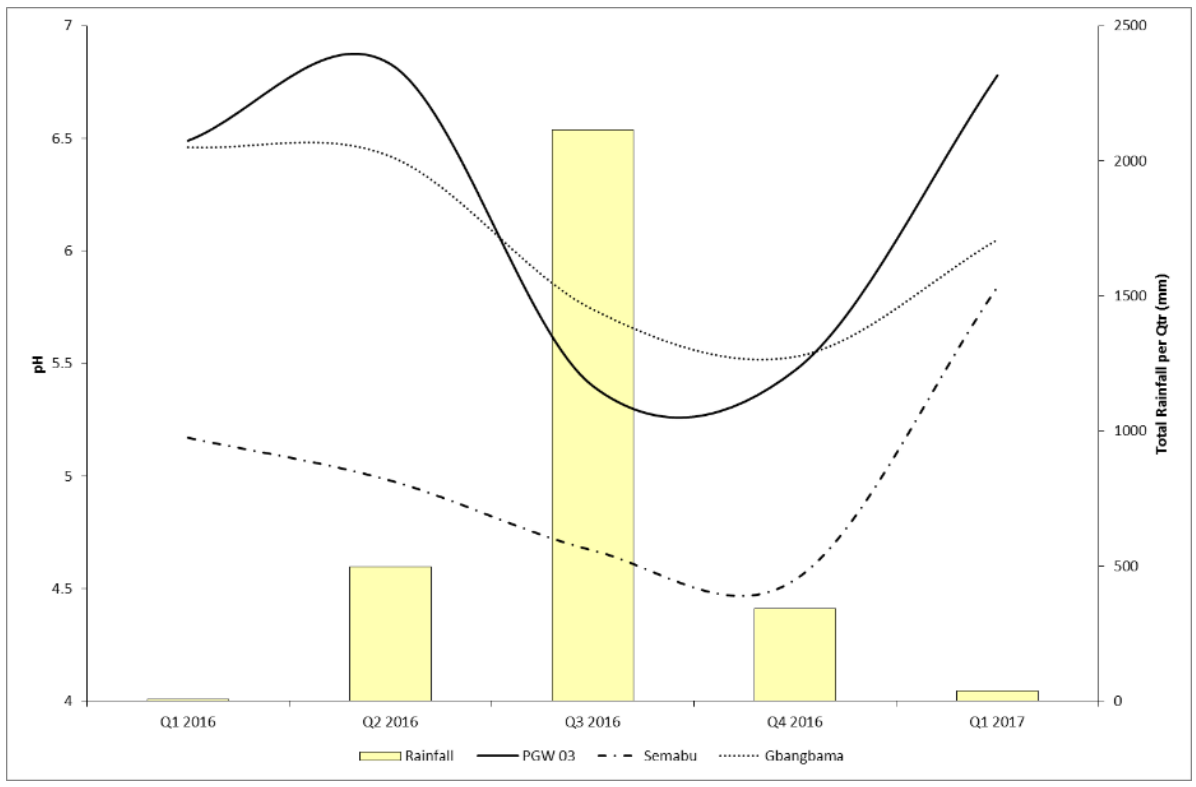
The groundwater TDS ranges from 5.56 mg/l to 77.9 mg/l which is considered to be good quality. Similarly to pH, the TDS shows a variable response to rainfall where the TDS either increases, decreases or shows a delayed response to rainfall as shown in Figure 4-38. It is anticipated that this variable response is due to either the dilution and / or mobilization of soluble salts. Interestingly the pH trends seem to lag behind the TDS trends at the individual monitoring points as shown in Figure 4-39. This suggests that pH variations may be in response to TDS fluctuations rather than vice versa.



pH Rise in response to rainfall



pH Drop in response to rainfall



Delayed pH response to rainfall

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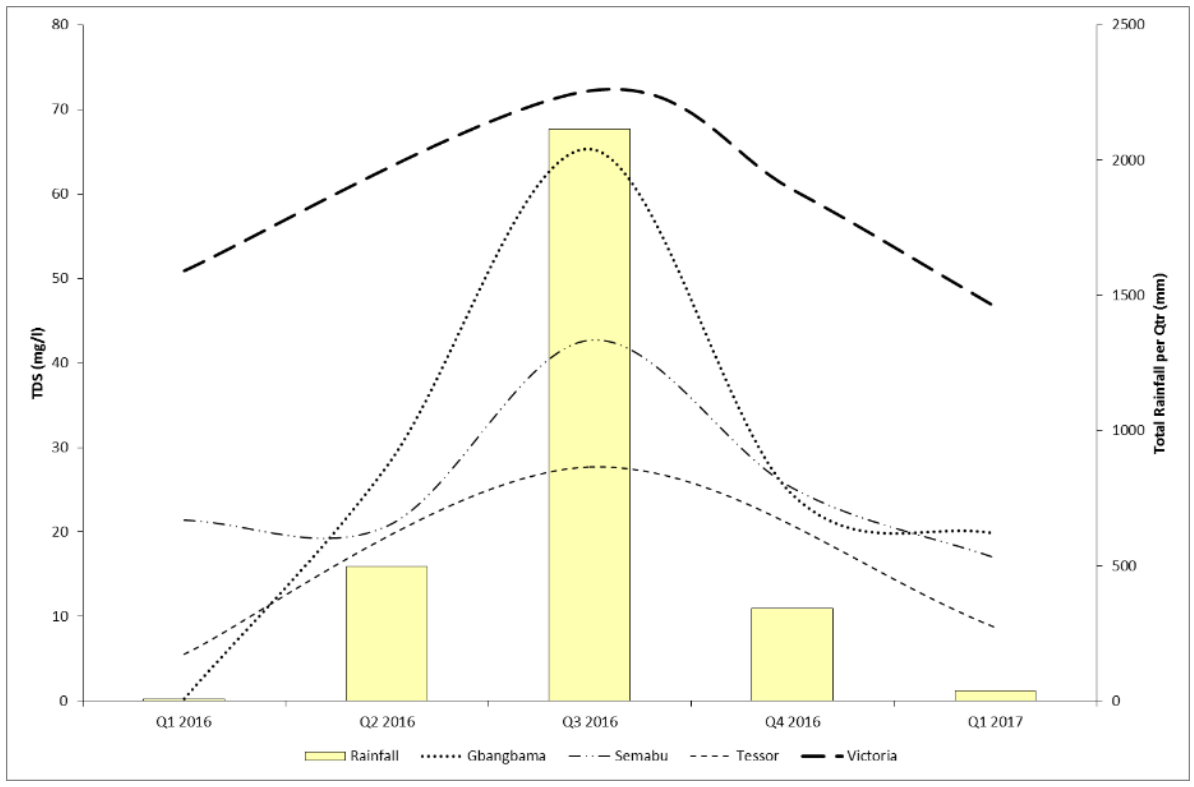
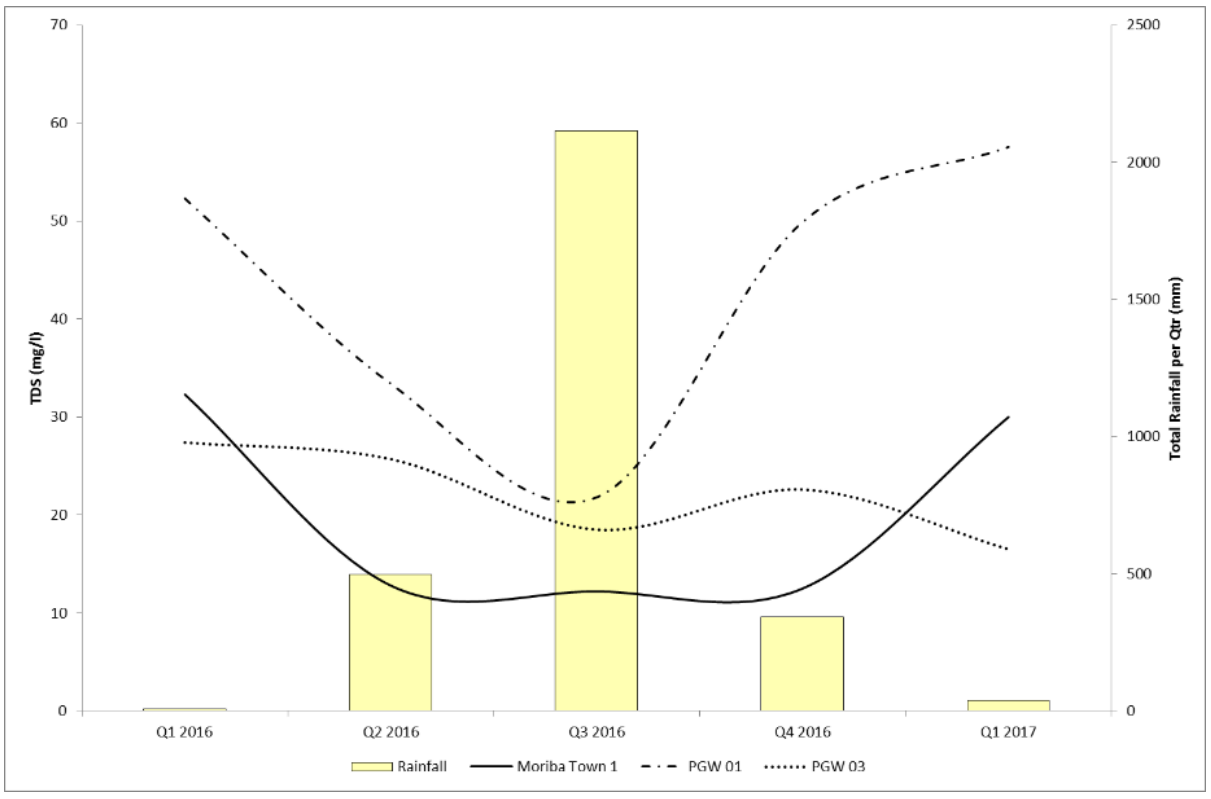
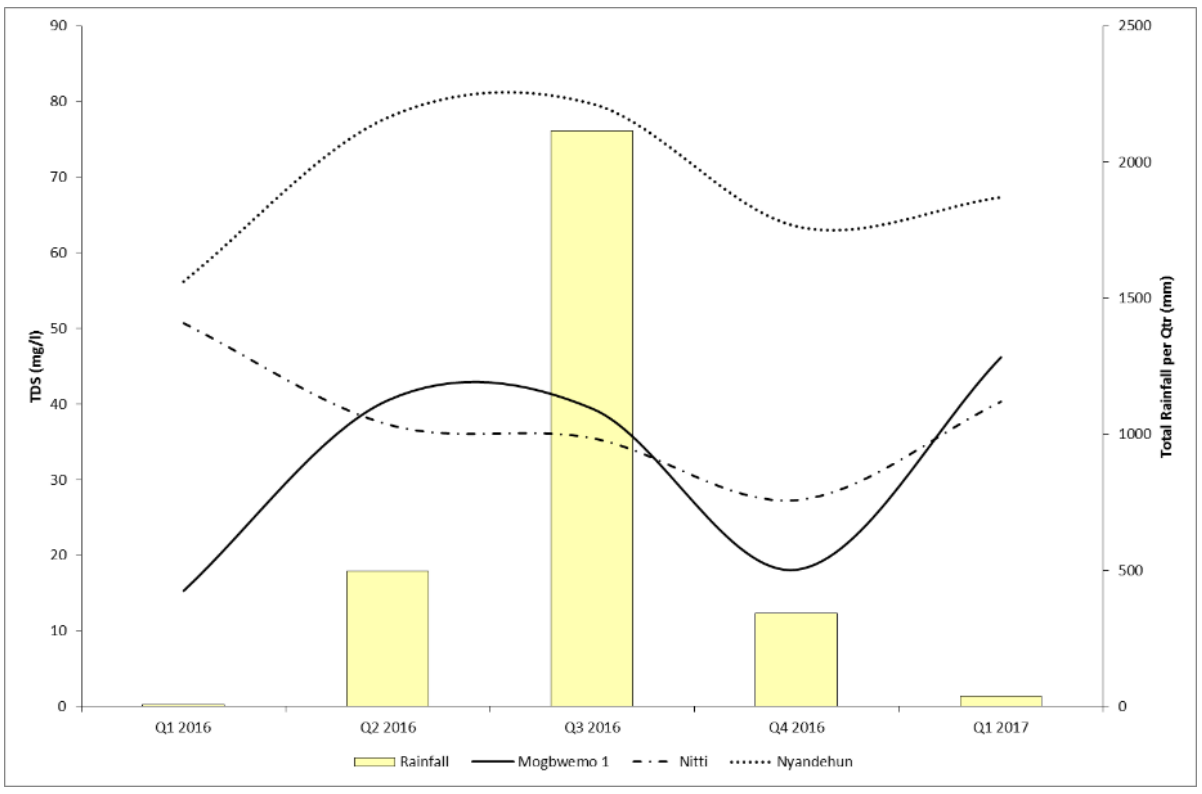
Figure 4-37: Goundwater pH response to rainfall (Graell 2018)



TDS Rise in response to rainfall



TDS Drop in response to rainfall



D Delayed TDS response to rainfall

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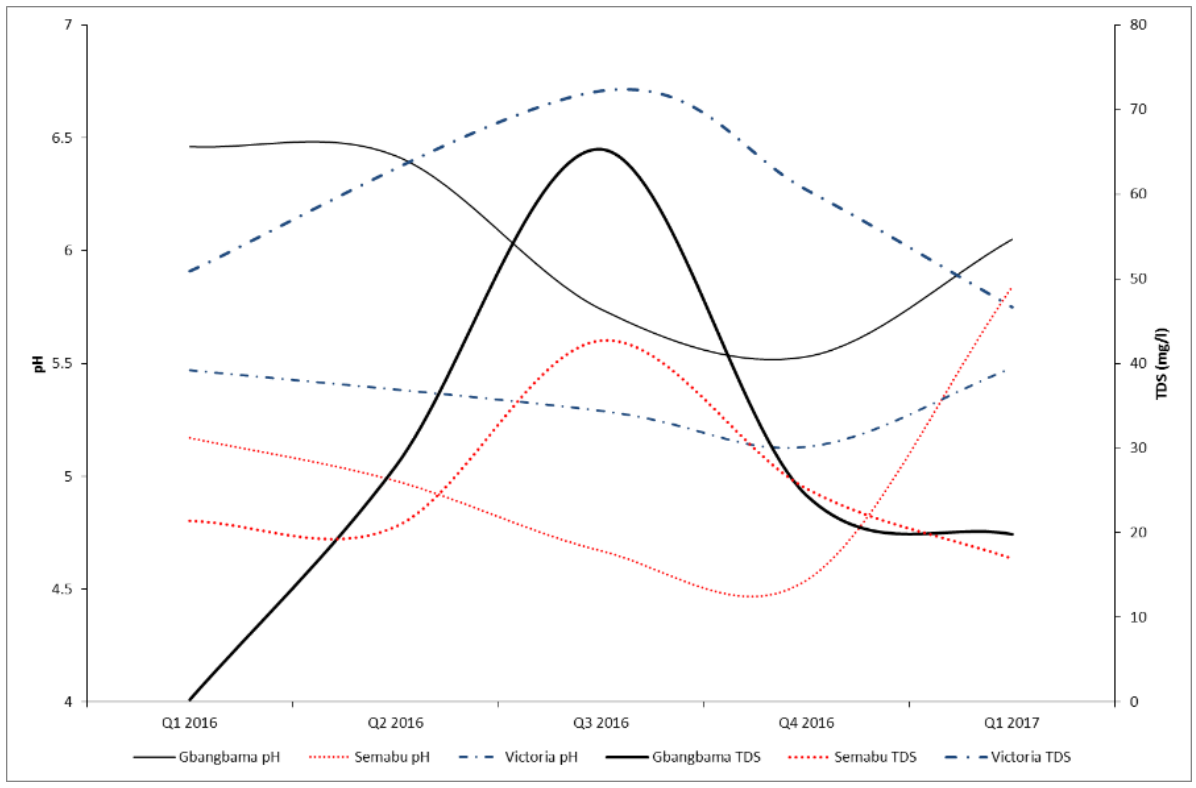
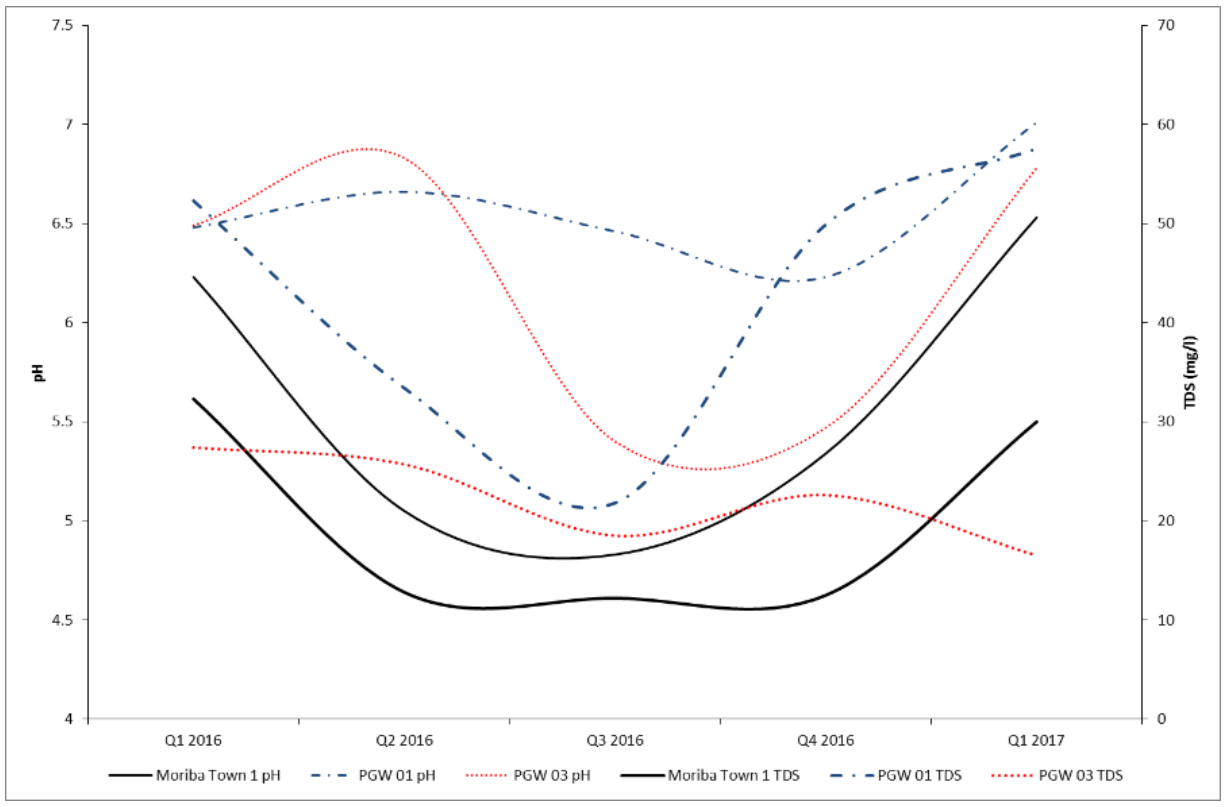
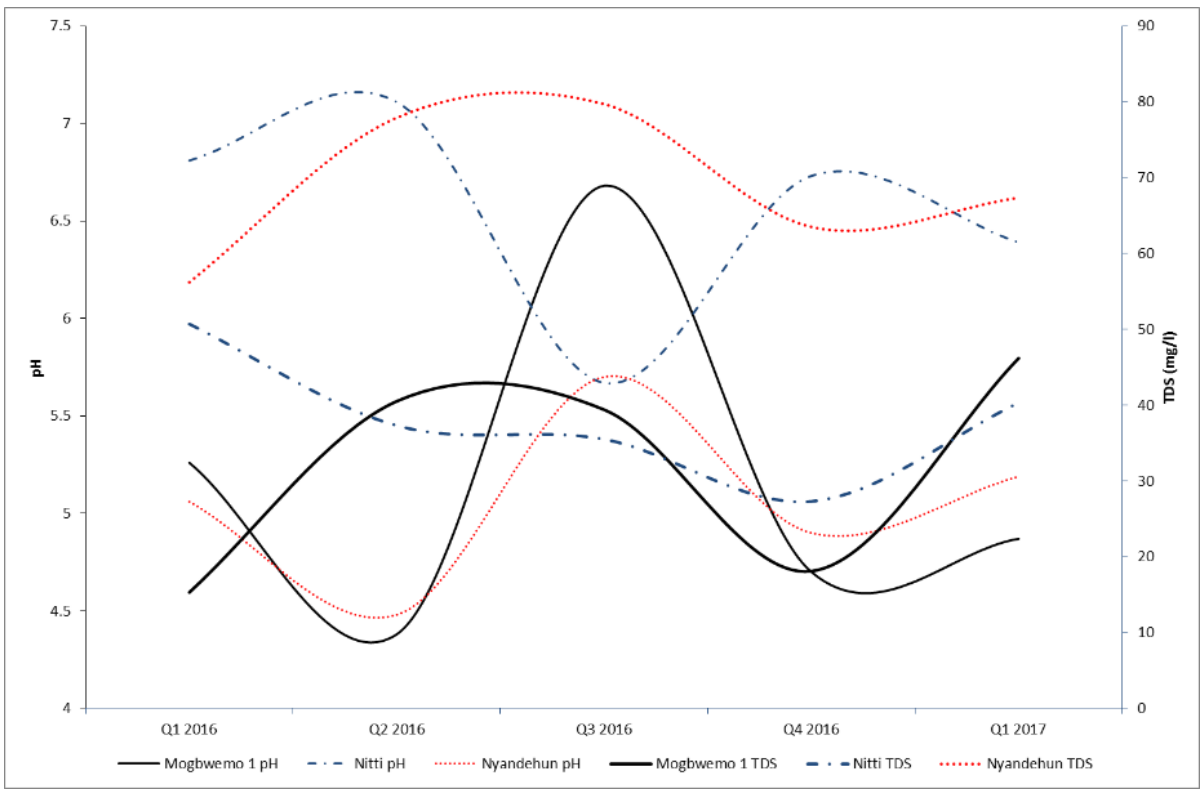
Figure 4-38: Goundwater TDS response to rainfall (Graell 2018)



A: TDS Rise vs pH



B: TDS Drop vs pH



C: Delayed TDS resonse vs pH

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Figure 4-39: Groundwater TDS response vs pH (Graell 2018)

In Graph A in Figure 4-39, the rise in TDS is associated with monitoring points that are located primarily downstream or at the edges of SR Area 1. Graph B illustrates the fall in TDS associated with monitoring points that are located primarily within the high ground towards the centre of SR Area 1 while Graph C has no clear trend with respect to the monitoring locations.

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

Detailed Historical Water Analyses

Detailed historical water analyses are included in SRK (2013) and Knight Piésold (2008), and are replicated in Appendix C. An extract of the effluent standard as prescribed in the SLEP (MM) Reg. 2013 is also included for comparison purposes. Since the latter standard has a limited list of chemical constituents, the WHO (2017) water quality drinking standards are also referenced in this evaluation.

Four samples were included in the SRK (2013) report two of which are from SRL groundwater wells, one from the Pejebu historical mining pond and one from rainwater. These samples are characterized by a slightly acidic to neutral pH with a very low EC ranging from 1.6 mS/m – 8.7 mS/m as is to be expected in this geological setting. All chemical constituents fall within the WHO (2017) drinking water and the SLEP (MM) Reg. 2013 effluent standards.

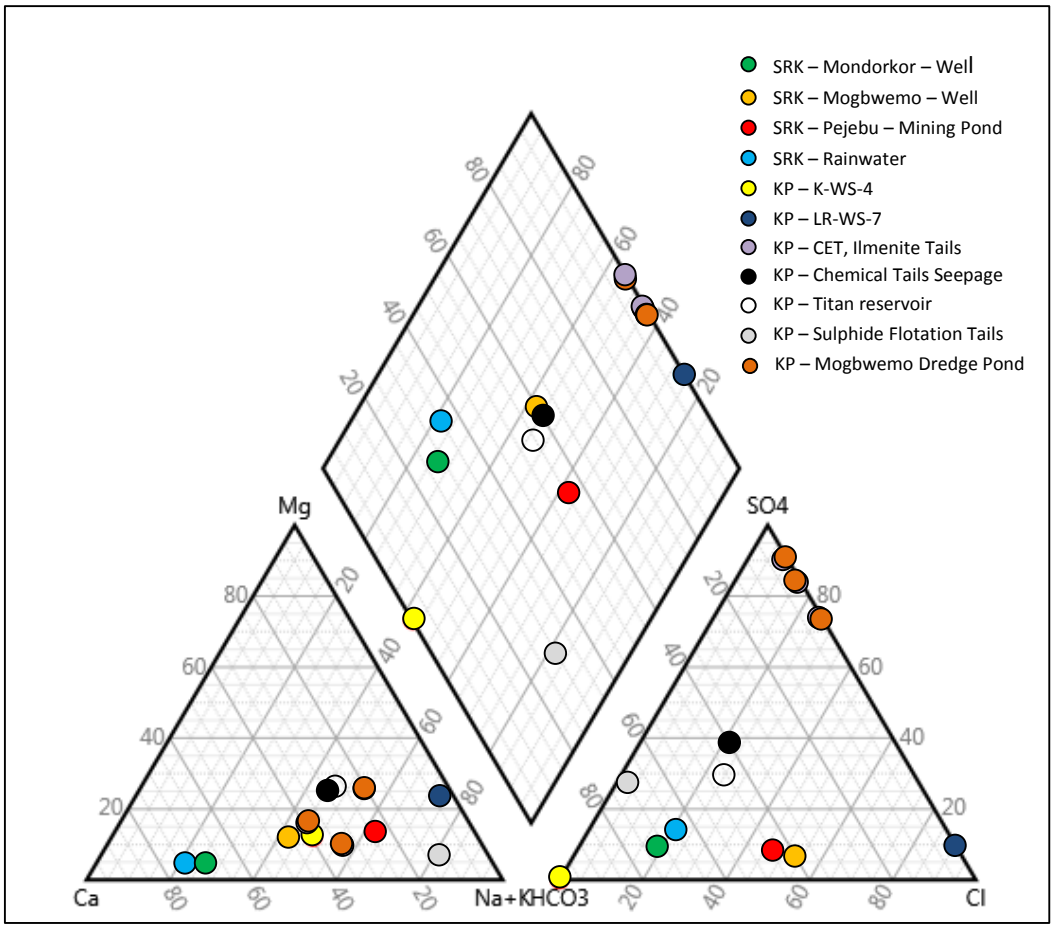
Knight Piésold (2008) presents two data sets from 2001, and surface water samples from 2006. A total of seven samples, two of which are groundwater, are presented for the 2001 data. With the exception of LR-WS-07 taken from Teso Creek, all samples generally fall within the WHO (2017) drinking water and SLEP (MM) Reg. 2013 effluent standards. An exception is the moderately acidic pH which ranges from 4.3 – 5.6 and aluminium ranging from 0.2 mg/l – 0.4 mg/l in three samples, two of which are groundwater. LR-WS-07 has an EC of 1,000 mS/m which is indicative of a tidal influence in this vicinity. The remainder of the samples have an EC ranging from 1.2 mS/m – 7.6 mS/m which is considered to be good quality.

The Knight Piésold (2008) 2006 data set consists of 21 samples taken from surface and process water sampling locations. The samples generally fall within the WHO (2017) drinking water and SLEP (MM) Reg. 2013 effluent standards with the following exceptions:

- All samples are moderately to very acidic (pH 3.2 – 4.5) with the exception of SR-12-WQ (pH 6.2) and SR-20-WQ-B (pH 7.5);
- Aluminium is exceeded for the WHO (2017) drinking water standards within a range of 0.22 mg/l – 0.76 mg/l for thirteen samples, and
- Gross alpha and gross beta is exceeded for SR-5-WQ (TT discharge), SR-6-WQ (IT discharge), SR-7-WQ (FET) and SR-8-WQ (CET).

Knight Piésold (2008) determined that the supernatant discharge from the coarse sulfide plant tailings outlet pipe into the sulfide plant tailings holding area had radioactivity levels that exceeded the WHO Guidelines (2008) for gross alpha and gross beta. Process / surface water locations downstream of the Mogbwemo Dredge Pond however did not exceed WHO Guidelines, indicating a minimal impact from these discharge sources.

The detailed analyses were plotted on a Piper diagram as shown in Figure 4-40.



srk consulting | **SR AREA 1 ESHIA & ESHMP** PIPER DIAGRAM (GRAELL 2018) | Project No. 515234

Figure 4-40: SR Area 1 Piper diagram (Graell 2018)

It can be seen from Figure 4-40 that the rainfall and the Mondorkor well plot towards the recent recharge area as expected. This is in contrast to the Titan reservoir, chemical tails seepage and the Mogbwemo well which are grouped together. The Pejebu historical mining pond also plots in this vicinity which suggests an improvement in water quality relative to the current tailings facilities. The CET, IT and Mogbwemo Dredge Pond plot between the sea water signature associated with the Teso Creek and the apex of the Piper diagram which is typically associated with mining related signatures. These samples show some mining related influence when compared to the other locations. The SFT plots towards the bottom of the Piper diagram in the sodium bicarbonate ($Na\text{-}HCO_3$) type waters. This may be due to the additives that have been used during the flotation process.

Elevated Al is observed at a number of the sampling locations. However, this is attributed to acidic soils which form within a belt across Africa including Sierra Leone (Hede et. al, 2001). Under these conditions, the primary and secondary minerals dissolve to a limited extent, releasing Al into the soil solution.

Although the historical water samples have a low TDS, there is an indication that the ambient water quality has been altered by the mining and mineral beneficiation process. Localized elevated radioactivity associated with the CET and FET discharge has been measured.

4.7.7 SR Area 1 mining influence on groundwater

There are seven operational areas which have been evaluated in terms of the impact of mining on the groundwater regime within SR Area 1:

- Historical mining ponds;
- MSP and processed tailings facilities;
- Lanti dredge mining and tails disposal areas (wet and dry mining);
- Gbeni dry mining;
- Gangama dry mining and tails disposal;
- Nitti Port, and
- Waste disposal site.

These areas will be discussed in more detail as follows.

Historical mining ponds

The historical mining ponds were created by the construction of engineered earth impoundments across the river valleys. Although this has altered the groundwater levels, flow patterns and baseflow seepage in the immediate vicinity, 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.

One of the greatest risks associated with the historical mining ponds is the potential failure of the earth impoundments. These structures have sand blankets built into the wall to reduce the internal phreatic surface. Nonetheless, excessive groundwater seepage through these structures may affect the stability and is currently being monitored. The current mine closure plan includes the lowering of the water levels within all the historical mining ponds to reduce the maintenance post closure. This is also a cost-effective method of reducing the risk of wall failure. However, this remedial measure may also lower the groundwater levels within any immediately adjacent community boreholes.

The water quality in the historical mining ponds has improved over time as shown in Pejebu. However, seepage and surface water discharge from the MSP secondary processed tailings disposal area has an impact on the immediately adjacent Mogbwemo Dredge Pond. This trend is likely to continue for the foreseeable future unless operational changes are made to the method of tailings disposal.

The water levels within the historical mining ponds will be lowered as part of the current Mine Closure Plan (SRK, 2018). This may expose pyrite or marcasite which may lead to further acidification. This could be significant given that the current groundwater and surface water within SR Area 1 has a low buffering capacity.

MSP and tailings facilities

There are a number of potential contaminant sources that have been previously identified within the immediate vicinity of the MSP. The majority of these are associated with the storage and use of hydrocarbons. Long term potential contaminant sources are the associated tailings disposal areas which are shown to have seepage with a lowered pH, elevated Al and radioactivity. SRK 2018 (2) has also determined that the tailings have acid generating potential. Any impact on the groundwater quality is very localized given the close proximity of the tailings to surface water features. The significance of the groundwater regime is that it acts as a conduit for possible contaminants to migrate from the tailings facilities through the subsurface into the surface water as baseflow.

Since the MSP will be operational beyond the mining operations within SR Area 1, the current potential risk to water quality will continue unless the method of tailings disposal is significantly altered.

It is anticipated that the greatest change to groundwater levels around the MSP will be in response to the tailings disposal. However, within the context of SR Area 1, this is likely to be very localized and insignificant.

Lanti wet mining

A dredge and wet processing plant is currently operational at the Lanti mining pond and it is anticipated that this process will continue for the following 18 months. The Lanti complex is also the repository for tailings from the processing plant treating dry mined ore. Historical water quality analyses have shown that the mining pond has a lower pH and higher TDS than the historical mining ponds (SRK, 2013). However, given that this operation is located within a broad valley, groundwater flow is expected to be towards rather than away from this area. Any potential groundwater contamination may occur through the weathered aquifer and seepage through the downstream earth impoundments. Field observations during the site visit undertaken as part of this investigation has shown that these pathways are insignificant when compared to the surface water decant.

Any changes in the groundwater elevations are anticipated to be restricted to the immediate shoreline of the Lanti mining pond and the mounding beneath the tails stacking.

Based on the historical monitoring data, the water quality in the Lanti Dredge Pond is likely to improve upon the cessation of mining. However, further acidification may occur if the pond level is lowered for closure thereby exposing any pyrite and marcasite to oxidising conditions.

Exposure of the tailings to oxidising conditions will occur once stacking is stopped and the induced groundwater mound beneath the tails dissipates. However, SRK (2018) has shown that the dredge spoils and dredge tailings are generally unreactive as they are composed primarily of inert minerals that are chemically resistant to weathering. The minerals are therefore considered to be non-acid generating. Nonetheless, elevated concentrations of Al, Cu, Fe, K, Mn, SO_4 and Zn in the leachate from the primary process tailings relative to background surface water is expected and will be included in any monitoring (SRK, 2018).

Similar to the historical mining ponds, the greatest risk of the Lanti wet mining is the potential failure of the downgradient earth impoundments. Since groundwater levels are a contributing factor to the stability of these structures, the groundwater levels are measured on a regular basis. The most cost-effective measure to reduce this risk is the lowering of the mining pond water level.

Ore is located within the vicinity of the pineapple farm immediately adjacent to the Lanti Dredge Pond. Monitoring borehole SRL17/14 in this area has a blow yield of 32 l/sec which suggests very high permeabilities associated with the underlying Bullom sediments. It is planned that this area will be dredged to avoid substantial water ingress during dry mining.

Gbeni dry mining

Mining operations at Gbeni have historically been undertaken by excavators and haulage trucks where ore has been removed at elevations above the groundwater surface. Some dewatering has been put in place to lower the groundwater by means of trenches. However, the impact of mining in this area on the groundwater regime has been limited. During December 2017, an in-pit mining unit was constructed where the mining occurs to the base of the ore deposit within a box cut. Ore is pushed towards a hopper by dozers and loaded by excavator, from where it is pumped to a scrubber and then on to the processing plant. Tailings deposition occurs behind the box cut as the mining face progressively advances.

During the construction of the initial box cut, it was evident that most of the water ingress occurred on the eastern face on the contact between the yellow orange profile and the underlying dark grey more silty clayey sediments as shown in Photo 4-1. Further inspection suggests that this ingress is related to the stream in this area which is seeping through the unsaturated zone into the box cut. The pumping

from the box cut will require monitoring to evaluate whether it is necessary to divert this stream further away from the box cut to reduce the water recirculation. Groundwater level measurements and pump testing results indicate that vertical seepage from the underlying weathered / fresh basement contact is also likely.

srk consulting	**SR AREA 1 ESHIA & ESHMP** GBENI DRY MINE – BOX CUT (GRAELL 2018)	Project No. 515234

Photo 4-1: Gbeni dry mine box cut (Graell 2018)

Based on the current observed make up water volumes in the box cut, the greater risk will be the saturation of the box cut floor affecting production rather than the volume of groundwater ingress into the mining cut. The yellow orange sediments tend to drain relatively quickly in comparison to the underlying dark silty clayey sediments.

Rainfall ingress will have a great influence on the degree of saturation and it will be important to slope the floor of the mining cut accordingly to prevent surface water ponding as seen in Photo 4-1. Given the relatively low permeability of the orebody in the Gbeni deposit, it is recommended that the groundwater levels are lowered in advance of mining by means of trenches on either side of the mining cut which are linked to dewatering sumps as is presently being used.

There are two implications as the mining advances towards the west in the direction of Foinda village:

- Seepage from the river adjacent to Foinda will increase the in-pit water volumes, and
- Bullom sediments may be located beneath Foinda village with significantly higher permeabilities leading to increased water ingress.

It is important that the river be diverted away from the proximity of the planned mining operations as soon as possible. The potential extent of the Bullom sediments should also be defined so that areas of greater water ingress may be anticipated. This may have implications for the in-pit mining unit which is planned to mine the area beneath the Foinda village.

During mining the groundwater water quality is unlikely to be affected since the groundwater flow patterns will be towards the pit. However, the dewatering volume may contain suspended solids which would need to be settled prior to discharge to the receiving environment. Some assessment would also be required of the pyrite or marcasite which may still be present in the remaining submerged ore, since this may lead to acidification of water pumped from the pit.

At this stage it is presumed that the tailings will be similar to that of the Lanti wet mining in that this will consist of inert material which is unlikely to generate additional acidity. The post mining groundwater quality is therefore expected to improve to ambient conditions subject to an assessment of the potential sulfides remaining in the Gbeni deposit and the backfill plan. However, elevated concentrations of Al, Cu, Fe, K, Mn, SO_4 and Zn in the leachate from relative to background surface water is expected and will be included in any monitoring.

Gangama dry mining

It is understood that the operations at Gangama will continue with excavators and haulage trucks. The mining has historically been undertaken above the groundwater surface which has had a limited impact on this regime. However, future mining operations will be deepened to the base of the orebody below the groundwater surface. For most of the deposit the conditions are anticipated to be similar to the Gbeni operations in that:

- Saturation of the mining floor is a greater risk to production than the groundwater ingress volume;
- Some upward vertical seepage from the weathered / fresh basement contact is to be expected;
- Dewatering trenches ahead of mining is recommended to cater for the relatively low permeable orebody, and
- The surface of the mining operations should be sloped in such a manner that surface runoff is promoted rather than ponding which may promote saturated conditions.

The northern portion of the Gangama deposit may lie adjacent to the Bullom sediments. This has major implications for potential groundwater ingress especially since the base of mining extends to -5 mamsl, and the area is also immediately adjacent to the estuary in this vicinity. If the ground conditions are similar to the remainder of the ore deposit, then the groundwater ingress may be manageable. However, if the sediments in this area are Bullom strata, then this may represent a 50-fold increase in groundwater ingress into the mining operations. Alternative mining methods to dry mining may have to be considered under these circumstances. Examples include a mini dredge or alternatively a floating excavator.

Saline intrusion is likely to be a concern if the northern portion of the Gangama deposit is dry mined due to the depth of mining and the close proximity to the estuary. Any water would have to be passed through a settling pond before being discharged back into the estuary to remove any suspended solids. Monitoring of the water quality would also have to take place under these circumstances to ensure that it complied with the current legislation before being discharged.

Nitti Port

Nitti Port is located on the estuary on the western boundary of SR Area 1. This facility is used to transfer product to ships via barges. There is no evidence that the port infrastructure alters the groundwater levels in the immediate vicinity. The greatest potential contamination sources are the fuel tanks which may leak hydrocarbons into the subsurface. Given the close proximity of the estuary, the impact on groundwater would be limited before any spill entered the surface water systems.

Waste disposal facility

An ad hoc waste facility has been used for the disposal of waste at SRL. The waste has historically been disposed of in trenches which are unlined. The potential for groundwater contamination therefore exists. A new engineered landfill is currently being designed.

4.8 Land use capability

The content of this section is adapted from the specialist Soils and Land Capability Study (ESS 2018) (Appendix K). The study which describes the methods used to classify land capability based on the soil characteristics and related geomorphological information (climate, ground roughness, and topography), and gives details of the present state of the soil environment in the dry mining areas of SR Area 1.

The mining areas and associated activities have been classified and rated in terms of a simplified version of the British Land Classification (BLC) System. The seven classes of the BLC system was reduced to four classes or rating categories. These four categories are considered to adequately describe and rate the site conditions that pertain to the areas under consideration. The categories are described in Table 4-29.

Table 4-29: Simplified criteria for land capability classification and rating

Classification	Criteria
Wetland status	• Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water dependent. This rating requires both soil and ecological inputs (fauna and flora) as part of the classification.
Arable land status	• Land, which does not qualify as wetland status; • The soil is readily permeable to a depth of 750 mm; • The soil has a pH value of between 4.0 and 8.4; • The soil has a low salinity and Sodium Absorption Ratio (SAR); • The soil has less than 10 % (by volume) rocks or pedocrete fragments larger than 100 mm in the upper 750 mm; • Has a slope (in %) and erodibility factor (“K”) such that their product is <2.0; and • The land is able to support crop yields that are at least equal to the current national average for the particular crops being considered.
Sub arable / subsistence / grazing land status	• Land, which does not qualify as wetland or arable land; • Has soil, or soil-like material, permeable to roots of native plants, that is more than 250 mm thick and contains less than 50 % by volume of rocks, or pedocrete fragments larger than 100 mm; and • Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.
Wilderness / natural conservation land status	• Land, which does not qualify as wetland, arable land or palatable grazing land, and as a result is regarded as requiring conservation practise / actions.

Land capability is the ability of the land to sustain a land use given its geomorphological attributes (topography, climate, soil etc.). Based on this rating system the mining areas were classified and rated for their land capability.

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 (>700 mm). 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.

The land capability aspects for SR Area 1 are described in the sections below and illustrated in Figure 4-41.

4.8.1 Arable potential land

There are no sites with an arable land capability rating associated with SR Area 1 in terms of the definitions. The basic requirement for a crop to obtain a yield equal to or higher than the national average for commercial crops under natural conditions, is unlikely to be achieved on any of the sites assessed due to the highly leached nature of the soils and the associated low nutrient stores measured.

Although the soil depths are often adequate, and the high rainfall of this area increases the utilisation potential of the site, the soil chemistry negates the potential for anything better than moderate subsistence farming or low intensity grazing, with significant portions of SR Area 1 comprising wilderness / conservation status land capability.

The soil's natural state is acidic (pH of 5.5 on average) and nutrient poor, conditions that are not conducive to a commercial yield for any of the national food crops. Significant additions of both lime / gypsum and basic nutrient supplies, are required to enhance the utilisation potential and ecosystem service potential.

4.8.2 Sub arable / subsistence / grazing land capability

The areas that classify as grazing land (subsistence farming) are generally associated with the poor quality and / or shallow rocky soils, as well as the transitional zones between the wetlands environment and the areas that are well drained.

However, in SR Area 1, the deep sandy natural soils (free draining) are not capable of supporting commercial plant species on a sustainable basis, due primarily to the highly leached nature of the soils and resultant poor nutrient stores, and classify as sub arable or grazing land capability.

The majority of the soils associated with the Fluvisols grouping meet the requirements for subsistence agriculture or low intensity grazing land potential, with the water holding capabilities, poor nutrient stores and leached status rendering these soils poor arable sites.

4.8.3 Wilderness / conservation land

The shallow soils mapped in association with the Ferralsols and steeper portions of the rocky hill slopes rate as wilderness or conservation land capability. This is due mainly to the shallow depths of rooting, the occurrence of a gravel layer within the lower profile, the generally low clay contents and the leached nature of the soils. These are generally of the poorer soils mapped in SR Area 1.

4.8.4 Wetland areas

Wetland areas are defined in terms of a set of wetland delineation guidelines, which use soil characteristics as well as vegetation criteria to define the domain limits.

These wetland zones are dominated by hydromorphic soils (wet-based) that often show signs of structure, and have vegetation that is associated with seasonal wetting or permanent wetting of the soil profile.

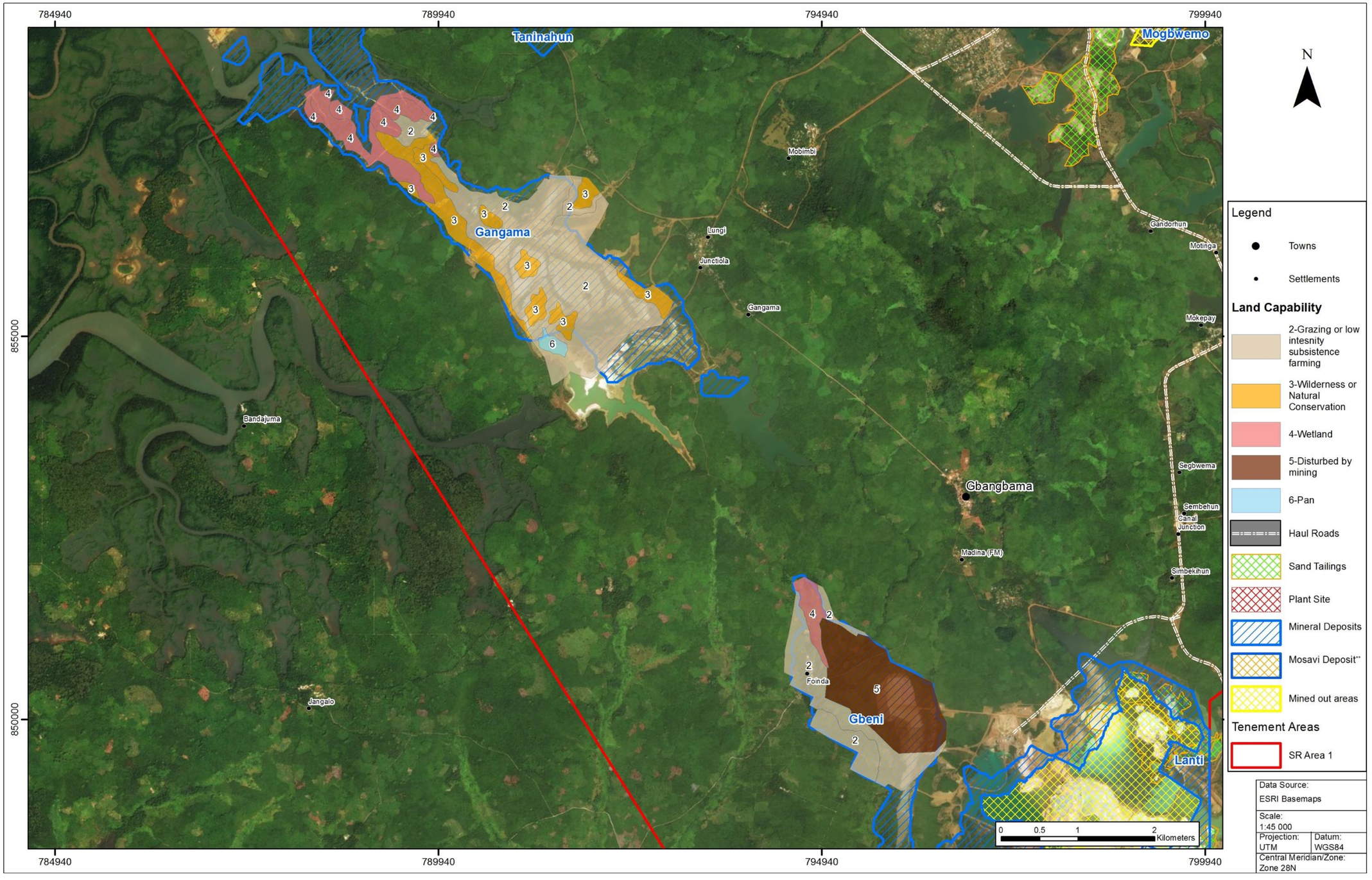
The wetland soils are generally characterised by dark grey to black colours (organic matter) in the topsoil horizons, are often high in transported clays and show variegated signs of mottling on gleyed backgrounds (pale grey colours) in the subsoil. Wetland soils occur within the zone of soil water influence.

There are a number of very distinctive wetland areas that rate as true wetlands based on the soils and vegetative cover, with zones of slight wetness at depth - where the stratification and structure is able

to hold water in the profile, or were the underlying lithologies are holding groundwater or perched soil water within the profile.

The mangrove swamps are a distinctive zone that classifies as a wetland, while the lower lying areas along some of the alluvial channels show signs of redoximorphic indicators within the prescribed upper 500 mm of the profile.

These zones are considered very important, sensitive and vulnerable in terms of their ecosystem services and ecological importance.



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SR AREA 1 ESHIA & ESHMP
LAND CAPABILITY (ESS 2018)

Project No. 515234

Figure 4-41: Land capability in the dry mining areas SR Area 1 (ESS 2018)

4.9 Air quality

The content of this section is adapted from the specialist Air Quality Impact Assessment (AQIA) (SRK, 2018(1)) (Appendix A). The specialist study describes the air quality baseline for SR Area 1, which is based on a review of historic climate and air quality data, dust and gas monitoring and analyses. Conducted in 2017, the study investigated the baseline ambient air quality conditions identifying mining and non-mining emission sources.

4.9.1 Existing sources of air emissions

SR Area 1 experiences two sources of air emissions, namely those that can be attributed to existing mining operations and non-mining sources.

Emission sources from SRL mining activities

There are a range of current mining activities that contribute to air emissions at SR Area 1. These include:

- Site clearing for the mining areas;
- Construction of roads to mining areas;
- Storage of topsoil stockpiles;
- Vehicle exhaust emissions;
- Dredging;
- Dam construction;
- Ore extraction (earth moving);
- Primary mineral processing;
- Secondary mineral processing;
- Tailings management;
- Transporting and storage of ore and product;
- Product handling at the port and shipping;
- Access road building and maintenance;
- Waste management;
- Power generation facility and transmission of power; and
- Rehabilitation.

The expansion phase activities for the project are similar to the operational phase operations with the exception of, secondary mineral processing, dam construction and cessation of dredging operations.

Materials handling, wind erosion (e.g. tailings, roads) and vehicle-entrainment of dust by haul trucks transporting ore and product are expected to be the main sources of dust in the SR Area 1 during the operational phase.

Emission sources from non-mining activities

The SR Area 1 experiences non-mining emission sources. However, sources such as roads are used both by mines and villagers. The SR Area 1 and surrounding land can be described as rural. The area is characterised by several populated villages and settled areas, subsistence cultivation and natural forest. The air emissions sources from non-mining sources in the SR Area 1 include:

- Traffic on the road network;
- Household fuel combustion;
- Fugitive dust sources (windblown dust from bare ground as well as dust being transported by the Harmattan winds, especially during the dry season);
- Biomass burning comprising of grass and bush burning during the dry season in preparation for crop planting ahead of the summer season;

- Vehicle exhaust emissions; and
- Agricultural activities (e.g. windblown dust from bare agricultural areas, clearing of vegetation, soil cultivation).

4.9.2 Ambient air quality standards and guidelines

Guidelines published by the WB / IFC EHS are presented in this section as there are no ambient air quality guidelines in Sierra Leone. It should be noted that the WB / IFC EHS Guideline, has been adopted from the WHO Guidelines.

As Sierra Leone does not have standards or guidelines for dust fallout, standards from South Africa have been used as applicable reference guidelines to interpret the data and not as a compliance tool.

Particulate Matter

Particulate Matter (PM) is airborne particles that include dust, smoke and soot. PM can either be emitted naturally (e.g. windblown dust of roads) or through human activity (e.g. stack emissions). PM is defined by size, with coarse particles being between 2.5-10 microns (µm), fine particles less than 2.5 µm, and ultrafine particles less than 0.1 µm.

PM has adverse effects on humans, such as respiratory illnesses (asthma, bronchitis) or cardiovascular diseases and is also considered as being carcinogenic. It can also affect vegetation in two ways. Firstly, by inhibiting the plant's photosynthetic properties by coating the leaves, thereby blocking the penetration of natural light. Secondly, various metals in the particulate matter could be deposited onto soils and absorbed by vegetation, hindering plant growth. The uptake of some metals by plants has the potential to contaminate the vegetables and fruit that may be consumed by humans and animals.

The ambient air quality guidelines and standards for inhalable particles (PM_{10} and $PM_{2.5}$) are presented in Table 4-30 and Table 4-31.

Table 4-30: Air quality guidelines and standards for PM_{10}

WB / IFC Guideline[1]	Maximum 24-hour Concentration	Annual Average Concentration
Units	µg/m^3	µg/m^3
Interim Target 1[2]	150	70
Interim Target 2[3]	100	50
Interim Target 3[4]	75	30
Guideline[5]	50	20

1) WB / IFC EHS Guideline: Environmental. Air emissions and ambient air quality.
2) Interim target-1 (IT-1) – These levels are associated with about a 15 % higher long-term mortality risk relative to the Air Quality Guideline level.
3) Interim target-2 (IT-2) – In addition to the other health benefits, these levels lower the risk of premature mortality by approximately 6 % [2-11 %] relative to the IT-2 level.
4) Interim target-3 (IT-3) – In addition to the other health benefits, these levels reduce the mortality risk by approximately 6 % [2-11 %] relative to the IT-2 level.
5) Guideline (AQG) – In addition to the lowest levels at which total cardiopulmonary and lung cancer mortality have been shown to increase with more than 95 % confidence in response to long term exposure to $PM_{2.5}$.

Interim targets are provided by WB / IFC in recognition of the need for a staged approach to achieving the recommended guidelines.

Table 4-31: Air quality guidelines and standards for $PM_{2.5}$

WB / IFC Guideline[1]	Maximum 24-hour Concentration	Annual Average Concentration
Units	µg/m^3	µg/m^3
Interim Target 1[2]	75	35
Interim Target 2[3]	50	25
Interim Target 3[4]	37.5	15
Guideline[5]	25	10

1) WB / IFC EHS Guideline: Environmental. Air emissions and ambient air quality.
2) Interim target-1 (IT-1) – These levels are associated with about a 15 % higher long- term mortality risk relative to the AQG level.
3) Interim target-2 (IT-2) – In addition to the other health benefits, these levels lower the risk of premature mortality by approximately 6% [2-11 %] relative to the IT-2 level.
4) Interim target-3 (IT-3) – In addition to the other health benefits, these levels reduce the mortality risk by approximately 6 % [2-11 %] relative to the IT-2 level.
5) Guideline (AQG) – In addition to the lowest levels at which total cardiopulmonary and lung cancer mortality have been shown to increase with more than 95 % confidence in response to long term exposure to $PM_{2.5}$.

Interim targets are provided by WB / IFC in recognition of the need for a staged approach to achieving the recommended guidelines.

Sulfur dioxide (SO_2)

Sulfur dioxide (SO_2) is a colourless gas and is characterised as having a sharp, irritant odour. It is a primary pollutant, which can react easily with other substances and form secondary pollutants such as sulfur trioxide and sulfuric acid, amongst others. SO_2 is formed by human activities through mainly industrial processes that contain sulfur, such as the combustion of coal, oil or gas.

SO_2 is damaging to the human respiratory function when inhaled, causing coughing and shortness of breath. Either long term exposure or exposure to a large dose can result in chronic respiratory disease and the risk of acute respiratory illness. With respect the impacts on vegetation, SO_2 can inhibit the photosynthetic properties of plants and in some cases, eliminate more sensitive species on the ecosystem level with continuous exposure. The relevant international guidelines and standards for ambient SO_2 levels are presented in Table 4-32.

Table 4-32: Ambient air quality guidelines and standards for SO_2

WB / IFC Guideline[1]	Maximum 24-hour Concentration
Units	µg/m^3
Interim Target 1[2]	125
Interim Target 2[3]	50
Guideline[4]	20

1) WB / IFC EHS Guideline: Environmental. Air emissions and ambient air quality.
2) Interim target -1 (IT-1) - These levels are associated with about a 15 % higher long- term mortality risk relative to the AQG level.
3) Interim target -2 (IT-2) – Intermediate goal based on controlling either motor vehicle emissions, industrial emissions and / or emissions from power production. This would be a reasonable and feasible goal for some developing countries (it would be achieved within a few years) which would lead to significant health improvements that, in turn, would justify further improvements (such as aiming for that AQG guidelines).
4) Guidelines (AQG).

Interim targets are provided by WB / IFC in recognition of the need for a staged approach to achieving the recommended guidelines.

Nitrogen dioxide (NO_2)

Nitrogen dioxide (NO_2) is a naturally forming gas, characterised as having an irritating odour. Small quantities can be produced by plants, soil and water, but anthropogenic activities, such as the combustion of fossil fuels and biomass, are the sources of most NO_2 in the air. Human respiratory tract irritation represents a direct effect of NO_2 exposures. Due to it being relatively insoluble (relative to SO_2), NO_2 can penetrate deep into the lungs, causing potential tissue damage. Effects of NO_2 exposure include alveolar tissue disruption and obstruction of the respiratory bronchioles. Long term effects of exposure include increased potential for lung infections. The relevant international guidelines and standards for ambient NO_2 levels are presented in Table 4-33.

Table 4-33: Ambient air quality guidelines and standards for NO_2

WB / IFC Guideline[1]	Maximum 1-hour Concentration	Annual Average Concentration
Units	µg/m^3	µg/m^3
Guideline	200	40
1) WB / IFC EHS Guideline: Environmental. Air emissions and ambient air quality.		

Dust fallout

Monitoring of dust fallout is considered to be the most practical and cost-effective approach to obtaining an indication of baseline dust levels across the SR Area 1, and dust fallout was monitored during the baseline study for this ESHIA.

Since there are no local Sierra Leone standards or WB / IFC EHS Guideline for dust fallout, the South African Dust Fallout Standards (*National Environmental Management Air Quality Act No. 39 of 2004* (NEM: AQA)) were used as reference guidelines in this assessment. The South African Standard is presented in Table 4-34.

Table 4-34: NEM: AQA, 2004 acceptable dust fallout standards

Restriction area	Dust fall rate (D) (mg/m^2/day, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential Area	D < 600	Two within a year, not sequential months
Non-residential Area	600 < D < 1,200	Two within a year, not sequential months

4.9.3 Ambient air quality data

Air quality monitoring data for the period July to August 2017 was used to determine ambient air quality for SR Area 1. The monitoring locations are presented Table 4-35 and Figure 4-42.

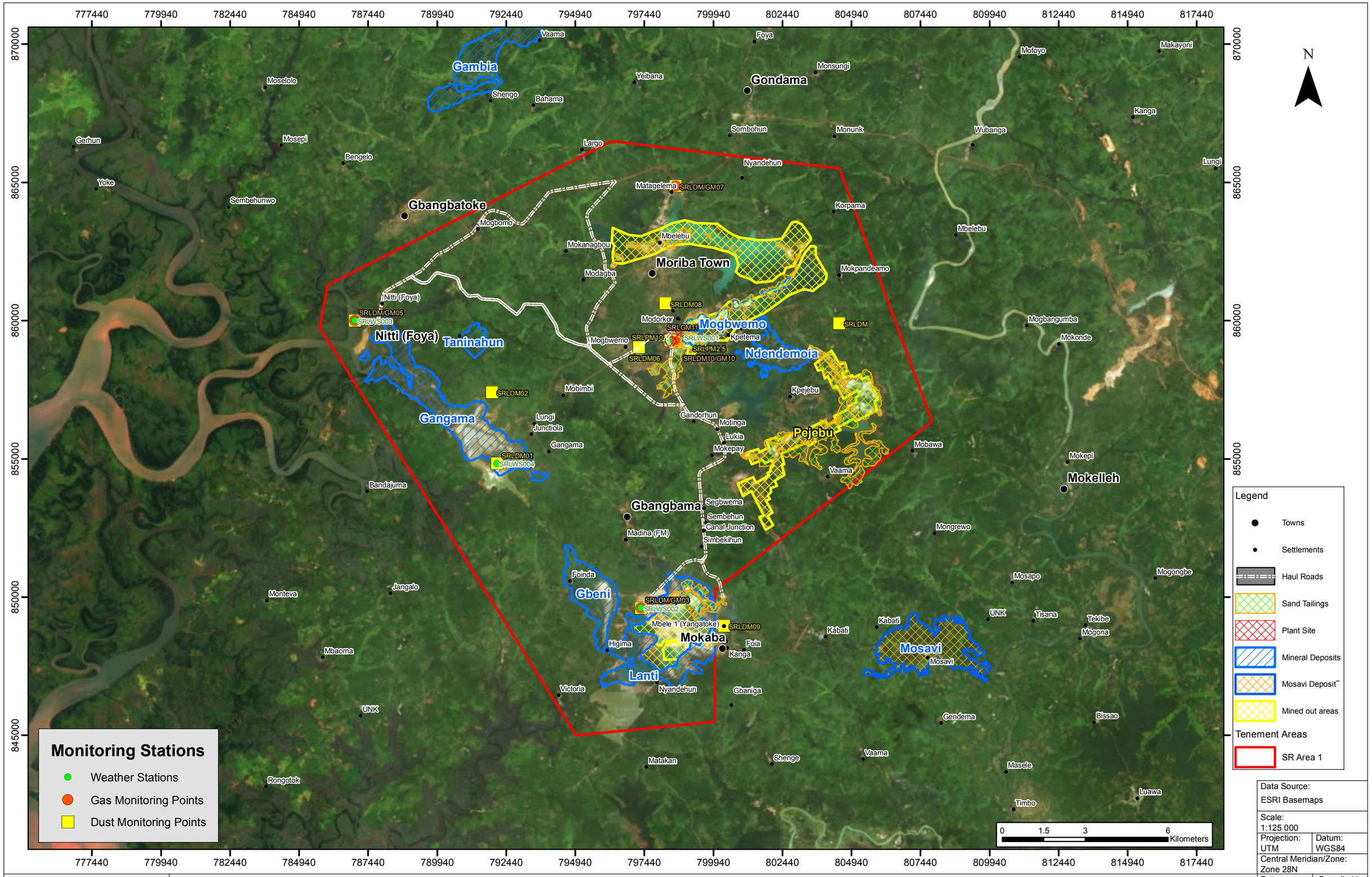
The following datasets have been collated:

- Dust fallout results for August 2017;
- Daily PM_{10} and $PM_{2.5}$ concentrations for the period 29 July 2017 to 31 August 2017; and
- Gas results for July 2017.

Table 4-35: Dust, gas and particulate matter monitoring locations and weather stations

Field ID	Village / Area	Co-ordinates UTM	
Dust and gas monitoring locations			
SRLDM01[6]	Gangama MD2	792097	854837
SRLDM02	Semabu Village	791917	857409
SRLDM/GM03	Lanti MD 1	797319	849607
SRLDM	Mukaba Village	804497	859908
SRLDM/GM05	SRL Nitti Port	786957	860000
SRLDM06	Mogbwemo Village	797245	859043
SRLDM/GM07	Matagelema Village	798573	864867
SRLDM08	Moriba Town Police Station	798205	860620
SRLDM09	Yangatoke Village	800326	848958
SRLDM10/GM10	SRL MSP Site	798583	859223
SRLGM11	Plant Site Admin	798389	859286
Monitoring locations for PM and weather stations			
SRLPM$_{10}$	Plant Site Admin	798389	859286
SRLPM$_{2.5}$	Plant Site Admin	798389	859286
SRLWS001	Plant Site Admin	798389	859286
SRLWS002	Lanti MD1	797319	849607
SRLWS003	SRL Nitti Port	786957	860000
SRLWS004	Gangama MD2	792097	854837

[6] DM refers to Dust Monitor and GM refers to Gas Monitor



Data Source:	ESRI Basemaps
Scale:	1:125 000
Projection: UTM	Datum: WGS84
Central Meridian/Zone:	Zone 28N
Date:	Compiled by:
21/09/2017	ALLK
Project No:	Fig No:
515234	4-42

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SR AREA 1 ESHIA & ESHMP

DUST AND GAS MONITORING LOCATIONS

**Note
The Mosavi Deposit is not included in the SRL Area 1 Study, but is shown on the locality due to its proximity to Area 1.

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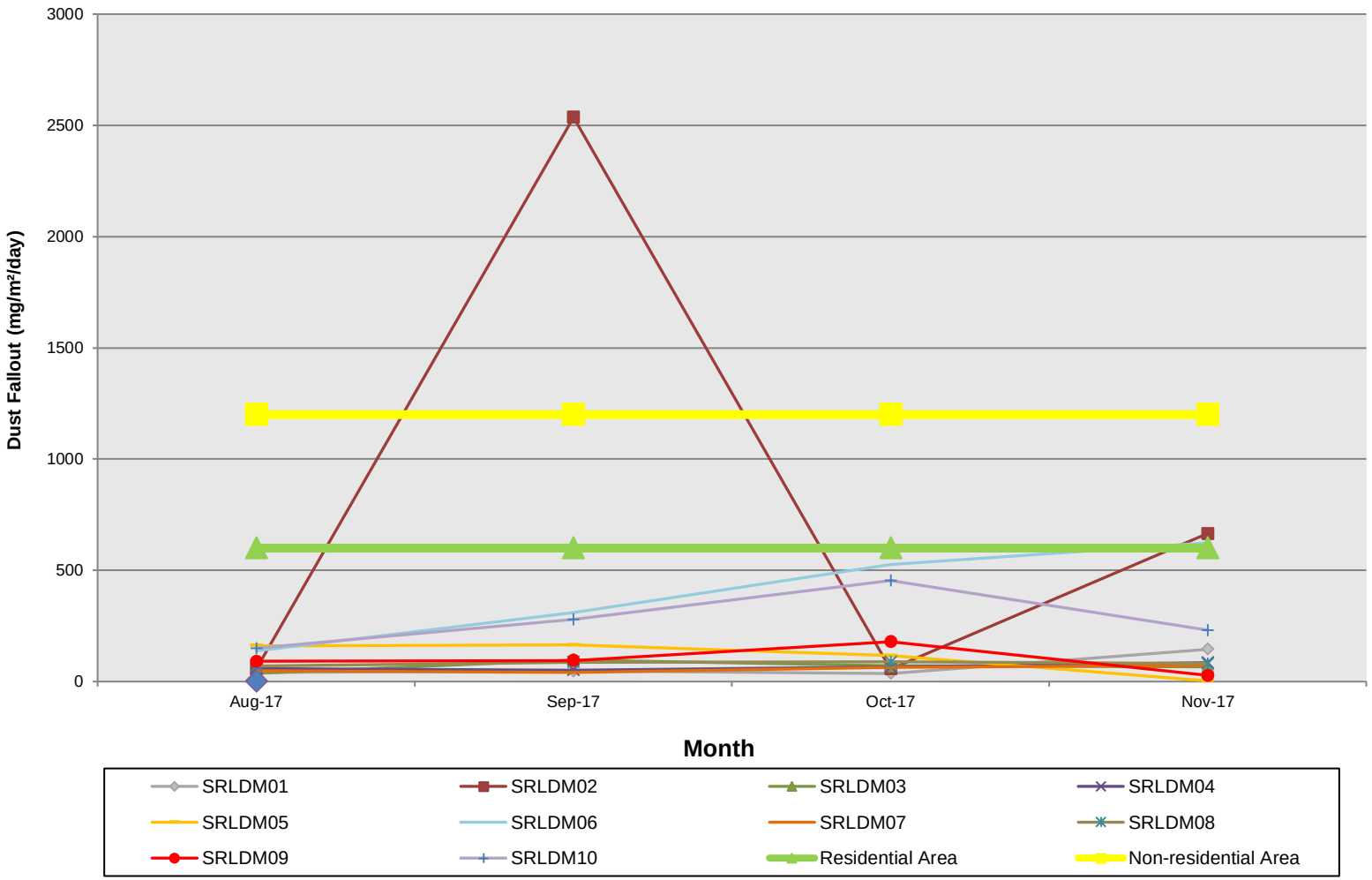
Dust fallout

The dust fallout results for August 2017 to November 2017 are presented in Table 4-36 and in Figure 4-43.

All four non-residential sites are below the South African Non-residential Area Standard of 1,200 mg/m^2/day, with the highest dust fallout rate measured at SRLDM10-MSP (454 mg/m^2/day in October 2017). Dust fallout at the six villages are below the South African Residential Area Standard of 600 mg/m^2/day for the majority of the period, except on 3 occasions. The exceedances occurred at SRLDM02-Semabu Village (September 2017 and November 2017) and SRLDM06-Mogbwemo Village (November 2017) with the highest concentration measured at SRLDM02-Semabu Village (2.536 mg/m^2/day). The exceedance at SRLDM02 should be excluded from the September 2017 monitoring round as it was noticed that material had been thrown into the bucket by the villagers. As expected, the results were low for the majority of the monitoring period which occurred during the wet season.

Table 4-36: Dust fallout for August to November 2017

Field ID	Village	Designation	Aug-2017	Sep-17	Oct-17	Nov-17
			mg/m^2/ day			
SRLDM01	Gangama MD2	Non-residential	40	48	36	145
SRLDM02	Semabu Village	Residential	56	2,536	57	665
SRLDM03	Lanti MD 1	Non-residential	37	97	71	65
SRLDM04	Mukaba Village	Residential	59	51	66	85
SRLDM05	SRL Nitti Port	Non-residential	161	165	116	3
SRLDM06	Mogbwemo Village	Residential	138	309	526	624
SRLDM07	Matagelema Village	Residential	49	41	63	73
SRLDM08	Moriba Town Police Station	Residential	70	87	89	81
SRLDM09	Yangatoke Village	Residential	91	95	179	28
SRLDM10	SRL MSP Site	Non-residential	150	279	454	231
Residential Area Standard			600	600	600	600
Non-residential Area Standard			1,200	1,200	1,200	1,200



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DUST FALLOUT RESULTS – AUGUST 2017 TO NOVEMBER 2017 (SRK, 2018 (1))

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515234

Figure 4-43: Dust fallout results for August 2017 to November 2017 (SRK, 2018(1))

Particulate Matter

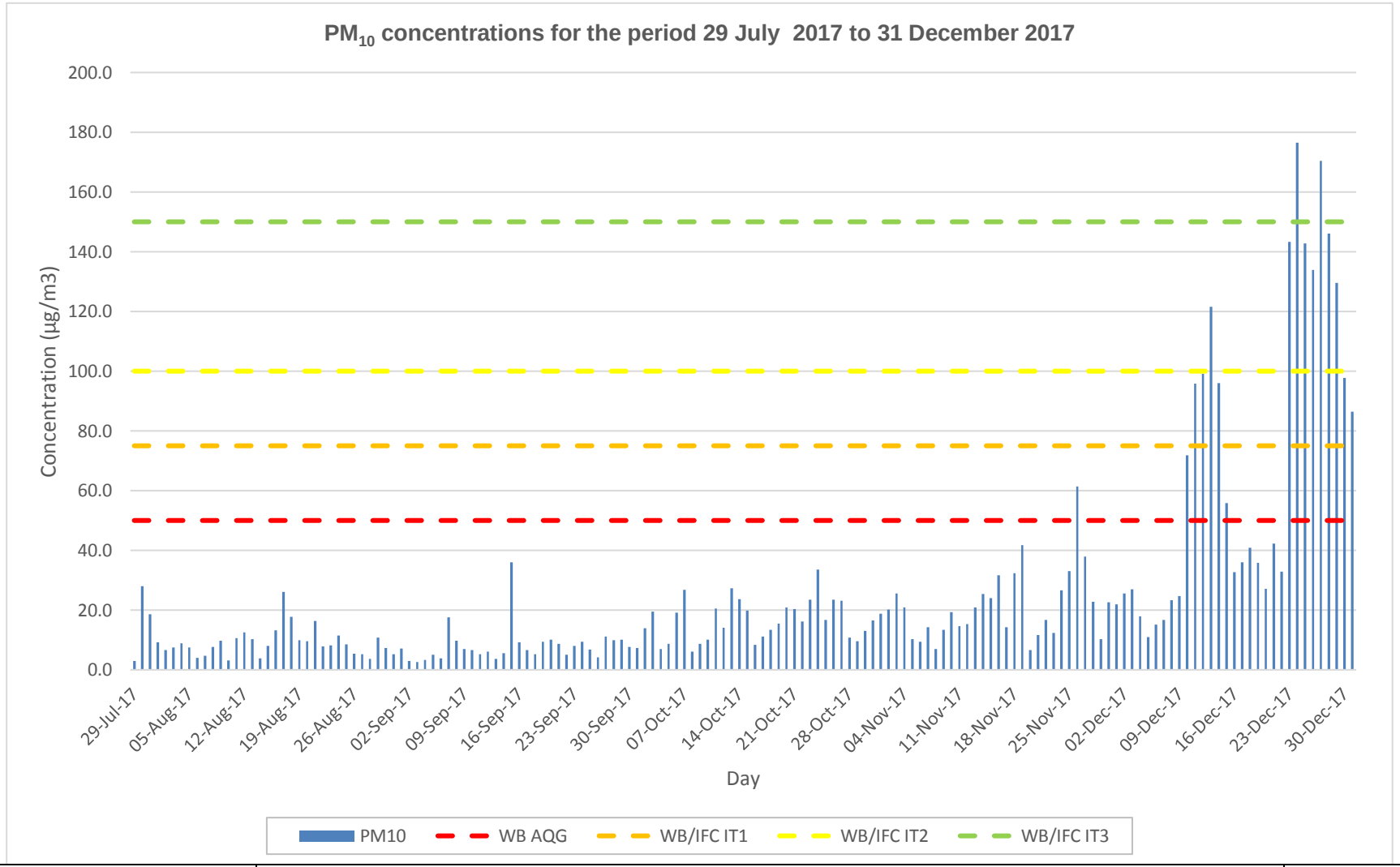
PM data was collected for the period from 29 July 2017 to 31 December 2017. The PM_{10} and $PM_{2.5}$ monitors are located at the SRL mine offices as the location is secure with constant electricity supply (Figure 4-42). The PM_{10} and $PM_{2.5}$ data was validated for accuracy.

PM_{10}

The average 24-hour PM_{10} concentrations are presented in Table 4-37 and the daily concentrations are presented in Figure 4-44. The monthly average 24-hour PM_{10} concentrations were below the WB / IFC EHS Guideline of 50 µg/m^3 for the majority of period, except in December 2017 (74.5 µg/m^3). The PM_{10} concentrations for July 2017 represents data collected from 29 July 2017 (3 days). The daily concentrations, as presented in Figure 4-44, are below the WB / IFC EHS Guideline of 50 µg/m^3 during the wet season. However, once the dry season begins, concentrations exceed the WB / IFC EHS Guideline of 50 µg/m^3. There were 16 exceedances of the WB / IFC Guideline, 2007 of 50 µg/m^3 during the monitoring period from July to December 2017, with the majority occurring in December 2017.The highest 24-hour concentration measured occurred on the 24 December 2017 (176.5 µg/m^3) and may have been a factor of low rainfall and / or increased dust generation through on-site activities or the influence of Harmattan winds which blow from the north east.

Table 4-37: Monthly average 24-hour PM_{10} concentrations

Month	PM_{10} concentration (µg/m^3)
July 2017	11.0
August 2017	9.0
September 2017	8.1
October 2017	16.5
November 2017	21.3
December 2017	74.5
WB / IFC EHS Guideline	50



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PM_{10} CONCENTRATIONS – JULY 2017 TO DECEMBER 2017 (SRK2018(1))

Project No. 515234

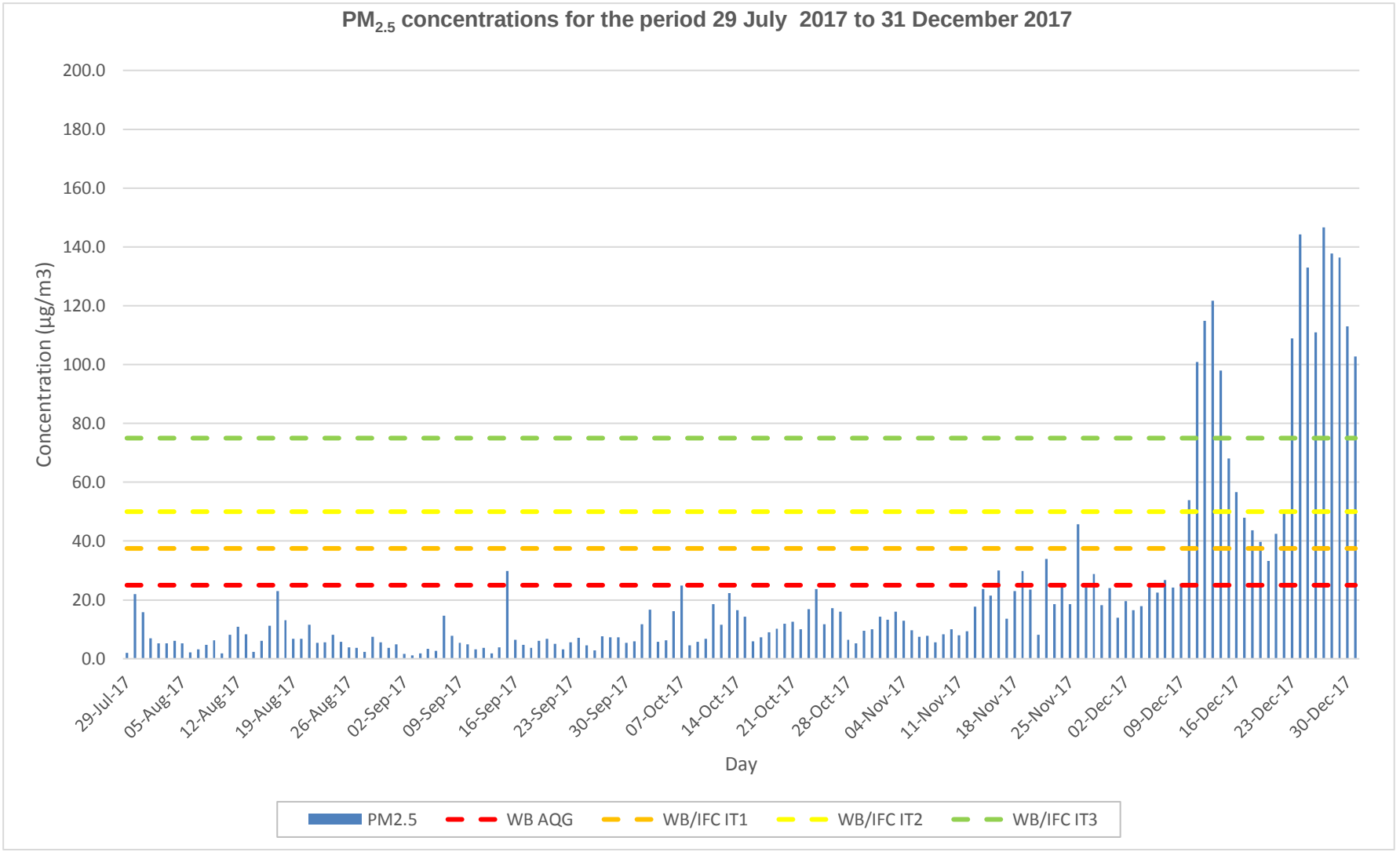
Figure 4-44: PM_{10} concentrations for the period July 2017 to December 2017 (SRK, 2018(1))

$PM_{2.5}$

The average 24-hour $PM_{2.5}$ concentrations are presented in Table 4-38 and the daily concentrations are presented in Figure 4-45. The average 24-hour $PM_{2.5}$ concentrations were below the WB / IFC EHS Guideline of 25 µg/m^3 for the period, except in December 2017 (70.8 µg/m^3). The daily concentrations, as presented in Figure 4-45, are below the WB / IFC EHS Guideline of 25 µg/m^3 during the wet season. Similar to PM_{10}, once the dry season begins, concentrations exceed the WB / IFC EHS Guideline of 25 µg/m^3. There were 31 exceedances of the WB / IFC EHS Guideline of 25 µg/m^3 during the monitoring period from July to December 2017.The highest 24-hour concentration measured occurred on the 27 December 2017 (146.7 µg/m^3) and may have been factor of low rainfall and / or increased dust generation through on-site activities and the influence of Harmattan winds which blow from the north east.

Table 4-38: Monthly average 24-hour $PM_{2.5}$ concentrations

Month	$PM_{2.5}$ concentration (µg/m^3)
July 2017	9.5
August 2017	6.7
September 2017	5.8
October 2017	11.9
November 2017	18.4
December 2017	70.8
WB / IFC EHS Guideline	25



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SR AREA 1 ESHIA & ESHMP

$PM_{2.5}$ CONCENTRATIONS – JULY 2017 TO DECEMBER 2017 (SRK, 2018(1))

Project No. 515234

Figure 4-45: $PM_{2.5}$ concentrations for the period July 2017 to December 2017 (SRK, 2018(1))

PM_{10} and $PM_{2.5}$ comparison

A comparison of the PM_{10} and $PM_{2.5}$ data is shown in Figure 4-46. $PM_{2.5}$ concentrations are generally below the PM_{10} concentrations, except in a few instances where the $PM_{2.5}$ results are higher. Activities, such vehicle entrainment of dust and windblown dust, occurring near the $PM_{2.5}$ monitor have increased the concentration of $PM_{2.5}$ in the air.

Across the period from July to December 2017 the $PM_{2.5}$ concentrations are at an average of 83 % of PM_{10}. Hence, the majority of PM_{10} consist of particulates that are less than 2.5 microns. For the monitoring period, high rainfall coincided with a decrease in PM concentrations and low rainfall with an increase in PM concentrations.

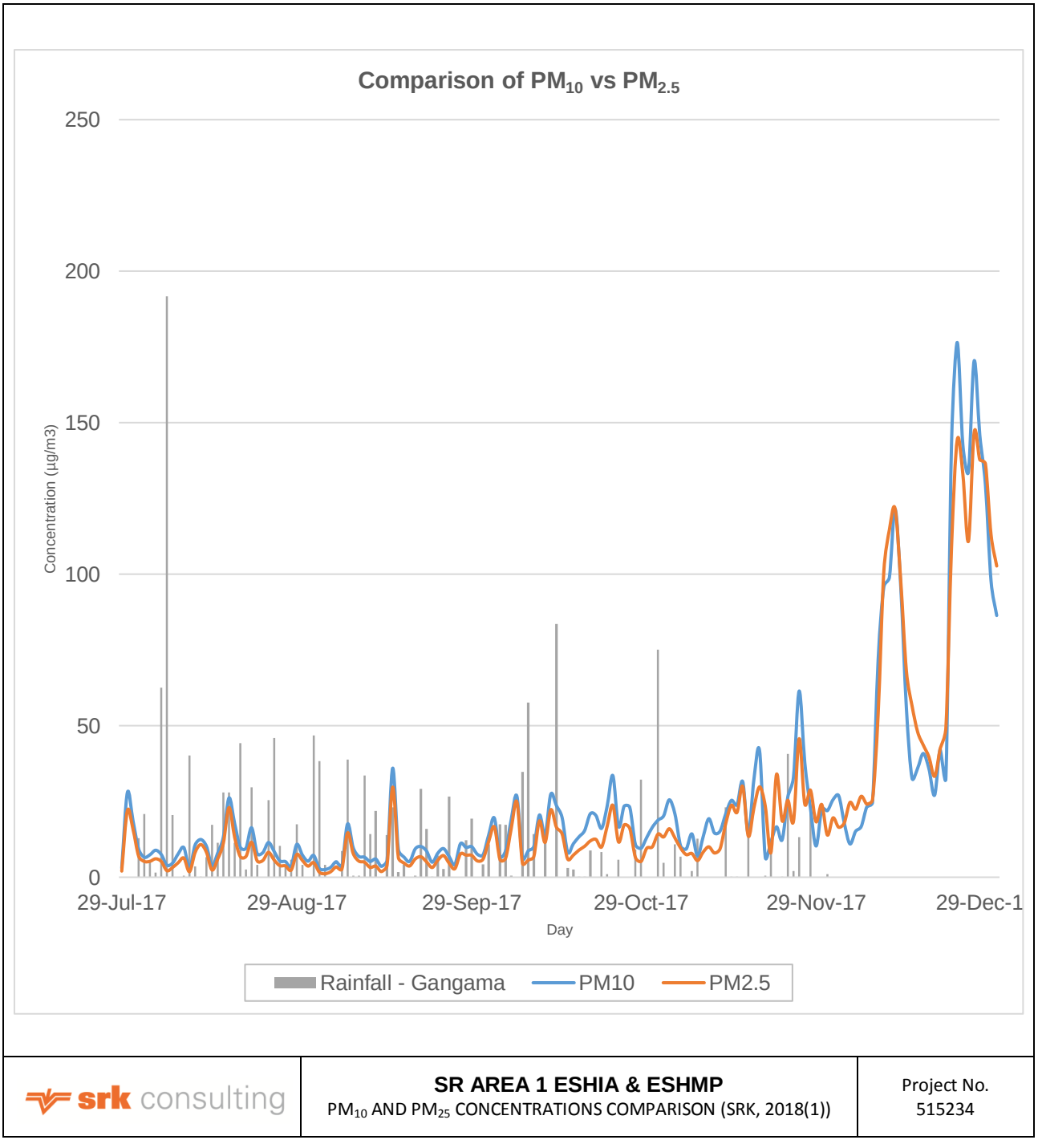


Figure 4-46: Comparison of PM_{10} and $PM_{2.5}$ concentrations (SRK, 2018(1))

Passive Gas

SO_2 and NO_2 monitoring was conducted for July 2017 at the five locations within SR Area 1, as indicated in Figure 4-42. The results of gas monitoring are presented below.

SO_2 levels

SO_2 monitoring was conducted using Radiello badges. The concentrations for all monitoring points were below the 24-hour period WB / IFC EHS Guideline of 20 µg/m^3 (Table 4-39).

Table 4-39: 24-hr SO_2 concentrations

Field ID	July 2017
Units	µg/m^3
SRLGM03	< 0.7
SRLGM05	1.5
SRLGM07	< 0.7
SRLGM10	< 0.7
SRLGM11	< 0.7
WB / IFC EHS Guideline	**20**

NO_2 levels

NO_2 concentrations for all monitoring points were below the 1-hour period WB / IFC EHS Guideline of 200 µg/m^3 (Table 4-40).

Table 4-40: 1-hr NO_2 concentrations

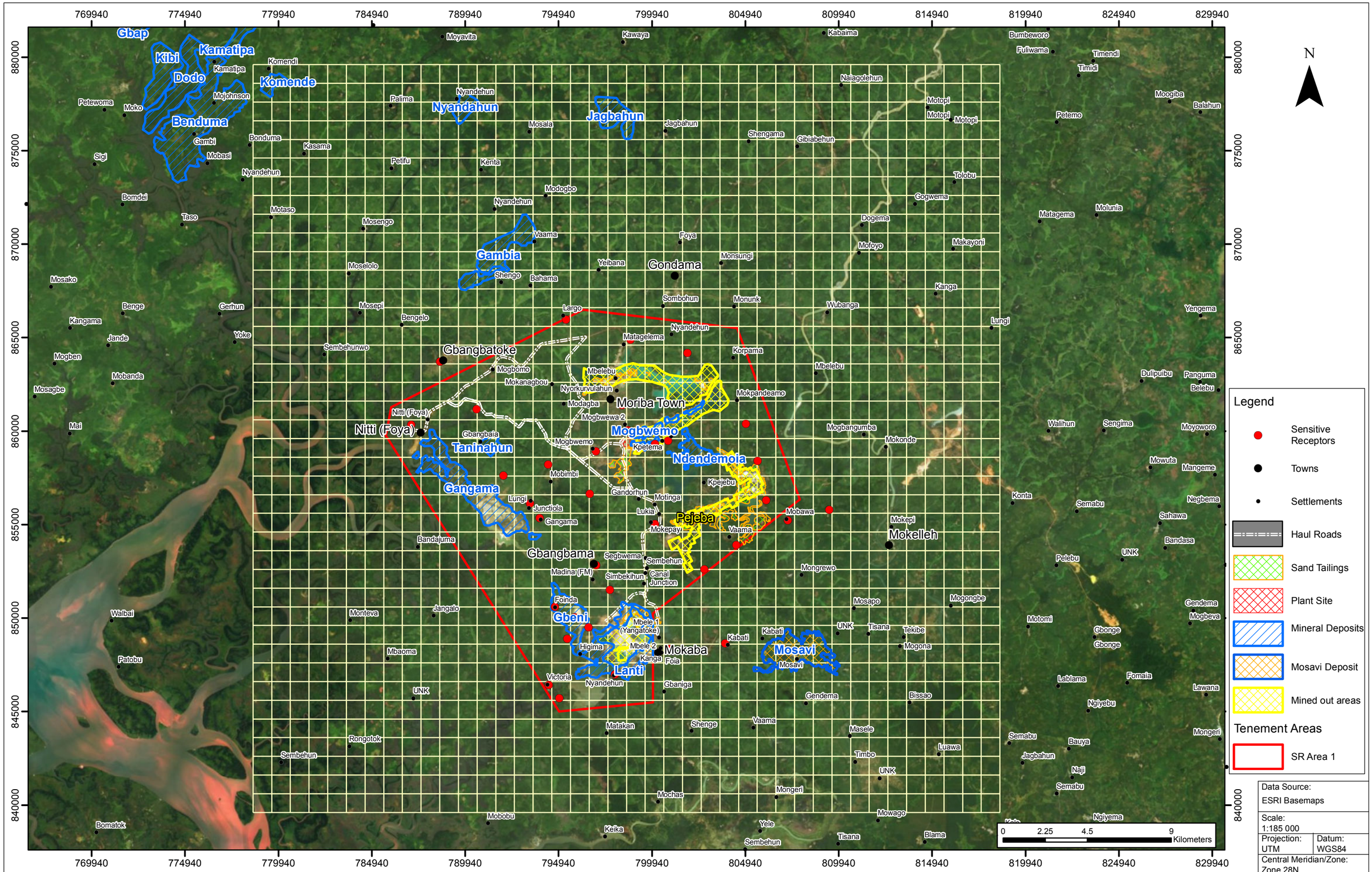
Field ID	July 2017
Units	µg/m^3
SRLGM03	0.7
SRLGM05	0.5
SRLGM07	0.6
SRLGM10	0.6
SRLGM11	0.7
WB / IFC EHS Guideline	**200**

4.9.4 Potential sensitive receptors

The villages presented in Table 4-41 and Figure 4-47 have been identified as potential sensitive receptors in close proximity to mining areas. The villages presented all fall within the dispersion modelling domain (i.e. the grid shown in Figure 4-47) and have been included into the dispersion model as discrete receptors.

Table 4-41: Villages in close proximity to the mine

Name	Co-ordinates	
Kabati	803863.4	848630.9
Mokaba	800839.3	848362.0
Nyandehun	797961.0	846988.9
Teso	794987.6	845698.9
Victoria	794417.6	846427.5
Foinda	794744.2	850601.4
Yangatoke	797690.2	851497.1
Gbamgbama	796955.0	852835.7
Bonjema	802754.7	852601.9
Vaama	804456.4	853894.1
Bamba	801843.2	864196.6
Mokepay	800110.5	855051.1
Mombaya	807221.1	855236.6
Njagbahun	806053.8	856299.5
Mondokor	805606.6	858415.0
Pendembu	804977.6	860393.1
Moriba Town	798345.5	861393.9
Gondama	796608.1	856663.9
Gangama	793937.2	855349.5
Junctiola	793418.1	856132.9
Mobimbi	794381.2	858220.2
Mogbwemo	796939.6	858917.4
Matagiema	798788.2	864875.9
Gbangbatoke	788586.9	863712.0
Nitti Port	787056.2	860342.5
Gbangbama	790540.8	861161.5
Semabu	791988.4	857628.3
Fago	795348.2	865972.0
Mokpandi	809441.6	855773.1
Kpetema	800109.4	859325.6
Mogbewa	798657.4	860059.6
Ndendomoia	800812.7	859486.5
Total: 32 Villages		



Data Source:	ESRI Basemaps
Scale:	1:185 000
Projection: UTM	Datum: WGS84
Central Meridian/Zone:	Zone 28N
Date:	21/09/2017
Compiled by:	ALLK
Project No:	515234
Fig No:	4-47

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SR AREA 1 ESHIA & ESHMP

LOCATION OF VILLAGES

Path: G:\519230_AECI_BB_PERF_MON_2017\8GIS\GISPROJ\MXD\515234_F4_47_AQIA_SensRes_A3L_23022018.mxd

Revision: A Date: 23 02 2018

4.10 Noise quality

The content of this section is adapted from the specialist Noise Study (Acusolv 2018) which is attached as Appendix H. This section describes the noise quality baseline for SR Area 1, which is based on a review of historic data, noise monitoring and analyses (Acusolv 2018). Conducted in 2017, the study investigated the baseline ambient noise quality conditions from current and proposed future mining activities.

4.10.1 Sources of noise

Noise-generating construction activities

Current noise-generating construction activities (Table 4-42) take place concurrently with, though intermittently and at a much smaller scale than operation activities. Swamped by operation noise, noise modelling and computation of current SR Area 1 noise footprints in this assessment account for existing construction activities as an integral part of the existing operation.

Table 4-42: Current noise generating construction activities

Construction activity	Sources of noise
Site clearing	Bulldozers, trucks
Dam construction	Excavation, bulldozers and trucks
Road construction and maintenance	Mostly graders. Other include trucks and compactors

Future noise-generating construction activities and equipment operations will mainly relate to road construction and maintenance and emanate from vehicles such as bulldozers and graders. These activities will not differ in nature or magnitude from current construction activities (i.e. as listed in the table above); the only variable is that they will change location over deposit areas as mining progresses.

Operation sources of noise

Current noise-generating operational activities and equipment are summarised in Table 4-43.

Table 4-43: Current noise-generating operation activities and equipment

Operation activity	Sources of noise
Dredging	On-board scrubbing and screening
Wet plant operation	Mineral product processing
Ore extraction	Excavation, dozing. Loading and truck movements
Primary mineral processing	Scrubber, screens, spirals and conveyor operations
Secondary mineral processing	MSP plant operation
Tailings management	Pumps, dozing and truck movements
Transporting of ore and product	Haul truck engines and road noises
Port handling and shipping	Material handling, barge engine noise, truck noise
Power generation	Generator and engine noise

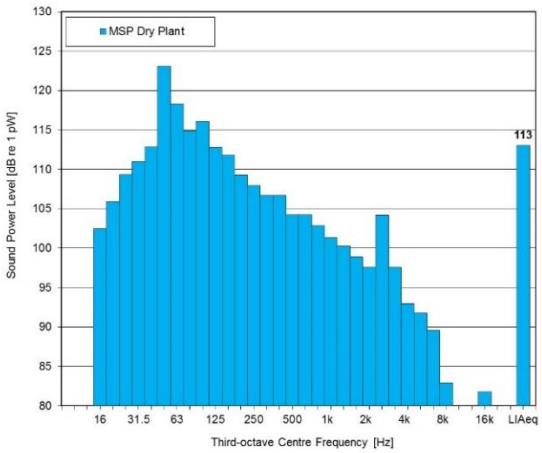
Noise source tests

In addition to baseline ambient noise surveys, noise tests at source were carried out to obtain noise emission (sound power) data. This was used in noise modelling to quantify primary sources of noise in current and future SR Area 1 operations. Figure 4-48 to Figure 4-53 show characteristic noise emission spectra for some of the primary SRL plants and operations. These are extracts of more

comprehensive data derived from tests conducted within the proximity, but in the acoustic far-fields of the various sources.

Similar information used in the simulation of various other sources of noise embodied by activities at SR Area 1, such as excavators, dozers, trucks and power generators, were obtained from noise emission data archives built from numerous measurements previously conducted by Acusolv for similar equipment and activities.

MSP dry plant

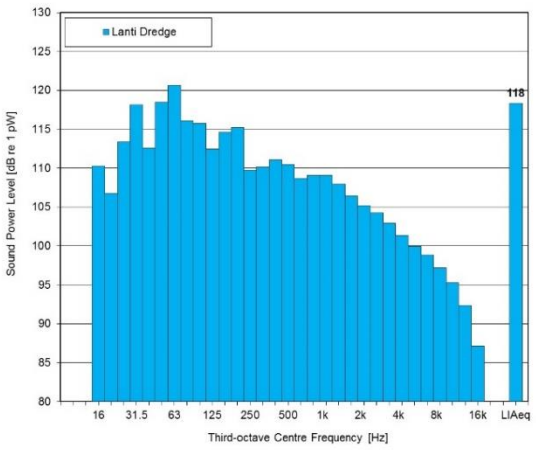


Characteristic third-octave noise emissions spectrum

srk consulting	**SR AREA 1 ESHIA & ESHMP** NOISE EMISSION CHARACTERISTICS MSP DRY PLANT	Project No. 515234

Figure 4-48: MSP dry plant noise emission characteristics

Lanti dredge

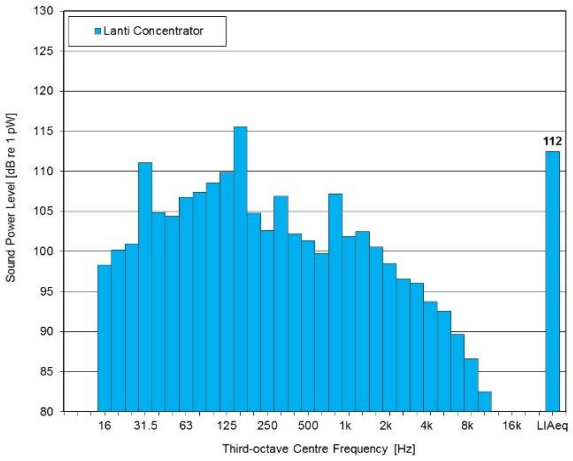


Characteristic third-octave noise emission spectrum

srk consulting	**SR AREA 1 ESHIA & ESHMP** NOISE EMISSION CHARACTERISTICS LANTI DREDGE	Project No. 515234

Figure 4-49: Lanti dredge noise emission characteristics

Lanti floating concentrator

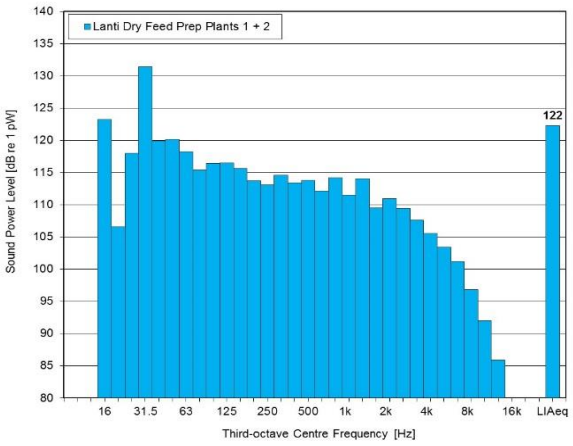


Characteristic third-octave noise emission spectrum

srk consulting	**SR AREA 1 ESHIA & ESHMP** NOISE EMISSION CHARACTERISTICS LANTI CONCENTRATOR	Project No. 515234

Figure 4-50: Lanti floating concentrator noise emission characteristics

Lanti feed preparation plant (one of two)

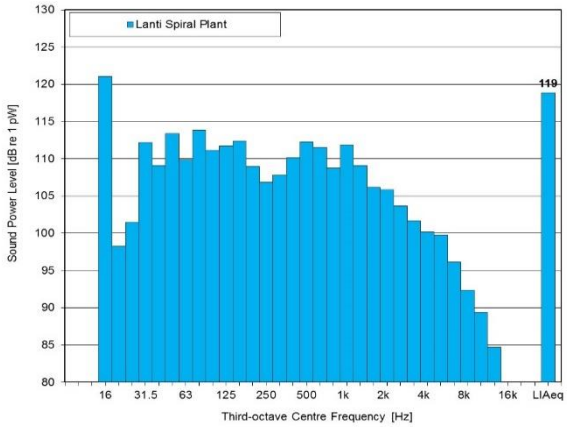


Characteristic third-octave noise emission spectrum

srk consulting	**SR AREA 1 ESHIA & ESHMP** NOISE EMISSION CHARACTERISTICS LANTI DRY MINING FEED PREPARATION	Project No. 515234

Figure 4-51: Lanti dry mining feed preparation plant noise emission characteristics

Lanti dry mining spiral plant

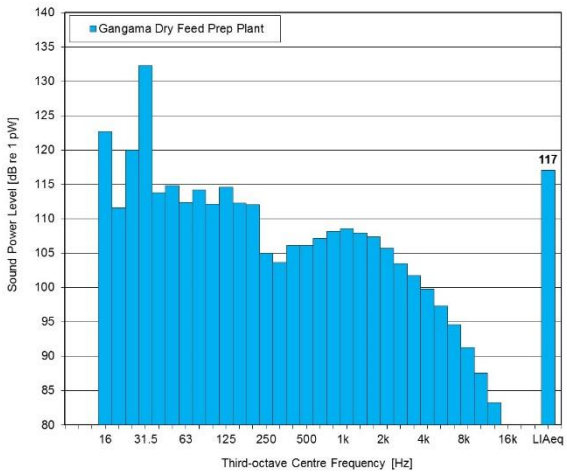


Characteristic third-octave noise emission spectrum

srk consulting	**SR AREA 1 ESHIA & ESHMP** NOISE EMISSION CHARACTERISTICS LANTI DRY MINING SPIRAL PLANT	Project No. 515234

Figure 4-52: Lanti dry mining spiral plant noise emission characteristics

Gangama dry mining feed preparation plant



Characteristic third-octave noise emission spectrum

srk consulting	**SR AREA 1 ESHIA & ESHMP** NOISE EMISSION CHARACTERISTICS GANGAMA DRY MINING FEED PREPARATION PLANT	Project No. 515234

Figure 4-53: Gangama dry mining feed preparation plant noise emission characteristics

4.10.2 Noise standards and guidelines

The IFC 2012 Performance Standards, in conjunction with the WB / IFC EHS Guideline, advise that pollution in general be prevented by control at source. Noise abatement measures are required to meet either Condition (a), or Condition (b).

Condition (a) states that noise levels from the development at the most sensitive point of reception should not exceed the limits specified in Table 4-44. Condition (b) states that noise levels from the development at the most sensitive point of reception should not cause background levels to increase by more than 3 dB. Measurements are to be taken outside the project property boundary and noise levels are to be measured on the A scale (dBA).

Implicit in Condition (a) is what may be referred to as the acceptable level criterion, allowing the use of a nominal table value, rather than the actual pre-development ambient level, as the baseline reference. Post development noise is usually measured at noise receptors located outside the project

boundary (e.g. the mining rights boundary) and compared with the applicable baseline level derived from the table. Condition (b) employs the noise emergence criterion, using as baseline the actual ambient level determined by measurement at receptor locations, i.e. both pre- and post development levels are determined by measurement.

What may not be so obvious, is that the noise level referred to in Condition (a) is the level of the specific noise emanating from the development, i.e. not including the background ambient noise, while the level in Condition (b) is the total level, including background noise. The acceptable level criterion is an essential and practical option in cases where the actual pre-development ambient level is unknown or if it cannot be measured at the time of the investigation, e.g. where construction work or operation has already started by the time the noise study commences.

Table 4-44: WB / IFC EHS Guideline - noise level guidelines

Receptor	Noise Level	
	One Hour L_{Aeq} (dBA)	
(Type of district)	**Daytime**	**Night-time**
	07h00 – 22h00	22h00 – 07h00
(a) Residential; institutional; educational	55	45
(b) Industrial; commercial	70	70

In line with international standard practice, noise levels in Table 4-44 are quantified as A-weighted equivalent continuous levels, denoted as LAeq with units in dBA. Such levels represent the true energy averages of the sound under consideration, regardless of impulsiveness, on-off ratios, or how the level may be fluctuating. The reference period or averaging time T is usually denoted in the level term as $L_{Aeq,T}$. Hence, daytime and night-time levels are commonly denoted as $L_{Aeq,d}$ and $L_{Aeq,n}$ respectively, or Ld and Ln, for short.

By specifying the 1-hour L_{Aeq} in Table 4-44, the WB / IFC EHS Guideline implicitly requires that measurement samples taken for the determination of average daytime or night-time levels be averaged over at least a 1-hour period. In addition to daytime and night-time noise levels specified in Table 4-44, international standards commonly also employ the so-called day-night level L_{dn}, which represents a 24-hour average of the ambient noise level, with a weighting of +10 dB applied to night-time levels. With this weighting applied, the nominal 24-hour level (the table value) turns out to be numerically equal to the daytime level. L_{dn} is usually applied in the assessment of road and air traffic noise.

The WB / IFC EHS Guideline acceptable noise level criteria (i.e. 55 dBA daytime level) is adopted as a blanket development target for residential areas, which are in line with the policies and recommendations of the European Union as well as the WHO. Although a daytime rating of 55 dBA is generally accepted as an ideal, though hard to achieve, planning target for Urban Residential development, the use of a single level without differentiation between residential districts of varying population densities, is rather simplistic. It would be too high in scarcely populated rural districts on the one hand and unachievable and inappropriate in high-density areas on the other.

It is for this reason that most national noise standards (e.g. Australian Standard AS 1055.3, 1997) differentiate between various district residential types. These typically ascend in 5 dB steps from areas with negligible road traffic, or rural districts (the lowest noise category) with a typical daytime level of 45 dBA, to areas with high density of transportation and commerce, or Central Business Districts at 65 dBA and industrial districts at 70 dBA. In all these categories, the corresponding night-time noise level is typically 10 dB lower than the daytime level.

4.10.3 Existing ambient noise levels

Observations and ambient noise surveys confirm that ambient noise in SR Area 1 has evolved in character and level from a former rural district to what is now characteristic of a mining district interspersed with rural villages. In assessing this scenario, the following should be borne in mind:

- The location of a village amidst mining developments does not necessarily imply that mining noise should impact significantly or audibly on ambient levels in the village. The influence of mining related noise on any particular receptor area will depend on several factors. This includes the levels of residual and domestic activity background noises. It also depends on the noise outputs of the nearest mining activities (e.g. extraction, plants and roads) and the distances between each noise generating activity and the receptor area;
- Even without any influence from external mining activities, a rural village by virtue of its own activities, entails a degree of urbanisation. Urbanisation results in a gradual increase in ambient levels above that of a purely rural district. With population growth, ambient levels tend to rise towards typically 55 dBA during the day and 45 dBA at night, which are the ratings designated to residential districts in accordance with WB / IFC EHS Guideline criteria; and
- When evaluating the results of the current or any future SR Area 1 survey, it should be realised that ambient noise levels, whether purely residual, or elevated by intrusive noise, are bound to fluctuate perpetually. Although specific ratings have to be assigned for purposes of assessment, the actual level in any area will never be constant. Hence, in an area rated at 45 dBA for example, the actual level will from one day to the next, characteristically vary by several decibels around this value, even during the course of a single night.

The relevance of conditions (a) and (b) in SR Area 1 are substantiated by the results of the 2017 baseline survey depicted in Figure 4-54. The map shows that ambient levels in the villages vary around 55 dBA during the daytime and 45 dBA at night.

Except for the intrusion of truck noise in a few villages intersected by haul roads, daytime and night-time background noise in villages predominantly accrues from natural sounds (e.g. rain, wind, birds, insects and amphibia) and noises produced by community activities (e.g. local traffic, trade, work, living, leisure, speech communication, children having fun and the sounds of radios and music being played). Local traffic mainly comprises motor cycles used for private and public (taxi) transport. Although noisy, the traffic volumes of motor cycles in villages are generally very low and mostly confined to a single road running through the centre of a village.

When taking readings of noise levels during surveys, particular attention was paid to listen to the content of ambient noise and to detect the presence and prominence of audible mining activity noises, especially during night-time. In villages not intersected by haul roads, very little evidence of such audible plant or any other SR Area 1 activity noises could be detected during the course of the 2017 survey. It is possible and likely, however, that the audibility would vary over time with natural variances in atmospheric propagation conditions.

One location where evidence of audible SR Project noise was found, was Mogbewa village where, on the edge of the village in a clearing with line-of-sight view of the MSP, plant noise was audibly discernible during the quiet hours of the night. The effect on the measured ambient noise reading was relatively small (in the order of 2 dB), elevating the recorded night-time level to 47 dBA. Similar observations of audible MSP noise were made in Kpetema village. In this case, the effect was smaller, with a recorded night-time level of 43 dBA.

Lungi was another location where SR Project noise could be detected. In this case it was coming from the Gangama dry mining Feed Preparation Plant. Apparently, the night-time ambient level at 44 dBA is not significantly affected by this noise (see Figure 4-54).

Prompted for comment, residents of Nyandehun noted that they had previously experienced significant night-time noise disturbance from Lanti wet mining operations at a stage when dredging took place to the south in close proximity of the village. In the meantime, the operation has moved away, and the

disturbance has ceased. Neither the wet plant and dredge, nor the Lanti dry plant could be heard above community background noise during the course of the 2017 survey.

Due to higher volumes of motor cycle traffic, as well as higher levels of trade activities, average background noise levels in towns such as Moriba are considerably higher than corresponding levels in villages. In the town centre daytime levels surged to 72 dBA during the day. Daytime and night-time levels of 49 dBA and 48 dBA, respectively, mapped in Figure 4-54, were obtained from samples taken at residences located away from the busy Moriba town centre. Although elevated above typical levels in villages, this is due entirely to community activities. SR Area 1 operations have no effect on ambient noise levels in this area.

The effect of haul road noise on current ambient levels in villages intersected by haul roads constitutes a component of the current noise impact of SR Area 1 operations. Its effect on levels captured during the 2017 survey was not very noticeable, but it does, for example, reflect in the somewhat elevated levels measured in Foya Nitti.

The results of the baseline field survey shown on the map in Figure 4-54, were used in conjunction with noise modelling to create a global map of the current ambient noise profile of SR Area 1 shown in Figure 4-55. The map shows estimated contours of existing night-time ambient noise levels. The model accounts for all primary sources of noise; i.e. excavation, plant and haul road activities. Daytime and night-time periods are as defined in terms of the WB / IFC EHS Guideline criteria presented in Table 4-44.

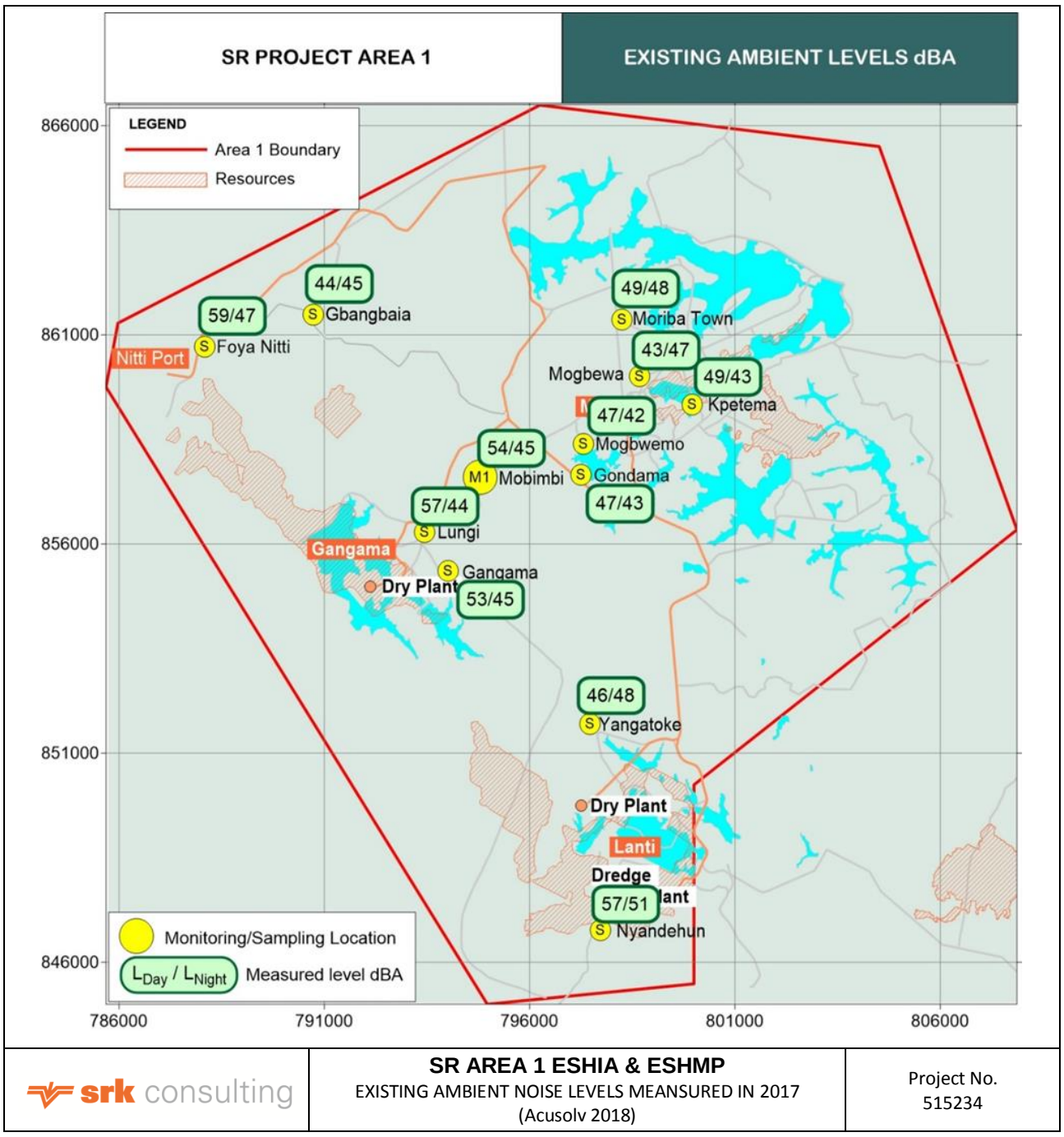


Figure 4-54: Existing ambient noise levels measured in the SR Area 1 survey in 2017 (paired values L_{Day}/L_{Night} dBA are daytime and night time levels) (Acusolv 2018)

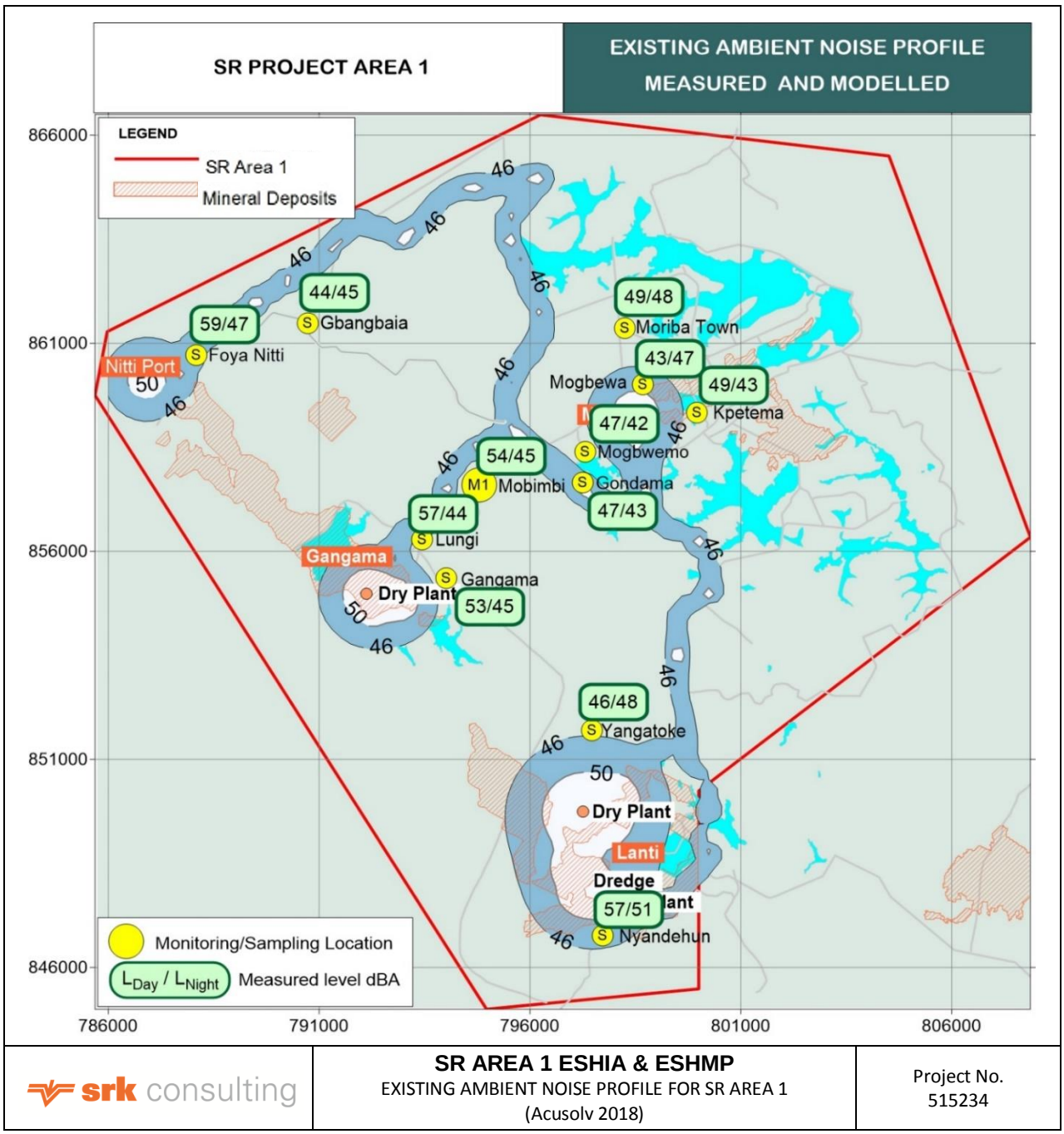


Figure 4-55: Existing ambient noise profile for SR Area 1 (Acusolve 2018)

4.10.4 Baseline reference ambient levels

Baseline reference for current operations

When defining reference ambient levels for purposes of noise impact assessment, the WB / IFC EHS Guideline should be borne in mind. In the context of the SR Area 1 study, the background level in the assessment of the existing overall impact of current operations would be the ambient sound level in the absence of project operations; or the levels that theoretically prevailed prior to commencement of any mining activities. Without any records of useable measurement data dating back that far (since 1967) and because it cannot be determined by measurement at this stage, condition (a) of the WB / IFC EHS Guideline, i.e. employment of a nominal table rating, is applicable. Hence the assessment of current SR Area 1 noise impacts is made by modelling and estimation of the elevation in ambient noise levels relative to 55 dBA daytime and 45 dBA night-time baseline ratings.

Baseline reference for proposed future operations

The best estimate and representation of existing conditions in SR Area 1 is the ambient noise profile depicted in Figure 4-55. This map was derived from the 2017 baseline survey, supplemented by noise modelling. The profile is produced by energy-based summation of the background ambient noise and noise from existing SR Area 1 operations; i.e. noise produced by excavation, plant and haul road activities. Background noise is the nominal night-time rating of 45 dBA in accordance with the WB / IFC EHS Guideline, which was also confirmed by the levels recorded in the 2017 baseline survey.

Total noise levels and the expected incremental impact due to new activities arising from the proposed changes in SR Area 1 operations are computed relative to the contours shown on the map Figure 4-55.

4.11 Terrestrial, aquatic and wetland biodiversity

The content of this section is adapted from the specialist Terrestrial, Aquatic and Wetland Ecological Studies (STS 2018) which are attached as Appendix B. This section describes the terrestrial and aquatic biodiversity baseline for SR Area 1.

4.11.1 Regional biodiversity setting

Terrestrial ecoregions

The majority of SR Area 1 occurs within the Guinean Mangroves (AT1403) terrestrial ecoregion, while the remaining portion of SR Area 1 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[7]. 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 the 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

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

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 Broadleaf Forests 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.

4.11.2 Biodiversity features in SR Area 1

Habitats

The field assessments identified five habitat units (expanded further in Table 4-45 to Table 4-49):

- 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.

Table 4-45: Summary of the Degraded Forest habitat type

Habitat Unit description	Degraded Forest, which historically consisted of Moist Semi-Deciduous Forest which has been degraded by extensive, long term, slash-and-burn subsistence agriculture.
Floral Species of Conservation Concern (SCC)	As the natural floral community structure has been subjected to long term impacts associated with subsistence agriculture, floral SCC are no longer abundant within this habitat unit. However, *Terminalia ivorensis* (Bajii / Black Afara) and *Nauclea diderrichii* (Bundui / Opepe), both of which are listed as Vulnerable by the IUCN, were encountered sporadically throughout this habitat unit. These trees are under pressure due to over-harvesting for timber purposes. During the field assessment, it was evident that these trees were also actively planted by host communities, presumably for their useful nature as a timber resource.
Floral Diversity	Floral diversity was moderately low as is to be expected in habitat subjected to long term disturbances. Dominant species included *Bombax buonopozense* (Titii / West African Bombax), *Ceiba pentandra* (Nguwei / Ceiba), *Musanga cecropioides* (Ngovui / Umbrella Tree), *Scleria barteri* (Razor Grass), *Trema orientalis* (Ngombei / Pigeonwood), *Elaeis guineensis* (Oil Palm) and *Albizia zygia* (Kpakpei / Nongo).
Conservation Status of Vegetation Type / Ecosystem	Very little data is available on the conservation status of this habitat type. According to the WWF, 2001, these lowland forests are Critically Endangered. However, due to its degraded nature and the fact that it is well represented regionally, it is considered to be of moderately low importance.
Habitat Integrity / Alien and Invasive species	Habitat integrity has been compromised by extensive, long term, slash-and-burn subsistence agriculture. As such, it is natural that a high abundance of alien floral species, mostly associated with agriculture such as *Manihot esculenta* (Cassava), *Psidium guajava* (Guava) and *Mangifera indica* (Mango) have invaded this habitat unit. Furthermore, various exotic timber species, including *Acacia mangium* (Forest Mangrove), *Acacia auriculiformis* (Earleaf Acacia) and *Eucalyptus globulus* (Southern Blue Gum), which have been cultivated as part of rehabilitation efforts, have invaded this habitat unit. Finally, *Chromolaena odorata* (Famine Weed) is also abundant and seems to pose a significant threat to floral habitat associated with SR Area 1.
Presence of Unique Landscapes	This habitat type is not considered to be unique and is well represented regionally.

Table 4-46: Summary of the ridges and remnant Semi-deciduous Moist Forest habitat type

Habitat Unit description	Ridges associated with remnant Semi-Deciduous Moist Forest.
Floral Species of Conservation Concern (SCC)	This habitat unit is associated with various SCC namely *Khaya senegalensis, Afzelia africana* (Kpendei / Afzelia)*, Entandrophragma utile* (Jelei / Utile)*, Albizia ferruginea* (Kpakpei / West African Albizia)*, Nesogordonia papaverifera* (Majaagei / Danta)*, Terminalia ivorensis* (Bajii / Black Afara) and *Nauclea diderrichii* (Bundui / Opepe)*.* These trees are listed as Vulnerable by the IUCN and are under pressure due to over-harvesting for timber purposes. This elevates the sensitivity of this habitat unit as floral SCC were the most abundant and diverse within these remnant forests.
Floral Diversity	Floral diversity was moderately high to high as this habitat unit has been excluded from subsistence agriculture and mining due to the steep terrain and also local taboos where forests known as 'society forests' are left undeveloped for spiritual reasons. Dominant species included *Albizia adianthifolia* (Kpakpei / Nongo)*, Nesogordonia papaverifera* (Majaagei / Danta)*, Ceiba pentandra* (Nguwei / Ceiba)*, Musanga cecropioides* (Ngovui / Umbrella Tree), *Uapaca guineensis* (Kondii)*, Brachystegia leonensis* (Bojei)*, Celtis zenkeri* (Ohia)*, Bridelia grandis* (Kui / Asas)*, Cordia platythyrsa* (Pulii)*, Piptadeniastrum africanum* (Mbelei)*, Terminalia ivorensis* (Bajii / Black Afara) and *Zanthoxylum gilletii* (Sowuli / African Satinwood).
Conservation Status of Vegetation Type / Ecosystem	According to the WWF, these lowland forests are Critically Endangered*.* Furthermore, this habitat unit was relatively ecologically intact and is the best representation of Semi-Deciduous Moist Forest within the SR Area 1. Thus, it is of high conservation value.
Habitat Integrity / Alien and Invasive species	Habitat integrity has been compromised in isolated areas where forest has been cleared for agricultural purposes. Furthermore, exotic trees such as *Mangifera indica* (Mango) have invaded sections of the forests, especially close to Mobimbi village. However, habitat integrity is considered to be moderately high.
Presence of Unique Landscapes	This habitat type is unique within the study area and also contained unique species when compared to other habitat types. As such, it is of high sensitivity.

Table 4-47: Summary of the unaltered watercourses (including mangroves) habitat type

Habitat Unit description	Watercourses not affected by mining or decant, and mangrove areas.
Floral Species of Conservation Concern (SCC)	The watercourses are associated with two SCC namely *Mitragyna stipulosa* (Mboi / Abura) and *Gilbertiodendron splendidum* (Gogoi). These trees are listed as Vulnerable by the IUCN and are under pressure due to habitat loss and as such, the watercourses are considered to be of moderately high sensitivity in terms of floral SCC.
Floral Diversity	Floral diversity in the watercourses was moderately high and contained species unique to this habitat unit. Dominant species included *Cleistopholis patens* (Moigbamei), *Anthocleista nobilis* (Pongoi), *Oxytenanthera* spp., *Raphia vinifera* (Raphia), *Newtonia elliotii* (Hele-lahei), *Imperata cylindrica* (Satintail Grass), *Macaranga heudelotii* (Ndewei), *Gilbertiodendron splendidum* (Gogoi), *Pteridium aquilinum* (Bracken) and *Elaeis guineensis* (Oil Palm). The mangroves were associated with *Avicennia africana* (Gbelettii), *Conocarpus erectus, Laguncularia racemosa* (Lakentmabi) and *Rhizophora* spp. (Dengii).
Conservation Status of Vegetation Type / Ecosystem	Watercourses are inherently sensitive environments, and are generally protected by international best practice guidelines. Furthermore, the mangroves fall within a Marine Protected Area (MPA) according to the National Minerals Agency of Sierra Leone's Geo-Data Information Database (refer to Section A of the specialist terrestrial, aquatic and wetland ecological study in Appendix B for further detail). As such, this habitat unit is considered to be of high sensitivity.
Habitat Integrity / Alien and Invasive species	In general, habitat integrity is moderately high, with isolated areas of disturbance encountered, especially where mining activities have encroached into the mangroves. Of concern is the invasion of exotic trees such as *Acacia mangium* (Forest Mangrove), *Acacia auriculiformis* (Earleaf Acacia) and *Eucalyptus globulus* (Southern Blue Gum) into the watercourses, which will likely result in further proliferation of these species downstream.
Presence of Unique Landscapes	This habitat type is unique as very few watercourses unaffected by mining are left within the study area. As such, it is of high sensitivity.

Table 4-48: Summary of the altered watercourses habitat type

Habitat Unit description	Watercourses associated with historic dredge ponds where bankside vegetation has re-established, as well as systems downstream of the dredge ponds.
Floral Species of Conservation Concern (SCC)	Although affected by decant, the watercourses are associated with two SCC namely *Mitragyna stipulosa* (Mboi / Abura) and *Gilbertiodendron splendidum* (Gogoi). These trees are listed as Vulnerable by the IUCN and are under pressure due to habitat loss. During the dry season assessment, it was confirmed that these species are presented within the bankside vegetation communities along the old dredge ponds.
Floral Diversity	Floral diversity in the watercourses was moderately high and contained species unique to this habitat unit. Dominant species included *Cleistopholis patens* (Moigbamei), *Anthocleista nobilis* (Pongoi), *Oxytenanthera* spp., *Raphia vinifera* (Raphia), *Newtonia elliotii* (Hele-lahei), *Imperata cylindrica* (Satintail Grass), *Macaranga heudelotii* (Ndewei), *Gilbertiodendron splendidum* (Gogoi), *Pteridium aquilinum* (Bracken) and *Elaeis guineensis* (Oil Palm).
Conservation Status of Vegetation Type / Ecosystem	Watercourses are inherently sensitive environments, and are generally protected by international best practice guidelines. Even though these systems have been affected by decant, the floral species composition associated with the watercourses is similar to the natural, unaffected watercourses. Furthermore, the bankside vegetation of the old dredge ponds is approaching a secondary to sub-climax state and as such, this habitat unit is considered to be of moderately high sensitivity.
Habitat Integrity / Alien and Invasive species	In general, floral habitat integrity is moderately high, with degradation only encountered where historic mining activities have affected the watercourses. Furthermore, the historic dredge pond bankside vegetation is also considered to be in a secondary to sub-climax state of ecological succession. However, of concern is the invasion of exotic trees such as *Acacia mangium* (Forest Mangrove), *Acacia auriculiformis* (Earleaf Acacia) and *Eucalyptus globulus* (Southern Blue Gum) into the watercourses, which will likely result in further proliferation of these species downstream.
Presence of Unique Landscapes	Although the old dredge ponds can be considered artificial to a degree, they form part of a larger interconnected watercourse network which provides habitat for niche floral species. Furthermore, the riparian vegetation associated with the watercourses downstream of these ponds is unique from surrounding terrestrial areas. Thus, this habitat unit is considered to be of moderately high sensitivity.

Table 4-49: Summary of the transformed areas habitat type

Habitat Unit description	Transformed habitat associated with villages, active agricultural fields, borrow pits, active dredge ponds and mining areas, and associated infrastructure.
Floral Species of Conservation Concern (SCC)	As the natural floral community structure has been completely altered by mining activities, slash-and-burn agriculture and the establishment of villages, floral SCC are highly unlikely to occur within this habitat unit. Furthermore, during the field assessment none were encountered. Thus, this habitat unit is of low sensitivity in terms of floral SCC conservation.
Floral Diversity	Floral diversity was moderately low as is to be expected in habitat subjected to long term disturbances. Dominant species included pioneer species such as *Cynodon dactylon* (Couch grass) and agricultural species such as *Manihot esculenta* (Cassava)*, Psidium guajava* (Guava) and *Mangifera indica* (Mango)*.* Exotic and invasive species dominated this habitat unit.
Conservation Status of Vegetation Type / Ecosystem	The floral communities associated with this habitat unit are mostly completely transformed and no longer representative of the historic vegetation type of the region. Thus, this habitat unit is considered to be of low sensitivity in terms of floral habitat conservation.
Habitat Integrity / Alien and Invasive species	Habitat integrity has been compromised by complete alteration of the natural floral communities. As such, it is dominated by exotic and pioneer species, mostly associated with agriculture such as *Manihot esculenta* (Cassava)*, Psidium guajava* (Guava) and *Mangifera indica* (Mango)*.* Furthermore, various exotic timber species, including *Acacia mangium, Acacia auriculiformis* and *Eucalyptus globulus,* which have been cultivated as part of rehabilitation efforts, have invaded this habitat unit. Finally, *Chromolaena odorata* is also especially abundant in this habitat unit.
Presence of Unique Landscapes	This habitat type is not considered to be unique as floral habitat has been completed altered and is considered to be of low sensitivity.

Floral Species of Conservation Concern

An assessment considering the presence of any floral Species of Conservation Concern (SCC), as well as suitable habitat to support any such species was undertaken, the outcomes of which are summarised in Table 4-50. Threatened species are species that are facing a high risk of extinction. Any species classified in the IUCN categories as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) is a threatened species. SCC are species that have a high conservation importance floristic diversity and include not only threatened species, but also those classified in the categories Extinct in the Wild (EW), Regionally Extinct (RE), Near Threatened (NT), Critically Rare, Rare and Declining.

Table 4-50: Floral SCC identified during the assessment

Latin name	Common Name	Habitat Unit	IUCN Status
Afzelia africana	Afzelia	Ridge Forest	Vulnerable
Albizia ferruginea	West African Albizia.	Ridge Forest	Vulnerable
Entandrophragma utile	Sipo Mahogany	Ridge Forest	Vulnerable
Gilbertiodendron splendidum	Gogoi	Watercourses	Vulnerable
Khaya senegalensis	African Mahogany	Ridge Forest	Vulnerable
Mitragyna stipulosa	Abura	Watercourses	Vulnerable
Nauclea diderrichii	Opepe	Degraded Forest; Ridge Forest	Vulnerable
Nesogordonia papaverifera	Danta	Ridge Forest	Vulnerable
Terminalia ivorensis	Bajii / Black Afara	Degraded Forest; Ridge Forest	Vulnerable

Faunal Species of Conservation Concern

Specific study sites were selected that were considered to be representative of the habitats found within SR Area 1, with special emphasis being placed on areas that may potentially support faunal SCC. Sites were investigated on foot in order to identify the occurrence, and potential occurrence of fauna. Species listed below whose known distribution ranges and habitat preferences according to the IUCN include SR Area 1, were taken into consideration. It is not always feasible to identify or observe all species within the study area, as such, and to specifically assess an area for faunal SCC, a Probability of Occurrence (POC) matrix is used. The species listed below are considered to have an increased probability of occurring within the study area. Table 4-51 presents the results of the survey, noting threat status and POC.

Table 4-51: Potential faunal species of conservational concern found within SR Area 1

Scientific Name	Common Name	Threat Status	POC %
Mammals			
Eidolon helvum	African Straw-coloured Fruit-bat	NT	70 %
Aonyx capensis	African Clawless Otter	NT	70 %
Hydrictis maculicollis	Spotted-necked Otter	NT	70 %
Pan troglodytes	Chimpanzee	EN	60 %
Miniopterus schreibersii	Schreibers' Long-fingered Bat	NT	70 %
Cercocebus atys	Sooty Mangabey	VU	60 %
Hipposideros jonesi	Jones's Roundleaf Bat	NT	70 %
Pipistrellus brunneus	Dark-brown Serotine	NT	60 %
Caracal aurata	African Golden Cat	VU	60 %
Smutsia gigantea	Giant Ground Pangolin	VU	60 %
Cephalophus jentinki	Jentink's Duiker	EN	60 %
Genetta bourloni	Bourlon's Genet	VU	60 %
Genetta johnstoni	Johnston's Genet	VU	60 %
Rhinolophus ziama	Ziama Horseshoe Bat	EN	70 %
Phataginus tricuspis	Tree Pangolin	VU	60 %
Colobus polykomos	King Colobus	VU	60 %
Piliocolobus badius	Western Red Colobus	EN	60 %
Hipposideros marisae	Aellen's Roundleaf Bat	VU	70 %
Panthera pardus	Leopard	NT	60 %
Hipposideros vittatus	Striped Leaf-nosed Bat	NT	70 %
Rhinolophus guineensis	Guinean Horseshoe Bat	VU	70 %
Casinycteris ophiodon	Pohle's Fruit Bat	NT	60 %
Avifauna			
Ceratogymna elata	Yellow-casqued Hornbill	NT	70 %
Bycanistes cylindricus	Brown-cheeked Hornbill	NT	70 %
Scotopelia ussheri	Rufous Fishing-Owl	NT	70 %
Limosa lapponica	Bar-tailed Godwit	NT	70 %
Calidris canutus	Red Knot	NT	70 %
Numenius arquata	Eurasian Curlew	NT	70 %
Limosa	Black-tailed Godwit	NT	70 %

Scientific Name	Common Name	Threat Status	POC %
Ciconia episcopus	Woolly-necked Stork	VU	70 %
Calidris ferruginea	Curlew Sandpiper	NT	70 %
Psittacus timneh	Timnehs Grey Parrot	NT	100 %
Rynchops flavirostris	African Skimmer	NT	100 %
Gallinago media	Great Snipe	NT	70 %
Phoeniconaias minor	Lesser Flamingo	NT	70 %
Neotis denhami	Denham's Bustard	NT	70 %
Hylopsar cupreocauda	Copper-tailed Starling	NT	70 %
Amphibians			
Kassina cochranae	Red-legged kassina	NT	60 %
Hyperolius chlorosteus	NA	NT	60 %
Phrynobatrachus phyllophilus	NA	NT	60 %
Arthroleptis crusculum	Guinea Screeching Frog	NT	60 %
Ptychadena superciliaris	NA	NT	60 %
Hyperolius zonatus	NA	NT	60 %
Leptopelis macrotis	Amani Forest Tree Frog	NT	60 %
Phrynobatrachus guineensis	NA	NT	60 %
Phrynobatrachus liberiensis	LIberia River Frog	NT	100 %
Phrynobatrachus alleni	NA	NT	60 %
Conraua alleni	NA	VU	60 %
Odontobatrachus natator	NA	NT	60 %
Sclerophrys togoensis	NA	NT	60 %
Reptiles			
Osteolaemus tetraspis	Dwarf Crocodile	VU	60 %
Crocodylus cataphractu	African Slender-snouted Crocodile	CR	60 %
Insects			
Elattoneura dorsalis	Yellow-fronted Threadtail	VU	60 %
Agriocnemis angustirami	Liberian Wisp	VU	60 %

Medicinal Plant Species

A list of plant species with traditional medicinal value is provided in Table 4-52. Plant parts traditionally used and their main applications, which were identified during the field assessment is also provided. The majority of the medicinal species listed below are all considered to be common to the region and were encountered throughout SR Area 1, especially within the degraded forest areas.

Table 4-52: Traditional medicinal plants identified during the field assessment

Scientific name	Local name	Plant part used	Medicinal use
Macaranga heudelottii	Njekoi	Leaves, fruit, bark, roots	An infusion of the leaves in water is prepared and is applied to skin conditions. For coughs, the pith of the wood is chewed.
Cola chlamydantha	Ndogbojeh	Leaves	Leaves are roasted and mixed with palm oil and taken orally as a general emetic to treat various diseases.

Scientific name	Local name	Plant part used	Medicinal use
Piptadeniastrum africanum	Mbelie	Bark, roots	A pulp of the bark and roots is prepared and rubbed onto the head to treat migraines.
Morinda geminata	Njasui	Roots	A decoction is prepared from the roots and taken orally to treat anaemia in children.
Ficus capensis	Ndahie	Bark	A decoction is prepared from the bark and taken orally to treat dysentery.
Salacia senegalensis	Giboi	Leaves	A decoction is prepared from the leaves and taken orally to treat constipation.
Mimosa pudica	Dbagbomei	Leaves	A paste of the leaves is prepared and mixed with white river clay and applied to the skin to treat inflammation.
Dissotis rotundifolia	Mbongei	Leaves	A decoction is prepared from the leaves and taken orally 3 times daily to treat gonorrhoea.
Gouania longipetala	Sawai	Leaves	A decoction is prepared from the leaves and taken orally to treat fever and hallucinations.
Costus afer	Hoiweh	Roots	A decoction is prepared from the roots and applied into eyes to treat eye infections. Roots are also chewed to induce vomiting to treat snake bite.
Anthocleista procera	Pongoe	Roots / leaves	A decoction is prepared from the roots and leaves and taken orally to stimulate growth of babies in pregnant women.
Brachiaria serrata	Kpandai	Leaves	A decoction is prepared from the leaves and applied to the body where affected by polio.
Canna indica	Jaikie	Root	Root pulp is applied to treat leprosy.
Musanga cecropioides	Ngovoi	Bark / roots	A decoction is prepared from the bark and roots and taken orally to treat high blood pressure.
Myrianthus serratus	Foi	Bark	Dried bark is crushed and the powder is mixed with water and taken orally to treat stomach aches and rheumatism.

Exotic and invasive flora species

Alien floral species in SR Area 1 were mostly associated with villages, agricultural and mining disturbances, where in some instances they were completely dominant. Table 4-53 lists the exotic and invader species identified during the assessment along with their basic methods of control.

Table 4-53: Exotic or invasive species identified during the assessment

Scientific name	Common name	Control
Acacia auriculiformis	Earleaf Acacia	Mechanical control, herbicide
Acacia mangium	Forest Mangrove	Mechanical control, herbicide
Alpinia speciosa	Wild Ginger	Mechanical control, herbicide
Bidens pilosa	Spanish Blackjack	Pre-emergence herbicide
Chromolaena odorata	Tiffid weed / Siam weed	Mechanical control, herbicide
Eucalyptus globulus	Southern Blue Gum	Mechanical control, herbicide
Hibiscus trionium	Bladder Hibiscus	Herbicide
Lantana camara	Lantana	Mechanical control, herbicide
Mangifera indica	Mango	None required (Agricultural Crop)
Manihot esculenta	Cassava	None required (Agricultural Crop)
Psidium guajava	Guava	None required (Agricultural Crop)

Scientific name	Common name	Control
Sesbania bispinosa	Spiny Sesbania	Mechanical control
Tithonia diversifolia	Mexican sunflower	Mechanical control, herbicide
Tithonia rotundifolia	Mexican sunflower	Mechanical control, herbicide
Zinnia peruviana	Redstar Zinnia	Herbicide

Fish

Historic dredge ponds are utilised as an aquaculture resource by the community. In this regard, Guinean tilapia (*Tilapia guineensis*) and Nile tilapia (*Oreochromis niloticus*) were introduced to some of these ponds as part of an active aquaculture program. Records supplied indicate that the aquaculture effort can be considered effective (289,582 fish harvested during 2015, and 295,750 fish harvested during 2016). However, the stocking efforts also led to the introduction of these alien species to the aquatic systems in the area (including certain historical dredge ponds), as was evident from collections and communication with subsistence fishermen. In total seven fish species were reported from site SR1 and SR5 (excluding the brackish water fish captured at SR1), three species from site SR3 and SR4, two species from site SR4 (sampling sites are shown in Figure 4-57). Overall the aquatic resources in SR Area 1 presented with a fair prevalence and diversity of fish species. At site SR5, the spatial reference site, one taxon was collected which was not reported from the other sites (a representative of the family *Petrocephalus bovei*). Of the taxa identified, the conservation status of all are classified as “Least Concern” or “not yet assessed”. No species of conservation concern were identified. Species identified during the assessment is found in Table 4-54.

Table 4-54: List of fish species identified during the assessment

Scientific Name	Common Name	Threat Status
Tilapia guineensis	Guinean tilapia	LC
Oreochromis niloticus	Nile tilapia	
Clarias sp		
Brycinus longipinnis	Robber	LC
Brycinus imberi	Spot-tail robber	LC
Hepsetus odoe	African pike	LC
Papyrocranus afer	Reticulate knifefish	LC
Hemichromis fasciatus	Banded jewelfish	LC
Pelvicachromis humilis (not definitive)	Mouthbrooder / Cichlid	LC
Epiplatys barmoiensis	Killifish	LC
Petrocephalus bovei		
Hemichromis guttatus	Jewel cichlid	LC

Figure 4-56 presents photographs taken of biodiversity features during the site visit.

Adult Guinean tilapia (*Tilapia guineensis*)	**Suspected juvenile Guinean tilapia (*Tilapia guineensis*)**	***Oreochromis niloticus*** Not collected, but local fishermen harvest fish from the old dredge ponds stocked with the fish
Clarias sp Not collected / photographed, but local fishermen confirmed presence (photograph from personal collection)	**African pike (*Hepsetus odoe*)**	**Reticulate knifefish (*Papyrocranus afer)***
Hemichromis fasciatus **Pending final identification**	***"Mouthbrooder / cichlid"*** **Pending identification**	**Killifish** ***Epiplatys barmoiensis***
srk consulting	**SR AREA 1 ESHIA & ESHMP** AQUATIC ASSESSMENT (STS 2018)	Project No. 515234

Figure 4-56: Species from aquatic assessment (STS 2018)

Macro-invertebrate community and habitat

The aquatic assessment serves to document the condition and the state of the riverine ecological integrity at the time the assessment was undertaken in July 2017, when relatively high flows were experienced at the onset of the wet season, as well an assessment which was undertaken in January 2018, when relatively low flows were being experienced at the onset of the dry season. In selecting the representative sites for the aquatic ecological sampling, consideration was given to several aspects:

- Accessibility and safety; and
- The presence of a diversity of habitat, cover and flow.

Four sites were chosen that represent the aquatic ecology of SR Area 1. These are outlined in Table 4-55 and represented in Figure 4-57. The position of the sampling point was informed by the anthropogenic influences, including the position in relation to various mining operations such as:

- Downstream of decant points;
- Downstream of older mining operations;
- Downstream of newer mining operations; and
- Areas not affected by mining, for use as reference sites.

Table 4-55: Description of biomonitoring reference sites

Site	Description
SR1	The site is located downstream of the Gangama mining operations on an unnamed tributary of the Sherbro River that is affected by decant from the Gangama pit lake systems.
SR3	The site is located on the Yumbei River. The site is affected by decant from an old pit lake system which may lead to impacts on the Ecostatus of the system.
SR4	The site is located downstream of a very large decant from some of the older lakes in the mining study area. The system is known as the Pekote Stream which consists entirely of decant at the sampling point.
SR5	The site is located in the Rokpoi Stream and serves as a reference site. The site is located to the south east of the mining study area. This system has not been affected by mining activity.

Figure 4-58 and Figure 4-59 presents photographs of the sampling points.

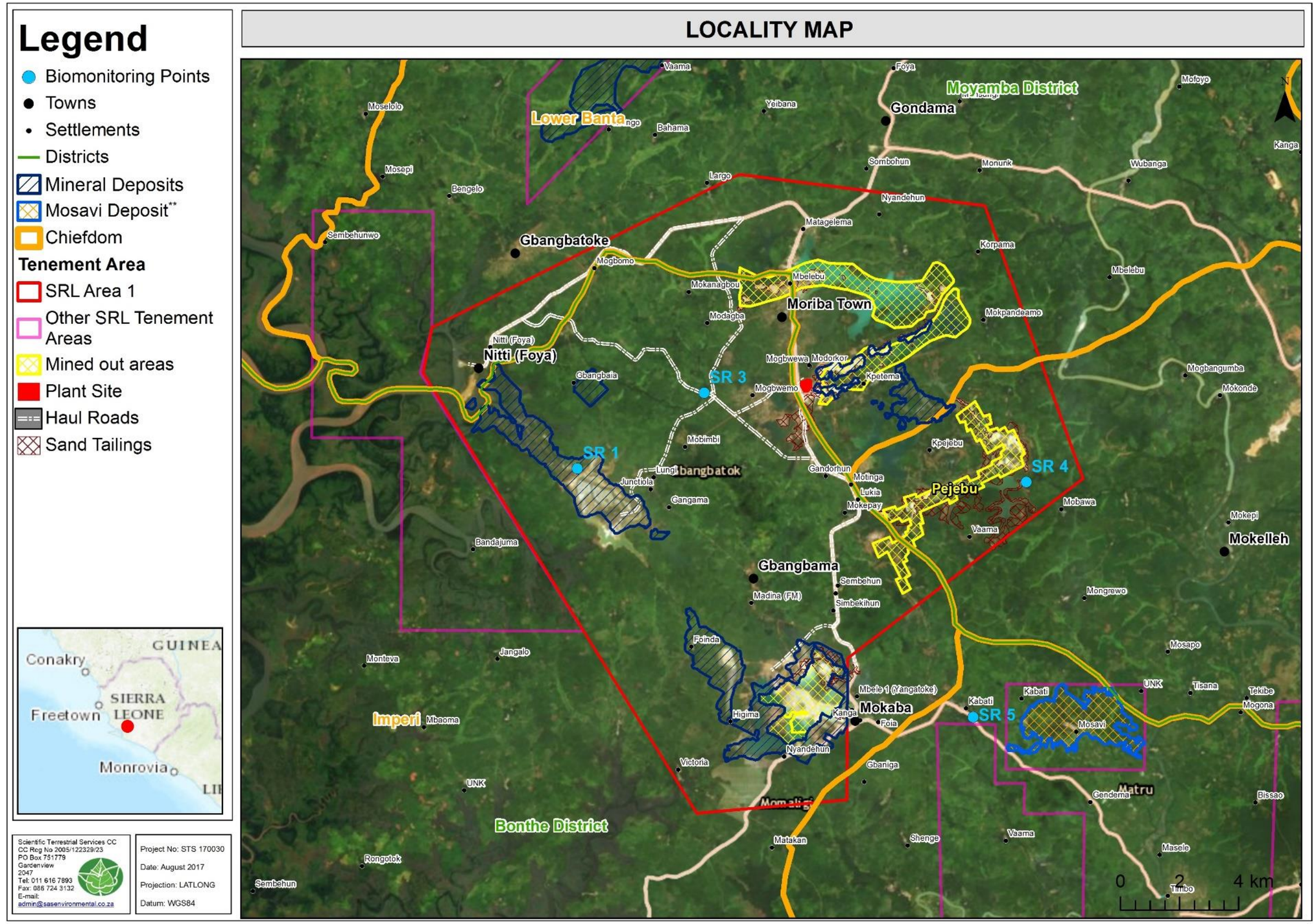


Figure 4-57: Location of aquatic ecological assessment study sites (STS 2018)

Upstream view of the SR1 site on the unnamed tributary of the Sherbro River in the wet season showing the presence of a fish trap of belonging to the local community, not in use at the time of assessment due to high flows (July 2017).	Downstream view of the SR1 site on the unnamed tributary of the Sherbro River with mangrove vegetation in the background (high flow, July 2017).	Upstream view of the SR3 site on the Yumbei River with excellent substrate (high flow, July 2017).	Downstream view of the SR3 site on the Yumbei River showing the relatively intact riparian vegetation and a deep refuge pool (high flow, July 2017).
Upstream view of the SR1 site on the unnamed tributary of the Sherbro River showing the low flow in the dry season (January 2018).	Downstream view of the SR1 site on the unnamed tributary of the Sherbro River showing the lack of flow variation in the system under low flow conditions (January 2018).	Upstream view of the SR3 site on the Yumbei River showing clear water and low flow in the dry season survey (January 2018).	Downstream view of the SR3 site on the Yumbei River showing a refuge pool during low flow conditions (January 2018).
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Figure 4-58: Photographic documentation of aquatic sampling sites SR1 and SR3

General view of the SR4 site on the Pekote Stream downstream of a major decant point in the wet season showing strong flow (July 2017).

Upstream view of the SR5 site on the Rokpoi Stream which is unimpacted by mining (high flow, July 2017).

Downstream view of the SR5 site on the Rokpoi Stream showing dense riparian vegetation growth (high flow, July 2017).

Upstream view of the SR4 site on the Pekote Stream showing the low flow and significant algal proliferation (January 2018).

Downstream view of the SR4 site on the Pekote Stream showing some diversity in flow but a lack of bankside cover (low flow, January 2018).

Upstream view of the SR5 site on the Rokpoi Stream showing dense bankside vegetation (low flow, January 2018).

Downstream view of the SR5 site on the Rokpoi Stream showing sluggish flow in the low dry season (low flow, January 2018).

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SR AREA 1 ESHIA & ESHMP
AQUATIC STUDY SAMPLING POINTS SR4 AND SR5

Project No.
515234

Figure 4-59: Photographic documentation of aquatic sampling sites SR4 and SR5

Habitat suitability for maintaining a diverse macro-invertebrate community in SR Area 1, varied from adequate to excellent at the time of assessments. However, despite suitable available habitat, macro-invertebrate diversity was generally lower than expected, but with a high prevalence of sensitive taxa. Diatom community results also presented with lower classifications at sites SR1 and SR4, indicating some impact on systems affected by decant. However, diatom species composition in the study area does not necessarily imply impacts from mining only, but rather from all anthropogenic activities resulting in nutrient, electrolyte and organic material input, which includes activities not associated with mining. There is evidence that the aquatic systems reach a state of equilibrium with the older historic dredge ponds over time.

Reference scores employed to interpret macro-invertebrate community integrity assessment results, were determined by combining data for all four sites, and then respectively adding up the sensitivity score per taxon observed, as defined by Dickens and Graham (2002) (referred to as South African Scoring System (SASS)), and defining the Average Score Per Taxon (ASPT), scores for the suite of taxa observed. At all sites, low SASS but high ASPT scores were recorded, i.e. large diversity was evident when considering all sites (high SASS reference score), but with less than expected overlap between sites in terms of taxa prevalence, resulting in lower SASS scores per individual site. A summary of the findings from the four study sites is provided in Table 4-56.

Table 4-56: Summary of results for the macro-invertebrate integrity assessment

Site	Macro-Invertebrate Community Integrity	Species present
SR1	• Despite an Invertebrate Habitat Assessment (IHAS) classification score that indicate habitat conditions are fair and adequate to sustain a diverse macro-invertebrate community, the SASS score (a measure of diversity and overall integrity) at this site is very low compared to both the expected reference score and that obtained at the SR5 reference site; • Decant from the pit resulting and turbid conditions, impacts on water quality and impacts on instream flow are likely to negatively affect macro-invertebrate diversity. However, despite these factors ASPT score was relatively high, and on par the expected reference values, and less than 15 % lower compared to the SR5 site which serves as a reference site; • These observations indicate that diversity is affected to a greater degree compared to sensitivity and thus habitat impacts on the system are considered more significant than water quality impacts; • This deduction is supported by water quality measurement results, with all parameters measured appearing largely natural (absolute value for EC is still low, even though elevated from that at site SR5). Habitat impacts as indicated by the application of the IHI data (high flow assessment in July 2017 only) are more significant, with instream habitat considered moderately modified and riparian habitat largely modified; • The fish community is diverse in relation to all other assessed sites although it must be noted that additional fish records were obtained at this point form local fisherman in the wet season survey; • During the dry season survey no fish were captured and no fishermen were present which likely indicates a low abundance of fish under low flow conditions; and • Harvesting by the local community (note fish trap fence in Figure 19) highlights the importance to the local community of the fish in the mangroves and the river systems of the area.	*Tilapia guineensis; Clarias gariepinus; Hepsetus adoe; Brycinus longipinnis; Hemichromis fasciatus; Epiplatys barmoiensis*(not definitive)*, Hemichromis bimaculatus, Papyrocranus afer*
SR3	• Despite an IHAS score that indicates habitat conditions are good to ideal and suitable for sustaining a diverse macro-invertebrate community, SASS score (a measure of diversity) at this site is lower compared to both the expected reference score and SR5 spatial reference site;	*Mouthbrooder / Cichlid* (species to be identified), *Epiplatys barmoiensis, Brycinus imberi*

Site	Macro-Invertebrate Community Integrity	Species present
	• Water clarity data indicate that decant from the Bamba / Belebu Dredge Pond pond upstream is unlikely to significantly increase turbidity; • The generally fast flow during the wet season (as assessed July 2017) may negatively affect macro-invertebrate diversity and abundance. However, despite these factors, ASPT score was high and on par with or slightly below the expected reference values, but lower than the SR5 reference score (particularly with reference to low flow conditions). This indicates that diversity is generally affected to a greater degree compared to sensitivity, but during low flow conditions sensitive species seem to be negatively affected to a greater degree compared to high flow conditions; and • Based on the above it is unlikely that water quality parameters are negatively affecting the macro-invertebrate community during high flow conditions, as this would most significantly impact on sensitive species, and hence would have also resulted in a lowered ASPT score. However, decreased pH and slightly elevated EC may in the long term negatively affect macro-invertebrate community integrity. This is evident under low flow conditions, where slightly elevated EC corresponds with both lowered SASS and ASPT scores. • Diversity (number) of fish species collected were lower compared to that from reference site SR5. This may be due to the effects of historical mining.	
SR4	• Despite an IHAS score that indicates habitat conditions are adequate to sustain a diverse macro-invertebrate community, both SASS and ASPT scores (measure of diversity and sensitivity, respectively) at this site is very low compared to both the expected reference score and the spatial reference site SR5. This trend was more pronounced during the low flow assessment (January 2018); • Decant from the disused dredge pond significantly affects instream flow which is the most likely driver of change in the system, reducing macro-invertebrate diversity and to a lesser degree affecting the macro-invertebrate community sensitivity of the at this site. However, as was the case at site SR1, diversity is affected to a greater degree compared to sensitivity. Any potential impact from the mine is compounded during the dry season, based on reduction in SASS and ASPT scores in the January 2018 assessment; and • Fish community diversity and abundance was significantly lower than the other sampling sites, especially when compared to site SR1 and SR5.	*Tilapia guineensis,* *Epiplatys barmoiensis*
SR5	• IHAS score indicate that habitat conditions are excellent to sustain a diverse macro-invertebrate community. However, SASS score (a measure of diversity) at this site is still lower compared to the theoretical reference score developed. The system can be considered largely natural, despite potential catchment-wide impact due to domestic uses and slash and burn agricultural practices. However, ASPT score (a measure of sensitivity) was higher than the expected reference score, confirming the largely natural macro-invertebrate community integrity classification. • An increased variety of fish species were collected and / or observed as presented in the data above, also indicating no significant negative impact on fish community integrity; and • A diversity of flow and cover provides excellent habitat for a diversity of fish species.	*Mouthbrooder / Cichlid (species to be identified), Epiplatys barmoiensis, Pollimyrus adspersus (species to be confirmed), Brycinus imberi* Other species of larger fish observed in the deeper pools but could not be captured for identification

Wetland and riparian systems

Numerous drainage systems characteristic of SR Area 1 are often located in the valley bottom positions. The actual drainage features consist of both wetland and riparian systems with channelled flow, mostly the larger systems, as well as systems with more diffuse flow, mostly smaller systems flowing beneath trees within areas best defined as riparian zones. The drainage systems in the area are characterised by a mosaic of riparian and wetland vegetation. The systems are dominated by characteristics best defined as riparian forest or secondary riparian forest in various stages of succession. Within these areas as well as the areas with less dense tree growth, the soils often have increased concentrations of organic material. For the purposes of this study, it was decided to assess the watercourses on a system level and group them into similar groups in relation to their position in the landscape and in relation to the mining activities within the SR Area 1. These groupings correspond with the watercourse habitat units as considered in the aquatic ecological assessment and comprise the following:

- Group 1: Reference systems, in largely natural condition and as yet unaffected by the existing mining operations, although these systems have all been affected by domestic use as well as use in agricultural production;
- Group 2: Impounded systems (due to mining operations);
- Group 3: Systems located downgradient and downstream of impoundments; and
- Group 4: Mangrove forests on the western side of SR Area 1.

It is apparent that the naturally occurring wetland and mangrove swamp systems identified in the vicinity of the SR Area 1 are generally deemed in a largely natural to moderately modified condition. Impounded systems, largely modified due to the extent and severity of impacts associated with historical dredge ponds on these systems. All four groups are considered of moderate to very high Ecological Importance and Sensitivity (EIS), and are deemed to provide essential goods and services to the surrounding communities along with important ecological functions. The summarised results of the wetland system assessment are provided in Table 4-57 to Table 4-60.

The Present Ecological State (PES) of the freshwater resource is presented in Figure 4-60 to Figure 4-62, whilst Figure 4-63 to Figure 4-65 depicts the EIS of the freshwater resource.

Table 4-57: Summary of the results of the assessments applied to the wetland systems for Group 1

Wetland system group	Group 1: Reference system
PES	***Largely Natural to Natural*** Few modifications to these systems have occurred, and conditions should be considered largely natural, and ecological processes intact. Some minor alterations to the hydraulic processes have occurred, such as the creation of artificial drainage channels and some effects from subsistence agriculture, but the extent and magnitude of these impacts is very low. Similarly, the geomorphology of these systems has been impacted negligibly. Vegetation has been marginally altered due to crop cultivation and the recruitment of alien floral species within abandoned lands, but otherwise remains largely natural. The ecology of these systems is considered stable and not currently prone to positive or negative change.
EIS	***High*** Considered to be ecologically important from a hydro-functional perspective, and on a local scale, in terms of the contribution it makes to the ecological functions within the landscape. These wetland systems are also deemed to be important for the provision of goods and services and the ecology is likely to be sensitive to flow, water quality and habitat modifications.
Eco-services provision (including socio-	***Moderately High*** This group of watercourses are considered particularly important for the provision of goods and services to the local communities. This includes the provision of harvestable

Wetland system group	Group 1: Reference system
cultural provisioning)	resources such as reeds, water for domestic and farming purposes, and the provision of cultivated foods (rice is grown in many of the wetland areas). However, these watercourses are also deemed important for the provision of various ecological services, including streamflow regulation (i.e. recharge of downstream systems), nutrient and toxicant assimilation, carbon storage and flood attenuation, although the opportunity for the provision of such services is limited due to limited toxicant input and downstream infrastructure risk, for example. Biodiversity maintenance is also considered of importance, as the ecological integrity of this group of wetlands provides ample habitat, refugia and faunal migratory corridors.
Recommended Ecological Category (REC)	***A (Largely Natural to Natural)*** Since these systems are deemed to be in ecologically intact, with few impacts having previously occurred, efforts should be made to retain these conditions in order to ensure the ongoing ecological functioning of the systems. Should it be impossible to avoid impacting on these systems, then very strict mitigation measures must be implemented throughout all phases of the proposed mining activities in order to minimise the extent and magnitude of such impacts, with the aim of retaining the ecological processes as much as possible.

Table 4-58: Summary of the results of the assessments applied to the wetland systems for Group 2

Wetland system group	Group 2: Impounded system
PES	***Largely Modified*** The ecological integrity of these systems has been compromised largely as a result of significant impacts to the hydrological regime and vegetation of the environment though impounding. The hydraulic regime has been considerably altered as a result of the impoundments (i.e. the dredging ponds) within the systems. Additionally, the method of mining requires clearing of extensive areas of vegetation; thus significant losses of riparian and wetland vegetation have occurred in this regard. Furthermore, the alterations to the hydraulic regime, including decant from the impoundments (one to another) and diversion of water between drainage features, have resulted in some riparian vegetation being affected by the altered hydraulic regimes. A clear example of this is the small stream near the small village of Foinda which is downstream of the Gangama mining operations where the riparian vegetation was flooded by the decant from the mine workings. Geomorphology, although modified to a degree by mining activities, is considered to be in balance, as the impacts are limited in extent (largely to the impounded sections of the affected watercourses) and magnitude. Some impact due to reduced sediment load on the downstream resources may occur in systems that have been disused for a significant period of time. The systems that are currently being mined have increased sediment loads, which may affect downstream watercourses negatively. Vegetation integrity is generally stable on a regional scale. Although declining vegetation integrity on a localised scale in some systems is occurring while others are reaching new equilibrium. Impacts on riparian vegetation are predicted to increase due to ongoing impacts from slash and burn / subsistence agriculture.
EIS	***Moderate*** Due to the significantly decreased ecological integrity of the wetlands, ecological sensitivity is considered to be low, although these systems are nevertheless deemed important for hydrological functioning, providing services such as flood attenuation, sediment trapping, nutrient and toxicant assimilation and carbon storage. Additionally, the impoundment systems are considered to have significant socio-cultural value.
Eco-services provision (including socio-cultural provisioning)	***Intermediate*** Despite the significantly reduced ecological integrity of this group of watercourses, the provision of goods and services (such as water for domestic use, recreation and fish harvesting) to the community is considered very important. Whilst the provision of ecological functions, such as nutrient and toxicant assimilation and erosion control, are deemed of limited importance. This is due to the reduced ecological integrity of these systems, and in particular, ongoing disturbances in the western and southern systems (in the vicinity of Lanti wet mine and Gangama dry mine). The reduced ecological integrity does not have a significant impact on all aspects of socio-cultural service provision however, the local community has raised concerns through the stakeholder

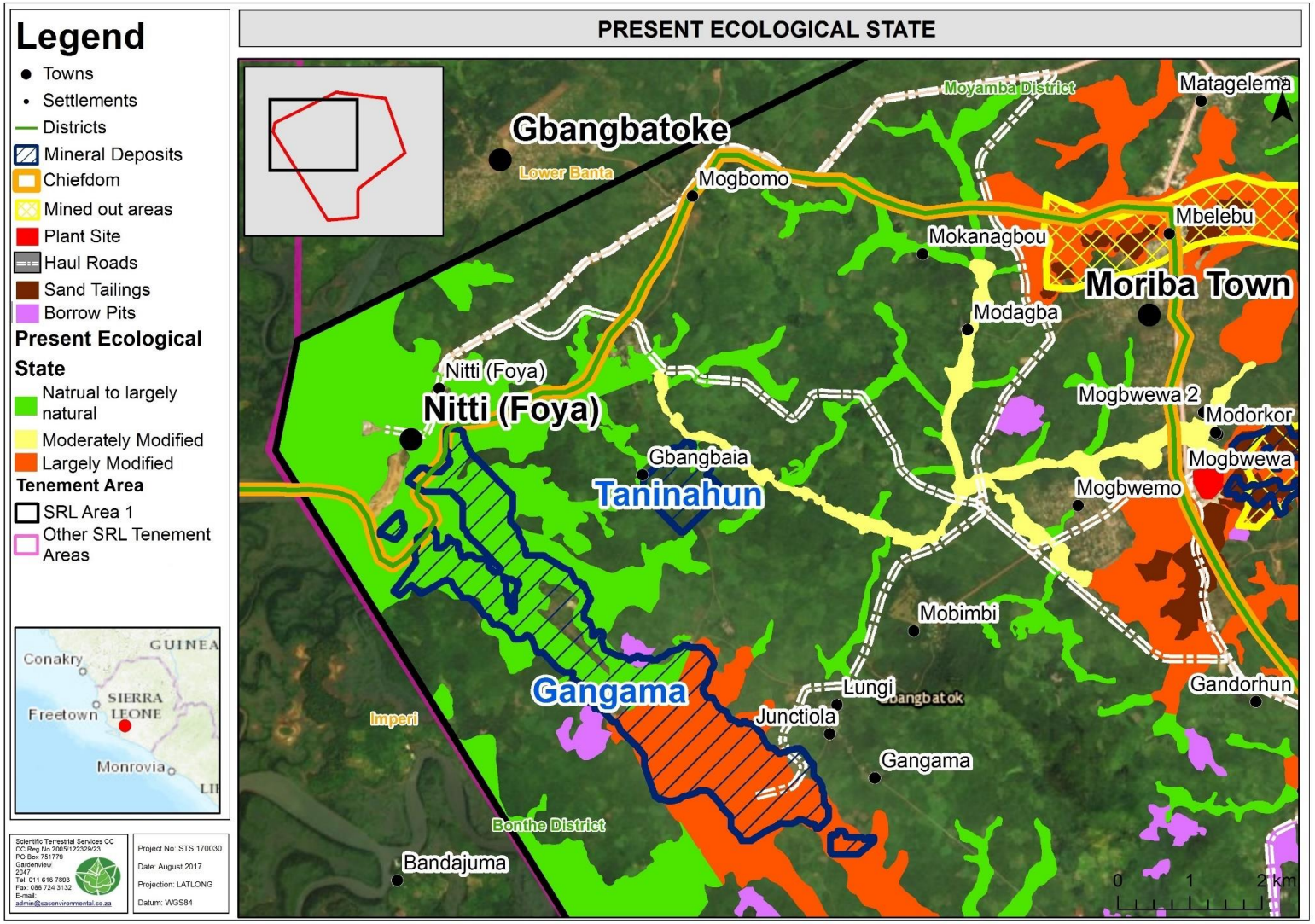
Wetland system group	Group 2: Impounded system
	engagement process that impacts on water quality are a concern. The dredge ponds continue to supply sufficiently large areas with appropriate water quality to provide water and support fishing, especially after the introduction of tilapia into the systems as a source of protein to the local community. The local communities have however raised concerns that the dredge ponds affect the quality (taste) of the fish. Furthermore, the communities downstream of the dredge ponds have indicated that the dredge ponds affect fishing activities in the systems below the lakes.
Recommended Ecological Category (REC)	***D (Largely Modified)*** At minimum, the ecological integrity of these systems should not be permitted to degrade further, and the present ecological state should be retained. The Mine Closure Plan must aim to, to rehabilitate the dredge ponds once mining is complete to minimise the negative impact on the downstream ecology of the watercourses and in such a way as to enhance the goods and services provided by any latent dredge ponds post mining. Latent negative impacts as a result of the dredge ponds must be minimised, as these features form part of the drainage network which drain into freshwater systems to the east and south-west, and thus affect ecological function and the provision of goods and services to communities downstream since these systems are actively used by the local community. The socio-cultural goods and services provided by these systems should by retained and where possible the extent to which these services are supported should be improved and current levels of ecological functioning supported.

Table 4-59: Summary of the results of the assessments applied to the wetland systems for Group 3

Wetland system group	Group 3: Downstream system
PES	***Moderately Modified*** The wetland systems downgradient of the impoundments have been indirectly impacted by mining-related impacts, specifically, decant from the dredging ponds, which have resulted in an altered hydraulic regime, inundation of vegetation and the formation of channels (thus affecting geomorphology and flow velocity). Within their existing context, the ecological conditions of these wetland systems is likely to remain largely unchanged in the future, except for systems downstream of the actively mined areas, which are likely to improve in condition over time as water quality improves. Ongoing impacts from subsistence agricultural activities are likely to occur.
EIS	***Moderate*** Due to the decreased ecological integrity of these watercourses, ecological sensitivity is considered moderate (as with the impounded systems). Nevertheless, these systems remain important for the provision of goods and services to the surrounding communities, particularly in terms of cultivated foods and domestic water supply. Whilst unlikely to be particularly sensitive to changes in water quality and flood peaks, these systems are nonetheless considered important for hydrological functions such as streamflow Regulation and nutrient and toxicant assimilation.
Eco-services provision (including socio-cultural provisioning)	***Intermediate*** As with the other watercourses within the study area, the systems downgradient / downstream of the impacted areas are deemed important for the provision of socio-cultural benefits such as harvestable resources, cultivated foods and water for human consumption (including agricultural purposes). These systems are considered important for hydrological functions such as streamflow Regulation as well as nutrient and toxicant assimilation, and as such are considered sensitive to low flows within the systems.
Recommended Ecological Category (REC)	***Moderately Modified*** At a minimum, efforts should be made to maintain the present ecological state of these wetland systems, in order to ensure the ongoing functioning and goods and service provision to the communities that rely on the goods and services provided by these systems. Furthermore, future negative impacts on these systems may impact on the downstream freshwater environments, and therefore as far as possible, additional impacts should be avoided. Where possible, rehabilitation of these wetland systems is recommended, in order to improve ecological integrity and goods and services provision.

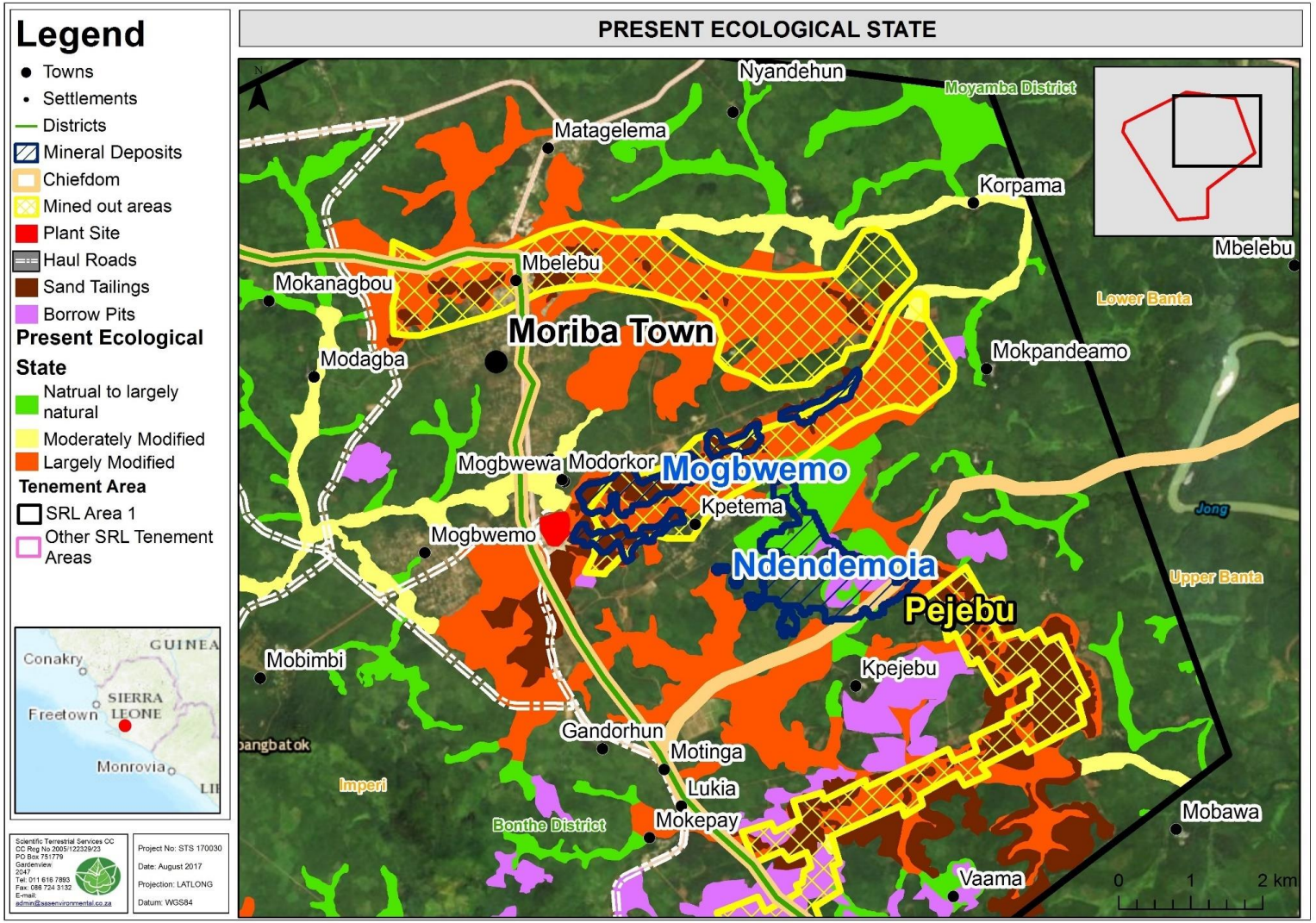
Table 4-60: Summary of the results of the assessments applied to the wetland systems Group 4

Wetland system group	Group 4: Mangrove system
PES	***Largely Natural to Natural*** The mangrove system is considered in a natural state although in some areas some impacts from historical mining have occurred primarily due to the impoundments and levees which have been constructed which affect the hydrological function of the system and which affect ecological connectivity. In addition, the Nitti Port is also located within the Mangrove system which as the potential to contaminate the receiving environment. These impoundments have impacted upon hydraulic processes and geomorphological characteristics of the affected portions of the system, in turn most likely impacting on the floral community composition and structure. The decant from mining activities ultimately enters the mangrove systems.
EIS	***Very High*** The mangrove system is deemed to be of significant importance from a human perspective in-so-far as the provision of livelihoods and sustenance is concerned. Furthermore, the system is considered important both in terms of hydrological functioning on a local scale and also in terms of the contribution of the system to the downstream estuarine system on the west coast and in terms of conservation initiatives. The mangrove system is deemed sensitive to direct disturbances and construction activities within the mangroves, since such impacts will change the hydraulic and geomorphological processes within the system.
Eco-services provision (including socio-cultural provisioning)	***Very High*** The mangrove system is deemed to be critically important from an ecological as well as socio-cultural perspective. The Sherbro River from just downstream of the Nitti Port forms part of the Sherbro River MPA. This area is considered important for the conservation of some species such as manatees. From a cultural point of view the results of the social impact assessment (SRK, 2018(3)) confirmed that there are no significant cultural beliefs and rituals linked to the estuarine system. From a socio-cultural, goods and service provision point of view the mangrove areas are also considered important for harvestable goods, with specific mention of fishing activities which provide local inhabitants with a valuable source of income and sustenance. The system is also used to a small degree for tourism and recreation and has some potential for education and research. The mangrove system is also deemed to be some importance for ecological processes, particularly storm surges (flood attenuation), erosion control (over a long period of time) and carbon storage. Additionally, it is deemed important for biodiversity maintenance, providing important breeding habitat and refugia for a variety of estuarine fauna.
Recommended Ecological Category (REC)	***A (Largely Natural to Natural)*** At a minimum, efforts should be made to maintain the present ecological state and functioning of the Sherbro River, in order to ensure the ongoing functioning and service provision to the communities that rely on the goods and services provided by the system. Furthermore, future negative impacts on this system is highly likely to have a negative impact on the estuary system downstream of SR Area 1, and therefore, as far as possible, additional impacts should be avoided. As with the Group 2 and 3 systems, rehabilitation of the mangrove system where possible, is strongly recommended and particular mention is made of removal of the berms and levees to reinstate the natural hydrology and geomorphological processes of the estuary.



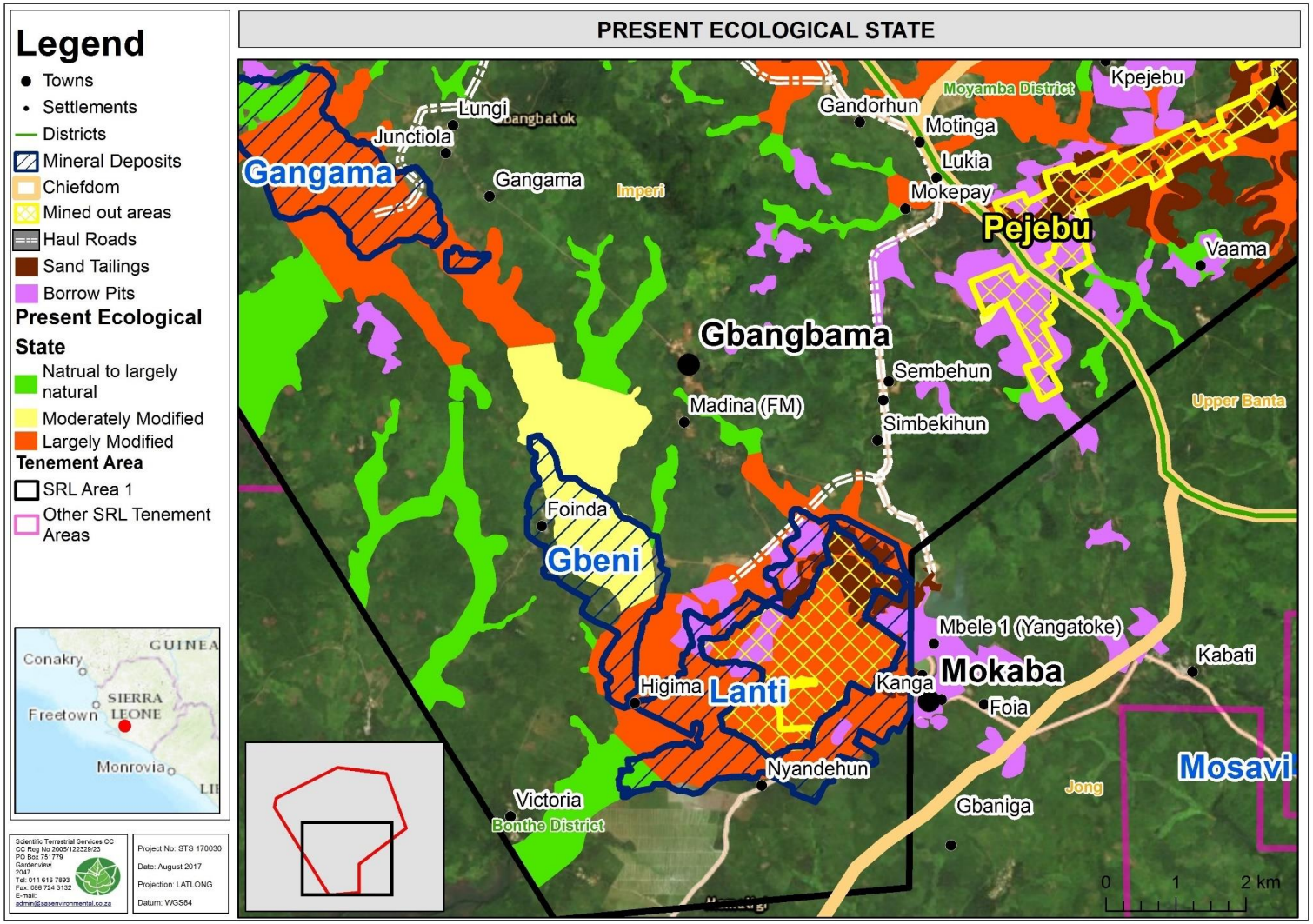
srk consulting	**SR AREA 1 ESHIA & ESHMP** PRESENT ECOLOGICAL STATE – FRESHWATER RESOURCE – WESTERN PORTION OF SR AREA 1 (STS 2018)	Project No. 515234

Figure 4-60: Conceptual illustration of the freshwater resource PES – western portion of SR Area 1 (STS 2018)



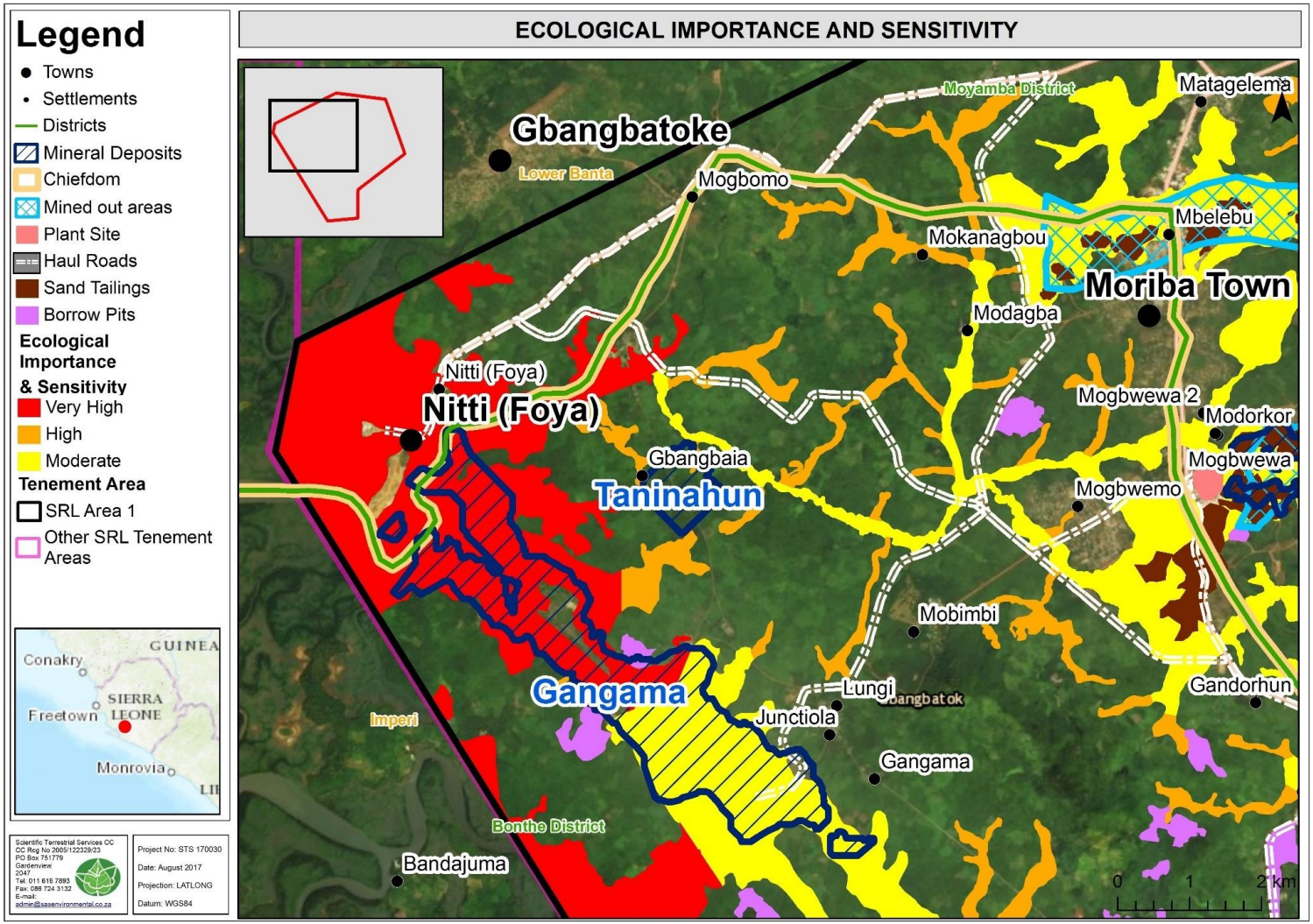
srk consulting	SR AREA 1 ESHIA & ESHMP PRESENT ECOLOGICAL STATE – FRESHWATER RESOURCE – EASTERN PORTION OF SR AREA 1 (STS 2018)	Project No. 515234

Figure 4-61: Conceptual illustration of the freshwater resource PES – eastern portion of SR Area 1 (STS 2018)



srk consulting	SR AREA 1 ESHIA & ESHMP PRESENT ECOLOGICAL STATE – FRESHWATER RESOURCE – SOUTHERN PORTION OF SR AREA 1 (STS 2018)	Project No. 515234

Figure 4-62: Conceptual illustration of the freshwater resource PES – southern portion of SR Area 1 (STS 2018)



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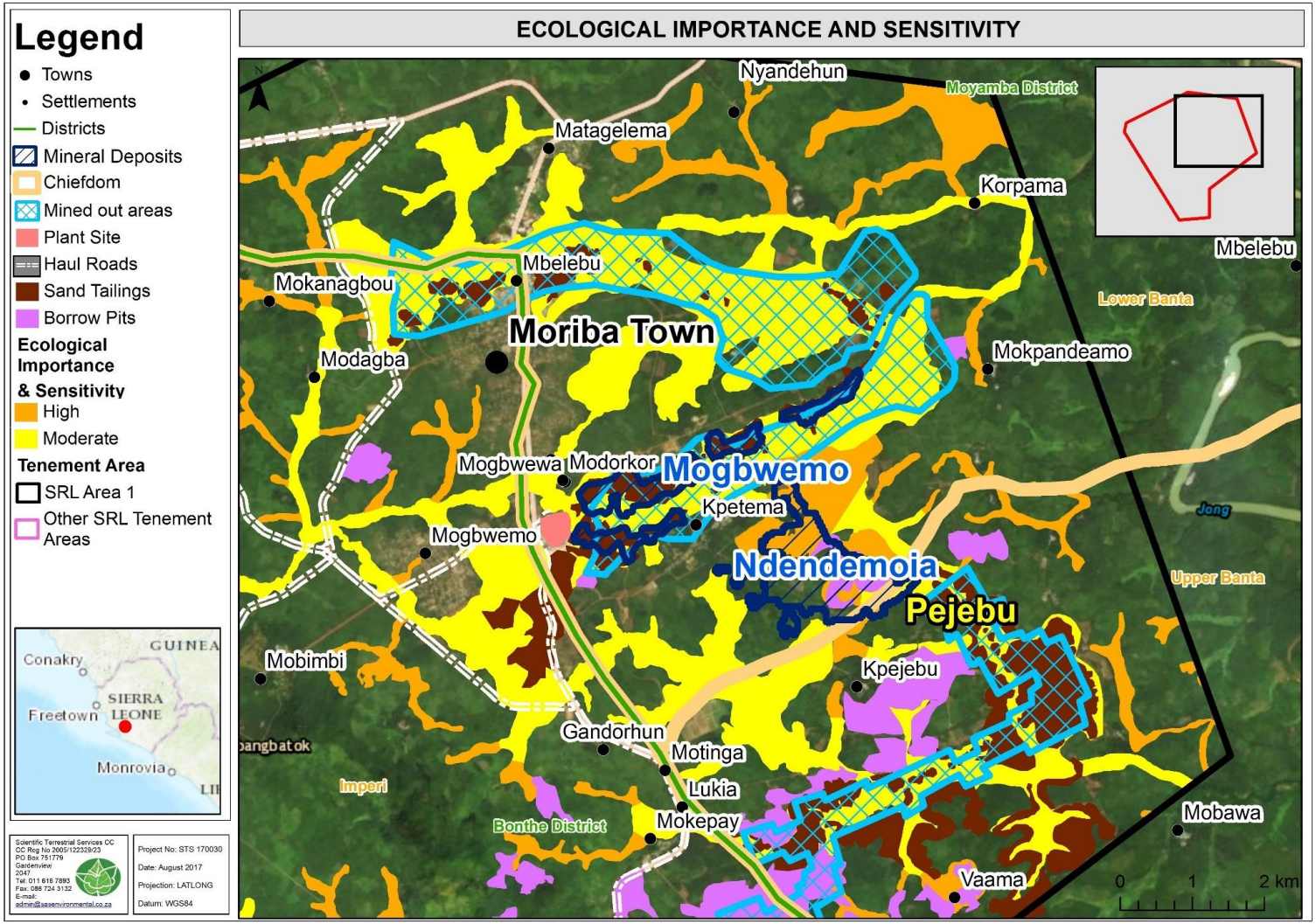
SR AREA 1 ESHIA & ESHMP
FRESHWATER RESOURCE EIS – WESTERN PORTION OF SR AREA 1 (STS 2018)

Project No. 515234

Figure 4-63: Conceptual illustration of the freshwater resource EIS - western portion of SR Area 1 (STS 2018)

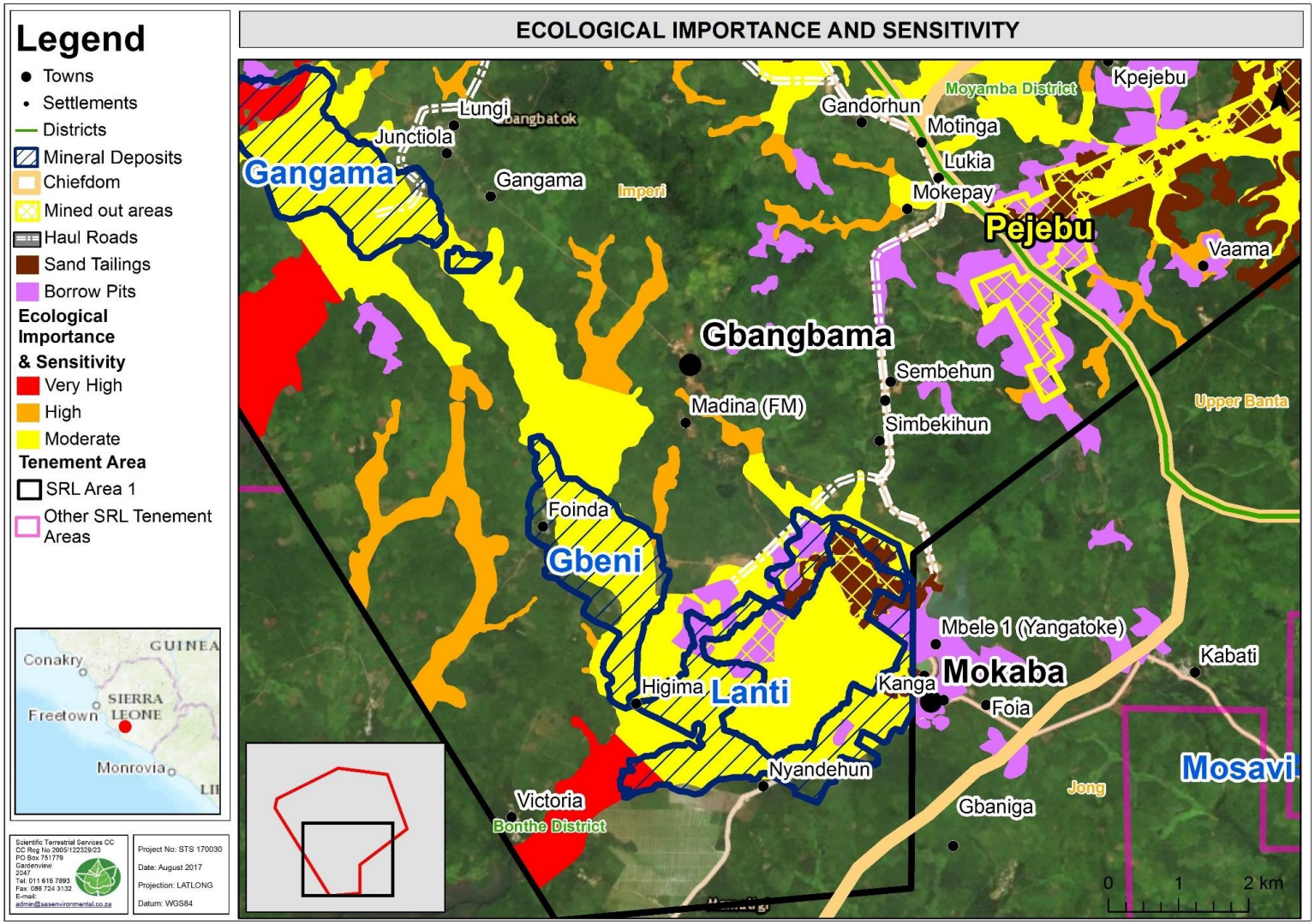


srk consulting

SR AREA 1 ESHIA & ESHMP
FRESHWATER RESOURCE EIS – EASTERN PORTION OF SR AREA 1 (STS 2018)

Project No. 515234

Figure 4-64: Conceptual illustration of the freshwater resource EIS - eastern portion of SR Area 1 (STS 2018)



srk consulting	SR AREA 1 ESHIA & ESHMP FRESHWATER RESOURCE EIS – SOUTHERN PORTION OF SR AREA 1 (STS 2018)	Project No. 515234

Figure 4-65: Conceptual illustration of the freshwater resource EIS - southern portion of SR Area 1 (STS 2018)

4.12 Estuarine environment

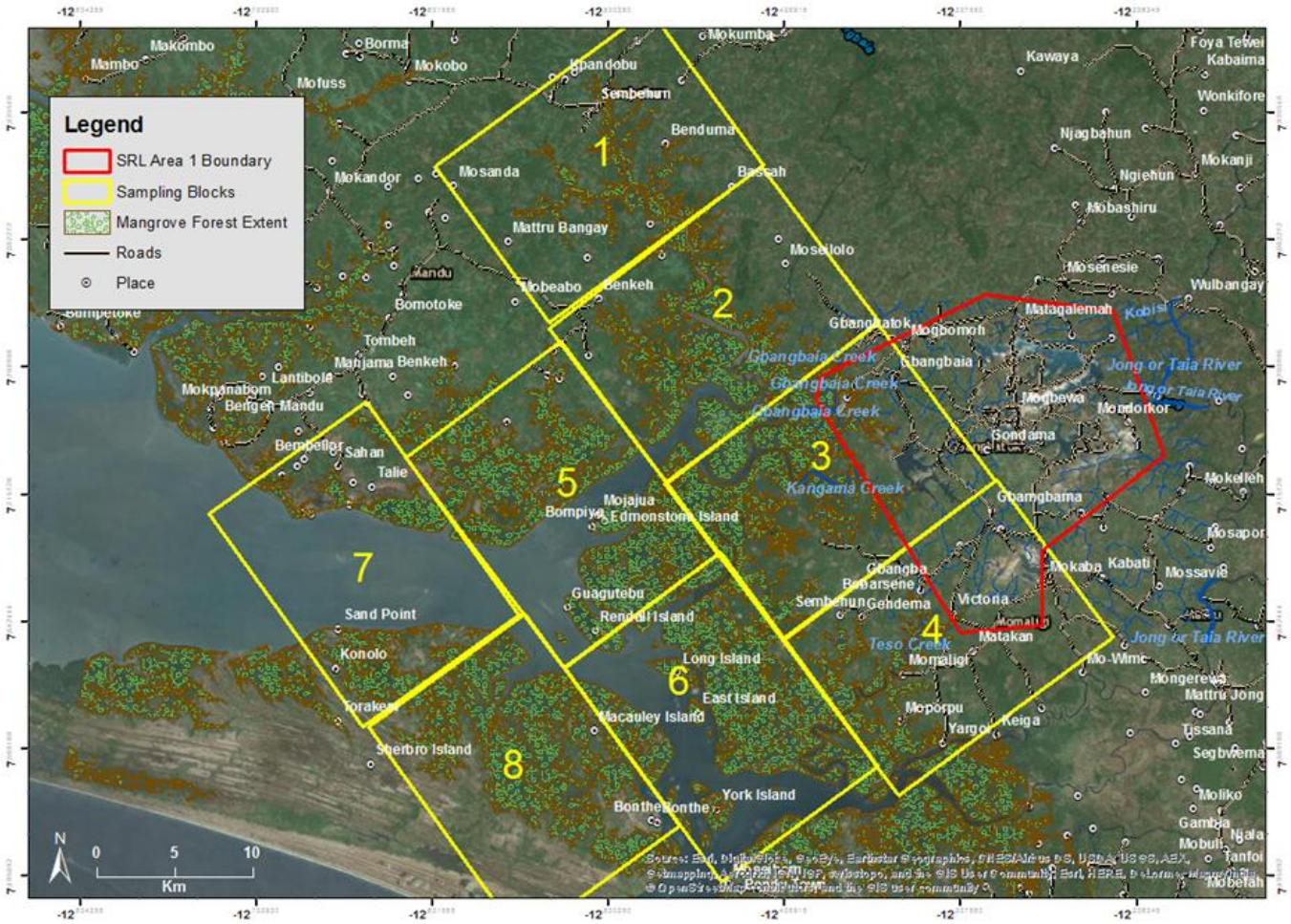
The content of this section is adapted from the specialist Estuarine Study (Anchor 2018) which is attached as Appendix C. This section describes the baseline conditions of the estuarine environment for SR Area 1.

4.12.1 Methodology

The estuarine ecological survey focussed on estuarine habitats between SRL's Area 1 operation and the coast in the vicinity of Sherbro Island. Sampling was undertaken in Gbangbaia, Kangama, Bagru, Telo, Motevo and Teso Creeks (Blocks 2, 3, 4, 5 and 6 in Figure 4-66), and between Sherbro Island and the mainland (Block 7).

A total of 27 sites were sampled on the Gbangbaia, Kangama, Teso and Motevo Creeks, along the Bagru River and the northern shore of Sherbro Island near the mouth of the Bagru River in the wet season (Figure 4-67). These sites were sampled again in the dry season along with an additional four sites on Teso Creek (T1, T2, T4, T5) and two sites in Telo Creek (C1, C2). Teso Creek is very remote from Nitti Port and sampling was thus conducted from the shore at one station only in the wet season using a small inflatable boat. Location of a launch site on this creek in the dry season enabled us to sample additional stations during this sampling trip. Two additional sites in Telo Creek were added in the dry season to bolster the number of control stations (i.e. those unlikely to be affected by mining) in the dataset.

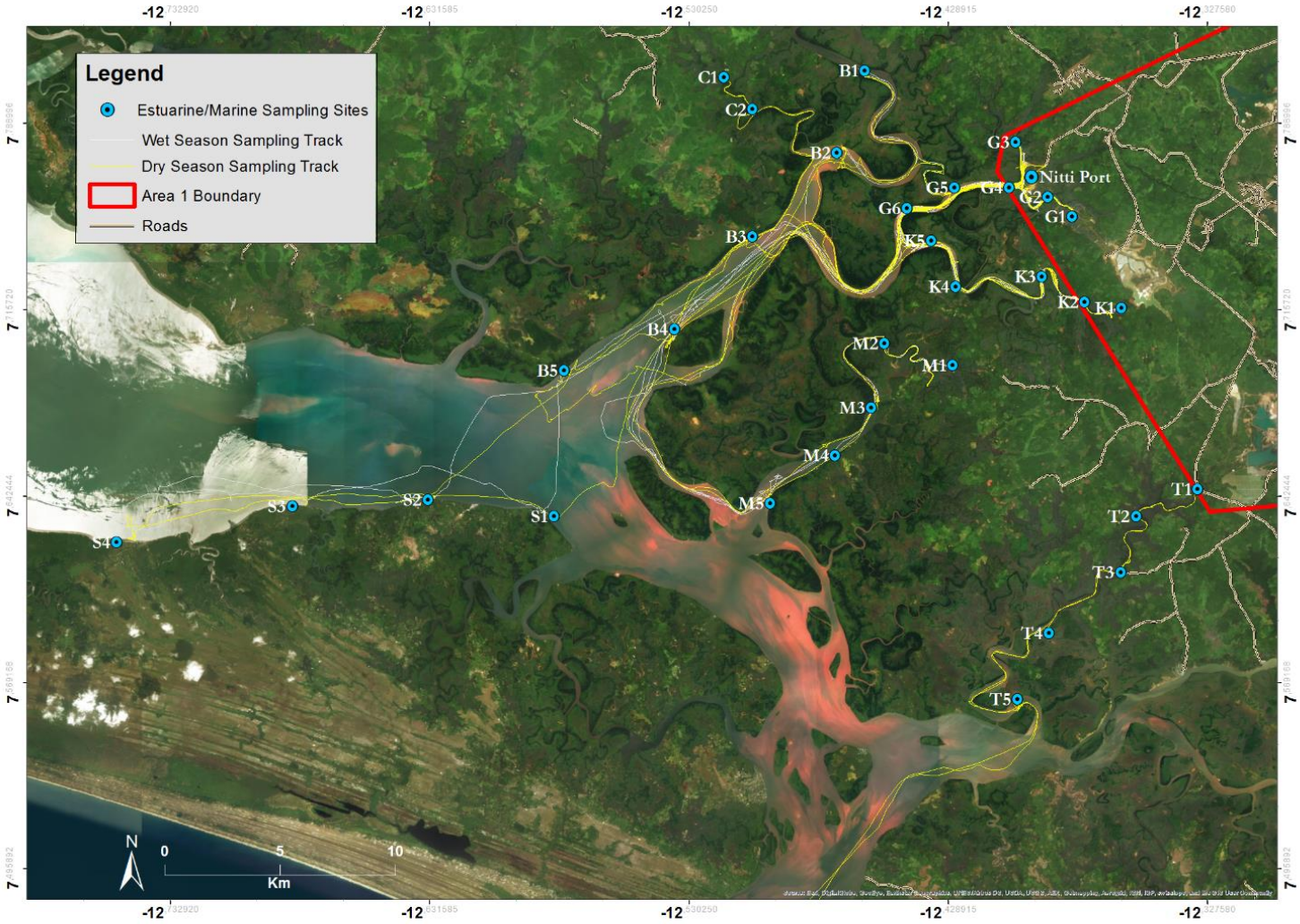
In situ water quality measurements and water and sub-tidal sediment were collected at all sites in the wet and dry seasons (Table 4-61). Intertidal sediment and macrofauna samples, vegetation transects and fish samples were collected at alternate sites (2-3 samples per creek). Oysters were collected at all sites where they were present (this was the case for many more sites in the wet compared with the dry season); the tissue was removed and was analysed for trace metal content. Bird counts, observations of other wildlife and human use of natural resources was noted and recorded at all times during the field survey.



srk consulting	**SR AREA 1 ESHIA & ESHMP** SR AREA 1 AND DOWNSTREAM ESTUARINE AND MARINE HABITATS USED IN ECOLOGICAL SURVEYS (ANCHOR 2018)	Project No. 515234

Figure 4-66: Map of SR Area 1 and downstream estuarine and marine habitats where the ecological surveys were undertaken (Anchor 2018)

[Note: The extent of the mining concession area is delineated by a red line. Mangrove extent layer provided by Giri et al. (2011).]



srk consulting	**SR AREA 1 ESHIA & ESHMP** SR AREA 1 AND DOWNSTREAM ESTUARINE AND MARINE HABITATS SHOWING INDIVIDUAL SAMPLING STATIONS FOR BOTH WET AND DRY SEASONS (ANCHOR 2018)	Project No. 515234

Figure 4-67: Map of SR Area 1 and downstream estuarine and marine habitats showing individual sampling stations for both wet and dry seasons (Anchor 2018)

Table 4-61: Sample log showing sampling activities undertaken at each sampling station

Sampling conducted	G1	G2	G3	G4	G5	G6	K1	K2	K3	K4	K5	B1	B2	B3	B4	B5	M1	M2	M3	M4	M5	C1	C2	T1	T2	T3	T4	T5	S1	S2	S3	S4	Nitti Port
In situ water quality (Temp, Cond, Dissolved oxygen, pH, turbidity)	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	D	D	WD	D	D	WD	WD	WD	WD	
Water samples for nutrients (NO_2, NO_3, NH_4)	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	D	D	D	D	WD	D	D	WD	WD	WD	WD	
Water samples for Cha and TSS	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	D	D	D	D	WD	D	D	WD	WD	WD	WD	
Biomonitoring (oyster) samples		W	W	W	W	W	W	W	W	W	WD	W	WD	WD	WD	WD		D	WD	WD	WD								WD	WD	WD	WD	W
Sediment samples for trace metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, Mn, Al, Fe)	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	D	D	D	D	WD	D	D	WD	WD	WD	WD	WD
Sediment samples for grain size and TOC	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	D	D	D	D	WD	D	D	WD	WD	WD	WD	
Grab samples for macrofauna	WD	W	W	WD	W	WD	WD	W	WD	W	WD	W	WD	W	WD	W	WD	W	WD	W	WD	D	D	D		WD	D	D	WD	WD	WD	WD	
Seine net(fish)	WD			WD		WD	WD		WD		WD		WD		WD	W	WD		WD		WD	D	D	D		WD		D		WD		WD	
Gill net (fish)	WD			WD		WD	WD		WD		WD		WD		WD	W	WD		WD		WD	D	D	D		WD		D		WD		WD	
Fyke net (fish)	W			W		WD	W		W		WD		WD		WD	W	WD		W		W												
Intertidal core samples (grain size, TOC)	WD			WD		WD	WD		WD		WD		WD		WD	W	WD		WD		WD	D	D	D		WD		D		WD		WD	
Intertidal core samples (macrofauna)	WD			WD		WD	WD		WD		WD		WD		WD	W	WD		WD		WD	D	D	D		WD		D		WD		WD	
Mangrove composition and density	W	D		W		W	W		WD		W		W	D	W	W	W		WD		W					W				W		W	
Bird counts (species composition and abundance)	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	WD	D	D	D		WD	D	D	WD	WD	WD	WD	WD

4.12.2 Estuarine water quality

Data on temperature, salinity, pH, dissolved oxygen (DO) and turbidity levels in surface and bottom waters at each sampling site in the wet (August 2017) and dry seasons (January 2018) are presented in Figure 4-68 below. I

Water temperature across all sampling sites varied between 26.3 and 28.2°C (wet season) and 26.3-29.1°C (dry season) and on average was slightly higher 28.1 vs. 27.0°C. No evidence of vertical stratification[8] was evident in the temperature data from any of the sampling sites. Salinity varied between 0.10 and 18.95 Practical Salinity Units (PSU)9 in the wet season (average = 3.0) but was markedly higher in the dry season (4.8-32.8, average = 19.7). In the three creeks that drain directly from the SR Area 1 (Kangama, Gbangbaia and Teso Creeks) PSU was very low (<1.0) in both the surface and bottom waters, but this was much higher in the dry season when run-off was much lower (K1 = 11.1, G1 = 15.0, T1 = 4.8). Salinity in Motevo Creek, which is closer to the mouth of the estuary, was higher than the Kangama or Gbangbaia Creeks in the dry (2.60-3.17) and wet seasons (21.3-29.4), but also displayed no evidence of stratification. Telo Creek was only sampled in the dry season, drains into Bagru Creek from the north, and had a salinity range from12.7-15.4. Bagru Creek, into which Kangama and Gbangbaia Creeks also drain, exhibited a clear salinity gradient from almost fresh at the top (0.05) to brackish at the lower end near Sherbro Island in the wet season (surface: 3.82, bottom: 8.26) and was also correspondingly more saline in the dry season (13.6-25.1). Some evidence of stratification was evident in the lower reaches of this creek in the wet but not in the dry season. Salinity levels in Sherbro Creek, which is closest to the mouth of the estuary, were not surprising, higher than the other creeks, and ranged from 5.06-22.50 in the wet season and 31.7-32.8 in the dry season. Clear evidence of stratification was also evident in this area, with higher salinity readings on the bottom than at the surface.

pH showed little variation across the various survey sites, ranging from slightly acidic (6.68) to slightly alkaline (8.20) in the wet season, and was slightly more alkaline in the dry season (6.86-8.66). Levels of dissolved oxygen (DO) were moderate to high at all sites in both seasons, but were slightly higher in the wet compared with the dry season. Wet season values ranged from 5.72-8.02 mg/l (average = 6.76 mg/l) while dry season values ranged from 4.35-7.68 (average = 6.07 mg/l). Where there was some evidence of stratification in the water column, DO levels at the bottom tended to be higher than at the surface. DO levels also tended to be higher near the mouth of the estuary compared with the upper reaches of the creeks. 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, this is counter intuitive inasmuch as one would normally expect that TSS to be correlated closely with turbidity (higher suspended sediment loads generally result in reduced water clarity) (Figure 4-69). However, in this instance it is thought that the higher TSS levels in the dry season are linked to elevated phytoplankton abundance. Sechii depth, a measure of the distance that light is able to penetrate through the water column, varied from 24-121

[8] Layering or separation between cooler and/or denser, saltier water on the bottom and lighter/warmer freshwater above.
[9] The Practical Salinity Scale 1978 (PSS-78) has been considered by the Joint Panel on Oceanographic Tables and Standards and is recommended by all oceanographic organizations as the scale in which to report future salinity data. The PSS scale has replaced the older PPT or Parts Per Thousand scale since electrical conductivity measurements became the most common method used to estimate the ionic content of seawater. By convention, practical salinity is expressed as a dimensionless number only and should be written as, e.g. S = 35.034.

cm in the wet season but was considerably higher (i.e. indicative of clearer waters) in the dry season (50-198 cm). The relationship between Sechii depth and TSS was poor but that between Sechii depth and Chlorophyll-a (Chl-a) concentration was more clear, suggesting that phytoplankton[10] 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 in surface water samples was highly variable during the dry season and ranged from 4.5-105.0 µg.l-1. During the dry season survey Chl-a concentrations were mush less variable ranging between 9 and 81.9 µg.l-1. Although the maximum recorded value during the dry season was lower than that recorded during the wet season, overall, the Chl-a concentrations were elevated. In the dry season elevated Chl-a was evident throughout the creeks surveyed especially at the sampling sites in the upper creeks furthest from the sea, while Chl-a concentrations at Sherbro Island were comparable to those recorded during the wet season. There was a trend of lower Chl-a values at sampling sites in the upper creeks furthest from the sea (Kangama, Gbangbaia, upper Bagru and Teso Creeks) with higher values recorded in the lower Bagru, Motevo Creeks and Sherbro Island during the wet season. 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 depths) would have increased primary production and resulted in phytoplankton blooms and the elevated Chl-a values.

[10] Plankton consisting of microscopic plants.

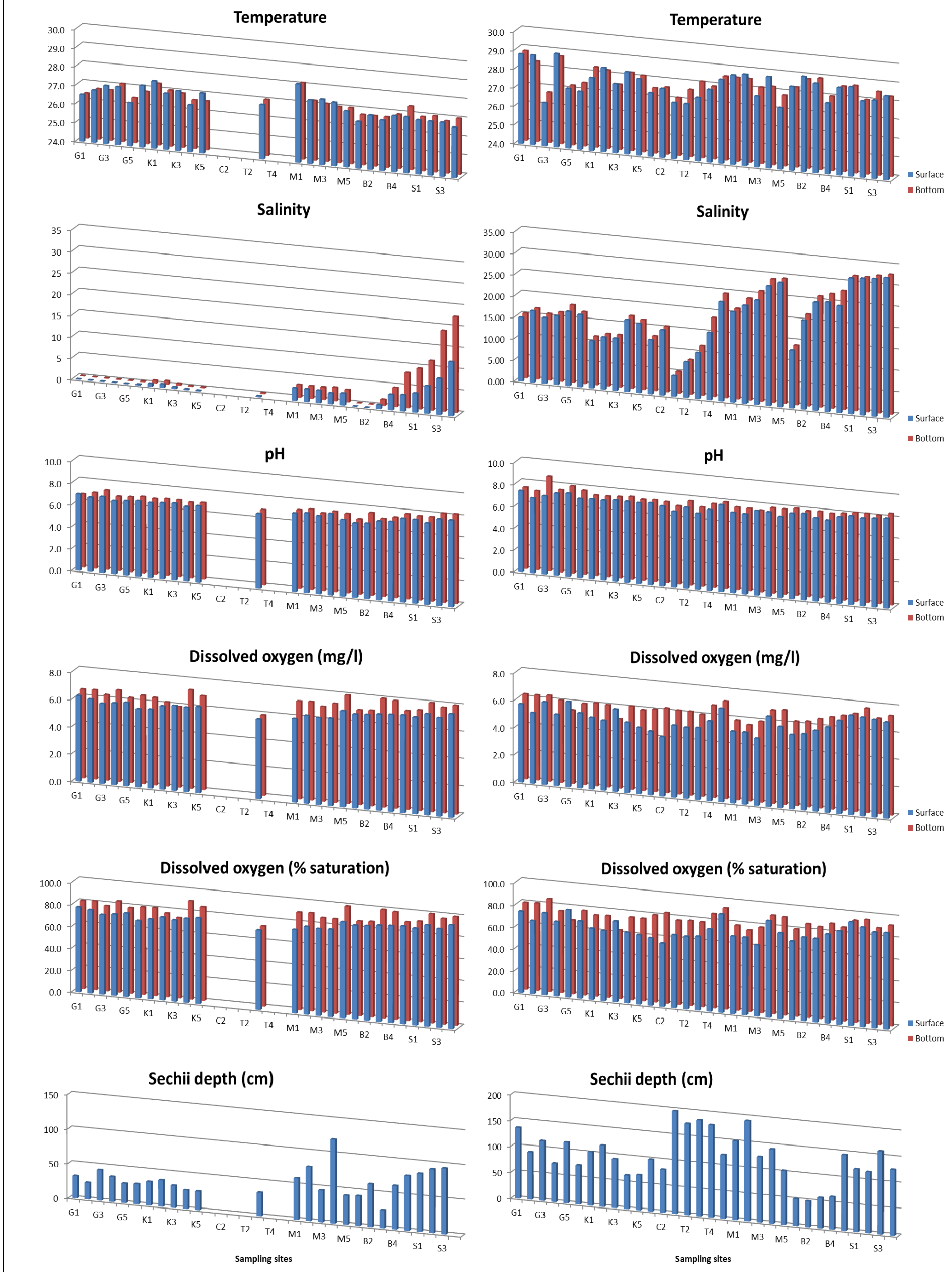


Figure 4-68: Temperature (°C), salinity (PSU) and pH in surface and bottom at each sampling site during the wet season (left) and dry season (right) (Anchor 2018)

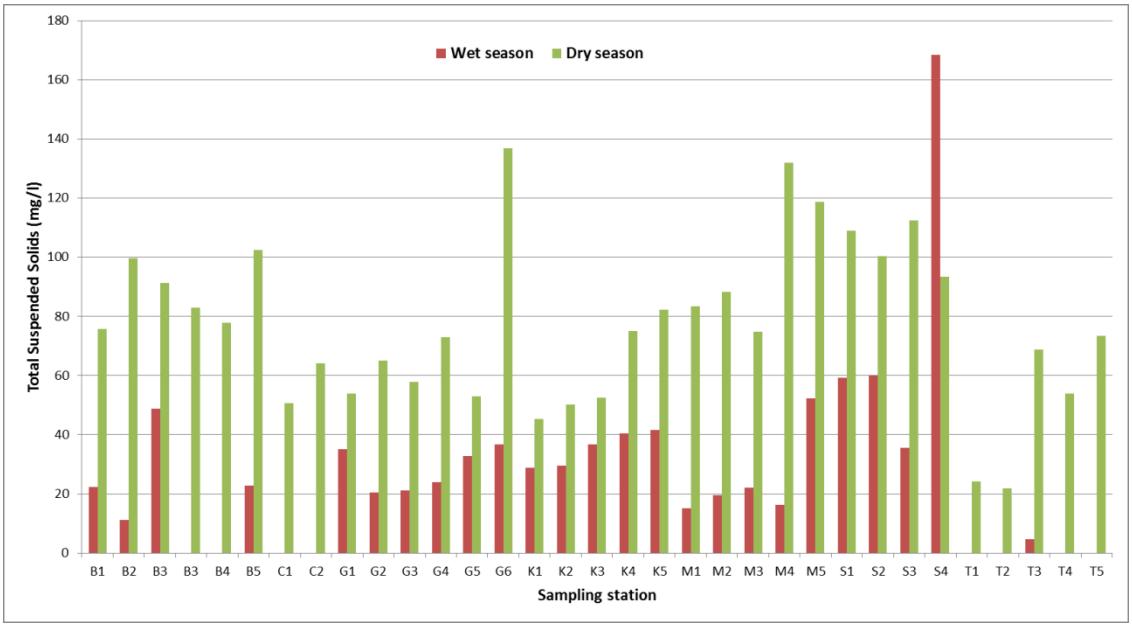


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Figure 4-69: Total Suspended Solids (TSS) at each sampling station in the wet and dry season (Anchor 2018)

4.12.3 Estuarine sediment quality

Grain size

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. Silt also formed an important component of the sub-tidal sediment indicating a constant supply of fine material passing through the creeks.

Total organic content

Total Organic Content (TOC) in intertidal sediments was high, averaging 26%. The lowest values were recorded close to the sea, at the lower Bagru Creek and Sherbro Island sites, where coarser marine sediments dominated. Intertidal sediments within the mangrove creeks showed no clear spatial trend in TOC that was nearly always greater than 20 %.

Mangroves are known to trap fine sediment within their root structure, thereby acting as a sedimentary sink for organic carbon, as well as acting as a source of organic carbon from the constant organic input from the trees themselves. TOC in sub-tidal sediments was much lower on average (8.8%) than that observed in the intertidal sediments. TOC in sub-tidal sediments was highly variable with no clear longitudinal spatial trend from river to marine dominated areas, with across channel variability exceeded any longitudinal gradient throughout the study area.

Trace metals in sediments

The measured concentrations of trace metals in the estuarine subtidal sediment samples taken during the wet and dry season surveys are shown in Table 4-62. Only three (arsenic, chromium and nickel) out of the eight trace metals analysed exceeded the Median Level 1 concentration as well as the ERL guideline (Figure 4-70).

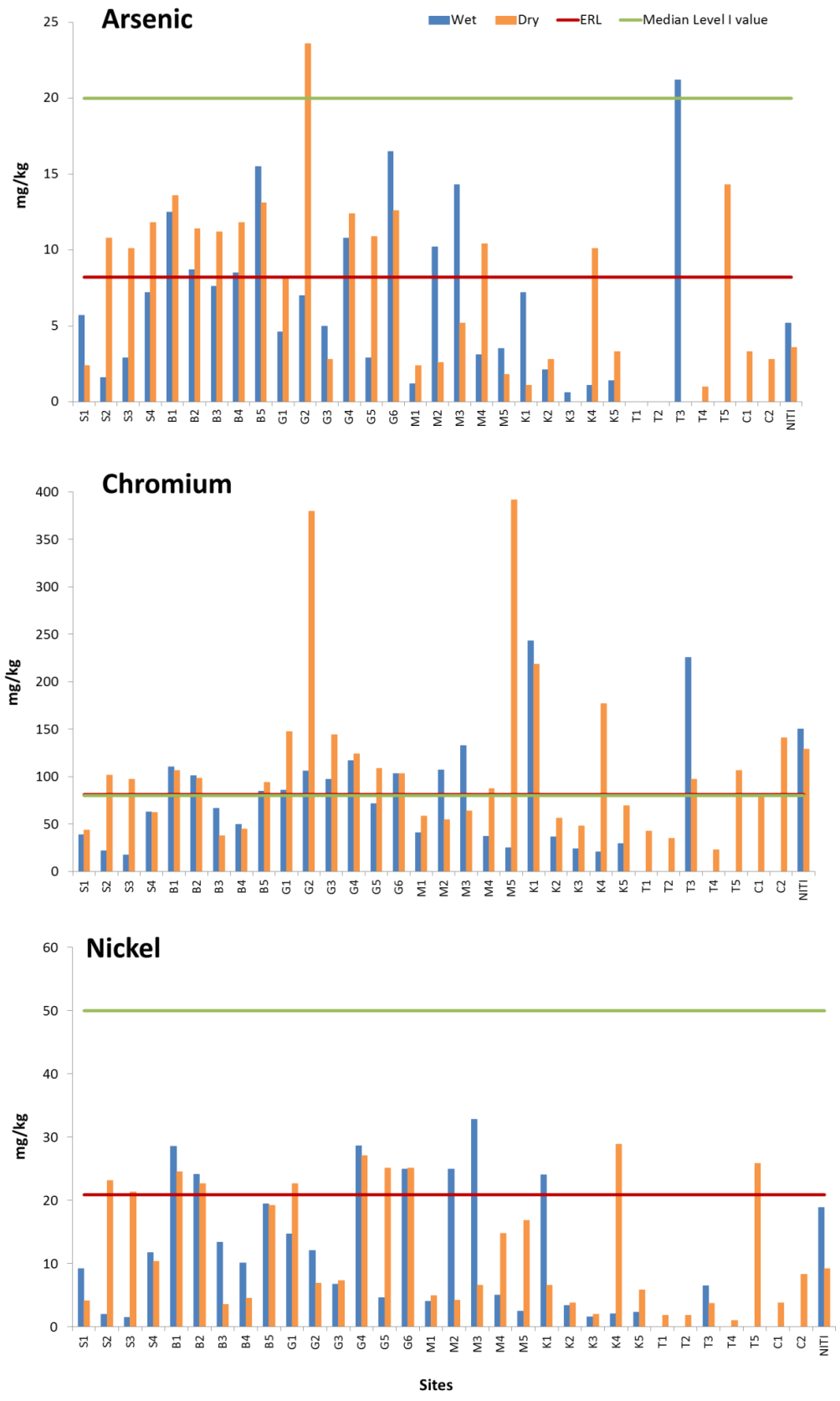
There were noticeable differences between the number of sites that exceeded the ERL concentration between the wet and dry season. Six additional sites exceeded the ERL concentration for arsenic and chromium trace metals and three for nickel in the dry season. Furthermore, there are also increases in the concentration of these trace metals at some of the sites surveyed in the dry season. Sites 2 and 3 of Teso Creek, sites 4 and 5 of Kangama Creek, site 5 of Gbangbaia Creek and site 4 of Motevo Creek had substantial increases in all three trace metals in the 2018 dry season survey. Site 5 of Motevo Creek also had a noticeable increase in chromium and nickel concentrations between the wet and dry season surveys.

Due to these distinct increases of trace metal concentration between the wet and the dry season surveys, toxicity may likely be observed in sensitive species. For arsenic, only Teso Creek site 3 for the wet season and Gbangbaia Creek site 2 for the dry season exceeded the median Level 1 concentration from available international guidelines. For chromium, 13 and 19 sites exceeded the level 1 concentration in both the wet and dry season. None of the sites exceeded the level for nickel during either survey. There is some uncertainty as to why sediment samples from many sites had increased trace metal concentrations between the wet and the dry season surveys. It is suspected that the increase in finer sediment particle sizes and increased TOC in sediments observed during the dry season (to which trace metals adhere) are the reason rather than an increase in input from anthropogenic sources. Ongoing monitoring of trace metal levels in sediments and biota is therefore recommended. This will improve understanding of seasonal changes and potential sources of trace metals in the estuarine environments and the associated risk for estuarine biota and people consuming seafood.

Table 4-62: Concentration of trace metals (mg/kg) in subtidal sediment samples collected from 27 estuary sampling stations in the 2017 wet and 2018 dry surveys. Values highlighted in red font exceed the Effects Range Low (ERL) NOAA guidelines.

Site / Metal	Al		As		Cd		Cr		Cu		Fe		Pb		Mn		Hg		Nil		Zn	
ERL			8.2		1.2		81		34				46.7				0.15		20.9		150	
Median Level I			20		1.35		80		47.5				72.5				0.35		50		185	
Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
S1	16,000	5,562	5.7	2.4	<0.1	<0.1	38.5	43.6	3	<1	16,170	6,298	<5	<5	99	64	<0.1	<0.1	9.2	4.1	23	7
S2	2,931	39,270	1.6	10.8	<0.1	<0.1	21.7	101.3	<1	5	2,019	28,780	<5	7	52	279	<0.1	<0.1	2	23.1	<5	44
S3	1,497	40,280	2.9	10.1	<0.1	<0.1	17.2	97	<1	5	6,227	29,220	<5	8	39	193	<0.1	<0.1	1.5	21.3	<5	43
S4	19,720	17,550	7.2	11.8	<0.1	<0.1	62.6	62	3	<1	17,120	63,900	6	7	97	323	<0.1	<0.1	11.7	10.3	23	40
B1	53,060	45,500	12.5	13.6	<0.1	<0.1	110	106.6	8	6	3,7810	35,530	11	9	568	524	<0.1	<0.1	28.5	24.5	51	51
B2	46,400	40,900	8.7	11.4	<0.1	<0.1	101	98.4	8	7	31,720	31,050	11	10	186	196	<0.1	<0.1	24.1	22.6	44	48
B3	24,080	4,358	7.6	11.2	<0.1	<0.1	66.4	37.6	5	<1	26,480	21,570	5	<5	230	144	<0.1	<0.1	13.4	3.5	31	14
B4	16,350	4,415	8.5	11.8	<0.1	<0.1	49.4	44.6	2	<1	23,530	26,710	<5	<5	215	206	<0.1	<0.1	10.1	4.5	26	19
B5	36,030	34,580	15.5	13.1	<0.1	<0.1	84.4	93.8	6	5	37,660	29,320	8	7	241	312	<0.1	<0.1	19.4	19.2	42	39
G1	24,010	40,010	4.6	8.1	<0.1	<0.1	85.4	147.6	4	7	23,110	34,510	5	7	185	211	<0.1	<0.1	14.7	22.6	29	49
G2	19,370	13,840	7	23.6	<0.1	<0.1	106	379.4	7	24	31,580	143,300	6	7	109	259	<0.1	<0.1	12.1	6.9	30	39
G3	11,640	8,588	5	2.8	<0.1	<0.1	97.2	144.4	5	4	28,810	27,890	<5	<5	159	140	<0.1	<0.1	6.7	7.3	21	17
G4	50,100	45,000	10.8	12.4	<0.1	<0.1	117	123.8	10	7	34,900	40,160	14	7	178	225	<0.1	<0.1	28.6	27.1	57	55
G5	5,054	47,960	2.9	10.9	<0.1	<0.1	71.4	108.5	2	7	20,480	35,360	7	8	60	340	<0.1	<0.1	4.6	25.1	9	53
G6	45,320	48,650	16.5	12.6	<0.1	<0.1	103	102.9	9	7	39,860	35,450	10	12	266	487	<0.1	<0.1	24.9	25.1	46	54
M1	4,488	7,554	1.2	2.4	<0.1	<0.1	41.1	58.4	2	2	3,725	6,037	<5	<5	18	21	<0.1	<0.1	4	4.9	5	8
M2	46,410	5,139	10.2	2.6	<0.1	<0.1	107	54.7	9	<1	28,700	8,038	8	<5	171	50	<0.1	<0.1	24.9	4.2	44	7
M3	53,590	11,400	14.3	5.2	<0.1	<0.1	133	63.6	10	<1	40,630	18,190	11	<5	216	87	<0.1	<0.1	32.8	6.6	54	16
M4	7,361	24,880	3.1	10.4	<0.1	<0.1	36.9	87.3	2	4	7,984	25,820	<5	8	37	137	<0.1	<0.1	5	14.8	9	31
M5	2,351	3,565	3.5	1.8	<0.1	<0.1	25	391.7	<1	2	6,953	19,280	<5	<5	32	60	<0.1	<0.1	2.5	16.8	5	6
K1	42,830	13,230	7.2	1.1	<0.1	<0.1	243	218.7	15	9	41,870	37,630	9	<5	159	127	<0.1	<0.1	24	6.6	41	15
K2	4,403	4,963	2.1	2.8	<0.1	<0.1	36.6	56	1	1	5,074	8,725	<5	<5	104	56	<0.1	<0.1	3.4	3.8	5	7
K3	990	1,203	0.6	<0.5	<0.1	<0.1	23.8	47.8	<1	<1	1,878	3,261	<5	<5	16	34	<0.1	<0.1	1.6	2	<5	<5
K4	1,626	43,660	1.1	10.1	<0.1	<0.1	20.8	177.1	<1	8	2,653	37,660	<5	8	20	317	<0.1	<0.1	2.1	28.9	<5	54
K5	3,237	7,734	1.4	3.3	<0.1	<0.1	29.3	69.2	1	2	3,865	8,372	<5	<5	19	52	<0.1	<0.1	2.3	5.8	<5	10
T1	-	1,211	-	<0.5	-	<0.1	-	42.5	-	1	-	1,531	-	<5	-	6	-	<0.1	-	1.8	-	<5
T2	-	476	-	<0.5	-	<0.1	-	34.9	-	<1	-	736	-	<5	-	6	-	<0.1	-	1.8	-	<5
T3	25,960	1,064	21.2	<0.5	<0.1	<0.1	226	97	<1	1	65,630	1,152	<5	<5	26	9	<0.1	<0.1	6.5	3.7	22	<5
T4	-	609	-	1	-	<0.1	-	22.8	-	<1	-	3,333	-	<5	-	19	-	<0.1	-	1	-	<5
T5	-	47,360	-	14.3	-	<0.1	-	106.4	-	7	-	36,370	-	8	-	415	-	<0.1	-	25.8	-	50
C1	-	5,814	-	3.3	-	<0.1	-	79.5	-	<1	-	12,250	-	<5	-	34	-	<0.1	-	3.8	-	<5
C2	-	5,267	-	2.8	-	<0.1	-	141.1	-	2	-	7,964	-	<5	-	37	-	<0.1	-	8.3	-	5
NITI	42,240	14,660	5.2	3.6	<0.1	<0.1	150	128.6	11	15	46,450	36,760	10	27	207	109	<0.1	<0.1	18.9	9.2	43	37

Note: Values highlighted in orange font exceed the Effects Range Low NOAA guidelines



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SR AREA 1 ESHIA & ESHMP
TRACE METAL CONTENT – SUBTIDAL SEDIMENT SAMPLES

Project No.
515234

Figure 4-70: Trace metal content in subtidal sediment samples taken in the 2017 wet and 2018 dry surveys as well as showing sediment quality guidelines (ERL: Effects Range Low).

Hydrocarbons in sediment samples

PAH concentrations were below the laboratory detection limits in the wet season in all sub-tidal sediment samples collected from the estuaries below the SR Area 1, which suggests that fresh water input from during the wet season disperses any PAHs present. During the dry season survey, PAH concentrations were below the laboratory detection limits in all subtidal sediment samples collected except at Nitti Port. Of the PAHs detected, Benzo(a)anthracene, Chrysene, Benzo(bk)fluoranthene, Benzo(a)pyrene, Indeno(123cd)pyrene are known to be carcinogenic to humans (Nikolaou *et al*. 2009). However, the levels detected were all well below the NOAA ERM and ERL guidelines (Buchman 1999) indicating that although contamination is occurring it is not at a level to warrant concern. PAHs should continually be monitored at Nitti Port to ensure contamination does not exceed the levels outlined in the NOAA guidelines

4.12.4 Biomonitoring

Trace metal concentrations in oyster flesh exceeded the median recommended levels for human consumption at at least one sampling station for five of the six metals for which guidelines are available. Zinc (Zn) concentrations exceeded the NOAA Effects Range Low guideline at 20 sites, arsenic (As) at 16 sites, copper at seven sites, lead and cadmium at three sites each (Table 4-63). These results suggest either naturally high levels of some trace metals in the estuarine environment and bioaccumulation by oysters (particularly Zn and As), or anthropogenic enrichment from a source other than the SR Area 1 mining activities. Ongoing biomonitoring is recommended and this should provide a more comprehensive picture of trace metal levels and potential risks these pose to local people who consume the oysters.

Table 4-63: Concentrations of trace metals in oyster tissue collected at different sites in the estuaries of the study area

Sample #	Cu (wet)	Cu (dry)	Pb (wet)	Pb (dry)	Zn (wet)	Zn (dry)	Co (wet)	Co (dry)	Ni (wet)	Ni (dry)	Al (wet)	Al (dry)	As (wet)	As (dry)	Cd (wet)	Cd (dry)	Cr (wet)	Cr (dry)	Fe (wet)	Fe (dry)	Mn (wet)	Mn (dry)	Hg (wet)
Median Guideline	70	70	1.7	1.7	1,000	1,000							2	2									0.5
B1	95.1	-	ND	-	2,609	-	0.5	-	0.4	-	962.4	-	2.4	-	1.9	-	2.0	-	733.8	-	57.8	-	0.1
B2	39.3	61.3	0.1	3.3	1,387	1,844	0.4	0.6	ND	3.0	741.4	1,160	3.0	4.6	1.3	1.5	0.2	4.3	560.3	832	13.1	33.1	0.1
B3	61.5	55.0	0.3	2.4	1,378	1,446	0.4	0.4	0.5	2.0	631.9	353	2.8	4.7	1.4	1.7	0.9	2.4	622.9	296	20.3	12.1	0.1
B4	52.6	32.6	0.9	5.3	1,209	695	0.4	0.3	0.6	1.9	591.3	253	4.0	4.6	1.8	1.6	7.7	3.3	535.1	363	21.1	14.1	0.1
B5	79.6	32.5	1.1	ND	1,363	639	0.4	0.1	0.5	1.5	465.4	285	4.4	3.2	1.8	1.3	1.0	2.0	466.2	284	25.3	9.3	ND
G2	39.6	-	1.8	-	3,266	-	0.5	-	0.3	-	531.5	-	1.4	-	1.4	-	0.6	-	515.0	-	36.5	-	ND
G4	88.6	-	0.2	-	5,894	-	0.5	-	0.9	-	268.2	-	2.9	-	1.7	-	2.7	-	372.0	-	24.6	-	ND
G5	75.1	-	0.4	-	4,326	-	0.5	-	0.5	-	247.0	-	0.9	-	2.5	-	ND	-	322.4	-	21.6	-	ND
G6	38.5	-	ND	-	1,373	-	0.4	-	ND	-	555.2	-	2.1	-	1.2	-	ND	-	514.6	-	24.9	-	ND
K1	53.1	-	0.4	-	4,463	-	0.6	-	ND	-	302.2	-	1.9	-	1.7	-	ND	-	377.8	-	56.0	-	ND
K3	63.7	-	0.7	-	3,416	-	0.5	-	0.3	-	214.6	-	2.4	-	1.5	-	0.8	-	355.6	-	32.8	-	ND
K4	55.8	-	ND	-	2,901	-	0.3	-	ND	-	121.3	-	1.4	-	1.5	-	ND	-	326.6	-	27.7	-	0.1
K5	122.9	41.5	2.0	0.6	4,385	1,701	0.5	0.3	0.9	2.0	517.9	450	2.2	3.0	2.4	1.7	0.9	3.2	582.4	454	25.0	20.0	0.1
M2	46.6	36.0	0.2	ND	2,799	3,498	0.6	0.3	0.3	1.6	483.3	236	1.7	2.5	0.5	0.4	1.5	1.1	486.4	253	20.2	17.5	ND
M3	45.5	41.2	0.6	ND	1,796	2,335	0.4	0.1	0.8	1.8	407.3	282	2.6	1.3	0.7	0.8	1.6	2.9	540.9	279	17.5	11.2	ND
M4	52.5	37.7	1.3	ND	1,167	1,000	0.4	0.3	ND	2.4	463.6	264	4.1	4.5	1.0	1.4	0.7	2.9	624.1	250	15.2	13.7	ND
M5	44.0	37.4	1.4	ND	1,139	917	0.4	0.1	0.6	1.3	175.1	207	3.9	3.2	1.3	1.4	0.8	2.6	283.3	230	10.4	16.5	ND
S1	37.6	25.3	1.6	ND	994	597	0.5	0.1	1.2	1.8	576.4	709	2.9	3.3	1.5	1.6	2.7	3.7	779.7	576	19.3	17.8	0.1
S2	46.7	34.3	1.8	0.5	1,002	658	0.7	0.3	1.8	1.8	385.6	370	5.0	2.8	2.8	1.7	1.5	3.6	588.4	357	19.2	8.8	ND
S3	-	24.3	-	ND	-	612	-	0.3	-	1.6	-	948	-	3.8	-	1.3	-	3.9	-	1237	-	18.0	-
S4	96.4	29.7	0.7	3.4	1,430	691	0.5	0.2	1.0	1.4	487.8	376	4.9	3.0	1.5	1.7	0.8	3.1	505.5	282	16.3	10.5	ND
Nitti Port	88.8	-	0.9	-	7,966	-	0.3	-	0.9	-	155.5	-	2.5	-	1.7	-	1.3	-	297.9	-	17.6	-	ND

Note: The median guideline value for the maximum concentration of trace metals in shellfish suitable for human consumption are provided, and values exceeding these guidelines are highlighted in red font.

4.12.5 Vegetation

The total mangrove area for Sherbro Island and adjacent mangrove delta stands at an estimated 681.9 km^2. Mangrove habitat lost to mining activities is currently estimated to be 1.25 km^2 or 0.18 % of the mangrove forest area in the Sherbro River Estuary with a total 3.00 km^2 or 0.44 % to be lost with future mining plans in the Kangama Creek area. Eight mangrove[11] species were identified during the wet and dry season surveys and included *Avicennia germinans* (Black mangrove), *Conocarpus erectus* (Button wood), *Dodonaea viscosa* (Hopbush), *Guilandina bonduc* (Grey nicker), *Laguncularia racemose* (White mangrove), *Rhizophora racemose*, *Rhizophora harrisonii* (both Red mangrove), and *Phoenix reclinata* (a palm). These species are typical of West African mangrove ecosystems.

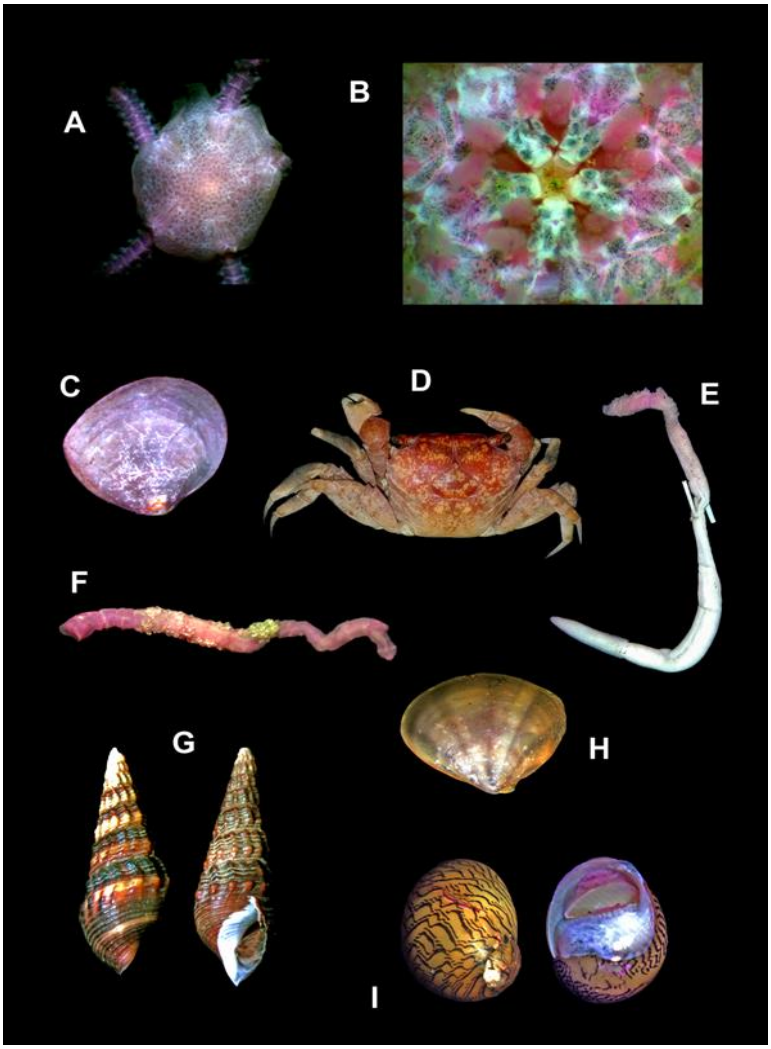
The sites surveyed were predominately composed of *R. racemosa* which is characteristic of the zone closest to the river channels. *A. marina* occurred in small clumps in places and was likely due to a change to topography or sediment characteristics of that specific site. Sites surveyed within the delta were mostly similar to one another in terms of species composition and tree densities, while sites surveyed at Sherbro Island exhibited differences to their river delta counterparts.

Transects walked through the mangroves on each of the sample creeks (Bagru, Gbangbaia, Kangama and Motevo Creeks) revealed different species compositions and vegetation structure. The Gbangbaia Creek mangrove had the greatest total forest density (117.61 trees/0.1 ha) but the lowest basal area overall (0.49 m^2/0.1 ha). The Motevo Creek transect had a high total forest density (117.61 trees/0.1 ha) and high basal area (1.39m^2/0.1 ha). Both the Kangama and Bagru Creek transects had similar basal areas (1.25m^2/0.1 ha) but different total forest density, 78.97 and 41.58 trees/0.1 ha trees respectively.

Macrofauna

A total of 324 invertebrates representing 54 species and 45 families were collected during the wet and dry season field surveys (Figure 4-71). Abundance and diversity were both higher in the sub-tidal compared with the intertidal samples. Diversity was highest at sites near the sea while abundance was highest at the upstream sites. Diversity and abundance is similar to that recorded in other mangrove estuaries in West Africa and species recorded are typically of the East Atlantic / Gulf of Guinea biogeographic region.

[11] Mangroves comprise of a group of shrubs and small tree that grows in coastal saline or brackish water and have specific adaptations for dealing with saline, muddy and oxygen poor environments where they live. Only a few mangroves are from the iconic mangrove plant genus, *Rhizophora.*



A. *Amphipholis squamata* (Brittle star)
B. *A. squamata* mouth parts (integral for identification purposes)
C. *Austromacoma nymphalis*
D. *Metagrapsus curvatus*
E. *Pteroeides* sp. (Sea pen)
F. *Maldanidae* sp. (Bamboo worm)
G. *Pachymelania fusca*
H. *Gari* sp.
I. *Natica fulminea*

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Figure 4-71: Examples of benthic invertebrate macrofauna found in sub-tidal grab and intertidal core samples (Anchor 2018)

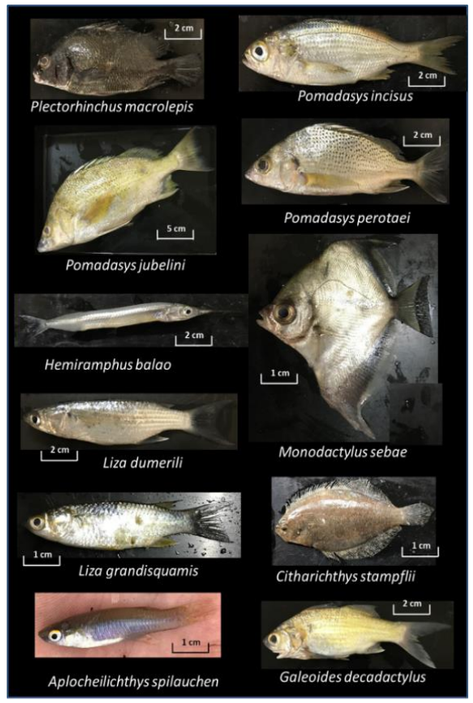
4.12.6 Fish

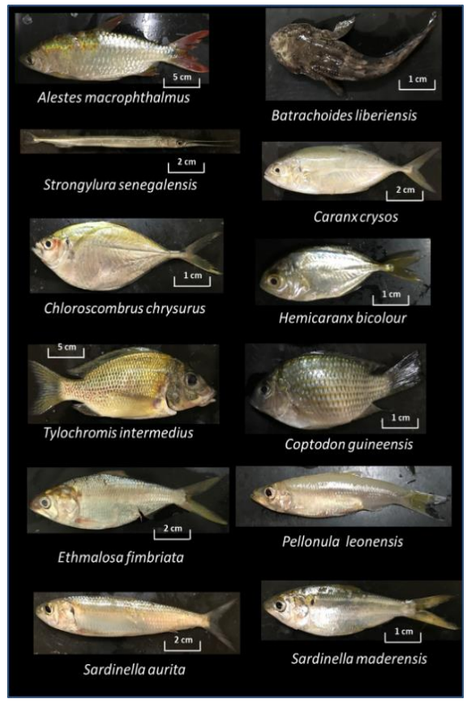
A total of 1,273 fish representing 55 species from 28 families were collected during the wet and dry season field surveys (Figure 4-72). The diversity of fish sampled during these surveys is lower than that reported in other fish surveys in the region. The dry season survey recorded an additional 10 species, mostly marine taxa (9 out of the 10) that were not found during the wet season survey, however the catch diversity for both surveys was similar with 44 and 45 species recorded during the wet and dry season surveys respectively). Fish abundance during the dry season was however greater with more than double the number of fish caught (1,273) compared to during the wet season (544). Combining the data for both surveys, the most diverse fish families in the samples were the Carangidae (jacks) represented by six species, Clupeidae (herring and sardines) represented by five species, the Haemulidae (grunts), Cichlidae (cichlids) and Sciaenidae (croakers and drums) with four species each. In terms of abundance, four families dominated numerically with Mugilidae (59 %), Pristigasteridae (31 %), Clupeidae (14 %) and Poeciliidae (4 %) contributing 87 % of the total catch.

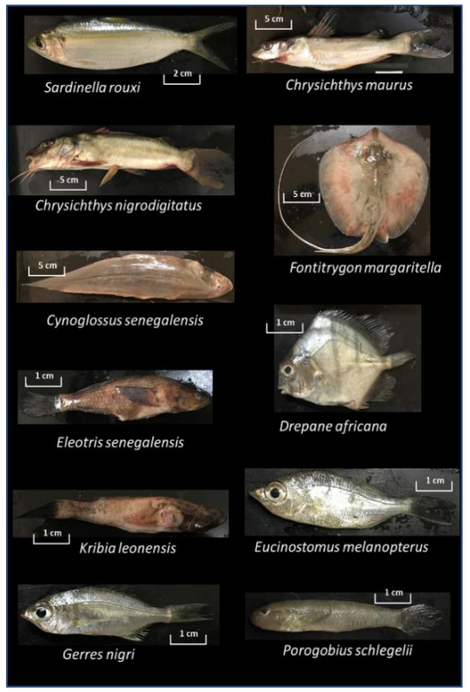
There were noticeable seasonal changes in the fish community composition between surveys with the wet season survey catches having similar contributions by three families, Pristigasteridae (31 %), Clupeidae (22 %) and Mugilidae (21 %), and a noticeable proportion of the catch comprising species of Poeciliidae (8 %) and Sciaenidae (5 %); dry season catches on the other hand were dominated by Mugilidae (76 %), and Clupeidae (11 %). The surveys of the estuaries downstream of the SR Area 1 mining area indicated an estuarine fish community dominated by marine species that contributed 39 of the 55 species, whilst more freshwater species (10) were recorded then strictly estuarine species (6). During the wet season survey, the marine guild was also dominant in terms of fish abundance (69 %) but the freshwater group contributed a significant 28 % numerically to the total catch. The dry season survey saw a shift in relative abundance, with the marine guild contributing 90 % to the total catch and a substantial reduction in the numerical contribution of freshwater taxa to just 7 % of the total catch. The estuarine fish community was dominated by carnivorous and omnivorous species with only one species classified as herbivorous (the phytoplanktivorous Bonga shad). Most species present in the wet season fish community were first level predators consuming mainly benthic invertebrates, zooplankton, macro-crustaceans and insects; or second level generalist predators consuming mainly fish, shrimps and crabs. In terms of abundance, the phytoplanktivorous mullets dominated, whilst the mainly zooplanktivorous predators that included the three Sardinella species and Ilisha africana were the next most common trophic group.

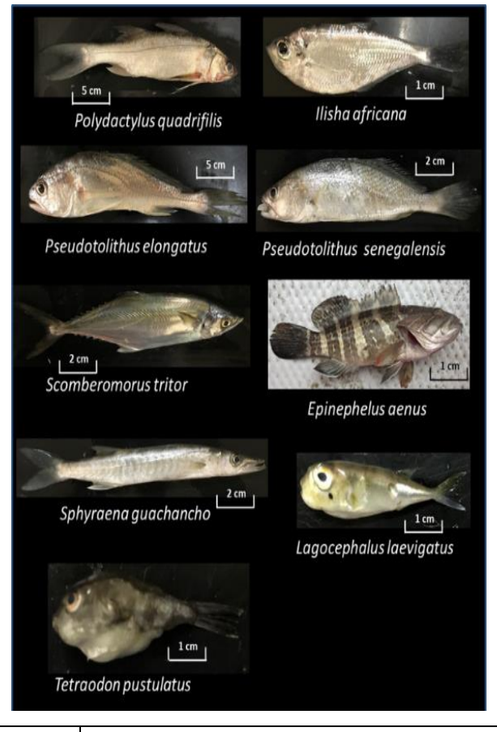
Fish diversity in samples collected from the Bagru, Gbangbaia and Kangama Creeks increased noticeably between the wet and dry season surveys, whilst small decreases in the number of species caught were observed in the Motevo and Teso Creek samples. Similarly fish abundance in all creeks, with the exception of Kangama Creek and the Sherbro Island sites, was higher during the dry season surveys. Wet season fish diversity was higher at the Motevo Creek and Sherbro Island sites compared to other sampled creeks, whilst dry season diversity was similar across all sites except for the Telo Creek where only one species of mullet was caught. Total catches (fish abundance) was similar across most creeks, with the exception of high catches at Sherbro Island during the wet season and in Motevo Creek during the dry season. 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. A loss of the freshwater component (including catadromous[12] species) of the fish community is a potential impact of dams created by the current and historical SRL operations. This impact would have been most evident during the dry season survey when freshwater flows are at their lowest. However both surveys indicated seasonal diversity and abundance of freshwater species that is comparable to other studies in the region. 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.

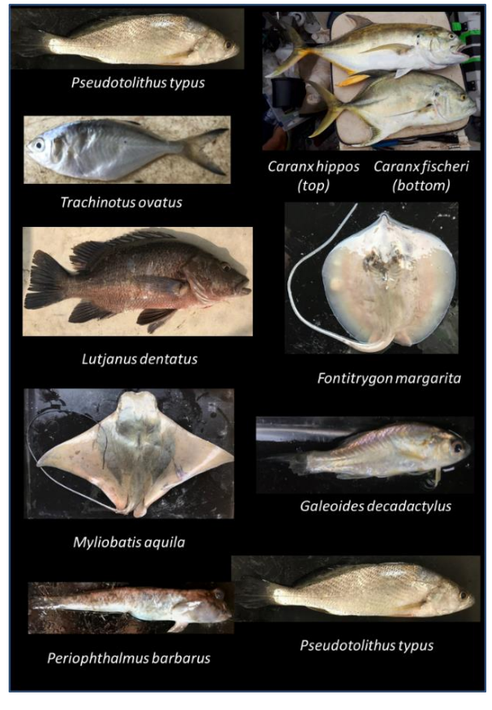
[12] Definition: Adjective of fish migrating from fresh water to spawn in the sea, as eels of the genus *Anguilla* (distinguished from anadromous) (source: http://www.dictionary.com/browse/catadromous)











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SR AREA 1 ESHIA & ESHMP
FISH SPECIES RECORDED AUGUST 2017 (ANCHOR 2018)

Project No. 515234

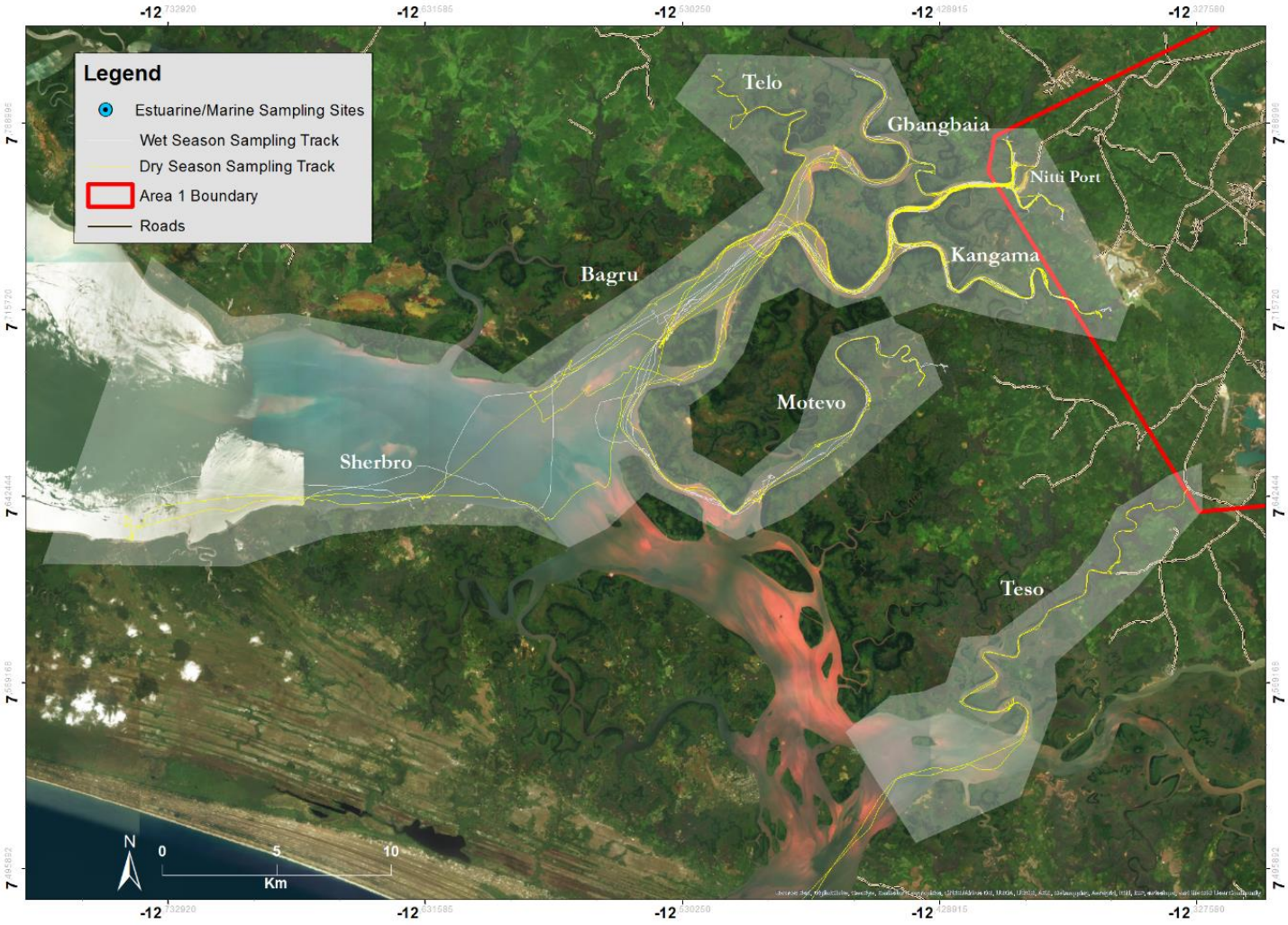
Figure 4-72: Fish species recorded during the wet season field survey conducted during 2017 in the estuarine creeks draining SR Area 1 (Anchor 2018)

4.12.7 Birds, reptiles and mammals

In all, 20 species of water birds were recorded during the wet season survey and more than double this (50) during the dry season. Numbers of birds recorded was highest in Bagru and Sherbro Creeks in both seasons and is believed to be linked to the much greater sand and mudflat habitat availability as feeding areas for many water birds in these two counting areas. Species that were encountered most frequently included *Calidris minuta* (Little stint), *Thalasseus maximus* (Royal tern), *Sternula albifrons* (Little tern), *Ardea alba* (Great white egret), and *Egretta gularis* (Western reef heron). Historical bird surveys conducted during the dry season (northern summer) in the vicinity of Sherbro Island (but excluding the mangrove creeks) recorded a total of 14 515 birds from 56 species (Van der Winden *et al.* 2007). Species that were highlighted as being particularly important (in terms of the numbers recorded) included *Tringa totanus* (Common redshank), *Gelochelidon nilotica* (Gull-billed tern), *Thalasseus bengalensis* (Lesser crested tern), *Sternula albifrons* (Little tern) and *Rynchops flavirostris* (African skimmer). It has been recommended that Sherbro Island be designated as a Wetland of International Importance in terms of the Ramsar Convention, and as an Important Bird Area (COP11 National Reports for Ramsar: Sierra Leone, 2011, Van der Winden *et al.2007*). No aquatic reptiles or mammals were recorded during this survey.

Although no mammals were encountered in the mangroves during the 2018 dry season survey, several mammal tracks were evident in some of mangrove transects. Otter and monkey tracks were abundant in the Motevo and Bagru Creek transects and a single feline track was further noted in the Motevo Transect. The otter track is likely to be that of *Aonyx capensis* (African clawless otter) as this species has previously been recorded in Sierra Leone estuaries (Van der Winden *et al*. 2007). The monkey tracks could be from several different species (*Chlorocebus sabaeus* (Green Monkey), *Cercopithecus campbelli* (Campbell's Monkey), or *Procolobus badius* (Western Red Colobus)) which utilise mangroves for refuge and food resources.

Figure 4-73 shows the bird counting areas in the study area, while Table 4-64 lists bird species recorded on the estuary.



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SR AREA 1 ESHIA & ESHMP
BIRD COUNTING AREAS

Project No.
515234

Figure 4-73: Bird counting areas (shading) and vessel tracks during the wet season (white lines) and dry season (yellow lines) (Anchor 2018)

Table 4-64: List of bird species recorded on the estuary

Common name	Species	Gbangbaia Creek		Kangama Creek		Bagru Creek		Telo Creek	Motevo Creek		Teso Creek		Sherbro Island	
Pink-backed pelican	*Pelecanus rufescens*						W				D		D	W
Long-tailed cormorant	*Microcarbo africanus*	D				D	W		D					W
White-breated cormorant	*Phalacrocorax capensis*													
Cattle egret	*Bubulcus ibis*	D												
Little egret	*Egretta garzetta*	D									D		D	
Great egret	*Ardea alba*	D		D				D	D		D		D	
Western reef egret	*Egretta gularis*	D		D		D			D		D		D	
Purple heron	*Ardea purpurea*					D								
Grey heron	*Ardea cinerea*	D				D			D		D		D	W
Greenback heron	*Ardea melanocephala*	D				D	W		D					W
Goliath heron	*Ardea goliathi*								D					
Hammerkop	*Scopus umbretta*	D	W		W	D	W			W		W	D	W
Wooly necked stork	*Ciconia episcopus*	D				D			D					W
Yellow-billed stork	*Mycteria ibis*								D					
Osprey	*Pandion haliaetus*				W	D	W						D	
Palm-nut vulture	*Palmiste africain*	D	W	D	W	D	W	D	D	W	D	W	D	W
Yellow-billed kite	*Milvus migrans parasitus*	D		D		D		D	D		D		D	
Water thicknees	*Burhinus vermiculatus*						W							W
Common ringed plover	*Charadrius hiaticula*	D				D							D	
Kentish plover	*Charadrius alexandrinus*	D											D	
Grey plover	*Pluvialissquatarola*	D		D		D							D	
Bar-tailed godwit	*limos lapponica*					D							D	
Whimbril	*Numenius phaeopus*	D		D							D		D	
Eurasian curlew	*Numenius aquata*						W						D	W
Little stint	*Calidris minute*	D				D	W		D	W			D	W
Sanderling	*Calidris alba*	D									D		D	
Curlew sandpiper	*Calidris ferruginea*	D				D			D				D	
Ruff	*Combattant punax*	D											D	
Common redshank	*Tringa totanus*	D				D			D				D	
Common greenshank	*Tringa nebularia*	D				D							D	
Marsh sandpiper	*Tringa stagnatilis*					D							D	
Wood sandpiper	*Tringa ochropus*	D				D								
Common sandpiper	*Actitis hypoleucos*	D	W	D	W	D	W		D	W	D		D	W
Ruddy turnstone	*Arenaria interpres*						W							W

Common name	Species	Gbangbaia Creek		Kangama Creek		Bagru Creek		Telo Creek	Motevo Creek		Teso Creek		Sherbro Island	
Royal tern	*Thalasseus maximus*	D		D		D	W				D		D	W
Gull-billed tern													D	
Sandwich tern	*Thalasseus sandvicensis*	D				D			D		D		D	
Common tern	*Sterna hirudo*												D	
Arctic tern	*Sterna paradisaea*												D	
Little tern	*Sternula albifrons*	D				D	W		D				D	W
Little swift	*Apus affinis*		W											
Malachite kingfisher	*Corythornis cristatus*	D	W	D	W			D		W				
Pied kingfisher	*Ceryle rudis*	D	W	D	W	D	W	D		W		W		W
Giant kingfisher	*Megaceryle maxima*							D						
Rock martin	*Ptyonoprogne fuligula*	D												
White-throated blue swallow	*Hirundo nigrita*										D			
Preuss's cliff swallow	*Petrochelidonpreussi*	D	W											
Africa pied wagtail	*Motacilla aguimp*									W				
Brown sunbird	*Anthreptes gabonicus*	D		D										
Total number of species		31	7	11	7	27	16	6	18	9	14	4	29	16

No aquatic reptiles or mammals were recorded during the wet season survey, but corresponds with the findings of Van der Winden et al. (2007) who also recorded low numbers of aquatic mammals and reptiles in the surveys conducted. Other recordings in the Van der Winden et al. (2007) study were:

- The Nile crocodile (*Crocodylus niloticus*) in low numbers at the three other major coastal wetland sites in the country (Scarcies, Sierra Leone River estuary and Yari Bay) but not in the Sherbro Estuary;
- The West African Manatee at the Great Scarcies River estuary but not at any of the other estuary sites; Local fishermen mentioned that manatee were still present in the Sherbro Estuary at the time that their surveys were conducted (2005), but that these animals were killed whenever they were encountered. It is not clear whether the manatee still exist in this area, but it is likely that this is not the case; and
- The clawless otter (*Aonyx capensis*) from the Sierra Leone River estuary but not in any of the other systems that was surveyed.

Although no mammals were encountered in the mangroves during the 2018 wet season survey, several mammal tracks were evident in some of mangrove transects. Otter and monkey tracks were abundant in the Motevo and Bagru Creek transects and a single feline track was further noted in the Motevo Transect (Figure 4-74). The otter track is likely to be that of *Aonyx capensis* as this species as it has previously been recorded in Sierra Leone estuaries (Van der Winden *et al*. 2007). The monkey tracks could be from several different species which utilise mangroves for refuge and food resources. The monkey species typically associated with mangroves include Campbell's Monkey (*Cercopithecus campbelli*) which has been noted to readily adapt to mangrove forest where it forages on mangrove leaves, Rhizophora propagules, crabs, shrimps and mud skippers (Grubb *et al.* 1998, Kingdon *et al.* 2013). The Green Monkey (*Chlorocebus sabaeus*) it a noted good swimmer and readily feeds on fiddler crabs associated with mangrove habitats (Galat and Galat-Luong 1976, Kingdon *et al.* 2013). The Western Red Colobus (*Procolobus badius*) utilises mangrove forest as refuge and a food source as a means to increase survivorship (Galat-Luong and Galat 2005, Kingdon *et al.* 2013).

Monkey tracks through the mangrove *Rhizophora racemosa* band adjacent to the channel in Motevo Creek.

Otter tracks in the *Rhizophora racemosa* band adjacent to the channel in Motevo Creek.

Feline track in the *Rhizophora mangle* band along the Motevo Creek transect.

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Figure 4-74 Mammal tracks in mangrove transects (Anchor 2018)

4.12.8 Human use

Extensive fishing activity or evidence of fishing was observed in all the creeks surveyed during this study (Figure 4-75). Three main types of fishing gear were observed: gill nets, long lines and purse seine nets. Gill net fishing was practised throughout the study area, but the highest densities of fishers were encountered near the mouth of Bagru Creek in the lee of Sherbro Island, and in the lower stretches of Motevo Creek. These gill nets mostly target pelagic species[13] such as Clupeids (sardinellas) and mullets, although bentho-pelagic Sciaenids (croakers) and Polynemidae (threadfins) were also present in the gill net catches.

Longlines predominantly target and catch demersal fish[14] such as catfish, tonguesole and grunts. Observed catches by both gill net fishers and long liners were modest, ranging from nothing to a few kilograms per boat. 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.

Purse-seine fishing was only observed near the open sea adjacent to Sherbro Island during the wet season, but in the dry season two purse-seine vessels were observed operating in the lower Bagru Creek, inland of Sherbro Island. This type of fishing involved the use of a large planked canoe around 10 m in length and powered by an outboard motor. The net was hauled manually by approximately 15 fishers and the catch was dominated by sardinellas (Clupeids), although some large croakers (Sciaenids) were also caught in the haul observed.

Large oyster shell middens were observed at many small villages along the mangrove creeks and provided evidence of extensive oyster harvesting for subsistence purposes (Figure 4-76). These oysters are abundant, growing on mangrove roots throughout most of the estuary, except the very upper reaches of the creeks where salinity of tidal influence was insufficient to permit their growth. Whilst collecting oyster samples the survey team was questioned whether the Paramount Chief had given permission, which suggests some customary control of oyster harvesting and this resource certainly did not appear overexploited (although there is no data on historical oyster density or sizes).

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. Observed fishing effort during the dry season survey was substantially lower than that seen during the wet season survey and individual vessel catches were greater in the former season.

13 Those that inhabit the water column, not near the bottom or the shore.
14 Those that live near the bottom.

Fishers using scoop nets to catch shrimp (possibly for bait).

Gill net fishing and catch from the Sherbro River Estuary.

Purse seine fishing.

srk consulting	**SR AREA 1 ESHIA & ESHMP** FISHING ACTIVITIES	Project No. 515234

Figure 4-75: Fishing activities (Anchor 2018)

srk consulting	**SR AREA 1 ESHIA & ESHMP** OYSTER SHELL MIDDEN	Project No. 515234

Figure 4-76: Oyster shell midden showing extensive and long-term harvesting of oysters from the estuaries of the study area (Anchor, 2018)

4.13 Socio-economic environment

The content of this section is adapted from the specialist Social Impact Assessment (SIA) (SRK, 2018(3)) which is attached as Appendix J.

Sierra Leone is divided into four regions (Northern, Eastern, Southern Provinces and the Western Area), which are then further divided into twelve Districts. In the Southern Province, there are four Districts, including Bo, Moyamba, Bonthe and Pujehun.

This section presents the socio-economic baseline for the Bonthe and Moyamba Districts where SR Area 1 is located and focuses on demographic indicators, community and social organisation, housing, education, economy and livelihoods, land ownership and use and cultural heritage (SRK, 2018(3)).

4.13.1 Methodology

Primary and secondary data sources were consulted to ascertain the existing socio-economic conditions. Secondary data sources included socio-economic information that the mine had collected over the years, as well as general information such as the country's census data published in 2004 and 2015 (Statistics Sierra Leone, 2004 and 2015). Additional information was collected from primary data sources by way of a Rapid Rural Appraisal (RRA), Household Surveys (HHS), focus group discussions and interviews. Table 4-65 indicates the survey type and sample size for each of the data gathering methods. The CEMMATS ESIA (2012) is a key point of reference for this SIA. The alignment in study areas between this report and the CEMMATS ESIA of 2012 makes it possible, where relevant, to compare current baseline data against the baseline situation described in the CEMMATS ESIA (2012), and to use the CEMMATS ESIA (2012) data where the current socio-economic data may be limited.

Table 4-65: Summary of data gathering methods

Survey Type	Dates conducted	Targeted groups	Number of respondents / groups
Rapid Rural Appraisal	13-17 August 2017	Key areas of concern and areas that represented specific ecosystems services	92 respondents
Household Surveys	8-25 August 2017	Head of households in 37 villages in the SR Area 1 boundaries	562 respondents
Focus Group Discussions	22-23 August 2017	Organised business, Youth groups, Women's groups, Non-governmental organisations (NGOs), Land owners, Family Support Unit and Criminal Investigation Department (CID), Education Department and Ward councillors	Eight focus groups (61 participants)
Interviews	September 2017	Interviews with businesses focused on socio-economic aspects of the organisation/activity in the study area	Six interviews

4.13.2 National and regional context

The baseline first seeks to describe information derived at desktop level for national, regional, provincial, District and Chiefdom levels. This context informed the primary data collection in the study area. A summary of key social indicators is summarised in Table 4-66 and Table 4-67.

Table 4-66: Key National and Provincial social indicators

Sierra Leone and Southern Province*	
Demographic indicators	**Fertility rates** (refer to Section 4.1.8 of the SIA for detailed health information)**
• Sierra Leone had an estimated population of 7 million in 2015, of which, 20 % were living in the Southern Province (smallest number); • People living in rural areas in Sierra Leone accounted for 59 % of the population; • National population density was 79 persons per km^2, and 73 persons per km^2 in the Southern Province; • In 2015, 41 % of the national population comprised of children younger than 15; and • Average life expectancy in Sierra Leone is 58.2 years (expectancy for men at 55.6 years and for women at 60.9 years) (Central Intelligence Agency, 2016).	• Nationally, the overall fertility rate is lower in urban areas than rural areas (3.5 and 5.7 children per woman, respectively); • In the Southern Province, the Total Fertility Rate (TFR) is estimated at 5.4 children per woman; and • The national fertility rate was higher in rural areas (5.7 compared to 3.5 in urban areas). (Sierra Leone Demographic and Health Survey (SLDHS), 2013).
Ethnic groups	**Residential (housing)**
• Twenty languages are spoken nationwide and the official language is English; • Krio is the most widely spoken language in Sierra Leone, followed by Temne and Mende; and • Most widely practiced religion in Sierra Leone is Islam (78 %) but traditional beliefs are often interwoven with Christian and Islamic beliefs and practices.	• Total stock of houses in Sierra Leone in 2015 was 801,417, with 61 % located in rural areas and 39 % in urban areas; • Southern Province housing stock accounts for just 23 % of the national total stock; and • Average household population nationally was 8.8 persons per house.

Sierra Leone and Southern Province*	
Education	**Economy and labour**
• Nationally, among the 6,589,838 people aged three years and above, 55 % have attended school and 44 % never attended school. Some 37 % were currently in school; and • The percentage of the national population that has never attended school was shown to be nearly three times more in rural areas (33 %) than in urban areas (12 %).	• Men are more engaged in the labour market than women are, except for the youth, where women are more active; • Labour accounted for 84 % of total jobs; • An estimated 70 % of youth were unemployed or underemployed; and • Agriculture was largest employment sector, employing 59 %.

*Unless otherwise mentioned data is from the Population and Household Census (PHC), 2015

Table 4-67: Key District and Chiefdom social indicators - Bonthe

Bonthe District: Imperi and Jong Chiefdoms*	
Demographic indicators	**Fertility rate (Refer to Section 4.1.8 of the SIA for detailed health information)**
• The District population estimated at 200 781 people; • Population density was 58 persons per $km^{2;}$ • An estimated 81 % of the population lived in rural areas; • Some 17 % lived in the Imperi Chiefdom and 17% in the Jong Chiefdom; and • Life expectancy level of 49 years (Reliefweb, 2015).	• TFR stood at 4.2 (SLDHS, 2013).
Ethnic groups	**Residential (housing)**
• The Mende and Sherbro ethnic groups are in the majority; and • Sherbro, Mende and Krio are the most commonly spoken languages.	• A total of 32,538 households and 27,129 houses (an average of 1.2 households per house); and • Average household size was 6.2.

*Unless otherwise mentioned data is from the PHC, 2015

Table 4-68: Key district and chiefdom social indicators - Moyamba

Moyamba District: Lower Banta, Upper Banta, and Bagruwa Chiefdoms*	
Demographic indicators	**Public health**
• The District population was estimated at 318,588; • The population density was lower than Bonthe at 46 persons per km$^{2;}$ • An estimated t 93 % of the population were living in rural areas in 2015; • Of the population in the District, 12 %, 3 %, and 9 % were located in Lower Banta, Upper Banta, and Bagruwa Chiefdoms; and • Average life expectancy is below the national average at 45 years for both males and females (reliefweb, 2015).	• The TFR is 6.2 in Moyamba District (SLDHS, 2013).
Ethnic groups	**Residential (housing)**
• The District is home to the Temne, Susu, Limba, Fula and Mandingo ethnic groups; and • The most commonly spoken language in is Mende.	• There were 61,880 households and 53,516 houses (also an average of 1.2 households per house); and • Average household size was 5.1 in 2015.
Education	
Adult literacy rate was estimated by the Moyamba District Census (MDC) to be 30 %.	

*Unless otherwise mentioned data is from the PHC, 2015

4.13.3 Socio-economic conditions of the SR Area 1

This section presents the socio-economic conditions of SR Area 1 based on the analysis of primary data collected.

Demographic indicators

Demographic indicators represent important population dynamics based factors such as age, race and sex. These are in turn influenced by a number of factors such as birth and death rates, migration patterns and life expectancy. It is important to understand demographics as they play a critical role in the formulation of current social conditions in SR Area 1.

Population number, density and distribution

It is estimated that a total of 4,000 households reside within SR Area 1. The HHS (SRK, 2017a) recorded 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 Housing Census (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 SR Area 1 is 20,800. This suggests a population density to 71 people per km², including the areas taken up by mining related activities (20,800 persons / 291 km²). Assuming approximately 21 km² is taken up by mining activities, this suggests a population density of around 77 people per km² (20 800 persons / 270 km).

Population growth and increased migration was focused in Moriba Town and its surrounding villages, including Mogbwema, Mogbwemo, Kpetema, Pejebu and Ndendemoia (SRK, 2017a). Other towns experiencing growth included Mokaba, Gbangbaia, Gbangbama and Madina. Overall, 41 % of participants reported that they had experienced people moving into the household between August

2016 and August 2017 (of the 216 of the 517 households who responded, SRK, 2017a). Regarding movement out of the household experienced since last year August 2016, overall 35 % reported that they had experienced people moving out of the household (of the 176 of the 506 households responded, SRK 2017a). Main reasons cited for movement into and out of a household were related to seeking jobs and family matters. The effects of people moving in and out were mainly related to the negative or positive impact on access to food (SRK, 2017b).

In 2017, 1,407 males and 1,527 females were recorded (SRK, 2017a). The representation matches the male-female distribution recorded in the Population and Housing Census of 2015: 52 % females in the HHS (SRK, 2017a), and 52 % and 51 % in 2015 in the Moyamba District and Bonthe District respectively (Figure 4-78).

Contrary to the majority female representation at the two District levels, heads of households included in the sample had more male than female children (SRK, 2017a). Of the HHS (SRK, 2017a) sample, 46 % of children of the heads of households were males, and 42 % female.

Social organisation

Social organization informs the pattern of relationships amongst individuals and social groups. Characteristics of social organization include leadership, government structure and spatial divisions.

The Districts of Sierra Leone are divided into 149 Chiefdoms. Paramount Chiefs, who are elected by Chiefdom Councillors, govern Chiefdoms. Paramount Chiefs are in place for the remainder of their lives unless disputed. General administration, law enforcement and local economic development are the responsibility of the Paramount Chief and his / her council, as are land rights and land custodianship. Chiefdoms are broken down into sections and then villages, which are governed by Section Chiefs and Village Chiefs respectively. Chiefdoms in SR Area 1 include Imperi, Jong, Lower Banta and Upper Banta.

Women's and Youth groups are important voices for community development. In addition to these groups, a number of other CBOs are active in the SR Area 1, including the Community Empowerment Movement (CEM), Network Movement for Justice and Development (NMJD), Community Advocacy and Development Movement (CADAM) and UNICEF. Currently, the Network Movement for Justice and Development (NMJD) is probably the most important NGO in the region.

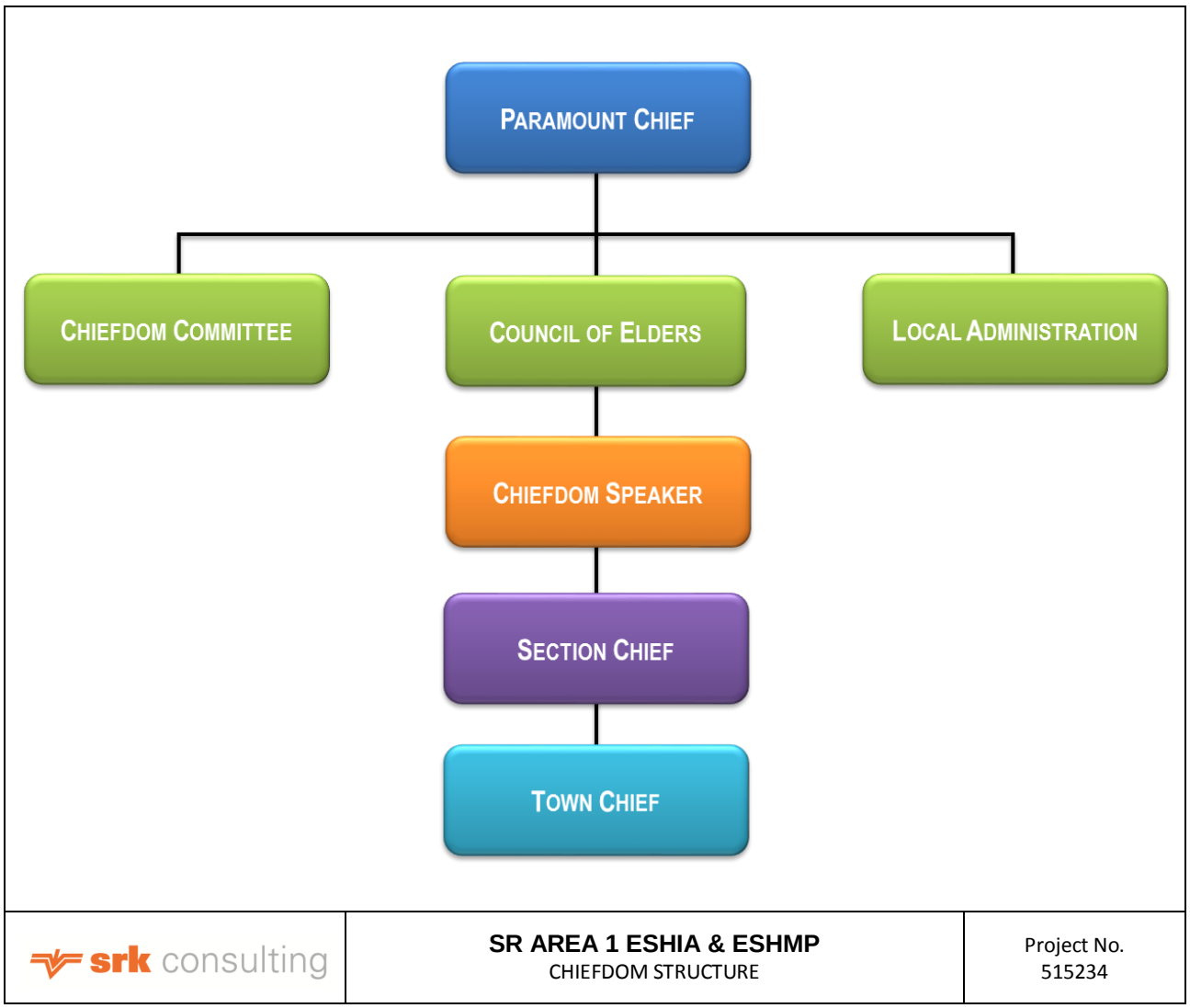
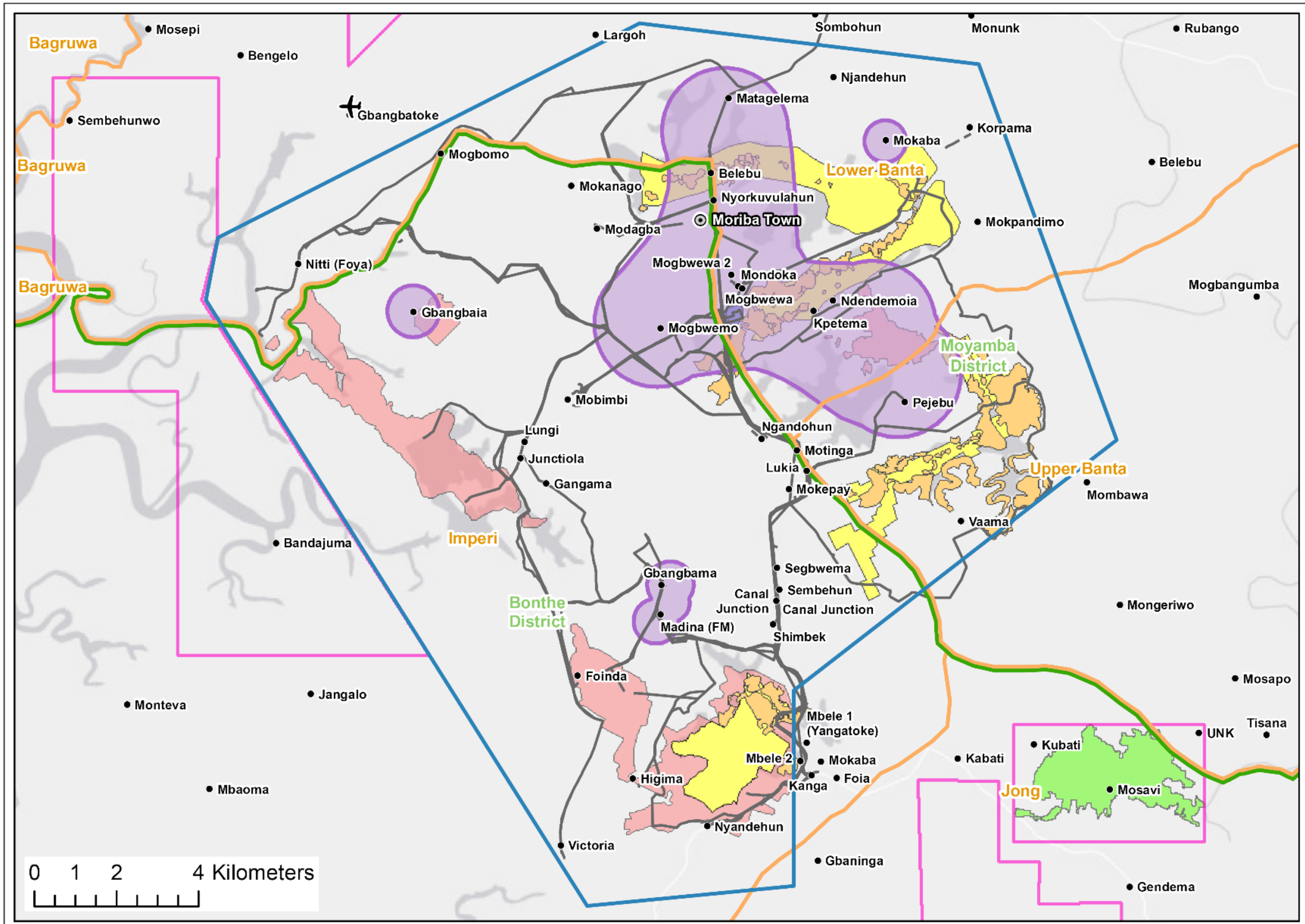


Figure 4-77: Chiefdom structure



Data Source:

Scale: 1:125 624	A4
Projection: UTM	Datum: WGS
Central Meridian/Zone: 28N	
Date: 14/03/2018	Compiled by: VERJ
Project No. 515234	Fig No. 4-78

srk consulting

SR AREA 1 ESHIA & ESHMP

POPULATION GROWTH HOTSPOTS IN SR AREA 1

Path: \\jhb-fs0\vol3\Proj\515234_Sierra Rutile\8GIS\GISPROJ\MXD\Social_Report_Maps\January 2018\515234_A4_Map11_SierraRutileMine_Population Growth Hotspots_30012018.mxd

Revision: A Date: 00 00 2013

Ethnic groups

Ethnic groups refer to a community or population who share a common cultural and / or religious heritage. The main religion amongst participants in the HHS (SRK, 2017a) was Islam (63 %), followed by Christianity (35 %). Some households simultaneously practice Islam and Christianity.

The predominant traditional belief system in SR Area 1 is based on influential secret societies for men (Poro) and women (Sande / Bondo). These secret societies are responsible for the initiation of girls and boys to adulthood. Traditional ceremonies are undertaken in numerous sacred sites, including the "society bush", cemeteries, caves and the "shrine bush" (CEMMATS, 2012; confirmed by SRK, 2017b).

CEMMATS (2012) reported the main ethnic groups in the study area as follows: the majority of the population (89 %) were from the Mende ethnic group, followed by Sherbro (4 %), Temne (3 %) and the remainder comprising of Fula, Kono, Limba and Susu. This pattern was slightly different for the SRK HHS (a, 2017) participants, with 93 % speaking Mende as their main language and 99 % being able to speak Mende.

In general, ethnic groups integrate well with one another and it is suggested that conflict is rare if not non-existent. Intermarriage is commonplace (CEMMATS, 2012, SRKb, 2017).

Public health

Health findings are presented in more detail in the health baseline in Section 4.14.3 below.

Education, economy, livelihoods and labour

Education improves access to employment opportunities and helps to sustain and accelerate overall economic development. This in turn affects the labour market, which relies on a broad range of skill sets for employment.

Education

Enrolment information shows a significant difference between the enrolment of boys and girls at various levels of education. In general, enrolment in the four Senior Secondary Schools drops for both groups for progressively higher levels, but the drop is much more pronounced among girls. The limited number of girls completing school are rooted in economic and social factors, including the involvement of young girls in subsistence agricultural activities at home, as well as early pregnancy and child bearing (CEMMATS, 2012).

There was a strong link between education and employment status (SRK, 2017a). Of the males no longer going to school, 14 % had a Junior Secondary School education, and 13 % a Senior Secondary School education. Only 5 % had completed vocational training, and 3 % had a degree or a post graduate degree. Similarly, 13 % of females had a Junior Secondary School, but only 7 % of females had a Senior Secondary School education. Only 2 % had completed vocational training, and 1.2 % had a degree or a post graduate qualification.

Economy

Gross Domestic Product (GDP[15]) in Sierra Leone had experienced strong growth of on average 8 % per year between 2003 and 2014, albeit off a low base. Growth was well above average in 2012 (15.2 %) and 2013 (20.7 %) (IFC, 2017). The twin shocks of the international commodities downturn

[15] Gross Domestic Product measures the value of output produced within the domestic economy, regardless of who owns the factors of production. GDP at market prices measures the value of domestic output inclusive of indirect taxes on goods and services.

and EVD outbreak in 2014 / 15 resulted in the collapse of iron ore prices and closure of the two major iron ore companies in Sierra Leone (Bank of Sierra Leone, 2016), and caused a notable retraction of the national economy. GDP growth reduced to 4.6 % in 2014 and the economy contracted by 20.5 % in 2015. Growth rebounded to 6.1 % in 2016, with GDP of Le23 848 billion, equivalent to US$3.9 billion and US$11.1 billion in terms of purchasing power parity (PPP[16]). GDP per capita[17] decreased from US$803 (US$2 100 PPP) in 2014 to US$577 (US$1 700 PPP) in 2016. Sierra Leone GDP per capita ranks 212 out of 230 countries, demonstrating the high poverty in the country (IFC, 2017, CIA World Factbook, 2017). The International Monetary Fund (IMF) (2017) expects medium-term growth of around 6.5 % by 2020.

The primary agricultural sector accounts for 60.6 % of GDP, and remains the backbone of the economy. Growth in the agricultural sector has been moderate, at 3.0 % in 2015. The secondary industrial sector, dominated by mining, collapsed following the twin shocks in 2014 / 15. The sector contracted 73.9 % in 2015, mainly on account of 83.7 % decline in mining attributable to a 96.5 % slump in iron ore production (from 19.4 million tonnes in 2014 to 0.8 million tonnes in 2015). The sector now contributes 6.5 % to GDP and includes mining of diamonds, iron ore, rutile and bauxite as well as small-scale manufacturing (beverages, textiles, footwear). The tertiary services sector accounts for 32.9 % of GDP and has shown very low growth of 0.51 % in 2015 (CIA World Factbook, 2017, Bank of Sierra Leone, 2016). However, better-than-expected services growth, notably tourism and commerce, was an important component in subsequent economic recovery (IFC, 2017).

Sierra Leone runs a trade deficit of US$646 million. While iron ore used to account for more than 75.0 % of export value, the collapse in the sector has significantly reduced the importance of this commodity. Diamonds now account for 24.5 % of export value in 2016, followed by iron ore at 21.2 % of export value (IFC, 2017). Other export products are rutile, cocoa, coffee and fish (CIA World Factbook, 2017).

Low fiscal revenue is a key structural problem, despite significant efforts to enhance revenues in recent years. Revenue of Le2 889 billion in 2016 was 12.2 % of GDP, below pre-crisis levels of 12.6 % of GDP in 2013. Taxes and royalties account for 94.0 % of fiscal revenue, driven primarily by personal income tax (Le936 billion in 2016), goods and services tax (Le666 billion), import duties (Le382 billion) and corporate income tax (Le324 billion). Mining royalties and licenses generated revenue of Le156 billion in 2016, down from Le235 billion in 2013. Grants (not included in revenue above) have reduced to 3.1 % of GDP, down from 5.4 % of GDP in 2015 at the height of the EVD outbreak, and are expected to reduce further as a percentage of GDP.

Sierra Leone ran a budget deficit of 8.3 % of GDP in 2016, significantly worse than expected. The government must increase domestic revenue mobilization to finance the authorities' Agenda for Prosperity (A4P), the medium-term anchor for economic development (IMF, 2017)

Public and publicly guaranteed (PPG) external debt amounted to US$1.53 billion in 2016, equivalent to 41.3 % of GDP. PPG has increased from 21.3 % of GDP in 2013, mainly due to debt incurred for post EVD recovery and infrastructure construction. Multilateral creditors account for approximately 85 % of PPG, while commercial creditors account for 15 % as of 2016. The latter mostly consists of arrears accumulated prior to and during the civil conflict. Domestic debt amounted to 14.6 % of GDP

[16] Purchasing power parity aims to determine the exchange rate of two currencies by aligning the purchasing power of the currencies. In other words, the expenditure on a similar commodity must be same in both currencies when accounted for by the exchange rate. The purchasing power of each currency is determined in the process.
17 Per capita GDP divides GDP by the number of people in the country. The per capita GDP is especially useful when comparing countries, because it shows the relative performance, and wealth, of countries.

in 2016. Total public debt was 55.9 % of GDP. Sierra Leone is at moderate risk of debt distress (IFC, 2017).

Contribution of the mining sector and SRL

Mining companies account almost solely for local procurement of goods in services amongst the economic sectors monitored for local content contribution. The majority of procurement benefits national companies in Sierra Leone (DAI and GIZ, 2017), given the lack of capacity of local businesses. SRL has the highest procurement spending amongst the four companies monitored for local content (DAI and GIZ, 2017), at some US$20 million in 2016, almost all of which goes to companies outside of the immediate mine region.

Considering SRL's contribution to the economy, capital expenditure on the construction of Gangama was approximately US$38 million over a 30-month period. Of this, 52 % was paid to foreign suppliers, 36.5 % to local suppliers and 11.5 % to payroll and stocks withdrawal. Capital expenditure on the construction of Gbeni was a further US$10.3 million, primarily to foreign suppliers.

Total SRL expenditure on workforce and goods and services was US$70.2 million in 2016, of which US$56.5 million were spent on goods and services (US$19 million of this was spent on goods and services in Sierra Leone) (DAI and GIZ, 2017). It is therefore assumed that US$13.7 million was spent on payroll. The 2016 SRL expenditure is equivalent to 1.8 % of Sierra Leone GDP.

Changes in output, employment and/or prices give rise to changes in demand for a range of goods and services, which in turn generate a further round of income and employment effects. Multipliers estimate these knock-on effects of e.g. an investment on output and employment in the economy. Effects are typically direct, indirect and induced:

- Direct economic effects occur through the employment of staff and direct procurement from suppliers, e.g. raw materials, equipment and contractors, in the sector where the shock occurs;
- Indirect economic effects arise mainly as a result of suppliers and service providers procuring goods and services from other businesses in other sectors; and
- Induced economic effects occur through increased demand from households earning additional income from direct and indirect effects of increased demand.

Multipliers are difficult to determine, and various estimates exist. A World Bank (2006) study estimated a multiplier of 1.56 for SRL, the highest multiplier of the four mining companies assessed. SRL's total economic contribution to the economy of Sierra Leone, including indirect and induced effects, was estimated at US$109 553 671 in 2016 (DAI and GIZ, 2017), the highest of the four mining companies assessed. Based on those figures, SRL's total contribution in 2016 was equivalent to 2.8 % of GDP, which is highly significant for a single operation, and illustrates the small size of the economy of Sierra Leone. Estimates of ongoing operational expenditure were not available, and it is not clear what component of the 2016 expenditure was directly related to the mine expansion.

As a broad overview of SRL's tax payments in 2015, as reported in SRL (2015), is provided below:

- Personal income tax in Sierra Leone is paid at a sliding scale of up to 35 % (SRL 2018). Payroll of US$13.7 million[18] could thus generate up to US$4.8 million personal income tax if all employees were taxed at the maximum rate. SRL reports paying Pay As You Earn (PAYE) personal income taxes of US$4.3 million in 2015, which is equivalent to approximately 2.7 % of government income from mining royalties and licenses that year [19];

[18] Total SRL expenditure on workforce and goods and services was US$ 70.2 million in 2016, of which US$ 56.5 million were spent on goods and services (US$19 million this expenditure was spent on goods and services in Sierra Leone) (DAI and GIZ, 2017). It is therefore assumed that US$ 13.7 million was spent on payroll.

[19] Personal income tax generated revenue of Le650 billion in 2015 (IMF, 2017), equivalent to US$151.2 million at an exchange rate of approximately 4 300 (www.xe.com).

- SRL reports paying royalties of US$4.1 million in 2015, which is equivalent to approximately 20.3 % of government income from mining royalties and licenses that year[20];
- SRL reports paying corporate (minimum turnover) tax of US$3.7 million in 2015, which is equivalent to approximately 6.5% of government income from corporate income tax that year[21]; and
- SRL also makes significant additional contributions to community development projects. Community development expenditure amounted to Le1.01 billion (approximately US$135,000) in the second half of 2016, and Le1.26 billion (approximately US$202,000) in the second quarter of 2017 (SRL 2018). The combined amount of those three quarters is approximately half of total surface rent payment made by SRL in 2018, which is another payment aimed at communities. Payments benefit various development project, such as education (e.g. school structures, furniture and teacher stipend) and health (e.g. water supply).

Livelihoods

CEMMATS assessed livelihoods dependencies and activities in 2012. The social survey conducted by SRK in 2017 found that the strong reliance on livelihood activities had not changed significantly, apart from the fact that irrigation was not mentioned by participants or observed by SRK (SRK, 2017b).

The HHS and RRA (SRK, 2017a; 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 common. All participants to the RRA (SRK, 2017b) said that manual labour was the only means of farming, and that mechanical systems were not available or affordable. Additionally, tools used to prepare land for crop, livestock and tree farming were reported to be either ineffective or non-durable. The majority of participants (SRK, 2017a) named cassava (33 %) as the most important livelihood crop, followed by groundnuts (24 %) and maize (10 %). Additionally, while it was not a crop farmed by the majority of the participants, uplands rice was identified as the third most important livelihood crop by 9 % of participants. Fruit and nut trees were found to be an important resource, with a wide variety of tree types present in the study area. The trees mostly reported in the HHS (SRK, 2017a) included mango (23 %), banana and oil palm (both 11 %), coconut (11 %) and orange (8 %). The same trees were also reported by participants to be the most important trees in terms of livelihoods. Livestock were also identified as an agricultural livelihood source, however not at the same level as crops and trees.

As presented in Figure 4-79, the main source of income for households in the study area who partook in the HHS (SRK, 2017a) was reported to be subsistence farming (38 %). The second most common income source was found to be remittances (36%) from family members working elsewhere. Of the 13 % that identified their main source of income as formal employment, 95 participants were currently working for SRL, while a further 20 had worked for SRL previously. Additionally, 41 participants had family members currently working at SRL, while 26 had family members who had previously worked for SRL.

In the HHS and RRA (SRK, 2017a and b), participants claimed that they used the majority of their income to pay for school fees, food, medication and utilities. Additional income generated by a job would be used for repairing houses, school fees, food, roofing, and vocational and technical training. School fees were not reported as the main expenditure in previous studies. CEMMATS (2012) reported that in 2001 approximately 58% of the household income was spent on purchasing food and 14 % was used for health and medical care. School expenses and clothing accounted for 11 % and 8 % respectively. The use of income changed slightly in 2012, with the majority of households

[20] Mining royalties and licenses generated revenue of Le87 billion in 2015 (IMF, 2017), equivalent to US$20.2 million at an exchange rate of approximately 4 300 (www.xe.com).
[21] Corporate income taxes generated revenue of Le245 billion in 2015 (IMF, 2017), equivalent to US$57 million at an exchange rate of approximately 4 300 (www.xe.com).

reportedly spending their income on food. This was ascribed to the increase in food prices (CEMMATS 2012).

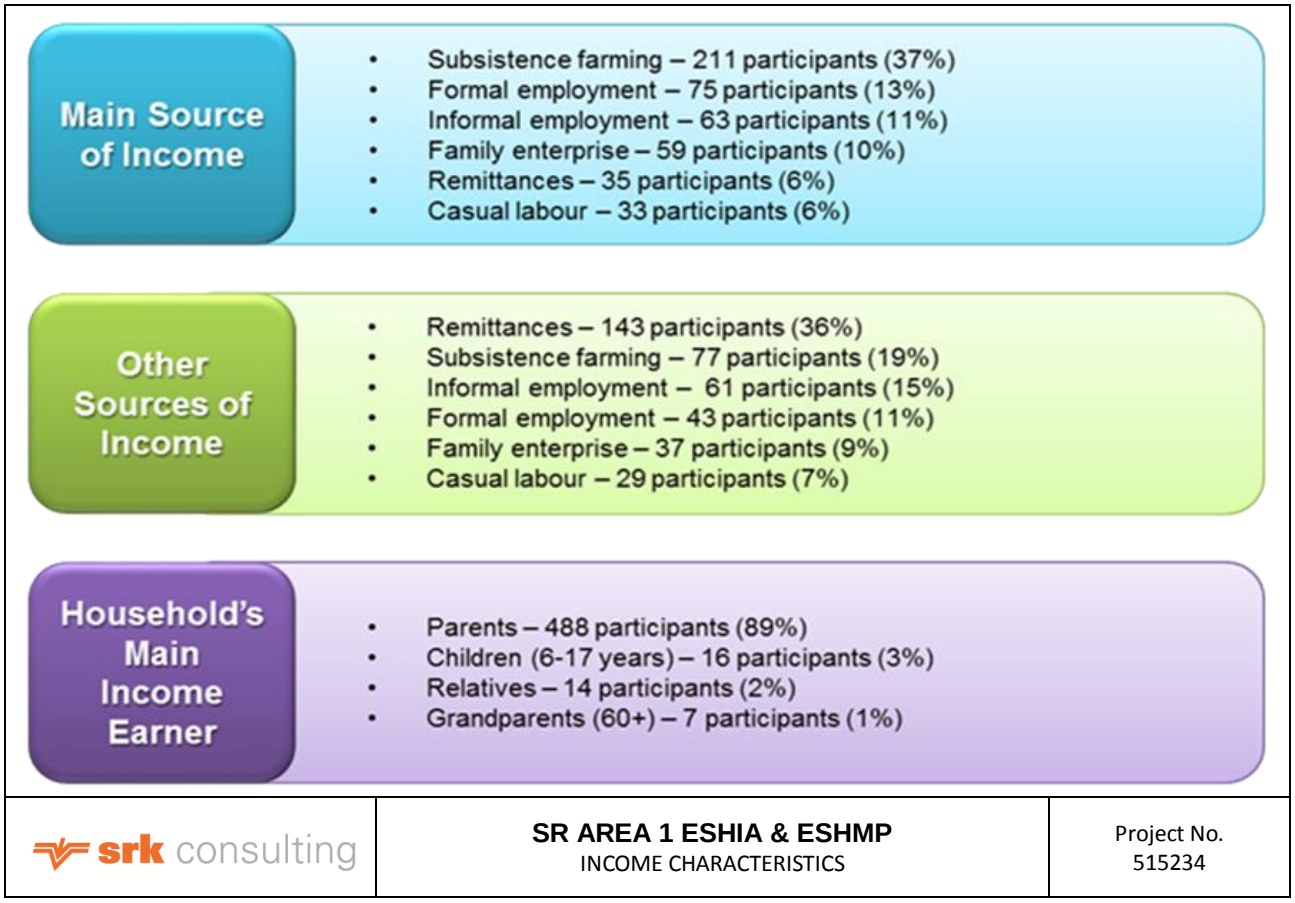


Figure 4-79: Income characteristics of SR Area 1

Labour

Employment was reportedly low: Of the male HHS participants (SRK, 2017a), close to 50 % were unemployed, 37 % were students, while the rest were employed (14 %). Amongst female participants, 60% were unemployed, 36 % were students and only 4 % were employed. Key employers in the study area included stone mining, the Sierra Tropical Pineapple farm, the Carmanor Oil Palm plantations and Beowulf Security Company.

Contribution of SRL to employment

SRL is the largest employer in the study area, and one of the largest private sector employers in Sierra Leone (SRL 2015). SRL has generated the direct employment of:

- 115 workers (34 nationals and 81 expatriates) during construction;
- 2 614 workers, comprised of 1 871 SLR employees (1 739 nationals and 39 expatriates) and 743 main contractor staff (725 nationals and 18 expatriates) during operation; and
- 300 casual employees.

SRL spent US$4.4 million on payroll during the construction of Gangama Phase over an approximately 30-month period. US$13.7 million was spent on payroll in 2016[22]. While information on average local

[22] Total SRL expenditure on workforce and goods and services was US$ 70.2 million in 2016, of which US$ 56.5 million were spent on goods and services (US$19 million this expenditure was spent on goods and services in Sierra Leone) (DAI and GIZ, 2017). It is therefore assumed that US$ 13.7 million was spent on payroll.

wages is not available, 93 % of SRL's workforce is national, and the income benefit will accrue predominantly at a national level.

Direct employment at the project may have generated up to:

- 897 indirect and induced employment opportunities during construction; and
- 19,605 indirect and induced employment opportunities during operation.

People who benefit directly or indirectly from the project also support a number of dependants. Based on the average household size of 5.2 persons and assuming one income earner per household, each income earner on average supports 4.2 dependants. Assuming that 22,000 nationals derive income from direct, indirect and induced employment (or reduced underemployment) related to the project, an additional 92,400 dependants could benefit (albeit to a modest extent considering the generally low earnings in the informal economy and the high dependency ratio).

When comparing the number of potential beneficiaries to the population of the study area, which is estimated at 20,800, it is clear that the benefits of employment extend beyond the direct project area.

Employment also conveys skills that make people more employable in this large sector, and increase their chances of earning a higher income in the long term. SRL dedicated 0.2% of manhours to training in 2016, below national targets for mining companies (DAI and GIZ, 2017).

Goods and services

Goods are best described items that are tangible, such as produce, clothes and building materials. Services are activities provided by other people, such as doctors, restaurants and hairdressers. The presence of towns and larger villages in SR Area 1 facilitate the trade of goods and services.

The local market economy is an important point from which communities buy and sell their produce and goods. Poor road conditions resulted in goods and services being more expensive due to access issues, according to the Focus Group Discussions with organised business. This was largely blamed on transport costs. The presence of SRL was reported to be central to trade and business in the area, because it encouraged buyers and sellers (SRK, 2017d).

Housing

Different housing standards and conditions depend on age, income, family and geographic location.

Housing conditions

Housing consists of a mixture of traditional buildings and buildings that were more modern. Households that were relocated during previous / historic mine expansion projects had rectangular structures, made of mud or cement brick walls and fibre concrete roofs. These houses were also usually found in the larger towns and villages. Raffia palm, grass, mud and bamboo are key components of structures. Sundried bricks, cement brick, mud and sticks are options used for walls, and corrugated iron walls were observed in the built-up areas. Where mud is used, erosion of the walls was evident due to heavy rains in the wet season. Roofs consist of corrugated iron, palm leaves, and grass thatch. Soil and concrete floors are present, some of these floors tiled.

Housing stock

SRL provides housing to specific groups of employees. There are two accommodation camps; i) Mobimbi camp for management employees, located on Mobimbi hill; and ii) Kpanguma camp for senior staff, located near the SRL clinic in proximity to the plant area. Staff from outside of the area who do not qualify to live in camps are required to find their own accommodation in the surrounding towns and those employed from the host communities reside in their private homes.

The HHS (SRK, 2017a) recorded 2 960 household members in 560 households in total, resulting in an average household size of 5.2 persons per household. The average number of households per house correlates with the Southern Province figure of an average of 1.4.

Housing arrangement

The majority of HHS participants reportedly used the main house for sleeping (SRK, 2017a). The number of rooms in the main building varied from one to 20. Kitchens were located outside for 97 % of households, as were areas for cleaning[23]. A total of 302 households had used the bush as toilets. A total of 293 households reported to use hand-made closed-off outside areas for cleaning the body[24] (not including mine ponds).

Ten households reported having outside living areas, with many using open spaces around their houses during the dry season for social gatherings. House verandas were also observed as a popular place to sit and live (SRK, 2017b).

Only five participants reported to have enclosures for livestock. Nineteen households had outside storerooms. Three households had additional structures, which were used as shops, or market structures. Seven households reported to have secret society houses[25] (SRK, 2017a).

Housing demand

Formal housing demand figures were not available. Nationally, the indication is that a level of demand will be driven by population growth, whilst in and around the study area, demand is likely to be driven by natural growth and in-migration. The indication is that approximately 10 % of the household survey participants rented the building and / or the land they occupied. Some respondents have a second dwelling in Moriba Town, for children to stay at when going to school, or for parents / owners to stay there for work. Many who use SRL accommodation also seem to rent out their private property.

Land ownership and use

In terms of law in Sierra Leone, all land is owned communally. In traditional areas, Paramount Chiefs mediate access and use. Typically, family elders grant house holds small agricultural plots (average 1.2 ha).

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. Some participants owned their land with no proof, rented or were using / occupying the land illegally. The most cited reasons for occupying specific land were inheriting (43 %), followed by only land available (24 %) and close to job opportunities (10 %). A minority of participants suggested that a large number of people in the study area were tenants and not outright landowners.

Slash and burn agriculture was mentioned as the most common land use practice in the study area (SRK, 2017a and b). This is similar to CEMMATS' report (2012), which reported that crop rotation using fallow periods was common, with a cycle of approximately 15 years. As land availability has decreased due to a combination of growing population, poor agricultural practice and land management and mining activity, these periods have reduced to as little as four years (CEMMATS, 2012).

According to CEMMATS (2012) slash and burn has been practiced in the region for years: "This has resulted in patches of remnant forests that reflect typical species of the original vegetation, prior to

[23] Cleaning refers to cleaning of household equipment in this instance
[24] Cleaning refers to cleaning of the body (personal) in this instance
[25] These houses are used as the meeting place of secret societies in the Study area

agricultural development". As a result of a history of slash and burn, "numerous succession vegetation stages exist throughout the area. The continued cycle limits growth to the early succession stages where weedy and invasive species typically dominate. Some primary growth species do occur in fallow areas, but are typically not allowed to mature. In addition, some species common to primary forests are not likely to re-grow in fallow fields or other disturbed areas".

SRK (SRK, 2017a and b) was informed by participants that the situation had not changed since 2012 (SRK, 2017a and b). Typically, slash and burn was performed in the dry season in preparation for the planting of crops in the wet season. It was described as an important method due to the perceived poor soil fertility levels in parts of the study area. An alternative reason given for slash and burn was that it was the most affordable method to clear land, since mechanised clearing was too expensive. Leaving land fallow was not listed as a viable option, as a reported shortage of arable land meant that land which was available had to be used with very short intervals between crops.

Typically slash and burn involves farmers clearing small patches of land for agricultural production by under-brushing, felling and burning existing natural vegetation. The method is favoured by many because it it the fastest and cheapest way to prepare land where access to land and equipment is difficult. Although efficient, slash and burn agriculture is widely regarded as unsustainable (Ecologic, 2018; Okese, 2018; Hauser *et.al,* 2013) because the soil nutrition value is depleted in a relatively short space of time, rendering that specific plot nutrient-deficient and non-arrable.

Remaining forests are restricted to tree lines along steep hilly areas, rivers, streams and as buffers around areas of cultural importance. Where forests have regrown, local people collect wood for building material and fuel. People also collected material for use in rope and string making, brushes and for medicinal reasons. Hunting for bush meat was also noted (CEMMATS, 2012 and SRK, 2017b).

Contrary to the 2012 findings (CEMMATS), hunting of birds and collecting of bird eggs were no longer a common practice (SRK, 2017b). Trapping of animals continued to be common (CEMMATS, 2012 and SRK, 2017b).

Palm wine and palm oil are made from oil palms, while raffia palm fronds are used for thatching of roofs. Traditional weave baskets were used for fishing in mine ponds, streams, rivers and mangroves. Fish traps, fishing rods, and hooks were used in deeper waterbodies (CEMMATS, 2012 and SRK, 2017b). According to participants of SRK's study (SRK, 2017b), and observations made by SRK (2017b), the presence of mine ponds made access to agricultural land and plantations more difficult in some cases. Competition for remaining arable land was reported to be growing as the population continued to rely on subsistence farming for food and livelihoods (SRK, 2017b).

Use of natural resources

Natural resources, which can include the ocean, forests, rivers, swamps and other naturally occurring systems are important resources in SR Area 1.

Forested areas, "swamps" (mangroves) and freshwater resources that the communities rely on for a number of ecosystem services, were reported to be in varying states of damage and reduced functionality (SRK, 2017b).

The freshwater systems and ocean are used for fishing by many. According to participants, both freshwater systems and the ocean were depleted of the crustaceans and fish that people used for both subsistence and income. The "swamps" were used for the collection of raffia palms, which are used to make thatching materials for roofs (SRK, 2017b). Other ecosystem services in the "swamps" include the collection of medicinal plants, which were said to be the primary source of treatment in most of the villages. Some plants mentioned in the RRA that were used for medicinal purposes included palms, Gbangbei, Yunbuyambia, Ogobai, Yunbuyambei, Gbogie and Jibui.

The collection of firewood, as well as the creation of charcoal, was another observed ecosystem-based service being utilised in a number of villages. Bush meat and fish were reported to be an important source of protein, and a number of species were mentioned. Fish were caught in nets or on hooks, while bush meat was largely caught in handmade traps (smaller animals) and snares (larger animals).

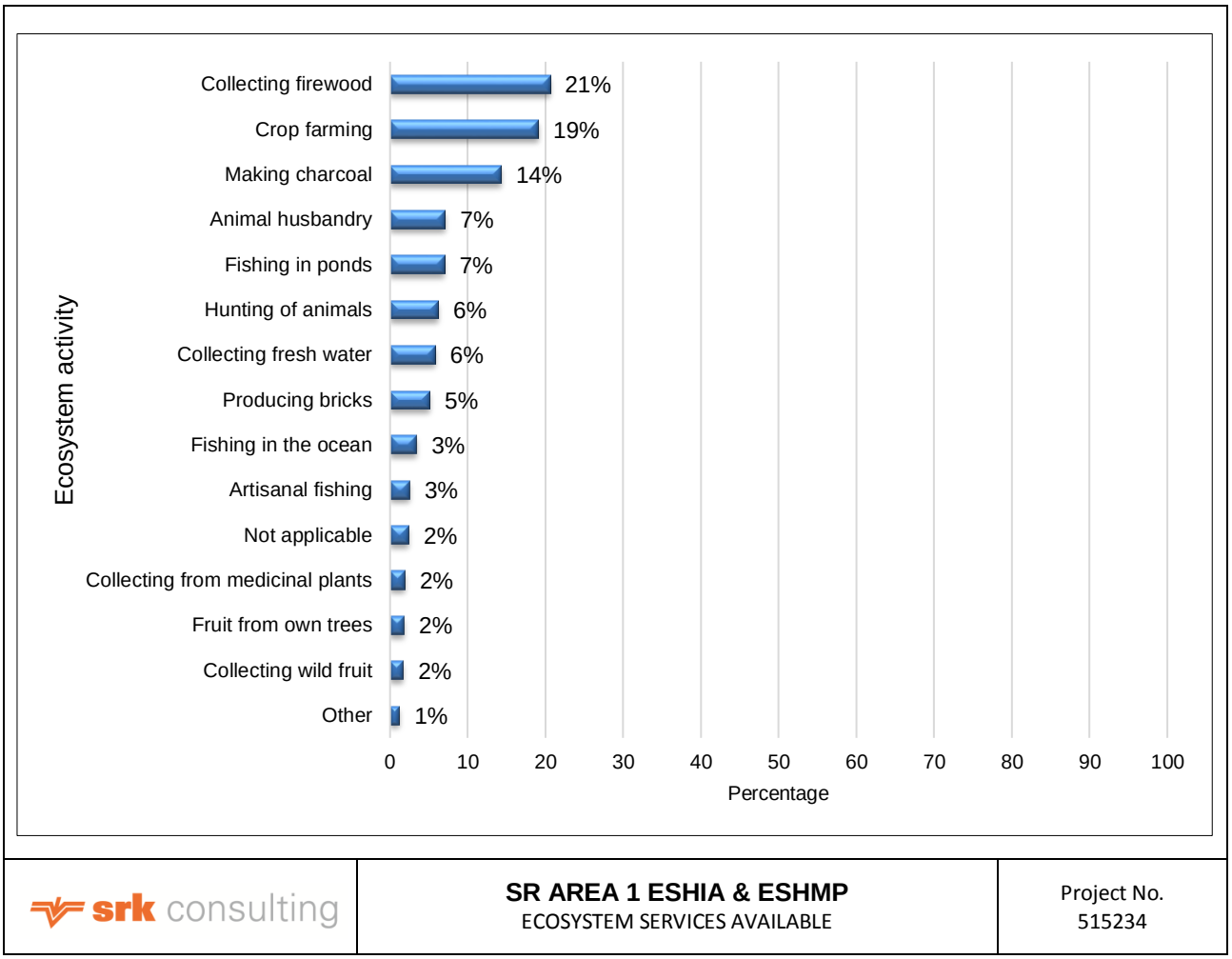


Figure 4-80: Ecosystem service activities

Utilities and service delivery

A breakdown of the availability of utilities and public services in the study area is provided below.

Energy

In the study area, Mobimbi and Kpanguma are supplied with electricity from the SRL power plant. These towns were built by SRL for employees and families (CEMMATS, 2012 and SRK, 2017).

SRK (2017a) found that wood was the preferred means of generating energy for cooking for 107 participants of the HHS, while batteries were the most cited means of generating energy for light amongst 113 participants. Only 38 participants used wood as the major source of energy for warming. The tropical climate of the study area or the fact that the SRK study was completed in the warm wet season probably explains this response (79 participants said they did not use energy for heating). Charcoal was more readily available and used as a source for energy in Moriba Town and Mogbwemo.

Roads

With the exception of the roads servicing the mines in the study area, road conditions are difficult throughout the Districts and access along most roads is restricted, if not entirely impossible, during

the wet season (May to October). Moreover, there are villages within riverine areas that are only accessible by boat. While the roads systems in and around the study area have been improved since the initiation of mining operations in the area, the operation of mine ponds has occasionally led to the flooding of access roads. Alternative routes were created, but these may be less convenient and longer for travellers (CEMMATS 2012).

Transport and travel

It was noted that there was not a lot of private motor vehicle traffic from sedans or light duty vehicles on the various roads around the study area due to low ownership levels, but motorcycles were common.

Water supply and access

CARE, an NGO based in the United States of America, initiated a five-year water, sanitation and waste project prior to the beginning of the civil war. The project, which was further supported and funded by SRL, included the provision of 56 wells and 1,785 pit latrines in 41 villages in SR Area 1 and its immediate surrounds. However, much of this infrastructure was damaged or fell into neglect during the war and is either no longer operational or has been abandoned (SRK, 2017a).

The majority of households sourced their potable water from communal taps, non-mechanical wells and mechanical well (Table 4-69). 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. When wells are dry, alternative water sources reportedly included the mine ponds, swamps, natural ponds and river water. Rain water is only available during the wet season and collected in containers, rather than in storage tanks (SRK, 2017b; Shape, 2018).

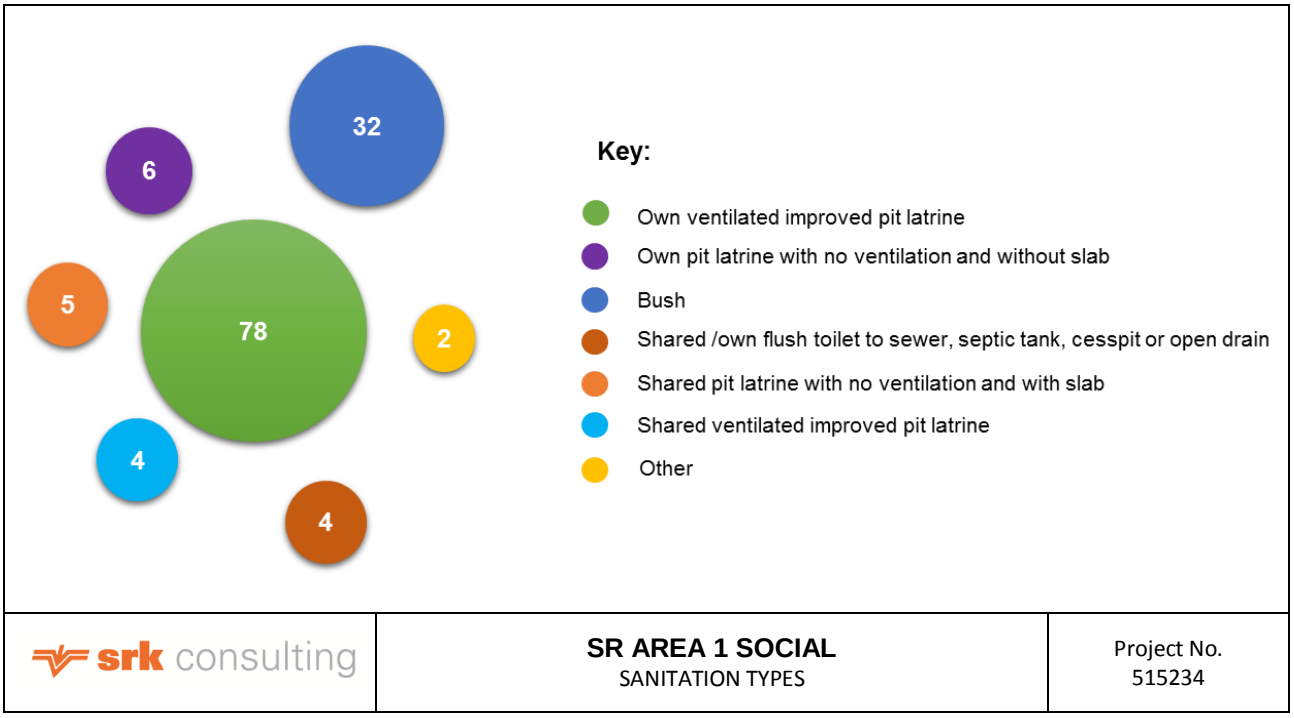
Approximately two thirds of households agreed that they had access to sufficient water (SRK, 2017a). For the majority, the water point was less than an hour's walk away, with some households reporting that it took them 30-50 minutes. For the minority of households, water points are 1-2 hours walking distance away. The majority of participants did not treat their water, while some participants used chlorine.

Table 4-69: Main source of water

Source	Number of Participants	Villages of participants who mentioned these sources
Communal tap	35	Lukia, Madina (FM), Mogbwemo, Mogbomo, Pejebu
Protected well, not mechanical	26	Foya (Nitti), Gbangbama, Kanga, Kpetema, Matagelema, Mokepay, Moriba Town, Segbwema, Shimbek, Victoria
Mechanical well	21	Foia, Kpetema, Yangatoke, Mokepay, Moriba Town, Nyandenhun, Nyorkurvulahun, Pejebu, Segbwema, Victoria
River / dam (mine pond)	18	Foia, Gangama, Gbangbaia, Gbangbama, Kanga, Lungi, Modagba, Motinga, Ngandohun, Nyandenhun
Unprotected spring	13	Canal Junction, Foia, Gbangbaia, Korpama, Lungi, Yangatoke, Mokepay
Borehole	10	Foia, Mogbewa, Mogbomo, Moriba Town, Nyorkurvulahun
Protected spring, not mechanical	6	Foinda, Gbangbaia, Mokepay, Ngandohun
Tap in house / yard	4	Nyorkurvulahun, Mogbomo. This information should be confirmed, since there are no taps in these villages according to the knowledge of the SRK team
Communal tank	1	Foinda

Sanitation

Ownership and use of sanitation facilities was highest in the urban settlements (Moriba Town, Mogbwemo, and Matagelema) and lowest in the more rural villages (Shape, 2018). Access to sanitation in the study area was reportedly limited, and largely, participants claimed to use their own ventilated improved pit latrine (78 participants) and the bush (32 participants) for latrines. SRK (2017a and b) observed that many of pit latrines were in actual fact not improved. A summary of sanitation facilities in the study area is provided in Figure 4-81.



Source: SRK, 2017a

Figure 4-81: Sanitation types

For ablutions, people were mostly observed to be bathing in hand-made structures using buckets outside of their homes and in both mining ponds and fresh water streams.

There were limited hand washing facilities recorded in HHS responses (SRK, 2017a), with 44 of the 134 participants claiming to have a hand washing facility at their house (34 %). Of the 134, 45 (34 %) said they used soap / detergent to wash their hands, 56 (42 %) said they did not wash their hands, and 32 (24 %) said they sometimes did.

In terms of refuse disposal, the majority of HHS participants (62 %) claimed to have their own waste disposal area. A further 21 % made use of a community waste pit, 11 % dumped their refuse anywhere, and 1 % burnt their waste. At the Moriba Town meeting the SRK team attended (SRK, 2017a), mention was made that the main refuse disposal source has to be moved due to the fact that it is situated amongst household structures.

Quality of life indicators

Using the information derived from this baseline, a high level, qualitative opinion of quality of life in the study area has been undertaken in Table 4-70 below.

Table 4-70: High level opinion on Quality of Life in the study area

Dimension	Basic quantitative indicators available for Sierra Leone that contribute to quality of life	Qualitative information at study area level that could contribute to Quality of life
Health	• Life expectancy at birth: 58.2 years.	• Limited use of mosquito nets; and • Low levels of detailed knowledge regarding HIV / AIDS and EVD.
Political stability and security	• Political stability and security ratings: 108th out of 194 countries (2017 estimate).	• Stable, potentially volatile.
Family life	• Divorce rate (per 1,000 population): 5.6 (2008 estimate).	• Divorce not common in the study area.
Climate and geography	• Latitude, to distinguish between warmer and colder climates: average deviation of temperatures more than 14 degrees C: 3 months with less than 30 mm rainfall (December to March).	• Similar to the national conditions; • Instances of flooding in the wet season; and • Low soil nutrition and high permeability.
Job security	• Unemployment rate: 3 % (subsistence agriculture considered as formal employment, therefore the actual rate could be considered much higher).	• Subsistence agriculture predominant economic activity in the study area..
Gender equality	• Parliamentary seats held by women: 13.2 %.	• High dropout rate for girls going into secondary school.
Quality of live summary for study area:	Quality of life factors in the study area generally align with those of Sierra Leone. A number of factors which appear to negatively affect general well-being amonts people in the study area include food shortages, unemployment and idleness, lack of sanitation and health services. Other factors which appear to be improving and may affect quality of life perceptions positively in the study area include improving access to education (including school attendance), diverse number of businesses, and road access to markets and town centres. Quality of life factors in the study area generally align with those of Sierra Leone. Poverty in the study area is likely to affect job security, family life, community life, health and material wellbeing.	

Cultural heritage, recreation and areas of historical, cultural or scientific interest

Cultural heritage

The study area does not host a museum. Areas of significant cultural interest have not been formally established (SRK, 2018(3)). CEMMATS (CEMMATS, 2012) reported that the possibility of finding intact historical and archaeological remains was low due to centuries of agricultural slash and burn activities. CEMMATS (CEMMATS, 2012) reported that *nomoli* figurines might be found, w which are spiritual symbols allegedly used to aid farming activities. Caves occur in the study area (CEMMATS, 2012), but these are known only by local people. These caves might have historical and archaeological value. CEMMATS (CEMMATS, 2012) mentioned the villages Hemabu, Jangaloh and Nyandehun as significant centres for herbal medicine and divination since pre-colonial times.

CEMMATS (CEMMATS, 2012) reported that the “Foot-in-Stone” artefact was identified during the March 2001 field studies for the SRL EIA at that time. This artefact located east of Yangatoke. The site is where Solondo, the founder of old Mbelleh, allegedly left his foot imprint in a stone and his wife left imprints for her resting stool. The area has been left untouched although encroachment from settlements is occurring.

A tall, high grave for a human being was pointed out to SRK (2017) in the area of Segbwema. This grave was supposed to be moved to make space for mining related activities, but the driver of the site clearing equipment claimed to have been stopped by a ghost to clear the gravesite. Subsequently the grave was left intact.

When asked about areas of historical and cultural significance, the majority of the participants referred to mosques and church buildings. The lack of Barris and / or the inability to maintain these buildings was mentioned as a key area of concern. The Barri, also used as a venue for Native Administration Courts to sit, is a “community hall” where community meetings are held and other gatherings take place. It is regarded as a central point where decisions are made. Assistance from SRL with maintenance and provision of these buildings have been requested by various villages.

The areas where secret societies meet had not been identified, since the disclosure of the location of these areas was not allowed. Mining activities had reportedly historically impacted on some of these areas, sometimes without allowing for the necessary cleansing rituals prior to transitioning to a new area. In order for these rituals to happen prior to mining activities proceeding, the communities had to be informed timeously about the land clearance and mining plan. SRL (2017) communicated to SRK that all the rituals required to cleanse the land had been conducted in accordance to local requirements since late 2016.

Recreation

While the large majority of respondents to the RRA suggested that they did not have a place they could go to for recreation purposes, others would spend their recreational time at the beach, the football field or their own / others houses.

Vulnerability

Social vulnerability refers to the inability of people to respond to negative impacts from multiple stressors to which they are exposed. Much like the quality of life indicators aforementioned, vulnerability cannot be determined without understanding the interactions between a number of socio-economic and environmental variables. Different variables contribute to each unique house holds vulnerability.

However, on a broad level, the study area and the majority of its households could be seen as potentially vulnerable. The prevailing poverty was noted in most households in the HHS and RRA. This, along with key social baseline conditions (e.g. unemployment, inadequate land for agriculture and poor nutritional health), decreases the study areas ability to build resilience to events. As such, a number of households are vulnerable. Households with persons with disabilities, the sick, elderly and children, are therefore considered vulnerable (at varying levels of interaction between variables).

4.14 Community health environment

The content of this section is adapted from the specialist Rapid Health Impact Assessment (SHAPE 2018) which is attached as Appendix D.

This section presents the community health baseline status of communities living in close proximity to the SR Area 1.

4.14.1 Methodology

It is important that a baseline description of the prevailing health status in the potentially affected communities be established as part of the Rapid Health Impact Assessment process. This provides for the evidence base to support the modelling of potential impacts and establishes a point of departure against which future impacts can be measured. The analysis and reporting of baseline information is

generally presented in the Environmental Health Area framework, which supports a systematic review of data and allows for flexibility in approach. Baseline data was collected from various primary and secondary data sources as described in Table 4-71.

Table 4-71: Source of baseline health data

Baseline Health Data Collection and Sources			
Primary Data		**Secondary Data**	
Type of data	**Source of data**	**Type of data**	**Source of data**
Qualitative from participatory discussions	Interviews with broad range of stakeholders including health authorities, local authorities and health development partners.	Health data	Literature review of health data in public domain including: • Standard open source literature (such as WHO reports etc.); • Published peer review studies; • Health statistics and records from national, District and local sources; and • Health studies performed by agencies and NGOs.
	Group meetings with local authorities and communities.	Social data	• Social baseline and impact assessment reports as well as community development reports; and • Other data such as traffic and crime reports.
	Focus Group Discussions with key sections of the community, including vulnerable groups. Women are often used as the default group.	Environmental data	• Specialist biophysical reports on aspects such as water and air quality; • Environmental monitoring data on aspects such as water and air quality; and • Maps and spatial areas of influence.
	Direct visualisation of communities, prevailing environmental health and social challenges.	Similar projects	Evaluating similar projects in similar settings and understanding their potential and actual impacts and what mitigation measures were applied.
Quantitative	Epidemiological cross-sectional baseline health surveys focussed at specific objectives.	Stakeholder engagement and reports	Analysis of minutes or reports from stakeholder meetings.
	Data sources from social and environmental baselines and impact assessments.		Community grievance or concerns register.
	Routine health information systems.		

4.14.2 National and regional context

National and district health profile and indicators

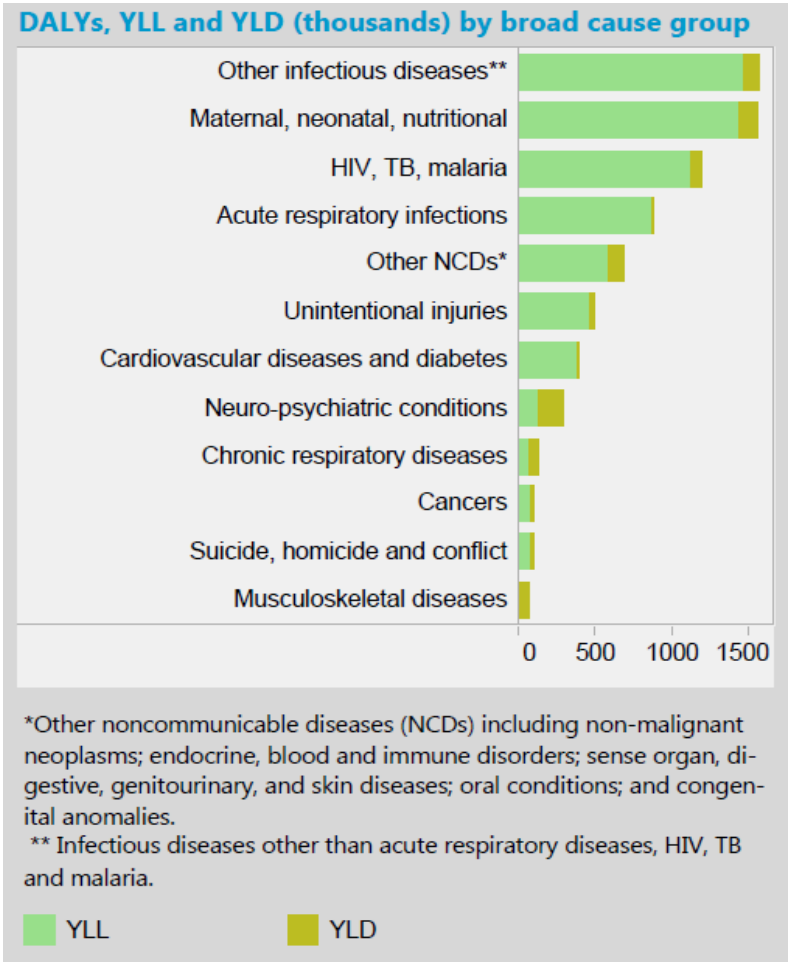
Years of conflict and the recent EVD epidemic have had a major impact on the health sector in Sierra Leone. Life expectancy at birth stands at 50.1, increasing by 11 years between 2000 and 2012, but still below the African average of 58 years and much lower than the global average of 70 years.

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 EVD epidemic in history, where 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 and injuries are increasing in significance, with cardiovascular diseases, cancer, diabetes and chronic respiratory disease, as well as injuries, are increasingly responsible for premature death and disability contributing to a double burden of communicable and non-communicable disease.

Figure 4-82 shows the leading causes of deaths nationally, according to latest estimates[26]. Malaria remains the single biggest cause, followed by lower respiratory infections and diarrhoeal diseases. EVD emerged as the fourth leading cause of deaths in 2015. Non-communicable diseases particularly cardiovascular disease and ischaemic heart disease[27] also rank among the top ten causes of deaths. HIV / AIDS, meningitis and neonatal sepsis complete the list.



srk consulting	SR AREA 1 ESHIA & ESHMP BROAD CAUSE OF DISEASE BURDEN IN SIERRA LEONE	Project No. 515234

Figure 4-82: Broad cause of disease burden in Sierra Leone, 2012[19]

[26] Source: WHO. Sierra Leone: Health Profile. January 2015 [cited 2017 July]; Available from: http://www.who.int/gho/countries/sle.pdf?ua=1.
[27] Ischaemic heart disease is a disease characterised by reduced blood supply to the heart.

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, an eye and skin disease also known as river blindness caused by a parasitic worm. 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.

Health system and infrastructure

Access to quality health care is a major national and public health concern in Sierra Leone. This is attributed to inadequate human resources, limited health expenditure, and problems d with the drug and medical supply chain. While the country had embarked on the process of rebuilding and rehabilitating its health system, following a decade-long civil, the vulnerability in the health sector was exposed during the 2014-2016 EVD epidemic. This highlighted many gaps in service delivery, and the lack of preparedness to respond to disease outbreaks. Post EVD, the country has embarked on another recovery plan and review of various health policies and plans.

The public health sector accounts for about 50 % of health care services nationally, with the other half provided through the private sector, mainly NGOs, health development partners, faith-based organisations and private-for-profit institutions.

4.14.3 Study area findings

Primary data collected from the SR Area 1 and informed by the national and regional context is presented in the sections below.

Communicable diseases linked to the living environment

Communicable diseases (e.g. Acute Respiratory Infections (ARIs), pneumonia, TB, EVD, meningitis, influenza, leprosy, etc.) rely on fluid exchange, contaminated substances, or close contact to travel from an infected carrier to a healthy individual. Therefore, they are directly linked to housing design, overcrowding and housing inflation, with the housing environment a determinant that affects human health.

Findings from key stakeholder interviews

Poor housing and crowding in Moriba Town and Mogbwemo were cited by stakeholders during the Key Stakeholder Interviews, as a key predisposing factor for communicable diseases in the study area. ARIs were 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 12 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.

It was reported by key stakeholders that influx management was handled well during the EVD outbreak as new arrivals (or harbouring of people) in the area were immediately noted, with reports of a few suspected cases (or known contacts under surveillance) detected and sent back to areas where they

were under monitoring. When other mines closed during the EVD outbreak, a lot of people descended on the study area in search of opportunities.

Findings from Focus Group Discussions

According to participants, most households in the area consist of five to seven persons and the majority of housing structures consist of two or three rooms. In Moriba Town and Mogbwemo, it was reported that housing was inadequate because of high demand. Participants living in rental accommodation especially in Moriba Town, Mogbwemo and Matagelema reported that rental fees were increasing every year. Coughs and colds (symptoms of ARI) were consistently mentioned among the top five ailments affecting young children. Participants attributed this to dust during the dry season, weather changes, and poor housing.

Findings from direct observations

Housing varied across the area. The more urbanised communities (Moriba Town, Mogbwemo and Matagelema) had predominantly solid housing made of cement and zinc sheet roofing. The more rural villages (Foinda, Gbangbaia, Junctuiola, etc.) had a mix of traditional structures made of mud walls and grass thatch roofing as well modern semi-solid or solid structures. Overcrowding was evident in some parts, especially Foinda and some sections of Moriba Town and Mogbwemo.

Vector related diseases

Vector-borne diseases are infections transmitted by the bite of infected arthropod species, such as mosquitoes, ticks, sand flies, and blackflies. Climatic factors influence survival and reproduction rates of vectors, in turn influencing habitat suitability, distribution and abundance; intensity and temporal pattern of vector activity.

Findings from key stakeholder interviews

Malaria was reported as the number one cause of morbidity. 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 wet season (May to October). 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).

Findings from Focus Group Discussions

Malaria was unanimously and consistently mentioned among the top three ailments in the study area, affecting both children and adults. Participants attributed the high burden of malaria to: high occurrence of mosquitoes in their surroundings; stagnant water; poor housing; and too much vegetation. ITN coverage was generally high with nearly all participants reporting to have at least one ITN for their household. The majority of the ITNs were received from a mass distribution campaign in June 2017. Participants also acknowledged that pregnant women and children under 5 years often receive at least one ITN during routine clinic visits. ITN utilisation ranged from 13 % in Matagelema, 42 % in Ndendemoia and 53 % in Moriba Town to 100 % (Gbangbama, Junctuiola, and Gbangbaia). A summary of coverage of malaria control in Bonthe and Moyamba Districts is provided in Table 4-72. Access to free treatment for malaria was limited as a result of frequent lack of medication at the local health facilities. Participants reported that they often buy anti-malarials from private pharmacies as the government facilities do not have these available.

Table 4-72: Coverage of malaria control interventions in Bonthe and Moyamba Districts, 2013

Intervention	Bonthe District	Moyamba District	National Average
ITN Coverage	72 %	71 %	64 %
Number of ITNs per household	1.3	1.5	1.2
ITN utilisation by children under-five years	56 %	59 %	49 %
ITN utilisation by pregnant women	59 %	65 %	53 %
IRS Coverage	0.2 %	0 %	4.8 %
IPT Coverage (at least one dose)	53 %	71 %	62 %

Findings from direct observations

Environmental risk factors for mosquito breeding were largely evident. The study was conducted during the wet season and pools of stagnant water were observed in all the villages. Several mining ponds were observed, and the majority of dwellings were surrounded by bushy vegetation. None of the observed community housing structures had windows or doors screened against entry for mosquitoes.

Soil, water and waste related diseases

The prevalence of soil, water and waste-related diseases highly depend on sanitation facilities and access to safe drinking water, factors which often show strong variations at local, national and regional levels.

Findings from key stakeholder interviews

Poor access to safe drinking water and inadequate sanitation was listed among key risk factors for disease burden in the study area. It was reported by the Bonthe District Medical Officer (DMO) (pers. comm, 2017) that less than half of households have access to improved water sources; principally boreholes and protected deep wells. The other half relies on unsafe sources such as shallow wells and surface water (rivers, ponds and dams). The Moyamba District public health superintendent indicated that very few households in the area have sanitation facilities and that open defecation was prevalent. The District is implementing initiatives to improve sanitation coverage including sensitisation and modelling of low cost latrine structures.

Diarrhoeal disease was mentioned among the top five ailments seen at the local health facilities. However, cases were decreasing, as a result of widespread adoption of hygiene practices such as hand washing, after the EVD outbreak. However, cholera remains an important risk in the area, with the last outbreak occurring in 2012. Typhoid fever also was reported to be highly prevalent in the study area. However, it was acknowledged that this may be over reported as the diagnostic tools used in the health facilities cannot confirm the diagnosis and many of the reported cases were likely to be false positives. Bilharzia also occurs in the area with the key predisposing factor being contact with contaminated surface water in ponds or streams.

SRL clinic reported that the general hygiene and sanitary situation in both Moriba Town and Mogbwemo was poor, with refuse disposal a major problem, as are the lack of sanitary facilities.

Findings from Focus Group Discussions

Poor access to safe drinking water emerged as a major theme in Focus Group Discussions. Sources of drinking water varied from boreholes with hand-pumps, protected wells, shallow wells, dams and streams. Rainwater was only available during the wet season and collected in containers during rains, rather than harvesting into storage tanks. Moriba Town was reported to have only one functional borehole. Mogbwemo had several functional boreholes and protected deep wells. Some of the villages

had boreholes that were not functional (three in Matagelema, two in Ndendemoia, one in Gangama). In Foinda, there was only one borehole (hand-pump) and three wells.

Few households have sanitation facilities and predominantly used pit latrines. Ownership and use of sanitation facilities was higher in the urban settlements (Moriba Town, Mogbwemo, and Matagelema) and lowest in the more rural villages. Open defecation is prevalent in the study area (in all the villages) and diarrhoea was mentioned among the most common ailments affecting young children in the study area.

Disposal of household waste was a challenge. Some households had garbage pits while others burnt or disposed waste near the dams, in the bush or garden. There were no garbage collection services.

Findings from direct observations

Various types of water sources were observed in the area and were mainly hand-pumps and protected deep wells. Some of the hand-pumps were not functional. The environment in most of the settlements was generally clean. In some host communities, garbage was piled up in designated areas.

Pit latrines were the predominant form of sanitation facility, where these facilities were in fact available.

SRL has provided water tanks in Foinda Village as the community has expressed concern that their normal drinking water sources have been contaminated by mining activities.

On observation during the field visit by the health specialist, the mine ponds were not used for any commercial purpose, but people using the water bodies to wash clothes and vehicles was noted.

Sexually-transmitted infections and high risk sexual practices, including HIV / AIDS

Findings from key stakeholder interviews

HIV / AIDS was mentioned among public health concerns in the study area, though the burden was generally low. The Moyamba DHMT identified ‘mining areas’ as a hotspot for HIV infection, with prevalence higher than the District average of 1.3 %. Sexually Transmitted Infections (STIs) were reported as a significant challenge. Gonorrhoea was specifically mentioned as a frequent diagnosis. Cases of syphilis are also recorded. Mining areas were identified as hotspots for the transmission of STIs. The Moriba Town community health post reported that STIs, particularly gonorrhoea, are among the top five diagnoses in adults. It was thought that stigma and concerns related to confidentiality would affect people seeking treatment for STIs, with patients potentially seeking treatment from street pharmacies or traditional medicine. Contributing factors to the high burden of STIs were identified as: the cultural practice of polygamy, multiple sexual partnerships and the low uptake of condom usage.

The Bonthe District Medical Officers reported that polygamy and multiple sexual partnerships were common, with both men and women having at least 2-3 boy / girlfriends. They acknowledged that the burden of disease or prevalence of HIV in the study area was far higher than reported. Sex is commonly sold for material gain in the bigger towns around SR Area 1 and the civil war affected transactional sexual practices, as orphans resorted to this practice as a form of livelihood. However, teenage pregnancy was not considered to be a major issue by the health authority (although this contradicts what other key stakeholders mentioned).

A large nursing school in Mattru was said to attract men from around the country in search of young single women. These young girls were highly vulnerable to advances of men with money, which lead to numerous ‘transactional’ sexual type relationships. It was apparently not uncommon to have many cases of STIs (even HIV) amongst nursing students. The District Medical Officers thought this relevant as young girls may be similarly vulnerable to advances from men with money around the mine.

The SRL clinic reported that HIV was routinely tested for during pre-employment medical examinations (as a compulsory test). While apparently it does not influence the decision regarding employment the individual is obliged to take Anti-Retroviral Treatment. The HIV prevalence rate in the workforce is about 3-4 %, higher than the District or national averages.

Condoms are available at the SRL clinic as well as the clinic pharmacy and are distributed to both Kpanguma and Mobimbi camps by the camp facilities management company, ATS.

Numerous entertainment areas and the impression that commercial sex work, drugs and alcoholism are common, creates a highly risky situation in Moriba Town and Mogbwemo. It was reported that girls from other areas come into the area to look for sex work opportunities, but transactional sex also occurs as a form of livelihood for local women given the high levels of poverty.

Findings from Focus Group Discussions

STIs emerged a major theme in most of the discussions particularly in Moriba Town, Mogbwemo, and Matagelema. Participants reported that polygamy is very common and generally an accepted cultural practice. Women participants claimed that most of the men are not faithful and admitted that women also have extramarital affairs. Women reported that in the context of polygamy, the men are less available for them hence they (women) “have to compensate” by having other partners.

Transactional sex is common and women in Moriba Town, Mogbwemo and Matagelema indicated that it is very common for men to “pay for sex” and that women (some of them identified as Commercial Sex Workers) often target mine employees because they “have more money”. It was also reported that workers from SRL and VIMETCO bauxite mine are clients.

Findings from direct observations

Multiple bars and lodges were evident in Moriba Town and a big night club was present in Mogbwemo, with a vibrant social night life was reported.

Food and nutrition related issues

While mining plays an important role in national domestic product, two-thirds of the national population survives on subsistence agriculture, which represents more than half of the national income. The 2015 National Census found that 56 % of households are engaged in agriculture (85 % practice crop farming, 74 % in livestock keeping, and 34 % in fishery).

Findings from key stakeholder interviews

Food security is a challenge in the study area. This was attributed to inadequate food production and reliance on subsistence agriculture. Livestock farming is done at very small scale. The Moyamba DHMT reported that malnutrition is a key challenge in the District. This was particularly manifest in young children and attributed to inadequate dietary intake, poor dietary diversification due to food taboos and availability of food and the loss of farming land in mining areas. At Moriba community health post and Mokelleh community health centre, malnutrition was listed among the top five diagnoses among young children. Additionally, the Moyamba DHMT reported that 70 out of the 102 facilities in the District had capacity to manage cases of malnutrition.

The Bonthe District Medical Officer reported that malnutrition was a challenge in the District, which was surprising given its proximity to the sea and the available source of protein. The District is doing some research on this to determine the burden of disease and potential contributing factors. A summary of nutritional indicators in Bonthe and Moyamba is provided in Table 4-73.

Findings from Focus Group Discussions

Participants in all the Focus Group Discussions reported that they do not have sufficient food for their household. It emerged that majority eat two meals a day; one in the morning and one in the evening.

The morning meal is often a left over from the previous evening. Food scarcity worsens during the wet season from May to October. A typical meal consists of “fufu” (made from cassava flour) and cassava leaves, beans, or dry fish. Rice is also frequently consumed. Beef or chicken is rarely available and only consumed on special occasion. Milk is generally not available and is hardly consumed (very little cattle farming in the area). Bush meat is less available and considered expensive. Some reported that they no longer eat bush meat since the EVD outbreak.

The majority of participants reported that they buy food and that the price of food has been increasing. The increase in price of food was attributed to bad national road infrastructure hampering food delivery and increasing transportation costs as well as high demand and “strong dollar”.

Table 4-73: Summary of nutritional indicators in Bonthe and Moyamba Districts

Indicator	Bonthe District	Moyamba District	National Level
Stunting (% of children under-5 years)	41.4	33.6	38.0
Underweight (% of children under-5 years)	9.2	11.7	16.4
Wasting (% of children under-5 years)	3.0	9.8	9.3
Anaemia (any) in children under-5 years (%)	79.4	85.4	80.0
Anaemia (any) in women aged 15-49 years (%)	65.5	40.0	44.8

Findings from direct observations

Few households appeared to practice some gardening despite the availability of abundant rainfall during the wet season. There were a few children with features of malnutrition amongst those who were present with their mothers at the focus group discussions.

Non-communicable diseases

The burden of disease attributable to chronic non-communicable diseases is on the increase globally, with a predication that non-communicable diseases and injuries may cause up to 60 % of morbidity and 65 % of mortality by 2020. Cardiovascular diseases, cancer, diabetes and chronic respiratory disease, as well as injuries, are increasingly responsible for premature death and disability Sierra Leone.

Findings from key stakeholder interviews

Non-communicable diseases are an emerging health challenge in the study area, especially increasing cases of hypertension. Stakeholders attributed this to changes in lifestyle and stress. Risk factors for non-communicable diseases such as excessive alcohol consumption and tobacco smoking are prevalent in the area. While local peripheral health units have capacity to diagnose hypertension, treatment remains a challenge. The Moyamba DHMT reported that they see only few cases of diabetes; however, local peripheral health units had no capacity to diagnose diabetes. The SRL clinic reported that hypertension and diabetes was common, and obesity was apparently on the increase.

The Bonthe District Medical Officer reported that there was hardly any data on non-communicable diseases in the District, with under reporting likely, as the disease burden is not well recognized.

Findings from focus group discussions

High blood pressure and palpitations were mentioned among health conditions affecting adults in the study area. Participants attributed this to stress while others did not know the cause. No other non-communicable diseases were mentioned.

Findings from direct observations

Alcohol consumption was evidenced by the presence of empty packets of spirits and bottles in the environment especially in Mogbwemo and Moriba Town. Smoking was apparent, and it was observed that most of the local shops sold cigarettes. Exposure to smoke from burning firewood was also observed commonly in most host communities.

Accidents and injuries

Traffic accidents and domestic or other forms of violence are generally of particular relevance in this type of setting where mine access roads are shared with the general public. It is estimated that injuries contribute 10 % of the global disease burden and 8 % of deaths in Sierra Leone.

Findings from key stakeholder interviews

Road traffic accidents did not emerge as a major concern in the study area owing to the poor road network and seemingly less road traffic. However, it was reported that areas in SR Area 1 see more cases, often involving motorcycles, the predominant means of transport. The SRL clinic reported that road traffic accidents were relatively common, especially from motorcycles. Children are often victims of pedestrian vehicle accidents.

The Bonthe District Medical Officer reported that while there is no data, the trend of road traffic accidents appeared to be increasing, with motorcycles especially a high risk. It was mentioned that the motorcycles played an important role in supporting the livelihoods of ex-combatants. All local health facilities lack the capacity to manage trauma or fractures that may be associated with road traffic accidents, and therefore cases are referred to secondary facilities, generally Serabu.

Inter-personal violence is not reported to be common.

Domestic violence was reported as an important concern. At Moriba community health centre, five to six assault related cases are seen every month. Cases are often referred to the police.

A few cases of drowning or near drowning were reported. The mining ponds in the area were seen as an important risk for drowning because they are accessible to the public.

Findings from focus group discussions

A poor road network emerged as an important theme and participants reported that mining activities in the area have contributed to the bad roads. Roads were reported to become very dusty in the dry season, and with reduced visibility accidents occur.

Domestic violence was considered a big issue. Women reported that cases of wife beating and assault are common. Participants attributed this to alcohol abuse, problems in marriages and “jealousy” linked to infidelity.

Findings from direct observations

The road network in the study area consists of unsealed roads. Roads in the SR Area 1 are generally in a good state as they are maintained by the SRL, but as one leaves SR Area 1, the condition deteriorates. The road to Mattru were little more than a track and in a very poor condition. The roads to Moyamba junction are maintained to some extent by the SRL and were in a varying state – with some areas severely potholed and others in good condition. The off-lease roads were also narrow with single carriage bridges with no side barriers. The condition of the roads clearly deteriorated in the wet season, but dust was not evident.

Veterinary medicine and zoonotic diseases

Zoonotic diseases are diseases caused by infectious agents that can be transmitted between animals and humans. Many factors, such as environmental changes, human and animal demography /

migration patterns, pathogen changes and changes in farming practices, as well as human social and cultural factors (burial practices) influence the emergence of zoonotic diseases. It is estimated to 80 % of any new emerging infectious disease will have a zoonotic origin, and these may have potential serious human health and economic impacts.

Findings from key stakeholder interviews

Cases of Viral Haemorrahgic Fevers occur in the area, but data is scarce due to challenges with diagnosis. Suspected cases are often managed in isolation and are samples sent to a reference laboratory for diagnosis.

The EVD outbreak posed a significant challenge to the entire health system in Sierra Leone. According to the Moyamba DHMT, the outbreak affected performance and coverage for routine programmes such as vaccination. The Moyamba District recorded 211-suspected cases and some deaths including three health personnel. At the start of the epidemic Moyamba District had only one holding centre. A new EVD treatment centre opened in the District in December 2014 and helped to contain the outbreak. In the aftermath of the EVD outbreak, surveillance and response to disease outbreaks has significantly improved as well as infection prevention control measures.

The Bonthe District Medical Officer reported that the District had five confirmed cases of EVD during the outbreak, with 136 contacts that were followed up as part of disease surveillance. SRL supported the District prior to and during the outbreak, specifically in terms of surveillance and reporting of suspected cases, supporting by-laws regarding harbouring of suspected cases, and communication and sensitization related to the disease. While health programmes such as the vaccination programme suffered during the outbreak, other areas have been strengthened including data management and reporting / surveillance as well as the outbreak response system.

The SRL clinic reported that bush-meat consumption was still common for those able to afford it.

Dog bites and snake bites are common in the study area. Outright cases of rabies are rare. Post exposure prophylaxis for rabies and snake anti-venom were not available in entire Moyamba District. Rabies vaccine was available in the SRL clinic.

Findings from focus group discussions

All participants reported that they have heard of EVD and were very aware that the outbreak ended in 2016. Since the outbreak, people have become more conscious of their hygiene especially hand washing with soap. Participants reported that they have gone back to their previous burial practices but mentioned that they now handle copses with gloves.

Findings from direct observations

Isolation facilities were seen at the secondary health facilities including at Mattru. Peripheral health units (Moriba Town Community Health Post, Mokelleh Community Health Centre and Gbangbatok) did not have isolation rooms. At Moyamba DHMT headquarters there was a large EVD treatment centre. The facility is now used for storage of equipment and parking for motorcycles.

Environmental health determinants: potentially hazardous materials, noise / vibration and malodours

Environmental health determinants include factors such as air, soil and water pollution as well as possible exposure to pesticides or other organic / inorganic pollutants, noise and malodours. The pathway of human exposure to pollutants can be complex and can occur from a variety of sources such as ambient air, drinking water, soil and food products. Water, air quality and noise management are crucial environmental health factors associated with the SR Area 1.

Findings from key stakeholder interviews

Soil erosion and pollution was reported as one of the contributing factors of food insecurity by stakeholders. This was attributed to negative impacts of mining activities in the area. Furthermore, the occurrence of artificial ponds from mining activities was seen as “damage to the environment” with stakeholders reporting that the activities are moving to new areas without reclaiming mined areas.

Stakeholder mentioned that host communities generally want to live close to roads as this promotes access, but it is a challenge in the dry season due to dust that is generated from passing vehicles.

Findings from focus group discussions

Poor soil quality was mentioned in some of the focus group discussions as a factor that has contributed to diminishing crop yields. Participants in Foinda reported that the local stream has been polluted and water wells have been contaminated. Noise pollution too was a concern in some host communities.

Findings from direct observations

It was observed that some mining activities were very close to the host communities – particularly in Nyandenhun where dredging was ongoing and Foinda where mining / exploration activities were ongoing. The main road in Matagelema was busy and there was a lot of noise from road traffic including mining trucks from VIMETCO bauxite mine. Finally, air quality in all the host communities was generally good and there were no obvious malodours noted at the time of the survey.

Social determinants of health

The health status of a population is affected by factors known as health determinants. These are varied and include natural and biological factors (age, gender and ethnicity); behaviour and lifestyles, such as smoking, alcohol consumption, diet and physical exercise; the physical and social environment, including housing quality, the workplace and the wider urban and rural environment; and institutional factors such as the access to medical care.

Findings from key stakeholder interviews

Mental health was not considered a major concern. Stakeholders reported that while people could be having mental health issues, most of these do not present at the local health facilities. Cases identified are often referred to the Freetown psychiatric hospital because of the limited capacity for mental health care at the District level.

Substance abuse emerged as a big concern. Alcohol abuse and smoking are particularly common. Abuse of illicit drugs such as cannabis and cocaine were reported, especially among the youth. Key stakeholders observed that drug abuse was higher in mining areas.

Poverty was reported to be very high and a key health determinant, with this cited as a contributor to various health challenges including malnutrition and water / sanitation and hygiene.

Teenage pregnancy was seen as a major concern. Moyamba DHMT reported that the District has one of the highest rates of teenage pregnancies in the entire country. He expressed an opinion that it was particularly a problem in the study area, due to the cultural practice of early marriage. Moriba community health post recorded eight cases of teenage pregnancy in June 2017 and twelve cases in May 2017. The facility has also recorded increasing cases of clandestine abortions.

Key stakeholders from the SRL clinic reported that:

- Before the civil war, SRL used to provide a host of services to the general community, including free healthcare. It was felt that the community had some sense of expectation that this paternalistic practice could be extended again;
- Alcohol abuse was not that common, but smoking marijuana was; and

- There is a feeling in government and the community that SRL should address community related issues as the government often lacks capacity to do this. The community generally understand it is the role of government, but prefers / expects the support from SRL as the Company is 'more part of the community'.

Findings from focus group discussions

Mental health did not emerge as a theme, however, substance abuse emerged as a significant challenge.

Poverty and lack of employment was mentioned as a key concern. This results in limited access to health care in terms of transportation and purchase of medication. This has pushed some to use traditional medicine.

Alcohol abuse was by far the most common and this ranged from local brews and palm wine to cheap spirits. Tobacco smoking is common among men. Marijuana is widely consumed by the youth and sold locally (Moriba Town and Mogbwemo). Use of heroine was reported but on a small scale.

Women felt that they were "disadvantaged" because of poor education and limited access to employment. Women also expressed that the burden of caring for children, reporting that men are abandoning their responsibilities, yet they seek to marry more wives.

Again, teenage pregnancies emerged a major theme. Young girls were said to be vulnerable to the many young men who come to the mining area to look for jobs and mine employees who offer them favours. Most of these girls drop-out of schools to assume the role of child rearing as single mothers with no support from the men.

Findings from direct observations

The sale of alcohol and cigarettes were evident. One of the participants in the focus group discussions came with her merchandise (sachets of spirits and cigarettes) and reported that the demand was good. Some of the focus group participants were teenage mothers themselves and a few others were evidently pregnant. Poverty was evident in most of the rural villages.

Health seeking behaviour / cultural health practices

Health seeking behaviour, and the manner in which people select which health provider to consult, and when to consult them, depends on a variety of factors. This supports an understanding of entry points into the formal and informal health sectors and is essential in planning interventions, as behaviours, culture and spirituality all influence health seeking behaviour. People may believe that western medicine may be effective in curing their ailment, but their conviction is that mystical causes have also intervened. This obliges them to combine visits to the health care facilities with visits to traditional healers. Several supply and demand factors influence health seeking behaviour. Traditional medicine plays an important role in local health provision and for a number of reasons this is often the primary health consultation route.

Findings from key stakeholder interviews

Health seeking behaviour is generally good and appears to be improving. The majority of the population prefer to use conventional medicine, and this is evidenced by increasing demand for these services. Having said this, traditional medicines are still common, and these are sometimes used concurrently with modern medicine. According to Moyamba DHMT, the use of traditional medicines contributes to delay in care seeking. A frequent lack of medication was identified as the biggest bottleneck to access to health care and a factor that indirectly promotes use of traditional medicines.

General health awareness and education on health prevention activities was poor, which limited health seeking behaviour, supported the use of traditional medicines and delayed seeking treatment. The cost and access to healthcare services drives traditional medicinal practices. However, some has a

clear cultural basis. Traditional medicine is commonly practiced in the area, even in SRL employees and dependents who had access to free healthcare services. Even well-educated and wealthy people go to traditional healers for certain things.

Findings from focus group discussions

The majority of participants reported that they prefer modern health care. Lack of medication at the local public health facilities was a predominant theme. Traditional medicine was still widely used and even preferred in the management of some conditions such as migraine, mental illness and fractures.

Traditional medicine was also used in the treatment of convulsions, abdominal pains, malaria and during pregnancy. Participants however reported that the use of traditional medication is declining, but this could have been in response to the drive from health authorities to use conventional medicine- rather than reflecting the actual practice.

Female circumcision was culturally practiced and largely accepted.

Findings from direct observations

An assessment of the local health facilities revealed that some of the essential drugs were chronically out of stock, including anti-malarial treatments and first line antibiotics.

Health systems issues

Access to quality health care is a major national public health concern. This is attributed to inadequate human resources, limited health expenditure, and problems with the drug and medical supply chain.

Findings from key stakeholder interviews

Reproductive health services are available at the local health facilities. The uptake of family planning services is increasing and is supported by regular health education and sensitisation. Activities are supported by the Marie Stopes NGO. Maternal mortality remains a challenge however. The Moyamba DHMT reported that the District recorded 36 maternal deaths in 2016 and 19 over the period from January to July 2017, an average of three maternal deaths per month. Limited access to emergency obstetric care was reported as the biggest challenge to maternal health. This is compounded by lack of emergency transport. Moyamba District for example, has only one functional ambulance. Most women deliver their children at the health facilities. Moriba community health post conducts around 20 normal deliveries per month. Following this, most children under-5 years attend routine clinics where they receive necessary vaccines and growth monitoring.

Outreach services are offered to some host communities with limited physical access to facilities. However, this is often challenged by lack of transport means (motorcycles or fuel).

There was a concern about vaccine coverage, as while the District coverage was above 80 %, there were hard to reach host communities who were not adequately covered. Measles outbreaks were more common in these areas. Weak cold chain maintenance was a noted challenge in the District. A breakdown of immunisation coverage in Bonthe and Moyamba Districts is provided in Table 4-74. Moyamba health care delivery is well supported by host community health officers who are represented by a focal person in the DHMT. The Bonthe District Medical Officer reported a lack of skilled health professionals, poor health infrastructure and a lack of funding as a result of the small size of the District.

Poor road and transport infrastructure making access to healthcare and referrals challenging. There are only three ambulances in the District with plans to get a speedboat to improve care to host communities located along waterways (a broken boat was noted in the DHMT office yard).

In 2016, Bonthe District had the highest maternal mortality rate nationally, but this had improved as four maternal deaths had been reported 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. This was a real opportunity to improve services. 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 currentlyvolunteers but there is a plan to try to pay wages in the future. Vounteers 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.

Findings from focus group discussions

Participants told how they witnessed maternal deaths in their community. Some of these occur at home while others occur at health facilities. Excessive bleeding was cited as common cause. Nearly all pregnant women attend antenatal care and receive routine services including blood boosters. Women reported that they experience numerous health problems during pregnancy citing malaria infection, vaginal infections and at times miscarriage (linked to heavy workload). Women further explained that family planning services were generally available, accessible and acceptable. Modern methods such as hormonal injections, pills or implants are commonly used. Challenges to the uptake of contraceptives include lack of support from men and "bad experiences" with some methods.

Nearly all births occur at a health facility. It was reported that home delivery attracts a "huge penalty" and this has been aggressively enforced by the Paramount Chiefs. Traditional Birth Attendants have been educated to refer or accompany their clients to a health facility.

Findings from direct observations

None of the local peripheral health units visited during the fieldwork had capacity to test for anaemia.

Table 4-74: Immunisation coverage (%) in Bonthe and Moyamba Districts, 2013 vs. 2015

Vaccine	National Coverage		Bonthe District		Moyamba District	
	2015	2013	2015	2013	2015	2013
Fully immunized	**-**	**68**	**-**	**77**		**66**
BCG	89	96	84	97	120	95
DPT - 3rd dose	86	78	69	81	120	79
Haemophilus Influenza – 3rd dose	86	78	69	81	120	79
Hepatitis B – 3rd dose	86	78	69	81	120	79
Polio (oral) – 3rd dose	85	78	69	81	120	80
Measles	82	79	67	93	117	78
Yellow fever	83	-	67	-	119	-
Pneumococcal vaccine (3rd dose)	86	-	69	-	120	-
Rotavirus (2nd dose)	85	-	71	-	122	-

5 Public Participation

Public participation has been carried out in accordance with Sierra Leonean legislation and SRL's Communication and Public Participation Plan. This engagement with the public, internal and external stakeholders has taken place during the scoping phase and during the impact assessment phase. It aligns with ongoing public participation processes that SRL currently undertakes. This includes the quarterly stakeholder meetings, quarterly chiefdom meetings and focused group meetings. SRK has worked with SRL's Community Affairs Department (CAD) during this process to ensure that the correct engagement protocol procedures are adhered to and to build on existing public engagement committees, forums and networks. SRK's involvement is to ensure independence, transparency and objectivity in recording and reporting on public participation meetings. Comments and findings from meetings held to date have been incorporated into the ESHIA and ESHMP. This section outlines the details of communication, public participation and stakeholder engagement during the ESHIA process.

5.1 Results of Public Participation during Scoping Phase

This section describes the stakeholder engagement process undertaken during the scoping phase of the SR Area 1 ESHIA. It describes the engagement objectives and methods used to consult with stakeholders, including host communities, and provides a summary of the key issues raised by stakeholders during the scoping phase. It also outlines the consultation that will be undertaken to finalise the ESHIA process. The engagement process has been designed to meet the requirements of the following Sierra Leonean legislation:

- EPA Act (Act No. 11 of 2008) as amended;
- *Mines and Minerals Act 2009*; and
- SLEP (MM) Reg. 2013.

SRL and Iluka corporate policies as well as GIIP principles and guidelines are also applicable to public participation during the ESHIA process. A Communication and Public Participation Plan has been developed to guide public participation during the ESHIA process. The Communication and Public Participation Plan forms part of the suite of management plans that accompany the ESHIA and ESHMP (Appendix L8).

5.2 Stakeholder identification

Project stakeholders were identified from the following sources of information:

- The Public Consultation and Disclosure Plan update conducted by SRK in 2012;
- Site visits by SRK in 2012, 2013 and 2016;
- Lists of stakeholders that SRL has regular contact with;
- Referrals from the SRL CAD team and liaison with affected host community leaders and government authorities; and
- Stakeholder details gathered during the SR Area 1 ESHIA scoping phase consultation meetings in June 2017.

The stakeholder database (Appendix L8) comprises approximately 1,551 interested and affected parties, representing a broad spectrum of all sectors of society, from both within SR Area 1 and beyond its boundaries.

It is important to note that the initial database was updated with the details of all stakeholders who attended meetings and / or submitted written comments during the scoping phase consultation. As such, they will receive further communication and information at key milestones in the project.

Stakeholders identified for the project represent several sectors of society:

- Host communities;
- Project affected people;
- Traditional leadership (Paramount Chiefs, Chiefdom Committee, Section Chiefs, Town Chiefs);
- CBOs / special interest group representatives;
- Landowner Associations;
- Local Government;
- National Government;
- Parliament;
- Health institutions;
- Transport authorities;
- Electricity utility;
- Labour Unions;
- Mining and industry;
- Business and commerce;
- Media;
- Educational institutions;
- Environmental and conservation organisations; and
- NGOs.

SRK will continue to review and expand the stakeholder database throughout the ESHIA process through networking and referrals, facilitated initially through a comment sheet circulated with the BID and from meeting attendance lists. SRK also maintains a record of all stakeholders consulted, comments received (both written and verbal), and these will be included in report submissions.

After completion of the ESHIA process, the database will continue to be updated by SRL throughout the life of the mine. This will ensure that the correct stakeholders are involved and that new stakeholders are continually identified and included.

5.3 Public participation process during the Scoping Phase

5.3.1 Project notification / announcement

Stakeholders were invited to meetings and notified of the SR Area 1 ESHIA and opportunity to comment, as follows:

- Letters of invitation (Appendix L8) were emailed or hand delivered to stakeholders by the SRL CAD team during late May and early June 2017, inviting them to participate in information sharing and consultation meetings; and
- All invitation letters were accompanied by a comment form for stakeholders to submit their comments and a BID (Appendix L83) providing information about the ESHIA process and meeting details.

5.3.2 Information sharing and issue gathering meetings

Seven (7) stakeholder meetings were held between 15 and 21 June 2017 with various stakeholder groups including government, civil society, traditional leadership and host communities in the Imperi, Lower Banta, Upper Banta, Jong and Bagruwa Chiefdoms. Consultation with government agencies were held in Freetown.

The primary objectives of the first round of stakeholder consultation were to:

- Share information about project (current and proposed mining in SR Area 1), the ESHIA process and the associated stakeholder engagement process;
- Identify the issues (including concerns and project alternatives) that should be investigated in the environmental, social and health specialist assessments and the impact assessment phase; and
- Provide stakeholders with an opportunity to comment on and share their views and suggestions about the project and ESHIA process.

Table 5-1 provides a summary of the meetings held during the Scoping Phase of the ESHIA process.

Table 5-1: Details of information sharing meetings held during the Scoping Phase

Meeting details		Stakeholder representation	Approx. no. of attendees	Approx. no. of documents distributed		
Sector / date	Venue/ Time			Invitations	BIDs	Comment forms
Lower Banta Chiefdom 15 June 2017	Ndendemoia 9h00 – 11h00	Members of Parliament, Paramount Chiefs, traditional leadership, district and local government, host community representatives, landowners, civil society organisations, religious leaders, women groups, youth groups and host communities.	231	150	231	231
Upper Banta Chiefdom 15 June 2017	Motinga 14h00 – 16h00		203	100	193	193
Imperi Chiefdom 16 June 2017	Gbangbama 9h00 – 11h00		325	200	300	300
Bagruwa Chiefdom 17 June 2017	Sembehun 11h00 – 13h00		245	150	219	219
Jong Chiefdom 19 June 2017	Kabati 9h00 – 11h00		315	150	315	315
Environment Protection Agency-Sierra Leone (EPA-SL) 20 June 2017	EPA-SL Offices, Freetown 14h00 – 15h00	EPA-SL Executive Chairperson, Director and relevant staff. Nuclear Safety and Radiation Protection Authority	6	3	6	6
Ministry of Fisheries and Marine Resources (MFMR) 21 June 2017	MFMR Offices, Freetown 9h00 – 10h00	Permanent and Deputy Secretary, Director and Deputy Director	4	1	4	4
		Totals	**1,329**	**754**	**1,268**	**1,268**

A set of A0 posters in English (Appendix L8) based on the BID was used to present information to stakeholders at the meetings. A set of A5 posters with identical information was left at each meeting venue after the meetings, next to the comments boxes provided for stakeholders in which to place their completed comment forms.

Government meetings were conducted in English, while the public / community meetings took place mainly in Mende with translation between English and Mende. Refer to Appendix M for photographs of the stakeholder engagement meetings that took place during June 2017.

Approximately 1,329 stakeholders representing various sectors of society, including host communities in the study area and beyond, attended the information sharing meetings in June 2017. Meeting attendance registers are included in Appendix N. Note that while the attendance registers provide a fair reflection of meeting attendance, there may be some attendees who have chosen not to complete the registers.

All comments, concerns, questions and suggestions raised by stakeholders during the information sharing meetings are recorded in an Issues and Response Report (IRR) (refer to Appendix L8).

5.3.3 Opportunities for comment

In addition to being provided with an opportunity to comment verbally at the various information sharing meetings, stakeholders were encouraged to submit their written comments on the comment sheet included in the BID. Comment sheets could be submitted to the SRK consultation team members present at the meeting or be placed in comment boxes provided at each meeting venue i.e., Ndendemoia, Motinga, Gbangbama, Sembehun and Kabati.

Stakeholders could also contact the SRK consultation team or SRL contact person telephonically, or via e-mail, to submit comments, and discuss issues and concerns.

At the end of the initial public comment period (5 July 2017), a total of 208 written comments were received. These included comment sheets (i.e. 55 from Lower Banta, 13 from Upper Banta, 71 from Imperi, 11 from Bagruwa, 44 from Jong, and 12 without undisclosed details) as well as two e-mail submissions.

5.3.4 Issues and Response Report

All comments, concerns, questions and suggestions raised during the consultation meetings, as well as any written comments received, have been recorded in the IRR (Appendix L8). The IRR provides a consolidated record of stakeholder comments, as well as responses from both SRL and the SRK ESHIA team, and is attached as (Appendix L8). Key issues raised by stakeholders are summarised below.

5.4 Key issues raised by stakeholders during scoping

The key comments, concerns and suggestions raised by stakeholders during the scoping phase to date are summarized in relevant categories below. A full report on all stakeholder comments received in writing and during the information sharing meetings, as well as the responses from the project team, is included in the IRR (Appendix L8).

In general, stakeholder comments across the five community meetings focused on legacy issues, while those of government representatives related mainly to their specific requirements for the ESHIA process, including involvement and collaborating with their officials on specialist studies. The key issues raised by stakeholders are summarised below.

5.4.1 Legacy issues

A number of legacy issues were identified including:

- Claims of unfair / inadequate compensation for loss of farming land and livelihoods, and perceived unfair crop assessment process;
- Claims of inadequate surface rent payments, and expectations for surface rent to be increased and extended to other areas;
- Reported delays in disbursement of the Agricultural Development Fund (ADF) and stakeholders requesting SRL's intervention in the process;
- Some relocation processes not being undertaken appropriately or not being completed according to commitments. A need for the rehabilitation of houses particularly of roofs;
- Reported poor management of environmental and social aspects, and corrupt practices by the previous company owners; and
- Claims of unmet commitments regarding host community development projects.

5.4.2 Company related issues

A number of company issues were identified including:

- While some stakeholders believed that not much will change in the project going forward, others welcomed the new owners, Iluka and expressed looking forward to a new beginning with improved overall management of the Company;
- There were high expectations for the new owners of SRL to honour commitments by the previous company, and to remedy legacy issues;
- Some allegations of corruption by some SRL staff in the recruitment and community affairs functions, were raised;
- The Company's perceived lack of respect for traditional authority, local tradition and culture, particularly greeting fees and other benefits for Paramount Chiefs; and
- The Company's apparent disregard for recruitment recommendations from Paramount Chiefs.

5.4.3 ESHIA and environment related issues

A number of ESHIA and environmental issues were identified including:

- Appreciation for the ESHIA process and for the opportunity to comment on SRL's current and planned activities;
- Appreciation for the inclusion of radiation and social studies in the ESHIA;
- Concerns were expressed about chemical contamination in the mining ponds;
- Concerns regarding the loss of biodiversity especially bush meat and thatching grasses in swamps, allegedly due to SRL activities in the area, were raised;
- Concerns were expressed about dust being generated from SRL vehicles and the dry mining activities;
- Concerns about noise from the dry mining operations were raised;
- A preference for wet mining methods was expressed due to perceived higher impacts from dry mining; and
- An emphasis is to be placed on avoiding / minimising negative impacts on host communities and the community's infrastructure that is located in close proximity to the mine.

5.4.4 Socio-economic issues

A number of socio-economic issues were identified including:

- Concerns were raised about drownings in the mining ponds;
- Concerns about SRL vehicles not adhering to speed limits and posing a safety risk to pedestrians, school children and livestock;
- Requests for permanent employment opportunities and preferential employment of people from host communities;

- Employment for relocated people and landowners who have lost their land and can no longer continue with farming activities;
- Requests for SRL to abide by the Local Content Policy; and
- Stakeholders freely expressed their host community development needs and suggestions.

5.5 Public participation during the Impact Assessment Phase

The objective of public participation during the impact assessment phase of the SR Area 1 ESHIA is to present the draft findings of the specialist studies to stakeholders for comment. Stakeholders will be afforded an opportunity to verify that their issues were considered in the investigations, and to comment on the findings and recommended management measures to avoid and minimise negative impacts and risks, and enhance positive impacts. The Draft ESHIA (which contains the ESHMP) was made available in the following documents:

- ESHIA Non-Technical Summary report, describing the project and providing a summary of the key findings and recommendations of the specialists' studies (English);
- Draft ESHIA Report, supporting documentation and specialist reports (English);
- IRR, providing a consolidated record of issues, comments, and suggestions made by stakeholders during the scoping phase, as well as responses from the SRK ESHIA team and SRL (English); and
- A public presentation by the SRK team, describing the proposed project, and findings and recommendations of the specialist studies (English).

The Draft ESHIA Report and associated appendices (English) was made available to stakeholders for their information and reference during the consultation process. The draft report was placed at the SRL site office and publicly accessible locations in the various chiefdoms (for example, Ndendemoia) for stakeholders to view and comment on.

5.5.1 Announcing opportunity to comment on the Draft ESHIA findings

The opportunity to comment on the Draft ESHIA was widely communicated to all stakeholders listed in the project stakeholder database, together with the details of where and when to find the documents and how to comment. Furthermore, stakeholders will be invited to feedback meetings, where the findings presented in the Draft ESHIA was presented. Stakeholder notification included:

- Distribution of an invitation letter in English to all stakeholders on the database, by email (to those with email addresses), and hand delivery by the SRL CAD team to key stakeholders, including Paramount Chiefs, government officials and other key stakeholders; and
- Telephonic notification (as appropriate) to key stakeholders by SRL CAD team members.

5.5.2 Availability of the Draft ESHIA findings for public comment

A copy of the Draft ESHIA report and associated appendices was submitted to the EPA-SL, prior to consultation with other stakeholders.

Copies of the Draft ESHIA Report, the Non-Technical Summary, comment sheets and the IRR in English was distributed in advance of government and community meetings (as per the scoping phase). These documents weremade available for public comment for a period of 30-days as follows:

- Placing them at the same publicly accessible locations in the Chiefdoms used during scoping where people can view the reports and provide comment; and
- Making printed copies of the non-technical summary available at the government and public / community meetings.

On request, a hard and / or electronic copy of the report was provided to other government stakeholders and traditional authorities.

5.5.3 Feedback meetings on Draft ESHIA findings

Meetings were held with various stakeholder groups, including national and local government, host communities and community representatives, traditional authorities, NGOs and civil society groups to present feedback on the outcomes of the ESHIA. These meetings were facilitated by SRK with the assistance of an EPA-SL registered environmental assessment practitioner.

The purpose of the meetings was to assist interested and affected parties to comment on the findings of the Draft ESHIA. During the meetings, information on the project description and the ESHIA process, a summary of the potential positive and negative environmental, social and health impacts, and proposed management measures were presented to stakeholders verbally, in writing (Non-Technical Summary), and visually on a set of posters in English. Stakeholders who attend the feedback meetings were encouraged to take documents and comment sheets for distribution to their colleagues, friends, and constituencies.

5.5.4 Submission of comments from stakeholders on the findings

Stakeholders were able to comment on the Draft ESHIA either in writing (by completing and returning comment sheets), verbally by telephone and / or attending one of the meetings. During these meetings, stakeholders had the opportunity to interact with both SRK and SRL team members, ask questions, discuss technical aspects, and raise comments, concerns and suggestions. Discussion sessions were conducted mainly in English, with translation into Mende where necessary, but participants were welcome to use their language of choice during discussions.

5.5.5 Issues and Response Report

All comments, concerns, questions and suggestions received from stakeholders, in writing and at meetings, during the comment period on the Draft ESHIA, were recorded and added to the IRR. The updated IRR was submitted to theEPA-SL in August 2018.

5.6 Public participation activities after the decision-making phase

Once the outcome of the decision by the EPA-SL on the ESHIA is known, notification letters will be distributed to key stakeholders by email (to those with email addresses) and hand delivery (by SRL CAD team members). Thereafter, SRL will be responsible for ongoing engagement with stakeholders.

6 Environmental, Social and Health Impacts

6.1 Introduction

This section of the report describes the assessment of environmental, social and health impacts associated with the activities of the project. The section starts with an overview of the impact assessment, describing the significance of biophysical and sociological impacts. Recommended management measures are presented for each impact and these are discussed in more detail in the ESHMP (refer to Section 7). The following current mining activities where included in the 2012 approved ESIA:

- Site clearing;
- Dredging;
- Dam construction;
- Ore extraction (earth moving);
- Primary mineral processing;
- Secondary mineral processing;
- Tailings management;
- Transporting and storage of ore and product;
- Port handling and shipping;
- Access road building and maintenance;
- Waste management;
- Power generation facility and transmission of power;
- Potable water services;
- Mine offices, workshops storage, accommodation and associated facilities; and
- Rehabilitation.

The following mining activities are proposed as part of the Lanti and Gangama dry mining operations:

- Site clearing;
- Haul roads;
- Ore extraction (earth moving);
- Access road building and maintenance;
- Primary mineral processing;
- Tailings management;
- Transporting of ore;
- Waste management;
- Power transmission services;
- Potable water services;
- Mine offices, workshops and storage; and
- Rehabilitation.

The purpose of this document, is an update to the approved 2012 ESIA and ESMP and to include the new dry mining operations at the Lanti and Gangama operation. As a result, the impact assessment below considers impacts from the current operations as well as impacts associated with the expansion activities.

6.2 Impact assessment methodology

The impact assessment has been conducted in an integrated manner that links the biophysical components with the socio-economic components of the environment. The impact assessment is divided into issue identification, impact definition, and impact evaluation. Iteration of these parts occurs in each stage of an ESIA process to varying degrees.

The basic elements used in the evaluation of impact significance are described in Table 6-1 and the characteristics that are used to describe the consequence of an impact are outlined in Table 6-2.

Table 6-1: Key elements in the evaluation of impact significance

Element	Description	Questions applied to the test of significance
Consequence	• An impact or effect can be described as the change in an environmental parameter, which results from a particular project activity or intervention. Here, the term "consequence" refers to: (a) The sensitivity of the receiving environment, including its capacity to accommodate the kinds of changes the project may bring about; (b) The type of change and the key characteristics of the change (these are magnitude, extent and duration); and (c) The importance of the change (the level of public concern / value attached to environment by the stakeholders and the change effected by the project). • The following should be considered in the determination of impact consequence: (a) Standards and guidelines (thresholds); (b) Scientific evidence and professional judgment; (c) Points of reference from comparable cases; and (d) Levels of stakeholder concern.	• Will there be a change in the biophysical and / or social environment? • Is the change of consequence (of any importance)?
Probability	Likelihood / chances of an impact occurring.	• What is the likelihood of the change occurring?
Effectiveness of the management measures	• The significance of the impact needs to be determined both without management measures and with management measures; and • The significance of the unmanaged impact needs to be determined so there is an appreciation of what could occur in the absence of management measures and of the effectiveness of the proposed management measures.	• Will the management measures reduce the impact to an acceptable level?
Uncertainty / Confidence	• Uncertainty in impact prediction and the effectiveness of the proposed management measures. Sources of uncertainty in impact prediction include: (a) Scientific uncertainty – limited understanding of an ecosystem (or affected stakeholders) and the processes that govern change; (b) Data uncertainty – restrictions introduced by incomplete, contradictory or incomparable information, or by insufficient measurement techniques; and (c) Policy uncertainty – unclear or disputed objectives, standards or guidelines. • There are a number of approaches that can be used to address uncertainty in impact prediction, including: ○ 'Best' and 'worst' case prediction to illustrate the spread of uncertainty; ○ Attaching confidence limits to impact predictions; and ○ Sensitivity analysis to determine the effect of small changes in impact magnitude.	• What is the degree of confidence in the significance ascribed to the impact?

Table 6-2: Characteristics used to describe impacts and impact consequence

Characteristics used to describe consequence	Sub-components	Terms used to describe the characteristic
Type		Biophysical, social or economic
Nature		Direct or indirect, cumulative etc.
Status		Positive (a benefit), negative (a cost) or neutral
Phase of project		During pre-construction (if applicable), construction, operation, decommissioning or post closure
Timing		Immediate, delayed
Magnitude	**Sensitivity of the receiving environment / receptors**	High, medium or low sensitivity Low capacity to accommodate the change (impact) / tolerant of the proposed change
	Severity / intensity (degree of change measured against thresholds and / or professional judgment)	Gravity / seriousness of the impact Intensity / influence / power / strength
	Level of stakeholder concern	High, medium or low levels of concern All or some stakeholders are concerned about the change
Spatial extent or population affected The area / population affected by the impact The boundaries at local and regional extents will be different for biophysical and social impacts.		Area / volume covered, distribution, population Site / local (social impacts should distinguish between site and local), regional, national or international
Duration (and reversibility / sustainability) Length of time over which an impact occurs and potential for recovery of the endpoint from the impact		Short term, long term Intermittent, continuous Reversible, irreversibility (negative impacts) Sustainable, unsustainable (positive impacts) Temporary, permanent
Confidence		**High, Medium, Low**

Impact significance rating

Practicable management measures will be recommended that avoid, and if avoidance is not possible, then reduce, restore, compensate / offset negative impacts, enhance positive impacts and assist project design. The impact significance rating system is presented in Table 6-3 and involves four parts:

Part A: Defines impact consequence using the three primary impact characteristics of magnitude, spatial scale and duration.

Part B: Uses the matrix to determine a rating for impact consequence based on the definitions identified in Part A.

Part C: Uses the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence.

Part D: Defines the Confidence level.

Table 6-3: Method for rating the significance of impacts

PART A: DEFINING CONSEQUENCE IN TERMS OF MAGNITUDE, DURATION AND SPATIAL SCALE ***Use these definitions to define the consequence in Part B***		
Impact characteristics	**Definition**	**Criteria**
MAGNITUDE	Major -	Substantial deterioration or harm to receptors in the receiving environment (e.g. the impact is of conservation importance or identified thresholds, will often be exceeded).
	Moderate -	Moderate / measurable deterioration or harm to receptors in the receiving environment (e.g. identified thresholds will occasionally be exceeded exceeded).
	Minor -	Minor deterioration (nuisance or minor deterioration) or harm to receptors in the receiving environment (e.g. not easiliy measurable or identified thresholds will not be exceeded).
	Mino r+	Minor improvement which is not easiliy measurable.
	Moderate +	Moderate improvement within or better (lower) than the threshold levels.
	Major +	Substantial improvement within or better (lower) than the threshold levels or publicity favorable.
SPATIAL SCALE	Site or local	Site specific or confined to the study area.
	Regional	May be defined in various ways, e.g. cadastral, catchment, topographic.
	National / International	Nationally or beyond.
DURATION	Short term / reversible / unsustainable	Less than 3 years.
	Medium term / partially reversible / sustainable	3 to15 years.
	Long term / irreversible / sustainable	>15 years.

PART B: DETERMINING CONSEQUENCE RATING ***Rate consequence based on definition of magnitude, spatial extent and duration***					
			SPATIAL SCALE / POPULATION		
			Site or Local	**Regional**	**National**
MAGNITUDE					
Minor	**DURATION**	**Long term**	Medium	Medium	High
		Medium term	Low	Low	Medium
		Short term	Low	Low	Medium
Moderate	**DURATION**	**Long term**	Medium	High	High
		Medium term	Medium	Medium	High
		Short term	Low	Medium	Medium
Major	**DURATION**	**Long term**	High	High	High
		Medium term	Medium	Medium	High
		Short term	Medium	Medium	High
PART C: DETERMINING SIGNIFICANCE RATING ***Rate significance based on consequence and probability***					
			CONSEQUENCE		
			Low	**Medium**	**High**
PROBABILITY **(of exposure to impacts)**		**Definite**	Medium	Medium	High
		Possible	Low	Medium	High
		Unlikely	Low	Low	Medium
PART D: CONFIDENCE LEVEL					
High		Medium		Low	

Notes: + denotes a positive impact.

Using the matrix, the significance of each described impact is initially rated. This rating assumes the management measures inherent in the project design are in place.

Management recommendations and post management significance

Practicable **management measures** were then listed, using the IFC's management hierarchy:

"Recommendations for management should focus on *avoidance, and if avoidance is not possible, then to reduce, restore, compensate / offset negative impacts*, enhance positive impacts and assist project design."

The significance of impacts was then re-assessed **with** assumed management measures in place ("**after management**"). Specialists also recommended and described appropriate **monitoring** and review programs to track the efficacy of management measures. These are included in the Action Plans.

An example of the table used to report the significance rating for each impact before and after the implementation of mitigation / management measures, and listing these measures, is provided as Table 6-4.

Table 6-4: Impact significance rating and mitigation measures for the Impact

Impact xx: Habitat disturbance resulting in invasion by exotic fauna and flora								
	Magnitude	**Duration**	**Scale**	**Consequence**	**Probability**	**SIGNIFICANCE**	**+/-**	**Confidence**
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: •								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*Medium*

6.3 Biophysical

The project will be undertaken in three phases, namely:

- **Operational phase:** Historical and current dredge mining operations and associated infrastructure (i.e. included in the 2012 ESIA and approved via Environmental Licence number EPA-SL030);
- **Expansion phase:** Construction, initial operational and expansion of the Lanti and Gangama dry mining operations (2013 onwards), including site and vegetation clearing, grubbing, establishment of layout area, contractors camp, widening of existing haul roads, dry mining, scrubbers, expansion of TSF, borrows pits and trucking of ore (haul roads); and
- **Decommissioning phase, closure and post closure phase**.

6.3.1 Air quality

The content of this section is adapted from the specialist Air Quality Impact Assessment (SRK, 2018(1)) (Appendix A).

Impacts associated with the current approved operations include the following:

- Impact AQ-1: Dust emissions during the operational phase;
- Impact AQ-2: Emissions from the power plant;
- Impact AQ-3: Emissions from the dryers at the SRL MSP; and
- Impact AQ-4: Emissions from the medical incinerators.

Air quality impacts associated with expansion of the Lanti and Gangama dry mining activities include the following:

- Impact AQ-5: Dust emissioins during the expansion phase.

Air quality impacts associated with decommissioning phase and closure phase:

- Impact AQ-6: Impact of dust and gas emissions during the Decommissioning and Closure Phase.

Air quality impacts associated with the post closure phase:

- Impact AQ-7: Impact of dust and gas emissions during the Post Closure Phase.

Stakeholders raised the following comments:

- There is dust in the dry season;
- Higher levels of dust in the area resulting in respiratory illnesses and TB;
- Elevated levels of dust generated by SRL machinery and vehicles;
- Heavy duty trucks transporting product cause irritational dust; and
- Road watering ineffective and should be solved by the tarring of roads.

Impact AQ-1: Dust emissions during the operational phase

Dust generating activities associated with the operational phase activities include materials handling at Lanti, Gangama, and Nitti Port, vehicle entrainment of dust on the haul roads, windblown dust from SR Area 1 as well as TSFs. Without management measures dust emissions will affect the immediate SR Area 1 and some of the villages to the south west of Lanti and Gangama but will decrease with distance away from the sources and in areas beyond the SR Area 1. Based on the dispersion modelling results, predicted dust (PM_{10}, and $PM_{2.5}$) concentrations without management are above the WB / IFC Guideline values. The significance of the impact is considered to be high at specific receptors, in close proximity to the operational activities if unmitigated. With mitigation, the majority of villages will show reduced concentrations that are below the WB / IFC Guideline values, except at Foinda which is in close proximity to the Lanti. The significance of the impact with management measures is considered low as the predicted concentrations at the sensitive receptors will not impact over a longer term but instead is considered to be a short-term impact.

Table 6-5: Impact AQ-1 – Dust emissions during the operational phase

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Site/ local*	***High***	***Definite***	***High***	-	*High*
Management Measures: • Pave or treat road surfaces for ore delivery within the MSP to suppress dust entrained by vehicles. Surface treatment of roads should also be considered before and after a sensitive receptor; • Use dust suppression techniques such as wet suppression or chemical suppression (must be environmentally friendly and non-polluting), to reduce dust on roads that exhibit an increase of dust entranment; • Where possible, design road alignments to minimise travel distances and eliminate unnecessary traffic; • Speed limits within the SR Area 1 should be adhered to for both treated haul roads and unpaved roads. Speed limits are 40 km/hr for haul trucks; 60 km/hr for light vehicles, and 30 km/hr for all SRL vehicles through villages; • Where necessary, grass should be planted along the boundary of the TSFs to lower the possibility of wind erosion. Re-vegetate or turf long side walls of the TSF to stabilise surfaces where required. Grass types planted along the boundary should be endemic to the area. Grass species that are not endemic to the area should not be considered as growing the grass may cause adverse effects to the natural flora in the area; • Maintain the current management measure of cladding with laterite. As the TSFs increase in height, the current management measures should continue; • If possible, keep the area of the sand TSF to a minimum and increase the area of active portions (wet state) to reduce windblown dust from this source during the dry season. Where necessary, apply a surface binder ((through the use of water cannons) on the TSFs, if monitoring indicates that dust is an issue from this source; • Attend to dust control when loading trucks by minimising drop heights and prevention of over loading; • Limit load size to reduce spillage and cover final product loads with tarpaulins where needed; • When stockpiling ore, the design specification of equipment should be considered to determine a suitable drop height to control the fall of materials which will reduce dust emissions; and • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact AQ-2: Emissions from the powerplant

The power plant is one of three point sources located within SR Area 1. A dispersion model was run for the power plant as emissions from power generating activities may be significant. Emissions modelled included NO_x, SO_2, PM_{10}, CO and VOCs. The ten highest concentrations at the villages are presented in detail in the Air Quality Specialist study included in Appendix A.

The NO_x concentrations are compared to the1-hour NO_2 WB / IFC Guideline value of 200 µg/m³. If NO_x concentrations are below the guideline it can be assumed that NO_2 concentrations will also be below the guidelines as NO_2 forms part of NO_x. Predicted NO_2 concentrations at the villages are below the 1-hour guideline of 200 µg/m³, with the highest predicted concentration at Mogbewa (140.32 µg/m³). The predicted NO_2 concentration at Mogbewo is an indication of the highest predicted at the sensitive receptors, however, it should be noted that the impact will be low as the predicted concentration is below the WB / IFC Guideline of 200 µg/m³. The predicted concentrations decrease away from the power plant. The annual NO_x concentrations at the villages are below the annual guideline of 40 µg/m³.

The predicted 24-hour SO_2 concentrations at the villages are below the WB / IFC EHS Guideline value of 20 µg/m³. Mogbewa, which is in close proximity to the power plant, shows the highest concentration at 10.34 µg/m³. Similar to the predicted NO_x concentrations, SO_2 concentrations decrease away from the power plant.

The predicted 24-hour PM_{10} concentrations emanating from the power plant at the villages are below the WB / IFC EHS Guideline value of 50 µg/m³. As with the models for NO_x and SO_2, Mogbewa which is in close proximity to the power plant, shows the highest concentration at 17.98 µg/m³. Similar to the predicted NO_x concentrations, PM_{10} concentrations decrease away from the power plant. The significance of the impact before and after management measures will be low.

Table 6-6: Impact AQ-2 – Increased emissions from the powerplant

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*
Management Measures: • Regular maintenance will ensure that the abatement technology will continue to meet Original Equipment Manuracturer (OEM) specifications and acceptable international emissions standards; • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors; and • Inline continuous monitors should be considered to monitor PM, SO_x and NO_x at the power plant. At least one round of stack emissions tests should be undertaken to determine if the legislated arsenic and lead parameters are present in the process.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact AQ-3: Emissions from the dryers at the SRL MSP

A dispersion model was run for the SRL MSP dryer to determine emissions from the combustion of diesel and compared to the WB / IFC Guideline. Emissions modelled for the SRL MSP dryer included NO_x, SO_2, PM_{10}, CO and VOCs. The ten highest concentrations at the villages are presented in detail in the Air Quality Specialist study included in Appendix A.

Similar to the power plant, the dryer NO_x concentrations are compared to the 1-hour NO_2 WB / IFC Guideline value of 200 µg/m³. Predicted concentrations at the villages are well below the guideline value of 200 µg/m³, with the highest predicted concentration at Mogbewa (2.8 µg/m³). The predicted concentrations decrease away from the SRL MSP dryer. The annual NO_x concentrations at from the SRL MSP dryer are low to negligible and below the WB / IFC Guideline annual value of 40 µg/m³ at the villages.

The predicted 24-hour and annual SO_2 concentrations at the villages are below the respective WB / IFC Guideline. Mogbewa which is in close proximity to the SRL MSP dryer, predicts the highest concentration at 0.008 µg/m³. Similar to the predicted NOx concentrations, SO_2 concentrations decrease away from the SRL MSP dryer.

The predicted 24-hour PM_{10} concentrations at the villages are below the WB / IFC Guideline value of 50 µg/m³. As with the models for NO_x and SO_2, Mogbewa which is in close proximity to the SRL MSP dryer, shows the highest concentration at 0.060 µg/m³. Similar to the predicted NO_x and SO_2 concentrations PM_{10} decrease away from the SRL MSP dryer. The significance of the impact before and after management measures will be low.

Table 6-7: Impact AQ-3 – Increased emissions from the dryers at the SRL MSP

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*
Management Measures: • Regular maintenance will ensure that the abatement technology will continue to meet OEM specifications and acceptable international emissions standards; • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors; and • Inline continuous monitors should be considered to monitor PM, SO_x and NO_x at the SRL MSP dryers. At least one round of stack emissions tests should be undertaken to determine if the legislated arsenic and lead parameters are present in the process.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact AQ-4: Emissions from the medical incinerators

A dispersion model was run for the two medical incinerators located at the SRL clinic. The incinerators are operated twice a week and were modelled as such. The predicted concentrations for NO_x, SO_2 and PM_{10} are presented in detail in Air Quality Specialist study included in Appendix A.

A dispersion model was run for the two medical incinerators located at the clinic in SR Area 1. The incinerators are operated twice a week and was modelled as such. The predicted concentrations for NO_x, SO_2 and PM_{10} are presented in detail in the Air Quality Specialist study included in Appendix A. The CO and VOC results and maps are presented in detail in Appendix E of the Air Quality Specialist study. Models were run for dioxins and furans, however due to the low emission rates, isopleth concentration maps could not be generated by the model, hence no results are presented. When no isopleths are generated in the model, concentrations are deemed to be 0 µg/m³

The predicted concentrations for NO_x, SO_2 and PM_{10} are well below the respective guidelines. The predicted concentrations are low to negligible due to the nature of the combustion process within the incinerator and, therefore, will not impact on sensitive receptors. The significance of the impact before and after management measures will be low.

Table 6-8: Impact AQ-4 – Increased emissions from the medical incinerators

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*
Management Measures: • Regular maintenance will ensure that the abatement technology will continue to meet OEM specifications and acceptable international emissions standards; • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors. • At least one round of stack emissions tests should be undertaken to determine if the legislated arsenic and lead parameters as well as dioxins and furans are present in the process.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact AQ-5: Dust emissions during the expansion phase

Dust generating activities associated with the expansion activities include materials handling at Lanti, Gangama, and Nitti, vehicle entrainment of dust on the haul road, windblown dust from the SR Area 1 as well as TSFs. As a result of the increase in throughput at Lanti and Gangama to 1,000 tph, there will be an increase in dust emissions.

Climatic conditions, such as rainfall and wind, may influence the impact of dust generation in and around the study area. Air quality improves during the wet season and the first part of the dry season when there is sufficient moisture to suppress dust being generated. Air quality reduces during the late dry season (March and April) when the burning of subsistence farming agricultural fields prior to planting increases the particulate matter of the ambient air within the region. Dust is also a factor during the dry season due to vehicle movements on exposed soil roads, agriculture practices, and Harmattan wind effects (ESIA, 2012).

The prevailing winds in the study area are relatively constant throughout the year. The prevailing winds from the south west and west-south west with lower occurrences from the south-south west and west. As illustrated in Figure 4-32 in Section 4.9.3, a number of settlements are in close proximity to the Lanti and Gangama dry mining construction and operational activities. Based on the predominant wind direction three settlements are located downwind of the Gangama activities. At the Lanti dry mine, three settlements are located up wind and another settlement downwind. As a result, settlements located downwind will be impacted by increased levels of dust.

Similar to the operational phase without management measures, dust emissions will affect the immediate SR Area 1 and the villages to the southwest of Lanti and Gangama, but will decrease with distance away from the sources and in areas beyond the SR Area 1. The significance of the impact is considered to be high with no management measure in place, as the predicted dust (PM_{10}, and $PM_{2.5}$) concentrations will exceed the WB / IFC Guideline values. The majority of villages will show reduced concentrations with management measures in place. In this scenario, the predicted concentrations will below the WB / IFC Guideline values, except at Foinda which is in close proximity to the Lanti mining operations. The significance of the impact with management is considered medium as the predicted concentrations will not impact over a longer term but a medium term. As some of the predicted concentrations lie slightly below the WB / IFC Guideline values, an anomalous event may result in an exceedance at the closest sensitive receptors, hence rating the probability of an impact as possible.

Table 6-9: Impact AQ-5 – Dust emissions during the expansion phase

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Site / local*	***High***	***Definite***	***High***	-	*High*
Management Measures: • Pave or treat road surfaces for ore delivery within the plant sites to suppress dust entrained by vehicles. Surface treatment of roads should also be considered before and after a sensitive receptor; • Use dust suppression techniques such as wet suppression or chemical suppression (must be environmentally friendly and non-polluting) to reduce dust on roads that exhibit an increase of dust emitted from the entrainment of dust; • Design road alignments to minimise travel distances and eliminate unnecessary traffic; • Speed limits within the SR Area 1 should be adhered to for both treated haul roads and unpaved roads. Speed limits are 40 km/hr for haul trucks; 60 km/hr for light vehicles, and 30 km/hr for all SRL vehicles through villages; • Where necessary, grass should be planted along the boundary of the TSFs to lower the possibility of wind erosion. Re-vegetate or turf long side walls of the TSF to stabilise surfaces where required. Grass types planted along the boundary should be endemic to the area. Grass species that are not endemic to the area should not be considered as growing the grass may cause adverse effects to the natural flora in the area; • Maintain the current management measure of cladding with laterite. As the TSFs increase in height, the current management measures should continue; • If possible, keep the area of the sand TSF to a minimum and increase the area of active portions (wet state) to reduce windblown dust from this source during the dry season. Where necessary, apply a surface binder ((through the use of water cannons) on the TSFs, if monitoring indicates that dust is an issue from this source; • Attend to dust control when loading trucks by minimising drop heights and prevention of over loading; • Limit load size to reduce spillage and cover final product loads with tarpaulins where needed; • When stockpiling ore, the design specification of equipment should be considered to determine a suitable drop height to control the fall of materials which will reduce dust emissions; and • Development and implementation of routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Medium***	-	*High*

Impact AQ-6: Impact of dust and gas emissions during the Decommissioning and Closure Phase

During the decommissioning and closure phases it is expected that all infrastructure will be demolished and removed. The areas will be revegetated after the demolition activities, hence leading into a closure phase. It is anticipated that the decommissioning activities will be staggered and will likely take place in phases with rehabilitation measures implemented during each phase. The major dust generating sources during the decommissioning and closure phases will be windblown dust from open and bare areas, materials handling and vehicle entrainment of dust. It is expected that these sources will be emitting until all rehabilitation measures have been implemented. Once rehabilitation measures are implemented, the air quality will begin to improve gradually, and the impact of the rehabilitation phase will be positive. Continuous air quality monitoring during these phases will determine the improvement in air quality.

The impact is considered to of medium (negative) significance before management and medium (positive) significance after management.

Table 6-10: Impact AQ-6 – Impact of dust and gas emissions during the Decommissioning and Closure Phase

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*
Management Measures: • Demolish all infrastructure and establish vegetation on the footprint exposed by demolition activities. • SRL will continue with the planting practice (referred to as SRL planting method) on all the areas to be rehabilitated during closure, not just the sand tailings. This will include: ○ Excavating a hole into the substrate being rehabilitated; ○ As topsoil resources are limited, topsoil will be used as an inoculum of microbes, rather than growth medium; ○ This requires that smaller holes for the establishment of woody species will be excavated for planting, with the current plan being that the holes will be 300 mm x 300 mm x 300 mm; ○ Tree planting will be by hand. • Non-mining roads will remain in the landscape, however, the mining roads will be subjected to the following: ○ Those that have no host community benefit will be rehabilitated; and ○ Those that the host community can utilize will remain. However, the plan is to only leave 50% of the current width of the road, with the other 50% rehabilitated and vegetation established. • Borrow pits will be rehabilitated by reshaping the high walls and then establishing vegetation on the reshaped walls and borrow pit base. • The pond retaining dams will be lowered, thereby lowering pond level. If the lowered dam is not stable, reshaping will be undertaken to reduce the downstream slope to 1:5. Sand tails will be deposited upstream of dam to further enhance stability. The remaining walls will be revegetated, and engineered spillways constructed. The exposed sand, sand / slimes and slimes will be revegetated. As the slimes has the potential to generate acidity, lime will be mixed into the profile, prior to vegetation. As the sand has poor water retention capacity, slimes will be added to a depth of two meters. Where necessary, reshaping of the material will occur to obtain a slope of 1:3 prior to adding amendments and vegetation establishment. • The residues associated with dry mining are expected to have classified under gravity, leaving discrete sand, sand / slimes and slimes bodies requiring vegetation establishment. These will be rehabilitated in similar manner to the drained ponds. • Slimes dams will be rehabilitated by the establishment of vegetation. As these have been exposed to wetting and drying cycles, there is no need to include lime prior to vegetation establishment. • Dredge mining sand tailings will be amended by mixing slimes to a 2m depth to improve water retention capacity prior to the establishment of vegetation. • MSP tails will be rehabilitated in situ, if they are not processed during operations or at the end of LoM. This will involve the placement of cover material, prior to vegetation establishment. The exception is the high sulfide tails, will be excavated and moved to an area where the acidity can be leached from the tails. Once leached, the tails will be replaced in the excavated footprint, covered and vegetation established. • All stockpiles at the various locations around the mine will be reprocessed through a dry mining primary concentrator. • Dry mining pit high-walls will be reshaped to 1:6 and vegetation established on the high-walls. Residues placed back in the pits will be rehabilitated as above, depending on textural / geotechnical properties. Exposed footprints not under residue will be re-profiled, ripped and vegetation established.								
After Management	*Minor +*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*High*

Impact AQ-7: Impact of dust and gas emissions during the Post Closure Phase

It is anticipated that the post closure period will take place over five years for the monitoring and maintenance period to demonstrate achievement of relinquishment criteria. With the rehabilitation plans expected to be put in place during the Closure Phase, it is envisaged that the impact will be positive and that the rehabilitation measures will improve the air quality within the SR Area 1. Table 6-12 rates the significance as of medium significance before and after management with a positive outcome.

Table 6-11: Impact AQ-7 – Impact of dust and gas emissions during the Post Closure Phase

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major +*	*Medium term*	*Site / local*	***Medium***	***Unlikely***	***Medium***	+	*High*
Management Measures: • Continuation of monitoring and maintenance procedures to ensure rehabilitation measures have been implemented adequately.								
After Management	*Major +*	*Medium term*	*Site / local*	***Medium***	***Unlikely***	***Medium-***	+	*High*

6.3.2 Biodiversity: Aquatic resources

The content of this section is adapted from the specialist Terrestrial, Aquatic and Wetland Ecological Studies (STS 2018) which are attached as Appendix B. The aquatic resources related impacts that are deemed potentially significant are presented below.

Impacts on aquatic resources associated with the current approved operations include the following:

- Impact BDA-1: Loss of habitat, biota and ecosystem services due to mining activities at the current wet mining operation;
- Impact BDA-2: Loss of habitat, biota and ecosystem services due to the MSP and haul roads; and
- Impact BDA-3: Loss of habitat, biota and ecosystem services due to handling and shipping at Nitti Port.

Impacts on aquatic resources associated with the expansion operations of Lanti and Gangama dry mining operations include the following:

- Impact BDA-4: Loss of habitat, biota and ecosystem services caused by expansion activities associated with dry mining at Lanti and Gangama.

Decommissioing / closure and rehabilitation phase and post closure impacts:

- Impact BDA-5: Loss of habitat, biota and ecosystem services due to lowering of dredge ponds during decommissioning / closure and rehabilitation;
- Impact BDA-6: Loss of habitat, biota and ecosystem services due to decommissioning of plant and unneeded haul roads; and
- Impact BDA-7: Loss of habitat, biota and ecosystem services due to earthworks associated with rehabilitation efforts.

Post closure / latent Phase Impacts

- Impact BDA-8: Loss of habitat, biota and ecosystem services due to lowering of dredge pond decant post closure; and
- Impact BDA-9: Loss of habitat, biota and ecosystem services due to dry latent impacts of decommissioned plant and haul road.

Stakeholders raised the following comments:

- Wetlands have been destroyed resulting in the loss of ecosystem goods and services;
- The mine ponds containing fish should be protected;
- Rivers have been contaminated by mining activities; and
- Siltation is affecting the health of the streams.

Impact BDA-1: Loss of habitat, biota and ecosystem services due to mining activities at the current wet mining operation

The current mining activities have resulted in loss of habitat, biota and ecosystem services. Wet mining activities have impacted water quality within the end pit lakes and resulted in changes in the pH regime of the system as well as slightly increased total dissolved solid concentrations. In addition, there has been an increase in concentration of specific metals and metal salts, which has affected the biological processes and human use value of the dredge ponds. Decant from the dredge ponds has negatively impacted downstream water quality.

In the low flow / dry season decant decreases significantly or ceases, the lack of flow in the downstream systems is likely to significantly impact the aquatic community of these systems, which generally rely on moderate to fast flowing clear water. The overall ecological status of the downstream areas due to decant of contaminated water (including change in pH regime and increase in TDS concentration) and reduction in water flow the EIS will be reduced or impaired.

Impact on instream and flow-sensitive biota and migratory taxa, will result in an impact on the overall PES of the system. Also, changes in habitat may contribute to changes in fish community composition.

Downstream effects will be largely linked to impacts on water quality affecting the human use value of the downstream watercourses, and in particular impact people's ability to use water for domestic purposes and food production.

The significance of the impact is considered to be medium (with a "major" magnitude) due to the large extent and duration of mining operations in the study area. However, with appropriate mitigation measures, the impact on the aquatic resources will be reduced to a medium (with a "moderate" magnitude) significance.

Table 6-12: Impact BDA-1 – Loss of habitat, biota and ecosystem services due to mining activities at the current wet mining operation

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Medium term*	*Regional*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Active dredging areas must be cordoned off, with specific reference to containing the sand and tailings which are by-products of the active dredging process; • Infrastructure should cross wetlands and rivers at right angles, with design of crossings allowing retention of wetland and riparian zone soil conditions; and • Engage with the host community and clearly communicate schedules for planned pit wall lowering and changes in decant rates that may occur, so that stakeholders know when to expect elevated water levels.								
After Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*

Impact BDA-2: Loss of habitat, biota and ecosystem services due to the MSP and haul roads

Paved areas within the MSP and associated infrastructure will result in increased run-off volumes hence increasing run-off to the receiving aquatic environment. Variability in flow rates may in turn affect habitat suitability and functionality, resulting in an impact on biota. Erosion and sedimentation / siltation resulting from increased run-off from hard surfaces, may result in settlement of suspended solids in the receiving aquatic environment. The settlement of suspended solids may affect sediment balances in these systems (aquatic and wetland), which could in turn affect substrate conditions (habitat availability and suitability) thus affecting instream and riparian biota. In addition, water quality contamination could be experienced due to hydrocarbons spills from operational machinery. However, given the small footprint of the MSP and its associated infrastructure in relation to the study area, the impacts are anticipated to be low.

Haul roads between the MSP and Nitti Port that are located in close proximity to aquatic resources may also contribute to sediment load via settlement of dust particles from vehicles entrainments and associated hydrocarbon spillages. Any such effects are anticipated to be low.

Table 6-13: Impact BDA-2 – Loss of habitat, biota and ecosystem services due to the MSP and haul roads

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
Management Measures: • Operational footprints must be kept to a minimum, and strict controls of edge effects implemented; • For the duration of the operational phase of the MSP, the controlled release of the water from the MSP ponds into the Mogbwemo Dredge Pond and into the natural water system is to occur; • Implement as applicable erosion management and sediment controls such as the use of rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented. This is particularly relevant to areas where topography has changed resulting in preferential flow paths prone to erosion, with associated sedimentation / siltation risks; • Vehicles must be services at a dedicated workshop in a bunded area to prevent spillage and contamination with hydrocarbons; • Develop and implement a leak / spill prevention and clean-up procedure for all areas storing and handling hydrocarbons and chemicals; • Spill kits will be provided for on site for spill clearing; and • Spills will be cleared and remediated immediately as per SRL hydrocarbon management procedure.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDA-3: Loss of habitat, biota and ecosystem services due to handling and shipping at Nitti Port

Aquatic impacts pertaining to handling and shipping at Nitti Port during the current operations pertain mainly to changes in water quality (resulting from spillages) and flow rates (due to run-off from hard surfaces), with associated loss of habitat, biota and ecosystem services.

The significance of the impact is considered to be medium negative due to the limited extent and duration of the water quality contamination and increased flow rates. With appropriate management and mitigation, the impact of Nitti Port operations on aquatic habitat, biota and ecosystems is anticipated to be low.

Table 6-14: Impact BDA-3 – Loss of habitat, biota and ecosystem services due to handling and shipping at Nitti Port

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Operational footprints must be minimised, and strict controls of edge effects implemented; • Dedicated fuel storage and facilities used to refuel vehicles must be secured, with procedures in place to clean up any fuel spillages; • Procedures must be in place for cleaning up any spillages of product.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDA-4: Loss of habitat, biota and ecosystem services due to expansion activities associated with dry mining at Lanti and Gangama

Dry mining areas and haul roads located near aquatic resources will contribute to sediment load via settlement of dust particles from vehicle entrainments and associated hydrocarbon spillages. Site clearing and mining activities will negatively affect riparian vegetation. The settlement of suspended solids may affect sediment balances in these systems (aquatic and wetland), which could in turn affect substrate conditions and thus affect instream and riparian biota.

Clearing, mining and haul road hard surfaces will alter the preferential flow paths and decrease surface flow friction resulting in increased run-off. This will contribute to variable flow rates in the receiving aquatic environment. Variability in flow rates may in turn affect habitat suitability and functionality, and have an impact on biota.

Changes in runoff characteristics and the significant increase in disturbed soils leads to significant increases in turbidity in downstream areas. This in turn affects suitability of aquatic resources for human use and their ability to support ecology in these systems.

The significance of the impact is considered to be medium negative due to the proximity of the mining activities to aquatic resources as well as the disturbance on the existing receiving environment due to current land use practices. This impact requires ongoing management to maintain the status quo.

Table 6-15: Impact BDA-4 – Loss of habitat, biota and ecosystem services due to construction and operation activities associated with dry mining at Lanti and Gangama

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Medium term*	*Regional*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Stream diversion structures should be as short as possible. In addition, stream diversion structures should be designed to ensure they are geomorphologically stable and are not prone to excessive erosion; • Clear separation of mine impacted and natural run-off water areas in as far as is practicable, so as to minimise the impact on water quality in the receiving environment; • Erosion management and sediment controls such as the use of rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented where relevant from the outset of dry mining activities. This is particularly relevant to areas where topography has changed and created run-off flow paths prone to erosion, with associated sedimentation / siltation risks; • An Alien and Invasive Plant Control Plan (AIPCP) must be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the dry mining process, as well as adjacent to disturbed areas such as haul roads. Further detail on this impact and the associated mitigation measures is provided in the botanical impact assessment sections; and • Engage the host community and clearly communicate schedules for the respective phases of the mine, also with reference to future plans for closure and rehabilitation.								
After Management	*Moderate*	*Short term*	*Regional*	***Medium***	***Possible***	***Medium***[28]	-	*Medium*

[28] No change in significance rating, however, the probability of the impact has been reduced.

Impact BDA-5: Loss of habitat, biota and ecosystem services due to lowering of dredge ponds during decommissioning/closure and rehabilitation

Water levels will be lowered increasing the euphotic zone of final voids left by the dredge ponds which will potentially increase nutrient levels and biological productivity. In the short term this will be positive as it will increase the potential for supporting sustainable subsistence and potentially small scale commercial fishing practices.

Lowering of the dredge ponds will temporarily result in increased flow rate and increased downstream water levels unless the levels are reduced in a controlled fashion as planned. Potential resulting impacts include inundation, flow rate and water level changes, loss of connectivity and loss of ecological functions.

Potential ongoing impact on water quality within the dredge ponds may occur with specific mention to changes in the pH regime of the system as well as slightly increased TDS concentrations. In turn some increase in concentration of specific metals and metal salts, such as manganese, nickel, selenium and zinc may occur which may affect the biological processes and human use value of the dredge ponds.

Similar impact on water quality as those occurring in the end pit lakes may occur which could affect the productivity and biodiversity of the system as well as the human use value of the downgradient systems for domestic use and for food production.

If in the low flow season decant decreases significantly or ceases, the lack of flow in the downstream systems is likely to significantly impact on the aquatic community of these systems which generally rely on moderate to fast flowing clear water. The overall ecological status of the downstream areas as well as their EIS may thus be reduced or impaired in perpetuity.

The impacts above will result in impact on instream and flow-sensitive taxa, impacts on migratory taxa, loss of species diversity, change in fish fauna species composition, and overall impact on the PES of the system.

Downstream effects will be largely linked to impacts on water quality and flow rate affecting the human use value of the downstream watercourses, and in particular the impact on the ability to use water for domestic purposes and for food production, as well as the impacts in fish harvesting.

Table 6-16: Impact BDA-5 – Loss of habitat, biota and ecosystem services due to lowering of dredge ponds during decommissioning / closure and rehabilitation

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Regional*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Dredge pond walls must be systematically lowered to allow regulated decant (downstream flow) and reduction of water levels in the dredge pond. Sloping and rehabilitation of dredge pond walls must be performed in such a manner so as not to compromise wall stability; • Rehabilitation footprints must be minimised, and strict controls of edge effects implemented; • Areas where the resource is located near the land surface, allow for shallow strip-mining excavations wide enough to extract most of the mined resource. As a result, such pits tend to be shallower compared to hard rock pit lakes, with generally large surface areas. Sand pit banks are thus generally also less steep. However, with lowering of dredge pond decants and hence water levels, exposed dredge pond banks may need to be reshaped to avoid slumping. Gradient of exposed dredge pond wall slopes must also be adjusted to ensure safety for recreational use, and sustained wall and bank stability must be ensured with the goal of long term, safe recreational use of the end pit lake resources. A viable option is using sand removed during previous mining activities for this purpose. Sand should be mixed with tailings material of increased fertility, which will assist with other functions such as revegetation rehabilitation efforts; • An AIPCP must be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the decommissioning process (particularly on barren dredge pond sediment / wall areas after lowering of dredge pond decant). Rehabilitation of disturbed areas after lowering dredge pond water levels, utilising indigenous wetland and suitable riparian vegetation species, will assist in retaining essential wetland ecological services, particularly flood attenuation, sediment trapping and erosion control, and assimilation of nutrients and toxicants. • Rehabilitation as per the Mine Closure Plan. • Erosion management and sediment controls such as the use of rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented as applicable from the outset of rehabilitation activities. This is particularly relevant to areas below dredge pond decant, where initial increased decant volumes after dredge pond decant lowering poses a significant erosion risk; • Support structures for infrastructure such as road crossings, must where possible, be placed outside of watercourses and wetlands; • Infrastructure should cross wetlands and rivers at right angles, with design of crossings allowing retention of wetland and riparian zone soil conditions; and • Engage the host community and clearly communicate schedules for planned pit wall lowering and increased decant volume, so they know when to expect elevated water levels.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDA-6: Loss of habitat, biota and ecoservices resulting from decommissioning of plant and unneeded haul roads

During decomissioning, ineffective removal of waste and demolished construction materials will hamper rehabilitation. There may also be direct vehicle impacts and impacts from supportive structures (such as personnel accommodation, stockpiles and waste areas) on riparian zone and wetland vegetation that may affect aspects such as bankside stability and hardening of surfaces.

The demolition of plant infrastructure, and subsequent sloping and rehabilitation activities could result in changes in topography and flow paths. This in return may lead to an increase in hard surface areas, run-off, changes in preferential flow paths and erosion and sedimentation.

Vehicles and related activities will result in increased hard surfaces due to compacting of soils. This will potentially result in increased run-off and creation of preferential flow paths, with potential impact on the hydrology (variability in flow rate and water levels) and sediment balance (erosion and sedimentation) of the nearby watercourses. Vehicles could potentially also contribute to spillages of hydrocarbons during rehabilitation. Over the short term this could affect surface water quality.

Decomissioning activities could also result in sedimentation / siltation and erosion of watercourses, leading to slight risk to in water quality degradation. The nearby watercourses area, however, is significantly altered by the presence of old dredge ponds.

Encroachment of alien vegetation is expected to increase as a result of the surface infrastructure demolition disturbances.

Table 6-17: Impact BDA 6 - Loss of habitat, biota and ecoservices resulting from decommissioning of plant and unneeded haul roads

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Site*	***Low***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Rehabilitation footprints must be minimised, and strict controls of edge effects implemented; • During rehabilitation, there may also be direct vehicle impacts and impacts from supportive structures (such as personnel accommodation, stockpiles and waste areas) on riparian zone and wetland vegetation, that may affect aspects such as bankside stability, and hardening of surfaces; • Demolition of the plant should be performed in a manner to salvage building materials that can be used by the host community; • All waste materials that cannot be recycled must be effectively removed and discarded in a safe and legal manner; • Compacted haul roads must be ripped, treated with available topsoil to allow establishment of natural vegetation and if necessary additional revegetation may need to take place; • An AIPCP must be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the decommissioning process; and • Erosion management and sediment controls such as rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented as applicable from the outset of rehabilitation activities. This is particularly relevant to areas where altered flow paths and increased run-off may pose an erosion risk.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDA-7: Loss of habitat, biota and ecosystem services due to earthworks associated with rehabilitation efforts

During decommissioning, potential impacts include changes in topography and flow paths which could be as a result of rehabilitation activities, as well as long term run-off related impacts due to ineffective rehabilitation activities. This will apply to all rehabilitation efforts, including lowering of dredge pond decants, sloping of dredge pond walls, preparation of exposed dredge pond walls and sedimentation from rehabilitation (spreading of previously removed sludge and soil material), demolition of surface infrastructure (plant and haul roads), removal of demolished building material, ripping of compacted haul roads, and sloping of demolished and ripped surface areas.

Disturbed loose soils will translate into increased risk for sedimentation / siltation and erosion with reference to altered topography and run-off.

Vehicles and related activities will result in increased hard surfaces due to compacting of soils. This will result in increased run-off and creation of preferential flow paths, with potential impact on both riverine and wetland hydrology (variability in flow rate and water levels) and sediment balance (erosion and sedimentation). Vehicles could potentially also contribute to spillages of hydrocarbons during rehabilitation. Over the short term this could affect surface water quality.

During rehabilitation, there may also be direct vehicle impacts and impacts from supportive structures (such as personnel accommodation, stockpiles and waste areas) on riparian zone and wetland vegetation.

Table 6-18: Impact BDA-7- Loss of habitat, biota and ecosystem services due to earthworks associated with rehabilitation efforts

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Site*	***Low***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Rehabilitation footprints must be minimised, and strict controls of edge effects implemented; • Replacement of topsoil and revegetation must be undertaken as guided by the Mine Closure Plan; • An AIPCP must be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the decommissioning process; and • Erosion management and sediment controls such as the use of gabions or reno mattresses, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented as applicable from the outset of rehabilitation activities. This is particularly relevant to areas where altered flow paths and increased run-off may pose an erosion risk.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDA-8: Loss of habitat, biota and ecosystem services due to lowering of dredge pond decant post closure

During post closure, it is expected that water levels will be lowered, increasing the euphotic zone reaching the bottom of the final void, which will potentially increase nutrient levels and biological productivity. In the longer term there is the potential for eutrophication of the system, as well as opportunistic and excessive growth of aquatic macrophytes in the littoral and sub-littoral zone of the dredge ponds. The rate at which this occurs will be driven by adjacent practices such as washing of clothes, and potential sewage ingress into the systems. After rehabilitation, shallower pits (lower water levels) may have a changed thermodynamic state.

Whilst any management to groundwater flow will most likely not be applicable, said flow compounded by other water inflow such as run-off, will result in decant volume variability. In-stream end pit lakes will potentially have an impact on river system connectivity due to inundation, especially during periods of no flow where there is no decant from the pits. This may result in loss of ecological function.

Water quality in end pit lakes are strongly influenced by geology and resultant chemistry found within the surface- and groundwater catchments of the lake. Additionally, other contaminants of concern are nutrients (e.g. nitrogen and phosphorous compounds) and road salts resulting from land use practises within the watershed. Contaminant sources generally also include agricultural activities and waste water treatment plants (or sewage ingress). The current end pit lakes exhibit low pH conditions, and impact on pH is considered a latent impact that will likely continue post closure.

“Terminal end pit lakes” (i.e. terminal in that there are no flow-through) can become increasingly saline due to evapo-concentration. However, the pits in question will function as “flow-through end pit lakes” during the post closure / latent phase. The end pit lakes in the current assessment already presented with low EC, and combined with the “flow-through” design any long term negative impact on EC is deemed unlikely. However, “flow-through” pits can in turn discharge other potential contaminants of concern to groundwater and / or surface water which can affect present and future human populations and ecosystems. As mentioned above this potentially includes organic compounds and trace metals (which were not specifically assessed in the aquatic assessment). Concentration of specific metals and metal salts may thus occur and affect the biological processes and human use value of the end pit lake.

Similar impact on water quality as those occurring in the end pit lakes may occur (including turbidity potential impact on pH), which could affect the productivity and biodiversity of the system as well as the human use value of the downgradient systems for domestic use and for food production.

The settlement of suspended solids in the end pit lake will affect sediment balances downstream which could in turn affect substrate conditions and thus affect instream and riparian biota.

A shift in fish fauna community composition is expected in the receiving riverine environment (i.e. a shift from typical river species to typical lake species). However, given that aquaculture practises have already been established in the lakes (with species already colonising the receiving riverine environment), and a self-sustainable long-term fishery is one of the desired end points, increase of already established ichthyofauna is considered a positive and desired impact.

If in the low flow season decant decreases significantly or ceases, the lack of flow in the downstream systems is likely to significantly impact on the aquatic community of these systems which generally rely on moderate to fast flowing clear water. The overall ecological status (PES) of the downstream areas as well as their EIS may thus be reduced or impaired in perpetuity.

Other potential effects include impact on instream and flow-sensitive and migratory biota and subsequent loss of species diversity, as well as alien vegetation invasion and opportunistic and excessive aquatic growth.

Downstream effects will be largely linked to impacts on water quality and flow rate affecting the human use value of the downstream watercourses, and in particular the impact on the ability to use water for domestic purposes and for food production as well as the impacts in fish harvesting. This may include reduced availability of river water downstream of pits (especially during the dry season). Flow variability and loss of connectivity has been discussed previously. During the dry season little or no decant from pits can thus affect water availability downstream, both in terms of fisheries activity and recreational and domestic use.

Table 6-19: Impact BDA-8 - Loss of habitat, biota and ecosystem services due to lowering of dredge pond decant post closure

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Continued rehabilitation of disturbed areas post closure, clearing alien vegetation and utilising indigenous wetland vegetation species, will assist in retaining essential wetland ecological services, particularly flood attenuation, sediment trapping and erosion control, and assimilation of nutrients and toxicants; and • Water resources need to be monitored for potential contaminants of concern as well as Diatom community monitoring during the post closure / latent phase.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definit***	***Medium***	-	*Medium*

Impact BDA-9: Loss of habitat, biota and ecosystem services due to dry latent impacts of decommissioned plant and haul road

Provided that the plant and haul roads which have no further use are appropriately rehabilitated, with specific mention of ensuring that they are geomorphologically stable and that the vegetation structure is not dominated by undesirable vegetation, no latent impacts from these areas are deemed likely. As such, no assessment table has been presented for this impact.

6.3.3 Biodiversity: Terrestrial resources

The content of this section is adapted from the specialist Terrestrial, Aquatic and Wetland Ecological Studies (STS 2018) which are attached as Appendix B. The terrestrial resources related impacts that are deemed potentially significant are presented below.

Impacts on terrestrial resources associated with the current operations include the following:

- Impact BDT-1: Loss of faunal and floral habitat, species diversity and SCC due to current wet mining operations; and
- Impact BDT- 2: Loss of faunal and floral habitat, species diversity and SCC due to ancillary human impacts.

Impacts on terrestrial resources associated with the expansion activities of the Lanti and Gangama dry mining operation include the following:

- Impact BDT-3: Loss of faunal and floral habitat, species diversity and SCC caused by construction and operation activities associated with dry mining at Lanti and Gangama.

Impacts on terrestrial resources associated decommissioning / closure and rehabilitation phase:

- Impact BDT-4: Loss of faunal and floral habitat, species diversity and SCC due to lowering of dredge pond decants; and
- Impact BDT-5: Loss of faunal and floral habitat, species diversity and SCC due to decommissioning / rehabilitation of active dry mining areas, plant and haul roads

Impacts on terrestrial resources associated post closure / latent phase:

- Impact BDT-6: Loss of faunal and floral habitat, species diversity and SCC due to inefficient rehabilitation and alien and invasive plant proliferation; and
- Impact BDT-7: Loss of faunal and floral habitat, species diversity and SCC due to latent impacts of decommissioned dredge ponds, mining areas, plant and haul road.

Stakeholders raised the following comments:

- Concerns about biodiversity loss due to mining activities;
- Dry mining causes deforestation, which in turn affects community ecosystem goods and services;
- Medicinal plants have been destroyed by mining activities affecting access to healthcare; and
- Mining activities have damaged habitats and naturally occurring flora and fauna.

Impact BDT-1: Loss of faunal and floral habitat, species diversity and SCC due to current wet mining operations

Vegetation clearing for mining and ancillary purposes has resulted in the loss of faunal and floral habitat, isolating floral populations and pushing the remaining faunal species into already congested pockets of natural habitat. In addition, this has resulted in fueling intra- and inter-specific competition among species for the remaining resources. The consequence being increased ease of hunting for bushmeat, species displacement and general decrease in abundance and diversity.

SCC are generally listed as such due to their already low numbers, high levels of persecution and / or decreasing favorable habitat. Further habitat loss, clearing of vegetation for timber, fuel and agriculture, increased competition for resources and the ever-present threat of hunting will further push these species numbers down.

The economic draw of mining, employment and associated business opportunities will always result in an increase in human population in the vicinity of mines. Greater population numbers in turn lead to a higher demand for food resources, with host communities often turning to bushmeat to supplement their dietary requirements. This is most notable in the rural areas. This trend places increased pressure on the faunal and floral component as species are destroyed, actively hunted and snared. Subsistence farming activities by host communities results in more forest areas being cleared in order to make way for agricultural lands.

During the operational activities, discharge and spillage of untreated substances can be caused by accidental instances or storm events. Such events may have a negative effect on faunal and floral habitat and diversity. If not sufficiently mitigated, it is likely that contamination of soil and water resources will detrimentally affect faunal and floral habitat, diversity and faunal and floral SCC. Improper implementation of mitigation measures will see continued loss of habitat, and in turn decreased faunal and floral species.

The significance of the impact is considered to be high negative due to the large extent and duration of mining operations in the study area. However, with appropriate management, the impact can be reduced to a medium significance.

Table 6-20: Impact BDT-1 - Loss of faunal and floral habitat, species diversity and SCC due to current wet mining operations

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Regional*	***High***	***Definite***	***High***	-	*Medium*
Management Measures: • Only clear vegetation and flood areas where necessary, avoid unnecessary vegetation clearing; • As far as possible utilise existing roads, if not feasible, construct roads where possible in areas that have already been disturbed, and not within sensitive habitat; • Throughout the operational phase, management and control of alien plant species is to be exercised; • Speed limits within the SR Area 1 should be adhered for both treated haul roads and unpaved roads. Speed limits are 40 km/hr for haul trucks; 60 km for light vehicles, and 30 km for all SRL vehicles through villages; • Educate drivers with regard to species conservation, and encourage them to not unnecessarily drive over faunal species; • Investigate the feasibility of developing a nursery utilising indigenous species and implement trials for rehabilitation to determine rehabilitation success; • The species composition can include medicinal and timber species as indicated in the floral ecological assessment, which will lessen the pressure on these species due to habitat destruction and utilisation by host communities; • Develop a Biodiversity Action Plan containing objectives to improve agricultural efficiency by host communities, improving current rehabilitation strategies and actively managing alien and invasive floral communities within SR Area 1; • Contamination prevention measures should be addressed in the Environmental Management Programme (EMP) for the mining activities; • All waste, including rubble, domestic waste, empty containers on the site should be disposed of at the dedicated licensed landfill facility; • No uncontrolled fires may be permitted within SR Area 1, unless it is part of a management plan; • With increased personnel the likelihood of poaching and trapping will also increase, and measures must be implemented to prevent poaching; and • Plan the location of dredge ponds in such a way that no terrestrial islands are formed, so as to ensure habitat connectivity is maintained.								
After Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*

Impact BDT-2: Loss of faunal and floral habitat, species diversity and SCC due to ancillary human impacts

The economic draw of mining, employment and associated business opportunities will always result in an increased human population in the vicinity of mines. Increased human populations will result in an increased need for food resources, with host communities often turning to bushmeat to supplement their dietary requirements, notably in the rural areas. As such, this places increased pressure on the faunal and floral component as species are destroyed, actively hunted and snared;

Subsistence farming needs by host communities will result in more forest areas being cleared in order to make way for agricultural lands, in order to increase food production and food security.The significance of the impact with management measures is considered medium (moderate, medium term impact on a local scale).

Table 6-21: Impact BDT-2 – Loss of faunal and floral habitat, species diversity and SCC due to ancillary human impacts

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Medium term*	*Regional*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Within SR Area 1, demarcate no go areas / areas of refuge for faunal species, where no hunting practices are allowed; • Educate mine workers and host communities about the long-term impacts associated with slash and burn activities, and the inevitable loss of forest and food resources; • Develop a Biodiversity Action Plan containing objectives to improve agricultural efficiency by host communities, improving current rehabilitation strategies and actively managing alien and invasive floral communities within SR Area 1; • Develop ecologically feasible and sustainable crop growing initiatives in areas already cleared / disturbed so as to negate the need to continue clearing forest areas; and • Set aside old mining areas for rehabilitation and include them as no hunting zones where feasible.								
After Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*

Impact BDT-3: Loss of faunal and floral habitat, species diversity and SCC caused by the expansion activities associated with dry mining at Lanti and Gangama

As noted for Impact BDT-1, vegetation clearing for dry mining and ancillary purposes will result in the loss of faunal and floral habitat, isolating floral populations and pushing the remaining faunal species into already congested pockets of natural habitat.

The dry mining activities at Lanti and Gangama are located on areas with a floral sensitivity classification of moderately low to low. SCC are generally listed as such due to their already low numbers, high levels of persecution and / or decreasing favourable habitat. Further habitat loss, clearing of vegetation for charcoal, agriculture, increased competition for resources and the ever-present threat of hunting will further push these species numbers down;

As noted for Impact BDT-1, during the operational activities, discharge and spillage of untreated substances can be caused by accidental instances or storm events. These events may have a negative effect on faunal and floral habitat and diversity if not sufficiently mitigated.

The significance of the impact is considered to be high negative due to the loss of fauna and floral habitat resulting from the clearing of vegetation and dry mining activities at Lanti and Gangama. In addition, there will be a loss of habitat breeding ground for the avifauna SCC species as a consequence of the new mining activities. However, with appropriate management, the impact can be reduced to a medium negative significance.

Table 6-22: Impact BDT-3 - Loss of faunal and floral habitat, species diversity and SCC caused by construction and operation activities associated with dry mining at Lanti and Gangama

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Regional*	***High***	***Definite***	***High***	-	*Medium*
Management Measures: • Avoid unnecessary vegetation clearing; • Wherever feasible, construct roads in areas that have already been disturbed and not within sensitive habitat; • Manage and control of alien plant species throughout the operational and rehabilitation phases; • Educate drivers with regards to species conservation, and encourage them to not unnecessarily drive over faunal species; • Investigate the feasibility of developing a nursery utilising indigenous species and implement trials for rehabilitation to determine rehabilitation success; • The species composition of vegetation used in rehabilitation should include medicinal and timber species; • Develop a Biodiversity Action Plan containing objectives to improve agricultural efficiency by host communities, improve current rehabilitation strategies and actively managing alien and invasive floral communities within the study area; • Place speed limits on haul roads in order to minimise faunal related mortalities from SR vehicle collisions; • Develop and implement a suitable Waste Management Plan; • All waste, including rubble, domestic waste, empty containers on the site should be disposed of at the dedicated licenced landfill facility; • Prevent uncontrolled fires within SR Area 1 where possible unless it is part of a management plan; • Plan the location of dredge ponds in such a way that no terrestrial islands are formed, so as to ensure habitat connectivity is maintained; • Contamination prevention measures should be addressed in the EMP for the mining activities; • No uncontrolled fires may be permitted within SR Area 1, unless it is part of a management plan; • With increased personnel the likelihood of poaching and trapping will also increase, and measures must be implemented to prevent poaching; and • In the mining areas, construct berms to help control surface water runoff, minimising erosion activities and excess sedimentation of the surrounding habitat.								
After Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*

Impact BDT-4: Loss of faunal and floral habitat, species diversity and SCC due to lowering of dredge pond decants

Impacts pertain mainly to proliferation of alien species, and loss of faunal and floral species abundance, diversity and habitat.

Lowering of the dredge ponds will create new terrestrial habitat as the water levels decrease, creating an ideal environment for the proliferation of alien plant species.

Excess water flowing out of the dredge pond that is not directed to the main water ways may end up temporarily flooding the surrounding terrestrial habitat, resulting in temporary inundation of faunal and floral habitat, and possible increased mortality rates of faunal and floral species unable to adapt to saturated conditions.

Excess sediment from the dredge ponds may end up in the existing water ways, wetlands and terrestrial habitat, smothering vegetation and altering the soil and vegetation component of the faunal and floral habitat. Possible contaminants present in the water will also be leached into the soils, affecting plant growth and faunal species who come into contact with the contaminants.

During the operation of the dredge ponds, vegetation and species would have begun to re-establish themselves along the banks. Lowering of the ponds may result in the loss of these habitat areas and as such the species therein, however these species are likely to self-relocate to new habitats.

The significance of the impact with management measures is considered low (minor, short term impact on a local scale).

Table 6-23: Impact BDT-4 – Loss of faunal and floral habitat, species diversity and SCC due to lowering of dredge pond decants

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Regional*	***Medium***	***Possbile***	***Medium***	-	*Medium*
Management Measures: • Footprint areas must be kept as small as possible; • Ensure that rehabilitation of the exposed areas is carried out as per the Mine Closure Plan; • Ensure that decant water is not released into existing terrestrial habitat areas; • Monitoring and control of alien and invasive plants must be performed during the decommissioning and closure phase; • It is recommended that an AIPCP be implemented and adhered to; and • Care must be taken when rehabilitation activities need to be performed within the watercourses as these areas are sensitive to disturbance.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDT-5: Loss of faunal and floral habitat, species diversity and SCC due to decommissioning/rehabilitation of active dry mining areas, plant and haul roads

Impacts pertain mainly to removal of existing infrastructure, vehicle movement through sensitive areas, ripping of compacted soils and roads, landform rehabilitation and proliferation of alien species. The significance of the impact with management measures is considered low (minor, short term impact on a local scale).

Ineffective removal of waste and demolished construction materials will hamper rehabilitation. During rehabilitation, there may also be direct vehicle and human impacts as well as impacts from supportive structures, that may affect species composition and faunal and floral habitat;

Ineffective reinstatement of landforms may lead to ineffective reestablishment of vegetation. Encroachment of alien vegetation is expected to increase as a result of the surface infrastructure demolition disturbances.

Vehicles movement through sensitive areas will result in the hardening of the soil surface, loss of faunal and floral habitat and possible creation of erosion gulleys.

Table 6-24: Impact BDT-5 – Loss of faunal and floral habitat, species diversity and SCC due to decommissioning / rehabilitation of active dry mining areas, plant and haul roads

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Local*	***Low***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Decommissioning and rehabilitation footprints must be minimised, and strict controls of edge effects implemented; • Demolition of the plant should be performed in a manner to salvage building materials that can be used by the host community; • Replacement of topsoil and revegetation must be undertaken as guided by the Mine Closure Plan; • All waste materials that cannot be recycled must be effectively removed and discarded in a safe and legal manner; • Compacted haul roads must be ripped and treated with available topsoil to allow establishment of natural vegetation. If necessary additional revegetation may need to take place using indigenous species. • An AIPCP must be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the decommissioning process; and • Erosion management and sediment controls such as rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps must be implemented as applicable from the outset of rehabilitation activities. This is particularly relevant to areas where altered flow paths and increased run-off may pose an erosion risk.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDT-6: Loss of faunal and floral habitat, species diversity and SCC due to inefficient rehabilitation and alien and invasive plant proliferation

Impacts pertain mainly to removal of existing infrastructure, vehicle movement through sensitive areas, ripping of compacted soils and roads, landform rehabilitation and proliferation of alien species. The significance of the impact with management measures is considered low (minor, short term impact on a local scale).

Areas which are inefficiently rehabilitated are unlikely to recover to a stable ecosystem, contributing to biodiversity loss.

Table 6-25: Loss of faunal and floral habitat, species diversity and SCC due to inefficient rehabilitation and alien and invasive plant proliferation

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Continued rehabilitation of disturbed areas post closure, clearing alien vegetation and utilising indigenous floral species, will assist in reinstating essential ecological functioning as part of the faunal and floral habitat; and • Monitor the progress of vegetation regrowth, as well as level of faunal and floral abundance and diversity increases within these areas.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact BDT-7: Loss of faunal and floral habitat, species diversity and SCC due to latent impacts of decommissioned dredge ponds, mining areas, plant and haul road

Even with extensive mitigation, latent impacts on the receiving faunal and floral ecological environment are likely. The following points highlight the key latent impacts that have been identified:

- Alien and invasive plant proliferation; and
- Disturbed areas are unlikely to be rehabilitated to pre-development conditions of ecological functioning and significant loss of faunal and floral habitat and species diversity can be permanent.

6.3.4 Biodiversity: Marine and estuarine resources

The content of this section is adapted from the specialist Estuarine Study (Anchor 2018) which is attached as Appendix C. The marine and estuarine resources related impacts that are deemed potentially significant are presented below.

Impacts on marine and estuarine resources associated with current operations include the following:

- Impact BDME-1: Modification of remaining estuarine habitat;

Impacts on marine and estuarine resources associated with the expansion of the Lanti and Gangama dry mining activities include the following:

- Impact BDME-2: Fragmentation of habitats and alteration of ecosystem functioning;
- Impact BDME-3: Changes in the community composition and distribution of estuarine biota;
- Impact BDME-4 Impacts on livelihoods, and / or loss or alteration of ecosystem services; and
- Impact BDME-5: Direct loss of estuarine habitat and biota within the mining footprint.

Impacts on marine and estuarine resources during the decommissioning and closure phase were not assessed as part of the specialist study. Decomissioning and closure of all mining activities are addressed in the Mine Closure Plan (Appendix L4).

Stakeholders raised the following comments:

- Mangrove swamps have been destroyed;
- Roads go through the swamps where ecosystem services are relied on;
- Sediment from dams has overlaid crops in the swamp areas affecting agricultural yield; and
- Estuarine fisheries have been affected by mining activities.

Impact BDME-1: Modification of remaining estuarine habitat

Modification of the remaining estuarine habitat downstream of the current mining operations could potentially be mediated through the following three mechanisms:

- Reduction in freshwater flow;
- Increase in suspended sediments and / or turbidity; and
- Contamination with other pollutants.

Mining activities in estuary catchments can impact estuaries by altering the quantity and quality of freshwater flows reaches these habitats. Current operations will decrease freshwater input in mangrove creeks below the mining areas, causing the intertidal areas to become hypersaline.

Runoff from cleared mining areas, access roads and sediment stockpiles, will flow at a greater velocity than under natural conditions, and increased erosion will result in an increase in the sediment load carried by the water. This will, in turn, result in increased turbidity in downstream estuaries. Increased turbidity and sediment can negatively impact estuarine ecosystem functioning in several ways.

Mining activities may also release trace metals and other minerals into estuarine environment via surface water flows, whilst the use of heavy and light machinery, port activities and shipping carries a risk of hydrocarbon pollution of estuary habitats.

Mining operations have the potential to act as a barrier to the migration of marine, freshwater and estuarine biota between the estuary and upstream freshwater habitats. Freshwater habitats upstream of the mining sites are not insignificant. It is, however, evident from the baseline survey that the biota of the estuaries include diverse freshwater, estuarine (brackish) and marine groups that will seasonally shift their distributions to suit their environmental requirements.

The wet season survey indicated that the freshwater group makes a significant contribution to the estuarine fish fauna, however, it was not possible to establish the extent to which this may have been reduced by barriers created during historical mining operations. It is likely that during the wet season, barriers to downstream migration are not significant as existing artificial impoundments have spill overs and the high flow rates would facilitate the movement of biota downstream.

During the dry season, these freshwater species would shift their distribution upstream, whist estuarine and marine species would expand their distributions inland. Existing and proposed dams, outfalls, silt traps and spill overs of the stormwater management systems required for dry mining activities may well constitute a significant barrier to upstream migration of biota during the dry season. The partial separation of estuarine habitats from inland freshwater habitats either through the creation of physical barriers, or unsuitable habitat in mined areas, could have negative impacts on estuarine biota potentially leading to changes in species composition, reduced diversity and abundance. Due to the regional nature of this impact (potentially throughout the catchment) and the long-term duration, this impact is rated as high negative significance without mitigation and medium negative significance with effective management.

Table 6-26: Impact BDME-1 – Modification of remaining estuarine habitat

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	Moderate	*Long term*	*Regional*	***High***	***Possible***	***High***	-	*Medium*
Management Measures: • Ensure that fresh water flow into each of the mangrove creeks is at least 60 % of the natural base flow especially during the dry season; • Ensure vegetation clearing and overburden stripping is conducted during the dry season to limit erosion sediment loads flowing into the lower reaches of the mangrove ecosystem; • Remove and store overburden in such a way that it is not washed into the mangrove creeks during the wet season. Follow recommended management measures in the Soils and Land Capability Specialist study (ESS 2018) to minimise erosion of stockpiled soils, specifically during the wet season; • Ensure there is adequate stormwater management to prevent erosion from the newly exposed mining areas and transport of sediment into the lower reaches of the mangrove channels; • Maintain and regularly service all equipment so as to minimise the risks of hydrocarbon spills; • Develop and implement a comprehensive water quality monitoring programme that includes sites where it enters the estuarine system and at stations in the vicinity of Nitti Port and along the ore transport route; • Develop and implement and Emergency Response and Contingency Plan which includes spill management and clean-up procedures to prevent and or remediate pollution incidents.								
After Management	*Minor*	*Long*	*Local*	***Medium***	***Possible***	***Medium***	**-**	*Medium*

Impact BDME-2: Fragmentation of habitats and alteration of ecosystem functioning

Mining operations have the potential to act as a barrier to the migration of marine, freshwater and estuarine biota between the estuary and upstream freshwater habitats. Freshwater habitats upstream of the mining sites are not insignificant. For example, rivers upstream of the Gangama dry mining operation drain a catchment of 175 km^2. There is insufficient life history information available on the biota of the study area to conclusively categorise fish or invertebrate species as anadromous or catadromous i.e. species that require a freshwater or marine phase in order to complete their life cycles. It is, however, evident from the baseline survey that the biota of the estuaries include diverse freshwater, estuarine (brackish) and marine groups that will seasonally shift their distributions to suit their environmental requirements. The wet season survey indicated that the freshwater group makes a significant contribution to the estuarine fish fauna, however, it was not possible to establish the extent to which this may have been reduced by barriers created during historical mining operations. It is likely though that during the wet season, barriers to downstream migration are not significant as existing artificial impoundments have spill overs and the high flow rates would facilitate the movement of biota downstream. However, during the dry season, these freshwater species would need to shift their distribution upstream, whist estuarine and marine species would expand their distributions inland. Existing and proposed dams, outfalls, silt traps and spill overs of the storm water management systems required for dry mining activities may well constitute a significant barrier to upstream migration of biota during the dry season (Figure 36). The partial separation of estuarine habitats from inland freshwater habitats either through the creation of physical barriers, or unsuitable habitat in mined areas, could have negative impacts on estuarine biota potentially leading to changes in species composition, reduced diversity and abundance. Due to the regional nature of this impact (potentially throughout the catchment) and the long-term duration, this Impact is rated as high significance without and medium significance with effective management.

Table 6-27: Impact BDME-2 – Fragmentation of habitats and alteration of ecosystem functioning

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	Moderate	*Long term*	*Regional*	***High***	***Possible***	***High***	-	*Medium*
Management Measures: • Ensure that freshwater flow into each of the mangrove creeks does not drop below 60 % of the natural base flow, especially during the dry season; • Design and manage diversion channels and outlets so as to allow migration of biota both upstream and downstream; • Create diversion channels that by-pass active mining pits and maintain the connection between estuarine and freshwater habitats; and • Lower pond retaining walls during the closure phase at end of mine life.								
After Management	*Minor*	*Long term*	*Regional*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact BDME-3: Changes in the community composition and distribution of estuarine biota

The loss of estuarine habitat within the mining footprint, potential deterioration in estuary water quality and fragmentation of habitat will potentially result in significant changes to the community composition abundance (relative abundance and biomass of different taxa) and distribution of estuarine biota. Loss of estuarine habitat will result in a nett overall loss of estuarine biota simply due to reduction in available space and resources.

Any estuarine creeks that are starved of freshwater will experience increased salinity particularly during the dry season. This will result in a decrease in the diversity and abundance of freshwater species as well as estuarine species with freshwater affinities. Depending on the magnitude of salinity increases in freshwater starved creeks, significant changes in mangrove vegetation could occur and the biota could become dominated by marine taxa with a complete loss of estuarine (brackish) and freshwater taxa.

Increased turbidity of estuary water downstream of mining activities could also cause a shift in community composition to taxa tolerant of altered conditions and a loss, or downstream shift, in the distribution of sensitive species. Pollution with trace metals and / or hydrocarbons could cause acute (mortalities) or chronic (e.g. reductions in longevity, reproductive output, growth rates) toxicity impacts on estuarine biota that would cause alterations in the abundance of affected species.

The creation of barriers to migration and the separation of estuarine and freshwater habitats would likely see a decline in diversity and abundance of estuarine species with freshwater affinities, and any catadromous or anadromous species. These species would decline in abundance both in estuarine areas downstream, and in freshwater habitats upstream of mining areas. It should also be noted that a large component of the estuarine biota (particularly fish) comprises the juveniles of marine fish species that use these warm, sheltered and productive environments as nursery areas (Wallace et al 1984, Whitfield 1998). Most estuary-dependent marine species enter the estuary as larvae or post larvae (Whitfield and Marais 1999; Harris *et al*. 1999) and once the estuarine dependent phase is complete, they leave the estuary for the marine environment where they become available to marine fisheries, and upon maturity, contribute to the spawning stock (Wallace 1975a, b). These species are particularly important to the estuary as they dominate both numbers and biomass of the fish fauna in the estuary. Potential reduction in the suitability of the estuaries as nursery habitat due to the identified potential impacts of mining would therefore also extend beyond the estuarine environment into the marine realm with potential negative impacts on regional fisheries (Lamberth and Turpie 2003).

Due to the regional nature of this impact (potential changes in the community composition and distributions of biota in marine, estuarine and freshwater habitats) and the long-term duration, this impact is rated as high significance without, and medium significance with effective management measures.

Table 6-28: Impact BDME-3 – Changes in the community composition and distribution of estuarine biota

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	Moderate	*Long term*	*Regional*	***High***	***Possible***	***High***	-	*Medium*
Management Measures:								
• As far as possible limit footprint of mining operations in estuarine habitat (channel and mangrove). If possible do not mine the channel and maintain a buffer of mangrove vegetation; • Where possible (unfortunately not the case for existing operations) undertake mining and phased rehabilitation starting at the downstream edge (closest to the sea) and move upstream; • Rehabilitate mined out areas once the operational phase has been completed, this will require infilling of mined out areas with overburden as far as possible, restoration of estuary channel profiles, removal of barriers to tidal flows and replanting of mangrove species in the affected areas; • Rehabilitation will be a fairly intensive and complex process with mangrove propagules having to be germinated and cared for in advance of the rehabilitation measures. Efforts should be made to plant the propagules in the same zonation bands commonly found in the surrounding mangrove regions. *Rhizophora* spp. should be planted along the creek channels at the water edge in band approximately 5-10 metres wide. Behind this band of *Rhizophora* spp., a mix of *Avicennia germinans* and *Laguncularia racemose* should be planted, with specimens of *Conocarpus erectus* and *Dodonaena viscosa* being planted along the landward margin of the rehabilitated areas; • Ensure that fresh water flow into each of the mangrove creeks is at least 60 % of the natural base flow especially during the dry season; • Ensure vegetation clearing and overburden stripping is conducted during the dry season to limit erosion sediment loads flowing into the lower reaches of the mangrove ecosystem; • Remove and store overburden in such a way that it is not washed into the mangrove creeks during the wet season; • Ensure there is adequate storm water management to prevent erosion from the newly exposed mining areas and transport of sediment into the lower reaches of the mangrove channels; • Maintain and regularly service all equipment so as to minimise the risks of hydrocarbon spills. • Develop and implement a comprehensive water quality monitoring programme that includes sites where it enters the estuarine system and at stations in the vicinity of Nitti Port and along the ore transport route; • Develop and implement and Emergency Response and Contingency Plan which includes spill management and clean-up procedures to prevent and or remediate pollution incidents; • Ensure that fresh water flow into each of the mangrove creeks does not drop below 60 % of the natural base flow, especially during the dry season; • Design and manage diversion channels and outlets so as to allow migration of biota both upstream and downstream; • Create diversion channels that by-pass active mining pits and maintain the connection between estuarine and freshwater habitats; • Lower pond retaining walls during the closure phase at end of mine life.								
After Management	*Minor*	*Long term*	*Regional*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact BDME-4: Impacts on livelihoods and/or loss or alteration of ecosystem services

The baseline estuary surveys indicated a strong reliance by host communities on estuarine resources to meet basic food requirements and for sustaining livelihoods. Artisanal fishers target numerous estuarine species including oysters, crustaceans (prawns and crabs) and many species of bony and cartilaginous fish. Evidence of the use of mangrove wood poles was also documented both for fishing related equipment and homestead construction. Indeed, most of the materials used in homestead construction in settlements adjacent to the estuarine creeks appear to have been sourced locally from the estuarine habitat. The changes in community composition and distribution of estuarine species identified above will affect the value and accessibility of these resources for the host communities that are reliant on them. The important nursery function that estuaries fulfil for marine fish species also means that this ecosystem service could be compromised by mining related impacts on the estuarine environments, with potential negative repercussions for regional marine fisheries (Lamberth and Turpie 2003). The potential impacts on estuarine biotic community composition and distribution can negatively impact ecosystem functioning and lead to significant declines in the productivity of the estuarine, freshwater and marine systems. These potential declines in productivity would have a direct negative impact on the livelihoods of host communities that are clearly reliant on these estuarine resources. The potential impacts of mining activities on livelihoods and ecosystem functioning is assessed as high significance without, and medium significance with effective management measures.

Table 6-29: Impact BDME -4 – Impacts on livelihoods and / or loss or alteration of ecosystem services

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	Moderate	*Long term*	*Regional*	***High***	***Possible***	***High***	-	*Medium*
Management Measures: • As far as possible limit footprint of mining operations in estuarine habitat (channel and mangrove). If possible do not mine the channel and maintain a buffer of mangrove vegetation; • Where possible (unfortunately not the case for existing operations) undertake mining and phased rehabilitation starting at the downstream edge (closest to the sea) and move upstream; • Rehabilitate mined out areas once the operational phase has been completed, this will require infilling of mined out areas with overburden as far as possible, restoration of estuary channel profiles, removal of barriers to tidal flows and replanting of mangrove species in the affected areas; • Rehabilitation will be a fairly intensive and complex process with mangrove propagules having to be germinated and cared for in advance of the rehabilitation measures. Efforts should be made to plant the propagules in the same zonation bands commonly found in the surrounding mangrove regions. *Rhizophora* spp. should be planted along the creek channels at the water edge in band approximately 5-10 metres wide. Behind this band of *Rhizophora* spp., a mix of *Avicennia germinans* and *Laguncularia racemose* should be planted, with specimens of *Conocarpus erectus* and *Dodonaena viscosa* being planted along the landward margin of the rehabilitated areas; • Ensure that fresh water flow into each of the mangrove creeks is at least 60 % of the natural base flow especially during the dry season; • Ensure vegetation clearing and overburden stripping is conducted during the dry season to limit erosion sediment loads flowing into the lower reaches of the mangrove ecosystem; • Ensure there is adequate storm water management to prevent erosion from the newly exposed mining areas and transport of sediment into the lower reaches of the mangrove channels; • Maintain and regularly service all equipment so as to minimise the risks of hydrocarbon spills; • Develop and implement and Emergency Response and Contingency Plan which includes spill management and clean-up procedures to prevent and or remediate pollution incidents (to specifically include sites where contaminants could enter the estuarine system and at stations in the vicinity of Nitti Port and along the ore transport route); • Ensure that fresh water flow into each of the mangrove creeks does not drop below 60 % of the natural base flow, especially during the dry season; • Design and manage diversion channels and outlets so as to allow migration of biota both upstream and downstream; and • Create diversion channels that by-pass active mining pits and maintain the connection between estuarine and freshwater habitats.								
After Management	*Minor*	*Long term*	*Regional*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact BDME-5: Direct loss of estuarine habitat and biota within the mining footprint

Estuarine habitat falling within the proposed future mining footprint is largely restricted to the Gangama dry mining and Niti Port areas. It is assumed that the whole of the Gangama Deposit will be mined in future, resulting in the removal of approximately 3 km^2 of estuarine habitat, including the estuarine channel and fringing mangrove vegetation. This will result in the mortality of all estuarine vegetation (predominately mangroves) and the less mobile estuarine biota in this area. Active backfilling and rehabilitation of the estuary and mangrove habitat will be difficult during the active mining period when it is assumed that saline (marine) waters will be prevented from intruding into the area as a result of normal tidal action (this will presumably be compatible with dry mining operations). It is anticipated that the sensitivity of the sediments found in mangrove stands will further complicate rehabilitation of the area, as highlighted in the Soils and Land Capability Specialist Study (ESS 2018) that states:

"*The sensitive soils and wet-based materials (Gleysols) should not be impacted if possible. However, as part of the mine plan this is not possible (mining of the mangrove swamp areas), and these areas will need to be managed with care. The loss of soil nutrients, organic matter and the drying out of the utilisable soil during storage will result in de-nutrification and formation of hard clods, something that is difficult to mitigate without substantial mechanical inputs and energy*."

This impact assessment takes cognisance of the spatial extent of the impacted habitat type, namely the mangrove lined estuary channel, and the relative scarcity or conservation importance of this habitat type. All vegetation within these two resource areas are considered to be of least concern on the ICUN red list or have not yet be assessed and incorporated in the ICUN red list ratings. Compared to the total of 682 km^2 of this habitat type downstream of the Mining Lease Area 1, including Sherbro Island and the adjacent Bagru Creek mangrove delta, the direct loss of estuarine habitat and biota within the mining footprint is only 0.44 %. The estuarine areas falling within the mining footprint will definitely be subjected to moderate impacts (loss of habitat and biota) at the local scale that will be of long-term duration and the significance of the impact prior to management is therefore medium. This Impact is revised to be low significance with effective implementation of management measures.

Table 6-30: Impact BDME -5 – Direct loss of estuarine habitat and biota within the mining footprint

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	Moderate	*Long term*	*Regional*	***High***	***Possible***	***High***	-	*Medium*
Management Measures: • As far as possible limit footprint of mining operations in estuarine habitat (channel and mangrove). If possible do not mine the channel and maintain a buffer of mangrove vegetation; • Where possible (unfortunately not the case for existing operations) undertake mining and phased rehabilitation starting at the downstream edge (closest to the sea) and move upstream; • Rehabilitate mined out areas once the operational phase has been completed, this will require infilling of mined out areas with tailings (sand and clay) where possible and in accordance with the Mine Closure Plan, restoration of estuary channel profiles, removal of barriers to tidal flows and replanting of mangrove species in the affected areas; and • Rehabilitation will be a fairly intensive and complex process with mangrove propagules having to be germinated and cared for in advance of the rehabilitation measures. Efforts should be made to plant the propagules in the same zonation bands commonly found in the surrounding mangrove regions. *Rhizophora* spp. should be planted along the creek channels at the water edge in band approximately 5-10 m wide. Behind this band of *Rhizophora* spp., a mix of *Avicennia germinans* and *Laguncularia racemose* should be planted, with specimens of *Conocarpus erectus* and *Dodonaena viscosa* being planted along the landward margin of the rehabilitated areas.								
After Management	*Minor*	*Long term*	*Regional*	***Medium***	***Possible***	***Medium***	-	*Medium*

6.3.5 Soils

The content of this section is adapted from the specialist Soils and Land Capability Assessment (ESS 2018) (Appendix K). The soil related impacts that are deemed potentially significant are presented below.

Impacts associated with the current operations and the expansion of the Lanti and Gangama operations include the following:

- Impact S-1: Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinization.

Decommissioning and closure phase impacts:

- Impact S-2: Net loss of soil volumes and utilisation potential due to change in material status (physical and chemical) and loss of nutrient base.

Stakeholders raised the following comments:

- Land degradation has taken place due to wet and dry mining;
- There has been a loss of productive agricultural land;
- Topsoil contains concentration of rutile and ilmenite; and
- Soil erosion has caused damage to crops.

Impact S-1: Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinisation

The operational phase involves the mining of the heavy mineral sands and the disturbance of the soils, leading to the potential loss of the soil resource and ecosystem services from the system as a result. The ability to rehabilitate and reinstate the lands to a sustainable end land use will be severely compromised and additions of both organic matter and nutrients will be required if the soils are not adequately managed.

The mining operations will result in the following disturbance of the soils, and the potential loss of the soil resource:

- The loss and sterilisation of the soil resource and a resultant loss of ecosystem services;
- The possible loss (through erosion) of utilisable soil down-slope / downstream, a resultant increase in sedimentary load / suspended solids, and the deposition of sediments within the stream, mangrove and river environments;
- The compaction of the in-situ and stored soils and the potential loss of utilisable materials from the system;
- The contamination of the soils by mine impacted water run-off and/or spillage of raw materials and / or hydrocarbons from vehicle and machinery;
- Contamination of soils by use of mine impacted water for road wetting (dust suppression);
- Potential contamination of soils by chemical spills of reagents being transported to site;
- Sterilisation (i.e. of soil microbes) and loss of soil nutrient pool, organic carbon stores and fertility of stored soils while in storage; The creation of a new soil comprising tailings, sand and slimes, a mix that is generally poor in water holding capability and low in nutrients; and
- Impact on soil structure and soil water balance.

The result of the operations associated with the mining on the soil resource will have a high negative intensity potential that is permanent and confined to the immediate site.

In the un-managed scenario, the frequency is likely to be continuous. This result is of a high significance.

Table 6-31: Impact S-1 – Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinization

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***High***	***Definite***	***High***	-	*Medium*
Management Measures: • Minimize the disturbed footprint as far as practically possible; • Timeously replace soils and undertake concurrent rehabilitation where possible as part of the Soil Management Plan; • Regular cleaning and maintenance (good housekeeping) of vehicles, erosion control by water and dust and on-going adherence to social and labour commitments to the loss of eco system services. Implement and maintain erosion control measures; • Implement the Mine Closure Plan to support the proposed project as and when appropriate; and • Install suitable erosion control infrastructure (i.e. Gabion boxes or mattresses) as needed.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*Medium*

Impact S-2: Net loss of soil volumes and utilisation potential due to change in material status (physical and chemical) and loss of nutrient base

The impacts on the soil resource during the decommissioning and closure phase are considered to be both negative as well as positive, with:

- The loss of the soils original nutrient store (de-nutrification) and organic carbon by leaching of the soils during mining and / or while in storage;
- Erosion and possible de-oxygenation of materials while stockpiled;
- Compaction and contamination (spillage) due to vehicle movement while rehabilitating the area;
- Erosion due to slope stabilisation and re-vegetation of disturbed areas;
- Contamination of replaced soils by use of mine impacted water for plant watering and possibly dust suppression; and
- Positive impacts of reduction in areas of disturbance and return of soil utilisation potential, uncovering of areas of storage and rehabilitation of compacted materials.

The impact will remain the net loss of the soil resource if no intervention or mitigating strategy is implemented. The intensity potential will remain moderate and negative for all of the activities if there is no active management (rehabilitation and intervention) in the decommissioning phase, and closure will not be possible. This will result in an irreversible impact that is continuous.

However, with mitigation and well-planned management, the impact significance can be meaningfully increased to a rating of positive moderate to high intensity as the utilisable soils are replaced and the sites are landscaped and re-vegetated.

Landscaping of the rehabilitated sites to be free draining, and the amelioration / fertilisation of the soils will assist in the implementation of a sustainable end land use.

On-going rehabilitation during the operational and decommissioning phases will bring about a net long-term positive impact on the soils, albeit that the land capability will likely only be returned to a status consistent with the present conditions (subsistence agriculture).

The significance rating associated with the re-instatement activities during rehabilitation and closure will be moderate and negative due to the necessity for vehicle movement while landscaping the operational footprint(s). Dust will potentially be generated and soil will potentially be contaminated, compacted and eroded.

However, the positive impacts of rehabilitation and re-instatement on the area, include the reduction in the footprint of disturbance, the amelioration of the affected soils and oxygenation of the growing medium, the stabilisation of slopes and the re-vegetation of disturbed areas. All of these actions and outcomes will have a positive effect on the impact significance.

On closure, the long-term negative impact on the soils will be reduced from a significance of moderate to low if the management plan set out in the ESHMP (Section 6) is effectively implemented.

Chemical amelioration (retention of organic material) of the soils will have a low but positive impact on the nutrient status of the soils in the medium term.

Table 6-32: Impact S-2 – Net loss of soil volumes and utilisation potential due to change in material status (physical and chemical) and loss of nutrient base

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*Low*
Management Measures: • Reduction in area if impact, restriction on vehicle and animal movement over rehabilitated lands and maintenance of restored vegetation (monitoring etc.); • Equipment maintenance; • Minimisation of dust and erosion by overland flow on unprotected areas; and • Implement the Mine Closure Plan to support the proposed project as and when appropriate.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Low*

6.3.6 Noise

The content of this section is adapted from the specialist Noise Study (Acusolv 2018) which is attached as Appendix H. The noise related impacts that are deemed potentially significant are presented below.

Impacts associated with the current operations include the following:

- Impact N-1: General rise in ambient noise levels due to current mining activities.

Noise impacts associated with the expansion of the Lanti and Gangama operations include the following:

- Impact N-2: General rise in ambient noise levels due to activities associated with dry mining at Lanti and Gangama; and
- Impact N-3: General rise in ambient noise levels due to ore transportation.

Decommissioning phase associated impacts:

- Noise in the decommissioning phase will be of a similar nature, but of a lower intensity and of shorter duration than noise in the construction phase. Decommissioning noise will not be audible at the nearest receptors and the noise impact will be negligible.

Closure phase associated impacts:

- No residual noise impacts will remain after decommissioning of SR Area 1 operations.

Stakeholders raised the following comments:

- Noise from SRL machinery and mining activities;
- Increase in noise levels since SRL operations began;
- Villages around Lanti are disturbed by the noise from the dredging; and
- Noise as a result from trucks.

Impact N-1: General rise in ambient noise levels due to current operational activities

The ambient surrounding noise conditions, since the commencement of mining, have changed from a rural district to what is now characterised as a mining district interspersed with rural villages and roads. Presently, the ambient noise levels in the villages or settlements directly adjacent to the mining activities vary around 55 dBA during the day and around 45 dBA at night. Noise modelling further indicates that villages and settlements not intersected by haul roads display little or no increase in current ambient noise levels.

The Noise Study (Appendix H) concludes that noise from current mining operations, dredging and excavation operations and activities do not have a significant impact on the nearest villages and settlements. Truck noise on haul roads running through the centres of villages and settlements, such as Foya Nitti and Lungi have a significant impact on the first rows of houses next to the haul road.

The significance of the impact is considered to be low as the modelled noise levels for the operational activities excluding the haul are limited to the direct footprint. The noise impacts associated with the haul road are limited to the three villages along the route.

Table 6-33: Impact N-1 – General rise in ambient noise levels due to current mining activities

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*Local*	***Low***	***Possible***	***Low***	-	*Medium*
Management Measures: • Ensure high level of equipment and vehicle maintenance, especially intake and exhaust mufflers; • Noise generating equipment should be designed to control and dampen noise emissions to ensure that the increase in ambient noise level will comply with relevant norms and standards; and • Host community members should be able to register their complaint / concern about noise through the SRL grievance mechanism. Complaints should be investigated and responded to as a matter of urgency and measures must be taken to minimize the noise if found to be related to SRL activities.								
After Management	*Minor*	*Medium term*	*Local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact N-2: General rise in ambient noise levels due to activities associated with dry mining at Lanti and Gangama (i.e. as part of the expansion phase)

As per the current operations, future noise-generating construction and operation activities for the dry mining activities at Lanti and Gangama will take place concurrently with current operational activities. The dominant audible source of noise will continue to be diesel engines (trucks, dozers, loaders and other earth-moving equipment). Compared to operational noise, construction noise will be of similar character but of a much lower intensity. It will seldom be audible above operation and general background noise. Moreover, considering that most construction activities will occur during daytime, it is not expected to have a discernible impact on the nearest noise receptors.

The net effect of the proposed doubling in throughput of the dry mining plant operations at Lanti and Gangama, will result in an increase in current ambient noise levels. Predictions based on noise modelling show that the proposed increases in throughputs and the corresponding increases in footprint ranges, will have a medium significance effect on the impacts on the nearest villages and settlements.

Table 6-34: Impact N-2 – General rise in ambient noise levels due to the construction and operation of the Lanti and Gangama dry mining operations

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Medium term*	*Local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Ensure high level of equipment maintenance, especially intake and exhaust mufflers; • Noise generating equipment should be designed to control and dampen noise emissions to ensure that the increase in ambient noise level will comply with relevant norms and standards; and • Host community members should be able to register their complaint / concern about noise through a complaints register. Complaints should be responded to as a matter of urgency and measures must be taken to minimize the noise.								
After Management	*Moderate*	*Medium term*	*Local*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact N-3: General rise in ambient noise levels due to transport and haul road operations

Based on the noise modeling the haul road noise footprints appear to be relatively small in extent. However, where haul roads run through the centres of villages, such as Foya Nitti and Lungi there are increased noise levels. Despite the mitigating effect of Soft Ground attenuation afforded by dense, evergreen vegetation in the larger area, the first rows of houses next to the haul road are exposed to direct noise from passing trucks. During each truck passing, houses next to the road are exposed to short duration peak levels (as measured on a sound level meter set to slow response) in the order of 65 to 70 dBA. Averaged over longer time periods, the corresponding equivalent continuous levels (dBA) are numerically lower, but still amount to major impacts of well over 5 dB. Moreover, the recurring short duration transients and the peak levels are what actually tends to interrupt sleep at night.

The significance of the impact is considered to be medium due to the extent of the haul road and the proximity of settlements and villages.

Table 6-35: Impact N-3 – General rise in ambient noise levels due to transport and haul road operations

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Medium term*	*Regional*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Ensure high level of equipment maintenance, especially intake and exhaust mufflers; • Noise generating equipment should be designed to control and dampen noise emissions to ensure that the increase in ambient noise level will comply with relevant norms and standards; • Where possible, design road alignments to minimise travel distances and eliminate unnecessary traffic; • Speed limits within the SR Area 1 should be adhered to for both treated haul roads and unpaved roads. Speed limits are 40 km/hr for haul trucks; 60 km/hr for light vehicles, and 30 km/hr for all SRL vehicles through villages; • Consider the construction of noise berms where needed; and • Host community members should be able to register their complaint / concern about noise through a complaints register. Complaints should be responded to as a matter of urgency and measures must be taken to minimize the noise.								
After Management	*Moderate*	*Medium term*	*Local*	***Medium***	***Possible***	***Medium***	-	*Medium*

6.3.7 Surface water

The content of this section is adapted from the specialist Surface Water Study (SRK, 2018(4)) which is attached as Appendix G. Surface water impacts associated with operation, expansion closure and post closure have been identified. As the existing operation (dredge mining, MSP, Nitti Port and associated mine infrastructure) and expansion activities (dry-mining) are operational, and the impacts on these activities on surface water are interlinked, these impacts have not been separated into the different phases.

Impacts associated with the operational, expansion, closure and post closure phases include the following:

- Impact SWSS-1: Construction of dams and ponds attenuate flood peaks resulting in changes in seasonal flooding patterns which affect sediment loading, sediment deposition on floodplains, fish ecosystem and host communities / residents;
- Impact SWSS-2: Increase in flooding in the pit due to lack of stormwater diversion from the Gbeni operations causing an impact on operations;
- Impact SWSS-3: Decrease in water quality downstream of the Gangama and Gbeni operations due to inadequate stormwater management;
- Impact SWSS-4: Dam walls being overtopped or failing as a result of freeboard requirements not being sufficient and a large flood event occurs;
- Impact SWSS-5: Insufficient water for mining and processing at Lanti operations and MSP;
- Impact SWSS-6: Excess water release may affect downstream users from Gangama operation;
- Impact SWSS-7: Discharge of acidic water from the MSP and Lanti operation leading to reduction in pH and increased acidity resulting in acidic, soft and corrosive water affecting the natural water system; and
- Impact SWSS-8: Potential use of acidic, soft and corrosive water at Lanti dry mine process plant resulting in corrosion and damage of metallic structures, equipment and pipes.

Stakeholders raised the following comments:

- Concerned about contamination of the mining ponds by chemicals from the plant site
- Tikoti River is contaminated with chemicals which effects communities' health
- There are impacts on Jong River in respect of the quality and quantity of water
- Mining and related activities have resulted in the creation of various water bodies for different use. Both ground water and surface water are all acidic as a result of mining activities
- No provision has yet been made for piped water supply for the immediate mining towns, and villages and treated water wells for other local communities
- In the wet season there is flooding. There used to be a swamp that prevented flooding however it has been destroyed due to mining activities and now the village floods

Impact SWSS-1: Construction of dams and ponds attenuate flood peaks resulting in changes in seasonal flooding patterns which effect sediment loading, sediment deposition on floodplains, fish ecosystems and host communities/ residents

The current and historical dredge ponds created through the dredge mining operations are used to supply domestic and process water for the mine facilities and for agricultural operations. SRL and its predecessor have constructed 28 dams to impound water at the site. Of these 28 dams, 14 of the dam walls exceed 15 m in height meaning that they impound a large volume of water and therefore severely attenuate the flood peaks. These dams are regularly inspected.

SRL dams and ponds play important role in attenuating the flooding effect into the workings and as water storage for mine sites. Host communities currently use the old dredge ponds as a domestic water source even though access and usage is prohibited. The dredge ponds and reservoirs were created by construction of engineered earthen embankments designed and positioned to collect base flow, runoff, and precipitation resulting in inundation of some areas underlain by the rutile deposits.

Construction of the dredge ponds and dams in local site drainages results in changes in seasonal flooding patterns of the affected rivers, which affect sediment loading, sediment deposition on floodplains, aquatic ecosystems and host communities / residents.

Seasonal River Flow

Ponds and dams have altered river flow dynamics in downstream receiving waters which has caused an environmental impact on the natural functioning of the river system. Life in and around a river evolves and is conditioned on the timing and quantities of river flow. Disrupted and altered water flows can be as severe as completely de-watering river reaches and the life they contain during low flows.

Sediment loading

Sediment loading in a river helps to reduce the river bed and bank erosion which may weaken riverbank structures, infrastructure and riparian forests along the riverside. Sediment loading in river systems is critical for maintaining physical processes and the habitats downstream of the dam (these habitats include the maintenance of productive deltas, barrier islands, fertile floodplains and coastal wetlands).

Sediment deposition on floodplains

The presence of the dams will reduce flood peaks and therefore, the seasonal flooding of the floodplains adjacent to the river channel. This will in return reduce the fertility of the areas adjacent to the river channel as the nutrient rich soil, from upstream areas, is no longer deposited there. This nutrient rich soil also causes the sedimentation of the dams and reduces their capacity. This will be covered further in future soil scientist specialist studies.

Table 6-36: Impact SWSS-1 - Construction of dams and ponds attenuate flood peaks resulting in changes in seasonal flooding patterns which effect sediment loading, sediment deposition on floodplains, fish ecosystems and host communities / residents

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Regional*	***High***	***Definite***	***High***	-	*High*
Management Measures: • Investigate the removal of the dams to allow the natural functioning of the ecosystems in accordance with the Mine Closure Plan; and • Review of reservoir hydrology and spillway design depending on the Mine Closure Plan recommendations regarding the dams.								
After Management	*Minor*	*Short term*	*Site / local*	***High***	***Possible***	***High***	+	*High*

Once the dams are removed, the functioning of the river and ecosystems will begin to recover, and the effect would be a long term **positive** result. The only negative result that removing the dams would have, would be on the livelihoods of those who have adjusted their livelihoods due to the proximity and the resources that become available with the dams. The option of removal of the dams is further assessed Mine Closure Plan (Appendix L4). The findings of the estuarine and marine study will be taken into consideration during investigating the option of the removal of the dams.

Impact SWSS-2: Increase in flooding in the pit due to lack of stormwater diversion from the Gbeni operations causing an impact on operations

Currently a river runs through the Gbeni mining pit which increases the risk of flooding in the pit. The impact of the flooding would be minor, localised to the Gbeni operation and short term in nature. The implementation of a formalised natural water diversion drain (Gbeni East Trench), would reduce the localised flooding and allow mining to occur without interruption. The upgrading of the Gbeni West Trench would further assist in abating the flooding in the Gbeni operations.

Table 6-37: Impact SWSS-2 - Increase in flooding in the pit due to lack of stormwater diversion from the Gbeni operations causing an impact on operations

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*High*
Management Measures: • Formalise and size the river diversion (as per the SWMP) where the Gbeni East Trench is located; and • Ensure the correct sizing of the Gbeni West Trench as per the SWMP.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*

Impact SWSS-3: Decrease in water quality downstream of the Gangama and Gbeni operations due to inadequate stormwater management

Due to the lack of an adequate stormwater management system around the Gangama and Gbeni operations, stormwater with high concentrations of sand and sediment leave the operations under low flow conditions. The construction of relevant storm water management infrastructure such as river diversions and silt traps before the stormwater enters the downstream environments is thus crucial to maintaining a high water quality standard. The water flowing from the operations will then have a low impact on the receiving environment.

Table 6-38: Impact SWSS-3 - Decrease in water quality downstream of the Gangama and Gbeni operations due to inadequate stormwater management

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Formalise and size the river diversion (as per the SWMP) where the Gbeni East Trench is located; • Ensure the correct sizing of the Gbeni West Trench as per the SWMP; and • Construct silt traps as per the SWMP.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*High*

Impact SWSS-4: Dam walls being overtopped or failing as a result of freeboard requirements not being sufficient and a large flood event occurs

There is a risk that the dams may fail if the freeboard requirements are not adhered to and a large flood event occurs. Due to the height and the amount of water stored behind some of the dam walls, the potential for catastrophic consequences is a reality should a dam wall be overtopped or fail.

Table 6-39: Impact SWSS-4 - Dam walls being overtopped or failing as a result of freeboard requirements not being sufficient and a large flood event occurs

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Short term*	*Regional*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: *External measures:* • Investigate if an early warning system could be implemented to ensure that should one of the dam walls be noticed to be of failing integrity or about to be overtopped, the people downstream of that particular dam wall need to be informed so that they can vacate the area of concern. *Internal measures:* • Regular dam safety inspections should be conducted; • Piezometers have been installed in some of the dam walls and a TSF management plan is in place. The operation confirms to ANCOLD standards and the dams have a operating procedure in place; • A dam break study should be investigated to identify the zone of influence as a dam wall failing could be catastrophic; • The water balance should be looked at in greater depth with actual measured values being introduced to greater effect so that confidence can be built into the water balance and the projections made from it. This is currently underway; • The formal dams should have a 1.8 to 2 m freeboard, while tailings dams should have 0.8 m of freeboard; • Emergency planning and mitigation measures should be developed and implemented should the water level become too high. These should include: o Emergency pumps to assist the lowering of the water level in the dams; o An alternate dam dewatering outlet once a certain threshold limit has been reached to release water into the environment; and o Protocols surrounding human and machinery not being allowed within certain areas that may be in jeopardy. *Post closure measures:* • The dam walls should either be removed or reduced in their height. This is covered in more detail in the Mine Closure Plan (Appendix L4); • Once this is done, dam break scenarios for the remaining dam walls should be undertaken; • Regular dam safety inspections should be conducted and included as part of the rehabilitation plan. • The water balance should be updated to inform potential overtopping within certain allowable confidence levels; and • The spillways of the dams would, once again, need to be accurately sized so that the water levels do not build up to the level where the 0.8 m of freeboard in these dams is ever compromised.								
After Management	*Major*	*Short term*	*Regional*	***Medium***	***Unlikely***	***Low***	-	*High*

If the abovementioned mitigation and management measures are followed, the significance of the impact becomes low due to the unlikelihood of its occurrence.

Impact SWSS-5: Insufficient water necessary for mining and processing at Lanti and MSP operations

The future mining plan at Lanti operations includes dry mining. With the expansion of dry mining at Lanti there is a possibility of insufficient water due to the higher water demand. The scale of the impact is localized; however the lack of sufficient water has a higher long-term significance to the operational capacity of the mine and the plant.

At the MSP, if ponds are removed while the MSP is still operational, there is a possibility that the water available to run the plant and water used during processing may be insufficient.

Table 6-40: Impact SWSS-5 - Insufficient water necessary for mining and processing at Lanti and MSP operations

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Update water balance with dam volumes, actual water volumes used in the plant and during mining (long term data); • Provide data on current make-up water requirements; and • If ponds are to be removed from MSP area, ensure an alternate water supply to guarantee continuation of mineral processing activities.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*Medium*

Updating the conceptual water balance into a working model allows management to better understand the water demands during mining and processing. It also ensures that forward planning of water demands is possible based on projected mining and processing tonnages. When ponds at the MSP are removed it is important to ensure that there is an alternate water supply to continue with the mining activities.

Impact SWSS-6: Excess water release may affect downstream users from Gangama operation

Water from the Gangama operation has to be released downstream which could have a negative impact on downstream users.

The pH of the water being released from the Gangama operation is between 5.8 and 6.3 based on the samples taken. The majority of the other water quality parameters are well within the required the Sierra Leone standards apart from turbidity and aluminium, which are marginally higher than SANS (there were no Sierra Leone standards to compare these two parameters to).

Table 6-41: Impact SWSS-6 - Excess water release may affect downstream users from Gangama operation

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Monitoring of the water being released to the environment must continue. Should the water quality decrease due to mining, then additional controls will be needed.								
After Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*Medium*

Currently the water quality being measured downstream of the Gangama operation does not significantly deteriorate due to the mine. Monitoring of the water being released to the environment must continue. Should the water quality decrease due to mining, then additional controls will be needed.

Impact SWSS-7: Discharge of acidic water from the MSP and Lanti operation leading to reduction in pH and increased acidity resulting in acidic, soft and corrosive water affecting the natural water system

Given that, the natural surface water quality of the area is already slightly acidic and without buffering capacity, the discharge of acidic water from the MSP and Lanti Dredge Ponds may lead to further reduction in pH and increased acidity in the receiving surface water. The scale of the impact will mainly be localised in the surface waters around the MSP and Lanti Dredge Ponds within the mine lease area. This may result in acidic, soft and corrosive surface water. Table 6-42 presents a summary of the impact assessment for the potential change in water quality associated with the release of acidic water from the MSP and Lanti pond into the environment.

There is no evidence of heavy metal leaching, however water of pH below 4.0 may cause irritation to the skin and worsen existing skin conditions. Aquatic life also suffers from the effects of low pH and may die at pH levels below 4.5.

Table 6-42: SWSS-7 - Discharge of acidic water from the MSP and Lanti operation leading to reduction in pH and increased acidity resulting in acidic, soft and corrosive water affecting the natural water system

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Controlled release of the water from MSP ponds into Mogbwemo Dredge Pond and into the natural water system.								
After Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*Medium*

Controlled release of the water from the acidic ponds into the other less acidic water will help dilute the acidity and its effects.

Impact SWSS-8: Potential use of acidic, soft and corrosive water at Lanti Dry mine process plant resulting in corrosion and damage of metallic structures, equipment and pipes

Water from Lanti Dredge Pond flows into C3 Dam, through to L4 Dam, CP3A and CP3B Dams and is pumped into the process water tank for use at the Lanti Dry Mining WCP. The pH of the water is therefore an important operational water quality parameter. Acidic, soft and corrosive process water will potentially corrode metals and damage metal pipes at Lanti WCP. Table 6-43 presents a summary of the impact assessment for the potential use of acidic, soft and corrosive process water at Lanti WCP.

Table 6-43: SWSS-8 - Potential use of acidic, soft and corrosive water at Lanti WCP resulting in corrosion and damage of metallic structures, equipment and pipes

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Liming of the acidic water at the Process Water Tank to neutralize acidity and to buffer the water from rapid pH fluctuations if / when necessary; and • Monitoring of the quality of water used as process water.								
After Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*Medium*

Liming of the acidic water at the Process Water Tank will neutralize acidity and buffer the process water from rapid fluctuations in pH before use as process water. Monitoring of the pH of the process water is necessary to ensure that fluctuations are detected promptly and managed to within operational water quality levels.

6.3.8 Groundwater

The content of this section is adapted from the specialist specialist Hydrogeology Study (Greall 2018) (Appendix F). As noted in Section 4.7, ongoing roundwater sampling and modelling will be undertaken throughout 2018 and the results will be included in an undated hydrogeological report. As such, a preliminary groundwater impact assessment has also been undertaken. The impacts associated with the operation, expansion, closure and post closure phases have been identified and presented below.

Groundwater impacts associated with the current operations include the following:

- Impact GW-1: Elevated historical mining pond levels may increase the available drawdown in community boreholes
- Impact GW-2: Seepage from MSP tailings and dams raising groundwater levels;
- Impact GW-3: MSP hydrocarbon and sewage spills contaminating groundwater;
- Impact GW-4: MSP secondary processed tails acid generation contaminating groundwater (operational and decommissioning phase);
- Impact GW-5: Elevated Lanti mining pond levels may increase the available drawdown in community boreholes;
- Impact GW-6: Lanti dredge hydrocarbon and sewage spills contaminating groundwater;
- Impact GW-7: Lanti mining pond water may lead to groundwater contamination;
- Impact GW-8: Nitti Port hydrocarbon spillage contaminating groundwater;
- Impact GW-9: Waste disposal site leachate contaminating groundwater (operational and decommissioning phase);
- Impact GW-10: Raised historical mining pond levels altering groundwater baseflow distribution to surface water systems;
- Impact GW-11: Lanti mining pond retarding groundwater baseflow to surface water systems (operational and decommissioning phase);
- Impact GW-12: Seepage of poor quality groundwater through the lanti mining pond wall and weathered aquifer discharging into the surface water systems; and
- Impact GW-13: Failure of the historical and lanti mining pond walls as a result of groundwater seepage (operational and decommissioning phase);

Groundwater impacts associated with the expansion of the Lanti and Gangama operations include the following:

- Impact GW-14: Gbeni and Gangama dry mining dewatering leading to lowered groundwater levels;
- Impact GW-15: Gangama dry mining groundwater ingress adjacent to the estuary;
- Impact GW-16: Gbeni and Gangama dry mining hydrocarbons contaminating groundwater;
- Impact GW-17: Gbeni and Gangama dry mining sulfide exposure contaminating groundwater (operational and decommissioning phase);
- Impact GW-18: Gangama dry mining saline intrusion contaminating groundwater (operational and decommissioning phase);
- Impact GW-19: Gbeni and Gangama dry mining slope failure as a result of groundwater seepage;
- Impact GW-20: Gbeni and Gangama dry mining saturation due to groundwater ingress; and
- Impact GW-21: Suspended solids from the Gbeni and Gangama dry mining dewatering volumes contaminating surface water;

Groundwater impacts associated with the decommissioning phase include the following:

- Impact GW-22: Lowered historical mining pond levels may reduce the available drawdown in community boreholes;
- Impact GW-23: Lowered historical mining pond levels may expose sulfides leading to groundwater acidification;

- Impact GW-24: Decommissioning the MSP tailings and dams will lower groundwater levels beneath the tailings disposal area;
- Impact GW-25: Lowered Lanti mining pond levels may reduce the available drawdown in community boreholes;
- Impact GW-26: Lowered Lanti mining pond level may expose sulfides leading to groundwater acidification;
- Impact GW-27: Gbeni and Gangama dry mining groundwater gradients recover post mining; and
- Impact GW-28: Lowered historical mining pond levels altering groundwater baseflow distribution to surface water systems.

Stakeholders raised the following comments:

- Concerns about the contamination of wells by mining activities;
- Allegations that there is no clean drinking water and people have to drink bottled water; and
- Claims that the creation of large bodies of pond water by SRL mining activities has considerably altered groundwater levels;

Impact GW-1: Elevated historical mining pond levels may increase the available drawdown in community boreholes

The historical mining ponds have been created by the construction of engineered earth impoundments across the river valleys. This has resulted in a raised pond water level surface. Groundwater levels within the adjacent valleys to the historical mining ponds may have been raised as a result. Community boreholes would have a greater available drawdown which would allow more abstraction before the borehole needed to recover.

The magnitude of the impact of increasing the available drawdown within the community boreholes is considered to be minor when compared to the overall borehole yield. Since the historical mining ponds may remain in place for longer than five years, the duration is considered to be long term. Only those community boreholes in the immediate vicinity are likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. As there are no community borehole water level records prior to the construction of the historical ponds, the increased available drawdown is considered to be possible. The significance of the impact is medium and positive while the confidence of the assessment is medium.

Table 6-44: Impact GW-1 – Elevated historical mining pond levels may increase the available drawdown in community boreholes

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*
Management Measures: • As this is a positive impact, no management are proposed.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	+	*Medium*

Impact GW-2: Seepage from MSP tailings and dams raising groundwater levels

The MSP has a number of processed tailings which are deposited at the edge of the Mogbwemo Dredge Pond. Any water used during the deposition of these tailings will contribute to additional seepage from recharge over the unrehabilitated area. This additional seepage is likely to result in raised groundwater levels within the immediate vicinity.

The magnitude of the impact of the raised groundwater levels in response to additional seepage from the processed tailings and MSP dams is considered to be minor. Since the MSP will be operational for longer than five years the duration is considered to be long term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. Given the unrehabilitated nature of the tailings and the method of disposal the probability of this impact is considered to be definite. The significance of the impact is medium and negative while the confidence of the assessment is high.

Table 6-45: Impact GW-2 – Seepage from MSP tailings and dams raising groundwater levels

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Since the raised groundwater levels are localized and in close proximity to the Mogbwemo Dredge Pond, no mitigation measures are proposed.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*

Impact GW-3: MSP hydrocarbon and sewage spills contaminating groundwater

While the MSP is operational, there is a risk of hydrocarbon or sewage spills which may contaminate the groundwater in the immediate vicinity.

Since it is assumed that any incident will be quickly identified, the magnitude of any hydrocarbon or sewage spill is considered to be minor and the duration short term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as low. The probability of the exposure to this impact is considered to be possible. The significance of this impact is considered to be low and negative with the confidence in the assessment rated as high. With the implementation of the management measures the only change to the impact assessment is that the probability of exposure reduces from possible to unlikely. The significance of the impact remains low and negative while the confidence of the assessment remains high.

Table 6-46: Impact GW-3 – MSP hydrocarbon and sewage spills contaminating groundwater

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*
Management Measures: • Proper maintenance of all vehicles and machinery to prevent fuel or oil leaks and spillages; • Vehicles and machinery should be serviced in bunded areas with drip trays; • A hydrocarbon absorbing product should be kept on site and used to clean up hydrocarbon spills in the event that they should occur, and • The sewage treatment process should be properly maintained to ensure that it is operating within design specification.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-4: MSP secondary processed tails acid generation contaminating groundwater (operational and decommissioning phase)

The geochemistry study (SRK, 2018(2)), included in (Appendix E) has determined that the MSP secondary processed tailings are acid generating. Historical sampling by Knight Piésold (2008) has shown that the tailings are also associated with elevated Al and radioactivity. This hydrochemistry may lead to the contamination of groundwater in the immediate vicinity. The potential impact on groundwater during the operational and decommissioning phase is similar and both phases will therefore be addressed in this impact assessment. The significance of the groundwater contamination is that it acts as a pathway between the processed tailings and the nearby Mogbwemo Dredge Pond.

Given the potential for acidification etc., the magnitude of this impact is considered to be moderate. Since the tailings are likely to remain in place permanently, the duration is considered to be long term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. The probability of the exposure to this impact is considered to be definite since it is already occurring. The significance of this impact is considered to be medium and negative with the confidence in the assessment rated as high.

With the implementation of the management measures the magnitude of the impact is considered to be reduced to minor while the duration remains long term. The spatial scale remains site specific or local. The consequence of the impact remains medium while the probability of exposure reduces from definite to possible. The significance of the impact remains medium and negative while the confidence of the assessment remains high.

Table 6-47: Impact GW-4 – MSP secondary processed tails acid generation contaminating groundwater (operational and decommissioning phase)

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Acid generating material is identified and either disposed of sub aqueously or isolated from the receiving environment through appropriate rehabilitation measures; and • Radioactive material should be identified and isolated from the receiving environment through appropriate rehabilitation measures and as per radiation management plan.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*

Impact GW-5: Elevated Lanti mining pond levels may increase the available drawdown in community boreholes

The Lanti mining pond has also been created by the construction of engineered earth impoundments across the river valley. This has resulted in a raised pond water level surface. However, it is anticipated that the groundwater levels will only be raised in close proximity to the pond edge since the groundwater gradients will still mimic the topography in the remainder of the broad valley. Community boreholes would have a greater available drawdown which would allow more abstraction before the borehole needed to recover.

The magnitude of the impact of increasing the available drawdown within the community boreholes is minor when compared to the overall borehole yield. Since the Lanti Dredge Pond will still be operation for approximately 18 months, the duration is considered to be medium term. Only those community boreholes in the immediate vicinity of the mining pond edge are likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as low. As there are no community borehole water level records prior to the construction of the Lanti Dredge Pond, the increased available drawdown is considered to be possible. The significance of the impact is low and positive while the confidence of the assessment is medium.

Table 6-48: Impact GW-5 – Elevated Lanti mining pond levels may increase the available drawdown in community boreholes

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*
Management Measures: • None proposed as this is a positive impact.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*

Impact GW-6: Lanti dredge hydrocarbon and sewage spills contaminating groundwater

While the Lanti dredge and wet processing plant is operational, there is a risk of hydrocarbon or sewage spills which may contaminate the groundwater in the immediate vicinity.

Since it is assumed that any incident will be quickly identified, the magnitude of the impact of any hydrocarbon or sewage spill is considered to be minor and the duration short term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as low. The probability of the exposure to this impact is considered to be possible. The significance of this impact is considered to be low and negative with the confidence in the assessment rated as high. With the implementation of the management measures the only change to the impact assessment is that the probability of exposure reduces from possible to unlikely. The significance of the impact remains low and negative while the confidence of the assessment remains high.

Table 6-49: Impact GW-6 – Lanti dredge hydrocarbon and sewage spills contaminating groundwater

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*
Management Measures: • Hydrocarbon transportation and storage on the dredge and wet plant should be kept to a minimum to prevent spills into the mining pond; • Appropriate booms and spill kits should be kept on board so that any spills may be addressed immediately; • Proper maintenance of all vehicles and machinery to prevent fuel or oil leaks and spillages; • Vehicles and machinery should be serviced in bunded areas with drip trays; • A hydrocarbon absorbing product should be kept on site and used to clean up hydrocarbon spills in the event that they should occur, and • The sewage treatment process should be properly maintained to ensure that it is operating within design specification.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-7: Lanti mining pond water may lead to groundwater contamination

It has been established from historical sampling that the Lanti mining pond water quality is more acidic with a higher TDS than the historical mining ponds. The water quality of any groundwater abstraction wells in close proximity may be affected where the drawdown cone alters the localised groundwater flow patterns.

The magnitude of the impact of the community boreholes in the immediate vicinity of the Lanti mining pond no longer being fit for use is considered to be moderate. Since the dredge mining operations will continue at Lanti for less than five years, the duration is considered to be medium term. Only those community boreholes in the immediate vicinity of the mining pond are likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. As there is uncertainty whether any community boreholes are affected, the impact is considered to be possible. The significance of the impact is medium and negative while the confidence of the assessment is low. After the implementation of the management measures, the magnitude of the impact reduces to minor while the duration remains medium term and the spatial scale remains site specific or local. The consequence therefore reduces to low and the probability of exposure to this impact decreases to unlikely. The consequence of the impact reduces to low while the confidence in the assessment of the management measures is high.

Table 6-50: Impact GW-7 – Lanti mining pond water may lead to groundwater contamination

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Alternative water supply to be provided if the Lanti mining pond has affected the water quality in the community boreholes in the immediate vicinity to the point where they cannot be used.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-8: Nitti Port hydrocarbon spillage contaminating groundwater

Nitti Port contains a number of large fuel storage tanks. Leaks or spills from these tanks may cause groundwater contamination. However, given the close proximity of the estuary to the storage tanks, the groundwater mainly acts as a pathway for any contaminants to migrate from the storage tanks to the surface water system where it may be spread relatively rapidly due to currents and tides.

The magnitude of the impact of a hydrocarbon spill at Nitti Port is considered to be major given the proximity of the estuary and the volume of fuel storage involved. Since the clean-up from any spill is likely to last beyond 5 years, the duration of the impact is considered to be long term. Given the potential for any major spill to spread throughout the estuary and ocean under tidal influences and currents the spatial scale is considered to be regional. The consequence of this impact is therefore rated as high. The potential exposure to this impact is considered to be possible. The significance of the impact is therefore high and negative while the confidence in the assessment is high. Since mitigation measures should be identified by specific experts in this field, there is no impact assessment for the implementation of management measures.

Table 6-51: Impact GW-8 – Nitti Port hydrocarbon spillage contaminating groundwater

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Regional*	***High***	***Possible***	***High***	-	*High*
Management Measures: • Mitigation measures should be identified by specific experts in the field;								

[Note: Although further investigations are recommended by the specialist, the following interim measures have been included in the Environmental and Social Management Plan section (Section 7, Table 7.2):

- A groundwater quality monitoring programme should be implemented; and
- Accurately record fuel stored and consumed onsite as a possible early warning measure.]

Impact GW-9: Waste disposal site leachate contaminating groundwater (operational and decommissioning phase)

Waste disposal has been undertaken on an ad hoc basis at the small waste disposal site to the north of the MSP. Leachate from this site may contaminate groundwater.

The magnitude of the impact of groundwater contamination from any landfill leachate is considered to be minor given the size of the current waste disposal site. Since the waste has been buried the duration of the impact is considered to be long term. Any leachate will seep into the groundwater within the immediate vicinity before discharging into the surrounding historical mining ponds and the spatial scale is therefore considered to be site specific or local. The consequence of this impact is therefore rated as medium. The potential exposure to this impact is considered to be possible. The significance of the impact is therefore medium and negative while the confidence in the assessment is high. With the implementation of the management measures the magnitude of the impact remains minor. The duration remains long term and the spatial scale remains site specific or local. The consequence of this impact remains medium while the probability of the potential exposure to this impact remains possible. Hence the significance of the impact remains medium and negative while the confidence in the assessment remains high.

Table 6-52: Impact GW-9 – Waste disposal site leachate contaminating groundwater (operational and decommissioning phase)

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*
Management Measures: • The waste disposal site should be properly capped and shaped to promote runoff and reduce infiltration; and • Install monitoring bores upgradient and downgradient from the waste disposal site and monitor as part of water quality monitoring programme.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*

Impact GW-10: Raised historical mining pond levels altering groundwater baseflow distribution to surface water systems

The raised water levels in the historical mining ponds have altered the groundwater gradients in the immediate vicinity. This will also have affected the groundwater baseflow distribution to the surface water systems. . The environment has already adjusted to the altered baseflow as the historical mining ponds have been in place for a long duration.

The magnitude of the impact of the baseflow variation due to the raised historical mining pond levels is considered to be minor. The current historical mining pond water levels may be in place for longer than five years and the duration of the impact is therefore considered to be long term. Since the baseflow that is affected is restricted to the catchments of the historical mining ponds and their immediately adjacent valleys, the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. The potential exposure to this impact is considered to be definite. The significance of the impact is therefore medium and negative while the confidence in the assessment is medium. No mitigation measures are proposed for this impact.

Table 6-53: Impact GW-10 – Raised historical mining pond levels altering groundwater baseflow distribution to surface water systems

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • No mitigation measures are proposed for this impact.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*

Impact GW-11: Lanti mining pond retarding groundwater baseflow to surface water systems

The Lanti mining pond was created by the construction of engineered dams across the river valley. This has resulted in the retardation of the baseflow of the surface water systems. This impact will continue post mining as it is anticipated that the earth impoundments will remain in place albeit at a lower level. Similarly to GW-10, the environmental has already adjusted to the altered baseflow as the Lanti mining pond has been in place for a long duration.

Table 6-54: Impact GW-11 – Lanti mining pond retarding groundwater baseflow to surface water systems

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • No mitigation measures are proposed for this impact, however a groundwater model should be used to determine the order of magnitude for the baseflow variations to the various surface water systems; and • Surface water flow volumes should be monitored downstream in the immediate vicinity to determine the response of the environment to the Lanti mining pond.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*

Impact GW-12: Seepage of poor quality groundwater through the Lanti mining pond wall and weathered aquifer discharging into the surface water systems

Historical sampling has shown that the water quality within the Lanti mining pond is more acidic and has a higher TDS than the historical mining ponds. Some of this water seeps through the earth impoundment and weathered aquifer as groundwater and discharges into the surface water downstream. It is anticipated that the pond water quality will improve post mining.

The magnitude of the impact of any poor-quality groundwater seepage through the dam wall and weathered aquifer is considered to be minor. Since the Lanti dredge operations will continue for approximately 18 months the duration of the impact is considered to be medium term. After this period the groundwater quality is likely to improve. The groundwater seepage occurs at the Lanti mining pond wall and the spatial scale is therefore considered to be site specific or local. The consequence of this impact is therefore rated as low. The potential exposure to this impact is considered to be definite. The significance of the impact is therefore medium and negative while the confidence in the assessment is high. No mitigation measures are proposed for this impact.

Table 6-55: Impact GW-12 – Seepage of poor quality groundwater through the lanti mining pond wall and weathered aquifer discharging into the surface water systems

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*High*
Management Measures: • No mitigation measures are proposed for this impact.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*High*

Impact GW-13: Failure of the historical and Lanti mining pond walls as a result of groundwater seepage (operational and decommissioning phase)

The historical and Lanti mining ponds have sand blankets built into the impoundment wall to reduce the internal phreatic surface. Nonetheless, excessive groundwater seepage through these structures may affect the stability. The raised water levels in the historical and Lanti mining ponds has resulted in additional groundwater seepage through the earth impoundments.

Given the size of the mining ponds the magnitude of the impact of dam failure due to groundwater seepage is considered to be major due to the potential loss of life and damage downstream. The destruction associated with a dam wall failure is substantial and the duration of the impact is considered to be long term. The affected area from a dam wall failure would extend beyond the site boundaries. However, the implications will extend beyond the region and the spatial scale is therefore considered to be national. The consequence of this impact is therefore rated as high. The potential exposure to this impact is considered to be possible. The significance of the impact is therefore high and negative while the confidence in the assessment is high. Following the implementation of the mitigation measures the magnitude of the impact remains major and the duration remains long term. Since the spatial scale is still considered to be national, the consequence of this impact is still rated as high. However, the potential exposure to this impact with management measures is reduced to unlikely. The significance of the impact is therefore reduced to medium and negative while the confidence in the assessment remains high.

Table 6-56: Impact GW-13 – Failure of the historical and Lanti mining pond walls as a result of groundwater seepage (operational and decommissioning phase)

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*National*	***High***	***Possible***	***High***	-	*High*
Management Measures: • Lower the water levels in the mining ponds in accordance with the Mine Closure Plan to reduce maintenance and risk of wall failure, and • Tailings should be deposited downstream of the mining pond walls to ensure greater stability.								
After Management	*Major*	*Long term*	*National*	***High***	***Unlikely***	***Medium***	-	*High*

Impact GW-14: Gbeni and Gangama dry mining dewatering leading to lowered groundwater levels

The future Gbeni and Gangama dry mining operations will extend to the base of the orebody which will be below the groundwater surface. This will lead to the formation of a dewatering cone which will lower the groundwater levels within the immediate vicinity.

The magnitude of the impact of lowering the groundwater levels in response to dewatering around the dry mining is considered to be minor due to the relatively shallow drawdown of less than 10m which is expected. Since dewatering will occur over the following 4 years the duration is considered to be medium term. Only groundwater in the immediate vicinity of the dry mining operations is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as low. Dewatering will occur and the exposure to this impact is therefore considered to be definite. The significance of the impact is medium and negative while the confidence in the assessment is high.

After the implementation of the management measures, the magnitude of the impact remains minor and the duration remains medium term. The spatial scale remains site specific or local. As a result, the consequence of this impact after management measures remains low. After management measures the exposure to this impact decreases to unlikely. The significance of the impact reduces to low while the confidence in the assessment remains at high.

Table 6-57: Impact GW-14 – Gbeni and Gangama dry mining dewatering leading to lowered groundwater levels

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*High*
Management Measures:								
• Alternative water supplies will have to be provided where community boreholes in the immediate vicinity are not functional due to the dewatering; and • Rivers or surface water systems should be diverted away from the mining operations to prevent water loss to the mine workings.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-15: Gangama dry mining groundwater ingress adjacent to the estuary

Although the ore deposit generally has a low permeability, the geological map indicates the occurrence of highly permeable Bullom sediments on the north-western boundary of the Gangama deposit. This area also coincides with the close proximity of the estuary which has a constant piezometric head due to the connection to the ocean.

Since the depth of mining may extend to -5 mamsl, the anticipated groundwater ingress could be 50-fold higher than elsewhere in the dry mining operations.

The magnitude of the impact of the increased groundwater ingress while dry mining adjacent to the estuary is considered to be moderate. Mining would take place for approximately 4 years and the duration is therefore considered to be medium term. This greater influx will only occur in the north-western portion of the Gangama deposit hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. The potential exposure to this impact is considered to be definite. The significance of the impact is therefore medium and negative while the confidence in the assessment is high. With the implementation of the management measures the magnitude of the impact reduces to minor. The duration remains medium term and the spatial scale remains site specific or local. As a result, the consequence of this impact decreases to low. The probability of the potential exposure to this impact is rated as unlikely. Hence the significance of the impact is reduced to low and negative while the confidence in the assessment remains high.

Table 6-58: Impact GW-15 – Gangama dry mining groundwater ingress adjacent to the estuary

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • The location of the Bullom sediments should be mapped in relation to the boundary of the Gangama orebody, and • If these strata cover a significant area that would be affected by mining, then alternative mining methods and environmental / community health and safety impact mitigation should be investigated.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-16: Gbeni and Gangama dry mining hydrocarbons contaminating groundwater

There is a risk of hydrocarbon spills which may contaminate the groundwater during mining at Gbeni and Gangama deposits.

Since it is assumed that any incident will be quickly identified, the magnitude of the impact of any hydrocarbon spill is considered to be minor and the duration short term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as low. The probability of the exposure to this impact is considered to be possible. The significance of this impact is considered to be low and negative with the confidence in the assessment rated as high. With the implementation of the management measures the only change to the impact assessment is that the probability of exposure to this impact reduces from possible to unlikely. The significance of the impact remains low and negative while the confidence of the assessment remains high.

Table 6-59: Impact GW-16 – Gbeni and Gangama dry mining hydrocarbons contaminating groundwater

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*
Management Measures: • Proper maintenance should be undertaken on all vehicles and machinery to prevent fuel or oil leaks and spillages; • Vehicles and machinery should be serviced in bunded areas with drip trays, and • A hydrocarbon absorbing product should be kept on site and used to clean up hydrocarbon spills in the event that they should occur.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-17: Gbeni and Gangama dry mining sulfide exposure contaminating groundwater (operational and decommissioning phase)

The geochemistry study (SRK, 2018(2), included in Appendix E) has determined that the general tailings are inert within the mining operations. However, mining at Gbeni and Gangama deposits has predominantly occurred above the groundwater surface. Future mining may expose material which has been under anoxic conditions and which may contain sulfide minerals. Oxidation of this material may lead to further acidification of the groundwater with a potential increase in salinity and heavy metal concentrations.

The magnitude of the impact of the exposure of sulfide minerals during mining at Gbeni and Gangama is considered to be moderate. Although mining would take place for approximately 4 years, the acidification process would continue post mining and the duration is therefore considered to be long term. Exposure of any sulfides would only occur within the dry mining workings hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. The potential exposure to this impact is considered to be possible since the current sulfide content in the remainder of the ore deposit is unknown. The significance of the impact is therefore medium and negative while the confidence in the assessment is medium. With the implementation of the management measures the magnitude of the impact reduces to minor. The duration remains long term and the spatial scale remains site specific or local. As a result, the consequence of this impact remains medium. The probability of the potential exposure to this impact remains possible. Hence the significance of the impact remains medium and negative while the confidence in the assessment remains medium.

Table 6-60: Impact GW-17 – Gbeni and Gangama dry mining sulfide exposure contaminating groundwater (operational and decommissioning phase)

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • The orebody sulfide content beneath the groundwater surface should be established; • A review of the mineral separation process should be undertaken to confirm that the majority of the high sulfide material can be extracted for selective handling; and • Any high sulfide material should be deposited sub aqueously or rehabilitated in such a manner that it is isolated from the environment.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact GW-18: Gangama dry mining saline intrusion contaminating groundwater (operational and decommissioning phase)

The north-western boundary of the Gangama deposit lies adjacent to the estuary which is subjected to tidal influences. Any dewatering within this immediate vicinity will lead to saline intrusion towards the workings thereby contaminating the groundwater regime.

The magnitude of the impact of the potential saline ingress is considered to be moderate since the nearby estuary is already subjected to tidal influences. Although mining would take place for approximately 4 years, the saline intrusion would last post mining and may take decades to reverse. The duration is therefore considered to be long term. The area for the potential saline intrusion is limited to the north-western boundary of the Gangama dry mining operations hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore medium. The potential exposure to this impact is considered to be definite given the close proximity of the dry mining to the estuary. The significance of the impact is therefore medium and negative while the confidence in the assessment is high. With the implementation of the management measures the magnitude of the impact reduces to minor. The duration remains long term and the spatial scale remains site specific or local. As a result, the consequence of this impact remains medium. The probability of the potential exposure to this impact remains possible. Hence the significance of the impact remains medium and negative while the confidence in the assessment remains high.

Table 6-61: Impact GW-18 – Gangama dry mining saline intrusion contaminating groundwater (operational and decommissioning phase)

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • The extent of the more permeable Bullom sediments should be defined as accurately as possible to identify areas of potential greater ingress; • If the Bullom strata areas are extensive then alternative mining methods to the current dry mining operations should be considered since excessive volumes of saline water might be generated; • Groundwater ingress is anticipated to be manageable where the orebody permeability is typically low. However, since the dewatered volume is likely to be saline, this will have to be passed through a settling pond to remove any suspended solids prior to discharge into the estuary. The discharged water quality will have to be monitored to ensure that it complies with legislation; • Any saline water should be kept separate from other fresh dewatering volumes which may be discharged to nearby freshwater streams, and • Rehabilitation should consider the extent of any saline intrusion and the impact that this may have on vegetation and the final land use in this area.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*

Impact GW-19: Gbeni and Gangama dry mining slope failure as a result of groundwater seepage

Future Gbeni and Gangama dry mining operations will occur beneath the groundwater surface. Dewatering will be required presumably through the use of trenches given the low permeability of the orebody. Groundwater seepage towards the trenches is an influencing factor for the slope stability of the dry mining operations.

The magnitude of the impact of groundwater seepage induced slope failure is considered to be moderate. Since the depth of the dry mining is relatively shallow it is anticipated that any slope failure could be repaired within a year. The duration of the impact is therefore considered to be short term. Slope failure would be limited to the dry mining operations and the spatial scale is therefore considered to be site specific or local. The consequence of this impact is therefore rated as low. The potential exposure to this impact is considered to be possible. The significance of the impact is therefore low and negative while the confidence in the assessment is high. Following the implementation of mitigation measures the magnitude of the impact is reduced to minor while the duration remains short term. The spatial scale remains site specific or local. The consequence of this impact therefore remains low. However, the potential exposure to this impact with management measures is reduced to unlikely. Nonetheless, the significance of the impact remains low and negative while the confidence in the assessment remains high.

Table 6-62: Impact GW-19 – Gbeni and Gangama dry mining slope failure as a result of groundwater seepage

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*
Management Measures: • Groundwater levels should be lowered as much as possible ahead of mining to reduce the risk of failure, and • Slopes of the dry mining operations should be reduced appropriately to minimize slope stability risks.								
After Management	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-20: Gbeni and Gangama dry mining saturation due to groundwater ingress

Dewatering will be required for the future Gbeni and Gangama dry mining operations. Although the current information suggests that the orebody has a low permeability, the orebody may remain saturated as a result which may affect production.

The magnitude of the impact of saturated conditions in the Gbeni and Gangama dry mining operations due to groundwater ingress is considered to be moderate. Mining operations will occur over the following 4 years and the duration is therefore considered to be medium term. Only the immediate dry mining operations are affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. Based on the available field observations the potential exposure to this impact is considered to be definite. The significance of the impact is medium and negative while the confidence in the assessment is high.

After the implementation of the management measures, the magnitude of the impact is reduced to minor while the duration remains medium term. The spatial scale remains site specific or local. The consequence of this impact after management measures is therefore reduced to low. After management measures the probability of exposure to this impact reduces to possible. The significance of the impact therefore reduces to low while the confidence in the assessment remains at high.

Table 6-63: Impact GW-20 – Gbeni and Gangama dry mining saturation due to groundwater ingress

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Surface water courses should be diverted away from the perimeter of the dry mining operations where possible to reduce water recirculation; • The mining operations surface should be shaped in such a manner as to promote rapid runoff with minimal infiltration; • High permeable zones should be identified prior to the advance of mining particularly any occurrence of Bullom sediments; • Dewatering trenches, sumps and pumping equipment should be sized correctly to cater for any sudden ingress, and • Dewatering should occur ahead of mining to ensure that the groundwater levels have been lowered sufficiently to increase the margin of safety.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*

Impact GW-21: Suspended solids from the Gbeni and Gangama dry mining dewatering volumes contaminating surface water

Dewatering will occur as the dry mining operations at Gbeni and Gangama extend beneath the groundwater surface. It is anticipated that this groundwater will be intercepted by trenches and pumped into the surface water systems. Any suspended solids that are contained within this water may have an impact on the surface water quality.

The magnitude of the impact of suspended solids from the dewatering volumes is considered to be minor given the relatively low dewatering volumes that are expected. Since the dry mining operations will continue for another 4 years the duration of the impact is considered to be medium term. The discharge occurs from the dry mining operations and the spatial scale is therefore considered to be site specific or local. The consequence of this impact is therefore rated as low. The potential exposure to this impact is considered to be possible. The significance of the impact is therefore low and negative while the confidence in the assessment is high. Following the implementation of the mitigation measures the magnitude of the impact remains low and the duration remains medium term. The spatial scale remains site specific or local. The consequence of the impact therefore remains low. After the implementation of the management measures the potential exposure to the impact is reduced to unlikely. Therefore, the significance of the impact remains low and negative while the confidence in the assessment remains high.

Table 6-64: Impact GW-21 – Suspended solids from the Gbeni and Gangama dry mining dewatering volumes contaminating surface water

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*
Management Measures: • The dewatering volumes should be pumped into a settling pond or wetland so that the water quality can be improved prior to the discharge to the surface water systems.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*High*

Impact GW-22: Lowered historical mining pond levels may reduce the available drawdown in community boreholes

In the current mine closure plan the water levels within the historical mining ponds will be lowered to reduce maintenance and the risk of dam wall failure. This may cause the groundwater levels in the community boreholes in the immediate vicinity to fluctuate and / or drop to the point where they can no longer function.

The magnitude of the impact of the community boreholes in the immediate vicinity no longer functioning is considered to be moderate. It is assumed that any reduction in the historical mining pond water levels is a permanent management measure and the duration is therefore considered to be long term. Only those community boreholes in the immediate vicinity are likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. As there are no community borehole water level records prior to the construction of the historical ponds, the impact is considered to be possible. The significance of the impact is medium and negative while the confidence of the assessment is medium. After the implementation of the management measures, the magnitude of the impact is reduced to minor while the probability of exposure decreases to unlikely. The consequence of the impact is reduced to low while the confidence in the assessment of the management measures is high.

Table 6-65: Impact GW-22 – Lowered historical mining pond levels may reduce the available drawdown in community boreholes

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Provide alternative water supply if community boreholes in the immediate vicinity no longer function.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*High*

Impact GW-23: Lowered historical mining pond levels may expose sulfides leading to groundwater acidification

In the current mine closure plan the water levels within the historical mining ponds will be lowered for maintenance and to reduce the risk of dam wall failure. This may in turn expose previously inundated sulfides which may lead to acidification and contamination of the groundwater regime in the immediate vicinity.

The magnitude of the impact of the exposure of sulfides during the lowering of the historical mining pond water levels and subsequent contamination of groundwater is considered to be moderate. It is assumed that any reduction in the historical mining pond water levels is a permanent management measure and the duration is therefore considered to be long term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. It is uncertain whether sulfides exist at the base of the historical mining ponds and the impact is therefore considered to be possible. The significance of the impact is medium and negative while the confidence of the assessment is low.

After the implementation of the management measures, the magnitude of the impact is reduced to minor while the probability of exposure to this impact remains at possible. The confidence in the assessment of the management measures is medium.

Table 6-66: Impact GW-23 – Lowered historical mining pond levels may expose sulfides leading to groundwater acidification

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Low*
Management Measures: • Sample for sulfides and rehabilitate potentially acid generating material or dispose of sub aqueously beneath a permanent water level elevation.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact GW-24: Decommissioning the MSP tailings and dams will lower groundwater levels beneath the tailings disposal area

After the MSP secondary processed tailings disposal area is decommissioned, the seepage to groundwater will reduce particularly if the area is properly rehabilitated. Groundwater gradients are expected to return to ambient conditions especially if the water level in the Mogbwemo Dredge Pond is lowered as part of the mine closure plan.

The magnitude of the lowered groundwater levels in response to the decommissioning and rehabilitation of the MSP tailings area is considered to be minor. Since the decommissioning of the MSP is considered to be permanent the duration is considered to be long term. Only groundwater in the immediate vicinity is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. Prior to the implementation of management measures the probability of this impact is considered to be possible. The significance of the impact is medium and positive while the confidence of the assessment is medium. Assuming the rehabilitation of the MSP tailings area is appropriate, the probability of exposure to this impact is raised to definite. The post management significance of the impact remains medium and positive although the confidence of the assessment is high.

Table 6-67: Impact GW-24 – Decommissioning the MSP tailings and dams will lower groundwater levels beneath the tailings disposal area

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*
Management Measures: • Appropriate rehabilitation of the processed tailings area.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	+	*High*

Impact GW-25: Lowered Lanti mining pond levels may reduce the available drawdown in community boreholes

In the current mine plan, the water level within the Lanti mining pond will be lowered to reduce the maintenance and risk of dam wall failure. This may cause the groundwater levels in the community boreholes in the immediate vicinity of the pond edge to fluctuate and / or drop to the point where they can no longer function.

The magnitude of the impact of the community boreholes in the immediate vicinity of the Lanti mining pond no longer functioning is considered to be moderate. It is assumed that any reduction in the Lanti mining pond water levels is a permanent management measure and the duration is therefore considered to be long term. Only those community boreholes in the immediate vicinity of the mining pond are likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. As there are no community borehole water level records prior to the construction of the Lanti pond, the impact is considered to be possible. The significance of the impact is medium and negative while the confidence of the assessment is medium. After the implementation of the management measures, the magnitude of the impact is reduced to minor while the duration of the impact remains long term. The spatial scale remains site specific and the consequence remains medium. The probability of exposure to this impact decreases to unlikely and the significance of the impact is reduced to low while the confidence in the assessment of the management measures is high.

Table 6-68: Impact GW-25 – Lowered Lanti mining pond levels may reduce the available drawdown in community boreholes

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Provide alternative water supply if community boreholes in the immediate vicinity no longer function.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*High*

Impact GW-26: Lowered Lanti mining pond level may expose sulfides leading to groundwater acidification

In the current Mine Closure Plan, the water levels within the Lanti mining pond will be lowered to reduce maintenance and the risk of dam wall failure. This may in turn expose previously inundated sulfides which may lead to acidification and contamination of the groundwater regime in the immediate vicinity.

The magnitude of the impact of the exposure of sulfides during the lowering of the Lanti mining pond water levels and subsequent contamination of groundwater is considered to be moderate. It is assumed that any reduction in the Lanti mining pond water level is a permanent management measure and the duration is therefore considered to be long term. Only groundwater in the immediate vicinity of the Lanti pond is likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. It is uncertain whether sulfides exist at the base of the Lanti mining pond and the impact is therefore considered to be possible. The significance of the impact is medium and negative while the confidence of the assessment is low.

After the implementation of the management measures, the magnitude of the impact is reduced to minor while the probability of exposure to this impact remains at possible. Nonetheless, the significance of the impact remains medium while the confidence in the assessment of the management measures increases to medium.

Table 6-69: Impact GW-26 – Lowered Lanti mining pond level may expose sulfides leading to groundwater acidification

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Low*
Management Measures: • Sample for sulfides and rehabilitate potentially acid generating material or dispose of sub aqueously beneath a permanent water level elevation.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*

Impact GW-27: Gbeni and Gangama dry mining groundwater gradients recover post-mining

Following mining at Gbeni and Gangama deposits, dewatering will cease, and the area will be rehabilitated. This will lead to the recovery of the groundwater gradients to ambient conditions.

The magnitude of the impact of the recovery of the groundwater gradients to ambient conditions post mining is considered to be minor. Since this would be the final land form the duration is considered to be long term. Only the groundwater gradients in the immediate vicinity of the dry mining operations are likely to be affected hence the spatial scale is considered to be site specific or local. The consequence of this impact is therefore rated as medium. The potential exposure to this impact is considered to be definite. The significance of the impact is therefore medium. If the rehabilitation does not mimic the pre-mining topography and diverted rivers are not reinstated, then the impact will be considered to be negative while the confidence in the assessment is high.

After the implementation of the management measures, the magnitude of the impact remains minor and the duration remains long term. The spatial scale remains site specific or local. As a result, the consequence of this impact after management measures remains medium and the potential exposure to this impact remains definite. The significance of the impact remains medium. However, the impact becomes positive while the confidence in the assessment remains at high.

Table 6-70: Impact GW-27 – Gbeni and Gangama dry mining groundwater gradients recover post mining

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • The rehabilitated topography should mimic pre-mining conditions and diverted rivers should be reinstated as per the Mine Closure Plan; • Installation and monitoring of shallow monitoring bores on the perimeter of the depoists for response of groundwater griendts to dewatering.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*

Impact GW-28: Lowered historical mining pond levels altering groundwater baseflow distribution to surface water systems

In the current Mine Closure Plan, the water levels within the historical mining ponds will be lowered to reduce maintenance and the risk of dam wall failure. This will also alter the groundwater baseflow distribution to the surface water systems in the immediately adjacent valleys. The baseflow will adjust to the new lowered mining pond levels until approximate steady state conditions are achieved.

The magnitude of the impact of the baseflow variation due to the lowered historical mining pond levels is considered to be minor. Since the lowering of the historical mining pond water levels forms part of the mine closure plan, the duration of the impact is considered to be long term.

It is anticipated that the historical mining pond dam walls will not be completely removed and hence the baseflow within the historical mining pond catchments would remain restricted. This would mean that the greatest changes in baseflow would occur within the valleys adjacent to the historical mining ponds and the spatial scale is therefore considered to be site specific or local. The consequence of this impact is therefore rated as medium. The potential exposure to this impact is considered to be definite. The significance of the impact is therefore medium and negative while the confidence in the assessment is medium. No mitigation measures are proposed for this impact.

Table 6-71: Impact GW-28 – Lowered historical mining pond levels altering groundwater baseflow distribution to surface water systems

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • No mitigation measures are proposed for this impact.								
After Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Medium*

6.3.9 Radiation

The content of this section is adapted from the specialist Radiological Assessment and Gap Analysis report (i.e. radiadiation study) (SRL 2018) which is attached as Appendix I. The following potentially significant impact associated with project activities is identified relating to radiation:

- Impact RI-1: Impact on social and biophysical receiving environments based on radiation exposure.

Stakeholders raised the following request:

- Identify host community health impacts associated with radiation.

Impact RI-1: Impact on social and biophysical receiving environments based on radiation exposure

From the dose assessment conducted across all the operational sites at SR Area 1, it was determined that the largest contributing exposure pathway for workers is from external gamma, followed by dust inhalation. Inadvertent soil ingestion dose was shown to be a negligible contributor to total dose. The estimated dose to workers at mining and WCP operations was shown to be 0.1 mSv/y.

At the MSP it was determined that the largest dose from an individual material would be incurred from exposure to zircon product. The zircon product however only constitutes 0.5 % of the total material treated through the MSP; is bagged directly from the product chute (to mitigate dust exposure); and stored in an area of the plant with controlled access to workers, thereby limiting gamma exposure. The estimated annual dose for workers at the MSP is 1.49 mSv/y (excluding background), which is consistent with radiation doses of Iluka Australian operations, which record total annual doses below 5 mSv/y. The current personal gamma monitoring program conducted at SRL (TLD badges) to date has shown that doses are in line with those predicted from the dose assessment.

At the tailings storage area, it was determined that the largest dose from an individual material would be incurred from exposure to CET. This dose would however be an over-estimate, as CET constitutes only 2.8 % of the total tailings material stored in the area. Further to this, the only individuals exposed to radiation dose at the tailings storage area are the security guards which control access to the area (some distance away from the actual tailings stockpiles); front-end-loader operators; dozer operators and truck drivers (some shielding provided by the machinery). The estimated annual dose for workers at the tailings storage is 1.19 mSv/y (excluding background) and the current personal gamma monitoring program conducted at SRL (TLD badges) to date have shown that doses are in line with those predicted from the dose assessment.

At Nitti Port, it was determined that the largest worker dose from an individual material would be incurred from exposure to zircon, followed by ilmenite. The estimated annual dose for workers at the Port is however 0.69 mSv/y (excluding background), as calculated from exposure to "*reconstructed MSP products".*

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 operations; MSP and Tailings operations; and close to Nitti Port is below the public exposure limit of 1 mSv/y.

Gamma screening level surveys conducted of the SRL operational areas, confirmed that the areas with the highest gamma radiation exposure are the MSP; the tailings storage area; and Nitti Port.

The emanation of radon from heavy minerals has been found to be very low (KER 1988). In the open, any radon released from an ore body or a stockpile will be rapidly diluted in the atmosphere and dispersed. It is therefore likely that in open pit mining and associated processing, the radon levels will be comparable to ambient levels and this exposure pathway is not considered to be significant for workers or members of the public.

Other potential pathways of exposure, such as from the ingestion of surface or groundwater by members of the public, are not expected to be significant.

The significance of the impact is considered to be medium as 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 social and biophysical receiving environments.

Table 6-72: Impact RI-1 – Impact on social and biophysical receiving environments based on radiation exposure

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site*	***Medium***	***Possible***	***Medium***	-	*Medium*

Management Measures:
• Undertake baseline monitoring to determine the following:
  ○ Radionuclide concentrations in soil across the current (and future) project areas through the soil profile;
  ○ The radionuclide concentrations in tailings across the current project areas. Full radionuclide analysis of selected tailings streams for future human health and biota modeling purposes;
  ○ The absorbed (radiation) gamma dose rates in air across the current (and future) project areas;
  ○ The radon (Rn-222) and thoron (Rn-220) concentrations in the air;
  ○ The groundwater radionuclide concentrations (incl. U, Th, Ra-226, Ra-228, gross alpha and beta);
  ○ The surface water radionuclide concentrations (incl. U, Th, Ra-226, Ra-228, gross alpha and beta); and
  ○ The long lived alpha activity (LLAA) in airborne dust.
• Conduct a ERICA assessment (biota modelling) once processing materials have been characterized in terms of full radionuclide analysis; and
• Update and implement the radiation management plan based on findings from the baseline monitoring and ERICA assessment.								

After Management	*Moderate*	*Long term*	*Site*	***Medium***	***Possible***	***Medium***	-	*Medium*

6.4 Health impacts

The content of this section is adapted from the specialist Rapid Health Impact Assessment (SHAPE 2018) which is attached as Appendix D.

The health impacts identified in this section were determined to be applicable at construction, current approved operations and proposed future operations. Where an impact is not applicable at a project phase, it is indicated in the impact table. As such, the following potentially significant health impacts associated with current approved operations and proposed project activities include the following:

- Impact H-1: Transmission of communicable diseases from workforce to the host community due to influx and general hygiene;
- Impact H-2: Increased burden of disease associated with malaria due to modification of the environment (including current mining activities such as mine dredge ponds and in-migration of work-seekers);
- Impact H-3: Risk of outbreak of arbo-viral diseases due to influx and opening of transport corridors;
- Impact H-4: Effects on human health as a result of changes in the biophysical environment incurred by current and future mining activities;
- Impact H-5: Increased risk of sexually-transmitted diseases and high risk sexual practices due to current and future mining activities;
- Impact H-6: Food and nutrition-related issues due to influx and land use change;
- Impact H-7: Increase in non-communicable diseases as a result of lifestyle and demographic changes;
- Impact H-8: Emergence and spread of veterinary medicine and zoonotic diseases due to inadequate camp and waste facilities; and
- Impact H-9: Influence on cultural health practices due to influx and pressure on limited available health services.

[Note: The specialist health study (Appendix D) assesses and ranks 18 inherant and residual health impacts in terms of the IFC's Environmental Health Areas (EHA) framework and its specific methodology. For purposes of this ESHIA, only the most significant of the EHA assessed impacts have been carried forward for inclusion in this document. Furthermore, the SRK impact assessment methodology (Section 6.2 above) has been applied in order for consistency with the biophysical (Section 6.3) and social (Section 6.5) impacts assessed.]

Stakeholders raised the following comments:

- SRL operations are considered to bring harmful insects to the villages;
- Host communities do not have clean drinking water, and this causes illness;
- Due to an increase in the local population, there are diseases around including HIV/AIDS, Gonorrhea and other related illnesses;
- SRL was requested to aid with monthly food packages due to a lack of farmland to produce food;
- Existing healthcare facilities are ill-equipped to deal with the current demand;
- Dry mining causes deforestation in the surrounding areas; and
- The host community do not have ease of access to clinics.

Impact H-1: Transmission of communicable diseases from workforce to the host community due to influx and general hygiene

There is the potential for the introduction of communicable diseases that are not common or circulating locally from the workforce who are hired / or travel from outside the immediate SR Area 1. This can include conditions such as seasonal influenza, meningitis, TB (especially multi drug resistant TB) and other novel diseases such as pandemic influenza. This potential risk may be magnified by the weak local public health system.

There is also the potential for transmission of these communicable diseases from the workforce to the host community. This risk is higher where people live / work in close contact with one another, e.g. mine accommodation areas.

Additionally, the workforce who rent local accommodation may choose to share accommodation or live in close quarters to one another to save on rental costs. This may promote overcrowding, potentially supporting transmission of communicable diseases.

The Project is an attractor for job and opportunity seeking migrants, which has led to movement of people in and out of the area and resulted in the unplanned development of settlements. This has led to challenges with housing and general environmental health conditions. There is limited capacity in local and District authorities to support or implement effective town planning. Impacts may include:

- Introduction of communicable disease due to high movement of people and mixing of people who live in close association to one another;
- Supply and demand constraints due to pressure on the availability of housing due to rental cost and costs of building materials. Members of the community that cannot afford rentals/housing will be particularly vulnerable, as they may be forced to build make-shift structures; and
- Weak health services and inability to support health prevention or curative health services.

Before management, the impact was given a medium negative significance rating. By implementing the appropriate management measures recommended below, the significance of this impact can be managed down to a low negative significance.

Table 6-73: Impact H-1 - Transmission of communicable diseases from workforce to the host community due to influx and general hygiene

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Regional*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Develop a communicable disease strategy (HIV, TB etc.) and plan that includes employees, contractors and visitors. The strategy should include elements that reduce the risk for local introduction of communicable disease; • Develop an outbreak preparedness and response plan that includes business resilience elements. This should include cooperation with the DHMTs; • Develop an influx management plan; • Develop a monitoring system as part of the CHMMP to monitor specific health indicators; • Develop an agreement with the DHMT(s) to support the care and treatment of employees / contractors for TB (and HIV) so that when employees / contractors leave the project that they can be referred back into the public health system, or traced to their place of origin (this is particularly important for people undergoing treatment); • Ensure adequate camp facility management in company accommodation so adequate environmental health / hygiene standards are maintained; and • Develop a vaccine preventable disease programme for all employees and contractors..								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

Impact H-2: Increased burden of disease associated with malaria due to modification of the environment (including current mining activities such as mine dredge ponds and in-migration of work-seekers)

Changes to the environment from current and future mining and associated activities have the potential to create localised mosquito breeding areas. As vector densities increase, so may the potential for disease transmission.

This may occur for future mining activities where there is ground disturbance including general clearing, rutting on access / haul roads, construction yards and dredge ponds. The mine ponds may also influence mosquito breeding patterns, with this most likely to occur on the margins or backwaters, or when dams dry out to leave puddles in the dry season. Human and animal activities on the banks of dams may also create a suitable habitat. The main body of water (mine pond) does not constitute a suitable breeding habitat for malaria.

Malaria poses a significant health risk to employees and an economic risk to the project. These risks should be considered as part of the workplace health programmes.

Indirectly, project induced influx may influence malaria transmission patterns by:

- Unchecked development in host communities with creation of breeding sites through poor environmental management and inadequate waste management;
- Poor housing that allows for easy entry of mosquitoes into dwellings;
- Increased population limiting the effectiveness of public health controls, e.g. new arrivals not having ITNs, or not enough ITNs as population has increased in size after planning; and
- Pressure on public health services due to increased malaria case-loads and a larger population.

A project benefit was noted as improved access to SR Area 1 from the maintained roads which supports the delivery of outreach public health interventions as well as access to the health referral network.

Prior to the application of recommended management measures, the significance rating of the impact is high negative. Should management measure be implemented, significance becomes medium positive.

Table 6-74: Impact H-2 – Increased burden of disease associated with malaria due to modification of the environment

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Regional*	***High***	***Definite***	***High***	-	*High*

Management Measures:
• Evaluate opportunities to work with the National Malaria Control Programme (NMCP) and DHMT including:
  ○ Perform a malaria indicator study to determine the local burden of disease;
  ○ Conduct a baseline entomology study to determine the presence of disease transmitting mosquitoes and other vectors, their behaviours and what controls could be effective;
• Develop an influx management plan that may consider environmental management and health systems strengthening in collaboration with the DHMT; and
• Develop an integrated workplace malaria and vector control programme that has a focus on environmental management, integrated vector control, bite prevention, behaviour management and effective case management within the workplace.								

After Management	*Minor*	*Long term*	*Regional*	***Medium***	***Possible***	***Medium***	+	*Medium*

Impact H-3: Risk of outbreak of arbo-viral diseases due to influx and opening of transport corridors

There is the potential for arbo-viruses to be introduced into SR Area 1 through goods and equipment, especially items that can hold water such as tyres, that are shipped from endemic areas, e.g. China and South East Asia. Infected larvae and eggs may be transferred in these goods, with the emerging mosquito vector able to transmit disease immediately as the virus can be transferred through infected eggs. The Nitti Port area is specifically at risk as goods may be transferred at this location, but goods shipped from other areas such as Freetown port also pose a risk.

Movement of people from areas where arbo-viral diseases are circulating may result in the local introduction of the disease. This potential risk is present regardless of the presence of the project, but increased migration of people due to the project exacerbates the risk. In addition, unplanned development and poor environmental hygiene conditions may lead to the increase in mosquitoes, with a potential risk for disease transmission.

As such, before management measures, significance of the rating is medium negative, however it is reduced to low negative following the implementation of recommended management measures.

Table 6-75: Impact H-3 – Risk of outbreak of arbo-viral diseases due to influx and opening of transport corridors

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Include vector control measures in the proposed integrated workplace vector control programme but ensure a focus for *Aedes* spp. control. This can include source reduction where water may collect (tyres, lay down yards etc.) with environmental controls the main intervention, e.g. draining water or preventing collection, and chemical larval controls may also be considered as required; • Include the potential transmission of arbo-viral disease in the proposed outbreak preparedness and response plan. This is especially important for yellow fever as it can mimic other viral haemorrhagic fevers, such as EVD; • Develop an influx management plan; • As part of the proposed entomology study in Table 6-27 for impact H-2, include screening for other species that have the potential to transmit disease and develop vector control actions based on findings; • Develop capacity in the workforce to diagnose and manage suspected or confirmed cases of arbo-viral disease; and • Based on the threat of a (or a confirmed) yellow fever outbreak, vaccinate the workforce. This will require collaboration with the National or District health authorities.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Unlikely***	***Low***	-	*Medium*

Impact H-4: Effects on human health as a result of changes in the biophysical environment incurred by current and future mining activities

Activities in the workplace and from the workforce could potentially impact on water, hygiene and sanitation conditions in the host communities. Chemical and hydrocarbon spills from workshops, or from accidents while transporting goods, as well as the potential pollution of surface and ground water sources from inadequate sewerage management, or inappropriate discharge of waste water from sewerage treatment plants are examples of this.

Additionally, access to surface water or superficial groundwater sources that were used traditionally may be impacted due to mining activities resulting in an increase distance and time to collect water in certain host communities. The mine ponds are mainly used for domestic purposes with the potential that people urinate or defecate in the water body. This has the potential to promote the localised transmission of bilharzia, noting that SR Area1 is located in a low risk area.

Ultimately, influx into SR Area1 and an increased population size has placed pressure on the already limited water, sanitation and waste management services due to an increased demand. These factors have the potential to increase water, sanitation and hygiene related diseases including diarrhoeal disease, e.g. dysentery, cholera and typhoid outbreaks, intestinal parasites (especially hookworm), as well as skin (scabies, fungal infection) and eye infections.

While it is difficult to quantify, the development of the mine has potentially led to an improvement in water and sanitation services in the broader area. This is due to economic development, but also due to the direct support in the provision of improved water sources and latrines by SRL. However, these gains may have been offset by the impacts associated with influx.

With the prescribed management measures, the significance of the impact is low negative. However, before mitigation, the significance rating is low positive.

Table 6-76: Impact H-4 – Effects on human health as a result of changes in the biophysical environment incurred by current and future mining activities

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Implement the water management measures presented in Sections 6.3.7 and 6.3.8 for surface and ground water respectively; • Review statistics on bilharzia in local clinics and health posts to determine if there are any trends in burden of disease in host communities that are closer to mine ponds; • Consider conducting baseline studies to determine the burden of disease from bilharzia and soil transmitted helminths; • Develop an influx management plan; • Effective controls to prevent spills or leaks from chemicals or hydrocarbons, including during transport; • Ensure that accommodation camps and all work areas have adequate potable water facilities, sanitation services and the ability to maintain good personal and hand hygiene. This must include the provision of adequate facilities for workers who are in remote areas to prevent indiscriminate defaecation; • Ensure proper disposal of human waste through the selection and proper management of sewerage treatment plants, with these facilities having the capacity to manage the expected throughput with adequate contingencies such that if there is a failure, that the risk of direct exposure to host communities and their water sources is minimised; • Develop information education and communication (IEC) campaigns in the workforce on proper water use, hygiene and sanitation; and • Ensure effective waste collection from camps and work areas as part of the Waste Management Plan.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*

Impact H-5: Increased risk of sexually-transmitted diseases and high risk sexual practices

The transport corridor from Freetown and along the access route from Moyamba Junction is a potential high-risk transport corridor. In addition, there is no dedicated truck stop in SR Area1 with truck drivers generally overnighting in the larger towns (Moriba Town and Mogbwemo) due to the availability of accommodation, food and recreational services. Drivers may also seek out s exual encounters, potentially targeting local women, with these encounters often being transactional in nature.

Furthermore, the nature of the mine supports the movement of people in and out of the area. Mixing of people, especially those who have higher rates of STIs and HIV than the local population may give rise to increased rates of disease transmission.

High-risk areas include single accommodation facilities as well as restaurants, taverns etc. where food and entertainment facilities are provided. These areas may attract sex workers, and women who work in these establishments are especially vulnerable to transactional sexual advances from men. Bars, taverns and other areas of entertainment are likely to be more frequented by those with disposable income, with those that benefit directly and indirectly from the project more likely to be patrons.

This is considered to be a high negative significance rated impact before management measures but can be lowered to a medium negative significance rating following the implementation of suggested management measures.

Table 6-77: Impact H-5 – Increased risk of sexually-transmitted diseases and high risk sexual practices due to current and future mining activities

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Regional*	***High***	***Definite***	***High***	-	*High*
Management Measures: • As part of the proposed communicable disease strategy and plan, review the HIV Policy and plan to ensure it is meeting the potential risks and the needs of the project; • SRL should review their partnership with National HIV / AIDS Secretariat (NAS) and become more involved with activities and review effectiveness of interventions. As part of the review consider upgrading Information, Education and Communication (IEC) and Behaviour Change Communication (BCC) interventions; support effective care and treatment; undertake baseline surveys and develop metrics to design and track interventions to review if they are effective; • Target specific interventions in the sector of the workforce that is hired from outside SR Area 1 to reduce risks where rental accommodation is most commonly sourced. Interventions can include IEC and BCC programmes as well as distribution and social marketing of condoms to the workforce and host community; • Develop HIV and STI prevention strategies and interventions for transport workers, especially long-distance truck drivers. These may include IEC and BCC programmes as well as condom distribution interventions; • Work with contracted transport companies to reduce the number of trucks that overnight in the immediate area around host communities such as Moriba Town, Mogbewa, Mogbwemo and Mataglema. Administrative controls should support the driving in and delivery of loads to limit the amount of time that trucks spend in the Project area where this is possible; • Develop a contractor management plan to support these strategies in the contracted workforce, with effective enforcement and monitoring to track compliance as relevant; • Develop an influx management plan; • As part of the CHMMP, develop a monitoring system for specific health indicators related to STIs and HIV; • Promote HIV counselling and testing in the workforce through various means, with support to accessing and initiating care and treatment and thereby promoting HIV and STI prevention. These will need to be supported by the NAS, with the SRL clinic staff involved in care and treatment as well as adherence monitoring. SRL should aim to meet the 90:90:90 target[29]; • Support widespread availability and social marketing of condoms in the workplace; • Develop a blood borne pathogen control procedure in the SRL clinic and emergency response team that includes prevention practices for exposure to blood, e.g. needle stick injuries, and post exposure prophylaxis as required; and • Increase the capacity of host community health officer's in the potentially affected host communities as a resource to extend programme interventions.								
After Management	*Moderate*	*Long term*	*Regional*	***High***	***Unlikely***	***Medium***	-	*Medium*

[29] The 90:90:90 target aims to address HIV transmission by setting the target that 90% of all people living with HIV will know their HIV status, 90% of all people with diagnosed HIV infection will receive sustained ART, and 90% of all people receiving ART will have viral suppression (measured by CD4 and viral load)

Impact H-6: Food and nutrition-related issues due to influx and land use change

There is evidence of economic displacement and physical relocation of households impacting on agricultural practices and access to natural resources. This has impacted on livelihoods and food security.

Malnutrition plays an important comorbid role in infectious diseases, especially in children, e.g. pneumonia, TB, malaria and HIV. They are more likely to acquire infections through low levels of inherent resistance and potentially die from common childhood illnesses like diarrhoea and respiratory infections. Therefore, any increase in these conditions due to direct and indirect project activities may be influenced by, or influence, malnutrition.

In addition to the above factors, historical mining activities have created large mining ponds that have reduced access to potential arable land that could be used for agriculture. While these ponds are in SR Area 1, the fact that the 'mine is in the host community and the host community is within the mine' creates challenges when access to land to support subsistence agriculture is central to local livelihoods. However, alteration of the environment due to mining and reduced access or displacement to areas that provided natural resources (fishing and gathering of natural food products) may also play a role in food security. It is important to note that SRL pays surface rent to landowners on whose land the mine is located.

The significance rating of this impact is medium negative prior to management measures, however following the implementation of recommended management measures, the rating would drop to a low positive impact.

Table 6-78: Impact H-6 – Food and nutrition-related issues due to influx and land use change

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Evaluate opportunities to support farming ventures in SR Area 1 to offset the loss of land through the Agricultural Development Fund. This should focus on food crops, with the type of crop chosen to support local demand, access to markets and promote food security; • Effective resettlement planning and execution that considers access to arable land and support of farming as a key livelihood; • In partnership with the respective DHMTs, perform a baseline nutritional indicator survey and develop a surveillance system to monitor changes in important nutritional indicators; • Develop an influx management plan; and • Develop and implement a communicable disease strategy and plan as per previous sections.								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*

Impact H-7: Increase in non-communicable diseases as a result of lifestyle and demographic changes

Improvement in the local economy due to direct and indirect project benefits has supported better socio-economic conditions with a likely increase in life expectancy. This supports a transition to a more "urbanised" lifestyle with causal factors potentially predisposing sectors of the host community to an increase in lifestyle related diseases such as obesity, hypertension, diabetes, dental caries and some forms of cancer.

The local public healthcare system is poorly resourced to manage any increase in the burden of disease from non-communicable diseases. This includes financial capital in terms of the supply of chronic medications and cost to manage complications, and human capital in terms of skills and adequate numbers of medical staff to deal with the increased case load and long term follow up of patients. The referral of patients from the SRL clinic to the public sector has the potential to place an added burden on this already over-stretched service.

With this in mind, the impact was given a medium negative significance rating before management measures, with the potential to become a medium positive significance should recommended measures be instituted.

Table 6-79: Impact H-7 – Increase in non-communicable diseases as a result of life style and demographic changes

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*

Management Measures:
• Initiate wellness programmes in the workplace;
• Evaluate opportunities to reduce modifiable risk factors as part of the wellness programme including:
  ○ Management of the type of food and size of portions in company canteens;
  ○ Smoking cessation;
  ○ Exercise programmes etc.;
• As part of the occupational health programme screen for hypertension and diabetes as a health promotion intervention; and
• Ensure the SRL clinic is capacitated to effectively manage non-communicable diseases as far as possible. Referrals should be to at least level two facilities.								

After Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*

Impact H-8: Emergence and spread of veterinary medicine and Zoonotic diseases due to inadequate camp and waste facilities

Poor hygienic conditions and ineffective management of especially food waste from mine accommodation and work areas may attract rodents and other wild animals to the camps, or to the waste management facility / landfill. The localised density of rodents may rise with an increased risk for potential zoonotic disease transmission. An increased number of rodents may also attract snakes into the area, with an increased potential for snake bites in both the workforce and host community.

Clearing of forest and bush, as well as the disturbance of the environment has the potential to disturb snakes and other forms of wildlife. This may increase human / animal contact in both the workforce and the host community in proximity to these activities. This may increase the risk for bites.

Finally, in-migration, food inflation and pressure on local food sources (especially sources of protein) may increase hunting and consumption of bush-meat. This may pose a risk for the transfer of various zoonotic diseases, including EVD and possibly novel infections.

This impact received a high negative significance rating before management measures. Following the implementation of recommended measures however it would become a low negative significance rating.

Table 6-80: Impact H-8 – Emergence and spread of veterinary medicine and Zoonotic diseases due to inadequate camp and waste facilities

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Major*	*Long term*	*Site / local*	***High***	***Possible***	***High***	-	*Medium*
Management Measures: • Consider conducting studies with the Lassa Fever Research Centre (in Kenema) to determine the presence of the reservoir host in the general host community, accommodation camps and around land-fill / waste disposal sites. If the species is present, it would be beneficial to conduct further studies to determine if rodents are carrying the virus; • Implement rodent controls in accommodation camps, work and landfill areas; • Develop an influx management plan; • Continue to support the DHMT(s) with outbreak preparedness and response as a strategic intervention; • Implement effective camp facility management to prevent rodents from gaining access to accommodation, kitchens and food / water storage areas; • Implement effective waste management practices in all accommodation, work areas and landfills to reduce the risk for pests being attracted or proliferating in these locations; • Limit the presence of pets (dogs and cats) in accommodation areas, and if they are present ensure they are properly vaccinated. Dogs that may be used for security should also be appropriately vaccinated; and • Develop procedures to avoid or avoid, the risk of, snake bites. Protocols should be developed for immediate first aid and management of snakebites in the SRL clinic (including assuring correct anti-venoms are present).								
After Management	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*

6.5 Social

The content of this section is adapted from the specialist Social Impact Assessment (SIA) (SRK, 2018(3)) which is attached as Appendix J. The social impacts identified in this section were determined to be applicable at construction, current approved operations and proposed future operations. Where an impact is not applicable at a project phase, it is indicated in the impact table. This study is situated in a particularly complex context:

- Sierra Leone has navigated a difficult socio-economic and developmental path, even by the standards of developing countries around the world. A civil war erupted in 1991, and ended in 1995, leaving a seriously damaged economy and a disrupted (and in some cases traumatised) population. The outbreak of the Ebola Viral Disease (EVD) in 2014 brought a new cycle of economic and social shocks;
- The country has a long and variable history of mining, interwoven with the above events, and with other external and internal drivers of investment and activity (including market conditions and management shortcomings); and
- Rutile mining potential was identified in south eastern Sierra Leone in the 1920s, and mining activities started in earnest in 1967. The civil war stopped all rutile mining activity for its duration, and the re-establishment of mining infrastructure and activity took many years following the war. Around these events rutile mining has proceeded and stalled in several cycles, under multiple ownership and management arrangements.

This context, and especially the extended history and legacy of mining presents the following challenges to the current study:

- Local stakeholders attribute many felt impacts of historic mining to mining in general, and sometimes to the current SRL operation in particular. The challenge in this context is to clearly isolate study impacts from those of historical mining;
- Resettlement is an important example of the challenge outlined above. Mine-driven displacement and related relocation have taken place, but decades ago under different mine ownership and management arrangements. The lived experience of resettlement is an important element of the baseline, but it is not an impact of current mining or planned expansion;
- Similarly, input from stakeholders sometimes referred to perceived corruption, in many forms and involving a variety of transacting bodies (including leadership, the mine and its officials, government, and local structures and organisations). In the context of the study it has proved difficult to verify reported instances of corruption. It important to note the awareness of corruption, however, and the importance of measures to combat it.
- In these and related examples, the study has to remain honest to its participants, whilst drawing a responsibility boundary where necessary. Again, with reference to resettlement, the study has noted the commitment of Iluka and SRL to international resettlement good practice going forward.

The requirement by the regulator that identified impacts relate both to current and proposed activities introduces a further set of considerations, especially in seeking to separate current activity impacts and management measures from those linked to new activities. Key implications are the following:

- The new activities proposed by SRL are spatially confined and are likely to have relatively limited impact. Current activities are shown to be significantly impactful in some areas, for example in terms of employment and associated multipliers and the link between mine ponds and community access to facilities and resources; and
- The impacts of existing activities are already in place, often with accompanying management measures. Where new measures might be required for new activities, existing management often requires continuation or in some cases elaboration.

As such, the following potentially significant social impacts associated with current approved operations and proposed project activities are expanded on below.

The social impacts presented in this section are categorised according to:

- Health and safety;
- Use of land and loss of access to resources;

- Economy, work and livelihood;
- Uses of and access to infrastructure and social services;
- Social divisions and vulnerable groups; and
- Physical and economic displacement.

Stakeholders raised the following comments:

- Crime was raised as a concern in most focus group discussions;
- Drowning in mine ponds has occurred;
- Heavy trucks transporting rutile with zircon and ilmenite from wet plants to land plants are not covered to prevent air-pollution;
- Growing incidence of social ills in the study area due to unemployment of youth;
- People are using/occupying land illegally;
- Good infrastructure development is needed;
- The absence of extensive agricultural activities has made members of the host community idle;
- Without access to agricultural land on which to farm, resettled villagers found themselves “unemployed”;
- Cemeteries, traditional secret sites and secret society bushes must be protected;
- There are inadequate drinking water resources;
- Many of the host communities use shallow groundwater as their primary source of drinking water and land. This water has been polluted by the process plant and the discharge of solid waste;
- The mine ponds are an alternative water source in the dry season;
- Stone mining is an important employer in the study area;
- The presence of SRL has attracted new goods and services;
- Roads in the mine lease area are in a good condition;
- Roads between villages, towns and outlying areas are poor;
- SRL does not hire local people;
- There is corruption amongst officials and local government; and
- Compensation and resettlement processes of the past have been inadequate/failures.

6.5.1 Health and safety

The social impacts associated with health and safety deemed to be significant is as follows:

- Impact HS-1: Increased crime as a result of the influx of job seekers, employees and business owners.
- Impact HS-2: Instances of drowning due to mine ponds, resulting in mental health stress on next of kin and the broader host community;
- Impact HS-3: Increased traffic resulting in experiencing irritation relating to dust, and noise.
- Impact HS-4: Altered movement patterns to access services, fields, natural resources and villages resulting in frustration.

Physical health changes and impacts are discussed in the SC RHIA (2017).

Impact HS-1: Increased crime as a result of the influx of job seekers, employees and business owners.

The development of the mining operations at SRL has stimulated an influx of people into the area, increasing the population size. The social baseline findings in Section 4.5.5 of the Social Impact Assessment indicate that this influx is not only due to SRL's activities, but also other economic and infrastructure developments, which attract job seekers, and employees of businesses active in the area.

Some participants of the social baseline study (SRK, 2017d) raised concerns that the influx of job seekers, employees and business owners into the area increased the incidence of crime. Crimes that were reported in the study area included syphoning of fuel from the SRL operations, general theft, commercial sex work, drug and alcohol abuse, assault and domestic violence. Some crimes such as general theft were attributed to unemployed youths, with domestic violence and assault were connected with a rise in alcohol abuse.

While an influx of people into developing areas does contribute to an increase in crime, the social baseline findings indicate that the incidence of social pathologies, including crime, increased in areas where there was a combination of poverty, lack of education, vulnerability, higher population numbers, and opportunities to benefit from criminal activities.

In light of the numerous drivers that encourage the people to move to the study area, which has a socio-economic profile that triggers crime, the extent to which SRL has affected criminal activity in the area cannot be determined, even should local statistics be available to compare against national and provincial data.

With the information available, the potential impact of crime as a result of an influx of job seekers, employees of SRL and business owners specific to the expansion was therefore determined to be of a medium-low negative significance before mitigation because it was already occurring prior to the expansion, and not only as a result of SRL's influence, and unlikely to be significantly changed by recent and planned developments. After recommended mitigation, the significance of the impact was deemed to be low negative. After closure of the mine, the impact will not be maintained.

Table 6-81: HS-1 - Increased crime as a result of the influx of job seekers, employees and business owners.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Medium-Moderate*	*Medium term*	*Site / local*	***Medium-Low***	***Possible***	***Medium-Low***	-	*Moderateh*
Management Measures: **Opportunities for mitigation and management** External measures: • Continue to liaise with local police to monitor social changes in crime patterns; • Continue to liaise with existing crime control organisations, such as the Criminal Investigation Department, host community policing forums and other crime prevention organisations; and • Initiate multi-stakeholder influx management planning process and include crime-related measures in a regional Influx Management Plan. Internal measures: • Strengthen security measures on mine premises; • Minimise opportunities for criminal activity; • Continue to communicate the recruitment policy and process regularly to local people; • Local employment to remain a focus area; • Continue to ensure that potential workers are screened including doing criminal background checks; • Continued dyeing of SRL fuel to identify the culprits; • Ensure construction workers and contractors are always clearly identifiable by wearing proper uniforms displaying the logo of the construction company; • Ensure that SRL workers, contractors and security are always issued with identification tags; • Encourage workers to recognize and report suspicious activity and signs of burglary; • Develop and communicate crime prevention measures that employees can take; • Establish clear rules and regulations for access to the expansion site; and • Opportunities to educate and upskill local people to an employable level are explored and will be implemented once a feasible option(s) had been identified. Closure measures: • Adhere to the Mine Closure Plan to manage crime flux in the study area following closure.								
After Management: operation	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*
After Management: post closure	Will not occur as a result of SRL, although a residual impact will be present.						+	*High*

Impact HS-2: Instances of drowning due to mine ponds, resulting in mental health impacts on next of kin and the broader host community

The presence of mine ponds (including historical and currently active ponds), as well as naturally occurring estuarine systems, has reportedly resulted in occurrences of drownings in and around the study area. The mental health implications and trauma experienced by the next of kin and the broader community of these victims were specifically noted in Madina (FM), Modagba, Foinda and Ganga. The nature of drowning requires next of kin and the broader affected host community to cope with both the trauma of the drowning event as well as the grief affiliated with the loss of a host community member. This is an intangible and emotive impact, and with preventative measures it could be minimised / avoided.

The occurrence and risk of drowning cannot be ascribed to recent and planned developments, and the presence of the mine ponds only. Historically, drownings have occurred in mine ponds and estuarine systems. Due to the fact that drownings seldom occur and the mental health impact have not and will not be experienced by all the people in the study area, but definitely by those who had lost a person to drowning, the impact has been deemed as being of minor magnitude and medium negative consequence and significance in an unmitigated scenario. The implementation of management measures resulted in similar ratings, but with a reduction in the likelihood of a drowning occurring, and hence the reduction in the number of people experiencing mental health stress as a result. The "unlikely" probability rating after mitigation therefore reflects that less people will experience the mental health stress. Once ponds have been drained / water levels reduced, the risk of drowning will be reduced and the impact unlikely to occur.

Table 6-82: Impact HS-2 – Instances of drowning due to mine ponds, resulting in mental health stress on next of kin and the broader host community

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Continue to provide boat taxis to cross ponds to access agricultural fields and villages, and continue to ensure that all safety measures are adhered to; • Continue to maintain bridges that give access to agricultural fields and villages; • Place warning signs, indicating the risk of drowning and incorporating clear imagery and local languages; • Should a drowning occur at an SRL site, SRL will investigate the incident, giving feedback to the next of kin and broader host community timeously and identify preventative measures for implementation; and • Continue safety briefings at local schools and Court Barris. Closure: • In accordance with the Closure and Rehabilitation Plan timeframes and methodology, reduce the water levels in the mine ponds, which will assist in mitigating incidences of further drownings.								
After Management: operation	*Minor*	*Long term*	*Site / local*	***Medium***	***Unlikely***	***Low***	-	*Medium*
After Management: post rehabilitation	*Highly unlikely to occur, but the mental health impact on next of kin and host community members of a drowning that occurred during operation will still be present albeit not as acute.*						+	*High*

Impact HS-3: Increased traffic and activities resulting in irritation relating to dust, and noise

The extension of mine operations, including current expansion activities, has resulted in an increase in heavy vehicle and mine personnel vehicle traffic on roads. In the villages of Matagelema, Moriba Town and those located on the haul roads, irritation due to noise and dust from the road were mentioned. In Foinda (Nitti) particularly, the speed and frequency of trucks reportedly caused noise and dust irritation for other road users including pedestrians, and households living by the road side.

The roads are not only used by SRL trucks, but also trucks from other companies in the area such as Vimetco. A 30 km/hr speed limit has been implemented for all SRL vehicles when travelling through villages, and SRL vehicles are tracked by GPS to deter SRL drivers from exceeding the speed limit. It is therefore unlikely that SRL trucks are the main contributors to the noise and dust generation.

Without mitigation, the impact was found to be of medium negative consequence and significance. Following mitigation, the impact received a low consequence and low negative significance rating. Post closure SRL vehicles will no longer be on the road, and SRL trucks will not be a contributor to dust and noise irritation.

Table 6-83: Impact HS-3 – Increased traffic and activities resulting in irritation relating to dust, and noise

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: Opportunities for mitigation and management: • Continue to enforce the 30 km/hr speed limit; and • Continue to deal with drivers exceeding the limit through the disciplinary process that has been implemented. Dust: • Adhere to measures stipulated in the Air Quality Management Plan. Noise: • Adhere to measures stipulated in the Noise Management Plan.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
After Management: post closure	*Will not occur as a result of SRL trucks*						+	*High*

Impact HS-4: **Altered movement patterns to access services, fields, natural resources and villages resulting in dissatisfaction and frustration.**

As a result of mine ponds and other mine related infrastructure, traditional movement patterns and access have been altered in some areas. The expansion contributes to continuation of the situation (Section 4.8 of the social baseline study).

Without mitigation, the impact was found to be of negative medium consequence and significance. Following mitigation, the impact received a low negative consequence and low significance rating. Post closure, people will most likely be able to return to previous movement patterns due to the draining of mine ponds.

Table 6-84: Impact HS-4 – Altered movement patterns to access services, fields, natural resources and villages resulting in dissatisfaction and frustration.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: Operation: • Continue with time saving through dedicated bus services to transport SRL workers to the work; • Where possible, future operation and construction planning to include considerations regarding access and movement patterns before infrastructure is placed; • Continue with provision of taxi boats, bridges and alternative roads; and • Maintain a Grievance Management Procedure to allow local people to report concerns relating to access and movement. Rehabilitation and closure: • Consider current and historical movement patterns in closure rehabilitation; and • Plan for maintenance of infrastructure services by third parties in instances where access cannot be shortened / returned to what it was.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Low*
After Management: rehabilitation	*Highly unlikely to occur, but may occur in isolated instances where movement patterns could not be adapted to suit local people. Frustration might be experienced during the transition period.*						+	*Low*

6.5.2 Population, political structures and organisations

Social impacts associated with population, political structures and organisations are as follows:

- Impact PP-1: Host community disruption due to influx of non-local job seekers, employees and business owners.
- Impact PP-2: Increased pressure on infrastructure and social services due to influx, impacting on quality of life.

Impact PP-1: Host community disruption due to influx of non-local job seekers, employees and business owners.

Local and non-local job seekers and their families may move / have moved into the study area. The social baseline study results suggest influx continues to be focused in the built-up nodes including Mogbwemo, Matagelema and Moriba Town. The social baseline study also indicates low employment and skills levels in the study area. A significant portion of those individuals currently employed by, or who could be employed at SRL in future, are from outside of the study area. Influx was noted to come particularly from northern Sierra Leone (see Figure 4.4). Influx into the smaller, more rural villages in the study area was not a notable finding in the social baseline study, and the impact on smaller, decentralised villages is seen to be negligible.

Host community disruptions, including migrants not affiliating with local leadership and communal structures has led allegedly, in some instances, to tension and issues relating to social cohesion. Influx has occurred in the study area prior to the current phase of this expansion, so any additional host community disruption as a result of influx specific to this expansion are difficult to isolate.

The impact was deemed to carry a negative medium significance prior to mitigation and a negative low significance after mitigation. Post closure, the impact will not occur as a result of SRL mining activities, since people will not move into the area as a result of opportunities presented by the mine. However, some residual impact might be present.

Table 6-85: Impact PP-1: Host community disruption due to influx of non-local job seekers, employees and business owners

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*
Management Measures: • Preparation and implementation of a code of practice to guide the management and onsite behaviour of construction and operational teams. The code should include terms relating to host community relations, culturally appropriate behaviour and conduct towards women specifically; • Procurement of goods and services should continue to be only done through a formal process; • Develop and implement an Influx Management Plan in conjunction with the relevant external stakeholders; • Apply approach to recruitment as set out in the relevant national legislation; • Continue to communicate the recruitment policy and process regularly to local people and contractors; • Inform host communities about the construction and operation timeframes and the Grievance Management Procedure; • Opportunities to educate and upskill local people to an employable level are explored and will be implemented once a feasible option(s) had been identified; and • Engage regularly, with the Paramount Chiefs to manage and monitor influx and housing / site allocations.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
After Management: post closure	***Will not occur as a result of SRL activities, but some residual impact may be present.***						+	*High*

Impact PP-2: Increased pressure on infrastructure and social services due to influx, impacting on quality of life.

Job seekers and their families may move or have moved into the study area, thus competing with local residents for basic services including water supply and energy sources. Referring to the social baseline information, the study area has existing health, education and housing shortages (Section 4.3 of the social baseline study). The existing infrastructure and housing is currently deemed by locals to be insufficient to support the existing population and the incoming population, according to feedback from some participants that partook in the baseline data collection process. A continuation of influx will intensify this shortfall. Migrant workers may rent backrooms or establish informal settlements (as has resulted in the urban sprawl seen in Moriba Town outwards), thereby exacerbating the existing situation.

Furthermore, the government is tasked with the provision of water, electricity, and sanitation and waste services. This is unlikely to happen due to human and financial resource constraints. The maintenance of current SRL facilities for SRL's workforce, the development of facilities for SRL's external workforce, and the provision of construction accommodation on site in the future might reduce these impacts.

The impact was deemed to carry a negative medium significance prior to mitigation and a negative low significance after mitigation, since the increased pressure was present prior to the expansion. After closure, the impact will not occur as a result of mining activities, since people will not move into the area as a result of opportunities presented by the mine.

Table 6-86: PP-2: Increased pressure on infrastructure and social services due to influx, impacting on quality of life.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*High*
Management Measures: • In consultation with the local leadership, implement measures to decrease the in-migration of potential job seekers into the area through the development and implementation an Influx Management Plan in conjunction with relevant external stakeholders; • Continue to provide construction accommodation on site for employees that do not come from the study area in the existing SRL camps; • Opportunities to educate and up-skill local people to an employable level are explored by SRL and will be implemented once a feasible option(s) have been identified; and • Engage regularly with the Paramount Chiefs to manage and monitor influx and housing / site allocations.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
After Management: rehabilitation	*Will not occur as a result of SRL activities, but some residual impact may be present.*						+	*High*

6.5.3 Use of land and loss of access to resources

Social impacts associated with the use of land and loss of access to resources are as follows:

- Impact LR-1: Loss of (or loss of access to) land, crops and livelihood resources in the expansion footprint areas due to mining activities.
- Impact LR-2: Loss (or loss of access to) cultural resources and sites due to mining activities restricting / encompassing land.
- Impact LR-3: Increase in fishing and aquaculture opportunities as a result of mine ponds (existing and non-rehabilitated).
- Impact LR-4: Perceived decrease in the quality of drinking water and perceived unsuitability of mine pond water for drinking, resulting in lack of access to drinking water.
- Impact LR-5: Increased access to domestic water due to existence of mine ponds.

Impact LR-1: Loss of (or loss of access to) land, crops and livelihood resources in project footprint areas due to mining activities

Over the years, SRL's mining activities have resulted in land take and loss of access to land. The loss of land and reduced access to land has reportedly impacted on livelihoods resources such as agricultural activities, medicinal plants, and bushmeat. Previous mitigation measures that were implemented to manage the impacts related to loss of livelihoods resources included cash compensation for crops, payment of surface rent, providing access to existing agricultural fields where the mine has disrupted access routes, and stocking mine ponds with fish. SRL still provides access to agricultural land by providing boat taxis, alternative roads, and bridges. However, many of these diversions have resulted in more time and money required to get to fields.

Although SRL's mining activities have resulted in land take and some loss of access to land and livelihoods resources, the increase in population in the area has also resulted in an increase in competition for these livelihoods resources.

As part of this ESHIA, the current rehabilitation practise were reviewed and an improved Conceptual Mine Closure Plan (SRK, 2018 (5)) was developed. The Mine Closure Plan (SRK, 2018 (5)) aims to progressively restore land post mining to a land use capability of subsistence farming (refer to the Mine Closure Plan in Appendix L4 for further details).

Rivers are also livelihoods resources, and fish stocks have allegedly decreased as a result of the mining activities. Fish stocks are impacted by water quality, water quantity, and habitat (including cover, spawning areas flow and depth of water column). The activities of the mine could affect these three aspects to an extent, in addition to aspects such as over fishing and fishing methods used. Using traditional fish trapping methods are easier in the rivers than in the mine ponds. For fishing in mine ponds, baited hooks or gill nets are most effective. It is likely that gill nets are not accessible to fishermen due to the cost implications. Traditional methods are therefore relied on to access this source of protein, placing additional pressure on those who depend on mine ponds for fish (STS, 2018).

According to stakeholders, the occurrence of flooding has also increased as a result of mining activities. However, as per the surface water specialist study conducted as part of this ESHIA (SRK, 2018), localised flooding has occurred as a direct result of mining ponds, but in general, the mine ponds have reduced flood peaks when compared to natural systems. Post rehabilitation, the lowering of the pond water levels, will result in the riverine systems returning closer to its original state, which may again increase flooding. However, it will also result in more land being available for agricultural activities and establishment of other livelihoods resources.

The remaining land and natural resources not impacted by mining activities were and still are used extensively to provide for an increase in livelihoods needs due to the population increase. Extensive use has led to a reduction in the period for land lying fallow, affecting the fertility of land and hence the productive use of land. Over exploitation of forests (for wood and charcoal making, bushmeat hunting) and other natural resources such as raffia palm and medicinal plants, continue as a result of ongoing population growth.

The impact was deemed to carry a negative medium significance prior and after mitigation during operation. Post closure, the impact is deemed to carry a positive medium significance, since more land will be available.

Table 6-87: Impact LR-1 – Loss of (or loss of access to) land, crops and livelihood resources in project footprint areas due to mining activities

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***High***	-	*High*
Management Measures: Operation: • As intended, design and implementation of GIIP RAP, inclusive of livelihood restoration measures for all new physical displacement; • As intended, design and implementation of GIIP Livelihood Restoration Plans for economic-only displacement; • Consider supporting an NGO to facilitate breeding cane rat (“cutting grass”) and rabbits (or similar small livestock as may be culturally appropriate), as sources of bush meat; • SRL is exploring the implementation of improved / modernised fishing and aquaculture opportunities during operation and closure in co-operation with relevant NGOs; • SRL is considering supporting the development of agricultural training courses in co-operation with relevant NGOs. • Identify areas to be protected from exploitation for livelihoods needs in collaboration with the host communities; • Consider supporting an NGO to protect medicinal plants, setting up / supporting expansions where medicinal plants can be grown / sold / getting an NGO involved to possibly take some of the medicinal products into the western pharmaceutical market (if suitable); • Consider hydroponic / aquaponic systems (either at household / village level) for improved crop yields as part of closure planning; and • Integrate with the rehabilitation team to determine if it is possible to set up raffia palm groves. Rehabilitation: • Increase agricultural land post mining where practicable, as per the Mine Closure Plan.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*Medium*
After Management: rehabilitation	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	+	*Medium*

Impact LR-2: Loss (or loss of access to) cultural resources and sites due to mining activities restricting / encompassing land.

Mining activities have resulted in the loss of some cultural resources and have restricted access to others, according to feedback provided by participants of the social baseline study. The expansion had not and is not likely to impact on any cultural resources going forward. As a result, the impact was deemed to carry a negative low significance prior and after mitigation. Post closure, the impact will not occur as a result of the presence of SRL.

Table 6-88: Impact LR-2: Loss (or loss of access to) cultural resources and sites due to mining activities restricting / encompassing land.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site or local*	***Low***	***Possible***	***Low***	-	*Medium*
Management Measures: • Consult proactively with host communities to identify culturally significant sites prior to accessing areas for future expansion; • Where possible, identify culturally significant sites; and where possible, ensure expansion infrastructure does not encroach on these sites; • Where site loss cannot be avoided, negotiate a culturally appropriate response; • Where loss of access occurs, providing alternative access must be made a priority; • Design and implement a Chance Finds Procedure to guide actions where cultural sites are discovered; • Conduct an archaeological / cultural heritage survey for areas to be disturbed / well ahead of mining; and • Develop a Cultural Heritage Resources Management and Monitoring Plan.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
After Management: post closure	*Will not occur as a result of SRL activities*						+	*High*

Impact LR-3: Increase in fishing and aquaculture opportunities as a result of mine ponds (existing and non-rehabilitated).

The presence of mine ponds has given rise to an additional aquaculture / fishing livelihood option for some of the adjacent mine host communities. Given that fishing and aquaculture activities support local livelihoods, the impact significance is set at positive low. With the implementation of enhancement measures, this significance rating can increase from low to medium positive during operation and after closure.

Table 6-89: Impact LR-3: Increase in fishing and aquaculture opportunities as a result of mine ponds (existing and non-rehabilitated).

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor +*	*Medium term*	*Site or local*	***Low +***	***Definite***	***Low***	+	*Medium*
Management Measures: • SRL is exploring the implementation of improved / modernised fishing and aquaculture opportunities during operation and closure in co-operation with relevant NGOs; and • SRL is considering supporting the development of agricultural training courses in co-operation with relevant NGOs.								
After Management: operation	*Moderate +*	*Medium term*	*Site / local*	***Medium +***	***Possible***	***Medium***	+	*Medium*
After Management: rehabilitation	*Moderate +*	*Long term*	*Site / local*	***Medium +***	***Possible***	***Medium***	+	*Medium*

Impact LR-4: Perceived decrease in the quality of drinking water and perceived unsuitability of mine pond water for drinking, resulting in lack of access to drinking water.

A perception exists amongst some people in the study area that the SRL activities negatively impact on the quality of potable water, and that water from the mine ponds is not suitable to drink. Results from the surface water report suggest that the water quality in the study area and water quality of mine ponds are generally an acceptable standard, with some instances where the quality of the water exceeded drinking water guidelines.

Water quality in the study area may be affected by both natural and anthropogenic factors, as such the perception that any decreased water quality in the study area is a result of mining activities alone is unfounded. Of the 19 surface water monitoring points, only eight were noted to have exceeded the drinking water guidelines.

After mitigation, the significance of the impact changes from medium to low negative. After closure, the perception is likely to no longer exist, because of the cessation of mining activities and drying of ponds.

Table 6-90: Impact LR-4: Perceived decrease quality of drinking water and perceived unsuitability of mine pond water for drinking, resulting in perceived lack of access to drinking water

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site or local*	***Medium***	***Definite***	***Medium***	-	*Medium*
Management Measures: • Raise awareness about the quality of the water, the causes of water of unacceptable quality, and the characteristics of unsuitable water (colour, odour); and • Give feedback about the reasons why wells are no longer being treated, and the alternatives should host communities wish to treat their own wells.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
After Management: rehabilitation	*Will not occur as a result of SRL activities.*						+	*Medium*

Impact LR-5: Increased access to domestic water due to existence of mine ponds.

Although prohibited, some members of host communities do make use of mine ponds for domestic purposes because it is accessible and / or there are no immediate sufficient alternatives. Some host communities, on the other hand, do not make use of this water, as instructed by SRL, despite the reported need for domestic water.

After mitigation, the significance of the impact changes from positive low to medium during operation. After closure, SRL mine pond water for domestic use will be reduced due to the draining of some ponds and reduction of water levels in others, resulting in a low negative impact from a water availability point of view.

Table 6-91: Impact LR-5: Increased access to domestic water due to existence of mine ponds.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Short term*	*Site or local*	***Low***	***Possible***	***Low***	+	*High*
Management Measures: • Communicate consistent messages about the use of mine ponds; • Develop a policy / guidelines for workers about what is expected of them as SRL workers, and the ways in which to handle situations where they observe ponds being used; and • Investigate community complaints regarding water availability and/or quality, and where necessary, provide alternative water sources to the impacted communities.								
After Management: operation	*Moderate*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*
After Management: rehabilitation	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*High*

6.5.4 Economy, work and livelihoods

Social impacts associated with economy, work and livelihoods are as follows:

- Impact EW1: Contribution to national and regional economic growth due to investment;
- Impact EW2: Increased government income due to payment of taxes and royalties;
- Impact EW3: Continued employment and income opportunities as a result of on-going and expanded operations at SRL;
- Impact EW4: Opportunities for local business due to procurement by SRL; and
- Impact EW5: Lease payment income as a result of mining activities.

Impact EW-1: Contribution to national and regional economic growth due to investment

Capital expenditure on the construction of Gangama was approximately US$38 million over a 30-month period. Of this, 52 % was paid to foreign suppliers, 36.5 % to local suppliers and 11.5 % to payroll and stocks withdrawal. Capital expenditure on the construction of Gbeni was a further US$10.3 million, primarily to foreign suppliers.

Total SRL expenditure on workforce and goods and services was US$70.2 million in 2016, of which US$56.5 million were spent on goods and services (US$19 million of this was spent on goods and services in Sierra Leone) (DAI and GIZ, 2017). It is therefore assumed that US$13.7 million was spent on payroll. The 2016 SRL expenditure is equivalent to 1.8 % of Sierra Leone GDP.

Changes in output, employment and / or prices give rise to changes in demand for a range of goods and services, which in turn generate a further round of income and employment effects. Multipliers estimate these knock-on effects of e.g. an investment on output and employment in the economy. Effects are typically direct, indirect and induced:

- Direct economic effects occur through the employment of staff and direct procurement from suppliers, e.g. raw materials, equipment and contractors, in the sector where the shock occurs;
- Indirect economic effects arise mainly as a result of suppliers and service providers procuring goods and services from other businesses in other sectors; and
- Induced economic effects occur through increased demand from households earning additional income from direct and indirect effects of increased demand.

Multipliers are difficult to determine, and various estimates exist. A World Bank study (2006) estimated a multiplier of 1.56 for SRL, the highest multiplier of the four mining companies assessed. SRL's total economic contribution to the economy of Sierra Leone, including indirect and induced effects, was estimated at US$109,553,671 in 2016 (DAI and GIZ, 2017), the highest of the four mining companies assessed. Based on those figures, SRL's total contribution in 2016 was equivalent to 2.8 % of GDP, which is highly significant for a single operation, and illustrates the small size of the economy of Sierra Leone. Estimates of ongoing operational expenditure were not available, and it is not clear what component of the 2016 expenditure was directly related to the mine expansion.

Table 6-92: Economic multipliers for different sectors in Sierra Leone

Sector	No of companies considered	Multiplier
Mining	4	1.45
Banking	2	1.71
Agri-business	1	1.79
Logistics	1	1.80
Manufacturing	1	1.43
Hospitality	1	1.51
Aggregated	*10*	*1.49*

Source: DAI and GIZ (2017)

The study estimated a multiplier of 1.56 for SRL, the highest multiplier of the four mining companies assessed. SRL's total economic contribution to the economy of Sierra Leone, including indirect and induced effects, was estimated at US$ 109,553,671 in 2016 (DAI and GIZ, 2017), the highest of the four mining companies assessed. Based on those figures, SRL's total contribution in 2016 was equivalent to 2.8 % of GDP, which is highly significant for a single operation, and illustrates the small size of the economy of Sierra Leone. Estimates of ongoing operational expenditure were not available, and it is not clear what component of the 2016 expenditure was directly related to the mine expansion.

The above estimates refer primarily to the formal (measured) economy. Due to the largely informal nature of Sierra Leone's economy, the project will also increase demand (and therefore production) in the informal economy, especially locally. The benefits of economic growth include increased income (including in the informal economy locally), lower unemployment / underemployment and increased tax base and revenues.

The reported contribution is largely related to ongoing operations, and thus part of the baseline. The output effect of the expansion and upgrading of the mine could not be isolated. However, expansion provides an opportunity to extend the mining operation and associated economic stimulus.

The significance of the impact is positive medium during operation. After closure the positive impact will cease, since SRL will no longer contribute to the Sierra Leone economy.

Table 6-93: Impact EW-1 – Contribution to national and regional economic growth due to investment

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Regional*	***Medium***	***Probable***	***Medium***	+	*Medium*
Management Measures: • Procure goods and services from local or national suppliers as far as possible; • Procure ancillary services for goods purchased overseas, such as installation, customisation and maintenance, from national companies as far as possible.								
After Management: operation	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*
After Management: post closure	*The impact will cease after closure of the mine*							

Impact EW-2: Increased government income due to payment of taxes and royalties

The government of Sierra Leone receives revenue from SRL's operation in the form of taxation (including income tax, goods and services tax, corporate tax and import duties, all of which will apply to SRL) and royalties.

Information on SRL tax contributions is not available, but likely to be significant. As a broad overview:

- Personal income tax in Sierra Leone is paid at a sliding scale of up to 35 % (SRL, 2018). Payroll of US$13.7 million[30] could thus generate up to US$4.8 million personal income tax if all employees were taxed at the maximum rate, which is unlikely;
- Corporate tax rate is 30 % (PKF, 2016). SRL recorded a loss in 2016 (Iluka, 2017), affecting corporate tax incurred;
- Goods and Service Tax (GST) rate is 15 %, which for mining companies is levied on all non-production related items (PKF, 2016). It is not clear what portion of SRL's US$56.5 million expenditure on goods and services in 2016 was subject to GST; and
- Imports are taxed at the same rate as GST (PKF, 2016).

For 2016, Iluka (2017) reports that SRL paid approximately US$0.6 million (reported as 0.7 million Australian dollars) in government royalties, which is equivalent to approximately 2.3 % of government income from mining royalties and licenses that year[31].

The government revenue is largely related to ongoing operations, and thus part of the baseline. The revenue effect of the expansion and upgrading of the mine could not be isolated. However, expansion provides an opportunity to extend the mining operation and associated government revenue.

The significance of the impact is medium positive during operation. After closure the positive impact will cease, since SRL will no longer contribute to the Sierra Leone economy. As government revenue is related to tax regimes and company performance, no mitigation and optimisation measures are identified.

Table 6-94: Impact EW-2 – Increased government income due to payment of taxes and royalties

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*National*	***Medium***	***Probable***	***Medium***	+	*Medium*
Management Measures: • Continue adhering to legislative tax and royalty payments.								
After Management: operation	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*
After management: post closure	*The impact will cease after closure of the mine.*							

[30] Total SRL expenditure on workforce and goods and services was US$ 70.2 million in 2016, of which US$ 56.5 million were spent on goods and services (US$19 million this expenditure was spent on goods and services in Sierra Leone) (DAI and GIZ, 2017). It is therefore assumed that US$ 13.7 million was spent on payroll.

[31] Mining royalties and licenses generated revenue of Le 156 billion in 2016, equivalent to US$ 24.8 million at an exchange rate of 6 289.9 quoted in CIA Factbook (2017).

Impact EW-3: Continued employment and income opportunities as a result of ongoing and expanded operations at SRL.

Employment provides many socio-economic benefits to employees and their dependants, including:

- Improved material wealth and standard of living;
- Enhanced potential to invest and improved access to social services such as education and health services;
- Enhanced skills transferred to previously unskilled workers, facilitating employment prospects of such workers; and
- Contribution to a sense of independence, freedom and pride, which may promote a good work ethic.

The project is expected to create various types of employment:

- Direct employment, including employees and main contractors, at the project;
- Indirect employment, including sub-contractors and suppliers; and
- Induced employment, including employment generated by increased spending by businesses and by (host community) households earning an income from the project.

Mining companies in Sierra Leone contribute significantly to employment, but employ fewer nationals relative to other sectors (such as logistics, manufacturing, agriculture or hospitality). However, SRL is the only one of four mining companies assessed as part of the local content performance that meets five out of six targets for local employment (DAI and GIZ, 2017).

SRL is the largest employer in the study area, where only 13 % of HHS participants reported that they were formally employed. The project has generated the direct employment of:

- 115 workers (34 nationals and 81 expatriates) during construction; and
- 2,614 workers, comprised of 1,871 SLR employees (1,739 nationals and 39 expatriates) and 743 main contractor staff (725 nationals and 18 expatriates) during operation.

SRL spent US$ 4.4 million on payroll during the construction of Gangama Phase over an approximately 30-month period. US$13.7 million was spent on payroll in 2016[32]. While information on average local wages is not available, 93 % of SRL's workforce is national, and the income benefit will accrue predominantly at a national level.

MacGillivray *et al*. (2017) calculated the average employment multiplier in developing countries as 7.8, i.e. each direct worker is associated with more than seven additional indirect and induced jobs or livelihoods. The high multiplier is likely a function of labour intensive production as a result of low mechanisation, poor education and low skill sets, meaning that a high proportion of the increased expenditure is directed to labour, the largest factor of production in most sectors (based on Mendez-Parra, 2015). Based on the above multiplier, direct employment at the project may have generated up to:

- 897 indirect and induced employment opportunities during construction; and
- 19,605 indirect and induced employment opportunities during operation.

Observations during field work support the notion of ongoing growth in ATS agriculture, petty trading, stone mining, charcoal and motorbike taxi sectors. Although illegal, the theft of fuel, scrap steel and product from SRL has created an alternative form of income for local opportunists. The increased

[32] Total SRL expenditure on workforce and goods and services was US$ 70.2 million in 2016, of which US$ 56.5 million were spent on goods and services (US$19 million this expenditure was spent on goods and services in Sierra Leone) (DAI and GIZ, 2017). It is therefore assumed that US$ 13.7 million was spent on payroll.

demand for housing in the project area from workers and job seekers has increased income opportunities of the local population from the renting of rooms and beds.

Indirect and induced opportunities will be almost exclusively for Sierra Leone nationals. Based on the characteristics of the labour market in Sierra Leone, it is expected that the majority of indirect and induced employment opportunities will be in the informal economy. However, a significant proportion of new jobs, including direct employment, will be in the formal economy and associated with the benefits of formal employment: insurance, regular income and improved standard of living.

Because of the low unemployment rate in Sierra Leone, many employment opportunities created by the project in the informal economy are likely to manifest as a reduction in underemployment (or an increase in income for those already employed in the informal economy).

People who benefit directly or indirectly from the project also support a number of dependants, and an additional 92 400 dependants could benefit (albeit to a modest extent considering the generally low earnings in the informal economy and the high dependency ratio). When comparing the number of potential beneficiaries to the population of the study area, which is estimated at 20 800, it is clear that the benefits of employment extend beyond the direct project area.

Employment also conveys skills that make people more employable in this large sector, and increase their chances of earning a higher income in the long term. SRL dedicated 0.2% of manhours to training in 2016, below national targets for mining companies (DAI and GIZ, 2017).

It must be noted, however, that most of the employment opportunities are related to ongoing operations and are thus part of the baseline. The employment effect of the expansion and upgrading of the mine could not be isolated, but is likely to be relatively minor. However, expansion provides an opportunity to extend the mining operation and associated benefits derived by the local and regional community from direct, indirect and induced employment.

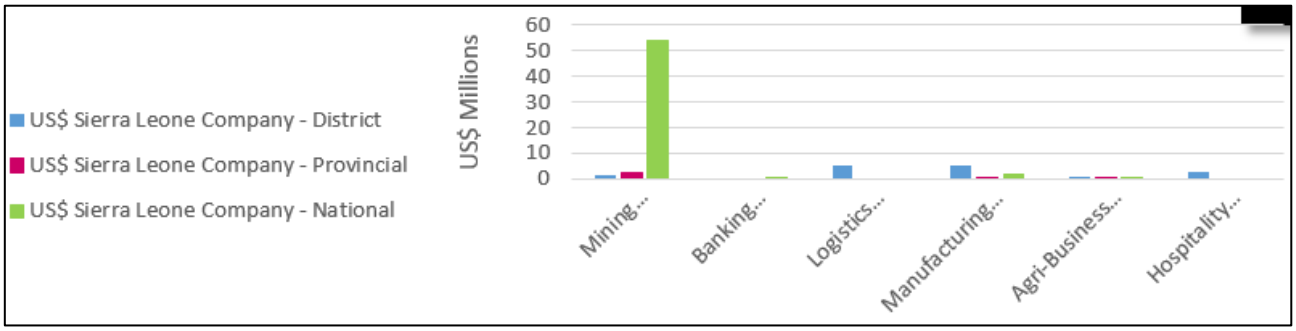
After mitigation, the significance of the impact changes from positive low to positive medium during operation. After closure the positive impact will cease, since those employed at that time will lose their jobs at SRL. However, alternative income opportunities may be identified with implementation of management measures.

Table 6-95: Impact EW-3 – Continued employment and income opportunities as a result of ongoing and expanded operations by SRL.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Low***	+	*Medium*
Management Measures: Operation: • Ensure fair access to information about jobs through the local radio station, the CAD office, and Chiefs; • Ensure access to jobs is transparent and in line with SRL's Human Resources and Anti-bribery and Corruption policies; • Continue to raise awareness amongst employees and host communities about SRL's Anti-bribery and Corruption Policy; • Facilitate fair access to jobs through the SRL Local Employment Policy; • Promote job security as per the SRL Local Employment Policy; • Develop a Downscaling and Retrenchment Plan; and • Opportunities to educate and upskill local people to an employable level are being explored and will be implemented once a feasible option(s) had been identified. Closure: • Update the social closure risk and SIA 3 years prior to closure, inclusive of pre-closure measures to minimise the impact of job losses at mine closure; • Implement business, life skills and investment training in the context of the in-house training programme. Training to be linked to counselling regarding the LOM and the implications of decommissioning and closure; • Investment and money management counselling for employees; and • Proactive planning for closure consequences and timely advice to current employees.								
After Management: operation	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*
After Management: post closure	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*

Impact EW-4: Opportunities for local business due to procurement by SRL.

Mining companies account almost solely for local procurement of goods in services amongst the economic sectors monitored for local content contribution. The majority of procurement benefits national companies (DAI and GIZ, 2017, see Figure 6-1), given the lack of capacity of local businesses.



Source: DAI and GIZ (2017)

Figure 6-1: Local procurement in different economic sectors

SRL has the highest procurement spending amongst the four companies monitored for local content, at more than US$ 25 million in 2016, almost all of which goes to companies outside of the region.

Procurement of goods and services by SRL therefore provides very few opportunities for local individuals and businesses, but is nevertheless significant. Over time, it is anticipated that SRL's operations may promote new local producers of goods and services. The intensity of this benefit is limited by the capacity of local industries to supply the development.

Dry mining activities will prolong the LOM, which in turn ensures the ongoing procurement of goods and services in general. The procurement of local goods and services in the short and long-term could positively impact recipients in the study area and surrounds, given prevailing levels of unemployment and poverty.

Procurement-specific mitigation measures should be further investigated by SRL, to ensure any action taken to enhance access and / or build capacity of local businesses is appropriately targeted. The undertaking for mitigation measures for this impact will begin to address the long-term implications of mine closure and the need for local contractors and businesses to diversify and become self-sufficient and viable without SRL.

This impact has a low positive significance before management and a potential medium positive significance with management during operation. The impact will no longer occur once the mine has been closed.

Table 6-96: Impact EW-4 – Opportunities for local business due to procurement by SRL.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Minor*	*Medium term*	*Site or local*	***Low***	***Possible***	***Low***	+	*Medium*
Management Measures: • Procure locally wherever possible and formalise procurement approaches in policies and procedures; • Monitor implementation of local recruitment; • Monitor incidences of corruption and nepotism; • Facilitate appropriate business training and provide assistance where local response to procurement opportunities can be enhanced; • Ensure fair access to information about tenders / opportunities; and • Support training of small and medium business enterprises.								
After Management: operation	*Moderate*	*Medium term*	*Site or local*	***Medium***	***Possible***	***Medium***	+	*Medium*
Afger Management: post closure	*Opportunities will no longer be available at SRL, although residual impacts might be present due to training and assistance provided by SRL.*						+	*High*

Impact EW-5: Lease payment income for land owners as a result of mining activities.

SRL pays surface rent in line with the Sierra Leone legislative requirements. In 2018 SRL paid Le 5,168,682,000 in surface rent, a 3% increase on the rent paid in 2017 (Awoko, 2018) and equivalent to US$821,743[33]. The surface rent income to land owners could therefore have a significant impact if managed. The feedback from land owners were that the income was not deemed sufficient and should be increased, especially in light of the lack of other benefits from the mine. With sufficient financial acumen and the appropriate application of the surface rent, the income could have a significant positive impact. SRL provided additional context (2017) noting that the number of people in the land holding families had grown, which meant the same land area had to be divided amongst more people. The same applies to the land for which ret is paid, where the increase in population means that more people have to make a living out of the same finite resource.

This impact has a medium positive significance before management and a potential high positive significance with management. The impact will no longer occur once the mine has been closed and the land has been returned to the landowning families post successful rehabilitation.

Table 6-97: Impact EW-5 – Lease payment income for land owners as a result of mining activities.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site or local*	***Medium***	***Definite***	***Medium***	+	*Medium*
Management Measures: • Work with the land owners to assess the possibilities for enhancing the benefits of the income; and • Discuss expectations and use of income for local infrastructure development and maintenance.								
After Management: operation	*Major*	*Long term*	*Site or local*	***High***	***Definite***	***High***	+	*Low*
Afger Management: post closure	*The benefit will cease after mine closure.*						-	*High*

[33] At an exchange rate of 6 289.9 quoted in CIA Factbook (2017)

6.5.5 Uses of and access to infrastructure and social services

Social impacts associated with uses of and access to infrastructure and social services are as follows:

Impact SS-1: Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL investment, resulting in better quality of life.

Impact SS-1: Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL investment, resulting in better quality of life.

Roads in the study area are important access routes to markets, schools and places of work. The continued maintenance and development of roads will facilitate business development in the study area and encourage economic activities outside of SRL's operations.

Improved infrastructure has been provided by SRL, which has resulted in an improved quality of life for people in the study area. SRL has indicated that while they will continue to maintain the road infrastructure relevant for current and future operations, they will not develop any new infrastructure programmes. Instead, the Community Development Committee established by SRL with the communities, will be responsible to identify development projects for implementation. SRL will fulfil a mentoring and supporting role to national, district and local government and non-profit organisations active in the study area, will help facilitate provision and maintenance of infrastructure.

As such, SRL's role in the continued maintenance and, where applicable, expansion of the road infrastructure network is seen to be a positive impact, particularly following suggested management measures. This impact has a positive low significance before management and a potential positive medium significance with management during operation and after closure.

Table 6-98: Impact SS-1 – Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL investment, resulting in better quality of life.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*
Management Measures: • Education provision to local business and government on the maintenance of roads provided by SRL; • Continue to provide infrastructure maintenance for existing SRL infrastructure; and • Implement regular briefing sessions with relevant Paramount Chiefs and sectoral ministries represented by local government. These meetings should clarify roles and responsibilities and SRLs role and contribution.								
After Management: operation	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*
After Management: post closure	*Moderate*	*Long term*	*Site / local*	***Medium***	***Possible***	***Medium***	+	*Medium*

6.5.6 Social divisions and vulnerable groups

The following potentially significant impacts associated with project activities are identified relating to the social divisions and vulnerable groups:

- Impact SD-1: Dissatisfaction over limited jobs due to high unemployment and poverty in the study area.
- Impact SD-2: Distrust in leadership due to corruption (or unfair advantage) or perceptions thereof.
- Impact SD-3: Dissatisfaction over perceived procurement inequities.
- Impact SD-4: Dissatisfaction over perceived preferences in development investment, and engagement.
- Impact SD-5: Disproportionate impacts on vulnerable groups due to their status in the host community / study area.

Impact SD-1: Dissatisfaction over limited jobs due to high unemployment and poverty in the study area.

Expansion of SRL operations has created an expectation of further and significant employment. Against the background of unemployment, poverty, and the dependency on subsistence agriculture (the main economic activity in the country), the finite number of jobs that SRL, the main employer in the area, can provide for the host community has promoted and may continue to promote a level of dissatisfaction. This is particularly true of the youth, many of whom voiced their frustration at an inability to find employment at SRL.

Conflict between the mine and host communities may occur should employment benefits not be evident and / or be deemed inadequate. The dissatisfaction impact has a negative medium significance before management and a potential negative low significance with management during operation. Post closure jobs will not be provided by SRL, and dissatisfaction about job losses may be present; this is dealt with in EW1.

Table 6-99: Impact SD-1 – Dissatisfaction over limited jobs due to high unemployment and poverty in the study area.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Implement mitigation measures as described in EW1; • Develop and maintain regular communication with host communities and other stakeholders to minimise tensions relating to employment and expansion benefits; and • In consultation with the local leadership, implement measures to decrease the in-migration of potential job seekers into the area through the development and implementation an Influx Management Plan in conjunction with relevant external stakeholders.								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Possible***	***Low***	+	*Medium*
After Management: post closure	*The dissatisfaction will cease after mine closure, although dissatisfaction with closure may occur.*						+	*High*

Impact SD-2: Distrust in leadership due to corruption (or unfair advantage), or perceptions thereof.

Dissatisfaction over alleged corrupt or unfair practices were raised. If leadership is seen by local people to benefit unfairly or illegally from this relationship, a lack of trust in the leadership and in SRL might ensue. Erosion of trust in leadership can have many consequences, including social division and the emergence of alternative power groupings.

Currently, this has a negative medium significance however if managed correctly as per SRL's current practices, the impact significance would present as negative low during operation and after closure. After closure, some distrust in leadership may still remain in the short term.

Table 6-100: Impact SD-2 – Distrust in leadership due to corruption (or unfair advantage), or perceptions thereof

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Strict adherence to the SRL's Anti-Bribery and Corruption Policy is enforced; • SRL to continue to acknowledge and respect local customs, in accordance with SRL's Anti-Bribery and Corruption Policy; • SRL to continue to encourage stakeholders to report evidence regarding alleged bribery and corruption to SRL for investigation; • Clarification and elaboration of recruitment and employment policies and practices during stakeholder engagement processes; • Clarification and elaboration of compensation policies and practices during stakeholder engagement processes; • Ensure fair access to information about jobs and compensation; and • Ensure the CAD team is adequate in size and competencies.								
After Management: operation	*Minor*	*Short term*	*Site / local*	***Low***	***Unlikely***	***Low***	+	*Medium*
After Management: post closure	*The impact will cease after mine closure, although residual distrust in local leadership might remain.*						+	*Medium*

Impact SD-3: Dissatisfaction over perceived procurement inequities.

The expansion of SRL operations may create an expectation of further and significant local procurement opportunities. Dissatisfaction is evident in the study area, where the social baseline suggests that opportunities have allegedly proven to be marred by reportedly corrupt or unfair practices. While this may only be a perception, it is one which can result in conflict between local service providers and SRL should it not be managed effectively.

Without mitigation, a negative medium significance rating was determined however mitigation would aid in changing this perception to negative low. After closure some dissatisfaction may still remain in the short term.

Table 6-101: Impact SD-3 – Dissatisfaction over perceived procurement inequities.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
Management Measures: • Implement mitigation measures as described in EW-1.								
After Management: operation	*Minor*	*Short term*	*Site / local*	***Low***	***Possible***	***Low***	-	*Medium*
After Management: post closure	*The impact will cease after mine closure, although residual dissatisfaction might remain.*						+	*Medium*

Impact SD-4: Dissatisfaction over perceived preferences in development investment and engagement.

SRL has undertaken social and development expansions under its community development programme. Against the background of ongoing operations and potential expansion, these activities are likely to continue through the Community Development Committee (CDC). An ongoing challenge for SRL is to ensure that, through the CDC, community development investment is fairly distributed among the settlements and communities impacted by SRL. If inequities in development investment are perceived, and especially if unfair practices are assumed, dissatisfaction will continue.

With and without mitigation, a negative medium significance rating was determined during operation. After closure, some dissatisfaction may still remain in the short term.

Table 6-102: Impact SD-4 – Dissatisfaction over perceived preferences in development investment and engagement.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*High*
Management Measures: • Active participation in the CDC, and mentoring and support for this initiative; • Promote and support participatory host community development planning; • Ensure adequate application and access to the Grievance Management Procedure as well as a reasonable response turnaround times; • Pursue joint social services and infrastructure expansions and programmes with NGOs (with a focus on education) through the CDC; and • Production and dissemination of information on development investments and activities, based on monitoring and evaluation results and reports.								
After Management: operation	*Moderate*	*Medium term*	*Site / local*	***Medium***	***Possible***	***Medium***	-	*Medium*
After Management: post closure	*The impact will cease after mine closure, although residual dissatisfaction might remain.*						+	*Medium*

Impact SD-5: Disproportionate impacts on vulnerable groups due to their status in the community / study area.

Vulnerable groups in the study area (specifically youth, elderly, women, children and disabled) may be disproportionately subject to negative impacts of mining and may have reduced access to positive benefits such as access to employment albeit short term and for unskilled labour, although this has not been identified as a key concern in an assessment of the social baseline data. These disadvantages may be underpinned by social and structural relationships, marginalisation and lack of access to information about mitigation measures and beneficial activities, and therefore not as a result of the conduct of the mine only. Community development expenditure amounted to Le1.01 billion (approximately US$135 000) in the second half of 2016, and Le1.26 billion (approximately US$202 000) in the second quarter of 2017 (SRL, 2018).

With and without mitigation, a negative medium significance rating was awarded. After closure, some vulnerable groups may be advantaged and others disadvantaged depending on their unique situations.

Table 6-103: Impact SD-5 – Disproportionate impacts on vulnerable groups due to their status in the host community / study area.

	Magnitude	Duration	Scale	Consequence	Probability	SIGNIFICANCE	+/-	Confidence
Before Management	*Moderate*	*Long term*	*Site / local*	***Medium***	***Definite***	***Medium***	-	*Low*
Management Measures: • Identification of vulnerable groups and understanding the sources of marginalisation and disadvantage; and • Inclusion of requirements to consider vulnerable groups in all mitigation measures and developmental activities (the latter including recruitment, procurement, training and capacity building and stakeholder engagement).								
After Management: operation	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*Low*
After Management: post closure	*Minor*	*Medium term*	*Site / local*	***Low***	***Definite***	***Medium***	-	*Low*

6.6 Cumulative impact assessment

This section outlines consideration of cumulative impacts of the project and other key past, present and future developments impacting on the receiving environment.

6.6.1 Objectives for assessing cumulative impacts

The objectives of the cumulative impact assessment (CIA) is to:

- Present the rationale for the consideration of cumulative impacts, outlining the most important international guidelines;
- Identify the valued environmental and social components (VECs) that require consideration and describe their potential reaction to stresses;
- Identify the area of influence for cumulative impact consideration;
- Undertake a high-level assessment of potential key cumulative impacts in the area of influence; and
- Recommend management strategies to address potential cumulative impacts.

6.6.2 Rationale for consideration of cumulative impacts

Cumulative impacts are those that result from the successive, incremental, and / or combined effects of an action, project, or activity when added to other existing, planned, and / or reasonably anticipated future ones (IFC, 2013). For practical reasons, the identification and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concerns and / or concerns of affected communities.

The IFC's Good Practice Handbook for *Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets* (IFC, 2013) sets out the procedure to identify cumulative impacts and includes detail requirements and methodology to identify and quantify cumulative impacts for past, present and future activities in a receiving environment. The undertaking of a CIA requires extensive cumulative knowledge and data of developments and their impacts on the receiving environment, of which little is currently known in the project area. In addition, the SR Area 1 is a long-term operational mine. A full CIA has therefore not been undertaken for the project area.

6.6.3 Identification of valued biophysical and social components

Valued environmental (biophysical and social) components (VECs) are environmental and social attributes that are considered to be important in assessing risks that may be: physical features, habitats, wildlife populations (e.g. biodiversity), ecosystem services, natural processes (e.g. water and nutrient cycles, microclimate), social conditions (e.g. health, safety, economics) or cultural aspects (e.g. burial areas).

While VECs may be directly or indirectly affected by a specific development, they often are also affected by the cumulative effects of several developments. VECs are the ultimate recipient of impacts because they tend to be at the ends of ecological pathways.

Understanding the existing condition of VECs as well as their potential reaction to stresses and trends are therefore important. The most important VECs were identified through, social and ecological scoping, stakeholder engagement, specialist studies and the impact assessment (refer to Chapter 6). The VECs relate to air quality, water resources, biodiversity economic development and road safety.

Area of influence

The project has multiple areas of influence, ranging from the national economy, social environment in the Southern Province and host Chiefdoms to specific catchment areas for SR Area 1 existing and

expansion mining areas. The baseline section provides a description of the spatial extent and characteristics of the biophysical and socio-economic setting for the area of influence for the CIA.

6.6.4 Natural and social external influences and stresses and impacts

The key natural and social external influences and stresses that may impact on the VECs that are located in the area of influence are presented below.

Air quality and noise impacts

The baseline air quality and noise conditions, as indicated through the available monitoring data, are influenced by mine related activities, with contributions from the villages and surrounding activities, resulting in an existing cumulative impact. Sources of dust and noise such as roads are used both by mines and villagers. The study area and surrounding land can be described as rural. The area is characterised by several populated villages and settled areas, subsistence cultivation and natural forest. The air emissions and noise sources from non-mining activities in the study area that result in an existing cumulative impact include:

- Traffic on the road network;
- Commercial activities in urban centres (e.g. artisan activities, trading and markets)
- Household fuel combustion;
- Fugitive dust sources (windblown dust from bare ground as well as dust being transported by the Harmattan winds, especially during the dry season);
- Biomass burning comprising of grass and bush burning at the end of the dry season in preparation for crop planting ahead of the summer season;
- Vehicle tailpipe emissions; and
- Agricultural activities (e.g. windblown dust from bare agricultural areas, clearing of vegetation, soil cultivation).

Land use impacts

Over the years, SRL's mining activities have resulted in land take and loss of access to land. The loss of land and reduced access to land has reportedly impacted on livelihoods resources such as agricultural activities, medicinal plants and bushmeat. Previous mitigation measures that were implemented to manage the impacts related to loss of livelihoods resources included cash compensation for crops, payment of surface rent, providing access to existing agricultural land, and stocking mine ponds with fish. SRL still provides access to agricultural land by providing boat taxis, alternative roads, and bridges. However, many of these diversions have resulted in more time and money required to get to fields.

Although SRL's mining activities have resulted in land take and some loss of access to land and livelihoods resources, the increase in population in the area has also resulted in an increase in competition for these livelihoods resources.

The remaining land and natural resources not impacted by mining activities were and still are used extensively to provide for an increase in livelihoods needs due to the population increase. Extensive use has led to a reduction in the period for land lying fallow, affecting the fertility of land and hence the productive use of land.

Biodiversity and surface water impacts

Rivers are also livelihoods resources, and fish stocks have allegedly decreased as a result of the mining activities and the flooding of rivers by mine pond water and sediment. According to the biodiversity specialist study, this is due to transformed habitats directly resulting from mining activities within the study area. While these are existing impacts that are maintained by the continued mining activities, some are likely to be reduced in future since flood peaks will be minimised, and the mine

will release less water. Post rehabilitation, the draining of mine ponds will result in the riverine systems returning to its original state, which may again increase flooding. However, it will also result in more land being available for agricultural activities and establishment of other livelihoods resources.

The presence of mine ponds has given rise to an additional aquaculture / fishing livelihood option for some of the adjacent mine communities (Section 4.6 of the social baseline).

Social and economic impacts

The civil war in Sierra Leone resulted in millions of Internally Displaced Persons (IDPs) as they fled war-affected areas in search of safety. An estimated 2.6 million people were displaced by the civil war. Both the Eastern and Southern Provinces suffered significant displacements during the war. Many people moved into the Western Area for better opportunities (ReliefWeb, 2015).

Following the civil war, populations in the study showed a drift to urban areas, likely driven by returning residents and former mine workers, job-seekers and people seeking to make a non-mine living in growing local economies (CEMMATS, 2012). CEMMATS (2012) reported a growth in population numbers in the larger villages closest to the mine site and operational areas, including Mogbwemo, Matagelema and Moriba Town. Other villages experiencing influx were Kpetema, Mokaba, Ndendemoia, Gbangbama and Gbangbaia. The presence of Vimetco, a bauxite mining operation located in the Upper Banta Chiefdom, contributed to influx according to CEMMATS (2012), with SRL and Vimetco probably having a cumulative effect in this context. This collective influx and increased economic activity, such as commercial fishing, has supported the growth of business centres, the establishment of new villages and the growth of existing towns.

The growth has continued, with Mogbwemo, Mogbwewa, Njorkuvulahun, Pejebu, Matagelema and Moriba Town, merging. The growth experienced is attributed by local stakeholders to an influx of mine workers, job seekers and business people, as well as those seeking better living conditions (SRK, 2017a and b).

Approximately two thirds (60%) of participants in the HHS (SRK, 2017a) reported that they had experienced an influx of people into the area. Of those reporting influx, more than 10% were located in Moriba Town / Mogbwemo. Fewer participants who live in villages closer to mined areas within SR Area 1 reported an influx of people into the area (Belebu, Gangama, Kanga, Lungi, Madina (FM), Mbelleh 1 (Yangatoke), Njorkuvulahun and Pejebu) than stakeholders from the other villages (excluding Mogbwemo and Moriba Town). An influx occurred in Nyandehun due to the presence of the pineapple farm.

Expansion of SRL operations has created an expectation of further and significant employment. Against the background of unemployment, poverty, and the dependency on agriculture (the main employer in the country), the finite number of jobs that SRL, the main employer in the area, can provide for the local community has promoted and may continue to promote a level of dissatisfaction. This is particularly true of the youth, many of whom voiced their frustration at an inability to find employment at SRL.

6.6.5 Key past, present and future developments with the Sierra Rutile region

In addition to the existing SR Area 1 operations, there are other past, present and future developments that might have caused, area causing, or may cause impacts. A summary of these activities are included in Table 6-104 below.

Table 6-104: Past, existing and future activities

Past activities	Existing activities	Future activities
• Development of ponds for wet mining activities and associated infrastructure (e.g. processing plants, tailings facilities, power station and roads); • Development of Nitti Port • Relocation of 13 villages (between 1985 and 1995). Involving 817 households and 5,781 individuals; • Change in land use from agricultural, wilderness or wetlands to mining.	• Dry and wet mining of numerous deposits by SRL. • Farming activities (including domestic fishing). • Activities associated with urban settlements; • Vimetco bauxite mine.	• Rehabilitation of wet and dry mining areas; • Land take and relocation of villages due the expansion of the current dry mining operations; • Mining of additional rutile and ilmenite deposits in an area north of the current project activities, called Sembehun.

6.6.6 Management of cumulative impacts

The management of cumulative impacts will depend on the context in which the development is occurring (i.e. the impacts from other projects and natural drivers that affect the VECs) and the characteristics of the SR Area 1 operation. As cumulative impacts result from the actions of multiple stakeholders, the responsibility for their management is collective. For instance, social influx cannot be managed by SRL alone, but requires the involvement of a number of stakeholders including government, traditional leaders and civil society.

In the context of the SR Area 1 existing activities and expansion, most negative cumulative impacts can be mitigated through proactive project design and management. Project-specific impacts identified in the ESHIA need to be carefully managed to control the cumulative effects of the project.

Section 7 presents the detailed environmental, social and health management plan containing measures that will address project related impacts.

6.6.7 Cumulative impact mapping

In order to display the above identified potential cumulative impacts associated with the SR Area 1 activities spatially, the key outcomes from various specialist assessments (i.e. linked to the VEC's described above) were combined as far as possible. The following section outlines the methodology used to combine the various impact assessment spatial layers as well as present the cumulative impact mapping (Figure 6-2).

In order to gain an understanding of the cumulative impacts associated with the development at the SR Area 1, four specialist impact layers were initially selected. These layers were are follows:

- The floodline assessment in the Surface Water study (SRK, 2018(4));
- Air quality assessment ($PM_{2.5}$ 24-hour concentrations) (SRK, 2018(1));
- Air quality assessment (PM_{10} 24-hour concentrations) (SRK, 2018(1)); and
- The noise impact assessment (Acusolv, 2018).

Within each of these layers, the expected impact was provided a rating based on the specialist report outcomes.

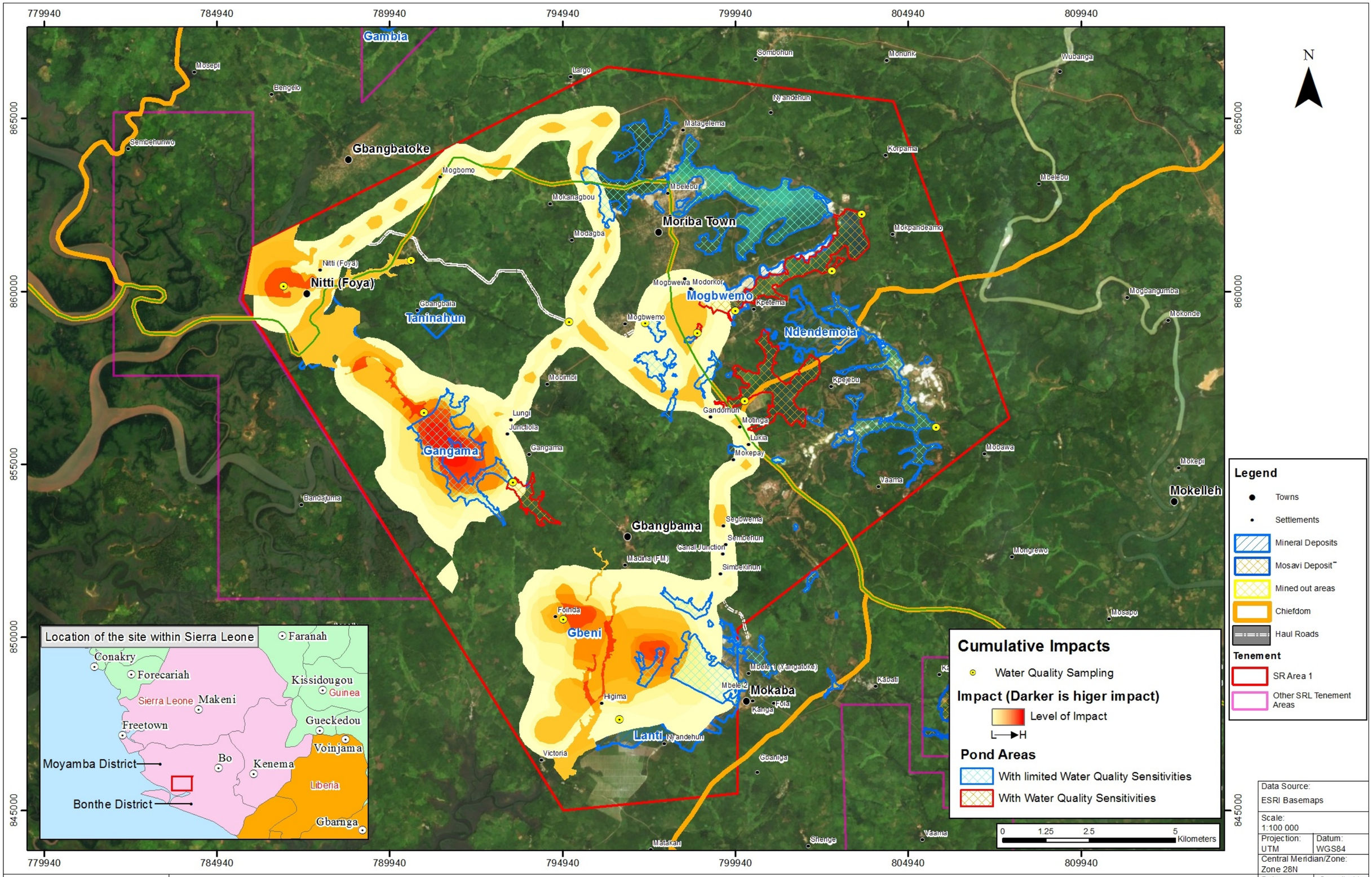
Coupled with the above approach, the following has also been mapped in Figure 6-2:

- Where water quality sampling points indicated exceedances in terms of applicable water quality guideline values (i.e. as detailed in the Surface Water study), those waterbodies have been indicated as having "*Water Quality Sensitivities*" (i.e. poor water quality with possible environmental and health implications); and

- Towns and settlements are indicated (i.e. sensitive human receptors to the cumulatively impacted areas).

[**Note**: Biodiversity sensitivity mapping is presented in Section 4.11 – see PES and EIS maps in Figures 4-60 to 4-65. As such, biodiversity sensitivity is not repeated in this cumulative impacts chapter.]

Figure 6-2 therefore provides a high-level spatial representation of expected cumulatively impacted areas within SR Area 1 in terms of potential flooding, air quality (dust), noise, water quality and social issues (i.e. the VEC's identified in Section 6.6.3 above). By overlaying a number of layers it is possible to determine areas of high sensitivity using combined impact values. The level of impact is designated a colour – the higher the potential cumulative impact the darker colour. From Figure 6-2, priority areas for focussed mitigation and management measures (i.e. from Tables 7-2, 7-3 and 7-4) can be identified for operational areas (e.g. where occupational health and safety should be prioritised) and community areas (e.g. where community health and safety should be prioritised).



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SR AREA 1 ESHIA & ESHMP

CUMULATIVE IMPACT MAPPING

**Note
The Mosavi Deposit is not included in the SRL Area 1 Study, but is shown on the locality due to its proximity to Area 1.

Data Source: ESRI Basemaps	
Scale: 1:100 000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 28N	
Date: 21/09/2017	Compiled by: ALLK
Project No: 515234	Fig No: 6-2

Revision: A Date: 23 02 2018

Path: G:\515234_ILUKA_SRK_ESIA_JNB\8GIS\GISPROJ\MXD\515234_Fx_AQIA_CumulativeMappingV2_A3L_23022018.mxd

7 Environmental, Social and Health Management Plan

7.1 Introduction

The purpose of the ESHMP is to ensure that social, health and environmental impacts, risks and liabilities identified during the ESHIA process are effectively managed during the various project phases. The ESHMP specifies the mitigation and management measures to which SRL is committed, and shows how the Project will mobilise organisational capacity and resources to implement these measures. The ESHMP also shows how mitigation and management measures will be scheduled.

The key objectives of the ESHMP are to:

- Formalise and disclose the programme for environmental, health and social management; and
- Provide a framework for the implementation of environmental, health and social management initiatives.

Best practice principles require that every reasonable effort be made to reduce and preferably to prevent negative impacts, while enhancing positive benefits, especially within the environment and communities most directly affected by SRL's current and proposed activities in their Area 1 operations. These principles are guiding in the ESHIA process.

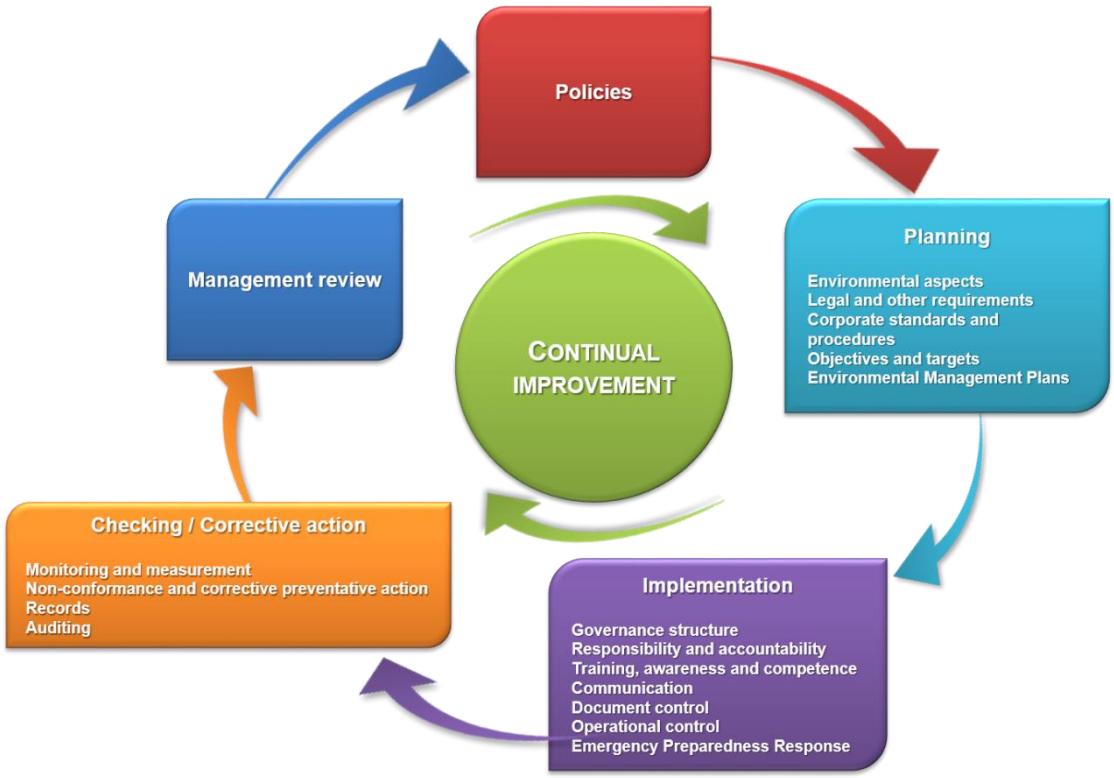
The ESHMP covers information on the management and / or mitigation measures that will be taken into consideration to address impacts in respect of:

- **Operational phase:** Historical and current dredge mining operations and associated infrastructure (i.e. included in the 2012 ESIA and approved via Environmental Licence number EPA-SL030);
- **Expansion phase:** Construction, initial operational and expansion of the Lanti and Gangama dry mining operations (2013 onwards), including:
    - Site and vegetation clearing, grubbing, establishment of layout area, contractors camp, widening of existing haul roads, dry mining, scrubbers, expansion of TSF, borrows pits and trucking of ore (haul roads)
- **Decommissioning phase, closure and post closure phase.**

It is necessary to highlight that the ESHMP is a living document that will be periodically reviewed and updated by SRL.

As part of ongoing implementation, this ESHMP will be publicly disclosed during the stakeholder engagement process. An opportunity will be offered to participating stakeholders to provide comment.

Figure 7-1 below illustrates the principle of continual improvement in development of a policy framework, environmental, health and social management planning, which are implemented through a number of plans, programmes and operating procedures using SRL's corporate governance structure. Implementation is monitored on a regular basis to determine environmental and social performance and conformance, and corrective action is taken where necessary. Management review is undertaken on scheduled basis to determine whether the system reflects the requirements and commitments of SRL. These combined elements comprise SRL's Health, Safety, Environmental and Community (HSEC) Management System (see Section 2.3).



srk consulting	SR AREA 1 ESHIA & ESHMP HSEC MANAGEMENT SYSTEM	Project No. 515234

*Source: http://infohouse.p2ric.org/ref/32/31028/ems/info/sme4.htm

Figure 7-1: Key elements of an HSEC Management System

7.2 Roles and responsibilities

SRL is responsible for ensuring adherence to the management and mitigation measures detailed in the ESHMP and the relevant approvals. SRL's management, employees and contractors are all bound by the ESHMP and SRL's HSEC Management System and must use these document as a guide to avoid, minimise and manage environmental, health and social impacts.

The sub-sections below provide recommendations for alignment of SRL organisational structure, to facilitate the mainstreaming of sustainability implementation.

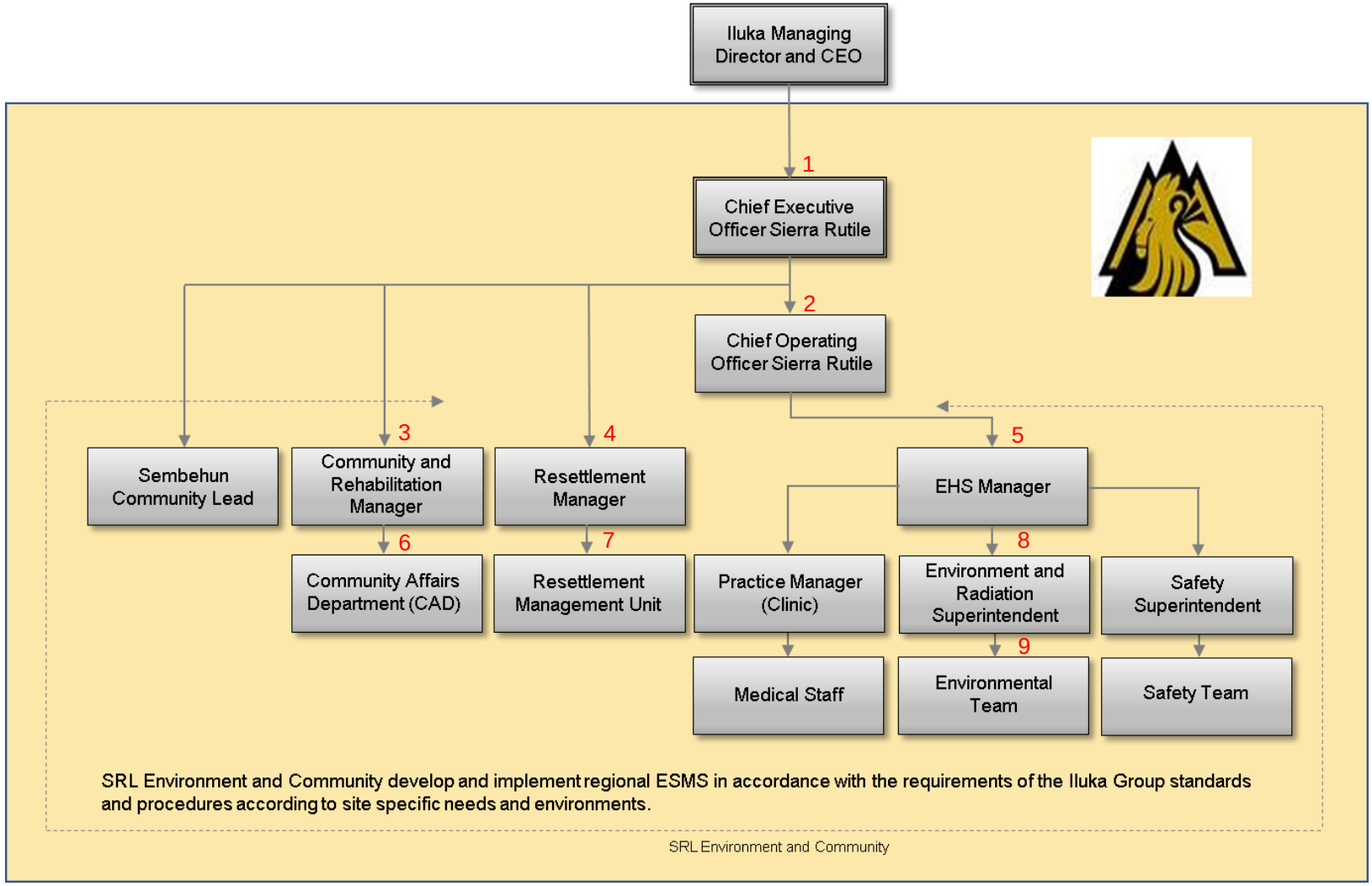
General management

Figure 7-2 and Table 7-1 show the general organisational structure for management within SRL.

Responsibilities and reporting lines of key sustainability functions

Responsibility for sustainability management, in particular the implementation of the HSEC Management System, will be a responsibility of numerous levels and functions in the organisation.

Accountabilities, reporting lines and responsibilities of key roles for the SRL operations are indicated in Table 7-1 but job titles and responsibilities are subject to finalisation.



[Note: The numbers in red correspond with the numbering in Table 7-1 below]

Figure 7-2: Organisational structure for SRL management

Table 7-1: Key responsibilities and reporting lines for SR Area 1 operations

Nr	Function / Position / Structure	Accountable to / reporting line	Responsibilities
1	SRL Managing Director and Chief Executive Officer	SRL Board of Directors Managing Director Iluka Resources Stakeholders	• Has ultimate accountability for sustainability performance at SRL; • Ensures that sustainability is integrated into company strategy, governance and decision-making; • Oversees the Company's risk strategy and management; • Recommends an external assurance provider for the disclosure of performance on material sustainability issues;Monitor SRL performance in relation to legal requirements and GIIP; • Monitor SRL liabilities; and • Approves policy and strategy related to sustainability.
2	Chief Operating Officer Sierra Rutile	Chief Executive Officer Sierra Rutile	• Ensure implementation of the HSEC Management System in the plant and mining operations, which will include the environmental and social management plan and action plan, and other components; • Incorporate financial resources related to the implementation of the HSEC Management System (e.g. salaries, skills development and training, equipment, liabilities including rehabilitation and closure, social development initiatives, independent audit / assurance etc.) into company financial systems; • Ensure sustainability is integrated into plant and mining management and decision-making processes such as management meetings and reporting, and risk management; • In charge of providing technical expertise for effective environmental and social management; • Ensure operational compliance with legal requirements (including Environmental Licences); • Develop, maintain and review of the HSEC Management System; • Hold the managers and their teams in the plant and mining operations responsible for sustainability performance; and • Attend stakeholder forums such as host community meetings, as appropriate, to demonstrate senior management support.
3	Community and Rehabilitation Manager	Chief Executive Officer Sierra Rutile	• In charge of providing technical expertise for effective environmental and social management; • Ensure operational compliance with legal requirements (including Environmental Licences); • Hold the CAD managers and their teams responsible for sustainability performance; • Attend stakeholder forums such as host community meetings, as appropriate, to demonstrate senior management support; • Ensure implementation of social policies, procedures, and management plans, notably the Stakeholder Engagement Plan, the social components of the ESHMP and the HSEC Management System; and • Management of the environmental related components of the grievance mechanism.

Nr	Function / Position / Structure	Accountable to / reporting line	Responsibilities
4	Resettlement Manager	Chief Executive Officer Sierra Rutile	• In charge of providing technical expertise for effective resettlement management; • Hold the Resettlement Management Unit team responsible for sustainability performance; and • Responsibility for ensuring implementation of the RAP.
5	Environmental, Health and Safety (EHS) Manager	Chief Operating Officer Sierra Rutile	• Implement an HSEC Management System that adheres to national and international standards; • Manage the support team of environmental, health and safety coordinators to implement the HSEC Management System; • Prepare monitoring reports for submission to the Chief Operating Officer and to stakeholders; • Ensuring integration of environmental, health and safety functions throughout the Project; and • Inspections / audits of safety requirements by employees and sub-contractors; sampling and data capture in accordance with safety monitoring program and analysis of results; assistance with the preparation of reporting and permit applications.
6	Community Affairs Department (CAD)	Community and Rehabilitation Manager	• Implementation of social policies, procedures, and management plans, notably the Stakeholder Engagement Plan, the social components of the ESHMP and the HSEC Management System; • Planning of and carrying out social and stakeholder engagement training programs for employees and contractors; • Developing and maintaining relationships with host community stakeholders, and in particular coordinate the Stakeholder and Community Forum in collaboration with stakeholders; • Establishment and overall management of the grievance mechanism in conjunction with the environmental, and health and safety coordinators, and in liaison with the Human Resources Manager; • Act as the primary points of contact between host communities and SRL; and • Implementation of the social management system including social management plans.
7	Resettlement Management Unit	Resettlement Manager	• Operational and daily responsibility for implementing the RAP.
8	Environment and Radiation Superintendent	Chief Operating Officer Sierra Rutile	• Providing technical expertise for effective environmental management; • Ensure operational compliance with legal requirements (including ESHIA and Environmental Licences); • Implement environmental policies, procedures, and management plans related to the biophysical environment and radiation; • Review and analysis of monitoring results and preparation of reports to management and stakeholders; • Planning of and carrying out environmental training programs for employees and contractors; and • Obtaining and maintaining all necessary environmental permits and licenses.

Nr	Function / Position / Structure	Accountable to / reporting line	Responsibilities
9	Environmental Team	Environment and Radiation Superintendent	• Inspections / audits of environmental protection requirements by employees and sub-contractors; • Sampling and data capture in accordance with the environmental monitoring program and analysis of results; and • Assistance with the preparation of environmental monitoring reporting and permit applications.

7.3 Structure of the ESHMP

SRK has developed an ESHMP which is supplemented by a series of conceptual environmental, social and health management thematic plans. This ESHMP has been compiled to include the following information:

- Management measures proposed in terms of the biophysical, social and health environment and what the objectives of implementing these would be. This has been further detailed in Table 7-2 to Table 7-4 to include:
  - Environmental aspects;
  - Environmental impacts (including a brief description of the activity generating impact);
  - Objectives / goals of management and / or measure of effectiveness;
  - Management measures;
  - Performance criteria;
  - Responsible party;
- Requirements for Checking and Corrective Action (Section 7.5); and
- Requirements for monitoring and performance assessment (Section 7.6).

In addition, the following stand-alone plans have been developed and are included in the list of appendices:

- Chemical Management Plan (Appendix L1);
- Waste Management Plan (Appendix L2);
- Tailings Management Plan (Appendix L3);
- Mine Closure Plan (Appendix L4);
- Occupation Health and Safety Plan (Appendix L5);
- Emergency Response and Contingency Plan (Appendix L6);
- Community Development Plan (Appendix L7); and
- Communication and Public Participation Plan (Appendix L8).

7.4 Impact Mitigation and Management

Key impacts identified by specialists as part of this ESHIA report will be managed in terms of SRL / Iluka's HSEC Management System Framework (Section 2.3.1). In addition to this, specific mitigation and management measures as identified through the various specialist studies are summarized in Table 7-2 to Table 7-4 below. These mitigation and management measures will be implemented as far as practically possible.

The tables are organised by project phase for:

- **Operational phase**: Historical and current dredge mining operations and associated infrastructure (i.e. included in the 2012 ESIA and approved via Environmental Licence number EPA-SL030);
- **Expansion phase**: Construction, initial operational and expansion of the Lanti and Gangama dry mining operations (2013 onwards), including: site and vegetation clearing, grubbing, establishment of layout area, contractors camp, widening of existing haul roads, dry mining, scrubbers, expansion of TSF, borrows pits and trucking of ore (haul roads); and
- **Decommissioning, closure and post closure phase.**

The tables below form the core of this ESHMP and are based on:

- The information provided to date;
- The assumptions made for this ESHIA report;
- The recommended mitigation measures which are assumed will be effectively implemented;
- The assessments provided by the specialists;
- SRL operating procedures and GIIP; and
- The practicality of the recommendations for mitigation.

It should be noted that although this document does not seek to assess the financial feasibility of mitigation measures proposed, the cost of their implementation would need to be considered by SRL during their ongoing operations in SR Area 1.

Table 7-2: Operational phase: Historical and current wet mining operations and associated infrastructure

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
Biophysical					
Air Quality	Impact AQ-1: Dust emissions during the operational phase.	Reduce PM_{10} and $PM_{2.5}$ concentrations and dust fall out below the WB / IFC EHS Guideline values.	• Road surfaces for ore delivery to the plant sites will be paved or treatedas may be apprpriate to suppress dust entrained by vehicles. Surface treatment of roads will also be considered before and after a sensitive receptor; • Dust suppression techniques such as wet suppression or chemical suppression (environmentally friendly and non-polluting) will be used to reduce dust on roads that exhibit an increase in dust entrainment; • Speed limits will be adhered to within the SR Area 1 for both treated haul roads and unpaved roads. Speed limits are: o 40 km/hr for haul trucks; o 60 km/hr for light vehicles; and o 30 km/hr for all SRL vehicles through villages. • Where practical and / or necessary: o Grass will be planted along the boundary of the TSFs to lower the possibility of wind erosion; o Long side walls of the TSFs will be re-vegetated / grassed to stabilise surfaces where required; and o Grass types will be endemic to the area. • Current management measures of rock cladding with laterite will be maintained. As the TSFs increase in height, the current management measures will continue as needed; • Where practical, a surface binder will be applied on the TSFs, if monitoring indicates that dust is an issue from this source; • Dust control will be attended to when loading trucks by minimising drop heights and prevention of over loading; • Load size will be limited to reduce spillage and final product loads will be covered with tarpaulins where needed; and • A routine emissions and ambient air quality monitoring program will be developed and implemented to determine whether there are any significant increases in emissions and impacts at sensitive receptors.	Continuation of dust monitoring; Compliance with WB / IFC EHS Guideline values.	Environment and Radiation Superintendent
	Impact AQ-2: Emissions from the Power Plant.	Maintain emission concentrations for NOx, SO_2, PM_{10}, CO, VOCs, dioxins and furans within WB / IFC EHS Guideline values, and applicable SL legislative requirements.	• Regular maintenance will ensure that the abatement technology will continue to meet Original Equipment Manufacturer (OEM) specifications and acceptable international emissions standards; • A routine emissions and ambient air quality monitoring program will be developed and implemented to determine whether there are any significant increases in emissions and impacts at sensitive receptors; • Inline continuous monitors will be considered to monitor PM, SO_x and NO_x at the Power Plant and MSP; • At least one round of stack emissions tests will be undertaken on the Power Plant, MSP and medical incinerators to determine if the legislated arsenic and lead parameters are present in the stack emissions; and • At least one round of stack emissions tests will be undertaken to determine the presence of dioxins and furans which may emanate from the medical incinerator stacks.	Monitoring programme; Compliance with WB / IFC EHS Guideline values and applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact AQ-3: Emissions from the dryers at the MSP.				
	Impact AQ-4: Emissions from the medical incinerators.				
Biodiversity: Aquatic resources	Impact BDA-1: Loss of habitat, biota and ecosystem services due to mining activities at the current wet mining operations.	Minimise impacts to aquatic ecosystems.	• Relevant stakeholders will be notified through existing forums regarding schedules for planned pit wall lowering and changes in decant rates that may occur; and • Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact BDA-2: Loss of habitat, biota and ecosystem services due to the MSP and haul roads.	As for BDA-1 above.	• Operational footprints will be kept to a minimum, and controls of edge effects implemented; • For the duration of the operational phase of the MSP, the controlled release of the water from the MSP ponds into the Mogbwemo Dredge Pond and into the natural water system will occur; • Erosion management and sediment controls such as the use of rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps will be implemented as applicable. This is particularly relevant to areas where the topography has changed, resulting in preferential flow paths prone to erosion, with associated sedimentation / siltation risks (also refer to SWMP, Section 7 of the specialist Surface Water study (Appendix G)); and • Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact BDA-3: Loss of habitat, biota and ecosystem services due to handling and shipping at Nitti Port	As for BDA-1 above.	• Operational footprints will be minimised, and controls of edge effects implemented; • Storm water and erosion management structures will be upgraded and maintained (see SWMP, Section 7 of the specialist Surface Water study (Appendix G)); and • Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
Biodiversity: Terrestrial resources	Impact – BDT-1: Loss of faunal and floral habitat, species diversity and Species of Conservation Concern (SCC) due to current wet mining operations.	To minimise impacts to important habitats and SCC. To maximise rehabilitation efforts to allow for the re-introduction of these species back into the SR Area 1.	• Vegetation will only be cleared in areas where necessary; • As far as possible existing roads will be utilised. If not feasible, roads will be constructed in areas that have already been disturbed, and not within sensitive habitat, as far as possible; • Throughout the operational phase, management and control of alien plant species will be exercised. For this, an AIPCP will be developed and implemented; • Speed limits will be adhered to within the SR Area 1 for both treated haul roads and unpaved roads. Speed limits are: o 40 km/hr for haul trucks; o 60 km/hr for light vehicles; o 30 km/hr for all SRL vehicles through villages. • Drivers will be educated with regard to species conservation, and encourage them to not unnecessarily drive over faunal species; • The existing nurseries for SR Area 1 will be further developed for utilising indigenous species and implementing rehabilitation trials. The species composition can include medicinal and timber species as indicated in the floral ecological assessment (STS, 2018), which will lessen the pressure on these species due to habitat destruction and utilisation by host communities; • A Biodiversity Action Plan will be developed containing objectives to improve agricultural efficiency by host communities, improving current rehabilitation strategies and actively managing alien and invasive floral communities within SR Area 1; • A Waste Management Plan will be developed and implemented (Appendix L2); • No uncontrolled fires will be permitted within SR Area 1, unless it is part of a management plan; and • Mined out areas will be set aside for rehabilitation (refer to Mine Closure Plan, Appendix L4).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact BDT-2: Loss of faunal and floral habitat, species diversity and SCC due to ancillary human impacts.	As for BDA-1 above.	• Mine workers and host communities will be educated about the long-term impacts associated with slash and burn activities, and the inevitable loss of forest and food resources; • A Biodiversity Action Plan will be developed containing objectives to improve agricultural efficiency by host communities, improving current rehabilitation strategies and actively managing alien and invasive floral communities within SR Area 1; • With increased personnel, the likelihood of poaching and trapping will also increase. Measures to prevent poaching will be investigated and implemented were practical; • Ecologically feasible and sustainable crop growing initiatives will be developed as per the Mine Closure Plan, as far as is practicable; and • Within the SR Area 1, no go areas / areas of refuge for faunal species, where no hunting practices are allowed, will be demarcated.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Biodiversity: Marine and Estuarine	Impact BDME-1: Modification of remaining estuarine habitat.	Manage discharge of water from mining activities in estuary surface water catchments; Prevent destabilization of the estuarine and marine habitats.	• Fresh water flow into each of the mangrove creeks will be maintained to at least 60% of the natural base flow, especially during the dry season; • Vegetation clearing and overburden stripping will be conducted, as far as possible, during the dry season to limit erosion sediment loads flowing into the lower reaches of the mangrove ecosystem; • Overburden will be removed and stored in such a way that it is not washed into the mangrove creeks during the wet season (see soils impact S-1 mitigation measures below); • Adequate storm water management will be ensured to prevent erosion from the newly exposed mining areas and transport of sediment into the lower reaches of the mangrove channels (i.e. as per the SWMP, Section 7 of the specialist Surface Water study (Appendix G)); and • A comprehensive water quality monitoring programme will be developed and implemented that includes sites where storm water enters the estuarine system and at stations in the vicinity of Nitti Port and along the ore transport route.	Compliance with GIIP standards and guidelines as appropriate	Environment and Radiation Superintendent
Soils and land capability	Impact S-1: Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinization (wet mining).	To minimise the loss of utilisable soil resources (i.e. due to sterilisation, contamination, erosion, compaction and loss of nutrients and structure).	• The disturbed footprint will be minimised as far as practically possible; • Replacement of soils and concurrent rehabilitation will be undertaken timeously where possible as per the Soil Management Plan (Section 6 of the specialist Soils and Land Capability Study, Appendix K); • The Mine Closure Plan (Appendix L4) will support the project as and when appropriate; and • Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Implementation of the Soil Management Plan. Compliance with GIIP standards and guidelines as appropriate; Erosion monitoring.	Environment and Radiation Superintendent Community and Rehabilitation Manager
Noise	Impact N-1: General rise in ambient noise levels due to current wet mining operations.	To minimise disturbance from noise impacts.	• A high level of equipment and vehicle maintenance, especially intake and exhaust mufflers, will be ensured; • Noise generating equipment will be designed to control and dampen noise emissions to ensure that the increase in ambient noise level will comply with relevant norms and standards; and • Host community members will be able to register their complaint / concern about noise through the SRL grievance mechanism. Complaints will be investigated and responded to as a matter of urgency and measures will be taken to minimise the noise if found to be related to SRL activities.	Compliance with GIIP standards and guidelines as appropriate	Community and Rehabilitation Manager EHS Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
Surface Water	Impact SWSS-1: Construction of dams and ponds attenuate flood peaks resulting in changes in seasonal flooding patterns which effect sediment loading, sediment deposition on floodplains, fish ecosystems and host communities / residents.	To manage surface water quality and quantity related issues.	• The removal of the dams to allow the natural functioning of the ecosystems in consultation with the Mine Closure Plan; and • Review the reservoir hydrology and spillway design in line with the Mine Closure Plan.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact SWSS-2: Increase in flooding in the pit due to lack of stormwater diversion from the Gbeni operations causing an impact on operations.	As for SWSS-1 above.	• The river diversion (as per the SWMP, Section 7 of the specialist Surface Water study (Appendix G)) where the Gbeni East Trench is located will be formalised and appropriately sized.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact SWSS-3: Decrease in water quality downstream of the Gangama and Gbeni operations due to inadequate stormwater management.	As for SWSS-1 above.	• Mitigation measures as for SWSS-1; and • Silt traps will be constructed as per the SWMP, Section 7 of the specialist Surface Water study (Appendix G).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent

	Impact SWSS-4:
	Dam walls being overtopped or failing as a result of freeboard requirements not being sufficient and a large flood event occurs.
		As for SWSS-1 above.	*External measures:*
			• It will be investigated if an early warning system could be implemented to ensure that should one of the dam walls be noticed to be of failing integrity or about to be overtopped, the people downstream of that particular dam wall need to be informed so that they can vacate the area of concern.
			Internal measures:
			• Regular dam safety inspections will be conducted;
			• Piezometers have been installed in some of the dam walls and a TSF management plan is in place. The operation confirms to ANCOLD standards and the dams have a operating procedure in place which will continue to be implemented;
			• A dam break study will be investigated to identify the zone of influence as a dam wall failing could be catastrophic;
			• The water balance will be looked at in greater detail with actual measured values being introduced to greater effect so that confidence can be built into the water balance and the projections made from it;
			• The formal dams will have a 1.8 to 2 m freeboard, while tailings dams will have 0.8 m of freeboard;
			• Emergency planning and mitigation measures will be developed and implemented should the water level become too high. These will include:
			  ○ Emergency pumps to assist the lowering of the water level in the dams;
			  ○ An alternate dam dewatering outlet once a certain threshold limit has been reached to release water into the environment; and
			  ○ Protocols surrounding human and machinery not being allowed within certain areas that may be in jeopardy.
				Monitoring programme.
				Compliance with GIIP standards and guidelines as appropriate.
				Compliance with applicable Sierra Leonean legislative requirements.
					Environment and Radiation Superintendent

	Impact SWSS-5: Insufficient water necessary for mining and processing at Lanti and MSP operations.	As for SWSS-1 above.	• The water balance will be updated with dam volumes, actual water volumes used in the plant and during mining (long term data); • Data on current make-up water requirements will be provided; and • If ponds are to be removed from MSP area, it will be ensured that an alternate water supply will be available to guarantee continuation of mineral processing activities.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact SWSS-6: Excess water release may affect downstream users from Gangama operation.	As for SWSS-1 above.	• The water being released to the environment will continue to be monitored. Should the water quality decrease due to mining, then additional controls will be needed.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
				Compliance with applicable Sierra Leonean legislative requirements.	
	Impact SWSS-7: Discharge of acidic water from the MSP and Lanti operation leading to reduction in pH and increased acidity resulting in acidic, soft and corrosive water affecting the natural water system.	As for SWSS-1 above.	• Controlled release of the water from MSP ponds into Mogbwemo Dredge Pond and into the natural water system will be ensured.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact SWSS-8: Potential use of acidic, soft and corrosive water at Lanti Dry Mine process plant resulting in corrosion and damage of metallic structures, equipment and pipes.	As for SWSS-1 above.	• Liming of the acidic water will be undertaken at the Process Water Tank to neutralize acidity and to buffer the water from rapid pH fluctuations if / when necessary; and • The quality of water used as process water will be monitored.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
Groundwater	Impact GW-1: Elevated historical mining pond levels may increase the available drawdown in community boreholes.	N/A	N/A [Note: As this is a positive impact, no management are proposed.]	N/A	N/A
	Impact GW-2: Seepage from MSP tailings and dams raising groundwater levels.	N/A	N/A [Note: Since the raised groundwater levels are localised and in close proximity to the Mogbwemo Dredge Pond, no mitigation measures are proposed.]	N/A	N/A
	Impact GW-3: MSP hydrocarbon and sewage spills contaminating groundwater.	To manage groundwater quality.	• Pollution control measures to implemented (see Impact GEN-1 Table 7.2); and • The sewage treatment process will be properly maintained to ensure that it is operating within design specification.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact GW-4: MSP secondary processed tails acid generation contaminating groundwater (operational and decommissioning phase).	To manage groundwater quality.	• Acid generating material will be identified and either disposed of sub aqueously or isolated from the receiving environment through appropriate rehabilitation measures; and • Radioactive material will be identified and isolated from the receiving environment through appropriate rehabilitation measures.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact GW-5: Elevated Lanti mining pond levels may increase the available drawdown in community boreholes.	N/A	N/A [Note: As this is a positive impact, no management are proposed.]	N/A	N/A
	Impact GW-6: Lanti dredge hydrocarbon and sewage spills contaminating groundwater.	To manage groundwater quality.	• Pollution control measures to implemented (see Impact GEN-1 Table 7.2); and • The sewage treatment process will be properly maintained to ensure that it is operating within design specification.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
	Impact GW-7: Lanti mining pond water may lead to groundwater contamination.	To manage groundwater quality.	Alternative water supply will be provided if the Lanti mining pond has affected the water quality in the community boreholes in the immediate vicinity to the point where they cannot be used.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact GW-8: Nitti Port hydrocarbon spillage contaminating groundwater.	To manage groundwater quality.	• Investigations will be undertaken by hydrocarbon contamination specialists – their receommendations will be implemented; • A groundwater quality monitoring programme will be implemented; and • An accurate record of fuel stored and consumed onsite will be maintained as a possible early warning measure.]	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact GW-9: Waste disposal site leachate contaminating groundwater (operational and decommissioning phase).	To manage groundwater quality.	The waste disposal site will be properly capped and shaped to promote runoff and reduce infiltration.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent
	Impact GW-10: Raised historical mining pond levels altering groundwater baseflow distribution to surface water systems.	N/A	N/A [Note: No mitigation measures are proposed for this impact.]	N/A	N/A
	Impact GW-11: Lanti mining pond retarding groundwater baseflow to surface water systems (operational and decommissioning phase).	N/A	N/A [Note: No mitigation measures are proposed for this impact.]	N/A	N/A
	Impact GW-12: Seepage of poor quality groundwater through the Lanti mining pond wall and weathered aquifer discharging into the surface water systems.	N/A	N/A [Note: No mitigation measures are proposed for this impact.]	N/A	N/A
	Impact GW-13: Failure of the historical and Lanti mining pond walls as a result of groundwater seepage (operational and decommissioning phase).	To manage groundwater quality and quantity related issues.	• As per the current Mine Closure Plan, the water levels within the mining ponds will be lowered to reduce maintenance and risk of wall failure; and • Tailings will be deposited downstream of the mining pond walls to ensure greater stability.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Compliance with applicable Sierra Leonean legislative requirements.	Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
Radiation	Impact RI-1: Impact on social and biophysical receiving environments based on radiation exposure.	To manage potential radiation related issues.	• Baseline monitoring to determine the following will be undertaken: ○ Radionuclide concentrations in soil across the current (and future) project areas through the soil profile; ○ The radionuclide concentrations in tailings across the current project areas. Full radionuclide analysis of selected tailings streams for future human health and biota modelling purposes; ○ The absorbed (radiation) gamma dose rates in air across the current (and future) project areas; ○ The radon (Rn-222) and thoron (Rn-220) concentrations in the air; ○ The groundwater radionuclide concentrations (incl. U, Th, Ra-226, Ra-228, gross alpha and beta); ○ The surface water radionuclide concentrations (incl. U, Th, Ra-226, Ra-228, gross alpha and beta); and ○ The long lived alpha activity (LLAA) in airborne dust. • An ERICA assessment (biota modelling) will be conducted once processing materials have been characterized in terms of full radionuclide analysis; and • The Radiation Management Plan will be updated and implemented based on findings from the baseline monitoring and ERICA assessment.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Health					
Communicable diseases	Impact H-1: Transmission of communicable diseases from workforce to the community due to influx and general hygiene.	To educate, minimise and manage the spread of diseases.	• A communicable disease strategy (HIV, TB, etc.) and plan that includes employees, contractors and visitors will be developed. The strategy will include elements that reduce the risk for local introduction of communicable disease; • An outbreak preparedness and response plan that includes business resilience elements will be developed. This will include cooperation with the DHMTs; • An Influx Management Plan will be developed (note: such a plan is a mitigation measure for most of the Health Impacts. Since it is stipulated here, this measure has not been repeated in the Health section of this table.); • A monitoring system will be developed and implemented as part of the CHMMP to monitor specific health indicators; • An agreement with the DHMT(s) to support the care and treatment of employees / contractors for TB (and HIV) will be developed - so that when employees / contractors leave the Project that they can be referred back into the public health system, or traced to their place of origin (this is particularly important for people undergoing treatment); • Adequate camp facility management in company accommodation will be ensured to maintain adequate environmental health / hygiene standards; and • A vaccine preventable disease programme will be developed for all employees and contractors.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Disease associated with malaria	Impact H-2: Increased burden of disease associated with malaria due to modification of the environment (including current mining activities such as mine dredge ponds and in-migration of work-seekers).	As for H-1 above.	• Opportunities to work with the NMCP and DHMT will be evaluated, including: ○ Performing a malaria indicator study to determine the local burden of disease; ○ Conducting a baseline entomology study to determine the presence of disease transmitting mosquitoes and other vectors; their behaviours and what controls could be effective; • An Influx Management Plan will be developed that may consider environmental management and health systems strengthening in collaboration with the DHMT; and • An integrated workplace malaria and vector control programme will be developed that has a focus on environmental management, integrated vector control, bite prevention, behaviour management and effective case management within the workplace.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
Arbo-viral diseases (e.g. Yellow Fever)	Impact H-3: Risk of outbreak of arbo-viral diseases due to influx and opening of transport corridors.	As for H-1 above.	• Vector control measures will be included in the proposed integrated workplace vector control programme, but a focus for *Aedes* spp. control will be ensured. This can include source reduction where water may collect (tyres, lay down yards etc.) with environmental controls the main intervention (draining water or preventing collection) and chemical larval controls may also be considered as required; • The potential transmission of arbo-viral disease in the proposed outbreak preparedness and response plan will be included. This is especially important for yellow fever as it can mimic other viral haemorrhagic fevers, such as EVD; • As part of the proposed entomology study referred to for Impact H-2, screening for other species that have the potential to transmit disease, and develop vector control actions based on findings will be included; • Capacity in the workforce will be developed to diagnose and manage suspected or confirmed cases of arbo-viral disease; and • Based on the threat of a (or a confirmed) yellow fever outbreak, the workforce will be vaccinated. This will require collaboration with the National or District health authorities.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Limited water, sanitation and waste management services	Impact H-4: Effects on human health as a result of changes in the biophysical environment incurred by current and future mining activities.	As for H-1 above.	• Water management measures will be implemented to limit the human health effects (such as sewage and other wastes) on the biophysical environment (refer to mitigation measures for surface water: impacts SWSS-1 to SWSS-8); • Statistics on bilharzia in local clinics and health posts will be reviewed to determine if there are any trends in burden of disease in host communities that are closer to mine ponds; • Consideration will be given to conducting baseline studies to determine the burden of disease from bilharzia and soil transmitted helminths; • It will be ensured that accommodation camps and all work areas have adequate potable water facilities, sanitation services and the ability to maintain good personal and hand hygiene. This will include the provision of adequate facilities for workers who are in remote areas to prevent indiscriminate defaecation; • It will be ensured that proper disposal of human waste through the selection and proper management of sewerage treatment plants will be implemented, with these facilities having the capacity to manage the expected throughput with adequate contingencies (such that if there is a failure, that the risk of direct exposure to host communities and their water sources is minimised); • Information education and communication (IEC) campaigns will be developed for the workforce on proper water use, hygiene and sanitation; and • SRL will ensure effective waste collection from camps and work areas as per the Waste Management Plan (Appendix L2).	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Sexually-transmitted diseases	Impact H-5: Increased risk of sexually-transmitted diseases and high risk sexual practices due to current and future mining activities.	As for H-1 above.	• As part of the proposed communicable disease strategy and plan, the HIV Policy and plan will be reviewed to ensure it is meeting the potential risks and the needs of the Project; • SRL will review their partnership with NAS and become more involved with activities and review effectiveness of interventions; • As part of the Influx Management Plan, specific attention will be given to contractor management, including reference to reference to temporary accommodation, HIV, STI and other health related performance measures; • As part of the CHMMP, a monitoring system for specific health indicators related to STIs and HIV will be developed for employees and contractors; • HIV counselling and testing in the workforce will be promoted through various means, with support to accessing and initiating care and treatment and thereby promoting HIV and STI prevention. These will need to be supported by the NAS, with the SRL clinic staff involved in care and treatment as well as adherence monitoring. The Project will aim to meet the 90:90:90 target[34]; • Widespread availability and social marketing of condoms in the workplace will be supported; • A blood borne pathogen control procedure will be developed in the SRL clinic and emergency response team that includes prevention practices for exposure to blood (e.g. needle stick injuries) and post exposure prophylaxis as required; and • The capacity of host community health officer's in the host communities will be increased as a resource to extend programme interventions.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Malnutrition	Impact H-6: Food and nutrition-related issues due to influx and land use change.	As for H-1 above.	• Opportunities to support farming ventures in SR Area 1 will be evaluated to offset the loss of land through the Agricultural Development Fund. This should focus on food crops, with the type of crop chosen to support local demand, access to markets and promote food security; • Effective resettlement planning and execution will consider access to arable land and support of farming as a key livelihood; and	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager

[34] The 90:90:90 target aims to address HIV transmission by setting the target that 90% of all people living with HIV will know their HIV status, 90% of all people with diagnosed HIV infection will receive sustained ART, and 90% of all people receiving ART will have viral suppression (measured by CD4 and viral load)

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
			• In partnership with the respective DHMTs, a baseline nutritional indicator survey will be performed and a surveillance system developed to monitor changes in important nutritional indicators.		

Non-communicable diseases	Impact H-7:
	Increase in non-communicable diseases as a result of life style and demographic changes.
		As for H-1 above.	• Wellness programmes in the workplace will be initiated where needed;
			• Opportunities to reduce modifiable risk factors as part of the wellness programme will be evaluated, including;
			  ○ Management of the type of food and size of portions in company canteens;
			  ○ Smoking cessation;
			  ○ Exercise programmes, etc.;
			• Screening for hypertension and diabetes as a health promotion intervention will form part of the occupational health programme; and
			• It will be ensured that the SRL clinic is capacitated to effectively manage non-communicable diseases as far as possible. Referrals will be to at least level two facilities.
				Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager

Hygiene	Impact H-8: Emergence and spread of veterinary medicine and Zoonotic diseases due to inadequate camp and waste facilities.	As for H-1 above.	• Consideration will be given to conducting studies with the Lassa Fever Research Centre (in Kenema) to determine the presence of the reservoir host in the general community, accommodation camps and around land-fill / waste disposal sites. If the species is present, it would be beneficial to conduct further studies to determine if rodents are carrying the virus; • Rodent controls in accommodation camps, work and landfill areas will continue to be implemented as necessary, including preventing rodents from entering into accommodation, kitchen and food / water storage areas; • SRL will continue to support the DHMT(s) with outbreak preparedness and response as a strategic intervention; • Effective waste management practices in all accommodation, work areas and landfills will be ensured to reduce the risk for pests being attracted or proliferating in these locations; • The presence of pets (dogs and cats) in accommodation areas will be limited, and if they are present ensure they are properly vaccinated. Dogs that may be used for security will also be appropriately vaccinated; and • Procedures will be developed to avoid, or avoid the risk of, snake bites. Protocols will be developed for immediate first aid and management of snakebites in the SRL clinic (including assuring correct anti-venoms are present).	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Socio-economic					
Health and safety	Impact HS-1: Increased crime as a result of the influx of job seekers, employees and business owners.	To minimise and manage health and safety related impacts.	*External measures*: • Continue to liaise with local police to monitor social changes in crime patterns; • Continue to liaise with existing crime control organisations, such as the Criminal Investigation Department, local community policing forums and other crime prevention organisations; • Consult with the local police service to establish standard operating procedures for the control and / or removal of loiterers; and • Initiate multi-stakeholder influx management planning process and include crime-related measures in a regional Influx Management Plan. *Internal measures:* • Improve security on mine premises; • Minimise opportunities for criminal activity; • Continue to communicate the Recruitment Policy and process regularly to local people; • Local employment to remain a focus area. Continue to ensure that potential workers are screened including doing criminal background checks; • Continued dyeing of SRL fuel to identify the culprits; • Ensure construction workers and contractors are always clearly identifiable by wearing proper uniforms displaying the logo of the construction company; • Ensure that SRL workers, contractors and security are always issued with identification tags; • Encourage workers to recognize and report suspicious activity and signs of burglary; • Develop and communicate crime prevention measures that employees can take; • Establish clear rules and regulations for access to the expansion site to control loitering; and • Encourage employees not to turn a blind eye to suspicious and / or prohibited behaviour.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
	Impact HS-2: Instances of drowning due to mine ponds, resulting in mental health stress on next of kin and the broader host community.	As for HS-1 above.	• SRL will continue to provide boat taxis to cross ponds to access agricultural fields and villages, and continue to ensure that all safety measures are adhered to; • SRL will continue to maintain bridges that give access to agricultural fields and villages; • Warning signs in Krio or English languages will be placed indicating the risk of drowning and incorporating clear imagery; • Should a drowning occur at an SRL site, SRL will investigate the incident, giving feedback to the next of kin and broader host community timeously and identify preventative measures for implementation; and • SRL will continue safety briefings at local schools and Court Barris.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
	Impact HS-3:	As for HS-1 above.	• Continue to enforce speed limits. Speed limits for both treated haul roads and unpaved roads are:	Compliance with GIIP standards and guidelines	EHS Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
	Increased vehicular traffic resulting in dust and noise.		○ 40 km/hr for haul trucks; ○ 60 km/hr for light vehicles; ○ 30 km/hr for all SRL vehicles through villages. • Enforcement of the speed limits will be implemented through a disciplinary process; • Regarding dust, refer to mitigation measures for Impact AQ-1 and Impact AQ-2; • Regarding noise, refer to mitigation measures for Impact N-1; and • A Grievance Management Procedure will be maintained to allow local people to report concerns relating to access and movement.	(WB / IFC EHS Guideline) as appropriate.	
	Impact HS-4: Altered movement patterns to access services, fields, natural resources and villages resulting in dissatisfaction and frustration.	As for HS-1 above.	• SRL will continue to provide a dedicated bus services to transport SRL personnel to the work; • Where possible, future operation and construction planning will include considerations regarding access and movement patterns before infrastructure is placed; • SRL will continue with provision of taxi boats, bridges and alternative roads; and • A Grievance Management Procedure will be implemented to allow local people to report concerns relating to access and movement.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
Population, political structures and organisations	Impact PP-1: Community disruption due to influx of non-local job seekers, employees and business owners.	To minimise and manage community disruption and pressure on services and infrastructure.	• A code of practice to guide the management and onsite behaviour of construction and operational teams will be prepared and implemented. The code will include terms relating to host community relations, culturally appropriate behaviour and conduct towards women specifically; • Procurement of goods and services will continue to be only done through a formal process; • The approach to recruitment as set out in the Issues and Responses Report (ESHIA, Appendix G) will be applied; • The recruitment process will be communicated to contractors and to host communities; • Host communities will be informed about the construction and operation timeframes and the Grievance Management Procedure; • Opportunities to educate and upskill local people to an employable level are being explored and will be implemented once a feasible option(s) had been identified; and • Regularly engagement, preferably monthly, will be undertaken with the Paramount Chiefs and other structures to manage and monitor influx and housing / site allocations.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
	Impact PP-2: Increased pressure on infrastructure and social services due to influx, impacting on quality of life.	As for PP-1 above.	• An Influx Management Plan will be developed and implemented in conjunction with relevant external stakeholders; • Construction accommodation will be provided on site for employees that do not come from the study area; • SRL will seek linkages with skills development programmes of the Department of Education, tertiary institutions and relevant Educational NGOs and consider investment aimed at improving skill levels in host communities; • SRL will link with government to discuss development requirements and the implementation thereof; and • Regularly engagement, preferably monthly, will be undertaken with the Paramount Chiefs to manage and monitor influx and housing / site allocations.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
Use of land and loss of access to resources	Impact LR-1: Loss of (or loss of access to) land, crops and livelihood resources in the expansion footprint areas due to mining activities.	To minimise and manage loss of land or access to as a result of mining activities. To enhance livelihood opportunities.	• GIIP RAP, inclusive of livelihood restoration measures will be designed and implemented; • Resolution of access issues will be done quickly where possible; • SRL will consider supporting an NGO to facilitate breeding cane rat (“cutting grass”) and rabbits (or similar small livestock as may be culturally appropriate), as sources of bush meat; • SRL will explore the implementation of improved / modernised fishing and aquaculture opportunities during operation and closure in co-operation with relevant NGO’s; • SRL will consider supporting the development of agricultural training courses in co-operation with relevant NGOs; • SRL will consider supporting an NGO to protect medicinal plants, setting up / supporting expansions where medicinal plants can be grown / sold / getting an NGO involved to possibly take some of the medicinal products into the western pharmaceutical market (if suitable); • SRL will consider hydroponic / aquaponic systems (either at household / village level) for improved crop yields as part of closure planning; and • The rehabilitation team will determine if it is possible to set up raffia palm groves.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
	Impact LR-2: Loss (or loss of access to) cultural resources and sites due to mining activities restricting / encompassing land.	As for LR-1 above.	• SRL will consult proactively with communities to identify culturally significant sites prior to accessing areas for future expansion; • Where possible, SRL will identify culturally significant sites; and where possible, ensure expansion infrastructure does not encroach on these sites; • Where site loss cannot be avoided, a culturally appropriate response will be negotiated; • Where loss of access occurs, provision of alternative access will be made a priority; • A Chance Finds Procedure will be developed and implemented to guide actions where cultural sites are discovered; • An archaeological / cultural heritage survey for areas to be disturbed will be conducted well ahead of mining; and	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
			• A Cultural Heritage Resources Management and Monitoring Plan will be developed and implemented.		
	Impact LR-3: Increase in fishing and aquaculture opportunities as a result of mine ponds (existing and non-rehabilitated).	As for LR-1 above.	• SRL will explore the implementation of improved / modernised fishing and aquaculture opportunities during operation and closure in co-operation with relevant NGOs; and • SRL will consider supporting the development of agricultural training courses in co-operation with relevant NGOs.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
	Impact LR-4: Perceived decrease in the quality of drinking water and perceived unsuitability of mine pond water for drinking, resulting in lack of access to drinking water.	As for LR-1 above.	• Awareness will be raised regarding the quality of the water, the causes of water of unacceptable quality and the characteristics of unsuitable water (colour, odour); and • Feedback will be provided regarding the reasons why wells are no longer being treated, and the alternatives should host communities wish to treat their own wells.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
	Impact LR-5: Increased access to domestic water due to existence of mine ponds.	As for LR-1 above.	• Consistent messages will be communicated regarding the use of mine ponds; • A policy / guideline will be developed for workers about what is expected of them as SRL workers, and the ways in which to handle situations where they observe ponds being used; and • It will be assessed whether it is possible to make water for domestic use available at dedicated points, without creating dependency.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
Economy, work and livelihoods	Impact EW-1: Contribution to national and regional economic growth due to investment.	To promote sustainable livelihoods.	• SRL will procure goods and services from local or national suppliers as far as possible; and • SRL will procure ancillary services for goods purchased overseas, such as installation, customisation and maintenance, from national companies as far as possible.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
	Impact EW-2: Increased government income due to payment of taxes and royalties.	N/A	N/A	N/A	N/A
	Impact EW-3: Continued employment and income opportunities as a result of ongoing and expanded operations at SRL.	As for EW-1 above.	• Fair access to information about jobs will be ensured through the local radio station, the CAD office, the CDC and Paramount Chiefs; • It will be ensured that access to jobs is transparent and in line with SRL's Human Resources and Anti-bribery and Corruption policies; • Awareness raising amongst employees and host communities about SRL's Anti-bribery and Corruption Policy will be continued; • Fair access to jobs through the SRL Local Employment Policy will be facilitated; • Job security will be promoted as per the SRL Local Employment Policy; • A Downscaling and Retrenchment Plan will be developed in conjunction with the Mine Closure Plan; and • Opportunities to educate and upskill local people to an employable level will be explored and will be implemented once a feasible option(s) had been identified.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
	Impact EW-4: Opportunities for local business due to procurement at SRL.	As for EW-1 above.	• SRL will procure locally wherever possible and formalise procurement approaches in policies and procedures; • Implementation of local recruitment will be monitored; • Incidences of corruption and nepotism will be monitored; • Appropriate business training will be facilitated and assistance provided where local response to procurement opportunities can be enhanced; • Fair access to information about tenders/opportunities will be ensured; and • Training of small and medium business enterprises will be supported.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
	Impact EW-5: Lease payment income for land owners as a result of mining activities.	As for EW-1 above.	• SRL will work with the land owners to assess the possibilities for enhancing the benefits of the income; and • SRL will discuss expectations and use of income for local infrastructure development and maintenance.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
Uses of and access to infrastructure and social services	Impact SS-1: Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL	To promote mobility and economic activity.	• Education will be provided to local business and government on the maintenance of roads provided by SRL; • SRL will continue to provide infrastructure maintenance for existing SRL infrastructure; and • Regular briefing sessions with relevant Paramount Chiefs and sectoral ministries represented by local government will be implemented. These meetings will clarify roles and responsibilities and SRL's role and contribution.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
	investment, resulting in better quality of life.				
Social divisions and vulnerable groups	Impact SD-1: Dissatisfaction over limited jobs due to high unemployment and poverty in the study area.	To manage host community perceptions and expectations regarding employment and provision of social services and infrastructure.	• Mitigation measures as described in Impact EW-1 will be implemented; • SRL will maintain regular communication with host communities and other stakeholders to minimise tensions relating to employment and project benefits; and • In consultation with the local leadership, SRL will implement measures to decrease the in-migration of potential job seekers into the area through the development and implementation an Influx Management Plan in conjunction with relevant external stakeholders.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD-2: Distrust in leadership due to corruption (or unfair advantage), or perceptions thereof.	As for SD-1 above.	• SRL's Anti-Bribery and Corruption Policy is will be adhered to and enforced; • SRL will continue to acknowledge and respect local customs, in accordance with SRL's Anti-Bribery and Corruption Policy; • SRL will continue to encourage stakeholders to report evidence regarding alleged bribery and corruption to SRL for investigation; • Recruitment and employment policies and practices will be clarified and elaborated upon during stakeholder engagement processes; • Compensation policies and practices will be clarified and elaborated upon during stakeholder engagement processes; • Fair access to information about jobs and compensation will be ensured; and • Adequate resources and capabilities in the CAD team will be ensured.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD3: Dissatisfaction over perceived procurement inequities.	As for SD-1 above.	• Mitigation measures as described in Impact EW-1 will be implemented.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD4: Dissatisfaction over perceived preferences in development investment and engagement.	As for SD-1 above.	• SRL will actively participate in the CDC, and mentoring and support for this initiative; • Participatory community development planning will be promoted and supported; • Adequate application and access to the Grievance Management Procedure as well as short response turnaround times will be ensured; • Joint social services and infrastructure expansions and programmes with NGOs will be pursued (with a focus on education); and • Information on development investments and activities, based on monitoring and evaluation results and reports, will be produced and disseminated.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD5: Disproportionate impacts on vulnerable groups due to their status in the host community / study area.	As for SD-1 above.	• Vulnerable groups and understanding the sources of marginalisation and disadvantage will be identified; and • Requirements to consider vulnerable groups in all mitigation measures and developmental activities will be included (the latter including recruitment, procurement, training and capacity building and stakeholder engagement).	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
General					
Pollution prevention and management (operational housekeeping)	Impact GEN-1: Soil and water contamination from day-to-day operational / housekeeping activities	Contamination prevention and management. Prevention of accidental spills or releases. Training and awareness. Monitoring.	SRL will implement general house-keeping / operational mitigation measures that will be appropriately implemented to avoid environmental and health impacts, including but not limited to: • Potentially hazardous materials / chemicals associated with the SR Area 1 activities will be idenitifed. A Chemical Mangemement Plan and Waste Mangement Plan have been developed and standard operating procedures (SOP) will be developed and implemented; • Review of all potential pollutants characteristics prior to introduction to site and establishment of proper storage, handling and transportation procedures; • Vehicles will be serviced at a dedicated workshop with suitable pollution control structures inplace, to prevent spillage and contamination with hydrocarbons; • Spill kits will be provided for on site for the cleaning of spills; • Spills will be cleared and remediated immediately; • SRL will maintain and regularly service all equipment so as to minimise the risks of hydrocarbon spills; • Regular cleaning and maintenance (good housekeeping) of vehicles will take place; • SDS for all contaminants on-site will be readily available. All appropriate PPE, handling and response procedures will also be identified in the SDS or otherwise recommended by the suppliers / manufacturers; • As part of the Chemical Management Plan and Emergency Response and Contingency Plan, procedures will be developed for: - Accidental spills or releases and countermeasures; - Fuel and bulk oil storage facilities; and - Accidental spills or releases from barges or boats.	Compliance with applicable Sierra Leonean legislative requirements. Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible party
			• A training and awareness programme will be developed and implemented to ensure that all the relevant staff, contractors and visitors have the necessary knowledge regarding contamination prevention and management at the SR Area 1. The training will include: - Chemical environmental and safety, spill response and first aid training; - Spill response training; and - Key personnel will be identified to receive hazard analysis training. • All high-risk spill hazards will be monitored on a frequency determined in the appropriate management procedures for the identified hazards. SRL will then include this monitoring into their auditing programs.		

Table 7-3: Expansion phase: Construction, initial operational and expansion of the Lanti and Gangama dry mining operations

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
Biophysical					
Air Quality	Impact AQ-5: Dust emissions during the expansion phase.	Reduce PM_{10} and $PM_{2.5}$ concentrations and dust fall below the WB /IFC Guideline values.	• See mitigation measures for Impact AQ-1 presented in Table 7-2 above; and • SRL will expand and implement routine emissions and ambient air quality monitoring program to determine whether there are any significant increases in emissions and impacts at sensitive receptors.	Continuation of dust monitoring; Compliance with WB / IFC EHS Guideline values.	Environment and Radiation Superintendent; Community and Rehabilitation Manager
	Impact AQ-6: Increased dust emissions due to ore transportation during the operational activities at Lanti and Gangama dry mining operations.	Reduce PM_{10} concentrations and dust fall below the WB / IFC Guideline values.	• See mitigation measures for Impact AQ-1 presented in Table 7-2 above.	Continuation of PM_{10} and dust monitoring; Compliance with WB / IFC EHS Guideline values.	Environment and Radiation Superintendent
Biodiversity: Aquatic resources	Impact BDA-4: Loss of habitat, biota and ecosystem services due to construction and operation activities associated with dry mining operations at Lanti and Ganagama.	Minimise impacts to aquatic ecosystems.	• Stream diversion structures will be as short as possible. In addition, stream diversion structures will be designed to ensure they are geomorphologically stable and are not prone to excessive erosion; • Clear separation of mine impacted and natural run-off water areas in as far as is practicable, so as to minimise the impact on water quality in the receiving environment (i.e. as per the SWMP, Section 7 of the specialist Surface Water study (Appendix G)); • Erosion management and sediment controls such as the use of rock packing, revegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps will be implemented as applicable from the outset of dry mining activities; and • Relevant stakeholders will be engaged with through existing forums to communicate schedules for the respective phases of the mine.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Biodiversity: Terrestrial resources	Impact BDT-3: Loss of faunal and floral habitat, species diversity and SCC caused the expansion activities associated with dry mining activities at Lanti and Gangama.	To minimise the important habitats and SCC. To maximise rehabilitation efforts to allow for the re-introduction of these species back into the Lease area.	• See mitigation measures for Impact BDT-1 presented in Table 7-2 above.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Biodiversity: Marine and Estuarine	Impact BDME-2: Fragmentation of habitats and alteration of ecosystem functioning.	Prevent destabilization of the estuarine and marine habitats. Manage discharge of water from mining activities into the estuary.	• Fresh water flow into each of the mangrove creeks will be maintained to at least 60% of the natural base flow, especially during the dry season; • Diversion channels and outlets will be designed and managed so as to allow migration of biota both upstream and downstream; and • Where possible, diversion channels that by-pass active mining pits and maintain the connection between estuarine and freshwater habitats will be created.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact BDME-3: Changes in the host community composition and distribution of estuarine biota.	As for BDME-2 above.	• As far as possible, the footprint of mining operations in estuarine habitat will be limited (channel and mangrove);; • Mined out areas will be rehabilitated once the operational phase has been completed, this will require infilling of mined out areas with overburden as far as possible, restoration of estuary channel profiles, removal of barriers to tidal flows and replanting of mangrove species in the affected areas; • Rehabilitation will be a fairly intensive and complex process with mangrove propagules having to be germinated and cared for in advance of the rehabilitation measures. Efforts will be made to plant the propagules in the same zonation bands commonly found in the surrounding mangrove regions; • *Rhizophora* spp. will be planted along the creek channels at the water edge in band approximately 5-10 m wide. Behind this band of *Rhizophora* spp., a mix of *Avicennia germinans* and *Laguncularia racemose* will be planted, with specimens of *Conocarpus erectus* and *Dodonaena viscosa* being planted along the landward margin of the rehabilitated areas; and • See mitigation measures for Impact BDME-2 presented immediately above (in Table 7-3).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact BDME-4: Impacts on livelihoods and/or loss or alteration of ecosystem services.	As for BDME-2 above.	• See mitigation measures for Impact BDME-1 presented above (in Table 7-2); • See mitigation measures for Impact BDME-2 presented above (in Table 7-3); and • See mitigation measures for Impact BDME-3 presented above (in Table 7-3).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Impact BDME-5: Direct loss of estuarine habitat and biota within the mining footprint.	As for BDME-2 above.	• See mitigation measures for Impact BDME-1 presented above (in Table 7-2); • See mitigation measures for Impact BDME-2 presented above (in Table 7-3); and • See mitigation measures for Impact BDME-3 presented above (in Table 7-3).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Soils and land capability	Impact S-1: Loss of utilisable resource (sterilisation and erosion), compaction, de-nutrification and contamination or salinization (dry mining).	To minimise the loss of utilisable soil resources (i.e. due to sterilisation, contamination, erosion, compaction and loss of nutrients and structure).	• See mitigation measures for Impact S-1 (Table 7-2).	Implementation of the Soil Management Plan. Compliance with GIIP standards and guidelines as appropriate. Erosion monitoring.	Environment and Radiation Superintendent Community and Rehabilitation Manager
Noise	Impact N-2: General rise in ambient noise levels due to construction and operation activities associated with dry mining at Lanti and Gangama.	To minimise disturbance from noise impacts.	• See mitigation measures for Impact N-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines as appropriate	Community and Rehabilitation Manager EHS Manager
	Impact N-3: General rise in ambient noise levels due to ore transportation.	As for N-1 above.	• A high level of vehicle maintenance, especially intake and exhaust mufflers, will be ensured; • Road alignments will be designed to minimise travel distances and eliminate unnecessary traffic; • Speed limits within the SR Area 1 will be adhered to for both treated haul roads and unpaved roads. Speed limits are: o 40km/hr for haul trucks; o 60 km/hr for light vehicles; and o 30 km/hr for all SRL vehicles through villages. • Host community members will be able to register their complaint / concern about noise through a complaints register. Complaints will be investigated and responded to as a matter of urgency and measures will be taken to minimise the noise if found to be related to SRL activities; • In high SRL noise generating areas (i.e. from ore transportation) consideration will be given to the construction of noise berms; and • Where possible, ore transportation activities will be restricted to 07h00 to 22h00.	Compliance with GIIP standards and guidelines as appropriate	Community and Rehabilitation Manager EHS Manager
Surface Water	The following surface water impacts have been listed in Table 7-2 above: Impact SWSS-1; Impact SWSS-2; Impact SWSS-3; Impact SWSS-4; Impact SWSS-5; Impact SWSS-6; Impact SWSS-7; Impact SWSS-8.	To manage surface water quality and quantity related issues.	See mitigation measures in Table 7-2 above for: • Impact SWSS-1; • Impact SWSS-2; • Impact SWSS-3; • Impact SWSS-4; • Impact SWSS-5; • Impact SWSS-6; • Impact SWSS-7; and • Impact SWSS-8.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Groundwater	Impact GW-14: Gbeni and Gangama dry mining dewatering leading to lowered groundwater levels.	To manage groundwater quality.	• Alternative water supplies will be provided where community boreholes in the immediate vicinity are not functional due to the dewatering; and • Rivers or surface water systems will be diverted away from the mining operations to prevent water loss to the mine workings.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact GW-15: Gangama dry mining groundwater ingress adjacent to the estuary.	To manage groundwater quality.	• The location of the Bullom sediments will be mapped in relation to the boundary of the Gangama orebody; and • If these strata cover a significant area that would be affected by mining, then alternative mining methods and environmental / community health and safety impact mitigation will be investigated.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Impact GW-16: Gbeni and Gangama dry mining hydrocarbons contaminating groundwater.	To manage groundwater quality.	• Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact GW-17: Gbeni and Gangama dry mining sulfide exposure contaminating groundwater (operational and decommissioning phase).	To manage groundwater quality.	• The orebody sulfide content beneath the groundwater surface will be established; • A review of the mineral separation process will be undertaken to confirm that the majority of the high sulfide material can be extracted for selective handling; and • Any high sulfide material will be deposited sub aqueously or rehabilitated in such a manner that it is isolated from the environment.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact GW-18: Gangama dry mining saline intrusion contaminating groundwater (operational and decommissioning phase).	To manage groundwater quality.	• The extent of the more permeable Bullom sediments will be defined as accurately as possible to identify areas of potential greater ingress; • If the Bullom strata areas are extensive then alternative mining methods to the current dry mining operations will be considered since excessive volumes of saline water might be generated; • Groundwater ingress is anticipated to be manageable where the orebody permeability is typically low. However, since the dewatered volume is likely to be saline, this will have to be passed through a settling pond to remove any suspended solids prior to discharge into the estuary. The discharged water quality will be monitored to ensure that it complies with legislation; • Any saline water will be kept separate from other fresh dewatering volumes which may be discharged to nearby freshwater streams, and • Rehabilitation will consider the extent of any saline intrusion and the impact that this may have on vegetation and the final land use in this area.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact GW-19: Gbeni and Gangama dry mining slope failure as a result of groundwater seepage.	To manage groundwater quality.	• Groundwater levels will be lowered as much as possible ahead of mining to reduce the risk of failure, and • Slopes of the dry mining operations will be reduced appropriately to minimize slope stability risks.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact GW-20: Gbeni and Gangama dry mining saturation due to groundwater ingress.	To manage groundwater quality.	• Surface water courses will be diverted away from the perimeter of the dry mining operations where possible to reduce water recirculation; • The mining operations surface will be shaped in such a manner as to promote rapid runoff with minimal infiltration; • High permeable zones will be identified prior to the advance of mining particularly any occurrence of Bullom sediments; • Dewatering trenches, sumps and pumping equipment will be sized correctly to cater for any sudden ingress, and • Dewatering will occur ahead of mining to ensure that the groundwater levels have been lowered sufficiently to increase the margin of safety.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
	Impact GW-21: Suspended solids from the Gbeni and Gangama dry mining dewatering volumes contaminating surface water.	To manage groundwater quality.	The dewatering volumes will be pumped into a settling pond or wetland so that the water quality can be improved prior to the discharge to the surface water systems.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Radiation	Impact RI-1: Impact on social and biophysical receiving environments based on radiation exposure.	To manage potential radiation related issues.	• See mitigation measures for Impact RI-1 presented in Table 7-2 above.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate.	Environment and Radiation Superintendent
Health					
Communicable diseases	Impact H-1: Transmission of communicable diseases from workforce to the host community due to influx and general hygiene.	To educate, minimise and manage the spread of diseases.	• See mitigation measures for Impact H-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Disease associated with malaria	Impact H-2:	As for H-1 above.	• See mitigation measures for Impact H-2 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB	EHS Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Increased burden of disease associated with malaria due to modification of the environment (including current mining activities such as mine dredge ponds and in-migration of work-seekers).			/ IFC EHS Guideline, WHO) as appropriate.	
Arbo-viral diseases (e.g. Yellow Fever)	Impact H-3: Risk of outbreak of arbo-viral diseases due to influx and opening of transport corridors.	As for H-1 above.	• See mitigation measures for Impact H-3 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Limited water, sanitation and waste management services	Impact H-4: Effects on human health as a result of changes in the biophysical environment incurred by current and future mining activities.	As for H-1 above.	• See mitigation measures for Impact H-4 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Sexually-transmitted diseases	Impact H-5: Increased risk of sexually-transmitted diseases and high risk sexual practices due to current and future mining activities.	As for H-1 above.	• See mitigation measures for Impact H-5 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Malnutrition	Impact H-6: Food and nutrition-related issues due to influx and land use change.	As for H-1 above.	• See mitigation measures for Impact H-6 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Non-communicable diseases	Impact H-7: Increase in non-communicable diseases as a result of life style and demographic changes.	As for H-1 above.	• See mitigation measures for Impact H-7 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Hygiene	Impact H-8: Emergence and spread of veterinary medicine and Zoonotic diseases due to inadequate camp and waste facilities.	As for H-1 above.	• See mitigation measures for Impact H-8 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Cultural health practices	Impact H-9: Influence on cultural health practices due to influx and pressure on limited available health services.	As for H-1 above.	• See mitigation measures for Impact H-9 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline, WHO) as appropriate.	EHS Manager
Socio-economic					
Health and safety	Impact HS-1: Increased crime as a result of the influx of job seekers, employees and business owners.	To minimise and manage health and safety related impacts.	• See mitigation measures for Impact HS-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
	Impact HS-2:	As for HS-1 above.	• See mitigation measures for Impact HS-2 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB	EHS Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Instances of drowning due to mine ponds, resulting in mental health stress on next of kin and the broader host community.			/ IFC EHS Guideline) as appropriate.	
	Impact HS-3: Increased vehicular traffic resulting in dust and noise.	As for HS-1 above.	• See mitigation measures for Impact HS-3 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
	Impact HS-4: Altered movement patterns to access services, fields, natural resources and villages resulting in dissatisfaction and frustration.	As for HS-1 above.	• See mitigation measures for Impact HS-4 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
Population, political structures and organisations	Impact PP-1: Host community disruption due to influx of non-local job seekers, employees and business owners.	To minimise and manage host community disruption and pressure on services and infrastructure.	• See mitigation measures for Impact PP-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
	Impact PP-2: Increased pressure on infrastructure and social services due to influx, impacting on quality of life.	As for PP-1 above.	• See mitigation measures for Impact PP-2 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager
Use of land and loss of access to resources	Impact LR-1: Loss of (or loss of access to) land, crops and livelihood resources in the expansion footprint areas due to mining activities.	To minimise and manage loss of land or access to as a result of mining activities.	• See mitigation measures for Impact LR-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
	Impact LR-2: Loss (or loss of access to) cultural resources and sites due to mining activities restricting / encompassing land.	As for LR-1 above.	• See mitigation measures for Impact LR-2 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
	Impact LR-3: Increase in fishing and aquaculture opportunities as a result of mine ponds (existing and non-rehabilitated).	As for LR-1 above.	• See mitigation measures for Impact LR-3 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
	Impact LR-4: Perceived decrease in the quality of drinking water and perceived unsuitability of mine pond water for drinking, resulting in lack of access to drinking water.	As for LR-1 above.	• See mitigation measures for Impact LR-4 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Impact LR-5: Increased access to domestic water due to existence of mine ponds.	As for LR-1 above.	• See mitigation measures for Impact LR-5 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Community and Rehabilitation Manager Resettlement Manager
Economy, work and livelihoods	Impact EW-1: Contribution to national and regional economic growth due to investment.	To promote sustainable livelihoods.	• See mitigation measures for Impact EW-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
	Impact EW-2: Increased government income due to payment of taxes and royalties.	N/A	• N/A	N/A	N/A
	Impact EW-3: Continued employment and income opportunities as a result of ongoing and expanded operations at SRL.	As for EW-1 above.	• See mitigation measures for Impact EW-3 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
	Impact EW-4: Opportunities for local business due to procurement at SRL.	As for EW-1 above.	• See mitigation measures for Impact EW-4 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
	Impact EW-5: Lease payment income for land owners as a result of mining activities.	As for EW-1 above.	• See mitigation measures for Impact EW-5 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
Uses of and access to infrastructure and social services	Impact SS-1: Improved infrastructure where provided by SRL (roads, water, sanitation etc.) due to SRL investment, resulting in better quality of life.	To promote mobility and economic activity.	• See mitigation measures for Impact SS-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager
Social divisions and vulnerable groups	Impact SD-1: Dissatisfaction over limited jobs due to high unemployment and poverty in the study area.	To manage community perceptions and expectations regarding employment and provision of social services and infrastructure.	• See mitigation measures for Impact SD-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD-2: Distrust in leadership due to corruption (or unfair advantage), or perceptions thereof.	As for SD-1 above.	• See mitigation measures for Impact SD-2 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD3: Dissatisfaction over perceived procurement inequities.	As for SD-1 above.	• See mitigation measures for Impact SD-3 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
	Impact SD4: Dissatisfaction over perceived preferences in development investment and engagement.	As for SD-1 above.	• See mitigation measures for Impact SD-4 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager

Aspect	Impact	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Impact SD5: Disproportionate impacts on vulnerable groups due to their status in the host community / study area.	As for SD-1 above.	• See mitigation measures for Impact LR-1 presented in Table 7-2 above.	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	Community and Rehabilitation Manager Resettlement Manager
General					
Pollution prevention and management (operational housekeeping)	Impact GEN-1: Soil and water contamination from day-to-day operational / housekeeping activities	Contamination prevention and management Prevention of accidental spills or releases Training and awareness Monitoring	Refer to Impact GEN-1 in Table 7.2 above.	Compliance with applicable Sierra Leonean legislative requirements. Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Environment and Radiation Superintendent

Table 7-4: Decommissioning / Closure Phase / Post Closure Phase

Aspect	Impact / Activity	Management Objective	Mitigation Measures	Performance criteria	Responsible person
Biophysical					
Air Quality	Impact AQ-7: Impact of dust and gas emissions during the Decommissioning and Closure Phase.	To manage the major dust and gas emission generating sources during the decommissioning and closure phases (e.g. windblown dust from open and bare areas, materials handling and vehicle entrainment of dust).	• During the closure and decommissioning phase, mitigation measures as presented for Impact AQ-1, AQ-2, AQ-3 and AQ-4 in Table 7-2 will be implemented as applicable; and • The routine emissions and ambient air quality monitoring program will continue to be implemented during the decommissioning and closure phases.	Continuation of dust monitoring. Compliance with WB / IFC EHS Guideline values. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact AQ-8: Impact of dust and gas emissions during the Post Closure Phase.	As for Impact AQ-7 above.	• Monitoring and maintenance procedures will continue in order to ensure rehabilitation measures have been implemented adequately.	Continuation of dust monitoring. Compliance with WB / IFC EHS Guideline values. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
Biodiversity: Aquatic resources	Impact BDA-5: Loss of habitat, biota and ecosystem services due to lowering of dredge ponds during decommissioning / closure and rehabilitation.	Minimise impacts to aquatic ecosystems during decommissioning, closure and post closure.	• Dredge pond walls will be systematically lowered to allow regulated decant (downstream flow) and reduction of water levels in the dredge pond. Sloping and rehabilitation of dredge pond walls will be performed in such a manner so as not to compromise wall stability; • An AIPCP will be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the decommissioning process (particularly on barren dredge pond sediment / wall areas after lowering of dredge pond decant); • Rehabilitation will be undertaken as per the Mine Closure Plan (Appendix L4); and • Erosion management and sediment controls will be undertaken as per the relevant measures stipulated for the surface water –SWMP, Section 7 of the specialist Surface Water study (Appendix G).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact BDA-6: Loss of habitat, biota and ecosystem services due to decommissioning of plant and unneeded haul roads.	As for BDA-5 above.	• Decommissioning of plant and infrastructure will be undertaken as per the Mine Closure Plan (Appendix L4); and • Erosion management and sediment controls will be undertaken as per the relevant measures stipulated for the surface water – SWMP, Section 7 of the specialist Surface Water study (Appendix G).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact BDA-7: Loss of habitat, biota and ecosystem services due to earthworks associated with rehabilitation efforts.	As for BDA-5 above.	• Earthworks associated with closure and rehabilitation will be undertaken as per the Mine Closure Plan (Appendix L4); • Replacement of topsoil and revegetation must be undertaken as guided by the Mine Closure Plan; • An AIPCP will be implemented, as encroachment of alien vegetation is expected to increase as a result of the disturbances resulting during the decommissioning process; • Erosion management and sediment controls will be undertaken as per the relevant measures stipulated for the surface water – SWMP, Section 7 of the specialist Surface Water study (Appendix G); and • Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact BDA-8: Loss of habitat, biota and ecosystem services due to lowering of dredge pond decant post closure.	As for BDA-5 above.	• Continued rehabilitation of disturbed areas post closure, clearing alien vegetation and utilising indigenous wetland vegetation species, will assist in retaining essential wetland ecological services, particularly flood attenuation, sediment trapping and erosion control, and assimilation of nutrients and toxicants; and • Water resources will be monitored for potential contaminants of concern as well as Diatom community monitoring during the post closure/latent phase (see monitoring recommendations in Section 8).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact BDA-9: Loss of habitat, biota and ecosystem services due to dry latent impacts of decommissioned plant and haul road.	N/A	N/A [Note: No latent impacts from these areas are deemed likely. As such, no assessment table has been presented for this impact.]	N/A	N/A

Aspect	Impact / Activity	Management Objective	Mitigation Measures	Performance criteria	Responsible person
Biodiversity: Terrestrial resources	Impact BDT-4: Loss of faunal and floral habitat, species diversity and SCC due to lowering of dredge pond decants.	To minimise impacts to important habitats and SCC during decommissioning and to maximise rehabilitation effectiveness.	• Footprint will be kept as small as possible; • Rehabilitation of exposed areas will be carried out as per the Mine Closure Plan (Appendix L4); • It will be ensured that decant water will not be released into existing terrestrial habitat areas; • Throughout the decommissioning and closure phase, management and control of alien plant species will be exercised. For this, an AIPCP will be developed and implemented; and • Care will be taken when rehabilitation activities need to be performed within the watercourses as these areas are sensitive to disturbance.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact BDT-5: Loss of faunal and floral habitat, species diversity and SCC due to decommissioning/ rehabilitation of active dry mining areas, plant and haul roads.	As for BDT-4 above.	• Decommissioning and rehabilitation footprints will be minimised; • Demolition of plant will be performed in a manner that building materials can be salvaged for use by the host community; • Replacement of topsoil and revegetation will be undertaken as guided by the Mine Closure Plan (Appendix L4); • All waste materials that cannot be recycled must be effectively removed and discarded in a safe and legal manner (i.e. as per the Waste Management Plan); • Compacted haul roads will be rehabilitated as per the Mine Closure Plan (Appendix L4); • Throughout the decommissioning and closure phase, management and control of alien plant species will be exercised. For this, an AIPCP will be developed and implemented; and • Erosion management and sediment controls will be undertaken as per the relevant measures stipulated for the surface water – SWMP, Section 7 of the specialist Surface Water study (Appendix G).	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
	Impact BDT-6: Loss of faunal and floral habitat, species diversity and SCC due to inefficient rehabilitation and alien and invasive plant proliferation.	As for BDT-4 above.	• Continued rehabilitation of disturbed areas post closure, clearing alien vegetation and utilising indigenous floral species, will assist in reinstating essential ecological functioning as part of the faunal and floral habitat; and • Progress of vegetation regrowth, as well as level of faunal and floral abundance and diversity increases within these areas will be monitored.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent
Biodiversity: Marine and Estuarine	[Note: Impacts on marine and estuarine resources during the decommissioning and closure phase were not assessed as part of the specialist study. Decommissioning and closure of all mining activities are addressed in the Mine Closure Plan (Appendix L4).]	N/A	N/A	N/A	N/A
Soils and land capability	Impact S-2: Net loss of soil volumes and utilisation potential due to change in material status (physical and chemical) and loss of nutrient base.	To minimise the loss of utilisable soil resources (i.e. due to sterilisation, contamination, erosion, compaction and loss of nutrients and structure).	• Replacement of soils and concurrent rehabilitation will be undertaken timeously where possible as per the Soil Management Plan, Section 6 of the specialist Soils and Land Capability Study (Appendix K); • Reduction in area of impact, restriction on vehicle and animal movement over rehabilitated lands and maintenance of restored vegetation (monitoring etc.) will be ensured; • Dust and erosion by overland flow on unprotected areas will be minimised (see air and surface water management measures); • Soil testing of rehabilitated areas will be undertaken. If testing of the soils replaced indicates nutrient deficiencies, then consideration will be given to enhancing fertility (e.g. through the use of leguminous species, microbe inoculation, fertilizers / soil improvers); • The Mine Closure Plan (Appendix L4) will support the project as and when appropriate; and • Pollution control measures to implemented (see Impact GEN-1 Table 7.2).	Monitor against the Soil Management Plan. Compliance with GIIP standards and guidelines as appropriate. Erosion monitoring. Monitor against Mine Closure Plan.	Environment and Radiation Superintendent Community and Rehabilitation Manager
Noise	Noise in the decommissioning phase will be of a similar nature, but of a lower intensity and of shorter duration than noise in the construction phase. Decommissioning noise will not be audible at the nearest receptors and the noise impact will be negligible. Post closure, no residual noise impacts will remain after decommissioning of SR Area 1 operations.	N/A	N/A	N/A	N/A

Aspect	Impact / Activity	Management Objective	Mitigation Measures	Performance criteria	Responsible person
Surface Water	The following surface water impacts have been listed in Table 7-2 above: Impact SWSS-1; Impact SWSS-2; Impact SWSS-3; Impact SWSS-5; Impact SWSS-6; Impact SWSS-7; Impact SWSS-8.	To manage surface water quality and quantity related issues during decommissioning, closure and post closure.	Closure and post closure mitigation and management measures will be as per the Mine Closure Plan (Appendix L4).	Water monitoring programme. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent Community and Rehabilitation Manager
	Impact SWSS-4: Dam walls being overtopped or failing as a result of freeboard requirements not being sufficient and a large flood event occurs.	To manage surface water quality and quantity related issues during decommissioning, closure and post closure.	• The dam walls will either be removed or reduced in their height. This is addressed in the Mine Closure Plan (Appendix L4); • Once the above is confirmed, dam break scenarios for the remaining dam walls will be undertaken; • Regular dam safety inspections will be conducted and included as part of the Mine Closure Plan; • The water balance will be updated to inform potential overtopping within certain allowable confidence levels; and • The spillways of the dams will, once again, need to be accurately sized so that the water levels do not build up to the level where the 0.8 m of freeboard in these dams is ever compromised.	Water monitoring programme. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent Community and Rehabilitation Manager
Groundwater	Impact GW-22: Lowered historical mining pond levels may reduce the available drawdown in community boreholes.	To manage groundwater availability to host communicates.	An alternative water supply will be provided if community boreholes in the immediate vicinity no longer functional.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
	Impact GW-23: Lowered historical mining pond levels may expose sulfides leading to groundwater acidification.	To manage groundwater quality.	SRL will sample for sulfides and rehabilitate potentially acid generating material or dispose of sub aqueously beneath a permanent water level elevation.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
	Impact GW-24: Decommissioning the MSP tailings and dams will lower groundwater levels beneath the tailings disposal area.	To manage groundwater quality.	Appropriate rehabilitation of the processed tailings area will be implemented.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
	Impact GW-25: Lowered Lanti mining pond levels may reduce the available drawdown in community boreholes.	To manage groundwater availability to host communicates.	An alternative water supply will be provided if community boreholes in the immediate vicinity no longer functional.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
	Impact GW-26: Lowered Lanti mining pond level may expose sulfides leading to groundwater acidification.	To manage groundwater quality.	SRL will sample for sulfides and rehabilitate potentially acid generating material or dispose of sub aqueously beneath a permanent water level elevation.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
	Impact GW-27: Gbeni and Gangama dry mining groundwater gradients recover post mining.	To manage groundwater quality and quantity.	The rehabilitated topography will mimic pre-mining conditions and diverted rivers will be reinstated.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent

Aspect	Impact / Activity	Management Objective	Mitigation Measures	Performance criteria	Responsible person
	Impact GW-28: Lowered historical mining pond levels altering groundwater baseflow distribution to surface water systems.	To manage groundwater quality and quantity.	No mitigation measures are proposed for this impact.	Monitoring programme. Compliance with GIIP standards and guidelines as appropriate. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
Radiation	Impact RI-1: Impact on social and biophysical receiving environments based on radiation exposure.	To manage potential radiation related issues during decommissioning, closure and post closure.	• The Radiation Management Plan to be implemented for the operational and expansion phases (see Impact RI-1 in Table 7.2) will be further updated to include the decommissioning, closure and post closure phases of the project.	Water monitoring programme. Monitor against the Mine Closure Plan.	Environment and Radiation Superintendent
Health					
Communicable diseases Disease associated with malaria Arbo-viral diseases (e.g. Yellow Fever) Sanitation and waste management services Sexually-transmitted diseases Malnutrition Non-communicable diseases Hygiene Cultural health practices	The following impacts are included in Table 7-2 Impact H-1; Impact H-2; Impact H-3; Impact H-4; Impact H-5; Impact H-6; Impact H-7; Impact H-8; Impact H-9.	To educate, minimise and manage the spread of diseases.	• A host community health monitoring system will be developed and implemented; • A social monitoring system will be developed and implemented; and Closure and post closure mitigation and management measures will be as per the Mine Closure Plan (Appendix L4).	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate. Monitor against the Mine Closure Plan.	EHS Manager
Socio-economic					
Health and safety Population, political structures and organisations Use of land and loss of access to resources Economy, work and livelihoods Uses of and access to infrastructure and social services Social divisions and vulnerable groups	The following impacts are included in Table 7-2: Impacts HS-1 to HS-4: Impacts PP-1 to PP-2; Impacts LR-1 to LR-5; Impacts EW-1 to EW-5; Impact SS-1; Impacts SD-1 to SD-5.	To minimise and manage socio-economic issues during decommissioning, closure and post closure.	• A social closure risk and impact assessment will be undertaken, and updated in preparation for closure, inclusive of pre-closure measures to minimise the impact of job losses at mine closure; • Business, life skills and investment training in the context of the in-house training programme will be implemented. Training will be linked to counselling regarding the LoM and the implications of decommissioning and closure; • Investment and money management counselling for employees will be provided; • Proactive planning for closure consequences and timely advice to current employees; Implementation of business, life skills and investment training in the context of the in-house training programme; and • Closure and post closure mitigation and management measures will be as per the Mine Closure Plan (Appendix L4).	Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate. Monitor against the Mine Closure Plan.	EHS Manager
General					
Pollution prevention and management (operational housekeeping)	Impact GEN-1: Soil and water contamination from day-to-day operational / housekeeping activities	Contamination prevention and management Prevention of accidental spills or releases Training and awareness Monitoring	• Refer to Impact GEN-1 in Table 7.2 above.	Compliance with applicable Sierra Leonean legislative requirements. Compliance with GIIP standards and guidelines (WB / IFC EHS Guideline) as appropriate.	EHS Manager Environment and Radiation Superintendent

7.5 Checking and Corrective Actions

Checking and, if necessary implementing corrective action, a key component of the ESHMP management cycle. They ensure that the:

- Required ESHMP management activities are being implemented; and
- Desired outcomes are being achieved.

7.5.1 Inspections

An ongoing, but pragmatic inspection regime will be developed that allows for potential environmental and social transgressions to be identified proactively so that mitigation can be quickly and effectively implemented.

7.5.2 Internal and external audits

Where the monitoring data and the inspection reports highlight problems, an internal audit will be used by SRL to ascertain the source of the problem and to define action to prevent its recurrence. The three key areas for audit are:

1) Facilities (i.e. are they operating properly);
2) Project procedures (i.e. are they approporailty designed and implemented); and
3) Contractor's environmental and safety performance.

The SRL auditing regime will, as a minimum, address the requirements of EPA-SL as well as regular audits of the ESHMP implementation.

Environmental audits will be aligned with SRL's auditing procedures and timetable which will fall under the auspices of the discipline leads and in line with the management system and legal compliance criteria. SRL will commit to a rolling program (at defined intervals) of audits focussing on key risk areas in the management system. Furthermore, external governance audits will undertaken per discipline against agreed audit protocols, every five years.

7.5.3 Corrective action

There are several mechanisms for implementing corrective action, including:

- Verbal instruction (in the event of minor transgressions from established procedure, usually following a site inspection);
- Written instruction (identifying source/s of problems, usually following an audit);
- Contract notice (following possible breach of contract).

7.5.4 Reporting

Audit findings will be structured into instructive reporting that provides information to all required parties on environmental, social and health performance, together with clearly defined corrective action where this is seen to be required. Both the monitoring and inspections will be reported on continuously. Within the reporting structure a review function will be created that continuously assesses the reporting and prescribes any necessary corrective action. Reporting will include the provision of information on the environmental, social and health performance to external stakeholders and host communities at an approiate level of detail.

7.5.5 Management review

SRL will undertake a formal management review of the ESHMP at defined intervals. The purpose of the management review is for management to review the environmental and social management performance during the preceding period and to propose measures for improving that performance in the spirit of continuous improvement.

7.5.6 Liaison

Throughout the project, ongoing liaison will be maintained with authorities and host communities alike to ensure the following:

- Timeous advance warning of any project activities that may have some adverse impact on host communities; and
- Ongoing feedback on the environmental, social and health performance of the project.

8 Environmental and social monitoring

Table 8-1 describes the proposed plan for assessing the effectiveness of environmental, social and health control measures set forth in the ESHMP (Section 7).

Table 8-1: Monitoring plan

<table>
<tr><th>Monitoring and inspection methodology</th><th>Inspection frequency</th><th>Location of monitoring stations</th><th>Reporting schedules</th><th>Technical team requirements</th></tr>
<tr><td colspan="5">Air Quality</td></tr>
<tr>
<td>Essential monitoring requirements:
○ Dust fallout monitoring involving: installation of dust monitors; preparation of sample containers for dust monitoring; sample collection; site records; and sample handling.
○ PM monitoring will involve: maintenance; data download; data storage.
○ Weather station monitoring involving: maintenance; and data download.
○ Gas monitoring requiring the preparation of Radiello badges.</td>
<td><u>Dust fallout monitoring:</u>
Sampling period will be monthly, using the schedule presented in Appendix D of the Air Quality Study.

<u>PM monitoring:</u>
The hourly results obtained from the PM monitors will be downloaded on a monthly basis for storage and interpretation.

<u>Weather station monitoring:</u>
The weather results obtained from the weather stations will be downloaded on a monthly basis for storage and interpretation.

<u>Gas monitoring:</u>
The gas sampling will be undertaken on a quarterly basis.</td>
<td>
Sampling locations for dust and gas monitoring
<table>
<tr><th>Field ID</th><th>Village/Area</th><th colspan="2">Co-ordinates UTM</th></tr>
<tr><td>SRLDM011</td><td>Gangama MD2</td><td>7° 43' 31.069" N</td><td>12° 21' 7.310" W</td></tr>
<tr><td>SRLDM02</td><td>Semabu Village</td><td>7° 44' 54.771" N</td><td>12° 21' 12.658" W</td></tr>
<tr><td>SRLDM/GM03</td><td>Lanti MD 1</td><td>7° 40' 39.881" N</td><td>12° 18' 18.092" W</td></tr>
<tr><td>SRLDM</td><td>Mukaba Village</td><td>7° 46' 13.449" N</td><td>12° 14' 21.871" W</td></tr>
<tr><td>SRLDM/GM05</td><td>SRL Nitti Port</td><td>7° 46' 20.054" N</td><td>12° 23' 53.905" W</td></tr>
<tr><td>SRLDM06</td><td>Mogbwemo Village</td><td>7° 45' 46.832" N</td><td>12° 18' 18.559" W</td></tr>
<tr><td>SRLDM/GM07</td><td>Matagelema Village</td><td>7° 48' 55.998" N</td><td>12° 17' 34.032" W</td></tr>
<tr><td>SRLDM08</td><td>Moriba Town Police Station</td><td>7° 46' 37.929" N</td><td>12° 17' 46.922" W</td></tr>
<tr><td>SRLDM09</td><td>Yangatoke Village</td><td>7° 40' 18.152" N</td><td>12° 16' 40.179" W</td></tr>
<tr><td>SRLDM10/GM10</td><td>Plant Site MSP</td><td>7° 45' 52.409" N</td><td>12° 17' 34.885" W</td></tr>
<tr><td>SRLGM11</td><td>Plant Site Admin</td><td>7° 45' 54.499" N</td><td>12° 17' 41.199" W</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>
Sampling locations for PM monitors and weather stations
<table>
<tr><th>Field ID</th><th>Village</th><th colspan="2">Co-ordinates UTM</th></tr>
<tr><td>SRLPM10</td><td>Plant Site Admin</td><td>7° 45' 54.499" N</td><td>12° 17' 41.199" W</td></tr>
<tr><td>SRLPM2.5</td><td>Plant Site Admin</td><td>7° 45' 54.499" N</td><td>12° 17' 41.199" W</td></tr>
<tr><td>SRLWS001</td><td>Plant Site Admin</td><td>7° 45' 54.499" N</td><td>12° 17' 41.199" W</td></tr>
<tr><td>SRLWS002</td><td>Lanti MD 1</td><td>7° 40' 39.881" N</td><td>12° 18' 18.092" W</td></tr>
<tr><td>SRLWS003</td><td>SRL Nitti Port</td><td>7° 46' 20.054" N</td><td>12° 23' 53.905" W</td></tr>
<tr><td>SRLWS004</td><td>Gangama MD2</td><td>7° 43' 31.069" N</td><td>12° 21' 7.310" W</td></tr>
</table>
</td>
<td>Reporting should follow after dust, PM and gas monitoring has taken place, i.e. quarterly.</td>
<td>Suitably skilled and trained air quality personnel to undertake maintenance schedules, monitoring programs and reporting.</td>
</tr>
<tr><td colspan="5">Biodiversity</td></tr>
<tr><td colspan="5">Aquatic biodiversity monitoring</td></tr>
<tr>
<td>Essential monitoring requirements:
• <u>Visual assessment:</u>
To identify visible impacts, with specific reference to impacts from surrounding activities and any effects resulting from activities occurring upstream in the catchment. Factors to be noted during site specific visual assessments should include: stream morphology; instream and riparian habitat</td>
<td><u>Water quality monitoring:</u>
Monthly during the operational and decommissioning/closure and rehabilitation phases for limited parameters (SRL laboratory), quarterly external monitoring, and</td>
<td>
The positions of the aquatic ecological assessment sites are as follows:
<table>
<tr><td>SR1</td><td>7°44'27.52"N</td><td>12°21'46.41"W</td></tr>
<tr><td>SR3</td><td>7°45'50.36"N</td><td>12°19'27.54"W</td></tr>
<tr><td>SR4</td><td>7°44'12.81"N</td><td>12°13'34.82"W</td></tr>
<tr><td>SR5</td><td>7°39'55.46"N</td><td>12°14'32.94"W</td></tr>
</table>
</td>
<td>Reporting should follow after diatom and macro-invertebrate monitoring has taken place.</td>
<td>Monitoring field work must be undertaken by appropriately qualified and skilled personnel</td>
</tr>
</table>

<table>
<tr><th>Monitoring and inspection methodology</th><th>Inspection frequency</th><th>Location of monitoring stations</th><th>Reporting schedules</th><th>Technical team requirements</th></tr>
<tr><td>diversity; stream continuity; erosion potential; depth flow and substrate characteristics; signs of physical disturbance and pollution of the area; and other life forms reliant on aquatic ecosystems.
• <u>Water quality (physico-chemical water quality data):</u>
Monitoring of biota specific water quality variables (Electrical Conductivity, Dissolved Oxygen, pH and temperature parameters). On-site testing of biota specific water quality variables will take place.
• <u>Diatom community integrity:</u>
Assessment of diatom community integrity in the aquatic systems receiving dredge pond decant, as well as appropriate reference sites. Diatoms are used as indicators of river and wetland health as they provide a rapid response to specific physico-chemical conditions in the water and are often the first indication of change.
• <u>Macro-invertebrate community integrity:</u>
Assessment of macro-invertebrate community integrity in the aquatic systems receiving dredge pond decant, as well as at least one appropriate reference site using the South African Scoring System (SASS5) method designed to comply with international accreditation protocols. All work is to be done by an accredited SASS5 practitioner
Spatial and temporal trends in data must be monitored.</td><td>quarterly during the post-closure phase.
<u>Diatom community integrity monitoring:</u>
Annual basis to monitor the integrity of the instream community.
<u>Macro-invertebrate community integrity monitoring:</u>
Recommended to be performed on an annual basis.</td><td></td><td></td><td>and the data analyses and reporting must be undertaken by an appropriately qualified aquatic ecologist.</td></tr>
<tr><td colspan="5">Biodiversity – terrestrial resources</td></tr>
<tr><td>Vegetation data will be collected according to the methods set out in the baseline ecological assessments. These censuses are to be conducted within each habitat unit in order to ascertain habitat utilization, species diversity as well as the overall abundance of mammal species within SR Area 1.</td><td><u>Terrestrial biodiversity monitoring:</u>
Annual (alternating between wet and dry seasons).</td><td>Monitoring stations should be located outside of the active mining areas, so as to ensure year on year repeatability of the station. Stations will only be relocated when the mine layout changes.</td><td>Annually alternating between wet and dry seasons.</td><td>Monitoring field work must be undertaken by an appropriately qualified and skilled personnel and the data analyses and reporting must be undertaken by an appropriately qualified terrestrial ecologist.</td></tr>
<tr><td colspan="5">Biodiversity – estuarine and marine</td></tr>
<tr><td>Conduct long-term monitoring of components of the estuarine environment downstream of the Area 1 at 9 monitoring stations set out in the estuarine impact assessment report. At each station the following should be monitored:
• Water quality
• Sediment quality
• Macro benthos
• Biomonitoring
Map the extent of the mangroves using remote sensing data (Landsat) every 3-5 years to quantify any changes in the spatial area of mangrove vegetation. Undertake baseline transects in the dry season as necessary to verify findings.
The implementation of an ongoing artisanal fishery monitoring programme should also be investigated in collaboration with the Sierra Leone Government.</td><td><u>Estuarine & marine biodiversity monitoring:</u>
Monitoring every 2 to 3 years.
Mangrove mapping every 3-5 years.</td><td>
<table>
<tr><th>Site</th><th>Latitude (DMS)</th><th>Longitude (DMS)</th></tr>
<tr><td>B3</td><td>7° 44' 39.721" N</td><td>12° 30' 19.800" W</td></tr>
<tr><td>G1</td><td>7° 45' 8.773" N</td><td>12° 22' 50.520" W</td></tr>
<tr><td>G4</td><td>7° 45' 49.799" N</td><td>12° 24' 18.000" W</td></tr>
<tr><td>G5</td><td>7° 45' 49.680" N</td><td>12° 25' 35.400" W</td></tr>
<tr><td>K1</td><td>7° 42' 59.080" N</td><td>12° 21' 41.040" W</td></tr>
<tr><td>K3</td><td>7° 43' 43.075" N</td><td>12° 23' 32.640" W</td></tr>
<tr><td>K5</td><td>7° 44' 34.440" N</td><td>12° 26' 7.800" W</td></tr>
<tr><td>M1</td><td>7° 41' 37.561" N</td><td>12° 25' 38.280" W</td></tr>
<tr><td>M3</td><td>7° 40' 37.499" N</td><td>12° 27' 32.040" W</td></tr>
<tr><td>M5</td><td>7° 38' 21.840" N</td><td>12° 29' 54.600" W</td></tr>
<tr><td>T3</td><td>7° 36' 43.996" N</td><td>12° 21' 41.400" W</td></tr>
<tr><td>T1</td><td>7° 38' 42.360" N</td><td>12° 19' 53.400" W</td></tr>
<tr><td>Niti Port</td><td>7° 46' 22.080" N</td><td>12° 23' 56.760" W</td></tr>
</table>
</td><td>Reporting post monitoring</td><td>Monitoring field work must be undertaken by appropriately qualified and skilled personnel and the data analyses and reporting must be undertaken by an appropriately qualified marine / estuarine ecologist</td></tr>
</table>

<table>
<tr><th>Monitoring and inspection methodology</th><th>Inspection frequency</th><th>Location of monitoring stations</th><th>Reporting schedules</th><th>Technical team requirements</th></tr>
<tr><td colspan="5">Soil and land capability</td></tr>
<tr><td>• Monitoring should always be carried out at the same times during the year and at least six weeks after the last application of fertiliser in the case of newly rehabilitated areas, checking for signs of plant stress and erosion.
• Monitoring for contamination should be considered if the audit findings warrant such action. Individual spills and accidental impacts on rehabilitated areas will need to be assessed on a one-on-one basis and the degree of rehabilitation determined at the time.</td><td><u>Soil & land capability monitoring:</u>
Annual monitoring of soil from pre-selected positions around the site. During the rehabilitation exercise, conduct preliminary soil quality sampling and analysis of the stockpiled materials to accurately determine the nutrient requirements that will be needed. Additional soil sampling should also be carried out on the reinstated materials as needed.</td><td>During the rehabilitation, one sample for every 1 hectare of land being actively rehabilitated..</td><td>Reporting post monitoring.</td><td>Monitoring field work must be undertaken by appropriately qualified and skilled personnel and the data analyses and reporting must be undertaken by an appropriately qualified soil scientist.</td></tr>
<tr><td colspan="5">Noise</td></tr>
<tr><td>Noise monitoring will be carried out in villages intersected by SRL haul roads to establish the extent of noise disturbance caused by haul roads. The focus will be on night-time conditions with monitoring conducted at locations representative of the worst affected areas.
In addition, routine noise monitoring will be conducted in the nearest villages around the MSP, the Lanti and Gangama Dry Mining Feed Preparation Plants, the excavation sites and Nitti Port.</td><td><u>Noise monitoring:</u>
Bi-annually, supplemented by ad-hoc inspections in response to noise complaints.</td><td>In villages intersected by SRL haul roads.
The focus will be on night-time conditions with monitoring conducted at locations representative of the worst affected areas.
Routine noise monitoring will be conducted in the nearest villages around the MSP, the Lanti and Gangama Dry Mining Feed Preparation Plants, the excavation sites and Nitti Port</td><td>Reporting for SRL record keeping should follow upon completion of each bi-annual or ad-hoc monitoring survey.</td><td>Monitoring field work must be undertaken by appropriately qualified and skilled personnel and the data analyses and reporting must be undertaken by an appropriately qualified noise specialist.</td></tr>
<tr><td colspan="5">Water quality (Surface water & groundwater)</td></tr>
<tr><td>The objective of the water monitoring program at SRL is to monitor and assess ground and surface water resources to provide data on existing mining operations and collect baseline data for future mining operations.
The monitoring protocol includes the following activities:
• Develop a monitoring network and schedule;
• Describe the procedures required to ensure uniform, reproducible, and reliable water sampling by using techniques which are consistent and suitable for the site and in accordance with internationally acceptable sampling practices;
• Ensure that the water quality data collected is compliant with Sierra Leone Gazette legislations;
• Ensure that the water quality data are compliant with global policies and legislations;
• Ensure that data obtained from the monitoring program can be confidently used to:
○ <u>Sampling parameters:</u>
The sampling parameters below are aligned by relevant legal limits and international guidelines.</td><td><u>Water quality monitoring:</u>
Surface water is currently being monitored monthly, with groundwater being monitored on a quarterly basis. These frequencies will be reviewed following the completion of the current year long baseline being collected, to ensure that informed decisions regarding monitoring frequency and parameters are made.</td><td>The monitoring protocol lists surface water sampling points only and will be updated to include groundwater sampling points when the drilling of monitoring boreholes that is currently in progress has been completed.
<table><tr><th>Name</th><th>Latitude (DMS)</th><th>Longitude (DMS)</th></tr><tr><td>SW 1</td><td>7° 47' 28.964" N</td><td>12° 14' 50.698" W</td></tr><tr><td>SW 2</td><td>7° 44' 34.129" N</td><td>12° 16' 42.279" W</td></tr><tr><td>SW 3</td><td>7° 44' 8.423" N</td><td>12° 13' 42.100" W</td></tr><tr><td>SW 4</td><td>7° 39' 35.428" N</td><td>12° 18' 42.372" W</td></tr><tr><td>SW 5</td><td>7° 41' 9.668" N</td><td>12° 19' 34.968" W</td></tr><tr><td>SW 6</td><td>7° 43' 18.879" N</td><td>12° 20' 21.478" W</td></tr><tr><td>SW 8</td><td>7° 44' 25.228" N</td><td>12° 21' 45.067" W</td></tr><tr><td>SW 9</td><td>7° 46' 25.010" N</td><td>12° 23' 56.605" W</td></tr><tr><td>SW 12</td><td>7° 46' 48.463" N</td><td>12° 21' 55.996" W</td></tr><tr><td>SW 14</td><td>7° 45' 49.739" N</td><td>12° 19' 27.455" W</td></tr><tr><td>SW 15</td><td>7° 45' 47.853" N</td><td>12° 18' 15.454" W</td></tr><tr><td>SW 17</td><td>7° 45' 58.793" N</td><td>12° 16' 50.326" W</td></tr><tr><td>SW 18</td><td>7° 46' 35.789" N</td><td>12° 15' 19.177" W</td></tr><tr><td>SW 19</td><td>7° 45' 38.199" N</td><td>12° 17' 26.485" W</td></tr></table></td><td>Reporting should follow after surface water sampling has taken place, i.e. quarterly.</td><td>Suitably skilled and trained hydrologist and technicians should be responsible for implementing the monitoring protocol.</td></tr>
</table>

Monitoring and inspection methodology	Inspection frequency	Location of monitoring stations	Reporting schedules	Technical team requirements

Parameter: Analyses in mg/ℓ (Unless specified otherwise)	Units	SANS 241:2015 (Standard Limits for Potable Water)	Applicable		
			Sierra Leone		World Bank Guidelines
			The Environmental Protection (Mines and Minerals) Regulation,2013		Mining (IFC EHS) 2007
			Limit at any moment	Annual average limit	
pH#	S.U.	5 - 9.7	6 - 9	6 - 9	6 - 9
Total Suspended Solids#		2	50	25	50
Total Mercury	mg/l	0.06	0.002	0.002	0.002
COD (Settled)#	mg/l	0.4			150
Total Arsenic	mg/l		0.1	0.08	0.1
Total Cadmium	mg/l		0.05	0.04	0.05
Total Chromium	mg/l				0.1
Total Copper	mg/l		0.6	0.4	0.3
Total Iron	mg/l		1.6		2
Total Lead	mg/l		0.2	0.16	0.2
Total Nickel	mg/l				0.5
Total Zinc	mg/l		1.5	1.2	0.5

Radiation

IAEA Safety Standards Series No. RS-G-1.7 (IAEA 2004), Application of the Concepts of Exclusion, Exemption and Clearance states that "the intensity of monitoring should be matched to the exposures potentially received". It is common practice to 'designate' employees who are likely to receive significant doses (for example, greater than 5 mSv/y). Such designated employees are then monitored more intensively (including, where appropriate, personal monitoring), and their doses are assessed individually. Non-designated employees will then be monitored less intensively, and their doses assessed as an average of their relevant workgroup(s)".

The frequency of monitoring has not been included and will be determined as soon as reasonably achievable.

The monitoring station and associated investigation levels that will be used for SR Area 1 are outlined in the table below:

Radiation Parameter	Investigation Level	Comment
1. Area Monitoring		
1.1 Site Boundary	>0.5 µSv/h	If not previously identified
1.3 Any Area	>5 µSv/h	If not previously identified
2. Personal External Exposure Monitoring		
2.1 Designated Worker	>2.0 mSv in a quarter	Assessed from personal radiation monitor
3. Personal Internal Exposure Monitoring		
3.1 Designated Worker	>1 mSv in a quarter	Assessed from air sampling
4. Airborne Radioactivity		
4.1 Total Alpha Activity on personal air sample	>4.0 Bq/m^3 for shift sample	Four times derived air concentration limit ~ 0.5 mSv
4.2 Total Alpha Activity on personal air samples	4 consecutive samples >1.0 Bq/m^3	Indicates potential for significant exposure
4.3 Total Alpha Activity	>Mean + 3 std deviations	Work category mean

The frequency of monitoring has not been included and will be determined as soon as reasonably achievable.

Monitoring work, data analysis and reporting must be undertaken by an appropriately qualified and skilled radiation specialist

Operational radiation monitoring for SR Area 1

Radiation parameter	Item/site monitored	Method/equipment and/or radiation measured
Personal dose - Hp(10)	Designated employees	Personal passive dose meters.
	Non-designated employees	Combination of area passive dose meter results, monitoring of Ambient Dose Equivalent Rate using suitable dose rate monitor (e.g. energy-compensated GM) and occupancy factors.
Absorbed gamma dose rate in air – SR Area	Designated locations	Combination of area passive dose meter results and monitoring of Ambient Dose Equivalent Rate using suitable dose rate monitor (e.g. energy-compensated GM).
Airborne radioactivity (dust) - Personal	Designated employees	Personal air sampling using portable, low-flow (2 LPM) pumps. Determination of activity concentration using alpha counting.

	Non-designated employees	Area air sampling using medium-flow pumps. Determination of activity concentration using alpha counting.
Airborne radioactivity (dust) – off-site locations	Site boundary at locations where environmental PM_{10} dust measurements are taken	Positional air sampling using high volume samplers. Determination of activity concentration using alpha counting and gamma ray spectrometry.
Radon & thoron gas concentrations – Off-site locations	Upwind and downwind locations in vicinity of closest residences to mining and operational areas	Track etch detectors – combination system to measure both radon (Rn-222) and thoron (Rn-220).
Surface contamination – on-site	Crib rooms, control rooms, change rooms in all areas; fixed and mobile plant	Visual inspection, contamination monitoring, and wipe tests or equivalent for transferable contamination.
Surface contamination – off-site removal	Materials/plant removed from site.	Inspection and logging by Radiation Safety Officer (RSO) or Iluka staff prior to clearance.
Particle size (AMAD) determinations	Work areas	Air sampling through a cascade impactor. Alpha counting of stage substrates and statistical determination of AMAD.
Radioactivity content of HMC, saleable products, MSP by-products/tailings and slimes	Concentrate, product and waste streams	Analysis of uranium and thorium content by ICPMS or other suitable technique (conversion of ppm to Bq/g)
Radionuclides in groundwater	Selected groundwater monitoring bore sites (based on pre- operational survey)	Analysis of radium (Ra-226, Ra-228) by scintillation counting by external laboratory.

The monitoring program will consider:

- Surveys of the ambient dose equivalent rate in air will consist of a series of measurements that adequately cover the regularly occupied locations of the areas under consideration, with typical and peak values being recorded. For gamma surveys, a portable hand-held survey meter with suitable sensitivity and energy response will be held at about 1 m from ground/floor level;
- For personal air sampling, employees will be assigned to relatively uniform exposure groups, to the extent practical, and the average exposure for the group will be determined by applying appropriate statistical analysis techniques to the measured airborne radioactivity concentrations. Assignment of personal air samplers will be on a rotational basis to ensure a spread of monitoring results on individuals within a work category;
- Personal sampling for airborne radioactivity will be undertaken in accordance with the assumed best practice procedure for inhalable dust monitoring as specified in Australian Standard AS-3640 – Workplace atmospheres – Method for sampling and gravimetric determination of inhalable dust;
- The sampling strategy for personal air sampling will include sampling on night shifts as well as during the day. Sample start times will be varied to ensure adequate coverage of all operational duties carried out throughout the shift; and
- Positional air samples will be usually taken for engineering control purposes or to assess the impact of changes to process conditions or control technology. As such, the frequency of measurement is left to the professional judgement of the RSO.

5. Airborne Dust		
5.1 Inhalable dust on personal air samples	>10 mg/m^3	Statutory limit for dust concentration

Monitoring and inspection methodology	Inspection frequency	Location of monitoring stations	Reporting schedules	Technical team requirements
Health				
The Health Impact Assessment (SHAPE 2018) recommends the development of a framework Community Health Management and Monitoring Plan (CHMMP) to outline proposed monitoring of health interventions. It is recommended that a number of management plans be prepared to address the following 12 environmental health areas (EHA): • EHA #1- Communicable disease linked to the living environment; • EHA #2- Vector related diseases; • EHA #3- Water, sanitation and waste related disease; • EHA #4- High risk sexual practices, STIs, including HIV/AIDS; • EHA #5- Food and nutrition; • EHA #6- Non-communicable diseases; • EHA #7- Injuries and accidents; • EHA #8- Veterinary medicine and zoonotic diseases; • EHA #9- Environmental health determinants; • EHA #10- Social determinants of health; • EHA #11- Health seeking behaviour and cultural health practices; and • EHA #12- Health service infrastructure and programme delivery.	The inspection frequency can only be determined once the EHA specific management plans have been developed. The inspection frequency will vary from plan to plan.	The location of the monitoring can only be determined once the EHA specific management plans have been developed. The location of the monitoring stations will vary from plan to plan.	The reporting schedule will vary from plan to plan.	Suitably qualified and skilled health professionals.
Social				
Safety in and around the mine ponds				
Essential monitoring requirements: • Adequacy of and adherence to warning signs at ponds, indicating health and safety related incidents at ponds; • Road, bridge and boat access and crossings provided by SRL; and • Grievances.	<u>Community safety monitoring:</u> Quarterly.	Visual inspections at high risk areas and crossings.	Quarterly reporting.	CAD team member.
Dust and noise nuisance				
Essential monitoring requirements: • Grievances; and • Drivers' adherence to speed limits.	<u>Monitoring of dust & noise nuisance:</u> Quarterly. *Refer to air quality and noise monitoring*	Linked to air quality and noise monitoring stations.	Quarterly reporting.	HSEC team.
Community disruption and competition for basic services due to influx of job seekers, employees and business owners				
Essential monitoring requirements: • Contractor and employee compliance to the code of practice and the Anti-Bribery and Corruption Policy; • Monitoring against the Influx Management Plan; and • Grievances.	<u>Monitoring of community disruption:</u> Quarterly.	No monitoring stations.	Aligned with health and safety reporting.	CAD team. HSEC team. HR team.
Local employment and procurement contribution, skills/capacity development, and expenditure				
Essential monitoring requirements: • Provision of local employment, procurement opportunities, skills and capacity development and expenditure in this regard; and • Effectiveness of internal training and capacity building programmes.	<u>Monitoring of employment and procurement:</u> Quarterly for the Sierra Leone Local Content Company Performance Report and Scorecard. Monthly internal review.	No monitoring stations.	Quarterly reporting as per the Sierra Leone Local Content Company Performance Report and Scorecards requirements.	Local Content Company Performance Report and Scorecards' reporting team. HR team.
Use of land and access to resources				
Monitor population and livelihoods changes within SR Area 1.	<u>Monitoring livelihoods:</u> Assess grievances monthly to identify livelihoods issues. Household survey 3-5 years prior to closure. Community development projects as required by the CDAP.	Settlements within SR Area 1. Community development project sites.	Grievances: as part of internal CAD reporting schedule Reporting on community development projects: as required by CDP.	CAD team members and external specialists where required
Cultural sites				
Monitor cultural sites affected by SRL activities	When cultural sites will be impacted / have been impacted.	At sites impacted and replacement sites.	Quarterly reporting	CAD team members and external specialists where required.

9 Closure principles, land use and financial provision

9.1 Introduction

As part of the ESHIA process, a Mine Closure Plan has been prepared by SRK and is presented in Appendix L4 (SRK, 2018(6)). This section of the ESHIA has been informed by the Mine Closure Plan.

The aim of the Mine Closure Plan is 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 GIIP. The Mine Closure Plan has been developed to be site specific and to address the particular risks associated with SR Area 1.

9.2 Closure obligations and commitments

The design of the Mine Closure Plan considers a number of interrelated components. Among these are legal and other obligations. The combination of these aspects, listed below, provided the key considerations used in the development of the plan (refer to Appendix L4 for more detail on each point listed):

- Applicable legislation, including:
  - *Sierra Rutile Agreement (Ratification) Act, 2002*;
  - *Mines and Minerals Act, 2009*;
  - *Environmental Protection Act, 2008*; and
  - SLEP (MM) Reg. 2013.
- International environmental and social principles, policies and standards, including:
  - Equator Principles;
  - IFC 2012 Performance Standards;
  - WB / IFC EHS Guideline; and
  - International Council on Mining and Metals (ICMM).
- Constructive obligations (i.e. a constructive obligation is an obligation that derives from an entity's actions where[35]), including:
  - Iluka Corporate Policies, Framework, standards and procedures (note: as SRL falls under the Iluka governance framework, SRL is required by Iluka to adhere to their policies, frameworks, standards and procedures):
    i. Iluka Health, Safety, Environment and Community (HSEC) Management System Framework; and
    ii. Iluka Health, Safety, Environment and Community Policy 2017.
  - Iluka Group standards, specifically for purposes of closure:
    i. Standard 8: Rehabilitation and Closure.
- Obligations arising from the previous ESIA and ESMP (i.e. from 2001 and 2012).

9.3 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 host communities using SR Area 1 after closure are not exposed to unacceptable risks;

[35] 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

- Utilise closure methodologies that relinquish areas in a self-sustaining condition with little or no need for ongoing care and maintenance;
- Understand and address host 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.

9.4 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 9-1) 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. 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
- 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 9-1: 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	Poorly segregated dry 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. Consequenty, 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.

Recognising the land use limitations identified in Table 7-1, prescriptions for landform modification will be developed. 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 uses 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 of the Mine Closure Plan, however, Table 9-2 below documents the existing landform, the key mitigation measures and the potential post closure land uses.

Table 9-2: 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

9.5 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).

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 wet 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 wet 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 2,000 m. This has the largest implication where topsoil or slimes are hauled for use as cover material. The 2,000 m 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 TT and SFT) 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 9-3. Iluka's closure provision applies an additional contingency to this liability estimate to allow for uncertainty in the estimation process.

Table 9-3: 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**

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10 Project alternatives

10.1 Introduction

Alternatives analysis are typically undertaken for new projects. Such analysis includes consideration of location, mining, processing and logistical alternatives relative to their potential direct and indirect impacts on biophysical and social environments.

However, the SR Area 1 mining operations and infrastructure are largely existing and have been operational for many years (i.e. since 1967). As such it is not considered practical to attempt to retrospectively assess alternative scenarios that were presumably considered (to some extent at least) prior to the time when operational and infrastructure investment decisions were made in the past.

Furthermore, the SR Area 1 operation has an existing Environmental Licence (reference number EPA-SL030) which approves wet mining (dredge mining) as the primary mining method, along with associated mining infrastructure and activities.

SRL has however, embarked on an “Expansion Phase”, which includes the introduction and improvement of the dry mining method of ore extraction. As such, the subsections which follow consider potential alternatives associated predominantly with SRL’s Expansion Phase, but link with the historical operational phase where applicable.

10.2 Location alternatives

10.2.1 Mine lease

The location of the dry mining operations is dictated by the location of the known ore bodies within SR Area 1. As there is an existing operational mine with all associated infrastructure already in existence, alternative dry mining locations are not considered feasible.

10.2.2 Location of land-based concentrators and associated infrastructure

The location of land-based concentrators and associated infrastructure was historically dictated by the location of the known ore bodies within SR Area 1. In this regard, locations for land-based concentrators were selected based on the following:

- Minimisation of pumping distances;
- Minimisation of the sterilisation of reserves;
- Location (in close proximity) to TSFs to minimise pumping distances;
- Accessibility of the plants and infrastructure; and
- Minimisation of the need for physical and economic displacement.

As there is an existing operational mine with all associated infrastructure already in existence at SR Area 1, alternative locations for concentrators and associated infrastructure are not considered feasible.

10.3 Activity alternatives (alternative mining methods)

As noted previously, two different mining methods are employed in SR Area 1: wet and dry mining. The methods deployed in particular areas depend on the nature and depth of the ore body and the depth to the water table. In light of this, deployment of either method in any particular area is dependent on the above-mentioned factors.

Both of the above methods broadly require the removal of all vegetation within the mining path, the processing of the sands and the replacement of the mined material in the mine void.

Given certain constraints posed on wet mining, including water demand (i.e. if this were the only mining method employed), it is proposed that a combination of wet and dry mining continue to be employed by SRL as may be appropriate.

Dry mining alternatives

Currently, SRL's dry mining operations use a load and haul mining method, whereby earth moving equipment is used to excavate ore (ROM feed). The ROM feed is then hauled by truck and stockpiled at the dry mining concentrators at Gangama and Lanti respectively, from where the ROM feed is further handled by earth moving equipment in the concentrator plants.

The Expansion Phase of this project (i.e. as assessed in this ESHIA) involves SRL's proposed amendment to their current dry mining operations by implementing a more cost-effective dry mining method. This will double the throughput of the Lanti and Gangama dry mining operations and greatly increase the throughput capacity of the MSP (also refer to Section 3.4.2). This proposed amendment is driven by capacity constraints, environmental as well as occupational health and safety related considerations.

The primary change in the dry mining process involves the installation of an in-pit Dry Mobile Mining Units at Lanti dry mine. This will replace the existing load and haul method and result in efficiency improvements. Ore will then be pumped as a slurry via pipeline up to the land based WCP (DM1) at Lanti dry mine. This reduces the need for haulage, stockpiling and reclaiming that is currently undertaken at the Lanit dry mining area and concentrator plants.

Since the above operational expansions will be undertaken within the existing operational footprints in areas that are already impacted from mining operations, environmental impacts have the potential to be reduced (i.e. positive impact), including:

- Air quality and social impacts: Fewer haulage trucks at Lanti dry mine means less dust from vehicle entrainment and less exhaust emissions;
- Noise: Fewer haulage trucks passing through villages and disturbing households adjacent to the road; and
- Occupational health and safety: Less ore handling and transportation using heavy equipment reduces the risk of health and safety incidents.

In terms of process efficiency as well as occupational health and safety and environmental and social effects, the alternative dry mining method proposed for the SR Area 1 Expansion Phase is considered desirable to mitigate potential negative socio-economic impacts.

10.4 Land use options after mine closure

Specialist studies commissioned as part of this ESHIA and ESHMP were tasked to consider end land use from the following perspectives:

- Biodiversity;
- Ecosystem services;
- Soil capability; and
- Socio-economic benefits.

On the basis of the outcome of these studies, a Mine Closure Plan has been developed and is presented in Appendix L4 (SRK, 2018(6)). Key outcomes of the Mine Closure Plan are presented in Section 9 of this ESHIA.

The Mine Closure Plan recognises the need to retain ecosystem services as far as possible, while at the same time, maximising biodiversity improvement opportunities. The plan makes provision for broad land use types that are further divided into a number of sub-types of activities, and considers

the “ease” to which the land uses could be implemented on the different landforms of SR Area 1 (refer to Table 9-1). In other words, the plan has taken cognisance of the rehabilitation that would be required to achieve one of the following broad land uses in terms of feasibility, practicality and sustainability:

- Forestry;
- Subsistence agriculture;
- Settlement;
- Conservation; and
- Aquaculture.

Land use planning post closure is a complex process and requires ongoing consideration throughout the life of the operation. Options (alternatives) therefore presented in this report in Section 9 will be reviewed and commented on by stakeholders. Management measures with regard to the remaining end land use planning process are detailed in Section 9 of this report.

10.5 The no-go option

The SRL operation in SR Area 1 has an existing Environmental Licence and approved ESMP for dredge mining.

Since dry mining operations commenced in 2013, SRL is now in the process of aligning legislative requirements (at the request of the EPA-SL) with their existing Environmental Licence for SR Area 1. In addition to this, SRL needs to update its approved ESMP to reflect dry mining as an approved mining method. This ESHIA and ESHMP has been undertaken in accordance with the EPA-SL’s requirements in order to meet the aforementioned conditions.

The introduction of dry mining has prolonged the LoM by four years at Gangama dry mine and six years at Lanti dry (Gbeni) mine. This increases the longevity of many livelihoods and other socio-economic benefits provided by SRL. As such, if the no-go option were to be implemented (i.e. dry mining and associated Expansion Phase not approved), the SR Area 1 mining areas will need to close earlier than the Mine Closure Plan has currently planned for (Appendix L4). Premature mine closure will result in the large-scale loss of employment over a relatively short period of time, with a subsequent negative socio-economic impact on the local and regional economy.

With reference to the Mine Closure Plan (Appendix L4) and Social Impact Assessment (Appendix J), the no-go option is not considered desirable in terms of the potential for unmanaged negative socio-economic impacts.

11 Conclusion

This ESHIA and ESHMP for the SR Area 1 Mining Lease Area situated in the Bonthe and Moyamba Districts of the Southern Province of Sierra Leone provides:

- A description of the current and planned operations at SR Area 1;
- A synopsis of the governance framework applicable to the ESHIA and ESHMP, including Sierra Leone legislation, good international practice standards and guidelines and corporate policies, frameworks and standards;
- An overview of the biophysical, socio-economic and host community health baseline context of the project, collected as part of the specialist studies;
- Detail of stakeholder engagement for the ESHIA and ESHMP process to date, as well as supporting documentation including the issues raised and responses from the project team;
- Environmental, social and health impact assessment and proposed management measures for all project phases; and
- A comprehensive ESHMP, which includes a plan for monitoring, as well as a suite of standalone management plans.

Situated approximately 30 km inland from the Atlantic Ocean and 135 km south east of Freetown, SRL has undertaken dry and wet mining activities to extract rutile deposits intermittently since 1967. 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); 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, clinic and roads.

The overall landscape consists of a series of prominent hills and slight undulations with an elevation range of 0.9 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 Moist Semi-Deciduous Forest has been degraded by extensive, long-term, slash-and-burn subsistence agriculture, with more intact remnant forests occurring on the ridges. Bankside vegetation occurs along watercourses. Estuaries including Gbangbaia, Kangama, Bagru, Motevo and Teso Creeks between Sherbro Island and the mainland are relatively undisturbed, although there are indications of consumptive use by locals.

It is estimated that a total of 4,000 households reside within Moriba Town and its surrounding villages, including Mogbwema, Mogbwemo, Kpetema, Pejebu and Ndendemoia. Other towns in the vicinity of the SR Area 1 are Mokaba, Gbangbaia, Gbangbama and Madina. The area is characterised by high levels of poverty and limited social services and infrastructure. Host communities are largely reliant on subsistence agriculture to meet their basic livelihood needs. Host communities use the surrounding natural resources such as forests, mangroves and freshwater streams and estuaries to source fuel wood, thatching and building materials, medicinal plants, food and water. Potable water for domestic and animal consumption is sourced from wells in the villages as well as streams and ponds.

The ESHIA and ESHMP process has thus far involved one round of stakeholder engagement, with the second and final round to take place following the release of the ESHIA and ESHMP report. Stakeholders consulted in the process include government, traditional leaders, host community and non-governmental role-players. A Grievance Management Procedure has been established by SRL to address stakeholder issues during all project phases. The project is widely welcomed by stakeholders, with development expectations including employment and improvement of services. Primary concerns about the project from stakeholders relate to loss of agricultural potential, soil

erosion, drowning in ponds, communicable diseases, dust, noise and soil and historical resettlement and compensation issues.

Specialist site work undertaken has involved soils and land capability, surface and groundwater, air quality, social, host community health, terrestrial, aquatic and estuarine biodiversity as well as noise studies. Monitoring to reflect seasonal changes is being undertaken as part of the terrestrial, aquatic and estuarine biodiversity, surface and groundwater and air quality studies. To accommodate this requirement, all monitoring is scheduled to be concluded by July 2018.

The project brings regional and local economic benefit, including job creation and provision of certain social and health services. Key potential negative impacts requiring careful management include: loss of fauna and flora, modification of estuaries, loss of soil resources, loss of land for crops, water availability, influx of people, and health notably sexually transmitted diseases and communicable disease.

A comprehensive suite of management measures is provided to avoid and mitigate impacts from the project. The ESHMP contains an environmental management system for SRL which sets out roles, responsibilities and lines of reporting on sustainability management to ensure effective ESHMP implementation. The ESHMP further details plans for management of environmental and social impacts for the lifetime of the project covering social impacts, air quality, water quality, noise, cultural heritage as well as biodiversity. Standalone plans include: Chemical Management Plan; Waste Management Plan, Tailings Management Plan; Mine Closure Plan; Occupational Health and Safety Plan; Emergency Response and Contingency Plan; Community Development Plan and a Communication and Public Participation Plan. Relevant monitoring for the lifetime of the project as well as the process for audit and review, are also set out in the ESHMP.

It is anticipated that it will be possible to successfully mitigate impacts associated with the current and planned mining activities at SR Area 1, with no fatal flaws having been identified. Should the ongoing monitoring findings differ from SRK's current understanding of air quality, water quality and biodiversity aspects; updates will be provided to SRL and stakeholders as relevant.

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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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Appendices

Appendix A: Air Quality Impact Assessment Report

Appendix B: Biodiversity - Terrestrial, Aquatic and Wetland Ecological Report

Appendix C: Biodiversity - Estuarine and Marine Report

Appendix D: Community Health Impact Assessment Report

Appendix E: Geochemistry Characterisation of Selected Residues

Appendix F: Groundwater Report

Appendix G: Surface Water Report

Appendix H: Noise Report

Appendix I: Radiation Report

Appendix J: Socio-economic Report

Appendix K: Soils and Land Use Capability Report

Appendix L: Management Plans

Appendix L1: Chemical Management Plan

Appendix L2: Waste Management Plan

Appendix L3: Tailings Management Plan

Appendix L4: Mine Closure Plan

Appendix L5: Occupational Health and Safety Plan

Appendix L6: Emergency Response and ContingencyPlan

Appendix L7: Community Development Action Plan

Appendix L8: Communication and Public Participation Plan

Appendix M: Photos of Stakeholder Meetings

Appendix N: Attendance Registers

Appendix O: Maps

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