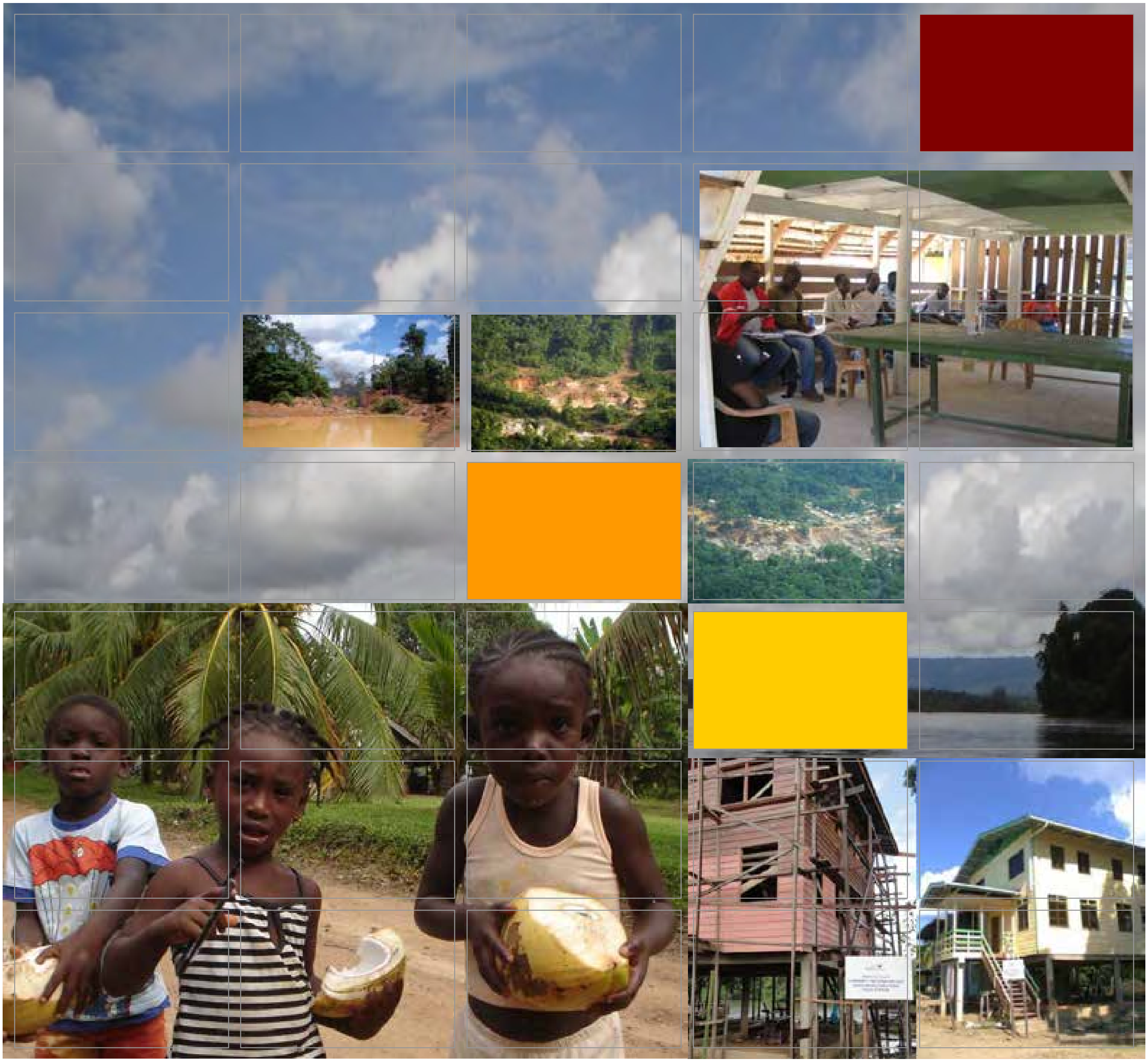

Merian Project
Final ESIA Report
Volume II - Environmental and Social Impact Assessment

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ERM

The world's leading sustainability consultancy

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LIST OF ACRONYMS:

Acronym	Definition
AAQ	Ambient Air Quality
ABA	Acid Base Accounting
ABS	General Bureau of Statistics
AERMIC	AMS/EPA Regulatory Model Improvement Committee
AERMOD	AERMIC Model
AIDS	Acquired immunodeficiency virus
ANFO	Ammonium Nitrate/Fuel Oil
ANSI	American National Standards Institute
ANZECC	New Zealand Environment and Conservation Council
ARD	Acid Rock Drainage
Area of Influence	Environmental Study Area and a Social Study Area
ARI	acute respiratory infections
ART	Antiretroviral Therapy
ARV	Anti-retroviral
As	Arsenic
ASM	Artisanal and Small-Scale Mining
ATM	Ministry of Labor, Technological and Environment
AWA	Alcoa World Alumina LLC
BAPP	Biological Acid Production Potential
BFA	Bench Face Angle
BMP	Best Management Practices
BOD	Biological Oxygen Demand
BOPH	Bureau of Public Health
BPL	below the poverty line

Acronym	Definition
BSC	Biodiversity Steering Committee
BSS	Behavioral Surveillance Survey
CBO	Community Based Organizations
CC	Climate Change
CCD	Counter Current Decantation
CCME	Canadian Council Of Ministers of the Environment
CDD	Current Decantation
CDMP	Caribbean Disaster Management Program
CEC	Cation Exchange Capacity
CELOS	Center for Agricultural Research in Suriname
CFR	Code Of Federal Regulations
CH4	Methane
CI	Community Investment
CIA	Cumulative Impacts Assessment
CIP	Carbon-In-Pulp
CITES	Convention on International Trade in Endangered Species
CO	Carbon Monoxide
CO2	Carbon Dioxide
COD	Chemical Oxygen Demand
CN	Cyanide
Cr	Total Chromium
CR	Community Relations
CSNR	Central Suriname Nature Reserve
Cyanide Code	Code for the Manufacture, Transport and Use of Cyanide in the Production of Gold
dB	Decibels

Acronym	Definition
dBA	A-Weighted Decibels
DBK	Soil Survey Department Of Suriname
dBL	Linear-Weighted Decibels
DD	Data Deficient
DUI	Driving Under the Influence
EA	Environmental Assessment
EBRD	European Bank for Reconstruction and Development
EBS	Energie Berdrijven Suriname
EDC	Environmental Design Criteria
EHS	Environmental, Health and Safety
EMP	Environmental Management Plans
EN	Endangered
EP	The Equator Principles
EP	Evaluation Point
EPFI	Equator Principles Financial Institution
ERM	Environmental Resources Management
ERP	Emergency Response Plan
ESIA	Environmental and Social Impact Assessment
ESC	Erosion and Sediment Control Plan
ESMMP	Environmental and Social Management and Monitoring Plan
ESR	Environmental and Social Responsibility
ETP	Endogenous Thrombin Potential
FGD	Focus Group Discussions
FHWA	Federal Highway Administration
GDP	Gross Domestic Product

Acronym	Definition
GFR	General Fertility Rates
Gg	Gigagrams
Gj	Gigajoule
GHG	Greenhouse gases
GII	The Gender Inequality Index
GIS	Geographic Information System
GISPLAN	Geografisch-Planologisch Adviesbureau
GNI	Gross National Income
GoS	Government of Suriname
GPS	Global Positioning System
GRDC	Global Runoff Data Center
H&S	Health & Safety
ha	hectares
HCS	Highway Capacity Software
HCT	Humidity Cell Test
HDI	Human Development Index
HDR	Human Development Report
HFO	Heavy Fuel Oil
HIV	Human immunodeficiency virus
HR	Human Resources
HRS	Human Resources Services
HRD	Human Resources Development
HSLP	Health, Safety and Loss Prevention
HWTA	Hazardous Waste Transfer Area
ICMM	International Council of Mining & Metals
ICMC	International Cyanide Management Code

Acronym	Definition
IFC	International Finance Corporation
IHDI	Inequality Adjusted HDI
ILO	International Labor Organization
In / s	Inches per second
IPPF	International Planned Parenthood Federation
ISO	International Organization for Standardization
IUCN	International Union for the Conservation of Nature
IPCC	International Panel on Climate Change
IRA	Inter Ramp Slope Angles
ISEC	International Society for Ecology and Culture
IT	Information Technology
IZ	Industrial Zone
JMP	Joint Monitoring Program
JV	Joint Venture
KII	Key Informant Interviews
km	kilometers
KPI	Key Performance Indicator
LAeq	A-weighted steady equivalent sound level
LBB	Suriname Forest Service
LBGO	Lower Vocational Education School
LOM	Life of Mine
LVV	Ministry of Agriculture, Animal Husbandry and Fisheries
masl	meters above sea level

Acronym	Definition
MDGs	Millennium Development Goals
ML	metal leaching
MM	Bureau of Public Health, Medical Mission
mm/s	millimeters per second
MMI	Modified Mercalli Intensity
MNH	Ministry of Natural Resources
MNH GMD	Geological Mining Service
MOH	Ministry of Health
Moz	million ounces
MRD	Ministry of Regional Development
MSD	Malaria Service Delivery
MSDS	Material Safety Data Sheets
MTI	Ministry of Trade and Industry
MW	Megawatts
MWE	Megawatts Electricity
MWT	Megawatt Thermal
N2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAF	Non-Acid Forming
NAG	Net Acid Generation Test
NAP	National AIDS Program
NAWQA	National Water Quality Assessment
NCD	Nature Conservation Division
NCD	Non-Communicable Disease
NEAP	National Environmental Action Plan
Newmont	Newmont Overseas Exploration Limited

Acronym	Definition
NGO	Non-Governmental Organization
Ni	Nickel
NIMOS	the National Institute of Environment and Development in Suriname
NL	Not listed
NL	Netherlands
NMR - National Council for the Environment	Nationale Milieuraad
NMS	Newmont Metallurgical Services
NO2	Nitrogen Dioxide
NPI	Australian National Pollutant Inventory
NTFP	Non Timber Forest Products
NZCS	National Zoological Collection of Suriname
OAS	Organization of States
OGS	Ordening Goud Sector
OP	Operating Procedure
OSHAS	Occupational Health and Safety Advisory Services
oz	ounces
PAF	Potentially Acid Forming
PAG	Potentially Acid Generating
PAG	Peroxide Acid Generation
PAHO	Pan American Health Organization
PAPs	Project Affected Peoples
PCS	Petroleum Contaminated Soils
PFCs	hydro-fluorocarbons
PK	Porknocking
PM	Particulate Matter
PMF	Probable Maximum Flood

Acronym	Definition
POI	Points of Interest
ppbv	parts per billion by volume
PPE	Personal Protective Equipment
PPP	Purchasing Power Parity
PPV	Peak Particle Velocity
PVC	Polyvinyl Chloride
QA / QC	Quality Assurance / Quality Check
REEEP	Renewable Energy and Energy Efficiency Partnership
RGD	Bureau of Public Health, Regional Health Service
ROM	Run-of-Mine
SAG	Semi-Autogenous Grind
SBB	Foundation for Forest Management and Production Control
SBC	Suriname Business Coalition
SCBA	Self-contained Breathing Apparatus
SCF	Suriname Conservation Foundation
SES	Stakeholder Engagement Strategy
SEP	Stakeholder Engagement Plan
SF6	sulfur hexafluoride
SIA	Security Industry Authority
SMP	Social Management Plans
SO2	Sulfur Dioxide
SOC	Species of Concern
SOP	Standard Operating Procedures

Acronym	Definition
SPCC	Spill Prevention and Countermeasures Plan
SPLP	Synthetic Precipitation Leaching Procedure
SPS	National Planning Office of Suriname
STINASU	Foundation for Nature Conservation in Suriname
SRH	Sexual and Reproductive Health
SRK	SRK Consulting
SRD	Surinamese Dollar
SRU	Seismic Research Unit
SSA	Social Study Area
SSSA	Soil Science Society of America
STI	Sexually Transmitted Infections
STP	Sewage Treatment Plant
Surgold or the Company	Suriname Gold Company
SW	Surface Water
SWM	Surinamese Water Company
SWMP	Solid Waste Management Plan
TANA	To Assist Needy Animals
TB	Tuberculosis
TCLP	Characteristic leaching Procedure
TDS	Total Dissolved Solids
the Project	Merian Gold Project
TNM	Traffic Noise Model
TNM	Noise Technical Manual
ToR	Terms of Reference
TRV	Toxicity Reference Values
TSF	Tailings Storage Facility

Acronym	Definition
TSP	Total suspended particulate matter
TSS	Total Suspended Solids
TWS	Treated Water Storage
TWSR	Treated Water Storage Reservoir
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USGS`	United States Geological Survey
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on
UNICEF	United Nations Children's Fund
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UV	Ultraviolet
VAC	Vacuum
VSB	Suriname Trade and Industry Association
VU	Vulnerable
WAD	Weak Acid Dissociable
WDI	World Development Indicators
WHIMIS	Workplace Hazardous Materials Information System
WHO	World Health Organization
WRD	Waste Rock Disposal
WRI	World Resource Institute
WSS	Water Supply and Sanitation

Acronym	Definition
WWF	World Wildlife Fund
XRD	X-ray Diffraction
XRF	X-ray Fluorescence
Zn	Zinc
mg/m^3	micrograms per cubic meter

15.0 IMPACT ASSESSMENT METHODOLOGY

The impacts identified in this ESIA study have been rated and ranked using an impact assessment methodology. The Project team used fieldwork, desk-top analysis, and professional judgment to identify potential impacts and their interactions. The impacts identified have been rated using a specific methodology elaborated in this chapter.

The methodology presented here has been followed to identify and assess the potential impacts of the proposed Project. Recognized best practice for environmental and social impact assessments is to “rate”, or quantify potential impacts. Impact ratings are derived to:

- Provide a basis for prioritization of impacts to be addressed;
- Provide a method of assessing the effectiveness of proposed mitigation measures; and
- Provide a scale which shows the level of impact both before and after a proposed mitigation measure has been applied.

For the Merian ESIA, a consistent system for rating impacts in order to apply analytical rigor to the assessment and rating process has been used. It must be remembered, however, that any outcome with regard to reducing major negative impacts or enhancing positive impacts is dependent on the selection, applicability, implementation and effectiveness of mitigation measures for the proposed Project.

15.1 STEPS OF IMPACT ASSESSMENT

The process of impact assessment is completed through a series of steps. In general, these steps are as follows:

1. Characterize the baseline – the existing conditions before the Project is undertaken and any effects are generated;
2. Describe the Project components throughout the Project lifespan (Pre-Production, Operations, and Closure and Post-closure) to develop a Project Description;
3. Evaluate alternatives to the Project to see if impacts can be reduced;
4. Based on the Project Description and evaluation of alternatives, identify sources of impacts and the impacts themselves that are generated by any aspect of the Project;
5. Rate impacts before any mitigation (for negative impacts) or enhancement (for positive impacts) is implemented;

6. Identify mitigation and enhancement measures to address the impact; and
7. Rate impacts after mitigation to produce a "residual" impact rating.

15.2 CRITERIA FOR RATING IMPACTS

Potential social and environmental impacts are rated based on two elements: (1) the severity and enhancement of the potential impact and (2) the likelihood that the impact will occur. The derivation of these elements is described in the subsequent sections. This methodology has been devised by ERM and is adapted from an Environmental Health and Safety (EHS) risk rating system and adapted to ESIAs. No standards or guidelines can be found for the same. The reader finds ranking of impacts useful because it helps a project address the major impacts first and prioritize mitigation measures.

15.2.1 Severity and Enhancement Criteria

The severity or enhancement of each potential impact has been rated using the criteria identified in Table 15-1, Table 15-2, Table 15-3, and Table 15-4. Note that colors are used to assist the reader in reviewing the impacts and their relative magnitude. As such the colors should not be considered definitive.

Table 15-1 Severity Criteria (Negative Environmental Impacts)

Severity	Duration	Description
Low	Short-term (up to one year) Low frequency	Affects environmental conditions, species, and habitats over a short period of time, is localized and reversible.
Medium	Medium-term (one to seven years) Medium or intermittent frequency	Affects environmental conditions, species and habitats in the short to medium term. Ecosystems integrity will not be adversely affected in the long term, but the effect is likely to be significant in the short or medium term to some species or receptors. The area/region may be able to recover through natural regeneration and restoration.
High	Long-term (more than seven years)/ Irreversible Constant frequency	Affects environmental conditions, species and habitats for the long term, may substantially alter the local and regional ecosystem and natural resources, and may affect sustainability. Regeneration to its former state would not occur without intervention. Affects environmental conditions or media over the long term, has local and regional affects or is irreversible.

Table 15-2 Severity Criteria (Negative Social or Health Impacts)

Severity	*Duration*	*Extent*	*Ability to Adapt*	*Socio-cultural Outcome*	*Health Outcome*
Low	Short-term (up to one year) Low frequency	Individual / Household	Those affected will be able to adapt to the changes with relative ease, and maintain pre-impact livelihoods, culture, quality of life and health.	Inconvenience but with no consequence on long-term livelihoods, culture, quality of life, resources, infrastructure and services.	Event resulting in annoyance, minor injury or illness that does not require hospitalization
Medium	Medium-term (one to seven years) Medium or intermittent frequency	Small number of households	Those affected will be able to adapt to change, with some difficulty, and maintain pre-impact livelihoods, culture, quality of life and health but only with a degree of support	Primary (direct) and secondary (indirect) impacts on livelihoods, culture, quality of life, resources, infrastructure and services	Event resulting in moderate injuries or illness, which many require hospitalization
High	Long-term (more than seven years) / Irreversible Constant frequency	Large part or entirely	Those affected will not be able to adapt to changes and continue to maintain pre-impact livelihood	Widespread and diverse primary and secondary impacts likely to be impossible to reverse or compensate for.	Catastrophic event resulting in loss of life, severe injuries or chronic illness requiring hospitalization.

Table 15-3 Enhancement Criteria (Positive Environmental Effects)

Severity/ Enhancement	*Duration*	*Extent*	*Degree of Change*	*Focus/ Sensitivity*
High level of enhancement	Benefits will be sustained over the long term.	Benefits will extend beyond local environment (i.e., linkage of fragmented habitat, e.g., regional corridor)	Direct benefits to species or resources will provide significant opportunities for sustainability.	Benefits will pertain to species, habitats and natural resources that are degraded, or are sensitive, rare, or in need of protection.
Medium level of enhancement	Benefits will be measurable in the short term and possibly longer.	Benefits to many species, habitats and natural resources in the local environment and beyond.	Moderate benefits to species, habitat, and natural resources that may provide some opportunities for sustainability.	Benefits will pertain to species, habitats and natural resources that have some level of degradation, sensitivity, or rarity.
Low level of enhancement	Benefits will be short term.	Benefits to a few species, associated habitat, and resources in the local environment only.	Minor benefits to species, habitat, and natural resources that may provide minor opportunities for sustainability.	Benefits will pertain to species, habitats and natural resources that are not sensitive or rare.

Table 15-4 Enhancement Criteria (Positive Social and Health Impacts)

Severity/ Enhancement	*Duration*	*Extent*	*Degree of Change*	*Focus/ Sensitivity*
High level of enhancement	Benefits will be lasting and sustained over the long term i.e.: more than 7 years	Benefits throughout the local community and beyond to **Regional** / National level.	Direct benefits to individuals and communities will provide significant opportunities for leveraging secondary benefits and significantly improving livelihoods for themselves and others	Benefits will pertain to vulnerable groups and those that would have otherwise have been 'losers' as a result of the Project.
Medium level of enhancement	Benefits will be felt for a medium period of time (1 to 7 years) or be intermittent over the longer term	Benefits to many individuals and households in the local community and beyond	Moderate benefits to individuals and communities which will provide some opportunities for furthering themselves and improving livelihoods	Benefits will possibly pertain to vulnerable groups and those that might have been 'losers' from the Project
Low level of enhancement	Benefits will be short-term (up to a year)	Benefits to a few individuals and households either in the local area and/or further afield.	Some benefits to individuals and communities, potentially improving opportunities for furthering themselves and improving livelihoods	Benefits will not pertain to vulnerable groups and will only benefit those that would have otherwise benefited from the Project.

15.2.2 *Likelihood Criteria*

Likelihood of the event occurring is comprised of the following categories:

- Low likelihood – Rare (e.g., few or no occurrences in Project-related mining industry);
- Medium likelihood – Uncommon (e.g., documented occurrences in Project-related mining industry); and
- High likelihood – Common (e.g., occurs within the mining industry).

15.3 *DETERMINING THE RATING MATRIX*

The overall rating of the impacts was determined by using the following matrix (Table 15-5). It should be noted that these matrices act as a guide and there may be situations where their rigid application is inappropriate and where stakeholder perceptions and feedback have a significant role to play. For specific impacts where this is the case, the rating is clearly explained in the evaluation of the impact.

Table 15-5 Rating Matrix

	Likelihood		
Severity/ Enhancement	*Low*	*Medium*	*High*
High level of enhancement	Moderate	Major	Major
Medium level of enhancement	Minor	Moderate	Major
Low level of enhancement	Insignificant	Minor	Moderate
Low severity	Insignificant	Minor	Moderate
Medium severity	Minor	Moderate	Major
High severity	Moderate	Major	Major

16.0 AIR QUALITY AND GREENHOUSE GAS IMPACTS

16.1 AIR QUALITY IMPACT ASSESSMENT

16.1.1 Methodology and Criteria

The ambient air impact assessment area for the Merian Project assesses impacts at the Industrial Zone boundary and at the closest potential receptors to the Study Area, including permanent settlements along the Marowijne River and receptors within a 15 meter distance from the Transportation Corridor (e.g., residences, schools, houses of worship). In addition to the Industrial Zone boundary, the Study Area for the air quality assessment includes the following permanent settlements: Langa Tabiki and Akati.

The methodology used in this analysis is based on policies and procedures recommended in USEPA's guidelines for air quality modeling. The ambient air quality analysis involves identifying and quantifying air emissions associated with potential sources; modeling the impacts of these emission sources on ambient air quality for comparison with applicable air quality standards. The air quality model used in this analysis was AERMOD, which is the current regulatory dispersion model for all near source ambient impact analyses. The AERMOD model was developed by a committee of scientists representing United States Environmental Protection Agency (USEPA) and the American Meteorological Society. The AMS/EPA Regulatory Model Improvement Committee (AERMIC) undertook an extensive model development process that emphasized model validation with real-world measurements. The result of their efforts was the AERMIC Model or AERMOD. It is publicly available at: www.epa.gov/ttn/scram.

The key elements of the modeling analysis include:

- Estimation of emissions of PM_{10}, $PM_{2.5}$, NO_x, SO_2, and CO from the air emission sources at the facility;
- Use of the latest version of AERMOD (version 12060);
- Use of surface meteorological data from Zanderij airport, Suriname (Station ID: 10509) and on-site measurements from the Merian Weather Station; and upper air data from Cayenne/ Rochambeau weather station in French Guinea (Station ID: 80405) for the years 2005 through 2009;
- Use of an extensive receptor grid extending up to 15 kilometers (km) from the facility designed to identify maximum predicted concentrations in the vicinity of the facility and the settlement areas; and
- Air quality modeling analysis to determine the magnitude and location of ambient PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO concentrations due to

emissions from the Mine Site plus measured baseline air concentrations for comparison with relevant air quality standards (see Chapter 6 for Air Quality and Greenhouse Gas Baseline).

Detailed information on the methodology, assumptions, and references used for the air emission calculations can be found in Appendix 16-A. Similarly, detailed information on the model selection, modeling methodology and analysis, stack parameters, meteorological data, and receptor grid development can be found in Appendix 16-B.

Project-related air emissions along the Transportation Corridor (wheel generated dust and vehicle exhaust emissions) were not modeled and assumed to be negligible in comparison to air emissions from Operations at the Mine Site. Project traffic volume (delivery trucks, employee buses, etc.) along the corridor during the Pre-Production and Operation phases are expected to be low (see Chapter 20 – Traffic and Transportation Safety Impacts).

There are no regulatory air quality standards in Suriname to which the impacts from the Merian Project can be compared. In the absence of national legislated standards specific to Suriname, the current World Health Organization (WHO) Air Quality Guidelines (WHO 2005; International Financial Corporation (IFC) 2007) will be used for evaluating air quality effects of this Project. For pollutants such as CO that are not addressed under the WHO guidelines, the National Ambient Air Quality Standards (NAAQS) promulgated by the USEPA are used as reference guidelines.

Ambient air quality guidelines are ambient quality levels primarily developed through clinical, toxicological, and epidemiological evidence such as those published by the WHO. Ambient air quality standards such as the USEPA NAAQS, are ambient air quality levels established and published through national legislative and regulatory processes, and developed to be protective of human health (primary standards) and the environment (secondary standards). The WHO air quality guidelines and the USEPA NAAQS have been adopted and are summarized in Table 16-1. As shown in the table, the WHO air quality guidelines are more stringent than the USEPA NAAQS for all pollutants, except for 1-hour NO_2. The interim target values under the WHO air quality standards are more comparable to the USEPA NAAQS and in some cases higher.

Table 16-1 Ambient Air Quality Standards and Guidelines for the Merian Project

Pollutant	Averaging Period[1]	Units	WHO Ambient Air Quality Guidelines	US EPA NAAQS Primary Standard	US EPA NAAQS Secondary Standard
Particulate matter less than 10 microns in diameter (PM_{10})	Annual	µg/m³	70 (IT1) 50 (IT2) 30 (IT3) 20 (GV)	NA	NA
	24-hour	µg/m³	150 (IT1) 100 (IT2) 75 (IT3) 50 (GV)	150	150
Particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)	Annual	µg/m³	35 (IT1) 25 (IT2) 15 (IT3) 10 (GV)	15	15
	24-hour	µg/m³	75 (IT1) 50 (IT2) 37.5 (IT3) 25 (GV)	35	35
Nitrogen Dioxide (NO_2)	Annual	µg/m³	40 (GV)	100 (0.053 ppm)	100 (0.053 ppm)
	1-hour	µg/m³	200 (GV)	188.7 (0.1 ppm)	188.7 (0.1 ppm)
Sulfur Dioxide (SO_2)	24-hour	µg/m³	125 (IT1) 50 (IT2) 20 (GV)	365 (0.14 ppm)	NA
	3-hour	µg/m³	NA	NA	1,300 (0.5 ppm)
	1-hour	µg/m³	NA	196 (0.075 ppm)	NA
	10 minute	µg/m³	500 (GV)	NA	NA
Carbon Monoxide (CO)	8-hour	µg/m³	NA	10,000 (9 ppm)	NA
	1-hour	µg/m³	NA	40,000 (35 ppm)	NA

Sources: WHO Ambient Air Quality Guidelines taken from IFC's General EHS Guidelines dated 30 April 2007; USEPA NAAQS taken from 40 CFR Part 50 (CFR = Code of Federal Regulations).
[1] Each standard or guideline has its own criteria for how many times it may be exceeded, in some cases using a three year average.

Key:
WHO = World Health Organization
USEPA = United State Environmental Protection Agency
NAAQS = National Ambient Air Quality Standards
µg/m³ = micrograms per cubic meters.
ppm = parts per million.
IT1 = Interim target 1
GV = Guideline value
NA = Not applicable (i.e., no standard exists or standards have been revoked)

16.1.2 Pre-Production Phase

The following potential impact to air quality is predicted to occur in the Pre-Production Phase:

- Short-term increase in fugitive dusts (PM_{10} and $PM_{2.5}$), and combustion emissions (NOx, SO_2, and CO) released to the atmosphere.

Construction of the mine infrastructure (Operations Camp, mine haul roads, waste disposal areas, etc), well drilling, and installation of the power plant, crushers, and other process facilities will generate short-term increases in fugitive dust and combustion emissions. The primary sources of fugitive dust emissions include construction activities (e.g., land clearing, grading, and excavation) and increased vehicle traffic on unpaved roads. The amount of dust generated will be a function of construction activities, soil type, moisture content, wind speed, frequency of precipitation, vehicle traffic, vehicle type, and roadway characteristics. Fugitive dust will be greater during drier periods in areas of fine-textured soils. Since the proposed Mine Site will be located in an area with high annual rainfall (estimated at over 2300 mm per year based on on-site and regional weather data), the relatively high residual soil moisture levels may prevent dust generation, particularly during the wet seasons. Some of the planned dust control measures during the Pre-Production Phase include:

- Dust suppression as needed (i.e., watering disturbed areas; and
- Reclaim or revegetate disturbed areas as they become available.

The primary sources of combustion emissions (e.g., SO_2, NO_x, CO, and particulates) include Operations of diesel-fired construction power generators (3.33 MWe) and diesel powered construction equipment such as drills, delivery trucks, dozers, graders, and other mobile sources.

Considering the Project dust controls (watering; stabilizing disturbed areas) and the fact that the fugitive dust and combustion emissions will be short-term and localized, air quality impacts from the construction activities at the Mine Site are expected to be minor (low severity; medium likelihood) at the Industrial Zone boundary and at the closest permanent settlements such as Langa Tabiki and Akati.

Traffic to and from site, including transportation of construction/borrow materials (via delivery trucks) will generate short-term increases in fugitive dust and exhaust/combustion emissions along the corridor. Due to the the short time extent and limited consequence, the potential air quality impacts associated with transporting construction materials along the corridor during the Pre-Production Phase will be minor (low severity; medium likelihood).

During the Pre-Production Phase, certain materials such as the main Heavy Fuel Oil (HFO) power generators and certain mill components may exceed the weight capacity of some bridges along the East-West Highway and as such, will need to be barged to Moengo. Unlike wheel-generated dust emissions from the road transportation, the water transportation will generate no dust emissions. The frequency of barge Operations (barge traffic) will be much lower than the vehicle traffic described above, so exhaust emissions from the diesel-fired tug/push boats will be minimal. Therefore, potential air quality effects associated with the infrequent barge traffic along the river will be insignificant (low severity; low likelihood). No specific mitigation measures are required for barge traffic or road traffic during the Pre-Production Phase.

Recommended air quality mitigation measures associated with construction activities during Pre-Production Phase are listed below.

Mitigation Measures

To avoid or reduce the air quality impacts during the Pre-Production Phase at the Industrial Zone boundary and at the settlement areas, the following mitigation measures are recommended:

- Implement an air quality monitoring program at the Mine Site during Pre-Production Phase to monitor TSP, PM_{10}, $PM_{2.5}$, NOx, SO2, and CO.
- Implement a concurrent rehabilitation program that minimizes the amount of land that will be disturbed at one time.
- Ensure that all construction and mine equipment is maintained in accordance with manufacturer's specifications.
- Implement a solid waste management plan and avoid open burning of wastes at the construction site.

Residual Impacts

Implementation of the above mitigation measures during the Pre-Production Phase will reduce the likelihood of air quality impacts at the Industrial Zone boundary and as such, will reduce air quality impacts from minor to insignificant (low severity; medium likelihood).

16.1.3 Operations Phase

The following potential impact to air quality may occur in the Pre-Production Operations Phase:

- Potential increase in fugitive dust emission concentrations (PM_{10} and $PM_{2.5}$) at the Industrial Zone boundary
- Potential increase in exhaust emission concentrations (NOx, SO2 and CO) at the Industrial Zone boundary

During the Operations Phase, fugitive dust emissions (TSP, PM_{10}, and $PM_{2.5}$) will be generated from surface disturbance at the Mine Site from activities such as grading, loading and unloading activities, bulldozing activities, drilling, blasting, truck traffic on unpaved roads, wind erosion from exposed surfaces, crushing and grinding activities, and material handling, transferring, and conveying activities at the process plant area. Combustion emissions (SO_2, NO_x, CO, and particulate matter) will be generated from operation of the onsite HFO power plant (52.5 MWe) and non-road diesel powered mine equipment such as excavators, haul trucks, dozers, and other mobile sources (mine fleet).

For this air quality assessment, Year 4 is considered the most conservative year in terms of potential impacts for mining Operations because it has the highest amount of overburden removed due to concurrent operation of all three mine pits(~72.2 Mtpa) as well as a maximum amount of ore to be processed (16 Mtpa)[1].

Estimation of fugitive dust and combustion emissions from activities at the Mine Site during the most conservative year involved the following general steps:

- Key activities likely to generate airborne particulates and combustion emissions were identified.
- Best available emission estimation techniques for each activity were obtained from various sources including:
    - USEPA AP-42 Compilation of Air Pollutant Emission Factors, Chapter 3.4, Chapter 11.9, Chapter 11.24, Chapter 13.2.2, Chapter 13.2.4, Chapter 13.2.5, and Chapter 13.3 (USEPA, 1996, USEPA, 1998; USEPA, 1995a; USEPA, 2006a; USEPA, 2006b; USEPA, 2006c; and USEPA, 1995b);
    - USEPA Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression Ignition (USEPA, 2010a);
    - USEPA Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling (USEPA 2010b);
    - USEPA Conversion Factors for Hydrocarbon Emission Components (USEPA 2010c);
    - IFC EHS Guidelines for Thermal Plants (IFC 2008); and
    - Australian National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining (NP1 2012).

[1] Year 8 has a higher amount of overburden removed annually (74.04 Mtpa), but the amount of ore processed in Year 8 is expected to be much lower (~10 Mtpa) due to more hard ore being mined during that year (in comparison to Year 4). As a result, Year 8 was not selected as the most conservative mine year.

- Emissions were calculated from the Operations data for each activity (e.g., material throughput, fuel use, annual hours of operation, vehicle kilometers traveled, number of blasts, amount of explosives) and the emission factors. Where necessary additional approximations were made based on best available information.

Manufacturer's specific emissions performance data for the new HFO power plant and the new non-road diesel engines for the mine fleet were not available, so conservative emission factors from the IFC guidelines and USEPA documents as described above were used. Emissions from sources such as the carbon regeneration kiln at the process plant, emergency diesel generators (< 200 hours of operation per year), employee commute vehicles, and contractor vehicles are expected to be much smaller in comparison to emissions from the power generators, non-road diesel powered mine equipment, and fugitive dust activities from surface disturbance at the Mine Site and hence, not included in this assessment. As indicated above, the emission factors used in quantifying the Project's combustion emissions are conservative, and as a result, will likely offset the other minor emissions not quantified (carbon regeneration kiln, etc).

Since the proposed Mine Site will be located in an area with high annual rainfall (estimated at over 2300 mm per year based on on-site and regional weather data), the relatively high residual soil moisture levels may prevent dust generation, particularly during the wet seasons. Some of the planned emission control measures during the Operations Phase include:

- Dust suppression as needed;
- Reclaim or revegetate disturbed areas as they become available;
- Use of low sulfur fuel for the new HFO power plant;
- Use of new HFO power plant compliant with good practice air quality performance standards for thermal power plants i.e., high energy efficiency reciprocating engines (> Tier 2 engines) and
- Use of mine equipment (drills, excavators, dump trucks, dozers, etc) with high efficiency non-road diesel engines (> Tier 2 engines).

Stack characteristics, including height, diameter, exhaust flow and temperature, were provided by the Project engineers. Table 16-2 provides a summary of the source parameters (including stack characteristics) used in the modeling analysis. Table 16-3 provides a summary of the emission rates in grams per second (or grams per second per square meters for area sources) for all sources modeled during worst-case Year 4. Detailed information on the methodology, control factors per activity, assumptions, and references used for the air emission calculations can be found in Appendix 16-A.

Table 16-2 Summary of Source Parameters used in the Modeling Analysis

(a) Point Sources

Source ID	**Source Name**	**Stack Height (m)**	**Diameter (m)**	**Exit Temperature (deg K)**	**Exit Velocity (m/s)**	UTM Easting	UTM Northing
PW1	Power Plant Recip. Generator No.1	30	1.2	586.2	32.8	771339.7	565302.3
PW2	Power Plant Recip. Generator No.2	30	1.2	586.2	32.8	771342.5	565301.3
PW3	Power Plant Recip. Generator No.3	30	1.2	586.2	32.8	771341.0	565297.2
PW4	Power Plant Recip. Generator No.4	30	1.2	586.2	32.8	771366.4	565295.2
PW5	Power Plant Recip. Generator No.5	30	1.2	586.2	32.8	771369.2	565294.0

(b) Area Sources

Source ID	**Source Name**	**Release Height (m)**	**Area (sq.m)**	**Number of Vertices**	UTM Easting	UTM Northing
MRB	Maraba_pit	0.50	1,038,383	47	772044	568715.3
ME1	Merian1_pit	0.50	869,706	104	773178	563762.2
ME2	Merian2_pit	0.50	2,107,262	114	771099	566896.9
TSF	TSF	0.50	13,265,446	164	768565	565485.2
WDA	Waste Dump Central	3.00	2,260,295	21	773567	568624.3
WDB	Waste Dump East	3.00	2,518,808	25	773210	566584.8
WDN	Waste Dump North	3.00	1,935,749	16	772046	570167.0
WDS	Waste Dump South	3.00	1,037,283	23	773535	564103.8
WDW	Waste Dump West	3.00	1,140,551	18	770114	567277.6

(c) Volume Sources

Source ID	**Source Name**	**Release Height (m)**	**Sigma-Y (m)**	**Sigma-Z (m)**	UTM Easting	UTM Northing
PPS	Process Plant - Stockpile	5	18.6	4.65	771464	565662.2
PPC	Process Plant - Crushing	8	4.65	7.44	771412	565488.0

1. The 52.5 MWe Power Plant consist of five reciprocating generators, each rated at 10.5 MWe; each generator has its own separate stack.

Table 16-3 Summary of Emission Rates for all Sources Modeled during the Most Conservative Year (Year 4)

(a) Point Sources

Source ID	Source Name	TSP	PM_{10}	$PM_{2.5}$	NOx	CO	VOC	SO_2
PW1	Power Plant Recip. Generator No.1		0.42	0.42	15.61	3.53	0.34	3.12
PW2	Power Plant Recip. Generator No.2		0.42	0.42	15.61	3.53	0.34	3.12
PW3	Power Plant Recip. Generator No.3		0.42	0.42	15.61	3.53	0.34	3.12
PW4	Power Plant Recip. Generator No.4		0.42	0.42	15.61	3.53	0.34	3.12
PW5	Power Plant Recip. Generator No.5		0.42	0.42	15.61	3.53	0.34	3.12

(b) Area Sources

Source ID	Source Name	TSP	PM_{10}	$PM_{2.5}$	NOx	CO	VOC	SO_2
MRB	Maraba Pit	15.15	4.90	0.50	0.052	0.021	0.0013	0.00022
ME1	Merian1 Pit	5.65	1.94	0.22	0.051	0.017	0.0013	0.00011
ME2	Merian2 Pit	14.38	5.11	0.51	0.053	0.024	0.0013	0.00032
TSF	Tailing Storage Facility	3.03	1.52	0.23				
WDA	Waste Dump Central	0.95	0.37	0.081				
WDB	Waste Dump East	1.02	0.40	0.086				
WDN	Waste Dump North	0.94	0.36	0.078				
WDS	Waste Dump South	0.62	0.21	0.057				
WDW	Waste Dump West	0.64	0.22	0.058				

(c) Volume Sources

Source ID	Source Name	TSP	PM_{10}	$PM_{2.5}$	NOx	CO	VOC	SO_2
PPS	Process Plant - Stockpile	0.68	0.34	0.051				
PPC	Process Plant - Crushing	10.18	3.57	0.76				

Notes:

1. The 52.5 MWe Power Plant consist of five reciprocating generators, each rated at 10.5 MWe; each generator has its own separate stack.
2. Point and volume source emissions are in units of grams per second (g/s)
3. Area source emissions are in units of grams per second per square meter (g/s-m^2)

Modeling Results and Discussion

To estimate potential air quality impacts at the Industrial Zone boundary and at closest receptors within the Study Area, air emissions from Operations at the Mine Site was modeled using the latest version of the AERMOD model (described in Chapter 16.1.1.) and associated processors, along with four years of meteorological data obtained from the nearest complete meteorological data station. Air quality impacts of PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO were predicted at the Industrial Zone boundary and at the closest receptors within the Study Area[2]. The closest and most populated receptor, Langa Tabiki, is a permanent settlement located along the Marowijne River approximately 17 km southeast of the Mine Site. Highest modeled air pollutant concentration contours from Mine Site Operations (including background ambient monitor values) experienced at the Industrial Zone boundary and closest receptors are shown on Figures 16.1-1 to 16.1-10. Summary of monitored background ambient air concentrations within the Study Area are discussed in Chapter 6; detailed information on background measurements can be found in Appendix 6-1. Detailed information on the model selection, modeling methodology and analysis, meteorological data, and receptor grid development can be found in Appendix 16-B. The modeled results reflect the maximum overall impacts of each pollutant. A brief discussion of the model results for each pollutant is provided below.

Particulate Matter less than 10 microns in diameter (PM_{10})

Figure 16-1and Figure 16-2 display contour plots (white lines) for the highest modeled annual PM_{10} and 24-hour PM_{10} concentrations respectively. Table 16-4 show that the modeled PM_{10} concentrations exceed the published IFC guideline values at Langa Tabiki and Akati with background ambient monitor values included (Apatou, which is located further northeast of the Mine Site is outside the Study Area; included in the table for information purposes only). However, Table 16-1 show that the predicted PM_{10} concentations meet the less stringent IFC/WHO interim target values of 30 to 70 µg/m^3 (annual) and 75 to 150 µg/m^3 (24-hour). The IFC guideline values are exceeded for both 24-hour and annual averaging period and their exceedances extend beyond the Industrial Zone boundary, under the assumption of Level 1 dust control (i.e., 2L/m^2/hr irrigation rates for unpaved roads, which is equivalent to 50 percent dust control). One major reason for the exceedances at the settlement areas is due to the slightly high background PM_{10} concentrations relative to the IFC limit. For example, the background annual PM_{10} concentration is 15.4 micrograms per cubic meter (µg/m^3) and the IFC guideline value for annual PM_{10} is 20 µg/m^3, which means the Merian Project annual PM_{10} concentrations should not exceed 4.6 µg/m^3 in order to meet the IFC guideline value. PM_{10} emissions are dominated by crushing activities and wheel generated dusts via haul trucks on unpaved roads at the Mine Site. While the predicted PM_{10} concentrations meet the IFC interim target values but exceed the guideline values, the goal of the Merian Project is to meet the

[2] The WHO ambient air quality standards and USEPA NAAQS have no standards or guidelines for total suspended particulates (TSP) and volatile organic compounds (VOCs), so these pollutants were not modeled. NOx was assumed to equal NO_2.

guideline values. Recommended mitigation measures listed in the following mitigation subsection (increased watering of unpaved haul roads, adding more sprayer / misters at the crusher area, etc) are expected to reduce the PM_{10} concentrations to acceptable levels.Particulate Matter less than 2.5 microns in diameter ($PM_{2.5}$)

Figure 16-3and Figure 16-4 presents the highest modeled annual and 24-hr concentrations of $PM_{2.5}$. Table 16-4 show that the modeled $PM_{2.5}$ concentrations meet the published IFC guideline values with background ambient monitor values included at all settlement areas including Langa Tabiki and Akati (Apatou, which is located further northeast of the Mine Site is outside the Study Area; included in the table for information purposes only). As shown in Table 16-1, the predicted $PM_{2.5}$ concentations also meet the less stringent IFC / WHO interim target values of 15 to 35 µg / m³ (annual) and 37.5 to 75 µg / m³ (24-hour). $PM_{2.5}$ emissions are dominated by crushing activities and wheel generated dusts via haul trucks on unpaved roads at the Mine Site. Both annual and 24-hour $PM_{2.5}$ concentrations met the IFC guideline and interim target values at all settlement areas, but the concentrations for both averaging periods extend beyond the Industrial Zone boundary.

Recommended mitigation measures listed in the following mitigation subsection (increased watering of unpaved haul roads, adding more sprayer / misters at the crusher area, etc) are expected to reduce the $PM_{2.5}$ concentrations to acceptable levels.

Table 16-4 Model Results Summary for PM_{10} and $PM_{2.5}$

	PM10 24-hr				PM10 Annual				PM2.5 24-hr				PM2.5 Annual			
Settlement Name	**Background**	**Modeled**	**Total Impact**	**IFC**	**Background**	**Modeled**	**Total Impact**	**IFC**	**Background**	**Modeled**	**Total Impact**	**IFC**	**Background**	**Modeled**	**Total Impact**	**IFC**
Langa Tibiki	21.1	29.95	**51.05**	50	15.4	7.63	**22.99**	20	7	4.81	11.81	25	5.37	1.10	6.47	10
Apatou	21.1	10.31	31.41	50	15.4	2.08	17.43	20	7	2.26	9.26	25	5.37	0.32	5.69	10
Akati	21.1	36.47	**57.57**	50	15.4	10.02	**25.37**	20	7	6.34	13.34	25	5.37	1.44	6.81	10

Note: PM10 24-hr is based on the 99th percentile (5th highest)

Nitrogen Dioxides and Sulfur Dioxide (NO_2 and SO_2)

Figure 16-5, Figure 16-6, Figure 16-7, and Figure 16-8 present the highest modeled annual NO_2, 1-hour NO_2, 24-hour SO_2, and 10-minute SO_2 concentrations, respectively. Tables 16-5 and 16-6 show that modeled NO_2 and SO_2 concentrations at all settlement areas are all below the published IFC guideline values with background ambient monitor values included. As shown in Table 16-1, the predicted 24-hour SO_2 concentations also meet the less stringent IFC / WHO interim target values of 50 to 125 µg / m³. There are no IFC interim target values for 10-minute SO_2, annual NO_2, and 1-hour NO_2 concentrations. NO_2 and SO_2 emissions are dominated by the HFO power plant located at the center of the facility and the predicted concentrations decrease rapidly with distance from the Industrial Zone boundary. Both NO_2 and SO_2 concentration met the IFC guideline values for all averaging period at all settlement areas, but the 1-hour NO_2 and 24-hour SO_2 concentrations slightly extend beyond the western portion of the Industrial Zone boundary. There are no permanent receptors within several kilometers of the Project in this direction. Recommended mitigation measures listed in the following mitigation subsection (adjusting or fine-tuning the fuel-to-air ratio for the HFO reciprocating engines during start-up and adequate maintenance of mine fleet and vehicles, etc) are expected to reduce the 1-hour NO_2 and 24-hour SO_2 concentrations to acceptable levels.

Table 16-5 Model Results Summary for NOx/NO_2

	NOx 1-hr					NOx Annual		
Settlement Name	**Background**	**Modeled**	**Total Impact**	**IFC**	**Background**	**Modeled**	**Total Impact**	**IFC**
Langa Tibiki	15	42.60	57.60	200	15	0.89	15.89	40
Apatou	15	20.78	35.78	200	15	0.35	15.35	40
Akati	15	47.40	62.40	200	15	1.17	16.17	40

Table 16-6 Model Results Summary for SO_2

		SO2 10-min					SO2 24-hr		
Settlement Name	**Background**	**1-hr Modeled**	**10-min**	**Total Impact**	**IFC**	**Background**	**Modeled**	**Total Impact**	**IFC**
Langa Tibiki	13.85	7.09	10.15	24.00	500	4.97	3.51	8.48	20
Apatou	13.85	3.47	4.96	18.81	500	4.97	2.09	7.06	20
Akati	13.85	7.97	11.40	25.25	500	4.97	4.17	9.14	20

Carbon Monoxide (CO)

Figure 16-9 and Figure 16-10 present the highest modeled 8-hour and 1-hour concentrations of CO. Modeled CO concentrations at the Industrial Zone boundary and at nearby settlements within the Study Area are all below the NAAQS published by US EPA with background ambient monitor values included. No mitigation measures are required for CO concentrations.

Table 16-7 Model Results Summary for CO

		CO 1-hr			CO 8-hr			
Settlement Name	**Background**	**Modeled**	**Total Impact**	**USEPA**	**Background**	**Modeled**	**Total Impact**	**USEPA**
Langa Tibiki	4,066.25	10.84	4077.09	40000	4,066.25	2.64	4068.89	10000
Apatou	4,066.25	5.32	4071.57	40000	4,066.25	1.22	4067.47	10000
Akati	4,066.25	11.98	4078.23	40000	4,066.25	2.99	4069.24	10000

Conclusion

Based on the information above, air quality impacts (particularly PM_{10} and $PM_{2.5}$) during Operations at the Mine Site will be moderate (low severity; high likelihood) at the Industrial Zone boundary and at the two closest permanent settlements - Langa Tabiki and Akati.

Movement of delivery trucks (supplies, reagents, etc) and fuel tankers/caravans along the Transportation Corridor (East-West Highway and Moengo-Langa Tabiki Road) will result in increased emission concentrations at nearby receptors along the corridor. Receptors such as residences, schools and houses of worship located along the corridor will likely experience increased air emissions, particularly fugitive dust during the dry season. Due to the relatively low volume of Project-related vehicle traffic volumes (23 delivery trucks and fuel tankers and 10 employee buses per day), the potential air quality impacts associated with transporting materials along the corridor during the Operation Phase will be minor (low severity; medium likelihood).

Recommended mitigation measures for air pollutant exceedances (particularly PM_{10} and $PM_{2.5}$) at the two settlements and Industrial Zone boundary are listed below. Recommended mitigation measures for the slight increase in vehicle traffic along the corridor are also listed.

Figure 16-1 Highest Modeled Annual PM10 Concentrations from Operations at the Mine Site

Figure 16-2 Highest Modeled 24-Hour PM10 Concentrations from Operations at the Mine Site

Figure 16-3 Highest Modeled Annual PM2.5 Concentrations from Operations at the Mine Site

Figure 16-4 Highest Modeled 24-Hour PM2.5 Concentrations from Operations at the Mine Site

Figure 16-5 Highest Modeled Annual NO2 Concentrations from Operations at the Mine Site

Figure 16-6 Highest Modeled 1-Hour NO2 Concentrations from Operations at the Mine Site

Figure 16-7 Highest Modeled 24-Hour SO2 Concentrations from Operations at the Mine Site

Figure 16-8 Highest Modeled 10-Minute SO2 Concentrations from Operations at the Mine Site

Figure 16-9 Highest Modeled 8-Hour CO Concentrations from Operations at the Mine Site

Figure 16-10 Highest Modeled 1-Hour CO Concentrations from Operations at the Mine Site

Mitigation Measures

To avoid or reduce the air quality impacts at the Industrial Zone boundary and at the settlement areas, the following mitigation measures are recommended:

- Implement an air quality monitoring program at the Mine Site during Pre Production and Operations phases to monitor TSP, PM_{10}, $PM_{2.5}$, NOx, SO2, and CO.
- Increase watering of disturbed surfaces such as mine haul roads, North Access Road, stockpile area, and material transfer points during dry, low humidity, and windy conditions.
- Ensure that all mine equipment, delivery trucks, and fuel tankers/caravans are maintained in accordance with manufacturer's specifications.
- Rotate spigoting of tailings to maintain moisture content and/or irrigate tailings surface to minimize dust generation.
- Implement a solid waste management plan to avoid open burning of wastes at the mine site.
- Perform regular visible fugitive dust checks on all active mine haul roads, North Access Road, stockpiles, and material transfer points.
- If required, adjust or fine-tune the fuel-to-air ratio for the HFO reciprocating engines during start-up to control NOx emissions.

Residual Impacts

Implementation of the above mitigation measures during continuous Operations at the Mine Site will reduce the air pollutant concentration levels at the Industrial Zone boundary and nearest settlements to acceptable levels and as such, will reduce air quality impacts from moderate to minor (medium severity; low likelihood).

16.1.4 Closure Phase

During the Closure Phase, the major air emission sources and activities at the Mine Site will cease and reclamation and rehabilitation will begin (for areas that have not been revegetated). Fugitive dusts and combustion emissions generated from machinery used for reclamation and re-vegetation will occur over a short time period and will be localized. Therefore, air quality impacts associated with the Closure Phase will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

16.1.5 *Post Closure Phase*

During the Post Closure Phase, air emissions will be generated from the intermittent use of vehicles / pick-up trucks during monitoring and maintenance activities after Closure activities are complete. These air emissions will occur over a short time period and will be localized. Therefore, air emission impacts associated with the Post Closure Phase will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

16.2 *GREENHOUSE GAS IMPACT ASSESSMENT*

16.2.1 *Methodology and Criteria*

The greenhouse gas (GHG) impact assessment area for the Merian Project assesses impact on a regional and global scale (not localized) due to the regional and global effects of increased GHG concentrations (released to the atmosphere) on climate change.

According to industry good practivce, projects such as the Merian Project, that are expected to produce more than 25,000 tonnes of carbon dioxide-equivalent (CO_2e)[3] annually should quantify direct emissions from the facilities owned or controlled within the physical Project boundary, as well as indirect emissions associated with the offsite production of energy used by the Project.

Direct emissions (also called Scope 1 emissions) are generally those that occur within a physical site, such as the carbon dioxide released when fuel is burned to power the mining fleet and onsite energy / electricity generation. Project-induced changes in above ground and belowground biomass (land use change) from commercial tree harvesting can also contribute to direct emissions and will be included in this GHG emissions quantification. Indirect emissions (also called Scope 2 emissions) are those that occur off the physical site, such as when electricity is purchased from the grid and coal, oil or gas is burned at some remote location to generate the power. While the emissions occur outside the physical Project boundary, the emissions will not otherwise have occurred if the facility did not purchase the electricity. For this reason, indirect emissions are also generally counted; however, there are no indirect emissions associated with the Merian Project as all electricity will be produced onsite by diesel-fired power

[3] Total GHG emissions from a source are usually reported as CO_2 equivalents (CO_2e), where the potential of each gas to increase heating in the atmosphere is expressed as a multiple of the heating potential of CO_2, or its global warming potential (GWP). For example methane (CH_4) has a GWP of 21, which means that it has a global warming effect 21 times greater than CO_2 on an equal-mass basis. The CO_2e is calculated by multiplying the emission of each GHG by its GWP and adding the results together to produce a single, combined emission rate representing all GHGs.

generators (3.33 MWe) during the Pre-Production Phase and HFO-fired power plant (52.5 MWe) during the Operations Phase.

The projected GHG footprint for the Merian Project has been developed using calculation methodologies and emission factors described in the following documents:

- International Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, Volume 4, Equation 2.12 (IPCC 2006).
- US Code of Federal Regulations, Title 40, Part 98, Subpart C - Mandatory GHG Reporting - General Stationary Fuel Combustion Sources (40 CFR 98.33).
- IFC EHS Guidelines for Thermal Plants, December 2008 (IFC 2008).

In Suriname, there are currently no policies, laws, or measures in place to reduce or mitigate the effects of GHG emissions. Industry good practice is to reduce Project-related GHG emissions. As discussed in Chapter 16.1.1, this requires projects, such as the Merian Project, that are expected to produce more than 25,000 tonnes of CO_2e annually to quantify their direct and indirect emissions. The value of 25,000 tonnes of CO_2e is not a criterion for assessing GHG impacts, but rather a value beyond which GHG quantification and reporting is required. Due to the lack of a specific numerical criteria for evaluating GHG impacts in Surinameindustry good practice, and other applicable guideline documents such as the IFC EHS Guidelines for Thermal Power Plants, or the IFC EHS Guidelines for Mining, a recommended approach for determining GHG impact criteria has been developed for the Merian Project.

For the purpose of the Merian Project, an assessment of GHG impact will be based on the likelihood and severity in terms of the Project's GHG intensity (i.e., kilograms of CO_2e per tonne of ore processed) relative to the average GHG intensity for the global gold mining industry. Based on a comprehensive data set of global gold mining (1991-2006) from multiple gold mines in Africa, Asia-Pacific, Australia, Canada, Central & South America, and United States, the average GHG intensity for the global gold mining industry is approximately 25 kg CO_2/tonne of ore processed (assumed to be 25 kg CO_2e/tonne of ore processed) (Mudd 2007).[4]

[4] The average greenhouse gas intensity for the global gold mining industry referenced in the Mudd document were in units of kg CO_2/t ore, not in kg CO_2e/t ore. For the purpose of this assessment, the CO_2 have been assumed to be in terms of CO_2 equivalents i.e., kg CO_2e/t ore, which is conservative.

Recommended criteria for determining GHG impacts are provided in Table 16-4. The impacts have been rated based on the severity of Project GHG intensity against the average GHG intensity for the global gold mining industry. The impact rating assumes that the likelihood of the event is definite.

Table 16-4 Recommended Greenhouse Gas Impact Criteria for the Merian Project

Severity of impacts	**Impact rating (where the likelihood of the event is definite)**	**Description**
< 25 kg CO_2e / t ore (i.e., less than the average GHG intensity for the global gold mining industry)	Minor	An acceptable regional impact on the social and / or natural environment (climate change) for which mitigation is desirable but not essential. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved.
25 – 50 kg CO_2e / t ore (i.e., greater than the average GHG intensity for the global gold mining industry by not more than an additional 25 kg CO_2e / t ore)	Moderate	An important regional impact on the social and / or natural environment (climate change) which requires mitigation. The impact is insufficient by itself to prevent the implementation of the Project, but in conjunction with other impacts may prevent its implementation.
> 50 kg CO_2e / t ore (i.e., greater than twice the average GHG intensity for the global gold mining industry)	Major	A serious regional impact on the social and / or natural environment (climate change) which, if not mitigated, may prevent the implementation of the Project.

Kg = kilograms; t = tonnes or metric tons; CO_2e = carbon dioxide equivalents.

16.2.2 *Pre-Production and Operations Phases*

The following potential impact to greenhouse gases is predicted to occur in the Pre-Production and Operation phases:

- Short-term increase in greenhouse gases (CO_2 equivalents) released to the atmosphere.

Construction, operation, and concurrent reclamation activities will occur concurrently during Project construction and Operations. GHG emissions will be generated mainly from commercial tree harvesting (loss of aboveground and belowground biomass), onsite power generation during construction (3.33 MWe diesel power generators), nonroad mobile diesel engine construction fleet, nonroad mobile diesel engine Operations fleet, and onsite power generation during Operations (52.5 MWe HFO power plant). The GHG emissions were quantified using the calculation methodologies and emission factors obtained from the various sources/documents listed in Chapter 16.2.1.

GHG emissions in tonnes per year were calculated from the Operations data for each activity (total area deforested, fuel use, annual hours of operation) and the emission factors. Where necessary additional approximations were made based on best available information.

Deforestation of mine haul roads, waste disposal areas, Tailings Storage Facility (TSF), and other infrastructure areas will result in the release of stored CO_2 into the atmosphere. Forests act as a major carbon store because CO_2 is taken up from the atmosphere and used to produce the carbohydrates, fats, and proteins that make up the tree. When forests are cleared, and the trees are salvaged, chipped, or left in place as mulch, this carbon is released as CO_2. This leads to an increase in the atmospheric CO_2 concentration. Approximately 5,000 ha of the Project area will be disturbed and 100 percent of this total disturbed area is conservatively assumed to contain mature canopy trees. A portion of the total disturbed area (approximately 10 percent) has already been disturbed by commercial timber companies and Artisanal and Small Scale Miners prior to/during the Pre Production Phase.

Manufacturer's specific emissions performance data for the new HFO power plant (52.5 MWe) were not available, so conservative CO_2 emission factors (449-505 g/kWh; average 477 g/kWh) from the IFC EHS Guideline for Thermal Plants (IFC 2008) were used. GHG emissions from sources such as the carbon regeneration kiln at the process plant, emergency diesel generators (< 200 hours of operation per year), employee commute vehicles (if any), and contractor vehicles are expected to be much smaller in comparison to emissions from the power generators, non-road diesel powered mine equipment, and hence, not included in this assessment. As indicated above, the CO_2 emission factors used in quantifying combustion emissions from the HFO power plant are conservative, and as a result, will likely offset the other minor emissions not quantified (carbon regeneration kiln, etc.).

Some of the planned GHG emission control measures during the Pre-Production and Operations phases include:

- Revegetate disturbed areas as they become available.
- Use of HFO in the power plant compliant with industry goo d practice; high efficiency (40-45%) and GHG performance standards for HFO-fired thermal power plants (reciprocating engines).

- Use of mine equipment (drills, excavators, dump trucks, dozers, etc) with high efficiency non-road diesel engines (> Tier 2 engines).

Table 16-5 provides a summary of the GHG emissions for the Merian Project.

Table 16-5 Summary of Greenhouse Gas Emissions for the Merian Project

Emission Source/ Activity	Maximum Greenhouse Gas Emissions (tonnes/year)[1]			
	CO_2	CH_4	N_2O	CO_2e[2]
Pre-production Phase (18 months)				
Commercial Tree Harvesting	67,689	0	0	67,689
Construction Power (3.33 MWe)	11,059	0.44	0.09	11,096
Nonroad Diesel Engines	82,254	3.29	0.66	82,526
Annual total	*161,002*	*3.73*	*0.75*	*161,311*
Year 1				
Commercial Tree Harvesting	28,550	0	0	28,550
Power Plant (52.5 MWe)	201,823	4.33	0.87	202,182
Nonroad Diesel Engines	136,466	5.45	1.090	136,919
Annual total	*366,838*	*9.78*	*1.96*	*367,650*
Year 2				
Commercial Tree Harvesting	12,463	0	0	12,463
Power Plant (52.5 MWe)	201,823	4.33	0.87	202,182
Nonroad Diesel Engines	136,466	5.45	1.090	136,919
Annual total	*350,751*	*9.78*	*1.96*	*351,563*
Year 3-12				
Commercial Tree Harvesting	0	0	0	0
Power Plant (52.5 MWe)	201,823	4.33	0.87	202,182
Nonroad Diesel Engines	136,466	5.45	1.090	136,919
Annual total	*338,289*	*9.78*	*1.96*	*339,101*

Notes:

(1) The estimated greenhouse gas emissions associated with the HFO power plant and nonroad diesel engines represent the maximum emissions that could occur in any year (worst-case emissions), so actual annual emission are expected to be lower for some years. Emissions associated with the preproduction phase represents total tonnes over an 18-month period.

(2) The carbon dioxide emisssion equivalents (CO_2e) were estimated based on the global warming potentials for carbon dioxide (1) , methane (21), and nitrous oxides (310)

Table 16-5 shows that the maximum amount of GHG emissions during Pre-Production and Operations phases is expected to occur in Year 1 (367,650 tonnes CO_2e / year). The table shows that the maximum CO_2 emissions will be generated from the HFO power plant (202,182 tonnes CO_2e / year). To put the Project's annual GHG emissions into a regional context, the emissions were compared to Suriname's annual GHG emissions. The total annual GHG estimates are small in comparison to the national (Suriname) GHG inventory of 8.802 million tonnes per year as of 2003 (Suriname, 2005). On an annual basis, the estimated 367,650 tonnes CO_2e per year from worst case Mine Year 1 is approximately 4% of the gross national emissions or 7% of national net emissions. While not certain, it is possible that Suriname's GHG inventory could have increased (due to increased mining, timber, and agricultural activities in the region) since the last national inventory in 2003, so the percent of the Merian Project GHG emissions relative to Suriname's total GHG emissions could be lower.

The maximum emissions estimate of 367,650 tonnes CO_2e / year will result in a Project GHG intensity of approximately 23 kg CO_2e per tonne of ore processed, which is less than the recommended GHG impact criteria of 25 kg CO_2e per tonne of ore processed in the global gold mine industry. Therefore, the GHG impact associated with the Pre-Production and Operations phases will be minor (severity < 25 kg CO_2e per tonne of ore processed; high likelihood). Recommended mitigation measures for GHGs released to the atmosphere (in terms of CO_2e) are listed below.

Mitigation Measures

To avoid or reduce the potential increases in GHGs (CO_2e) released to the atmosphere during Pre-Production and Operations phases the following mitigation measures are recommended:

- Ensure that all mine equipment is maintained in accordance with manufacturer's specifications.
- Implement a solid waste management plan and avoid open burning of wastes at the construction site.
- Quantify and report direct and indirect GHG emissions per good practice requirements.
- Implement energy conservation measures at the process plant. Such measures include using waste heat from the HFO power plant exhaust (exhaust gas steam boilers) to (a) heat HFO storage tanks and pre-heat HFO prior to consumption in the power plant; b) pre-heat eluate solutions to reduce diesel fuel consumption in the elution area; and (c) pre-heat carbon regeneration to reduce fuel consumption in carbon regeneration.

Residual Impacts

Implementation of the above mitigation measures during Operations at the Mine Site will reduce the severity of GHG impacts, but the Project's GHG impacts will still remain minor (severity < 25 kg CO_2e per tonne of ore processed; high likelihood).

16.2.3 Closure and Post Closure Phases

During the Closure and Post Closure Phases, the major GHG emission sources and activities at the Mine Site will cease and reclamation and rehabilitation will begin (for areas that have not been revegetated). GHG emissions generated from exhausts of machinery used for reclamation and re-vegetation (and a few vehicles/pick-up trucks used during monitoring and maintenance activities after Closure activities are complete) will occur over a short time period and will be minimal. Therefore, potential increase in GHG emissions during the Closure and Post Closure phases will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

16.2.4 Predicted Outcomes

After Project completion / Post Closure, GHG emissions at the Study Area (Mine Site and Transportation Corridor) will return to the same levels as it was prior to Pre-Production.

16.3 REFERENCES FOR CHAPTER 16

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17.0 NOISE AND VIBRATION IMPACTS

17.1 NOISE IMPACT ASSESSMENT

17.1.1 Methodology and Criteria

The noise impact assessment area for the Project assesses impacts at the Industrial Zone boundary and the closest noise sensitive receptors to the Study Area including permanent settlements along the Marowijne River and receptors within a 15 m distance from the Transportation Corridor (residences, schools, houses of worship, etc.). In addition to the Industrial Zone boundary, the Study Area for the noise assessment includes the following permanent settlements: Langa Tabiki and Akati.

The ISO 9613-2 sound propagation model (*Acoustics-Attenuation of Sound during Propagation Outdoors)* is used worldwide and was used to determine the extent of noise impacts from the Project. This model uses a standardized method for calculating sound propagation. It is also the basis for most sophisticated computer modeling programs (Ray 2010). This sound propagation model consists of octave-band algorithms with nominal mid-band frequencies from 63 to 8,000 cycles per second (hertz) for computing the attenuation of sound that originates from a point sound source, or an assembly of point sources. The source (or sources) may be mobile or stationary. The model predicts equivalent continuous A-weighted[5] sound pressure levels from sources of known sound emission and accounts for the following site conditions and physical effects:

- Meteorological conditions favorable to sound propagation (i.e., downwind propagation with wind speeds between 1 and 5 meters per second when measured 3 to 11 meters above the ground)[6];
- Ground topography and the extent of ground absorption from different surfaces;
- Octave band sound power level of each source as well as its location and elevation;

[5] A-weighted decibels, abbreviated dBA, are an expression of the relative loudness of sounds in air as perceived by the human ear. In the A-weighted scale, the decibel values of sounds at low frequencies are reduced, compared with unweighted decibels, in which no correction is made for audio frequency. This correction is made because the human ear is less sensitive at low audio frequencies, especially below 1000 Hertz, than at high audio frequencies.

[6] This is a conservative approach as not all receptors may be located downwind of the sources (i.e., receptors located upwind will experience less noise since noise propagates farther downwind than upwind).

- Location and elevation above local ground level of all sensitive receptors;
- Screening from any enclosures, barriers, earth berms, buildings or vegetation / foliage;
- Attenuation due to distance (geometrical divergence) and atmospheric absorption; and
- Increase in noise level due to reflections from nearby facades and reflective objects.

For the noise impact assessment of the proposed Merian Project, ground topography or surface effects were modeled assuming that the area around the source and the receptors is a mixed 10 percent hard, non-absorptive ground such as pavement, concrete, or water surfaces (Marowijne River) and 90 percent soft absorptive soil or grass field. Temperature and relative humidity of 20ºC and 80 percent, respectively were used in estimating the attenuation due to atmospheric absorption[7]. Attenuation due to geometric divergence or spreading is mainly a function of the distance between the sound source and the receiver. The modeling analysis followed a conservative approach by not including any potential shielding effects from pit walls, waste rock stockpiles, or vegetation / foliage.

Sound power levels for all mobile and stationary equipment at the Mine Site were based on measured octave band sound power data obtained from similar mine projects in Australia (Heggies 2010; SVT 2005). For modeling purposes it was conservatively assumed that all equipment at the Mine Site will operate continuously.

For noise modeling along the Transportation Corridor, total hourly L_{Aeq} levels for all vehicle types at 15m from center of the roadway was calculated in accordance with the United States Department of Transportation (USDOT) methodology for estimating traffic noise from highways and transit sources (USDOT 2006). The USDOT noise calculation parameters include each vehicle's reference sound levels at 50 miles per hour (80 km / hr) and at 50 feet (15 m) from center of roadways, daytime and nighttime hourly volumes of vehicles, average vehicle speed of 55 km / hr, and a speed constant for each vehicle type.

No specific regulatory standards for noise pollution exist in Suriname. In the absence of any specific standards, potential noise from the Mine Site will be

[7] Actual average temperature and relative humidity at the Mine Site (Merian Weather Station) were 26ºC and 85 %, respectively. The ISO 9613-2 model requires absorption data in multiples on ten (10ºC, 20ºC, 30ºC, 60% RH, 70% RH, 80% RH, etc) so slightly lower absorption values of 20ºC and 80 % RH were assumed. This is a conservative assumption as sound propagates farther under high temperatures.

evaluated using the noise level guidelines established by the IFC. According to the IFC General EHS Guidelines (IFC, 2007), average equivalent noise levels (L_{Aeq}) should not:

- Exceed 55 dBA during the daytime and 45 dBA during nighttime at residential, institutional, and educational areas[8];
- Exceed 70 dBA during daytime and nighttime at industrial and commercial areas; or
- Result in a maximum increase in baseline levels of 3 dBA at the nearest receptor location off-site.

17.1.2 Pre-Production Phase

The following potential impact to noise may occur in the Pre-Production Phase:

- Short-term increase in daytime and nighttime noise levels at Mine Site and along the transportation corridor.

Construction of mine infrastructure (e.g., Operations Camp, mine haul roads, waste disposal areas), well drilling, and installation of the power plant, crushers, and other process facilities will generate short-term increases in noise levels from diesel-powered construction equipment such as dozers, graders, and dump trucks. In general, average equivalent noise levels from typical construction sites range from 84 to 89 dBA at 15 m (USEPA, 1971). Using a typical 6 dBA reduction in noise level per doubling of distance for point sources (i.e., based on a general logarithmic computation that accounts for attenuation from distance/spherical spreading only), a worst case construction noise level of 89 dBA at 15 m from the Mine Site will be reduced to approximately 28 dBA at the closest and most populated settlement, Langa Tabiki, 17 km southeast of the Mine Site.

Noise levels from the construction activities will be short-term and intermittent, as equipment will be operated on an as-needed basis. All contractors on site will be required to undertake regular inspection and maintenance of all vehicles and construction equipment in accordance with manufacturer's specifications. Based on the information above (short-term construction period, distance to closest receptor, equipment maintenance, etc), the severity of impacts on noise at the Mine Site during the Pre-Production Phase is expected to be low. Therefore, the potential impacts to nearest noise receptors will be insignificant (low severity; low likelihood).

[8] For the purpose of this assessment, the receptor areas (residential, institutional, educational, etc) are defined as any area outside the Industrial Zone boundary, which includes the permanent settlements within the Study Area (i.e., along the Marowijne River).

Truck delivery of construction materials, fuel and other supplies, as well as transportation of construction workers / employees via buses along the Transportation Corridor (East-West Highway and Moengo-Langa Tabiki Road) during the Pre-Production Phase can result in increased noise levels at sensitive receptors along the corridor. Receptors such as residences, schools, and houses of worship located within 15 m from the corridor are currently being impacted by high noise levels (56-66 dBA at daytime and 50-64 dBA at night) due to the high peak hour vehicle traffic volumes ranging from 30 to over 900 vehicles per hour (see Chapter 7 - Noise and Vibration Baseline and Chapter 10- Traffic and Transportation Safety Baseline). Since the baseline noise levels along the Transportation Corridor currently exceed IFC daytime and nighttime noise guidelines for residential receptors and approach the noise guidelines for commercial and institutional receptors, construction impacts along the corridor are evaluated based on their potential to increase noise above baseline levels i.e., predicted noise levels - Project plus baseline levels - not to exceed baseline levels by more than 3 dBA, which is the threshold for perceived increases in noise (IFC 2007).

To estimate potential noise impacts on closest receptors, noise from the movement of delivery trucks and employee buses along the Transportation Corridor during the Pre-Production Phase was evaluated using the USDOT methodology as described in Chapter 17.1.1 (Methodology and Criteria). Table 17-1 shows that the addition of 16 daily round trips (six delivery trucks and 10 employee buses per day) or less than two vehicles per hour during daytime (7 a.m. and 10 p.m.) will result to 0 to 0.3 dBA increase above baseline noise levels along the transportation corridor. This level of noise increase will not be perceptible to the closest receptors (residences, schools, houses of worship, etc) and it is below the 3 dBA increase above baseline levels per IFC noise guideline (IFC 2007). In addition, the employee buses will be used during weekdays only (3-4 days per week) and the use of delivery trucks and employee buses during the Pre-Production Phase are not expected to occur at night (10 p.m. to 7 a.m.). During the Pre-Production Phase, residences located within 20 m from the Transportation Corridor will continue to experience high noise levels due to the existing traffic volumes on the corridor on weekends and weekdays with little-to-no noise increase from additional traffic from the Project. Therefore, potential noise effects on the closest receptors along the corridor due to Project-related vehicle traffic during the Pre-Production Phase will be insignificant (low severity; low likelihood).

During the Pre-Production Phase, certain materials such as the main HFO power generators and certain mill components may exceed the weight capacity of some bridges along the East-West Highway and as such, will need to be barged by river to Moengo. The frequency of barge operations (barge traffic) will be much lower than the vehicle traffic described above and the receptors / settlements along the river are much farther away than receptors along the East-West Highway and Moengo-Langa Tabiki Road. Therefore, potential noise effects on the closest receptors along the river due to infrequent barge traffic during the Pre-Production Phase will be insignificant (low severity; low likelihood).

Mitigation Measures

No additional noise mitigation measures are required during the Pre-Production Phase.

Table 17-1 Predicted Daytime Hourly Noise Levels at 15 meters from Transportation Corridor during Pre-Production Phase

Location	*Baseline Peak Hourly L_{Aeq} @ 15 m from center of Roadway*[1]	*Projected No. of Vehicle Round Trips per Day*[2]		*Projected No. of Vehicles per Hour*[3]		*Projected Hourly L_{Aeq} at 15 m from center of Roadway (dBA)*[4]			*Project plus Baseline Hourly L_{Aeq} at 15 m from center of Roadway (dBA)*	*Projected Noise Increase above Baseline Levels (dBA)*
		Heavy Trucks (for delivering construction materials, supplies, fuel, etc)	*Employee Buses*	*Heavy Trucks (for delivering construction materials, supplies, fuel, etc)*	*Employee Buses*	*Heavy Trucks (for delivering construction materials, supplies, fuel, etc)*	*Employee Buses*	*Heavy Trucks and Employee Buses*		
Weekends (Daytime)										
Bosje Brug	65.4	6	0	0.8	0	43.9	0	43.9	**65.4**	**0.0**
Tamanredjo	63.1	6	0	0.8	0	43.9	0	43.9	**63.2**	**0.1**
Abadu Kondre	59.1	6	0	0.8	0	43.9	0	43.9	**59.3**	**0.1**
Mora Kondre	55.9	6	0	0.8	0	43.9	0	43.9	**56.1**	**0.3**
Weekdays (Daytime)										
Bosje Brug	66.0	6	10	0.8	0.67	43.9	39.2	45.2	**66.0**	**0.0**
Tamanredjo	63.5	6	10	0.8	0.67	43.9	39.2	45.2	**63.6**	**0.1**
Abadu Kondre	59.0	6	10	0.8	0.67	43.9	39.2	45.2	**59.2**	**0.2**
Mora Kondre	57.4	6	10	0.8	0.67	43.9	39.2	45.2	**57.7**	**0.3**

Notes:

[1]Vehicular traffic is the dominant noise source along the Transportation Corridor so baseline hourly noise levels were estimated based on existing vehicular traffic volume on four different segments of the transportation corridor (Bosje Brug, Tamanredjo, Abadu Kondre, and Mora Kondre). See Chapter 7 - Noise and Vibration Baseline for baseline noise levels on the Transportation Corridor on weekends and weekdays.

[2] Projected number of round trips per day for heavy trucks and employee buses during Pre-Production Phase were provided by Surgold. The round trips are expected to occur during the daytime only (7 a.m. - 10 p.m.).

[3] Projected number of vehicles per hour was estimated based on the delivery trucks and employee buses operating for 15 hours during the daytime only (7 a.m. - 10 p.m.) and accounting for trips to and from the Mine Site.

[4] Total hourly L_{Aeq} for the heavy trucks and employee buses plus baseline levels was calculated in accordance with the USDOT methodology for estimating traffic noise from highways and transit sources (USDOT 2006). The calculation parameters include each vehicle's reference sound levels at 50 miles per hour and (80 km/hr) at 15 m from roadways, daytime hourly volumes of vehicles, average vehicle speed along the corridor (55 km/hr), and a speed constant for each vehicle type.

17.1.3 *Operations Phase*

The following potential impact to noise may occur in the Production Phase:

- Potential increase in daytime and nighttime noise levels at the Industrial Zone boundary.

During the Operations Phase, the primary sources of noise at the Mine Site include excavators, drills, dump trucks, loaders, track dozers, graders, water trucks, fuel lube trucks, primary gyratory crusher, pebble crusher, semi-autogenous grind (SAG) mill, ball mill, and a power plant. The primary gyratory crusher will be enclosed in a concrete building on three sides, with the fourth side partially open for access (including a roof over the top for rain protection). Similarly, the power plant will be fully enclosed, with steel/foam sandwich panel walls and roof for noise abatement, insulation, and protection for the equipment. Other noise sources at the Mine Site, such as pumps, are expected to generate noise levels much lower than the sources described above, so these were not included in the analysis. The sound power levels (L_w) for the major mobile and stationary noise sources at the Mine Site, based on data from similar operating mines, are summarized in Table 17-2.

Table 17-2 Typical Sound Power Levels for Equipment at the Mine Site

Noise Source Description	Quantity	Source Height[2] (m)	Octave Band Center Frequency (Hertz)								Overall Linear-Weighted Sound Power Level (dBL)	Overall A-Weighted Sound Power Level (dBA)
			63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz		
Each Mine Pit - Merian II, Maraba, and Merian I pits (Mobile Sources)[1]												
Hydraulic Excavator (Hitachi EX3600 Backhoe Configuration)	1	4	113	117	107	108	106	101	95	89	**119.4**	**110.4**
Hydraulic Excavator (Hitachi EX3600 Face Shovel Configuration)	1	4	113	117	107	108	106	101	95	89	**119.4**	**110.4**
Haul Truck (CAT 785D)	13	4	123	120	122	119	117	116	109	104	**127.8**	**122.3**
Blast Hole Rotary Drill (Atlas Copco DML)	2	4	120	109	104	110	112	114	116	113	**123.5**	**120.8**
Motor Grader (CAT 16H)	2	4	103	112	107	111	112	109	106	106	**118.3**	**116.2**
Large Track Dozer (CAT D10T)	2	4	118	117	104	108	107	105	97	91	**121.2**	**111.7**
Excavator	2	4	116	120	110	111	109	104	98	92	**122.4**	**113.5**

Noise Source Description	Quantity	Source Height[2] (m)	Octave Band Center Frequency (Hertz)								Overall Linear-Weighted Sound Power Level (dBL)	Overall A-Weighted Sound Power Level (dBA)
			63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz		
(CAT 349D)												
Water Truck (CAT 785D or smaller)	1	4	112	109	111	108	106	105	98	93	**117.0**	**111.5**
Fuel and Lube Truck (CAT 740B)	1	4	112	109	111	108	106	105	98	93	**117.0**	**111.5**
D-6 Wide Pad Utility Dozer	1	4	115	114	101	105	104	102	94	88	**118.2**	**108.7**
Total Lw from all sources at Merian II Pit[3]	26	4	127	126	123	122	120	119	117	114	**131.9**	**126.3**
Total Lw from all sources at Maraba Pit[3]	26	4	127	126	123	122	120	119	117	114	**131.9**	**126.3**
Total Lw from all sources at Merian I Pit[3]	26	4	127	126	123	122	120	119	117	114	**131.9**	**126.3**
Process Plant Area (Stationary Sources)[1]												
Primary Gyratory Crusher (Enclosed)	1	5	102	99	101	103	103	101	98	93	**109.9**	**107.6**
Pebble Crusher	1	5	111	112	110	110	109	106	99	89	**117.9**	**113.2**
SAG Mill	1	5	119	117	107	111	112	108	103	98	**122.4**	**115.5**
Ball Mill	1	5	119	117	107	111	112	108	103	98	**122.4**	**115.5**
Power Plant (Enclosed)	1	5	117	114	113	104	102	96	103	102	**120.1**	**110.2**
Total Lw from all sources at the Process Plant Area[3]	5	5	123	122	116	116	116	113	109	105	**127.1**	**120.3**
Total Lw from sources at all mine pits and process plant area[3]	83	4.3	132	131	128	127	126	124	122	119	**137.1**	**131.4**

Notes:
[1]Except for the excavators, SAG Mill, Ball Mill, and power plant, sound power levels (Lw) for all equipment (or equivalent) at each of the 3 mine pits and process plant area were taken from the Noise Impact Assessment for the Lynwood Quarry Minor Modification in New South Wales, Australia (Heggies 2010). Lw for the excavators, SAG Mill, and power plant were taken from the Noise Impact Assessment for the McArthur River Mine Open Cut Project in the Northern Territory of Australia (SVT 2005). Lw for the Ball Mill was assumed to be the same as the SAG Mill. The Lw for the primary gyratory crusher and power plant were each reduced by 10 dB to account for the building enclosures. Lw for sources with multiple units (e.g., 13 haul trucks) accounts for the logarithmic sum of all the units.
[2] The height for equipment at the mine pits were assumed to be 4 m based on the height for a typical dump truck. The heights for equipment at the process plant area were assumed to be 5 m based on the height for a typical primary crusher. The equipment heights were assumed as maximum height for modeling purposes.
[3] Total sound power levels from all major equipment at the mine pits and / or process plant area was calculated by logarithmically adding all the octave band sound power levels for each equipment at the site.

To estimate potential noise effects at the Industrial Zone boundary and at the closest receptors, noise from mine Operations was modeled using the ISO 9613-2 sound propagation model as described in Chapter 17.1.1. Noise effects were predicted at the Industrial Zone boundary and at the closest receptors within the Study Area. The closest and most populated receptor, Langa Tabiki, is a permanent settlement located along the Marowijne River approximately 17 km southeast of the Mine Site. Modeled daytime and nighttime noise contours from Mine Site Operations (including baseline levels) experienced at the Industrial Zone boundary and closest receptors are shown on Figure 17-1and Figure 17-2, respectively. Baseline daytime and nighttime levels at the permanent settlements along the Marowijne River were assumed to be 37.6 and 32.6 dBA, respectively (see Chapter 7)[9].

[9] Baseline daytime and nighttime noise levels were not measured at the permanent settlements. Baseline daytime levels were assumed to be 5 dBA less than the measured daytime levels at the Mine Site i.e., 42.6 dBA minus 5 dBA equals 37.6 dBA (see Chapter 7). The 5 dBA reduction accounts for the lack of exploration activities (e.g., well drilling) at the settlement areas. Baseline nighttime noise levels at the permanent settlements were assumed to be 5 dBA less than the daytime levels due to lower noise levels generally experienced at nighttime.

Figure 17-1 Daytime Noise Contours at Closest Receptors from Operations at the Mine Site

Figure 17-2 Nighttime Noise Contours at Closest Receptors from Operations at the Mine Site

Daytime Noise Effects

During the daytime (7 a.m. to 10 p.m.), total Project noise from operations at the Mine Site plus baseline levels is predicted to exceed the IFC daytime L_{Aeq} standard of 55 dBA at the northeastern and southwestern portions of the Industrial Zone boundary, but not at the nearby permanent settlements that are within the Study Area (Figure 17-1). The highest daytime L_{Aeq} level (including baseline levels) predicted at the closest and most populated settlement, Langa Tabiki (17 km southeast of the Mine Site), is 44.2 dBA, which is 10.8 dBA below the IFC daytime noise guideline. It should be noted that the noise model conservatively assumes all mine equipment shown in Table 17-2 to be operating simultaneously 24-hours a day. Under actual conditions, the predicted noise levels will likely be lower because not all equipment will be operating together simultaneously. Another conservative assumption is the fact that the model does not account for potential attenuation from vegetation / foliage or waste rock stockpiles between the mine sources and the receptors.

Blasting at the Mine Site is a source of impulsive or non-continuous noise. Blasting noise is not included in the predicted noise contours shown on Figure 17-1 because mine blasting is typically an extremely brief event (not continuous or steady) that will occur only during daytime periods. Noise impacts from blasting are unlikely for two primary reasons: 1) the uppermost several meters of ore and waste rock are saprolite and won't require blasting, and 2) when blasting occurs at depth in the pits, noise impacts from blasting will be attenuated by the pit walls and will become negligible.

Based on the information above, the total predicted noise effects at the northeastern and southwestern portions of the Industrial Zone boundary will exceed the IFC daytime noise guideline of 55 dBA; though no exceedances of the IFC guidelines are projected for any of the nearby permanent settlements within the Study Area (Langa Tabiki and Akati). Therefore, the noise effect of the Merian Project during the daytime will be minor (low severity; medium likelihood). Recommended noise mitigation measures during daytime operations at the Mine Site are listed below.

Nighttime Noise Effects

During the nighttime (10 p.m. to 7 a.m.), noise from operations at the Mine Site plus baseline levels is predicted to exceed the IFC L_{Aeq} standard of 45 dBA at the Industrial Zone boundary, but not at the nearby permanent settlements that are within the Study Area (Figure 17-2). The highest nighttime L_{Aeq} level (including baseline levels) predicted at the closest and most populated settlement, Langa Tabiki (17 km southeast of the Mine Site), is 43.5 dBA, which is 1.5 dBA below the IFC nighttime noise guideline. Blasting will not occur at night.

Based on the information above, the total predicted noise effects at the Industrial Zone boundary will exceed the IFC nighttime noise guideline of 45 dBA, though no exceedances of the IFC guidelines are projected for any of the nearby permanent settlements within the Study Area (Langa Tabiki and Akati). Therefore, the noise effect of the Merian Project during the nighttime will be minor (low severity; medium likelihood). Recommended noise mitigation measures during nighttime Operations at the Mine Site are listed below.

During the Operations Phase, movement of delivery trucks (supplies, reagents), fuel tankers/caravans, and employee buses along the Transportation Corridor (East-West Highway and Moengo-Langa Tabiki Road) will result in increased noise levels at nearby receptors along the corridor. Receptors such as residences, schools, houses of worship located within 15 m from the corridor are currently being impacted by high noise levels (56-66 dBA at daytime and 50-64 dBA at night) due to the high peak hour vehicle traffic volumes ranging from 30 to over 900 vehicles per hour (see Chapters 7 and 10). Since the baseline noise levels along the Transportation Corridor currently exceed IFC daytime and nighttime noise guidelines for residential receptors and approach exceeding the noise guidelines for commercial and institutional receptors, Project impacts along the corridor were evaluated based on the potential to increase noise above baseline levels i.e., predicted noise levels (Project plus baseline levels) not to exceed baseline levels by more than 3 dBA, which is the threshold for perceived increases in noise (IFC 2007).

To estimate potential noise effects on closest receptors, noise from the movement of delivery trucks, fuel tankers/caravans, and employee buses along the Transportation Corridor during the Operations Phase was evaluated using the USDOT methodology as described in Chapter 17.1.1. Table 17-3 shows that the addition of 33 daily round trips (23 delivery trucks and fuel tankers and 10 employee buses per day) or approximately three vehicles per hour during daytime (7 a.m. and 10 p.m.) will result to 0.1 to 0.7 dBA increase above baseline noise levels along the Transportation Corridor. This amount of noise increase will not be perceptible to the closest receptors (residences, schools, houses of worship, etc) along the corridor as it is below the 3 dBA increase above baseline levels per IFC noise guideline (IFC 2007). In addition, the employee buses will be used during weekdays only (3-4 days per week) and the use of delivery trucks, fuel tankers, and employee buses during the Operations Phase are not expected to occur at night (10 p.m. to 7 a.m.). During the Operations Phase, residences located within 20 m from the Transportation Corridor will continue to experience high noise levels due to the existing traffic volumes on the corridor with little-to-no noise increase from additional traffic from the Project. Therefore, the potential noise effects on the closest receptors along the corridor due to Project-related vehicle traffic during the Operations Phase will be insignificant (low severity; low likelihood). No additional mitigation measures are required for vehicle traffic along the corridor.

Table 17-3 Predicted Daytime Hourly Noise Levels at 15 meters from Transportation Corridor during Operations Phase

Location	Baseline Peak Hourly L_{Aeq} @ 15 m from center of Roadway[1]	Projected No. of Vehicle Round Trips per Day[2]		Projected No. of Vehicles per Hour[3]		Projected Hourly L_{Aeq} at 15 m from center of Roadway (dBA)[4]			Project plus Baseline Hourly L_{Aeq} at 15 m from center of Roadway (dBA)	Projected Noise Increase above Baseline Levels (dBA)
		Heavy Trucks (for delivering reagents, fuel, etc)	Employee Buses	Heavy Trucks (for delivering reagents, fuel, etc)	Employee Buses	Heavy Trucks (for delivering reagents, fuel, etc)	Employee Buses	Heavy Trucks and Employee Buses		
Weekends (Daytime)										
Bosje Brug	65.4	23	0	3.1	0	49.8	0	49.8	**65.5**	**0.1**
Tamanredjo	63.1	23	0	3.1	0	49.8	0	49.8	**63.3**	**0.2**
Abadu Kondre	59.1	23	0	3.1	0	49.8	0	49.8	**59.6**	**0.5**
Mora Kondre	55.9	23	0	3.1	0	49.8	0	49.8	**56.8**	**1.0**
Weekdays (Daytime)										
Bosje Brug	66.0	23	10	3.1	0.67	49.8	39.2	50.1	**66.1**	**0.1**
Tamanredjo	63.5	23	10	3.1	0.67	49.8	39.2	50.1	**63.7**	**0.2**
Abadu Kondre	59.0	23	10	3.1	0.67	49.8	39.2	50.1	**59.5**	**0.5**
Mora Kondre	57.4	23	10	3.1	0.67	49.8	39.2	50.1	**58.2**	**0.7**

Notes:

[1]Vehicular traffic is the dominant noise source along the Transportation Corridor so baseline hourly noise levels were estimated based on existing vehicular traffic volume on four different segments of the transportation corridor (Bosje Brug, Tamanredjo, Abadu Kondre, and Mora Kondre). See Chapter 7 - *Noise and Vibration* Baseline for baseline noise levels on the Transportation Corridor on weekends and weekdays.

[2] Projected number of round trips per day for heavy trucks and employee buses during Operations Phase were provided by Surgold. The round trips are expected to occur during the daytime only (7 a.m - 10 p.m.)

[3] Projected number of vehicles per hour was estimated based on the delivery trucks and employee buses operating for 15 hours during the daytime only (7 a.m. - 10 p.m.) and accounting for trips to and from the Mine Site.

[4] Total hourly L_{Aeq} for the heavy trucks and employee buses plus baseline levels was calculated in accordance with the USDOT methodology for estimating traffic noise from highways and transit sources (USDOT 2006). The calculation parameters include each vehicle's reference sound levels at 50 miles per hour and (80 km/hr) at 15 m from roadways, daytime hourly volumes of vehicles, average vehicle speed along the corridor (55 km/hr), and a speed constant for each vehicle type.

Mitigation Measures

To avoid or reduce the daytime and nighttime noise effect at the Industrial Zone boundary, the following mitigation measures are recommended:

- Ensure regular maintenance of all mine equipment and haul trucks in accordance with manufacturer's specifications;
- Install sound suppressive devices such as silencers and mufflers on mine equipment and haul trucks as necessary; and
- Implement a noise monitoring program at the Mine Site during the Operations Phase.

Implementation of the above mitigation measures during daytime and nighttime Operations at the Mine Site will reduce the likelihood of noise effects at the Industrial Zone boundary and as such, will reduce noise effects from minor to insignificant (low severity; medium likelihood).

Residual Impacts

The proposed controls and mitigations are effective at reducing impacts, leaving only a minor to insignificant residual impact.

17.1.4 Closure Phase

During the Closure Phase, the major noise sources and activities at the Mine Site will cease and reclamation and rehabilitation will begin. Noise generated from machinery used for reclamation and re-vegetation will be similar to noise generated during the Pre-Production Phase and will occur over a short time period and mostly during daytime periods when increased noise levels are more tolerable. Therefore, noise effects associated with the Closure Phase will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

17.1.5 Post Closure Phase

During the Post Closure Phase, noise will be generated from the intermittent use of vehicles / pick-up trucks during monitoring and maintenance activities after Closure activities are complete. These noise levels will occur over a short time period and mostly during daytime periods when increased noise levels are more tolerable. Therefore, noise effects associated with the Post Closure Phase will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

17.1.6 Predicted Outcomes

After Project completion / Post Closure, noise levels at the Study Area (Mine Site and Transportation Corridor) will return to the same levels as it was prior to Pre-Production.

17.2 GROUND VIBRATION AND AIRBLAST OVERPRESSURE IMPACT ASSESSMENT

17.2.1 Methodology and Criteria

Ground Vibration

The ground vibration impact assessment area for the Project assesses impacts at the Industrial Zone boundary and the closest receptors (humans and structures) within the area evaluated for air and noise impacts (i.e., permanent settlements along the Marowijne River and receptors within a 15 m distance from the Transportation Corridor; residences, schools, houses of worship).

When an explosive is detonated in a blasthole, a pressure wave is generated in the surrounding rock. As this pressure wave moves from the borehole it forms seismic waves by displacing particles beneath the ground (e.g., bedrock). Ground vibration varies with distance from the blast, charge mass per hole, type of explosive, geological conditions, and blasting specifications. For similar geological conditions and blasting specifications, ground vibration varies with distance from the blast and charge mass per hole, according to the Site Law formula. This formula has been used for assessing ground vibration impacts from blasting activities at similar mine and quarry sites and has also been used in this assessment. The formula accounts for different rock types with a site constant $k_{g;}$ typical k_g factors for free face hard / highly structured rock, free face average rock, and heavily confined rock are 500, 1,140, and 5,000, respectively (Dyno Nobel 2010). This ground vibration assessment has been conducted using a range of these three k_g factors to allow for varying degrees of vibration transmission through different rock types.

Airblast Overpressure

The impact assessment area for airblast overpressure for the Project is the same area that was used to evaluate ground vibration. An airblast is an airborne shock wave that results from the detonation of explosives. The magnitude of airblast overpressure levels at a point remote from the blast is a function of many parameters including charge mass (mass of explosive per drilled hole), confinement, burden (distance between two drilled holes and perpendicular to the free face), attenuation rate, shielding direction relative to the blast and meteorological conditions at the time of the blast. The attenuation rate for low frequency blast vibration has been found from experience to be a 9 dBL (Linear-weighted decibels) reduction per doubling of distance (Terrock 2009). Analysis of blasting data from mines and quarries has permitted a relationship to be established between the maximum 120 dBL distance (the distance in front of the blast that the 120 dBL contour occurs), charge mass per hole and burden using the Terrock model. This model has been used for assessing airblast impacts from blasting activities at similar mine and quarry sites and has also been used in this assessment. The model accounts for a dimensionless empirical constant, k_a (usually 250 for quarry and mine blasting) and determines the maximum distance to the 120 dBL contour from the blast site.

People feel vibration at very low levels and can become concerned at vibration levels well below those that can cause damage to their property. Vibration limits, therefore, have two aspects:

- An environmental or acceptable human response (annoyance) limit; and
- A limit to prevent structural damage (which should be considered separately from the limits above).

No regulations regarding ground or air vibration exist in Suriname. In the absence of any specific or absolute vibration limits, potential ground vibration and airblast overpressure from the Mine Site will be evaluated using the following guidelines or criteria:

1. New Zealand Environment and Conservation Council (ANZECC) guidelines – Technical Basis for Guidelines to Minimize Annoyance due to Blasting Overpressure and Ground Vibration (ANZECC 1990).
2. United States Department of Transportation (USDOT), Transit Noise and Vibration Impact Assessment, Federal Transit Administration (USDOT 2006).
3. Australian Standard 2187.2-2006, Explosives – Storage and Use Part 2: Use of Explosives (AS 2187-2 2006).

The criteria for control of human annoyance and structural damage are defined in terms of impact on ground vibration, measured as peak particle velocity (PPV) in millimeters per second (mm/s), and airblast overpressure, measured in Linear-weighted decibels (dBL), and are presented in Table 17-4 and Table 17-5.

Table 17-4 Recommended Ground Vibration and Airblast Overpressure Limits for Control of Human Annoyance

Vibration Type	Recommended 95th Percentile Maximum Level[1]	Maximum Level
Ground Vibration, PPV (mm/s)	5 mm/s	10 mm/s
Airblast (dBL, Peak)	115 dBL	120 dBL

Key:
PPV = Peak Particle Velocity; mm/s = millimeters per second; dBL = Linear-weighted decibel
[1]This may be exceeded on up to 5% of the total annual number of blasts
Source: ANZECC, 1990

Table 17-5 Recommended Ground Vibration and Airblast Overpressure Limits for Control of Damage to Structures

Vibration Type	Structure/ Building Category	Maximum Level
Ground Vibration, PPV (mm/s)[1]	I. Reinforced-concrete, steel or timber (no plaster)	12.7 mm/s
	II. Engineered-concrete and masonry (no plaster)	7.6 mm/s
	III. Non-Engineered timber and masonry buildings	5 mm/s
	IV. Buildings extremely susceptible to vibration damage (no plaster)	3 mm/s
Airblast (dBL, Peak)[2]	All structures/building	133 dBL

Key:
PPV = Peak Particle Velocity; mm/s = millimeters per second; dBL = Linear-weighted decibel
[1]Source: USDOT, 2006.
[2]Source: AS 2187.2, 2006.
Australian Standard 2187.2-2006 states: 'From Australian and overseas research, damage (even of a cosmic nature) has not been found to occur at airblast levels below 133 dBL…. A limit of 133 dBL is recommended as a safe level that will prevent structural/architectural damage from airblast.'

The Project will be assessed based on the most stringent ground vibration (3 mm/s) and airblast overpressure limits (115 dBL) shown in Table 17-4 and Table 17-5.

17.2.2 Pre-Production Phase

The following potential impact to ground vibration and airblast overpressure may occur in the Pre-Production Phase:

- Short-term increase in ground vibration levels at the Mine Site and along the Transportation Corridor.

Movement of loaded delivery trucks (construction materials and supplies) and employee buses on unpaved mine haul roads within the Mine Site could generate some ground vibrations within a few meters from the haul road, but such effects are expected to be insignificant (low severity; low likelihood) because rubber tired vehicles do not generate any significant amount of ground vibration (USDOT 2006). The potential for ground vibration associated with the movement of delivery trucks and employee buses on unpaved mine haul roads will be as expected for an industrial facility.

Movement of loaded delivery trucks (construction materials and supplies) and employee buses along the Transportation Corridor can generate some ground vibrations within a few meters from the haul road (particularly portions of the road with pot holes and irregularities / bumps), but such effects are expected to be insignificant (low severity; low likelihood) because rubber tired vehicles do not generate any significant amount of ground vibration (USDOT 2006).

No blasting will occur during the Pre-Production Phase, so there will be no airblast overpressure effects during this phase.

Mitigation Measures

No specific mitigation measures are required during the Pre Production Phase.

Residual Impacts

There will be no residual impacts for ground vibration and airblast overpressures during the Pre-Production Phase.

17.2.3 Operations Phase

The following potential impact to ground vibration and airblast overpressure may occur in the Operations Phase:

- Potential increase in ground vibration and airblast overpressure levels at the Industrial Zone boundary.
- Potential increase in ground vibration and airblast overpressure levels along the Transportation Corridor.

Potential increase in ground vibration and airblast overpressure levels at the Industrial Zone boundary

Modern crushers, SAG mill, ball mill, pumps, and other large stationary equipment such as those that will be installed at the process plant area are typically designed to ensure that potential ground vibration effects are minimized to acceptable levels. Vibration controls usually incorporated into the design of such large stationary equipment include vibration isolation systems such as active and cable isolators, machinery mounts, steel springs and vibration dampers. Therefore, ground vibration effects associated with the operation of these large stationary equipment is likely insignificant (low severity; low likelihood). However, blasting at the Mine Site can have adverse effects on surrounding permanent settlements and structures/ buildings with regard to ground vibration and airblast overpressure. Each of these potential effects from mine blasting is discussed further below.

Ground Vibration Effects from Blasting at the Mine Site

Except at very close distances to a blast when permanent ground displacement can occur, ground vibration is an elastic wave motion and the ground returns to its original position after the wave passes. The attenuation rate varies based on the characteristics of the rock through which the vibration travels. Characteristics such as faults and jointing planes, degree and depth of weathering and the top soil profile contribute to a wide variation of vibration levels.

The ground vibration effect from blasting at the mine pits was assessed using the Site Law formula as described in Chapter 17.2.1. The ground vibration assessment was conducted over a range of k_g factors that represent the vibration transmission through different types of ore or waste rock. Using the Site Law formula and appropriate blast parameters, the limiting distances (i.e., distances beyond which an impact will occur using different k_g factors) for ore and waste rock blasts at ground vibration levels ranging from 0.5 to 25 mm/s are shown in Table 17-6. Ground vibration contours from blasting at the Mine Site are shown on Figure 17-3 (based on a maximum k_g factor of 5,000 for heavily confined rocks).

Table 17-6 Limiting Distances for Ore and Waste Rock Blasts at Incremental Ground Vibration Levels

Blasthole Diameter[1], BD	Hole Depth or Length[1], L	Burden[1], B	Spacing[1], S	Charge Mass per hole[1], M	Ground Vibration Peak Particle Velocity, PPV	Distance from blast, D (m)		
(mm)	(m)	(m)	(m)	(kg/hole)	(mm/sec)	k_g = 500	k_g = 1,140	k_g = 5,000
171	10.0	6.10	5.3	203	25.0	92.7	155	391
171	10.0	6.10	5.3	203	20.0	107	178	449
171	10.0	6.10	5.3	203	15.0	128	213	538
171	10.0	6.10	5.3	203	10.0	164	275	693
171	10.0	6.10	5.3	203	5.0	253	424	1,068
171	10.0	6.10	5.3	203	3.0	349	584	1,470
171	10.0	6.10	5.3	203	0.5	1,068	1,788	4,506

Blasthole Diameter[1], BD	Hole Depth or Length[1], L	Burden[1], B	Spacing[1], S	Charge Mass per hole[1], M	Ground Vibration Peak Particle Velocity, PPV	Distance from blast, D (m)		
(mm)	(m)	(m)	(m)	(kg/hole)	(mm/sec)	k_g = 500	k_g = 1,140	k_g = 5,000

PPV = Peak Particle Velocity in millimeters per second (mm/s)

kg = Site specific empirical constant for predicting ground vibration levels (dimensionless). Usually determined by site calibration. Typical Kg factors for free face hard /highly structured rock, free face average rock, and heavily confined rock are 500, 1140, and 5000, respectively.
[1]Blast specifications such as blasthole diameter, hole depth or length, burden, spacing, and charge mass or explosives per hole was taken from a GMining memo titled "Conceptual Blasting at Merian dated 27 January 2012 (GMining 2012).

The recommended ground vibration limits for control of human annoyance and damage to buildings extremely susceptible to vibration damage are 5 and 3 mm/s, respectively (see Table 17-4 and Table 17-5). Assuming a worst case k_g-factor of 5,000 (heavily confined rocks) and 203 kg of explosives per blast hole, the limiting distance for blasts at ground vibration levels of 25 mm/s is 391m (Table 17-6). As shown on Figure 17-3predicted ground vibration levels will slightly exceed recommended limits at the northern and southern portions of the Industrial Zone boundary, but nearby permanent settlements within the Study Area such as Langa Tabiki and Akati will not be impacted. The maximum ground vibration level at the closest settlement from the blast site (Langa Tabiki, 17 km southeast of the Mine Site) is predicted to be in the order of 0.06 mm/s, or about 1-2% of the recommended limits. The predicted ground vibration levels at all nearby receptors due to blasting at Merian I, Merian II, and Maraba Sites will be well below the recommended ground vibration limits. Blasting will not occur at night.

Based on the information above, the total predicted ground vibration effects at the northern and southern portions of the Industrial Zone boundary will slightly exceed the most stringent ground vibration limits of 3 mm/s, but there are no projected impacts to any of the nearby permanent settlements (i.e., Langa Tabiki and Akati). Therefore, the ground vibration effect of blasting at the mine pits will be minor (low severity; medium likelihood). Recommended ground vibration mitigation measures during blasting at the Mine Site are listed in this section's mitigation measures below.

Figure 17-3 Predicted Ground Vibration Contours from Blasting at the Mine Site

Airblast Overpressure Effects from Blasting at the Mine Site

The airblast overpressure effect from blasting at the Mine Site was assessed using the Terrock model as described in Chapter 17.2.1. Using this analytical method for blasts in the pits, the 120 dBL distance for the proposed blast specifications is a maximum of 764 m in front of the blast (Table 17-7). The incremental distances for airblast overpressure levels from 100 dBL to 130 dBL were calculated using an attenuation rate of 9 dBL decrease per doubling of distance (Terrock 2009). Airblast contours for these overpressure levels from blasting at the Mine Site are shown on Figure 17-4.

Table 17-7 Limiting Distances for Ore and Waste Rock Blasts at Incremental Airblast Overpressure Levels

Hole diameter, d (mm)	**Burden, B (mm)**	**Charge mass per hole, M (kg/hole)**	**Distance to the 120 dBL contour, D_{120} (m)**	**Distance to the 130 dBL contour, D_{130} (m)**	**Distance to the 125 dBL contour, D_{125} (m)**	**Distance to the 115 dBL contour, D_{115} (m)**	**Distance to the 110 dBL contour, D_{110} (m)**	**Distance to the 105 dBL contour, D_{105} (m)**	**Distance to the 100 dBL contour, D_{100} (m)**
171	6,100	203	764	355	521	1,122	1,646	2,416	3,547

Note:
Based on the computed distance for the 120 dBL contours, the distances for the other airblast contour levels (130 dBL, 125 dBL, 115 dBL, 110 dBL, 105 dBL, and 100 dBL) were calculated using an attenuation rate of 9 dBL decrease per doubling of distance.

The most stringent airblast overpressure limits for control of human annoyance and damage to structures/buildings are 115 and 133 dBL, respectively (see Table 17-4and Table 17-5). As shown on Figure 17-4, predicted airblast overpressure levels will slightly exceed recommended limits at the northern and southern portions of the Industrial Zone boundary, but nearby permanent settlements such as Langa Tabiki and Akati will not be impacted. The maximum airblast overpressure level at the closest settlement from the blast site (Langa Tabiki, 17 km southeast of the Mine Site) is predicted to be in the order of 79.5 dBL. Therefore, the predicted airblast overpressure levels at all nearby receptors due to blasting at Merian I, Merian II, and Maraba Sites will be below the recommended airblast limits. Blasting will not occur at night.

Based on the information above, the total predicted airblast overpressure effects at the northern and southern portions of the Industrial Zone boundary will slightly exceed the most stringent airblast limits of 115 dBL, but none of the nearby permanent settlements (Langa Tabiki and Akati) are within the impacted areas. Therefore, the airblast overpressure effect of blasting at the mine pits will be minor (low severity; medium likelihood). Recommended airblast mitigation measures during blasting at the Mine Site are discussed below.

Figure 17-4 Predicted Airblast Overpressure Contours from Blasting at the Mine Site

Mitigation Measures

To avoid or reduce the ground vibration and airblast effect at the Industrial Zone boundary, the following mitigation measure is recommended:

- Monitor all open pit blasts and avoid blasting during unfavorable atmospheric conditions, such as low level inversions.

Implementation of the above mitigation measure during blasting at the mine pits will reduce the likelihood of ground vibration and airblast effects at the Industrial Zone boundary and as such, will reduce these effects from minor to insignificant (low severity; medium likelihood).

Residual Impacts

There will be no residual impacts to ground vibration or airblast overpressures at the Industrial Zone boundary after the implementation of the mitigation measures above.

Potential increase in ground vibration and airblast overpressure levels along the Transportation Corridor

During the Operations Phase, movement of loaded delivery trucks (reagents, fuel, supplies, etc.) and employee buses along the Transportation Corridor can generate some ground vibrations within a few meters from the haul road (particularly portions of the road with pot holes and irregularities/bumps), but such effects are expected to be insignificant (low severity; low likelihood) because rubber tired vehicles do not generate any significant amount of ground vibration (USDOT 2006).

No blasting will occur along the Transportation Corridor, so no airblast overpressure effects will occur along the corridor.

Mitigation Measures

No specific mitigation measures for ground vibration and airblast overpressures are required along the Transportation Corridor during the Operations Phase.

Residual Impacts

There will be no residual impacts for ground vibration and airblast overpressures along the Transportation Corridor during the Operations Phase.

17.2.4 Closure Phase

During the Closure Phase, blasting required for mine Operations will cease, so no blast-related ground vibration or airblasts will occur during this phase of the Project. Machinery used to restore / rehabilitate the Mine Site during the Closure Phase will not generate a significant amount of ground vibration, similar to Pre-Production. Therefore, potential ground vibration and airblast effects during the Closure Phase will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

17.2.5 Post Closure Phase

During the Post Closure phase, blasting at the Mine Site will have ceased, so no blast-related ground vibration or airblasts will occur during this phase of the Project. Vehicles such as pick-up trucks used intermittently during monitoring and maintenance activities after Closure activities are complete will not generate a significant amount of ground vibration. Therefore, potential ground vibration and airblast effects during the Post Closure Phase will be insignificant (low severity; low likelihood). No specific mitigation measures are required.

17.2.6 Predicted Outcomes

After Project completion / Post Closure, ground vibration and airblast overpressure levels at the Study Area (Mine Site and Transportation Corridor) will return to the same levels as it was prior to Pre-Production.

17.3 REFERENCES FOR CHAPTER 17

Australian and New Zealand Environment and Conservation (ANZECC). 1990. Technical Basis for Guidelines to Minimize Annoyance due to Blasting Overpressure and Ground Vibration.

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18.0 LANDSCAPE AND SOILS IMPACTS

18.1 METHODOLOGY AND CRITERIA

The methodology and criteria used in this assessment is based on policies and procedures recommended in industry good practice. The risks and impacts of the Project on landscape and soils were analyzed in the context of the area of influence and key stages of the Project cycle, including Pre-Production, Operations, Closure, and Post-closure phases. The risks and impacts considered direct and indirect Project-related impacts and identify any significant residual impacts.

18.2 PRE-PRODUCTION PHASE

The following potential impacts to landscape and soils are predicted to occur in the Pre-Production phase:

- Increase in soil erosion (or topsoil loss and sedimentation);
- Rutting and soil compaction; and
- Loss of growth media.

18.2.1 *Increase in Soil Erosion (or Topsoil Loss and Sedimentation)*

Impact Assessment

As described in Chapter 8 (Landscape and Soils Baseline), the soils in the northern section of the Study Area are characterized as sandy loams or mixed loams with gravel; while in the southern section, these soils tend to have a finer texture and are characterized primarily as silt loams, mixed with clays and gravel. Typical to similar tropical landscapes, the Study Area soils possess a good structure and a low to very low fertility, and are characterized by having a very thin topsoil layer.

Implementation of the proposed Project will result in the disturbance of approximately 4,965 hectares of soil, though as noted in the baseline Chapters, significant existing disturbance from Artisanal and Small-Scale Mining (ASM) activities is already present. Table 18-1provides a summary of the approximate hectares of soils to be disturbed by the various Project components and infrastructure. Potential impacts to soils could result from the Pre-Production construction of the various mine facilities, site preparation for mining (vegetation clearance and grubbing, landscape grading, and re-contouring to ensure proper drainage), and other construction activities.

Table 18-1 Summary of Total Hectares Potentially Impacted by Proposed Planned Mine Facilities

Mine Component	**Approximate Impacted Area (Ha)**
Pits	480
Waste Rock Disposal areas	940
Process Plant	40
Tailings Storage Facility	1,130
Airstrip	20
Accommodations Camp	15
Haul roads	30
Communications Tower	10
Other disturbed areas (i.e., ancillary access roads, stockpile and laydown areas, embankments, drainage works and sedimentation ponds)	2,300
Total	**4,967**

Key:
Ha = Hectares

One of the primary concerns during construction activities is soil erosion and sedimentation. Potential impacts to soils from erosion are expected to occur in areas where the slopes are steep and where the soil erosion potential is high. There are areas within the proposed Study Area that have steep slopes (i.e., greater than 20%) and where the erosion potential is moderate (i.e., soils with thin topsoil layers with sandy and loam textures, see Figure 18-1). Short-term and minor impacts are also expected to occur in areas where the soils have high erosion potential and where slopes are less than 20%. A summary of the approximate hectares of soils to be disturbed in areas where the slopes are greater than 20% is provided in Table 18-2.

Impacts due to potential increase in soil erosion (or topsoil loss and sedimentation) are considered moderate (severity: medium and likelihood: medium).

Table 18-2 Summary of Total Hectares Potentially Impacted by Proposed Planned Mine Facilities where the Slopes are Greater than 20 Percent

Mine Component	**Approximate Area Impacted with Slopes > 20% (Ha)[a]**
Pits	450
Waste Rock Disposal areas	780
Process Plant	4
Tailings Storage Facility	1,015
Airstrip	12
Accommodations Camp	1
Haul roads	6
Communications Tower	5
Other disturbed areas (i.e., ancillary access roads, stockpile and laydown areas, embankments, drainage works and sedimentation ponds)	851
Total	**3,124**

[a] Estimated based on analysis Figure 18-1 and aerial photographic interpretation.
Key:
Ha = Hectares

Mitigation

To minimize the effects of the Project on soil erosion and sedimentation, Surgold proposes to implement the following mitigation measures:

- Avoid the disturbance of areas with steep slopes to the extent possible (Figure 18-1);
- Implement best management practices in Sediment and Erosion Control Plan for soil erosion, stormwater runoff, and sedimentation control (e.g., silt fences, implementing progressive revegetation practices); and
- Implement a concurrent rehabilitation program (i.e., a Mine Closure and Rehabilitation Plan) during Operations that minimizes the amount of land that will be disturbed at one time.

Implementation of these mitigation measures would reduce the impact of the proposed Pre-Production activities on soils to minor (medium severity; low likelihood).

Figure 18-1 Slope Analysis

18.2.2 *Rutting and Soil Compaction*

Impact Assessment

Potential impacts resulting from the movement of heavy equipment required to support the planned clearance and construction activities may also impact the soil resources by causing the rutting[10] and compaction of susceptible soils. In general, compaction and rutting can affect hydrology and result in the loss of soil productivity. Given that the soils of the Study Area are primarily sands and loams mixed with gravel, which are less susceptible to compaction, compaction and rutting is not considered a widespread concern, and the impacts to the soil resources are expected to be minor (medium severity; low likelihood).

Mitigation

Rutting and compaction will be minimized by limiting off-road access. Following these mitigation measures, the impact of the proposed Pre-Production activities on soils would be insignificant (low severity; low likelihood).

Residual Impacts

The proposed controls and mitigations are effective at reducing impacts, leaving only an insignificant residual impact.

18.2.3 *Loss of growth media*

Impact Assessment

The potential for the loss of growth media (i.e., organic and mineral topsoil layers) by mixing is present during the construction of roads; during landscape vegetation clearance and re-contouring to ensure proper drainage; and during landscape grading. The mixing of the growth media with the subsoil and/or saprolite layers from these activities could impact the soils resources in the Study Area, because of the lost soil productivity and fertility, and the loss of viable seeds present in the surficial soil layers. However, as described previously the topsoil resources in the Study Area are not significant, the preservation or salvage of this resource during construction activities of mine facilities is not practical (see Chapter 8 – Landscape and Soils Baseline).

Mitigation

[10] Rutting occurs when soil strength is not sufficient to support the applied load from vehicle traffic.

Surgold proposes to salvage the topsoil layers only in those construction areas where direct salvage and replacement is possible and where concurrent reclamation is planned. In other areas where the salvage of topsoil is not feasible, Surgold proposes the salvage and the storage of the topsoil/subsoil/saprolite layers without segregating them by individual layers. This salvage material will be used as a growth media in the reclamation of the WRD and other closed facilities.

Residual Impacts

Following the described salvage and reclamation measures, the impact of the proposed Pre-Production activities on the growth media would be minor (low severity; medium likelihood).

18.3 OPERATIONS PHASE

The following potential impact to landscape and soils is predicted to occur in the Pre-Production phase:

- Soil contamination from spills or leaks.

Impact Assessment

During the planned Operations activities there would be few additional disturbances to the soil resources of the Study Area, other than the expansion of the mine pits. However, during this phase there is a potential for soil contamination to occur as a result of spills or leaks of lubricants and fuels, and chemicals handled on site that are used during the Operations of the mine or produced as a result of these activities

Mitigation

To minimize the potential for contamination of soils from accidental spills, control measures will be implemented, including use of secondary containment, drip trays for fueling, specialized training, inspections and a Spill Prevention, Control and Countermeasures Plan (SPCC). The SPCC Plan describes measures to be implemented by Surgold and its contractors to prevent, and if necessary, contain and control inadvertent spill of hazardous material such as fuels, lubricants, and mine operation chemicals, containment walls, and other measures. If soils are contaminated by an inadvertent spill, the contaminated soil will be removed and treated in an on-site treatment biopile facility or transported to an approved facility. In addition, a training module will be developed to educate employees on the SPCC Plan.

Residual Impacts

The proposed controls and mitigations are effective at reducing impacts, leaving only an insignificant residual impact.

18.4 CLOSURE AND POST-CLOSURE PHASES

The decommissioning, rehabilitation, and closure of the proposed mining areas and mining supporting facilities would have little additional impacts on the soil resources of the Study Area. Because rehabilitation and Closure activities involve the restoration of disturbed and waste rock disposal areas to a landform that approximates and blends in with the surrounding landform, no or minimal impacts to the soils are expected. Table 18-1 provides a summary of the hectares of soil expected to be disturbed by the proposed Project infrastructure and waste rock disposal facilities and tailings storage facilities, the majority of which will be rehabilitated.

The rehabilitation process involves salvaging and reusing available topsoil, subsoil, and saprolite in a timely manner, revegetating disturbed areas with native species, ripping hard-packed roads to encourage revegetation, controlling erosion, controlling invasive non-native plants and noxious weeds and monitoring results. In addition, the rehabilitation of the Tailing Storage Facility will include measures to control erosion, manage storm water runoff, minimize dust generation, and establish vegetation. Closure re-vegetation efforts will focus on areas within the tailings that are trafficable, with natural ingress of wetland species in flood prone areas.

The rehabilitation and closure process and measures to restore all disturbed areas will be detailed in a Mine Closure and Reclamation Plan prepared for the Project (a framework level closure plan is provided in Appendix 3-E). The long-term objectives of the Closure and Reclamation Plan are to establish structures and self-sustaining plant communities that blend with surrounding landscape.

19.0 WATER RESOURCES IMPACTS

This Chapter describes the impacts to water resources resulting from Project activities during all phases of the Project from Pre-Production to Operations to Closure and Post-Closure. The degree of the various impacts at the boundary of the Environmental Study Area are rated (insignificant, minor, moderate, major), based on pre-mitigation conditions including Project activities and environmental controls built into the Project design. Post-mitigation residual impact ratings are then provided, in consideration of the reduction of impacts associated with the implementation of recommended mitigation measures and the adaptive implementation of a comprehensive Water Management Plan.

19.1 OVERVIEW OF MINE SITE WATER MANAGEMENT

Open pit mining and ore processing operations such as proposed for the Merian Gold Project can potentially adverse surface water and groundwater resources both at the mining site and in the surrounding area. Surgold plans to eliminate, minimize, and / or mitigate potential impacts by incorporating numerous structural and operational environmental controls into the Project design and by developing and implementing a comprehensive adaptive Water Management Plan that actively manages the routing, collection, detention, treatment and discharge of water resources affected by Project activities.

The Project's Water Management Plan, a first draft of which is provided as an appendix to the ESMMP in Volume IV of this ESIA, establishes the framework for water management at the Project site. The Water Management Plan explains water management strategies (characterization, collection, treatment, routing, etc.) founded on the implementation of the embedded environmental controls noted below. The Water Management Plan includes plans for further reducing and mitigating potential impacts (e.g., Erosion and Sediment Control (ESC) Plan, Spill Prevention, Control and Countermeasures (SPCC) Plan, Conceptual Closure and Reclamation Plan, etc.), and provides an overview of the monitoring programs that will be implemented to confirm the effectiveness of the water management program;

The Project's water management concept, depicted schematically in Figure 19-1 and in a geographic context in Figure 19-2, will incorporate numerous structural and operational environmental controls designed to manage and minimize potential impacts t0 water resources. These include:

- Installation and active management of sediment ponds downstream of all major disturbance areas including construction areas, borrow areas, WRDs and pit disturbance areas. Sediment ponds will provide retention time to facilitate (with addition of flocculants, as necessary) the settling of suspended solids prior to discharge to local streams. Sediment ponds will be equipped with multi-level discharge outlets to manage discharge rates and attenuate peak flows;

- Incorporation of engineering controls in the process plant design, including a single stage counter current decantation (CCD) circuit to re-cycle cyanide into the process, a cyanide destruction circuit prior to discharge into the TSF, keyed dam design to minimize seepage through the surficial alluvial soil unit, and seepage collection and recovery systems described below;

- Installation and operation of an upstream drainage system to be located upstream of the main TSF dams to reduce groundwater piezometric heads, which in turn will reduce the flow of TSF-impacted seepage through the underlying quartz vein system and saprolite. The internal drainage systems will include pumps to facilitate tailing consolidation, which will further limit seepage;

- Installation of a seepage collection and recovery system along the downgradient perimeter of the TSF to capture a portion of seepage from through and under TSF dams and allow for its return to the TSF supernatant pool. Seepage collection system will include shallow seepage collection drains to capture seepage through the shallower parts of the quartz vein systems and seepage collection wells to capture seepage through the deeper parts of the quartz vein systems and the fractured saprock and fractured bedrock layers. This impact assessment chapter assumes a seepage collection efficiency of 50 percent (i.e., 50 percent of the TSF seepage will be captured and returned to the TSF), though this is thought to be conservative; and

- Installation and operation of Water Treatment Plant (WTP) to treat excess water from the TSF prior to discharge to a constructed Treated Water Storage Reservoir (TWSR) and then to the environment.

As noted above, the water resources monitoring program that has been initiated in the past several years (to establish baseline conditions) will be expanded to enable the characterization of potential Project impacts to local water resources (streamflow, TSS, water quality, etc.), establish conformance with Project EDC effluent limits and ambient water quality standards, and identify the need for additional adaptive management. The adaptive management may be in the form of implementation of site specific mitigation measures, such as implementation of ESC best management practices (BMPs) or may involve modification to water capture, routing and / or treatment practices.

In certain situations adaptive management could involve further development and implementation of contingency measures (i.e., measures not anticipated to be required, but preliminarily evaluated in case needed in the future). An example of a contingency measure would be the implementation of nitrate treatment downstream of sediment ponds should unanticipated elevated nitrogen (nitrates and / or ammonia) develop.

19.2 *GENERAL OVERVIEW OF ACTIVITIES AND POTENTIAL WATER RESOURCE IMPACTS*

The Project will be constructed along the topographic divide separating the Las Dominicanas Creek watershed (tributary to the larger Commewijne River watershed) to the west from the Merian Creek watershed (tributary to the larger Marowijne River watershed) to the east (Figure 19-2). Pre-Production, Operations and Closure activities will impact the surface water and groundwater resources in both watersheds. Impacts are discussed relative to either the Las Dominicanas or Merian Creek where impacts or mitigation differ between the two watersheds.

Project activities will alter the landscape of the Project area, changing the drainage areas contributing to the respective watersheds, filling creek beds in the Las Dominicanas Creek watershed in support of the TSF, excavating mine pits and building up WRDs in the Merian Creek watershed, and increasing impervious area with the construction of mining support infrastructure and facilities.

Without the implementation of an adaptive Water Management Plan and the installation and operation of effective structural and operational environmental controls, these alterations can result in physical impacts to local hydrology including changes to local drainage patterns, changes in average and peak flows in tributaries and the larger creeks, and changes in streambed morphology due to erosion and / or sediment deposition and increased sediment loadings (total suspended solids or TSS) in the runoff from various disturbed areas. Without implementation of effective water management, there would also be the potential for impacts to surface water quality in addition to the increased TSS / turbidity related impacts noted above, including possible increases in nitrogen, metals, and cyanide concentrations in local streams.

Project activities will also alter the groundwater hydrology of the Project area, as the TSF, mine pits, and WRDs will result in changes in groundwater elevations (e.g., water table mounding and depression effects), groundwater flow paths, infiltration patterns, seepage patterns, and recharge (baseflow contributions) in downgradient creeks. Groundwater quality will also be impacted by seepage from beneath the TSF (potential impacts related to metals and cyanide concentrations), runoff and seepage from the WRDs (potential metals and nitrogen impacts), and groundwater flow into and out of the mine pits (nitrogen, and TSF inflow related impacts). Groundwater recharges local streams (baseflow contribution), and therefore groundwater quality impacts can also contribute to surface water quality impacts.

The environmental impact assessment that follows provides a detailed discussion of potential Project impacts to surface water and groundwater resources. With one exception, the water resources impact assessment is performed in consideration of the fully developed Project, with production of approximately 5 million ounces of gold over a 14-year period (12 years mining and 14 years of processing).

The exception is related to TSF seepage and potential for water quality impacts at downgradient evaluation points. The water impacts evaluation relative to TSF seepage has been performed for the smaller, base case development project, which would involve the production of approximately 3.5 million ounces of gold over a 12-year period (10 years mining and 12 years processing). The base case would include only the Phase 1 TSF and would not include mining of the Merian 1 pits. The Project has opted to perform a detailed evaluation of the base case development as there is a greater degree of confidence in predictions for the somewhat smaller initial base case as there is uncertainty in the final design and need for Phase II of the TSF for the larger expansion case.

Water quality predictions for the base case are expected to be representative for the larger Project. This is based on the commitment that TSF seepage-related water management for the larger expansion Project will be developed using adaptive management approach based on knowledge gained during the early years of Project development relative to TSF seepage rates, seepage quality and the effectiveness of seepage collection and recovery practices.

19.3 METHODOLOGY

A detailed description of the methodologies applied in overall environmental impact assessment to estimate impacts and evaluate their severity and likelihood was provided previously in Chapter 15. The identification and evaluation of potential impacts to water resources for a mining Project can be complex, as numerous supporting technical studies are required to estimate potential changes in surface hydrology, groundwater hydrology and surface and groundwater quality as the Project progresses from Pre-Production through Post-Closure phases.

Water quality impacts were evaluated based on a comparison of predicted water quality with a set of established Project water quality criteria and existing baseline water chemistry in the receiving waters of Las Dominicanas and Merian Creeks. Water quantity impacts were evaluated based on changes from baseline flow conditions. Baseline flows are modeled flows established by means of runoff modeling as described in detail in the Merian Site-Wide Water Balance Memo (Appendix 3-D).

The following section identifies and describes the technical studies that have been performed in support of the water resources impacts evaluation and provides an overview the Project's established water quality criteria, as a component of the Project's Environmental Design Criteria (EDC).

19.3.1 Supporting Technical Studies

The water resources impact assessment is supported by a series of technical studies performed by Golder Associates Inc. (Golder). The Golder studies use various models to develop estimates of hydrologic and hydrogeologic water balances for the Project area including the initial pre-Project baseline conditions and estimated alterations in the water balances as the Project progresses through the Pre-Production, Operations, Closure and Post-Closure phases. These studies, which are provided in an Appendix to this water resources impact section, include:

- Merian Site-Wide Water Balance Model – Technical Memorandum (included as an Appendix 3-D);
- Merian Groundwater Impact Assessment (Appendix 19-A);
- Merian Pit Lake Water Balance Modeling – Technical Memorandum (Appendix 19-B); and
- Merian Geochemistry Baseline and Source Water Quality Predictions (Appendix 19-C).

The site-wide water balance was developed using the dynamic system modeling software GoldSim® to predict runoff, track water flows and establish a water balance of the surface water hydrology (streamflows) in the Project area. A conceptual model of the Project's predicted inputs to and influence on local hydrology was developed (Figure 19-1) and used as the basis of the development of the numerical model. The numerical model was run using climatic data (precipitation) for typical average, wet and dry years based on adjusted historic climate data observed in the general Project region (Alliance gauge). Runoff rates were estimated based on local topography and ground cover characteristics.

Water flows associated with Project Operations (e.g., withdrawal, discharge, evaporative losses, TSF seepage, etc.) were estimated based on changes in planned mine production rates and associated planned Operations of processing plant, TSF (including seepage collection and recovery system), WRDs, sediment ponds, Treated Water Storage Reservoir (TWSR) and other Project facilities over the life of the Project. Streamflow rates were estimated at a series of "evaluation points" at various locations in the Las Dominicanas Creek and Merian Creek watersheds, as shown in Figure 19-2.

Figure 19-1 Water Management Plan Conceptual Flow Diagram

Figure 19-2 Mine Site Water Management

Four representative periods were evaluated by the model:

- Baseline – current conditions (includes disturbed areas from historical ASM Operations);
- Pre-Production – before full scale mining; includes some harvesting and clearing to prepare site for mining;
- Operations – full scale mining;
- Post-closure – Closure restoration activities completed with Project area fully re-vegetated with mine pit lakes full.

Although variations in streamflow are anticipated at all of the evaluation points, the impact assessment is focused on potential variations in streamflow at the boundary of the Project's Environmental Study Area. Evaluation point EP-A0 is located approximately at the western limit of the Environmental Study Area, along Las Dominicanas Creek, downstream of its convergence with A3 Creek and Tempati Creek. Evaluation point EP-B0 is the most downgradient evaluation point along Merian Creek, although it is upstream of both the confluence with Tomulu Creek and the eastern boundary of the Environmental Study Area. By assessing impacts at EP-B0 the impact assessment is conservative with respect to possible impacts at the Study Area boundary, as EP-B0 does not include potential dilution afforded by inflows from the largely unaffected downstream watershed.

The groundwater flow model was developed to evaluate baseline groundwater conditions and estimate flow paths and time of travel for Project-impacted groundwater flows including seepage from the TSF, groundwater flows into and out of the mine pit, and seepage from the WRDs. Groundwater flow modeling was performed using the FEFLOW® finite element modeling software package. The groundwater flow model accounted for variations in stratigraphy (alluvial soils, saprolite (with and without quartz veins), saprock, and bedrock), and associated hydraulic conductivity, groundwater table elevations, recharge and boundary conditions.

Modeling was performed to predict groundwater flow conditions associated with Baseline (existing) conditions, during the Operations phase (at the end of mining), and during the Post-Closure phase (with Closure activities complete and mine pits flooded to an overflow elevation) approximately 25-years after the end mining. Modeling included consideration of the implementation of a range of TSF seepage collection and recovery scenarios. The impact assessment that follows assumes that a TSF seepage collection and recovery system, consisting of a series of drains and wells located downgradient of the TSF dams, will have a collection and recovery efficiency of 50 percent, though this is thought to be conservative.

The primary use of groundwater flow modeling predictions in the impact assessment was to evaluate the degree to which groundwater flows from Project areas such as the TSF, mine pit ponds, and WRDs affect baseflow and overall streamflow in downgradient surface waters (e.g., A3 Creek, Las Dominicanas Creek, Merian Creek, Tomulu Creek). Separate water quality characterizations allow for an assessment of potential water quality impacts of these baseflow contributions.

The pit lake water balance model (Appendix 19-B) was a Microsoft Excel® spreadsheet-based model that utilized output from the groundwater flow model presented above (groundwater inflow), along with assumptions relative to climatic conditions (e.g., precipitation, evaporation, evapotranspiration), runoff rates, pit configuration (e.g., storage levels, overflow elevation) to estimate the time required to naturally fill the open pits with water following the end of mining, the proportions of the various water sources entering the pits over time, and the estimated annual average discharge rates from the pit lakes, when full. The model also included a sensitivity analysis of the time for the pit to fill based on variations in precipitation, evaporation and groundwater discharge to the pits.

The geochemical characterization of mine materials, described in detail in the Merian Geochemistry Baseline and Source Water Quality Predictions Report (Appendix 19-C), involved testing of samples representative of ore, waste rock and tailings to characterize the acid rock drainage (ARD) and metal leaching (ML) potential of the mine materials and provide a basis for estimating water quality of WRD runoff and seepage and TSF supernatant and seepage. Geochemical characterization of ore, waste rock and tailings samples included chemical analysis (elemental chemical composition, whole rock analysis using x-ray fluorescence (XRF)) and mineralogical analysis using x-ray diffraction (XRD). A number of Acid Base Accounting (ABA) tests were conducted including:

- ABA by Modified Sobek Method;
- ABA by ASTM Method 1915-09;
- Biological Acid Production Potential (BAPP);
- Net Acid Generation Test (NAG); and
- Peroxide Acid Generation (PAG).

Leach testing was conducting using short-term and kinetic test methods: Synthetic Precipitation Leaching Procedure (SPLP)[11] and Toxicity Characteristic leaching Procedure (TCLP)[12] and Humidity Cell Test (HCT).

The baseline information and initial modeling results of WRD seepage and runoff quality and pit lake water quality presented in the Geochemistry report (Appendix 19-C) serve as the basis for predictions of impacts relative to ARD/ML potential and potential water quality runoff and seepage from the WRDs.

Appendix 19-C also provides estimation of TSF seepage quality based on modeling performed in support of mining associated with the base case of mining development (i.e., Phase 1 TSF). As noted previously, groundwater quality modeling was performed using the base case because the base case involves known resources and is better defined from a design perspective. Quantitative discussions of base case water quality estimates are supplemented by a qualitative discussion of anticipated expansion case water quality by comparing the relative footprints of the two cases and in consideration of the implementation of adaptive water management practices.

The geochemical evaluations indicate that the overall ARD potential of the waste rock and tailings due to sulfide oxidation is classified as "low". All tailings samples tested are considered non-acid forming (NAF), as is the bulk of the waste rock and ore, with potentially acid forming (PAF) material mostly restricted to saprolite and saprock. The fresh rock samples typically yield the highest acid generation potential; however these samples also contain the highest neutralization potential due to the presence of carbonate minerals.

Static and kinetic leach testing shows a potential for low-level leaching of metalloids specifically, arsenic, antimony, selenium and molybdenum under circum-neutral pH conditions. Release of these metalloids likely occurs in association with sulfide oxidation. Low-level cadmium leaching was observed during leach testing. Testing of tailings samples indicated a potential for copper leaching under alkaline conditions.

19.3.2 *Environment Design Criteria*

The primary basis for establishing and assigning the significance of potential water resources impacts relative to water quality is whether Project-induced water quality impacts comply with the discharge criteria and ambient water quality standards (aquatic life criteria) established in the Project's Environmental

[11] USEPA Method 1312.
[12] USEPA Method 1311.

Design Criteria (EDC). The EDC, as presented in Appendix 3-B, identifies applicable drinking water quality standards, mine effluent discharge criteria and sewage treatment plant effluent discharge criteria. The EDC also establishes site-specific ambient water quality criteria that are to be met at in receiving waters at designated points of interest (evaluation points). These standards and criteria have been developed based on the IFC EHS Guidelines, WHO drinking water standards, the International Cyanide Code and other internationally recognized standards such as those set forth by the USEPA.

This impact assessment asserts that water quality complying with established EDC effluent limits at the point of discharge and with water quality criteria at specified points of interest (evaluation points) is consistent with a minor impact designation. The EDC also addresses quantitative changes in flow in downgradient streams, indicating that controlled releases from sediment ponds, the TWSR, and the Sewage Treatment Plants (construction only), post-development peak flows in downstream receiving waters will be at or below pre-development peak flow rates.

19.4 PRE-PRODUCTION IMPACTS ON SURFACE WATER

The Pre-Production activities that have the potential to impact water resources include:

- Earth works;
- Access road construction;
- Construction of sediment pond dams and site drainage features (ditches, ponds, site diversion channels, and regrading)
- Clearing, grubbing and site preparation at west WRD site, Merian II pit site, Phase 1 TSF site, plant site and other active areas on the site;
- Stripping of Merian II pit area, excavation of Merian II pit and stockpiling of saprolitic ore;
- Construction of the main TSF dam across A3 Creek;
- Pioneer Camp sewage treatment and disposal;
- Transportation, handling and storage of fuel and reagents; and
- Commissioning and startup of the processing plant until it reaches at least 60% of its nameplate capacity.

Potential impacts that could occur to surface water resources during Pre-Production include:

- Degradation of water quality due to spills and accidents;

- Degradation of water quality due to discharge of treated sanitary sewage; and
- Increases in TSS concentrations in streams; and
- Degradation of water quality (unrelated to TSS) in Las Dominicanas Creek.

19.4.1 Degradation of Water Quality due to Spills/Accidents

During Pre-Production, a fleet of diesel fueled construction, mining and construction / mining support vehicles (e.g., excavators, haul trucks, drill rigs, graders, dozers, refueling trucks, water trucks) will operate at the Project site. Diesel generators will be installed to provide electrical power in support of Pre-Production worker camps and construction activities. Temporary storage of fuel and reagents (primarily construction related chemicals such as hydraulic fluids, lube oils, and reagents supporting operation of early sewage treatment facilities) will be established and will be replaced by permanent facilities as they are completed.

Accidents and spills associated with the transportation, handling and storage of fuel and reagents could result in the release of contaminants to the local environment, potentially adversely impacting local surface water quality. Project controls will be implemented during the Pre-Production phase to minimize the potential for such releases to the environment. These will include:

- Initial, temporary diesel fuel storage tanks will be double-walled tanks and will be stored within impermeable, bunded secondary containment areas;
- Permanent fuel farms (one for diesel and one for heavy fuel oil [HFO]) with tanks stored on impermeable surfaces within bunded secondary containment areas;
- Rain water collected within the temporary fuel storage tank containment areas and the latter permanent tank farm areas will be routed through oil / water separators prior to discharge;
- Impermeable secondary containment will be provided at the tank farm fuel transfer area to ensure containment of a spill, should one occur;
- Storage of reagents will within permanent indoor storage areas;
- Transportation of fuel and reagents will be performed in vehicles fully equipped with spill response materials and manned by staff trained in the use of this equipment.

Impact Assessment

While an accident or spill could occur, the in-place Pre-Production controls, as listed above, are anticipated to contain spills to the immediate vicinity of the incident, facilitate cleanup, and ensure that impacts, if any, are highly localized. The impact rating for potential degradation of surface water quality due to potential Project accidents or spills, as realized at the boundary of the Study Area, has been established as minor. The minor impact designation has been assigned because, without additional mitigation the likelihood of a potential accident/spill related release to impact surface waters is considered medium, but the severity of such an impact is considered low.

Mitigation

As a mitigation measure, a Spill Prevention, Control and Countermeasures (SPCC) has been developed and will be implemented. The SPCC plan, the first version is included as a component of the ESMMP in Volume IV, presents a system for reducing the potential for spills at the Merian Gold Project and for responding to such events as well as means to monitoring operations to confirm that preventative measures are in place and followed. The SPCC plan describes and specifies the measures that will be implemented by Surgold and its contractors to prevent, and if necessary, contain and control an inadvertent spill of fuels, hydraulic oils, lubricants, water treatment chemicals, paints and solvents and various reagents using sorbent pads, containment walls/berms, and other measures.

The SPCC plan provides an inventory of potential materials that could be spilled or released to the environment, their chemical properties, locations of potential spills specific controls to be implemented relative to the prevention, containment and cleanup of a spill. The plan discusses the training of operators regarding proper methods for transporting, transferring and handling substances that have the potential impact to human health or the environment and the procedures to be used to minimize the potential for releases.

The SPCC plan as provided in the ESMMP will become part of the Project's Emergency Response Plan and will be supplemented by a Cyanide Management Plan, a Hydrocarbons Management Plan and a Spill Response Plan. The Spill Response Plan will include specific details regarding the steps, roles and responsibilities in the event of a spill associated with the Project. A hazardous materials risk assessment will also be conducted and a Hazardous Materials Management Plan developed. This comprehensive approach to spill prevention and spill management will serve to prevent and/or mitigate potential spill impacts to water resources in the Project area.

Residual Impact Assessment

Effective development and implementation of the mitigation measures provided in the SPCC Plan, Spill Response Plan and other plans noted above is anticipated to reduce the impact rating for potential degradation of surface water quality due to potential Project accidents or spills, as realized at the boundary of the Study Area, to insignificant. This insignificant designation has been assigned because, with implementation of mitigation, the likelihood of a potential accident/spill related release to impact surface waters has been reduced to low.

19.4.2 Degradation of Water Quality Due to Discharge of Treated Sanitary Sewage

During the Pre-Production phase, the Pioneer Camp, Operations Camp and the Process Plant will all initially be served by temporary sanitary facilities, consisting of individual portable toilets and multiple mobile toilet trailers with holding tanks. During this initial period, portable units will be pumped out into sanitary vacuum trucks and the sewage will be transported offsite for subsequent treatment. As the Pre-Production phase moves forward, temporary facilities will be replaced by the semi-permanent facilities described below.

The Pioneer Camp sewage treatment plant (STP) will be a pre-fabricated rotary-biological treatment system with a 50 m^3/day design capacity (based on a maximum of 250 people). Treated effluent will meet Project sanitary effluent discharge criteria as presented in Table 4-5 of the EDC (Appendix 3-B). Treated effluent from the system will be discharged to the A3 Creek watershed in the vicinity of the North Fork A3 Creek.. Should the Pioneer Camp STP experience an upset condition (e.g., an equipment failure), discharge to the creek will be discontinued and effluent will be routed to the TSF (which will be in the initial stages of construction) for temporary storage until the problem in the sewage treatment system is addressed.

The Operations Camp STP will be brought on line during the latter stage of the Pre-Production phase, as the construction workforce increases. The Operations Camp STP will have a similar design as the Pioneer Camp STP and will have a capacity up to 300 m^3/day (assuming up to 1,500 people). Until the TSF becomes operational, treated effluent from the Operations Camp STP will be discharged to A3 Creek watershed in the vicinity of the North Fork A3 Creek. Once the TSF becomes operational, effluent will be discharged to the TSF.

Towards the end of Pre-Production the Process Plant STP will be brought on-line. The Process Plant STP will be similar to the treatment systems discussed above will have a capacity of up to approximately 60 m^3/day (assuming up to 1500 people) . Until the TSF becomes operational, treated effluent will be discharged to the discharged to the A3 Creek watershed in the vicinity of the North Fork A3 Creek. Once the TSF becomes operational, effluent will be discharged to the TSF.

Sewage sludge from each of the three STP's discussed above will be landfilled in an appropriate location within the confines of the future TSF or transported offsite for treatment if the TSF is not yet operational.

Impact Assessment

The North Fork A3 Creek is tributary to the larger A3 and Las Dominicanas Creek watershed. The flow rate of treated effluent from the Pioneer Camp STP is not expected to exceed 50 m^3/day (the system's design capacity). Although the Operations Camp and the Process Plant STPs have higher design capacity, it is likely that during the time that these systems discharge to A3 Creek (rather than to the TSF), their combined discharge rate is unlikely to exceed 200 m^3/day. The estimated baseflow in A3 Creek (at EP-A3) is approximately 3400 m^3/day (0.039 m^3/s) and baseflows in the larger Las Dominicanas Creek even greater (estimated at 8,640 m^3/day [0.10 m^3/s] at EP-A0). While the North Fork A3 Creek may have negligible assimilative capacity during dry periods, the larger A3 Creek and Las Dominicanas Creek watershed have substantial assimilative capacity and that, along with the fact that sewage will be treated to meet Project EDC should ensure potential water quality impacts in the larger watershed and at the boundary of the Study Area will be minor. The minor designation reflects a medium likelihood for perceptible water quality impacts, but low level of severity of impact. Impacts associated with Operations Camp and Process Plant STP discharges to the TSF (or temporary Pioneer Camp STP upset condition discharges to the TSF) are considered to be insignificant as this water will not be released to the environment but retained within the TSF and either recycled through the Process plant or treated and discharged as part of the TSF water management strategy.

Mitigation

Recommended mitigation measures have been established to maintain impacts within the watershed at a minor level. These include development and adaptive implementation of the Project's Water Management Plan that will include monitoring of sewage treatment plant effluent at the point of discharge from the treatment unit to confirm compliance with applicable Project EDC limits..

19.4.3 Increases in Total Suspended Solids (TSS) Concentrations in Streams

Pre-Production clearing, grubbing, stripping, earth moving, re-grading, and dam and structure construction activities will result in ground disturbance and increased TSS loadings in stormwater and site runoff, all of which can potentially result in increased TSS concentrations in streams downgradient of the activities. Increases in TSS concentrations can result in settling of solids (sedimentation) in low energy areas of the streams, potentially smothering areas of fish habitat, including spawning areas. Increased TSS can also adversely impact fish respiration (clogging of gills) and can contribute to water quality concerns such as reduced dissolved oxygen concentrations and increased dissolved metals concentrations.

It should first be noted that the Project area receiving waters (e.g., Merian Creek, A3 Creek, Las Dominicanas Creek and associated smaller tributaries) have all been impacted by artisanal or small scale mining (ASM) activities and regularly exhibited elevated TSS concentrations during precipitation events (concentrations in Las Dominicanas Creek have been observed to be as high as 1,440 mg/L (at SW-27 in November 2011)).

The Project will address the potential for increased sediment loadings in mine site discharge implementing a series of structural and operational environmental controls as described in greater detail in the Project Water Management Plan and its Erosion and Sediment Control (ESC) Plan component (the WMP is a component of the ESMMP as provided in Volume IV). Erosion and sediment control will be implemented using a combination source erosion control best management practices (BMPs), intermediate sediment controls in conveyance systems, and perimeter controls in the form of sediment ponds located downstream from all major disturbances. Each of these erosion and sediment controls is described in greater detail in the ESC Plan and summarized below:

- Source controls:
    - Construction of run-on diversion dikes, swales and channels to intercept, divert and convey surface runoff to prevent access to erodible areas; the planned flow diversion strategy is indicated by the blue arrows shown on Figure 19-2;
    - Use of grading and benching to control runoff from disturbed areas to receiving streams, decrease runoff velocities and collect and redistribute runoff to stable outlets;
    - Use of slope contouring, in conjunction with seeding and mulching of slopes, to reduce runoff velocities, stabilize slopes and reduce erosion;
    - Use of linear barriers and silt fences to intercept sediment-laden runoff and prevent it from exiting the source area; and
    - Use of stabilization measures such as seeding, mulching, and soil amendments to preserve existing vegetation and establish new vegetation to stabilize slopes and reduce erosion.

- Intermediate controls:

    - Placement of check dams across natural or man-made channels, across ditches along haul roads, and near the base of upper disturbed areas to reduce runoff flow velocities and reduce sediment transport by supporting settling of coarser sediments prior to runoff entering downstream sediment ponds;

    - Use of sediment traps to achieve similar goals as noted above for check dams; and

    - Use of conveyance channels to divert sediment laden runoff towards sediment trapping devices and away from undisturbed areas.

- Perimeter controls:

    - Construction of sediment ponds (shown on Figure 19-1) downstream from all major disturbance areas including all construction areas, borrow areas, WRDs, and pit disturbance areas to reduce the amount of TSS leaving the mine site into to downstream rivers;

    - Sediment ponds to be constructed prior to major disturbance and will remain in place throughout the life of the mine;

    - Sediment ponds will be impounded by earth fill (primarily compacted saprolite) embankment dams; dams will feature a principal spillway (outlet structure) designed to gradually release water and an emergency overflow spillway designed to only release flows associated with the 100-year storm event;

    - As noted above, sediment ponds have been designed to handle the 100-year, 24-hour storm event;

    - Sediment ponds have been designed to discharge water that meets EDC limits for TSS (<50 mg/L at least 95% of the time; for the remaining5% of the time the TSS can be as high as baseline conditions, up to the 25-year storm event); addition of flocculent will likely be required to meet the EDC due the high percentage of fines in the grain size distribution of saprolite; and

    - Sediment dams will also serve to control peak flow discharges. It is estimated that peak outflow from sediment pond dams for the

2-year through 100-year events will be about 40% to 95% less than the peak flow expected under existing conditions.

Source controls, intermediate controls and perimeter controls (sediment ponds) will be constructed and implemented as the Pre-Production phase progresses. Sediment ponds will play the critical role in minimizing discharges of sediment laden runoff by providing a means to capture flows with elevated sediment loadings and allow for settling of solids prior to discharge of water to the downstream watersheds beyond the delineated Study Area.

Sediment control structures will be built as the first activity within each drainage basin so that TSS concentrations from early construction activities are treated prior to discharge. Beginning during the very early period of Pre-Production phase (i.e., the brief period prior to construction of the sediment ponds) and continuing throughout the life of the Project, Best Management Practices (BMPs) for erosion and sediment control will be implemented as a means of minimizing potential elevated TSS water quality impacts.

As noted above, the TSS discharge criterion for the Project has been set at 50 mg/L, to be achieved 95 percent of the operational time period, as specified in the IFC EHS Guidelines for Mining. The remaining 5 percent of the time, releases from the Project will match or fall below the baseline TSS conditions in the receiving water.

Impact Assessment

The severity of TSS-related impacts on downstream creeks and streams at the boundary of the Study Area during the Pre-Production phase are expected to be low due to: 1) the early implementation of erosion and sedimentation control BMPs, 2) subsequent installation of sediment control structures, and 3) adherence to the Project's TSS limits. As specified in the EDC, TSS concentrations from the Project discharge points will be either lower or similar to conditions in the receiving streams for the majority of the time (50 mg/L 95% of the operational time period). This low severity rating along with a medium likelihood for elevated TSS in runoff results in a predicted minor impact rating.

Mitigation

Adaptive implementation of the Water Management Plan and its Erosion and Sediment Control Plan will serve as the means to identify excessive TSS levels in discharges and mitigate such impacts should they occur. Water quality monitoring performed of both Project discharges at the outlet of sediment ponds and the receiving waters at evaluation points EP-A0, EP-B0 and EP-C0 to confirm compliance with the Project EDC and identify the need for improvements in erosion and sediment control, if necessary.

Residual Impact Assessment

Implementation of structural and operational environmental controls along with the mitigation noted above will serve to further ensure compliance with Project EDC for TSS, reduce the potential severity of TSS-related impacts to surface water quality at the boundary of the Study Area to low, and reduce the overall impact rating to insignificant.

19.4.4 Changes in Streamflow Regime

Changes in streamflows are expected to occur during the Pre-Production Phase due to re-grading activities resulting in changes in basin divides removal of vegetation, and increased impervious areas. Re-grading around the West WRD and TSF will change the drainage divide between Merian Creek and Tempati Creek and A3 Creek resulting in a net gain (although minor) of drainage area to Tempati Creek. Absent the structural and operations controls noted in the previous section, an increase in drainage basin areas, reduction in vegetated areas, and increases in impervious areas would result in higher average streamflow rates as well as increases in peak flows.

During construction of the main TSF dam across A3 Creek, streamflow from upstream will be captured by a small sediment dam and then routed around the tailings dam construction or pumped over the embankment and discharged back into the existing streambed. Once the tailings dam is completed all surface water runoff above the dam will be ponded behind the dam and pumped to A3 Creek. The completion of the main tailings dam is likely to occur sometime near the end of Pre-Production; however, for simplicity, the impacts of the completed dam are evaluated in the Pre-Production phase of the Project.

Impacts resulting from an increase in peak flows can include increases in bank erosion, changes in stream morphology and changes to streambed characteristics, all of which can contribute to impacts to aquatic ecology. Stormwater management best practice is considered to include maintaining post-development peak flows to meet pre-development flow rates (Ontario Ministry of the Environment, 2003.)

As noted above, the combination of water storage provided in the sediment ponds and the controlled release of the water stored in the ponds by their principal spillway outlet discharge structure effectively reduce peak flow discharge rate from the disturbed watersheds to significantly less than pre-development peak flows. Table 19-1 presents an overview of peak flow analysis performed using the SEDCAD model and presented in more detail in the ESC Plan (a component of the ESMMP in Volume IV). The peak flow analysis indicates that the sediment ponds are estimated to reduce peak flows by as much as approximately 40 to 95 percent from the pre-development peak flow rates from the same watersheds. Note that these calculations were performed based on the fully developed mine site (i.e., they are more representative of the Operations Phase), but concept of reduction of peak flow discharges also applies to the Pre-Production phase.

Under normal (non-peak flow) operating conditions, outflow from the sediment ponds will be generally equal to inflow to the ponds. The outlets from the pond will also be designed to release water during low flow (dry) conditions. The outlets will be configured to release the lesser of either flow required to support downstream water needs or the minimum of inflow to the pond.

Estimated changes in average monthly streamflows for normal, wet and dry years for the Pre-Production phase at the boundary of the Project Study Area at Las Dominicanas Creek and Merian Creek are presented in Table 19-2 and Table 19-3, respectively. Dry and wet year estimates represent average monthly flows associated with monthly precipitation rates that are exceeded (based on annual recurrence intervals) 95 percent of the time for dry years and 5 percent of the time for wet years. These average monthly streamflow estimates assume that sediment ponds neither increase nor decrease the average flows in the watershed.

During Pre-Production, average streamflows are expected to increase from baseline at most evaluation points as areas are stripped of vegetation. The removal of vegetation, along with increased impervious surfaces in certain areas, will result in decreased water loss to the atmosphere via evaporation and evapotranspiration and result in increased runoff rates and increased streamflow.

As shown in Table 19-2 and Table 19-3, increases in streamflow at the boundaries of the Las Dominicanas Creek (EP-A0) and Merian Creek (EP-B0) watersheds during the last year of Pre-Production are relatively minor, generally between 2 to 5 percent at EP-A0 and generally between 0 to 20 percent at EP-B0.

Table 19-1 Estimated Peak Flows from Merian Sediment Ponds

Item	Return Period					
	2-year	5-year	10-year	25-year	100-year	500-year
SEDIMENT POND #1						
Existing Peak Flow (cms)	6.0	10.2	15.3	19.6	29.8	39.5
Estimated Peak Discharge (cms)	1.5	2.0	2.9	3.7	4.7	5.6
Percent of Existing	25%	20%	19%	19%	16%	14%
SEDIMENT POND #2						
Existing Peak Flow (cms)	21.3	37.6	57.5	74.5	115.5	155.0
Estimated Peak Discharge (cms)	1.2	3.3	4.7	4.9	5.3	8.2
Percent of Existing	6%	9%	8%	7%	5%	5%
SEDIMENT POND #3						
Existing Peak Flow (cms)	20.4	35.9	54.9	71.2	110.3	148.0
Estimated Peak Discharge (cms)	4.6	4.9	5.1	5.3	5.7	9.7
Percent of Existing	23%	14%	9%	7%	5%	7%
SEDIMENT POND #4						
Existing Peak Flow (cms)	16.3	28.6	43.7	56.7	87.7	117.7
Estimated Peak Discharge (cms)	3.0	4.7	4.9	5.1	5.5	9.4
Percent of Existing	18%	16%	11%	9%	6%	8%
SEDIMENT POND #5A						
Existing Peak Flow (cms)	5.2	9.2	13.9	18.0	27.7	37.1
Estimated Peak Discharge (cms)	2.1	3.7	5.1	5.2	5.5	8.3
Percent of Existing	39%	40%	37%	29%	20%	23%
SEDIMENT POND #5B						
Existing Peak Flow (cms)	5.5	9.5	14.4	18.6	28.5	38.1
Estimated Peak Discharge (cms)	3.1	5.1	5.3	5.4	5.8	9.0
Percent of Existing	56%	53%	36%	29%	20%	24%
SEDIMENT POND #6						
Existing Peak Flow (cms)	14.9	25.8	38.8	49.9	76.5	101.9
Estimated Peak Discharge (cms)	0.5	1.2	2.6	3.9	6.7	8.8
Percent of Existing	3%	4%	7%	8%	9%	9%
SEDIMENT POND #7						
Existing Peak Flow (cms)	6.6	11.1	16.4	20.9	31.3	41.2
Estimated Peak Discharge (cms)	4.2	4.8	5.0	5.2	5.7	9.7
Percent of Existing	63%	43%	31%	25%	18%	24%

Table 19-2 Estimated Monthly Average Streamflow in Las Dominicanas Creek at EP-A0 – Pre-Production (m3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	1.12	0.85	0.84	1.32	2.29	2.36	1.35	0.64	0.25	0.25	0.33	0.92
Wet	1.36	1.00	0.99	1.62	2.89	2.97	1.65	0.75	0.29	0.28	0.38	1.15
Dry	0.94	0.75	0.73	1.11	1.85	1.90	1.12	0.54	0.22	0.22	0.29	0.74
Last Year of Pre-Production Streamflow (m^3/s)												
Normal	1.16	0.88	0.87	1.37	2.35	2.42	1.38	0.66	0.26	0.26	0.34	0.94
Wet	1.42	1.03	1.03	1.68	2.97	3.05	1.70	0.78	0.30	0.29	0.39	1.18
Dry	0.97	0.77	0.75	1.15	1.90	1.95	1.15	0.56	0.23	0.23	0.30	0.76
% Difference Between Baseline and Last Year of Pre-Production												
Normal	3.6%	3.2%	3.4%	3.2%	2.7%	2.5%	2.9%	3.6%	4.2%	3.5%	4.2%	2.4%
Wet	3.9%	3.7%	3.8%	3.4%	2.9%	2.6%	3.1%	4.0%	4.9%	4.2%	4.8%	2.6%
Dry	3.3%	2.7%	2.9%	2.9%	2.5%	2.3%	2.6%	3.2%	3.5%	2.9%	3.6%	2.2%

Table 19-3 Estimated Monthly Average Streamflow in Merian Creek at EP-B0 – Pre-Production (m3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	2.60	1.84	1.86	3.03	5.40	5.53	3.09	1.45	0.55	0.51	0.73	2.20
Wet	3.26	2.26	2.29	3.83	6.95	7.09	3.90	1.78	0.66	0.61	0.88	2.82
Dry	2.10	1.54	1.55	2.46	4.26	4.34	2.49	1.18	0.46	0.44	0.62	1.72
Last Year of Pre-Production Streamflow (m^3/s)												
Normal	2.65	1.91	1.94	3.10	5.40	5.52	3.18	1.57	0.63	0.58	0.86	2.40
Wet	3.33	2.34	2.39	3.92	6.96	7.08	4.03	1.94	0.77	0.71	1.04	3.07
Dry	2.14	1.58	1.60	2.52	4.26	4.34	2.56	1.28	0.52	0.49	0.71	1.87
% Difference Between Baseline and Last Year of Pre-Production												
Normal	2.1%	3.4%	3.9%	2.4%	0.1%	-0.1%	3.1%	8.6%	14%	14%	17%	8.8%
Wet	2.2%	3.7%	4.2%	2.5%	0.1%	-0.1%	3.2%	9.1%	16%	16%	18%	9.1%
Dry	2.0%	3.1%	3.5%	2.2%	0.1%	-0.1%	2.9%	7.9%	13%	12%	15%	8.4%

Las Dominicanas Creek Pre-Production flows for normal years, while greater than baseline flows for normal years, are well below the baseline flow values for wet years. This indicates that during normal years, Pre-Production phase flows in Las Dominicanas Creek at the Boundary of the Study Area are expected to fall with the range of maximum flow values currently experienced in the creek. While Pre-Production wet year flows are expected to be greater than baseline wet year flows, only one months (June) is predicted to have flows in excess of the highest Baseline wet year monthly flow value. This indicates that, except for this one wetter month, Pre-Production wet year flow rates fall within the range of flows currently experienced in Las Dominicanas Creek at the boundary of the Study Area.

A similar comparison of data for Merian Creek indicates only minor differences in Pre-Production phase streamflow as compared to baseline flows. Maximum Pre-Production wet year flows are all predicted to be below the current baseline maximum wet year monthly flows, indicating that predicted Pre-Production streamflow at the Study Area boundary in Merian Creek are predicted to fall within the range of flows currently experienced in the creek.

Note that there is very limited disturbance in the Tomulu Creek watershed during the Pre-Production period, so tables of predicted changes in streamflow at evaluation point EP-C0 are not presented. Modeled predictions provided in the in the water balance technical memorandum (Appendix 3-D) indicate minor increases in streamflow of less than 3 percent for most of the year with the largest predicted increases approaching 7 percent in the dryer months of September through November.

Impact Assessment

This data demonstrates that while more substantial increases in streamflow may occur in the smaller tributary streams and creeks within the Study Area, impacts in the major receiving streams at the Study Area boundary should be less than those predicted further upstream. Furthermore, changes in streamflow will fall generally within the range of existing flows in the creeks. With Project controls in-place, the severity of streamflow impacts at the Study Area boundary at Las Dominicanas Creek, Merian Creek and Tomulu Creek are anticipated to be of low severity and the overall impact rating is predicted to be minor.

Mitigation

As with TSS, adaptive implementation of the WMP, its ESC Plan and associated monitoring will promote the early identification of potential downstream impacts relative to increased streamflow and the potential need for improvement of erosion control measures, such as implementation of channel improvements, bank stabilization, instream energy dissipation, and/or other mitigative measures as identified in the ESC Plan.

Residual Impact Assessment

Implementation of these various mitigation measures, as needed, is expected to maintain the potential severity of streamflow impacts at the Study Area Boundary at low and maintain the overall impact rating at minor.

19.4.5 *Degradation of Water Quality in Las Dominicanas Creek*

Potential Pre-Production phase impacts to water quality in Las Dominicanas Creek will be associated with discharge of treated water from the TWSR. Water collecting in the TSF pond will be routed through a water treatment system (the WTP) and the treated effluent will be conveyed to the TWSR. Excess water from the TWSR will be discharged to the North Fork A3 Creek, a tributary to Las Dominicanas Creek. Discharges from the TWSR will meet Project EDC discharge criteria.

Although potential contributions of TSF-impacted baseflow (seepage) discharging to surface water in A3 Creek could eventually pose a surface water impact, Pre-Production operation of the TSF will be at a reduced production rate and limited to just one or two years at the end of the Pre-Production phase. Due to the limited seepage of groundwater from the TSF during Pre-Production because of the small area inundated, it is not anticipated that seepage from the TSF could impact water quality during Pre-Production.

Impact Assessment

Based on the commitment by Surgold that the TWSR discharge will meet Project EDC discharge criteria, which is generally equivalent to the criteria for the protection of aquatic life, and the flow from A3 Creek will experience additional dilution as it enters Las Dominicanas Creek upstream of the Study Area Boundary, the Pre-Production water quality impact on Las Dominicanas Creek is defined as minor due to a medium likelihood of occurrence accompanied by a low intensity severity.

Mitigation

Recommended mitigation includes optimization of the operation of the wastewater treatment plant and adaptive implementation of the Water Management Plan that includes water quality monitoring of the discharge from the TWSR and water quality monitoring and biological monitoring (as described in the Chapter 21 Biological Resources Impacts) in Las Dominicanas Creek. Improvements to water management systems would be implemented in response to observed water quality issues, if necessary. With the implementation of these mitigation measures, as necessary, Pre-Production water quality impacts in Las Dominicanas Creek are predicted to remain minor.

19.5 *OPERATIONS IMPACTS ON SURFACE WATER*

The Operations activities that have the potential to impact water resources include:

- Open-pit mining and development / management of WRDs including progressive reclamation of WRDs;
- Management of mine pits and pit water;
- Ore processing and associated tailings management including management of TSF and associated seepage and supernatant water
- Treatment of supernatant water from TSF;
- Discharge of treated water from TWSR;
- Operation of accommodations including treatment and delivery of potable water and sewage treatment and domestic waste management;
- Waste management; and
- Transportation, handling and storage of fuels and reagents.

Potential impacts that could occur during the Operations phase are:

- Degradation of water quality due to spills and accidents;
- Increases in TSS in streams;
- Changes to streamflow regime in streams;
- Degradation of water quality in Las Dominicanas Creek;
- Degradation of water quality in Merian Creek; and
- Degradation of water quality in Tomulu Creek

19.5.1 *Degradation of Water Quality due to Spills/Accidents*

The Operations phase will involve a larger fleet of diesel fueled construction, mining and construction / mining support vehicles (e.g., excavators, haul trucks, drill rigs, graders, dozers, refueling trucks, water trucks) operating at the Project site. Power generation will be achieved using an HFO-fired power generating facility, with use of diesel generators as backup. Diesel fuel and HFO will be stored in separate permanent tank farms and various reagents will be stored in dedicated indoor storage areas.

Accidents and spills associated with the transportation, handling and storage of fuel and reagents could result in the release of contaminants to the local environment, potentially adversely impacting local surface water quality. Project controls will be implemented during the Operations phase to minimize the potential for such releases to the environment. These will include:

- Permanent fuel farms (one for diesel on for HFO) with tanks stored on impermeable surfaces within bunded secondary containment areas;
- Rain water collected within fuel storage tank containment areas will be routed through oil/water separators prior to discharge;
- Impermeable secondary containment will be provided during fuel deliveries to ensure containment of a spill, should one occur;
- Storage of reagents in indoor storage area and within double-walled storage tanks; and
- Transportation of fuel and reagents will be performed in vehicles fully equipped with spill response materials and staff trained in their use.

Impact Assessment

While an accident or spill could occur, the in-place Operations phase controls, as listed above, are anticipated to contain spills to the immediate vicinity of the incident, facilitate cleanup, and ensure that impacts, if any, are highly localized. The impact rating for potential degradation of surface water quality due to potential Project accidents or spills, as realized at the boundary of the Study Area, has been established as minor. The minor impact designation has been assigned because, without additional mitigation the likelihood of a potential accident/spill related release to impact surface waters is considered medium, but the severity of such an impact is considered low.

Mitigation

As noted in the Pre-Production evaluation, as a mitigation measure, an SPCC plan has been developed and will be implemented. The SPCC plan, the first version is included as a component of the ESMMP in Volume IV, presents a system for reducing the potential for spills at the Merian Gold Project and for responding to such events as well as means to monitoring operations to confirm that preventative measures are in place and followed. The SPCC plan describes and specifies the measures that will be implemented by Surgold and its contractors to prevent, and if necessary, contain and control an inadvertent spill of fuels, hydraulic oils, lubricants, water treatment chemicals, paints and solvents and various reagents using sorbent pads, containment walls/berms, and other measures. Refer to the Pre-Production impacts section for additional details regarding the SPCC plan.

Residual Impact

Effective development and implementation of the mitigation measures provided in the SPCC Plan, Spill Response Plan and other plans noted above in the Pre-Production impacts section (ESMMP, Emergency Response Plan, Cyanide Management Plan, Spill Response Plan, etc.) is anticipated to reduce the impact rating for potential degradation of surface water quality due to potential Project accidents or spills, as realized at the boundary of the Study Area, to insignificant. This insignificant designation has been assigned because, with implementation of mitigation, the likelihood of a potential accident/spill related release to impact surface waters has been reduced to low.

19.5.2 Increase in TSS concentrations in Receiving Streams

During Operations, runoff from exposed areas such as WRDs, material stockpiles, roadways, and the can potentially result in increased sediment (TSS) loadings to local receiving waters. As discussed in detail in the previous Pre-Production section, elevated TSS concentrations in local creeks and streams can contribute to increased sediment deposition in low energy areas, potentially smothering local fish habitats, can adversely impact fish respiration (clogging gills), and can contribute to water quality concerns such as reduced dissolved oxygen concentrations and increased dissolved metals concentrations.

The Project area receiving waters (Merian Creek, A3 Creek, Las Dominicanas Creek and associated smaller tributaries) have been impacted by ASM activities and regularly exhibit elevated TSS concentrations during precipitation events. As described in the Pre-Production impacts section, implementation of erosion and sediment control measures such a source controls (diversion swales, benching, silt fencing, etc.), intermediate controls (check dams, sediment traps, etc.), and most importantly perimeter controls (sediment ponds downstream of all major disturbances), will reduce soil erosion in disturbed areas and facilitate settling of suspended solids prior to discharge to local streams..

An additional measure that will be implemented to reduce potential TSS loadings will be the progressive and concurrent reclamation of WRDs and other disturbances. This will serve to reduce the total area of exposed disturbance at any given time, reducing overall sediment contributions to runoff.

Impact Assessment

Adherence to the relatively strict 50 mg/L (during 95 percent of the operational time period) Project EDC TSS discharge criterion will serve to ensure that TSS concentrations in Operations phase runoff discharges will be typically below and/or of the same general range as existing TSS concentrations in the receiving waters. As with the Pre-Production phase, the Operations phase impact rating for increased TSS levels in receiving streams is also anticipated to be minor. Sediment control in the Las Dominicanas Creek watershed will become easier as the mine develops as the TSF will serve as very effective controls of sediment generation and since the creation of the largest disturbances are during Pre-Production.

Mitigation

Adaptive implementation of the Water Management Plan and its Erosion and Sediment Control Plan will serve as the means to identify excessive TSS levels in discharges and mitigate such impacts should they occur. Water quality monitoring performed of both Project discharges at the outlet of sediment ponds and the receiving waters at evaluation points EP-A0, EP-B0 and EP-C0 to confirm compliance with the Project EDC and identify the need for improvements in erosion and sediment control, if necessary.

Additional mitigation will include the implementation of a concurrent rehabilitation program for not just WRD areas, but all exposed areas in order to minimize the total land area that is exposed at any given time.

Residual Impact Assessment

As with Pre-Production, implementation of structural and operational environmental controls along with the mitigation noted above will serve to further ensure compliance with Project EDC for TSS, reduce the potential severity of TSS-related impacts to surface water quality at the boundary of the Study Area to low, and reduce the overall impact rating to insignificant.

19.5.3 Changes in Streamflow Regime

Most of the changes in streamflow patterns and associated changes in streamflow rates initiated during the Pre-Production phase (and discussed in detail in the Pre-Production section) will continue to develop and expand during the Operations phase as mine area, WRD area development, and TSF area developments continue to progress and change.

The sediment ponds effectiveness in reducing peak flow discharges to below pre-development levels will continue during the Operations phase.

Estimated changes in average monthly streamflows for normal, wet and dry years for the last year of the Operations phase at the boundary of the Project Study Area at Las Dominicanas, Merian Creek and Tomulu Creek are presented in Table 19-4, Table 19-5 and Table 19-6, respectively

During Operations, average streamflows are expected to increase from baseline and Pre-Operation flows at most evaluation points as areas continue to be stripped of vegetation and impervious areas increase, which increases surface water runoff and streamflow.

As shown in Table 19-4 and Table 19-5, more substantial increases in streamflow are anticipated at the boundary of the Las Dominicanas Creek watershed due to the smaller watershed area (as compared to Merian Creek), shifting of some flow away from Merian Creek and towards the Las Dominicanas Creek watershed, and storage of water within open mine pits within the Merian Creek watershed. Predicted increases in streamflow in Tomulu Creek (Table 19-6) are minor, due to the land disturbance in the watershed.

As noted in the previous assessment of Pre-Production estimated streamflows, Las Dominicanas Creek and Merian Creek accommodate relatively large flows during wet periods at the boundary of the Project Study Area. Predicted Operations phase flows are greater than the predicted Pre-Production flows and, as result, will exceed existing baseline flows more frequently and to a greater degree. In all three watersheds, normal year and wet year Operations phase flows are predicted to exceed the maximum wet year baseline flow rate in the respective watershed only two months (May and June). While Operations phase flows in other months are greater than the respective monthly wet year flow values, they are within the range of maximum flow currently experienced in Las Dominicanas Creek, Merian Creek and Tomulu Creek at the Study Area boundary.

The Project's installation of sediment ponds downstream of disturbed area as well as the implementation of progressive or concurrent reclamation of disturbed areas as they become available will further contribute to reducing potential changes to both monthly average and peak streamflows. The sediment pond outlet structures will also be configured support, to the extent practicable, the discharge of minimum flows to support aquatic life in the downstream watershed during dry, low flow conditions.

Impact Assessment

This data again demonstrates that while more substantial increases in streamflow may occur in the smaller tributary streams and creeks within the Study Area, impacts in the major receiving streams at the Study Area Boundary should be less than those predicted further upstream. With Project controls in-place, the severity of streamflow impacts at the Study Area boundary at Las Dominicanas Creek, Merian Creek and Tomulu Creek are anticipated to be of low intensity and the overall impact rating is predicted to be minor.

Table 19-4 Estimated Monthly Average Streamflow in Las Dominicanas Creek at EP-A0 - Operations (m3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	1.12	0.85	0.84	1.32	2.29	2.36	1.35	0.64	0.25	0.25	0.33	0.92
Wet	1.36	1.00	0.99	1.62	2.89	2.97	1.65	0.75	0.29	0.28	0.38	1.15
Dry	0.94	0.75	0.73	1.11	1.85	1.90	1.12	0.54	0.22	0.22	0.29	0.74
Last Year of Operations Streamflow (m^3/s)												
Normal	1.62	1.23	1.24	1.85	3.20	3.29	2.07	1.21	0.60	0.47	0.62	1.41
Wet	2.20	1.68	1.69	2.49	4.07	4.28	2.69	1.58	0.80	0.73	0.72	1.89
Dry	1.34	1.05	1.05	1.53	2.42	2.47	1.54	0.86	0.44	0.43	0.54	1.14
% Difference Between Baseline and Last Year of Operations												
Normal	45%	45%	48%	39%	40%	39%	54%	90%	138%	92%	89%	54%
Wet	61%	68%	70%	54%	41%	44%	63%	110%	177%	162%	92%	65%
Dry	43%	41%	44%	37%	31%	30%	38%	58%	98%	90%	86%	54%

Table 19-5 Estimated Monthly Average Streamflow in Merian Creek at EP-B0 – Operations (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	2.60	1.84	1.86	3.03	5.40	5.53	3.09	1.45	0.55	0.51	0.73	2.20
Wet	3.26	2.26	2.29	3.83	6.95	7.09	3.90	1.78	0.66	0.61	0.88	2.82
Dry	2.10	1.54	1.55	2.46	4.26	4.34	2.49	1.18	0.46	0.44	0.62	1.72
Last Year of Operations Streamflow (m^3/s)												
Normal	3.37	2.50	2.54	3.83	6.31	6.44	3.91	2.08	0.90	0.81	1.19	2.97
Wet	4.27	3.12	3.17	4.89	8.14	8.28	4.98	2.58	1.11	0.99	1.45	3.81
Dry	2.70	2.05	2.07	3.09	4.96	5.04	3.12	1.67	0.74	0.68	0.97	2.31
% Difference Between Baseline and Last Year of Operations												
Normal	30%	36%	36%	27%	17%	16%	27%	43%	63%	58%	62%	35%
Wet	31%	38%	38%	28%	17%	17%	27%	45%	67%	63%	66%	35%
Dry	29%	33%	34%	26%	16%	16%	25%	41%	59%	54%	58%	34%

Table 19-6 Estimated Monthly Average Streamflow in Tomulu Creek at EP-C0 – Operations (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	0.62	0.45	0.45	0.71	1.23	1.25	0.73	0.36	0.14	0.13	0.19	0.53
Wet	0.78	0.56	0.56	0.91	1.58	1.61	0.92	0.45	0.18	0.16	0.23	0.68
Dry	0.50	0.37	0.37	0.58	0.96	0.98	0.58	0.29	0.12	0.11	0.16	0.42
Last Year of Operations Streamflow (m^3/s)												
Normal	0.65	0.47	0.48	0.74	1.26	1.28	0.76	0.39	0.16	0.14	0.21	0.56
Wet	0.82	0.59	0.60	0.95	1.62	1.65	0.96	0.48	0.20	0.18	0.26	0.72
Dry	0.52	0.39	0.39	0.60	0.99	1.00	0.61	0.31	0.13	0.12	0.17	0.44
% Difference Between Baseline and Last Year of Operations												
Normal	4.7%	5.8%	5.8%	4.2%	2.3%	2.3%	4.2%	7.0%	10%	10%	10%	5.5%
Wet	4.8%	6.1%	6.0%	4.3%	2.3%	2.3%	4.2%	7.2%	11%	10%	10%	5.5%
Dry	4.6%	5.5%	5.6%	4.1%	2.3%	2.3%	4.1%	6.8%	10%	9.7%	9.7%	5.5%

Mitigation

Adaptive implementation of the WMP, its ESC Plan and associated monitoring will promote the early identification of potential downstream impacts relative to increased streamflow and the potential need for improvement of erosion control measures, such as implementation of channel improvements, bank stabilization, instream energy dissipation, and/or other mitigative measures as identified in the ESC Plan.

Residual Impact Assessment

Implementation of these various mitigation measures, as needed, is expected to maintain the potential severity of streamflow impacts at the Study Area Boundary at low and maintain the overall impact rating at minor.

19.5.4 Degradation of Water Quality in Las Dominicanas Creek

Potential Operations phase impacts to water quality in Las Dominicanas Creek will be associated with TSF-impacted baseflow (seepage) discharging to surface water in A3 Creek and with discharge of treated water from the TWSR to A3 Creek. Impacts during the early years of Operations from the TSF seepage are likely to be negligible because of the small TSF area, however as Operations progress, seepage will begin to discharge to A3 Creek. The A3 Creek is a tributary to Las Dominicanas Creek and contributes to water quality in the larger watershed.

Groundwater modeling (Appendix 19-B) indicates that mounding of the groundwater table will occur beneath the TSF as it is gradually filled over the Pre-Production and Operations phase. Installation and operation of a drainage system upstream of the main TSF dams will lower piezometric heads upgradient of the TSF and reduce mounding to a limited degree. Without a seepage collection system, this mounding and the associated seepage from the TSF is predicted to contribute to substantial additional baseflow (as much as approximately 3,000 m^3/day [0.035 m^3/s]) to the Las Dominicanas watershed towards the end of the Operations period, that would enter the Las Dominicanas and A3 Creeks as baseflow. Modeling predicts that as much as 80 percent (2,401 m^3/day) of this TSF seepage would potentially be captured by the seepage collection system and pumped returned to the TSF pond. The resultant predicted baseflow contribution to Las Dominicanas Creek at EP-A0 is 599 m3/day (0.007 m^3/s).

Once TSF seepage reaches A3 and Las Dominicanas Creeks, any potential impacts will be larger during drier periods in September through November, when flows in the streams are dominated by groundwater contributions. Without the seepage collection system, during dry (baseflow) conditions, an estimated 32% of the streamflow at EP-A0 would be impacted by the Project. With the seepage collection system intercepting TSF seepage at the rate noted above, only approximately 9% of the streamflow at EP-A0 would be impacted by the Project.

As presented in more detail in the Geochemistry Baseline and Source Water Quality Prediction report (Appendix 19-C), TSF supernatant and seepage quality will be controlled by the qualities of the various inflows to the facility and their relative volumes as well as the tailings geochemistry. TSF supernatant water quality is expected to exhibit temporal variability due to changes in (1) TSF input water qualities, and (2) the relative volumes of TSF inputs and outputs (i.e., changes in the TSF water balance on a seasonal and annual basis). Recirculation of TSF supernatant for use in the process plant may result in concentration increases over time.

As described in detail in Appendix 19-C, two geochemical models were developed to estimate TSF supernatant quality: a metals model to evaluate metal and nutrient concentrations and a cyanide model to evaluate cyanide concentrations within the TSF supernatant.

Geochemical testing of the tailings was conducted by Newmont Metallurgical Services (NMS) to characterize the metal leaching and acid rock drainage (ARD) potential of the tailings. Testing included standard static and kinetic laboratory testing. Geochemical testing results indicate a low ARD potential for the Project tailings due to low sulfide content and the presence of carbonate minerals. In association with a low ARD potential, metal leaching is also classified as low; however, test results do indicate the potential for metal leaching to generate leachates with constituent concentrations that exceed project water quality standards in the TSF.

To estimate TSF pond water quality, a range of water qualities was assigned to each inflow. Input water qualities were defined based on the results of geochemical testing and baseline monitoring. Mixing geochemical modeling was conducted to estimate the range of expected constituent concentrations in TSF pond water during operations. Model results were generally consistent with water quality data presented for low sulfide gold quartz vein deposits and monitoring results from Rosebel mine, a gold mine in Suriname that is considered to be a useful analogue site for the Project.

The TSF pond water quality evaluation yielded the following predictions relative to supernatant water quality:

- Ammonia and copper are predicted to the primary contaminants of potential concern, with predicted water quality in the TSF pond greater than 5 times their most stringent respective Project EDC concentrations;
- Numerous metals (antimony, arsenic, barium, cadmium, chromium, cobalt, molybdenum, nickel, selenium, thallium and zinc), could also exceed their most stringent respective Project EDC concentrations, but the exceedance is predicted to be less than a factor of 5 times the EDC;
- Nitrate (based on total nitrogen) could also exceed it most stringent EDC, but by less than a factor of 5; total nitrogen concentrations on the order of 40 mg/L-N are predicted; and
- Cyanide concentrations in the TSF pond are predicted to be low, likely less than 0.5 mg/L and possibly less than 0.1 mg/L; this is due to implementation of cyanide destruction of tailings prior to discharge and natural attenuation of cyanide in the open pond environment

As described in Appendix 19-C, transport of constituents present in TSF seepage through groundwater has been characterized to evaluate impacts to both groundwater and surface water resources. The saprolite material underlying the TSF contains variable amounts of iron oxides, clays, and organics; all substances that have high inherent sorptive properties. Laboratory testing using saprolitic materials from the site indicates a potential for metals attenuation due to sorption onto saprolite. Groundwater modeling indicates that groundwater seepage velocities through the saprolite are low and that sorption is predicted to be a natural control on the transport of metals along saprolite pathways. No significant increase in most groundwater metals concentrations is predicted.

Nitrogen species (nitrate and ammonia) can attenuate under anaerobic (reducing) conditions; however, water quality evaluations performed in support of the ESIA assume nitrogen species to be conservative constituents that do not attenuate as they are transported along groundwater pathways.

Relative to saprolite, groundwater velocities in quartz veins are predicted to be much greater. Metals attenuation is not predicted to be significant for quartz vein groundwater pathways. However, the groundwater model predicts that a majority of the seepage flowing through quartz veins will be captured by the seepage collection system and returned to the TSF.

In addition to baseflow contributions and stormwater runoff from the immediate watershed, the other flow that will affect water quality in A3 Creek and Las Dominicanas Creek watershed will be discharges of water from the TWSR. Excess supernatant from the TSF pond will be routed to WTP, where it will be treated and the treated effluent will be sent to the TWSR and eventually discharged to the A3 Creek.

The conceptual design of the WTP is provided in Volume IV as a technical memorandum attachment to the Water Management Plan. Treatment in the WTP will include conventional lime and iron precipitation/co-precipitation system for the removal of metals supplemented by the ability to provide removal of ammonia, as needed, by breakpoint chlorination. The WTP will have a nominal treatment capacity of 1,200 m^3/hr, but will have the flexibility to treat up to 1,800 m^3/hr. Mean annual flow to the WTP is estimated to be approximately 800 m^3/hr or approximately 7 million m^3/yr.

In addition to the discharge from the WTP, the TWSR will receive approximately 6 million m^3/yr of unaffected runoff from the surrounding watershed and some limited quantity of TSF seepage that is not captured by the seepage collection system. Water quality of the discharge from TWSR will meet Project EDC discharge criteria. Water in the TWSR is expected to have high hardness as a result of lime addition during treatment. The TWSR discharge, mixed with direct runoff in the A3 and Las Domincanas Creek watershed and with TSF seepage baseflow contributions, is anticipated to result in an in-stream water quality at EP-A0 that complies with the applicable Project EDC. During the dry season (September and October) when baseflows dominate, the TWSR effluent will support compliance at EP-A0 both by diluting TSF seepage affected baseflow contributions and increasing hardness, which will increase the hardness dependent criteria of copper and other metals.

The TWSR as currently designed will have a 2 million m^3 live storage volume, and a regulating valve/gate that will allow stored water to be released as needed. Because the annual inflow volume to the TWSR will be much greater than the available storage volume, most flow will be immediately released and the TWSR will generally operate as a flow through system. During the dry season active management of the release from the TWSR will be implemented to ensure that sufficient water is available downstream to mix with TSF affected baseflow contributions so that by dilution and increased hardness levels, compliance will be achieved at EP-A0. Water balance modeling (Appendix 3-D) demonstrates that a minimum year round release rate of 700 m^3/hr from the TWSR would achieve Project water quality objectives at EP-A0. Releases greater than 700 m^3/hr are expected to occur most of the year when the TWSR pool is at its target operating volume.

Impact Assessment

The Site-Wide Water Balance and Mass Balance Mixing Model (Appendix 3-D) provides estimates of water quality in streams located downgradient of the TSF including A3 Creek at EP-A3 (an internal monitoring point) and Las Domincanas Creek at EP-A0 (the evaluation/compliance point at which Project instream EDC are to be met). Water quality estimates were developed for those constituents most likely to cause an exceedance of an EDC instream limit at an evaluation point, including copper, antimony, selenium, nitrogen and cyanide. The water quality estimates were developed using the "base case" development project as described previously in Section 19.2.

Water quality predictions for the base case are expected to be representative for the larger Project. This is based on the commitment that TSF seepage-related water management for the larger expansion Project will be developed using adaptive management approach based on knowledge gained during the early years of Project development relative to TSF seepage rates, seepage quality and the effectiveness of seepage collection and recovery practices.

Appendix 3-D provides a series of detailed tables and figures of predicted water quality during the last year of Operations at EP-A0 for the parameters listed above. The water quality evaluation assumes up to 50 percent capture of TSF seepage with return to the TSF pool and operation of the WTP to up to 1,800 m^3/hr depending on TSF pool volume. This information includes comparison of predicted water quality with baseline water quality at EP-A0 and the respective Project EDC limit. The discussion below provides a summary of the predicted instream concentrations; Appendix 3-D should be referenced for more detailed information.

<u>Metals</u>

Copper concentrations at EP-A0 during the Operations phase are predicted to be greatest during dry years and during dry months, consistent with periods when baseflow contributions of TSF affected seepage would make up a greater proportion of flow in the local streams. The assumed baseline concentration of copper at EP-A0 is approximately 0.001 mg/L. Predicted Operations phase copper concentrations range from 0.0016 to 0.0043 mg/L. The predicted hardness adjusted EDC limit values (chronic ambient water quality criteria) range from 0.0043 to 0.0151 mg/L. Predicted copper concentrations are typically at least 0.002 mg/L below the associated EDC limit, indicating that copper concentrations are anticipated to comply with the applicable Project EDC at the Study Area Boundary (EP-A0).

Antimony concentrations are predicted to be low throughout the life of the mine (and during the Operations phase), typically in the range of 0.0030 to 0.0035 mg/L. This is only slightly above the assumed baseline concentrations (0.0026 to 0.0028 mg/L) and below the applicable Project EDC value of 0.006 mg/L.

Selenium concentrations are similarly predicted to be low throughout the life of the mine (and during the Operations phase), typically in the range of 0.0031 to 0.0038 mg/L. This is only slightly above the assumed baseline concentrations (0.0026 to 0.0028 mg/L) and below the applicable Project EDC value of 0.005 mg/L.

Total Nitrogen

The Appendix 3-D model provides predictions of total nitrogen during the Operations phase. Baseline total nitrogen concentrations at EP-A0 are assumed to be in the range of 0.15 to 0.17 mg/L. The model predicts total nitrogen concentrations during the Operations phase in the range of 1.5 to 7.5 mg/L, with highest concentrations occurring during dry months (September and October) and dry years. The Project EDC provides limits for nitrate, nitrite and ammonia. If all of the nitrogen were present as nitrate, predicted concentrations would be below the Project EDC limit of 10 mg/l. The WTP will include a breakpoint chlorination process which should ensure that ammonia concentrations are below the 4.5 mg/L Project EDC. Nitrite is generally metastable and represents an intermediate form of nitrogen in nitrification and denitrification reactions. Nitrate is typically not the dominant form of nitrogen and WTP breakpoint chlorination process will oxidize nitrite to nitrate. Consequently, nitrate concentrations are expected to be low in the WTP discharge and at EP-A0.

Cyanide

The Appendix 3-D model provides predictions of total cyanide during the Operations phase. Baseline total cyanide concentrations at EP-A0 are assumed to be approximately 0.01 mg/L. The model predicts total cyanide concentrations during the Operations phase in the range of 0.019 to 0.050 mg/L, with highest concentrations occurring during dry months (September and October) and dry years. The Project EDC provides limits for total cyanide, weak acid dissociable (WAD) cyanide and free cyanide. The Project EDC for total cyanide is 1.0 mg/L and predicted concentrations at EP-A0 are well below this. The Project EDC for WAD cyanide and free cyanide are much lower; 0.5 mg/L and 0.005 mg/L, respectively. There is some potential to exceed the Project EDC at EP-A0 if a significant proportion of total cyanide were to exist as free cyanide. TSF pond water cyanide modeling results predict that pond water cyanide concentrations will remain below 0.1 mg/L. Based on data from an analogue site, WAD cyanide concentrations within the TSF pond are expected to be less than half of total cyanide concentrations. Further reductions in WAD and free cyanide concentrations are expected within the TWSR due to volatilization.

The water quality evaluation indicates that with adaptive implementation of the WMP including treatment of tailings in the process plant (CCD circuit and cyanide detoxification), treatment of TSF supernatant in the WTP, TSF seepage collection and return, and controlled discharge from the TWSR during the dry season, the Project is anticipated to meet Project EDC in Las Dominicanas Creek at the Study Area boundary (EP-A0) during the Operations phase. Based on this anticipated general compliance, the anticipated severity of potential water quality impacts in Las Dominicanas Creek at the boundary of the Project Study Area is considered low. The likelihood rating is considered medium. The overall impact rating has been assigned as minor.

Mitigation

Although a minor impact rating was assigned, TSF seepage quality and fate and transport can be unpredictable and there is the potential for short-duration exceedances of the Project EDC at EP-A0. Adaptive implementation of the WMP, including implementation of the water quality monitoring program, will allow for early detection of potential water quality issues and reactive implementation of mitigative actions such as treatment modifications at the process plant and/or WTP, increased seepage collection, and modified operation of TWSR discharges.

Residual Impact Assessment

Implementation of appropriate mitigation measures, as necessary, would serve to maintain the impact rating for potential Operations phase degradation of water quality in Las Dominicanas Creek at minor.

19.5.5 *Degradation of Water Quality in Merian Creek*

Operations phase impacts to water quality in Merian Creek will be associated with pit water and WRD seepage and runoff water discharged to the upper reaches of Merian Creek.

The water quality from the pits and the WRD seepage and runoff will be influenced by contact with the pits walls and the waste rock and thereby influenced by the geochemistry of the rock and the introduction of nitrogen from blasting. As discussed in Section 19.5.4, a geochemical characterization program was undertaken to characterize the ARD and metals leaching potential from the waste rock generated by the Project. The program included static and kinetic testing of waste rock.

Testing included multiple test methods to assess acid generating potential. The findings of the tests were generally in agreement and show that the majority of samples (approximately 80 percent) are non-acid forming. The remaining samples, principally saprolite and saprock, are classified approximately equally as uncertain or potentially acid forming. The neutralization potential of the majority of the mined rock, due to carbonate content, is sufficient to neutralize potential acid generation. The metal leaching testing shows the potential for some low level leaching of aluminum, arsenic, cadmium, molybdenum, and selenium.

WRD seepage and runoff quality were estimated based on the results of the geochemical characterization program, the characteristics of the WRDs (, i.e. tonnage and composition) and the WRD water balances using the geochemical model PHREEQC (details are provided in Appendix 19-C). Results from the HCT testing were used to define a range of representative WRD seepage water qualities. The short-term SPLP leach test results from all waste rock samples were used to define a range of representative waste rock runoff water qualities. Modeling results indicate the following:

- Seepage and runoff quality is expected to be similar for all WRDs;
- WRD runoff and seepage pH values are predicted to be circum-neutral to alkaline and have a wide range that extends above and below the Project water quality criteria;
- Metal concentrations in both runoff and seepage are predicted to be generally low but some constituent will have the potential to exceed Project criteria. Due to elevated reporting limits for some of the HCT and SPLP leachates used in the estimation of water qualities, some metal concentration are likely over predicted;

- Constituents (dissolved fraction) most likely to exceed Project EDC in WRD seepage and/or runoff include: aluminum, barium, manganese and zinc.
- Constituents in addition to those listed above may exceed Project water quality standards in seepage and runoff, including: arsenic, antimony, copper, molybdenum and selenium; and
- Secondary mineral precipitation is not expected to be a significant control on metal concentrations in seepage and runoff.

The WRD seepage and runoff will be conveyed to sediment ponds prior to discharge where physical settling will further reduce total metal concentrations. Pit water will also be conveyed to the same sediment ponds. Runoff from nearby undisturbed areas will be diverted so that enters local creeks downstream of the sediment ponds. Total metal concentrations were estimated assuming a sedimentation pond overflow TSS value of 50 mg/L. Discharge from the sedimentation ponds are estimated to meet Project discharge water quality criteria with the exception of iron (maximum predicted concentration = 6 mg/L compared to criterion = 2 mg/L) . As discussed in the Water Resources Baseline chapter (Chapter 9), baseline iron concentrations routinely exceed Project criteria and a Project-specific criterion is recommended.

Nitrogen (i.e. nitrate and ammonia) will likely be introduced to the pit water, WRD runoff and seepage due to flushing of residuals from blasting Operations. Nitrate and ammonium concentrations in WRD seepage and runoff are predicted to range from less than milligram per liter concentrations (as nitrogen) to tens of milligrams per liter. Nitrogen concentrations in seepage are predicted to be higher than nitrogen concentrations in runoff. Seepage and runoff from the Central and East WRDs are predicted to contain the highest nitrogen concentrations due to the greater proportion of fresh rock in these disposal facilities.

As discussed above, the Project will treat WRD runoff, seepage and pit water for TSS prior to discharge. Geochemical analysis indicates that treatment to address nitrate and ammonia may be needed downstream from WRD's depending on blasting practices. If blasting practices are successful at limiting wastage to one percent, the concentrations of nitrate and ammonia are expected to meet Project EDC at the compliance points. During Operations, if monitoring indicates that nitrate or ammonia concentrations are higher than expected in WRD seepage, treatment systems (e.g., treatment lagoons) will be added downstream from the sediment pond dams. It is not anticipated that such treatment lagoons will be required, but they will be implemented, if necessary, as a contingency. More detailed information regarding potential nitrogen treatment, including potential sizing of the lagoons, is provided with the WMP in Volume IV.

A spreadsheet water balance model was used to estimate water quality estimates for a set of key constituents of potential concern (antimony, copper, selenium, zinc, and nitrogen) in Merian Creek at the edge of the Study Area boundary (EP-B0). The evaluation considered the combined contribution of unimpacted baseflow from the 82.3 km^2 watershed with impacted seepage baseflow from the WRDs. To simulate worst case dry season conditions, watershed runoff contributions and pit discharge contributions, both of which would serve to dilute baseflow contributions, were not included in the spreadsheet model. Table 19-7 presents predicted concentrations during dry season (baseflow) conditions at EP-B0 as compared to Project EDCs for the respective parameters. Project EDC are provided as they appear in Table 4-2 of the EDC (based on in-stream hardness of 50 mg/L as $CaCO_3$) and adjusted (for copper and zinc) based on the assumed hardness of unimpacted baseflow (17.1 mg/L as $CaCO_3$).

Table 19-7 Estimated Metals and Nitrogen Concentrations in Merian Creek at EP-B0 – Operations

Parameter	Predicted Concentration at EP-B0 (mg/l)	Project EDC Hardness 50 mg/l (mg/l)	Project EDC Hardness 17.1 mg/l (mg/l)
Antimony	0.0047	0.006	0.006
Copper	0.0041	0.005	0.003
Selenium	0.0048	0.005	0.005
Zinc	0.0215	0.066	0.026
Total Nitrogen	1.76	10.0 – nitrate 4.5 – ammonia 1.0 - nitrite	10.0 – nitrate 4.5 – ammonia 1.0 - nitrite

Water quality for the metals parameters is predicted to meet Project EDC assuming an instream hardness of 50 mg/L. At the lower hardness concentration (i.e., without any runoff contributions from the watershed), and exceedance is possible for copper. Compliance is predicted for nitrogen, assuming that most of the nitrogen will be in the form of either nitrate or ammonia. As noted in the previous section, it is unlikely that nitrite nitrogen will be present at any meaningful concentration. Note that the potential copper exceedance is based the assumption that the creek is receiving no runoff from the watershed, indicating that potential exceedances might only be expected during dry periods (September and October) when baseflow dominates.

Impact Assessment

The water quality evaluation presented above indicates that Project EDC (effluent limits) are expected to be met at the discharge from sediment ponds. The evaluation also indicates that under worst case dry season conditions, the Project is anticipated to generally meet Project EDC in Merian Creek at the Study Area boundary (EP-B0) during the Operations phase. While exceedances are possible for copper, it is likely that excess copper concentration in WRD seepage will be attenuated (by sorption) along the groundwater flow path prior to recharging the creek. Based on this anticipated general compliance, the anticipated severity of potential water quality impacts in Merian Creek at the boundary of the Project Study Area is considered low. The likelihood rating is considered medium. The overall impact rating has been assigned as minor.

Mitigation

Although a minor impact rating was assigned, WRD seepage quality and fate and transport, WRD runoff, mining pit drainage can all be variable and there is the potential for short-duration exceedances of the Project EDC both at the sediment pond outlets and at EP-B0. Adaptive implementation of the WMP, including implementation of the water quality monitoring program, will allow for early detection of potential water quality issues and reactive implementation of mitigative actions such as treatment modifications at the sediment ponds relative to use of flocculants.

As a contingency, if monitoring indicates that nitrate or ammonia concentrations are higher than expected in WRD seepage, treatment systems (e.g., treatment lagoons) will be added downstream from the sediment pond dams. More detailed information regarding potential nitrogen treatment, including potential sizing of the lagoons, is provided with the WMP in Volume IV.

Residual Impact Assessment

Continued efforts to refine water quality predictions and tailor treatment systems as necessary as well as a rigorous monitoring program will serve to maintain the likelihood of the impact at low and the overall impact rating at minor.

19.5.6 Degradation of Water Quality in Tomulu Creek

Operations phase impacts to water quality in Tomulu Creek will be associated with TSF quartz vein seepage, TSF saprolite seepage and runoff from the Tomulu Creek watershed.

A spreadsheet water balance model was used to estimate water quality estimates for a set of key constituents of potential concern (antimony, copper, selenium, zinc, total nitrogen, ammonia, free cyanide and total cyanide) in Tomulu Creek at the edge of the Study Area boundary (EP-B0). The evaluation considered the combined contribution of unimpacted baseflow from the 19.6 km^2 watershed with impacted TSF quartz vein and TSF saprolite seepage baseflow. To simulate worst case dry season conditions, watershed runoff contributions, which would serve to dilute baseflow contributions, were not included in the spreadsheet model. Table 19-8 presents predicted concentrations during dry season (baseflow) conditions at EP-B0 as compared to Project EDCs for the respective parameters. Project EDC are provided as they appear in Table 4-2 of the EDC (based on in-stream hardness of 50 mg/L as $CaCO_3$) and adjusted (for copper and zinc) based on the assumed hardness of unimpacted baseflow (17.1 mg/L as $CaCO_3$).

Table 19-8 Estimated Dry Season Metals, Nitrogen and Cyanide Concentrations in Tomulu Creek at EP-C0 – Operations

Parameter	Predicted Concentration at EP-B0 (mg/l)	Project EDC Hardness 50 mg/l (mg/l)	Project EDC Hardness 17.1 mg/l (mg/l)
Antimony	0.0048	0.006	0.006
Copper	0.0061	0.005	0.003
Selenium	0.0048	0.005	0.005
Zinc	0.0245	0.066	0.026
Total Nitrogen	3.22	10.0 – nitrate 4.5 – ammonia 1.0 - nitrite	10.0 – nitrate 4.5 – ammonia 1.0 – nitrite
Ammonia Nitrogen	2.63	4.5	4.5
Free Cyanide	0.0035	0.005	0.005
Total Cyanide	0.0088	0.005	1.0

Except for copper, water quality for the metals parameters is predicted to meet Project EDC. Copper is predicted to potentially exceed the Project EDC at EP-C0. Compliance is predicted for nitrogen, assuming that most of the nitrogen will be in the form of either nitrate or ammonia. As noted in previous sections, it is unlikely that nitrite nitrogen will be present at any meaningful concentration. Cyanide concentrations are predicted to meet the Project EDC at EP-C0. Note that the potential copper exceedance is based the assumption that the creek is receiving no runoff from the watershed, indicating that potential exceedances might only be expected during dry periods (September and October) when baseflow dominates.

Impact Assessment

The water quality evaluation presented above indicates that under worst case dry season conditions, the Project is anticipated to generally meet Project EDC in Tomulu Creek at the Study Area boundary (EP-C0) during the Operations phase. While exceedances are possible for copper, it is likely that excess copper concentration in WRD seepage will be attenuated (by sorption) along the groundwater flow path prior to recharging the creek. Based on this anticipated general compliance, the anticipated severity of potential water quality impacts in Tomulu Creek at the boundary of the Project Study Area is considered low. The likelihood rating is considered medium. The overall impact rating has been assigned as minor.

Mitigation

Adaptive implementation of the WMP, including implementation of the water quality monitoring program, will allow for early detection of potential water quality issues and reactive implementation of mitigative actions such as treatment modifications at the process plant and/or WTP, increased seepage collection, and modified operation of TWSR discharges.

Residual Impact Assessment

Implementation of appropriate mitigation measures, as necessary, would serve to maintain the impact rating for potential Operations phase degradation of water quality in Tomulu Creek at minor.

19.6 CLOSURE IMPACTS ON SURFACE WATER

During the Closure phase, surface water resources could be potentially impacted by both Closure activities and discharges to surface waters (both direct and via seepage related baseflow) that will continue even after formal construction activities have ceased. Potential Closure related impacts may result from:

- Runoff associated with capping, regrading and revegetation of WRDs ;
- Runoff associated with site grading, as necessary, to ensure long-term site drainage conditions;
- Runoff associated with stabilization of slopes through regrading and revegetation;
- Water overflow from mine pit lakes; and

- Recharge (baseflow) contribution of seepage water from the TSF to the Las Dominicanas Creek, A3 Creek and Tomulu Creek.

Potential impacts to surface water during Closure may include:

- Degradation of water quality due to spills/accidents;
- Increase in TSS concentrations in streams;
- Changes in streamflow regime;
- Degradation of water quality in Las Dominicanas Creek; and
- Degradation of water quality in Merian Creek.

19.6.1 Degradation of Water Quality due to Spills/Accidents

Diesel fueled construction vehicles will continue to operate in the Project area during the Closure phase, performing capping, filling, and grading and stabilization activities. The diesel fuel tank farm and established fueling areas will continue to serve the Project during the initial portion of the Closure phase and will eventually be replaced with similar temporary facilities as site demolition and restoration activities advance.

Impact rating and mitigation measures for this Phase are the same as those identified during Pre-Production and Operations.

19.6.2 Increase in TSS concentrations in Receiving Streams

During the Closure phase, ground disturbing activities including general demolition, capping and regrading of the WRDs, regrading and stabilization in the vicinity of the mine pit lakes and TSF, and other general site grading, stabilization and revegetation activities will result in exposed soils, potentially resulting in increased sediment and TSS loadings in runoff discharges to local surface waters.

The sediment ponds, as installed along impacted streams downstream of Project activities during the Pre-Production and Operations phases, will remain in-place during the Closure phase, pending the completion of the various capping, grading, revegetation and stabilization activities. These ponds will allow for settling of sediments and reduce Project-related TSS loadings that might extend beyond the Project Study Area. Sediment structures will be removed or breached at the end of the Closure period to allow streams to return to more natural hydrologic conditions.

Impact Assessment

Adherence to the relatively strict 50 mg/L (for 95 percent of the operational time period) Project EDC TSS discharge criterion will serve to ensure that TSS concentrations in Closure phase runoff discharges will be typically below and/or of the same general range as existing TSS concentrations in the receiving waters. As with the previous phases, the Closure phase impact rating for increased TSS levels in receiving streams is also anticipated to be minor.

Mitigation

Recommended mitigation measures from the previous phase will be carried forward to the Closure phase. These will include continued adaptive implementation of the WMP and it ESC Plan and associated monitoring of both Project discharges and the receiving environment to confirm compliance with EDC and identify the need for improvements in sediment and erosion control, if necessary.

Residual Impact Assessment

As with previous phases, implementation of mitigation during Closure will serve to further ensure compliance with Project EDC for TSS, reduce the potential severity of TSS-related impacts to surface water quality at the boundary of the Study Area to low, and reduce the overall impact rating to insignificant.

19.7 CHANGES IN STREAMFLOW REGIME

As the Closure phase progresses, site grading, slope stabilization, restoration of vegetative cover, and the eventual removal or breaching of sediment structures will serve to reduce site runoff and return the streamflow regime in local streams to more natural hydrologic conditions. Conditions should approach baseline conditions, but will not be identical, as site topography in the mining area will be different from pre-Project conditions.

Estimated changes in average monthly streamflows for normal, wet and dry years at Post-Closure (after full revegetation) at the boundary of the Study Area at Las Dominicanas Creek, Merian Creek and Tomulu Creek are presented in

Table 19-9, Table 19-10 and Table 19-11, respectively. Toward the end of the Closure phase streamflow will begin to drop toward the estimated values in these tables, but will not fully achieve these values until Post-Closure, when full revegetation has been established.

The streamflow estimates in the tables below indicate that as the Project completes the Closure phase and moves towards full revegetation during Post-Closure, streamflows at the Study Area boundary will more closely match pre-mining baseline conditions. Streamflow in the Las Dominicanas Creek watershed will be slightly higher than baseline and streamflows in the Merian and Tomulu Creek watersheds will be slightly lower. This minor change in streamflow regime is due to the minor change in the respective drainage areas of these basins, where the drainage area of the Las Dominicanas watershed will slightly increase and the drainage area of the Merian and Tomulu watersheds will slightly decrease.

Impacts towards the end of the Closure phase and extending into Post-Closure are classified as minor, reflecting the minor change in flow patterns and flow rates as compared to baseline conditions.

Table 19-9 Estimated Monthly Average Streamflow in Las Domincanas Creek at EP-A0 – Post-Closure (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	1.12	0.85	0.84	1.32	2.29	2.36	1.35	0.64	0.25	0.25	0.33	0.92
Wet	1.36	1.00	0.99	1.62	2.89	2.97	1.65	0.75	0.29	0.28	0.38	1.15
Dry	0.94	0.75	0.73	1.11	1.85	1.90	1.12	0.54	0.22	0.22	0.29	0.74
Post-Closure (Full Revegetation) Streamflow (m^3/s)												
Normal	1.22	0.86	0.87	1.44	2.62	2.68	1.47	0.66	0.24	0.23	0.32	1.02
Wet	1.52	1.04	1.05	1.80	3.36	3.43	1.84	0.80	0.28	0.27	0.38	1.29
Dry	1.00	0.73	0.73	1.18	2.07	2.12	1.19	0.55	0.21	0.20	0.28	0.80
% Difference Between Baseline and Post-Closure												
Normal	9.0%	1.2%	3.1%	8.5%	14%	13%	8.9%	3.6%	-3.9%	-6.5%	-2.6%	11%
Wet	12%	4.3%	6.0%	11%	16%	15%	11%	6.2%	-1.2%	-3.7%	-0.1%	13%
Dry	6.1%	-1.9%	0.1%	5.7%	12%	11%	6.2%	0.7%	-6.6%	-8.9%	-5.3%	8.5%

Table 19-10 Estimated Monthly Average Streamflow in Merian Creek at EP-B0 – Post-Closure (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	2.60	1.84	1.86	3.03	5.40	5.53	3.09	1.45	0.55	0.51	0.73	2.20
Wet	3.26	2.26	2.29	3.83	6.95	7.09	3.90	1.78	0.66	0.61	0.88	2.82
Dry	2.10	1.54	1.55	2.46	4.26	4.34	2.49	1.18	0.46	0.44	0.62	1.72
Post-Closure (Full Revegetation) Streamflow (m^3/s)												
Normal	2.27	1.60	1.61	2.67	4.86	4.98	2.72	1.23	0.45	0.43	0.59	1.89
Wet	2.83	1.93	1.96	3.35	6.23	6.36	3.42	1.48	0.53	0.50	0.70	2.40
Dry	1.85	1.36	1.36	2.19	3.85	3.93	2.21	1.02	0.39	0.38	0.51	1.49
% Difference Between Baseline and Post-Closure												
Normal	-13%	-13%	-13%	-12%	-10%	-10%	-12%	-15%	-18%	-16%	-19%	-14%
Wet	-13%	-14%	-14%	-12%	-10%	-10%	-12%	-16%	-20%	-18%	-20%	-14%
Dry	-12%	-12%	-12%	-11%	-10%	-9%	-11%	-14%	-16%	-14%	-17%	-14%

Table 19-11 Estimated Monthly Average Streamflow in Tomulu Creek at EP-C0 – Operations (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline Streamflow (m^3/s)												
Normal	0.62	0.45	0.45	0.71	1.23	1.25	0.73	0.36	0.14	0.13	0.19	0.53
Wet	0.78	0.56	0.56	0.91	1.58	1.61	0.92	0.45	0.18	0.16	0.23	0.68
Dry	0.50	0.37	0.37	0.58	0.96	0.98	0.58	0.29	0.12	0.11	0.16	0.42
Post-Closure (Full Revegetation) Streamflow (m^3/s)												
Normal	2.27	1.60	1.61	2.67	4.86	4.98	2.72	1.23	0.45	0.43	0.59	1.89
Wet	2.83	1.93	1.96	3.35	6.23	6.36	3.42	1.48	0.53	0.50	0.70	2.40
Dry	1.85	1.36	1.36	2.19	3.85	3.93	2.21	1.02	0.39	0.38	0.51	1.49
% Difference Between Baseline and Post-Closure												
Normal	-13%	-13%	-13%	-12%	-10%	-10%	-12%	-15%	-18%	-16%	-19%	-14%
Wet	-13%	-14%	-15%	-13%	-10%	-10%	-13%	-16%	-20%	-18%	-21%	-15%
Dry	-12%	-12%	-12%	-11%	-10%	-9%	-11%	-14%	-16%	-14%	-17%	-14%

19.7.1 Degradation of Water Quality in Las Dominicanas Creek

During the early part of the Closure phase, Project water quality impacts to Las Dominicanas Creek will be similar to those during the late Operations phase and will include impacts associated with baseflow contributions of seepage from the TSF to Las Dominicanas Creek and A3 Creek and impacts associated with discharges of treated effluent from the TWSR.

Groundwater modeling (Appendix 19-B) indicates a minor increase in TSF seepage towards and baseflow into Las Dominicanas Creek watershed, as during Closure the mine pits will fill with water and the hydraulic gradient from below the TSF towards the mine pits will decrease. As a result, during Closure it is estimated that there will be a minor decrease in seepage flow towards mine pits and Merian Creek watershed and a minor increase in seepage flow towards the Las Dominicanas Creek watershed.

As discussed in the Merian Geochemistry Baseline and Source Water Quality Predictions Report (Appendix 19-C), the water quality of water in the TSF pond is expected to gradually improve during the Closure period, as ore processing activities and discharge tailing slurry to the pond will be discontinued. Associated improvements in seepage related baseflow discharge to the Las Dominicanas and A3 Creek would be expected to take longer to occur, due to the relatively slow groundwater transport travel times. Seepage collection systems will continue to operate during the Closure phase for as long as deemed necessary based on monitored water quality. Similarly, the TSF pond wastewater treatment system will continue to operate, with ultimate discharge to A3 Creek, until water quality data confirms that treatment is no longer required.

As presented in the Site-Wide Water Balance and Mass Balance Mixing Model (Appendix 3-D), Project related Closure phase water quality impacts to Las Dominicanas Creek are estimated to initially be similar to those of the Operations phase (moderate, reduced to minor with appropriate mitigation) and should continue to gradually decrease at the Closure period moves towards its conclusion. Mitigation implemented during the Closure period will be a continuation of the mitigation implemented during the Operations period.

19.7.2 Degradation of Water Quality in Merian Creek

During the early part of the Closure Phase, potential impacts to the water quality in Merian Creek are expected to be similar to those described during Operations. Low-level leaching of some metals / metalloids and contributions of nitrate and ammonia from blasting will continue to enter the seepage and runoff from the WRD. Nitrogen concentrations will decrease over time as all of the blasting residuals flushed from the rock. Metal / metalloid leaching will decrease as the WRDs are capped with saprolite and re-vegetated and total water seeping through the WRDs is reduced. Sediment ponds and lagoons will remain in place until monitoring shows that they are no longer required. Pit water will no longer be regularly discharged to Merian Creek, which will reduce some dilution to the WRD seepage and runoff prior to discharge. TSF seepage will continue to discharge to Tomulu Creek as baseflow, though this will also reduce as mounding of water under the TSF decreases.

Impact Assessment

Similar to the Operations phase, the potential degradation of water quality in Merian Creek is considered minor.

Mitigation

Mitigation measures recommended for Operations will remain in place until water quality is shown to meet discharge criteria without active management.

Residual Impact Assessment

Similar to Operations, adaptive implementation of the WMP and mitigation measures, as required, will serve to maintain the likelihood of impacts to Merian Creek (and Tomulu Creek) at minor.

19.8 *POST CLOSURE IMPACTS ON SURFACE WATER*

With the onset of the final, Post-Closure phase, all Project-related activities, both operational and restorative, will have been completed and all Project facilities and equipment will have been removed. As noted in the earlier Closure section, during Post-Closure full revegetation will be established and a “new” baseline flow regime will be established. Surface water flows (average and peak) in the Las Dominicanas Creek watershed are expected to be somewhat greater than original baseline flows and surface water flows in the Merian Creek and Tomulu Creek watersheds somewhat less than the original baseline flows, due to the increase and decrease of the respective watershed areas. Revegetation of the previously disturbed ASM areas is expected to further reduce average and peak flows in the Merian Creek and Tomulu watershed and slightly dampen the otherwise increased flows in the Las Dominicanas Creek watershed. Impacts associated with these minor changes in streamflow are expected to be minor to insignificant.

19.9 *PRE-PRODUCTION IMPACTS ON GROUNDWATER*

Pre-Production is a short phase and impacts to groundwater are not considered likely to be realized in such a short time. The only potential impact predicted for groundwater is potential degradation of groundwater quality due to spills/accidents.

19.9.1 *Degradation of Groundwater Quality due to Spills/Accidents*

Similar to potential impacts to surface water during Pre-Production, activities during Pre-Production including the operation of a large fleet of diesel-fueled construction, mining and support vehicles will operate at the Project site. Diesel generators will be used to power the camps and construction activities. Temporary storage of fuel and reagents (primarily construction related chemicals such as hydraulic fluids, lube oils, and reagents supporting operation of early sewage treatment facilities) will be established and will be replaced by permanent facilities as they are completed.

Accidents and spills associated with the transportation, handling and storage of fuel and reagents could result in the release of contaminants to the local environment, potentially adversely impacting groundwater quality. Project controls will be implemented during Pre-Production phase to minimize the potential for such releases to the environment. These will include:

- Initial, temporary diesel fuel storage tanks will be double-walled tanks and will be stored within impermeable, bunded secondary containment areas;
- Permanent fuel farms (one for diesel and one for heavy fuel oil [HFO]) with tanks stored on impermeable surfaces within bunded secondary containment areas;
- Rain water collected within the temporary fuel storage tank containment areas and the latter permanent tank farm areas will be routed through oil/water separators prior to discharge;
- Impermeable secondary containment will be provided during fuel deliveries to ensure containment of a spill, should one occur;
- Impermeable secondary containment will be provided at the tank farm fuel transfer area to ensure containment of a spill, should one occur;
- Storage of reagents will within permanent indoor storage areas;
- Transportation of fuel and reagents will be performed in vehicles fully equipped with spill response materials and manned by staff trained in the use of this equipment.

Impact Assessment

While an accident or spill could occur, the in-place Pre-Production controls, as listed above, are anticipated to contain spills to the immediate vicinity of the incident, facilitate cleanup, and ensure that impacts, if any, are highly localized. The impact rating for potential degradation of groundwater quality due to potential Project accidents or spills, as realized at the boundary of the Environmental Study Area, has been established as insignificant. The minor impact designation has been assigned because, without additional mitigation the likelihood of a potential accident/spill related release to impact groundwater is considered low, as is the severity.

Mitigation

As a mitigation measure, a Spill Prevention, Control and Countermeasures (SPCC) has been developed and will be implemented. The SPCC plan, the first version is included as a component of the ESMMP in Volume IV, presents a system for reducing the potential for spills at the Merian Gold Project and for responding to such events as well as means to monitoring operations to confirm that preventative measures are in place and followed. The SPCC plan describes and specifies the measures that will be implemented by Surgold and its contractors to prevent, and if necessary, contain and control an inadvertent spill of fuels, hydraulic oils, lubricants, water treatment chemicals, paints and solvents and various reagents using sorbent pads, containment walls/berms, and other measures.

Details of the SPCC plan are provided in the discussion of Pre-Production surface water impacts.

Residual Impact Assessment

Effective development and implementation of the mitigation measures provided in the SPCC Plan, Spill Response Plan and other plans noted above is anticipated to reduce the impact rating for potential degradation of surface water quality due to potential Project accidents or spills, as realized at the boundary of the Study Area, to insignificant. This insignificant designation has been assigned because, with implementation of mitigation, the likelihood of a potential accident/spill related release to impact surface waters has been reduced to low.

19.10 OPERATIONS IMPACTS ON GROUNDWATER

During Operations the following activities are expected to result in impacts to groundwater:

- Mining of the pits and subsequent dewatering;
- Construction of WRDs; and
- Active development and expansion of the TSF.

Impacts predicted to occur during Operations are:

- Degradation of groundwater quality due to spills and accidents;
- Changes to groundwater elevations;
- Changes to groundwater flows paths;
- Degradation of groundwater quality downgradient of the TSF; and
- Degradation of the groundwater quality downgradient of the WRDs.

19.10.1 Degradation of Groundwater Quality due to Spills/Accidents

The potential impacts and associated mitigation measures related to the potential degradation of groundwater quality due to spill or accidents are considered the same as those described in Section 19.9.1.

19.10.2 Changes to groundwater elevations

During Operations, as the pits advance, surrounding groundwater will flow into the pits, conveyed to the sedimentation ponds and discharged to Merian Creek. The pits will create a depression in the groundwater table surrounding the pits. At the same time, the TSF will be filled resulting in a groundwater mound developing below the TSF. Installation and operation of a drainage system upstream of the main TSF dams will lower piezometric heads upgradient of the TSF and reduce mounding to a limited degree .A 3D numerical groundwater model was used to predict groundwater elevations at the end of Operations as this reflects the largest change in groundwater elevations during Operations (details provided in Appendix 19-B). Drawdown around the Merian II and Maraba pits of more than 1 m extends from 1 km to up to 4 km from the pits. Drawdown is a temporary impact, as groundwater elevations will essentially return to pre-mining levels by the end of the Closure period.

Figure 19-3 Predicted Groundwater Elevations in Saprolite – End of Operations

Impact Assessment

The spatial extent of the drawdown and the groundwater mounding under the TSF is considered to be very limited; the impacts do not extend beyond the Study Area. No areas of terrestrial habitat or vegetation have been identified that are particularly dependent on the groundwater table, such as wetlands. There are no known uses of groundwater for drinking water or other uses in the area. The potential impacts on the environment are considered negligible and the severity of the impact is considered low. The likelihood of impacts to groundwater levels beyond the immediate areas of the TSF and pits is considered low based on results from the groundwater model (as shown in Figure 19-3). The impact is therefore evaluated to be insignificant and no mitigation is required.

19.10.3 Changes to groundwater flow paths from TSF area

During Operations, as the TSF is filled and the groundwater elevation begins to rise in the immediate area of the TSF, the groundwater flow patterns will change. Currently the groundwater flow patterns follow the topographical divide (as shown in Chapter 9 Water Resources Baseline). Once a groundwater mound is developed under the TSF, groundwater will flow radially from the TSF area. The change results in a shift in the groundwater divide to the west by approximately 800 m. The change in groundwater flow paths will result in increased baseflows (groundwater contribution to streamflow) in Las Dominicanas and Tomulu Creek. Some TSF seepage will also flow into the Merian II and Maraba pits. Predicted changes in baseflows to Las Dominicanas (without accounting for seepage collection) are presented in Table 19-12.

The dewatering of the pits will result is groundwater flow into the pits rather than discharging to the small tributaries located in the immediate area. These changes are also reflected in the changes in baseflows presented below.

Table 19-12 Changes in Predicted Baseflows (Operations – End of Mining)

Watershed	Evaluation Point	Stream	Changes in Baseflow from Baseline Closure Operations – End of Mining	
			(m3/day)	% change
Commewijne	EP-A0	A3 Creek	1000	12%
	EP-A2	Tempati creek	150	18%
	EP-A3	A3 Creek	-1800	-53%
Marowijne	EP-B0	Merian creek	-2000	-21%
	EP-B1	Upper Merian	-2650	-38%

Watershed	Evaluation Point	Stream	Changes in Baseflow from Baseline Closure Operations – End of Mining	
			(m3/day)	% change
		Creek		
	EP-B2	Merian Creek Tributary	100	8%
	EP-C0	Tomulu Creek	1400	45%
	EP-C1	Tomulu Creek	1450	94%

Baseflows are important to aquatic habitat during the dry season as these sustain the streamflow in the creeks during dry periods. Increases in baseflows are not considered to be negative impacts as an increase in baseflow could result in increased fish habitat if low flows limit habitat during the dry season. Decreases of more than 10% in baseflow conditions are considered to have the potential to affect aquatic habitat. Ten percent is selected as a conservative value likely to fall within natural variation in baseflows and model uncertainty. As shown in Table 19-12 at evaluation points A0 an increase in baseflow is expected. At point B0 a decrease in baseflow is anticipated in the order of approximately 20%. However, just downstream, in Tomulu Creek, baseflows are expected to increase by approximately 45%. Downstream of the confluence of Tomulu Creek and upper Merian Creek the change in baseflow is less than 5%. This indicates that any impacts in fish habitat due to changes in baseflow would be localized to the approximately 3 km reach in Merian Creek between EP-B2 and EP-B0.

Impact Assessment

Changes in groundwater flows paths and resulting secondary impacts on creek baseflows are limited in spatial extent to within the Study Area. Some localized negative impacts to creeks during dry periods can be expected as a result of decreases in baseflows in the small stream immediately downstream of the TSF, a short section of upper Merian Creek and in the Merian Creek tributary that drains the Maraba pit drainage basin. All of these creeks are already currently severely degraded due to ASM activities and aquatic habitat is also considered to be degraded.   Changes to baseflows will be reversed to a certain degree Post-closure but will not return to existing conditions. The severity of the impact is considered to be low and the likelihood of impacts extending beyond the boundary of the Study Area is considered to be low. Therefore the impact is evaluated to be insignificant.

Mitigation

If determined necessary, management of the sediment pond and lagoon discharges may be evaluated to determine if there are ways to offset decreases in baseflow during dry periods. Mitigation could also include adaptive implementation of the WMP that includes water quality monitoring and biological monitoring in Las Dominicanas Creek and Merian Creek and on-going improvements to water management systems to respond to any observed degradation of water quality in the creeks.

19.10.4 Degradation of groundwater quality downgradient of TSF

During Operations, as the TSF begins to fill with tailings seepage of water through the tailings will reach the groundwater below the TSF and begin to move out from the TSF. As discussed in Section 19.5.4 TSF supernatant and seepage quality will be controlled by the qualities of the various inflows to the facility and their relative volumes as well as the tailings geochemistry. Laboratory testing was conducted to evaluate the potential for the attenuation of metals that may be present in TSF seepage, due to sorption onto saprolite underlying the TSF. Results of attenuation testing of native saprolite show the potential for attenuation of some metals (e.g., As, Cu, Mo, Ni, Sb, Se and Zn). Test results indicated the potential for the mobilization of some metals (e.g. Al and Ba); however, the observed releases are not considered significant with respect to potential water quality impacts.

Fate and transport modeling of seepage exiting from the TSF has been con ducted and is presented in the Groundwater Impact Assessment Report (Appendix 19-A). Athough the modeling indicates that potential for certain TSF seepage related metals parameters in groundwater to exceed Project EDC at Las Dominicanas Creek compliance point EP-A0, time travel is very slow and such exceedances were not predictied occur for hundreds to thousands of years.

Groundwater quality is considered degraded if groundwater quality parameters exceed the Project drinking water criteria (Table 4-1 of the Project EDC) or if groundwater baseflow contributions to surface water result in degradation of surface water quality such that surface water quality parameters exceed Project criteria for the protection of aquatic life. In cases where baseline surface water quality already exceed aquatic life criteria, groundwater quality is considered degraded if baseflow contribution to the surface water results in increased degradation (beyond baseline conditions) of the surface water.

Impact Assessment

The spatial extent of potential impacts to groundwater quality downgradient of the TSF is considered to be localized, either through low-level quality impacts that are attenuated naturally or by designed controls such as seepage collection systems that will physically restrict the movement of contaminated groundwater beyond the Study Area boundary. Potential impacts to the groundwater quality are not expected to have negative impacts to the surrounding natural environment based on the commitment and contingency planning by Surgold to maintain the creek water quality in Las Dominicanas Creek such that it continues to protect aquatic life. The potential impacts of degradation of groundwater quality downgradient of the TSF are considered moderate. The likelihood of the impact is considered to be medium.

Mitigation

- Recommended mitigation measures to further reduce the potential impacts include:

- Continued optimization of water treatment process and a seepage collection system to reduce potential impacts to surrounding groundwater from TSF seepage.
- Continued adaptive implementation of the WMP that includes water quality monitoring and biological monitoring (as described in the Biological Resources Impacts Chapter 21) in Las Dominicanas Creek and on-going improvements to water management systems to respond to any observed degradation of groundwater quality.

Residual Impact Assessment

Mitigation measures are considered to reduce the likelihood of impacts to groundwater to reduce the likelihood of impact to low and the overall impact classification to minor.

19.10.5 Degradation of groundwater quality downgradient of waste rock disposal areas

During Operations, precipitation that falls on the WRDs will seep through the disposal areas resulting in the potential for low-level leaching of metals and metalloids from the water rock into the water. The water may also mobilize nitrate and ammonia residue left over from blasting. The WRD seepage water will percolate into underlying saprolite and potentially impact underlying groundwater quality. Each WRD is bordered by downgradient streams. It is expected that most groundwater will migrate to the small creeks as seepage and be collected in the sediment ponds prior to discharge.

Impact Assessment

Potential impacts to groundwater will be confined to a very limited area between the WRDs and the nearby creeks and streams. The severity is considered medium, due to the limited spatial extent of the impact and the potential for water quality criteria to be exceeded in the area adjacent to the WRDs. The likelihood that the WRDs will impact groundwater further afield is considered medium as there is potential for some seepage to migrate to the deeper groundwater system and not discharge to the boundary creeks.

Mitigation

It is recommended that the detailed analysis of seepage water quality continue and be used to support the continued development of tailored treatment or collection systems as required. Adaptive Implementation of the WMP is also recommended that includes monitoring of groundwater at different elevations (saprolite, saprock and fresh rock) and indicators that signify if changes are required to the site water management plans.

19.11 CLOSURE AND POST-CLOSURE IMPACTS ON GROUNDWATER

Closure is considered to be a relatively short period of activity (approximately 5 years) and therefore, changes to steady-state groundwater conditions are not expected to be realized over this period. Groundwater modeling included a scenario of 25-years Post-closure to evaluate long-term impacts of the Project on groundwater conditions. Once Operations cease the pits will be allowed to fill with water, the TSF pond will be treated and discharged and the TSF reconfigured so only a very small pond forms behind the final TSF dam. The TSF will be configured to discharge surface runoff to A3 Creek.

Impacts predicted to occur during the Closure / Post-Closure phases are:

- Degradation of groundwater quality resulting from spills and accidents
- Changes to groundwater elevations
- Changes to groundwater flow paths
- Degradation of groundwater quality downgradient of the TSF and
- Degradation of groundwater quality downgradient of the WRDs

19.11.1 *Degradation of groundwater quality resulting from spills and accidents*

As discussed previously, the operation of a fleet of construction or mining vehicles on-site presents the potential for spills or accidents resulting in a release of hydrocarbon contaminants to the environment. If unchecked these could percolate through the soil and into the groundwater. Closure will result in the cessation of the storage and handling of reagents and gradual decrease in the volume of fuel required on-site. The impact is considered to present a low severity and a low likelihood similar to the other phases. Similar mitigation is recommended including:

- An SPCC plan, and
- The storage of fuel in impermeable and bunded areas

19.11.2 Changes to groundwater elevations

Once Operations comes to the end no further tailings will be deposited in the TSF and the TSF pond will be treated and discharged. The TSF will be reconfigured so that only a very small pond may develop at the downstream end of the impoundment. The elevated groundwater under the TSF is expected to drop only marginally because there will be little change in total seepage from the TSF. The pits will be allowed to fill up to their overflow elevation (i.e. lowest surface elevation along the pit rim). The pits will take from 5 to 28 years to refill with Merian I pit filling the earliest and Maraba pit taking the longest to fill. Predicted groundwater elevations are presented in Figure 19-4.

Figure 19-4 Groundwater Elevations – Post Closure

Impact Assessment

Similar to the changes to groundwater elevations during Operations, the spatial extent of impacts to water levels will be limited to within the Study Area and will have limited impacts on the surrounding natural environment. Groundwater levels will remain sufficient that if a drinking water source needs to be developed this would remain feasible. The likelihood of impacts to groundwater elevations beyond the study boundary is considered low given the results of the model. The impact is considered insignificant (severity: low, likelihood: low).

Additional Mitigation measures are not considered necessary.

19.11.3 *Changes to groundwater flow paths*

Once Operations cease and the pits have re-filled, the depression in the water table associated with pit dewatering will dissipate and groundwater flow paths will re-adjust based the new steady-state groundwater elevations. Changes in the pit area will be a general return to existing conditions with some minor differences remaining around the pits. The changes in the flow paths around the TSF will be similar to those predicted during Operations: quasi-radial flow from the elevated groundwater mound under the TSF and a resulting shift of the groundwater divide by approximately 800 m to the west. These impacted flow paths will be realized in changes to baseflows in creeks, which are summarized in Table 19-13.

Table 19-13 Changes in Baseflows (25 years after Closure)

Watershed	Evaluation Point	Stream	Changes in Baseflow from Baseline Closure 25-years after end of mining	
			(m3/day)	% change
Commewijne	EP-A0	A3 Creek	1400	17%
	EP-A2	Tempati creek	250	29%
	EP-A3	A3 Creek	-1,900	-56%
Marowijne	EP-B0	Merian creek	300	3%
	EP-B1	Upper Merian Creek	-1000	-14%
	EP-B2	Merian Creek Tributary	1000	83%
	EP-C0	Tomulu Creek	1700	55%
	EP-C1	Tomulu Creek	1550	100%

As shown in Table 19-13, the only decreases in baseflows are predicted to occur with the Project Study Area within a short reach of upper Merian Creek and immediately downstream of the TSF. At EP-A0 and EP-B0 baseflow conditions approximate existing conditions or are greater than existing conditions.

Impact Assessment

The severity of the changes to groundwater flow paths and the associated impacts to baseflow are limited in spatial extent. The decreases in baseflow in A3 creek and in a short reach of upper Merian Creek are considered to be relatively minor as both of these creeks are currently significantly impacted by ASM mining activities and do not provide particularly valuable aquatic habitat. The likelihood that changes to baseflows will occur at the boundary of the Study Area is considered to be medium based on natural variability and modeling uncertainty.

Mitigation

It is recommended that both A3 and upper Merian Creek hydrology will be improved during Closure activities by the removal of ASM ponds and dams so that baseflow is not lost to evaporation or infiltration.

19.11.4 Degradation of groundwater quality downgradient of the TSF

As discussed in 19.10.4, seepage from the TSF has the potential to impact groundwater quality downgradient from the TSF. During Closure, the large TSF pond will be treated and discharged to the downstream watershed. The TSF will be reconfigured so that only a very small pond develops. Precipitation onto the pond surface will be the source of recharge. Seepage will continue to flow outward from the TSF. Metals leaching from the tailings will continue, although it is expected to slowly decrease over subsequent years.

Impact Assessment

The impact rating is evaluated to be moderate as described in Section 18.7.4.

Mitigation

The protection measures in place during Operations will have to continue to operate until monitoring indicates that they are no longer necessary.

19.11.5 Degradation of groundwater quality downgradient of the WRDs

As discussed in 19.10.5, seepage from the WRDs has the potential to degrade the water quality of the groundwater downgradient of the WRDs. As Closure progresses and precipitation inputs to the WRDs are reduced thanks to capping and re-vegetation of the WRDs, the potential impacts to groundwater will decline.

Impact Assessment

The severity of the impact is considered to remain medium as it is possible that seepage will continue to degrade water quality around the immediate WRD area to below drinking water criteria.

Mitigation

The protection measures in place during Operations will have to continue to operate until monitoring indicates that they are no longer necessary.

20.0 *TRAFFIC AND TRANSPORTATION SAFETY IMPACTS*

This chapter describes the impacts of Project-related traffic on road capacity and safety risks along the Transportation Corridor (i.e., from Paramaribo to the Merian site) for each phase of the Project. The Pre-Production phase of the Project is expected to extend from 2012 to 2014; the Operations phase would extend from 2015 to 2028 (extraction would cease after 12 years; activity during the final two years would consist only of processing).

20.1 *METHODOLOGY AND CRITERIA*

Impacts due to the Pre-Production Phase are evaluated based on projected conditions in 2013—the anticipated height of Pre-Production. Impacts from Operations are evaluated based on projected conditions in 2026—e.g., the last year of "full" operational activity involving extraction and processing. This is a conservative estimate that captures the highest background traffic volumes.

Changes in traffic volumes for the Pre-Production and Operations phases are based on assumptions about overall growth in traffic in Suriname, as well as the timing (time of day) of Project-related traffic. Those assumptions are outlined in the sections below. Traffic impact ratings are based on the degree to which Project-related traffic would worsen congestion or delay on public roads. These ratings reflect calculations using Highway Capacity Software (HCS).[13]

20.2 *PRE-PRODUCTION*

The following potential impacts to transportation and traffic safety are predicted to occur in the Pre-Production phase:

- Increased Project-related traffic volume on the Transportation Corridor.
- Increase in accidents and injuries along the Transportation Corridor.

The Operations and Closure phases would experience the same potential impacts, although to differing degrees, as described below.

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[13] Capacity calculations performed using Highway Capacity Software (HCS 2010). See Appendix 10-A for detailed calculations. HCS determines capacity mathematically by comparing the anticipated traffic volume (including cross-traffic at intersections) to the theoretical traffic-handling capacity of the road or intersection. The HCS methodology makes capacity determinations based on volume-to-capacity ratios, as well as anticipated delay at intersections. Because HCS primarily reflects driving conditions in the United States, determinations of capacity in this ESIA reflect a very conservative interpretation of HCS results—i.e., assuming that roads and intersections in Suriname have far lower theoretical capacities than their U.S. counterparts.

20.2.1 *Increased Project-Related Traffic*

The Pre-Production phase of the Project will take place over approximately a two-year period, and will involve frequent trips by large trucks and buses carrying equipment, building materials, supplies, and workers. The peak vehicular activity during the Project's Pre-Production phase is assumed to occur approximately in the middle of the Pre-Production process (transportation of reagents will commence during the latter portion of the Pre-Production Phase, coinciding with a reduction in other construction traffic). Table 20-1 summarizes the assumed vehicular traffic volumes associated with the Project. In addition to these regular trips, project managers and subconsultants would make approximately 10-12 trips per week (not included in Table 20-1) in pickup trucks or small buses.

Table 20-1 Pre-Production Phase Traffic

Trip Type	Vehicle Type	Round Trips Per Day[1]
Pre-Production supplies, equipment, building materials[2]	TEU/Tractor Trailer	6
Worker transport[3]	Bus	10
Source: Suralco Notes: 1: All round trips to the mine site are assumed to originate and terminate in Paramaribo, leaving at 06:00h, returning by 17:00h, with a 3-hour travel time for each leg. 2: Supplies, equipment, and building material deliveries are assumed to travel in convoys. 3: Worker trips would only occur 3-4 days per week, depending on shift schedule.		

To account for increases in background traffic volumes (traffic not associated with the Project), the baseline traffic volumes listed in Chapter 10 and in Appendix 10-A (including pedestrian volumes) were increased by approximately 1.22 percent, in proportion with recent population growth rates in Suriname.[14] Table 20-2 summarizes the anticipated peak hour traffic volumes (projected baseline traffic, plus Project-related traffic) in 2013, during Pre-Production. More detailed documentation of assumed Pre-Production-phase traffic volumes is included in Appendix 10-A.

Table 20-2 Pre-Production-Phase Peak Hour Traffic Volumes

Location	Peak Hour	Peak Hour Traffic (Total, All Directions) Vehicles/Percent of Forecasted Total[1]				
		Automobiles	Light Trucks	Heavy Trucks	Motor-cycles	Total Vehicles
Weekend Traffic						
Bosje Brug	1900h – 2000h	799 / 82%	89 / 9%	18 / 2%	64 / 7%	970
Tamanredjo	1900h – 2000h	369 / 77%	44 / 9%	16 / 3%	46 / 10%	482
Abadu Kondre	1600h – 1700h	97 / 66%	20 / 14%	29 / 20%	0	146
Mora Kondre	1500h – 1600h	9 / 25%	4 / 9%	16 / 44%	0	36
Weekday Traffic						
Bosje Brug	1700h – 1800h	693 / 74%	66 / 7%	60 / 6%	121 / 13%	940
Tamanredjo	0700h – 0800h	246 / 61%	32 / 8%	24 / 6%	98 / 25%	400
Abadu Kondre	1600h – 1700h	42 / 50%	19 / 23%	23 / 27%	0	84
Mora Kondre	0700h – 0800h	5 / 12%	5 / 12%	31 / 76%	0	41

Notes:
1: Includes projected baseline and Project-related traffic. Reflects heaviest Project-related traffic, when supply / material and employee trips would occur on the same day. Percent of total is the percent of trips during the peak hour that would be made by each vehicle type; e.g., 82 percent of all vehicle trips at Bosje Brug from 1900-2000h on weekdays would be automobiles.

Impact Assessment

The East-West Highway in the vicinity of Bosje Brug will continue to carry the highest traffic volumes among survey locations. The addition of Project-related traffic will shift the timing of the peak hour at the Mora Kondre and Abadu Kondre locations, although peak hour volumes would remain very low in both of these locations. Overall, peak hour traffic volumes during Pre-Production would be only slightly higher than current conditions; some of this increase is attributable to projected background traffic growth.

Congestion could still occur during peak hours, particularly along the more densely populated western portion of the Transportation Corridor; however, such congestion would not be markedly different from conditions already experienced along the Transportation Corridor. Based on these considerations and the data described above, the Transportation Corridor has sufficient capacity to accommodate projected background and Project traffic volumes during the Pre-Production Phase. Therefore, Pre-Production would have an insignificant impact (low severity, low impact) on traffic. Mitigation is not required.

20.2.2 Increase in Accidents and Injuries along the Transportation Corridor

Implementation of the Project could potentially increase the frequency and severity of crashes and injuries involving community members due to:

- Increased Project-related traffic (in the context of increased non-Project background traffic volumes);
- The lack of dedicated pedestrian facilities or areas;

- The use of heavy trucks for Project activities;
- Transportation of hazardous materials for the Project, in addition to existing non-Project large-truck and hazardous material (e.g., gasoline) transport;
- Unsafe driving practices and behavior in Suriname, including speeding, driving under the influence of alcohol, and driver fatigue;
- Unsafe road conditions, such as road dust reducing driver visibility, poor road drainage (water ponding), and limited right-of-ways;
- Limited access to emergency medical care outside of Paramaribo; and
- Coinciding peak Project, background, and pedestrian traffic during weekday morning commutes (7:00-8:30 am) and after school lets out (1:30 pm).

These considerations apply equally to the Operations phase, and also to the Closure phase (although to a lesser degree).

Impact Assessment

The transportation of hazardous materials (including cyanide and other reagents) will occur in accordance with industry good practice, standards and guidance, and other international best practice, such as the International Cyanide Management Code. In particular, Section 3.5 of the IFC EHS Guidelines describe requirements related to identification of hazardous materials and the requirement to have mobile response resources in case of spills (IFC 2007).

While increased traffic volumes are not, by themselves, a safety concern, increased truck traffic could pose additional safety risks. These risks include crashes, injuries (especially to pedestrians and bicyclists), property damage, and hazardous material spills. These safety risks (and thus the Project's impacts on transportation safety) rise in proportion to the number of truck trips associated with the Project. As a share of total traffic, heavy trucks would increase slightly in areas closer to Paramaribo, and substantially in more remote portions of the Transportation Corridor.

Heavy trucks, including those associated with the Project, are larger and more difficult to maneuver, and take longer to stop. While traffic speeds observed during baseline data collection were approximately 55 km/h, higher speeds have also been observed. Higher speeds are typically correlated with higher transportation safety risks.

The Moengo-Langa Tabiki Road is in poor condition. As part of the Project, Surgold will clear vegetation to improve safety and lines of sight, resurface the road with laterite, and upgrade four bridges to ensure they can support heavy vehicles. These improvements will reduce existing safety concerns related to crashes and pedestrian risks.

The severity of the potential impacts to transportation safety is directly related to changes to traffic volumes and traffic types. Therefore, the impacts vary by Project Phase based on the impacts to traffic volumes and vehicle types described in Chapter 10 Traffic and Transportation Safety Baseline.

Based on these considerations, the Pre-Production phase of the Project would have a moderate (medium severity, medium likelihood) impact on transportation safety, due primarily to the lack of pedestrian facilities and increased truck traffic.

Mitigation

Transportation safety mitigation measures associated with the Pre-Production phase are listed below. These measures are applicable across all phases of the Project, and thus are not repeated for the operations or closure sections.

The following mitigation measures presented here correspond to and supplement those presented in Chapter 23 - Social Impacts, regarding mitigation of the potential increase in accidents or injuries resulting from the Project.

Follow IFC guidelines and international best practice when hiring, training, and managing drivers. These guidelines include:

- Requiring licensing of drivers.
- Adopting limits for trip duration and arranging driver rosters to avoid fatigue.
- Avoiding dangerous routes and times of day to reduce the risk of accidents.
- Requiring drivers to follow speed limits and implementing speed monitoring.
- Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure.
- Require contractors and subcontractors to adhere to Surgold driving standards to contractors and subcontractors.

The following additional mitigation measures are recommended to reduce negative impacts on traffic and especially transportation:

- Include in the Project's health and safety plans training for drivers (including contractors). The training will include safety concerns specific to the Project—such as risks to pedestrians and cyclists and best practices for driving in these conditions.
- Adoption of a policy where drivers and contractors will not stop for unplanned/unauthorized breaks on the journey; and
- Integration of a worker fatigue and stress management program for long haul truck drivers.
- Include safety precautions in its contracts with subcontractors including substantial penalties for violation of traffic laws and safety procedures, especially speed limits and public road signage (e.g., stop signs)—regardless of whether a crash or injury occurs, GPS tracking systems installed on trucks, breaks to be taken at site and not enroute.

Engage with communities along the Transport Road corridor to raise awareness on road safety and accident prevention. Residual Impact

Implementing these mitigation measures would reduce the impacts on transportation safety from moderate to minor (medium severity, low likelihood).

20.3 OPERATIONS

The potential impacts to traffic and transportation safety during the Operations phase are similar to those described for the Pre-Production phase (Chapter 20.2).

20.3.1 *Increased Project-Related Traffic*

After the completion of Pre-Production, the Project will have a lifespan of approximately 14 years. Typical vehicular trips associated with Project operation are summarized in Table 20-3. In addition to these regular trips, mine managers and subconsultants would make approximately 10-12 trips per week (not included in Table 20-3) in pickup trucks or small buses.

Table 20-3 Operations Phase Traffic

Trip Type	Vehicle Type	Round Trips Per Day
Operations supplies, equipment, building materials[1]	TEU/Tractor Trailer	4
Fuel oil daily convoy[1]	Tanker	4
Worker transport[2]	Bus	10
Diesel daily convoy and spill truck[2]	Tanker	6
Trucks carrying mill reagents daily[4]	Tanker	9
Source: Suralco Notes:		

1: Round trips to the mine site are assumed to originate and terminate in Paramaribo, leaving at 06:00h, returning by 17:00h, with a 3-hour travel time for each leg. 2: Worker trips would only occur 3-4 days per week, depending on shift schedule, and would occur nearly simultaneous with Operations and fuel oil convoy. 3: Diesel convoy would follow supply / fuel oil / worker convoy by one hour. 4: Reagent and cyanide deliveries would be spaced across the day, beginning at 06:00h

As with the Pre-Production phase, to account for increases in background traffic volumes (traffic not associated with the Project), the baseline traffic volumes listed in Chapter 10 and in Appendix 10-A (including pedestrian volumes) were increased to reflect population growth. This analysis assumes compounded population (and therefore background traffic) growth of 1.22 percent per year through 2026, 14 years following the Pre-Production phase peak.[15] Table 20-4summarizes the anticipated peak hour traffic volumes in 2026. More detailed documentation of assumed Operations-phase traffic volumes is included in Appendix 10-A.

Table 20-4 *Operations Phase Peak Hour Traffic Volumes*

Location	**Peak Hour**	**Peak Hour Traffic (Total, All Directions)1 Number/Percent of Total**				
		Automobiles	**Light Trucks**	**Heavy Trucks**	**Motorcycles**	**Total Vehicles**
Weekend Traffic						
Bosje Brug	1900h – 2000h	935 / 82%	103 / 9%	22 / 2%	77 / 7%	1,154
Tamanredjo	1900h – 2000h	437 / 77%	52 / 9%	18 / 3%	61 / 11%	568
Abadu Kondre	1600h – 1700h	114 / 66%	24 / 14%	34 / 20%	2 / 1%	174
Mora Kondre	1500h – 1600h	11 / 26%	4 / 9%	28 / 65%	0	43
Weekday Traffic						
Bosje Brug	1700h – 1800h	802 / 73%	92 / 8%	66 / 6%	141 / 13%	1,129
Tamanredjo	0700h – 0800h	289 / 61%	39 / 8%	34 / 7%	115 / 24%	477
Abadu Kondre	1630h – 1730h	50 / 49%	23 / 22%	28 / 27%	2 / 2%	103
Mora Kondre	0700h – 0800h	5 / 10%	6 / 12%	36 / 73%	2 / 4%	49
Notes: 1: Reflects heaviest Project-related traffic, when supply / material and employee trips would occur on the same day						

Impact Assessment

As is the case during the Pre-Production phase, the western portion of the Transportation Corridor (the East West Highway) will carry the highest traffic volumes. Peak hour traffic volumes during Operations will be significantly higher than baseline conditions—with as many as 206 additional vehicles per peak hour at the Bosje Brug location. The vast majority of the increase from baseline conditions would be projected background traffic growth (i.e., growth that is completely unrelated to the Project). Project-related traffic would only add approximately 20 vehicles during these peak hours.

Peak hour congestion could still occur, and will likely be worse during the Operations phase than existing conditions, due almost entirely to background traffic growth. Furthermore, congestion would not be markedly worse than conditions already experienced along the Transportation Corridor. More important, the Transportation Corridor would still have sufficient capacity to accommodate projected traffic volumes during the Operations Phase. [16] Therefore, Operations would have a negligible impact (low severity, low impact) on traffic. Mitigation is not required.

20.3.2 Increase in Accidents and Injuries along the Transportation Corridor

The descriptions, analysis, mitigation, and residual impacts associated with the Operations phase are the same as described for the Pre-Production phase.

20.4 CLOSURE

At the end of the Production phase, the Project will transition into Closure, as mine-related structures are removed, the landscape is restored, and mine components such as the TSF are readied for long-term monitoring. During the initial stages of the Closure phase, the volume and type of Project-related traffic are assumed to be similar to the Pre-Production phase. Closure-related traffic would decline to near zero by the end of the Closure phase.

20.4.1 Increased Project-Related Traffic

Initial traffic volumes and traffic-related impacts at the start of the Closure phase would be similar to the Pre-Production phase. See Table 20-1.

Impact Assessment

Impacts on traffic and transportation facilities during the Closure phase would initially be similar to the impacts experienced during the Pre-Production phase: negligible (low severity, low impact). Once Closure activities are completed, impacts to traffic during post-Closure will be non-existent.

20.4.2 Increase in Accidents and Injuries along the Transportation Corridor

The types and sources of potential impacts associated with the Closure phase are the same as described for the Pre-Production phase in Chapter 20.2.

Impact Assessment

Impacts related to transportation safety during Closure would initially be the same as during Pre-Production (Moderate and mitigation measures will be similar to those identified in Chapter 20.2). However, the severity would lessen over the course of the Closure process, and would be zero by the start of the Post-closure period. The overall impact rating for the Closure phase is Minor (medium severity, low likelihood).

20.5 POST CLOSURE

Project-related traffic during the Post-closure phase would be minimal. Accordingly, there would be no traffic or transportation safety impacts during this phase.

20.6 *REFERENCES FOR CHAPTER 20.0*

International Financial Corporation (IFC). 2007. Environmental, Health, and Safety Guidelines. http://www1.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Environmental,+Health,+and+Safety+Guidelines Accessed 01 June 2012

CIA Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/ns.html, accessed 13 April 2012.

21.0 *BIOLOGICAL RESOURCES IMPACTS*

This chapter analyzes the potential positive and negative biological consequences of the Project and describes the recommended mitigation measures to avoid, minimize, or mitigate potential negative impacts and enhance potential positive effects. This chapter is divided into terrestrial and aquatic impacts, and the resource-specific impact discussions distinguish the early Pre-Production, Operations, Closure, and Post-Closure phases of the Project. In some cases impacts will be similar during different Project phases or will continue through more than one phase. In these cases, the discussion of these mine phases with similar impacts reference details and rationale that are presented for earlier mine phases.

21.1 *PRE-PRODUCTION IMPACTS ON TERRESTRIAL RESOURCES*

The following potential impacts on biological resources are predicted to occur in the Pre-Production phase:

- Fragmentation and loss of vegetation from timber harvesting and clearing to accommodate construction;
- Loss and degradation of wildlife habitat from timber harvesting and clearing to accommodate construction;
- Vegetative metabolic distress;
- Injury and mortality of wildlife; and
- Sensory disturbance of wildlife.

21.1.1 *Fragmentation and loss of vegetation from timber harvesting and clearing to accommodate construction*

Habitat fragmentation and the direct loss of vegetation will occur during Pre-Production as a result of timber harvesting and clearing to construct Project infrastructure. Indirect impacts on vegetation could result from desiccation and increased risk of blowdown along roads and timber harvest areas, increased fire risk along roads and near accumulated slash/logging debris, changes in vegetation structure and species assemblage (increased ground cover and lianas), and reduced genetic transfer across roads and logged areas.

Impact Assessment

Commercial timber harvesting will occur prior to clearing for Project infrastructure in order to salvage commercially valuable wood from the Study

Area before it is damaged by construction of Project infrastructure. The commercial timbering will be conducted by an independent third-party granted a timbering Right of Exploitation by the Government of Suriname. Figure 21-1 summarizes the number of species and individuals of commercial trees documented within each vegetation transect surveyed in the Study Area.

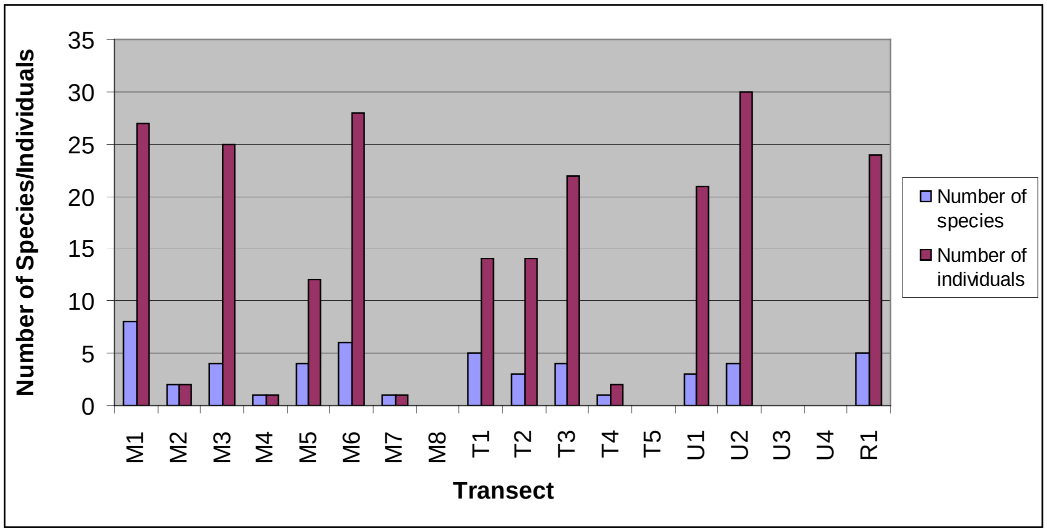

Figure 21-1 Commercial Trees in the Study Area

Based on the results of the vegetation surveys conducted in the Study Area and CELOS[17]' list of commercial tree species in Suriname (Werger, 2011), at least 75% of the transects surveyed to date within the Study Area have one or more species of tree that is known to have commercial value; many have more than one valuable species (Table 21-1). In areas where small numbers of commercial species occur, limited commercial harvest will likely occur. In these areas the primary impact of commercial clearing will be fragmentation rather than outright loss of forest. In other areas, the volume of commercial timber will warrant additional clearing, and forest loss will be more severe. Combining the harvested area, areas cleared for material laydowns, roads, and footprints of major Project infrastructure including pits, waste rock disposal facilities, the TSF, and airstrip, a total of approximately 7,300 ha will be cleared, harvested, or otherwise disturbed. Most of this area will cleared by the fifth year after Pre-Production begins. Table 21-1 summarizes the estimated land area to cleared, harvested, and excavated throughout the Project's duration.

Once the salvageable commercial timber resources have been removed from the Study Area, supplemental clearing to accommodate major Project infrastructure

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[17] Centre for Agricultural Research in Suriname

will begin. As summarized in Table 21-1, most of the timber harvesting will take place within the first two to three years of the Project. Cleared land area will increase through the fifth year of the Project. Some excavation will also take place during this period, but most of the impacts during the first five years of the Project will result from harvesting and clearing. Clearing to construct the processing plant, Operations camp, the pits, waste rock disposal facilities, and the TSF will ultimately represent just over half of the total area cleared or otherwise disturbed during this period.

Table 21-1 *Construction related impacts on vegetation*

Total maximum vegetation loss by vegetation type	
Vegetation Type	*Year 2026 Area impacted (Hectares)*
High Dryland Forest	5503
Creek Forest	368
Open Savannah Forest	0
Savanna Forest	0
Secondary vegetation / Disturbed Areas	1430
Total	7301

Impacts related to Clearing, Harvesting, and Excavating by Year			
Year	*Total Cleared Hectares*	*Total Harvested Hectares*	*Total Excavated Hectares*
2012	240	3,318	1094
2013	954	4,676	1516
2014	924	4,585	1638
2015	1,030	4,327	1789
2016	1,146	4,115	2037
2017	1146	4017	2136
2018	1145	3914	2239
2019	1145	3820	2310
2020	1145	3753	2400
2021	1145	3720	2420
2022	1145	3710	2460
2023	1145	3683	2472
2024	1145	3683	2472
2025	1145	3683	2472
2026	1145	3683	2472

After the sixth year of the Project, the area of harvested and cleared land will either remain constant or decline as previously de-forested areas are progressively excavated, primarily to accommodate the pits and waste rock areas. As summarized in Table 21-1, excavated areas will continue to increase through the first twelve years of the Project until reaching a maximum of approximately 2,470 ha excavated in 2023.

Altogether, the combined effect of constructing the Project on all vegetation types will be a loss of 7,301 ha of vegetation, accounting for 35% of the vegetated area within the Study Area. Most of the area to be cleared is forested (5,871 ha), and approximately 33% of all forested land combined within the Study Area will be lost during construction of the Project. As described in the vegetative baseline, approximately 77% of the Study Area consists of high dryland forest, 14% consists of secondary/disturbed areas, and the balance consists of creek forest and other minor vegetation types. Most of the Study Area consists of high dryland forest, but less than 35% of the high dryland forest within the Study Area will ultimately be impacted by the Project. Despite representing only 14% of the Study Area, slightly more than 49% of the secondary/disturbed vegetation type will be impacted by the Project. More high dryland forest will be lost in absolute terms within the Study Area than any other vegetation type, but a larger proportion of the disturbed/secondary vegetation in Study Area will be lost than any other vegetation type. Seven of the 18 vegetation transects included in the baseline surveys were in secondary/disturbed vegetation, and six of these seven transects (M7, M4, U3, U4, M8, and U2)[18] were the six transects with the lowest species richness. T4 was the only transect in secondary/disturbed vegetation that was richer than any other transect in any other forest type, and it was near the mean richness value for the entire Study Area. These data clearly indicate that the Project's direct impacts on vegetation will be proportionately concentrated in the less biodiverse vegetation communities in the Study Area. Although losses of vegetation would be concentrated in less diverse forest stands, individuals of IUCN-listed species would be lost from at least three transects, including T3 and T5 in the southern portion of Phase 2 of the TSF, and M3 in the southern portion of the Maraba pit.Many of the transects that have the highest number of commercial trees (e.g.; M1, M2, M6, U2, R1) are within or near the footprints of major Project components including the Waste Rock Disposal facilities and pits. Transects that have high vegetative species richness also tend to have moderate to high commercial timber value; the top four transects in terms of number of individual commercial trees (i.e.; U2, M6, M1, and M3) were ranked fifth, second, eighth, and fourth respectively in terms of species richness. Where Project components will be constructed in areas that currently have rich vegetative communities, the forest will likely have been impacted by commercial forestry Operations and/or ASM activities before the construction phase of the Project is initiated.

The significance of most, if not all, of the vegetative losses incurred as a result of the Project will be limited to the local scale. The Project is located near the southern end of a very large block of predominantly high dryland forest that extends the width of northern Suriname from near the coast to the northern end

[18] refer to Chapter 12: Aquatic Resources Baseline for details regarding transect locations and methodology.

of the interior forest. Figure 21-2 shows the Study Area juxtaposed against this larger forest.

Figure 21-2 Forested Areas in Northeastern Suriname

At a regional scale, loss of a portion of the forest within the Study Area will have little to no effect on the overall health of the larger forest ecosystem in northeastern Suriname; however, at a local scale these impacts become more significant. In the north, the block of forest between the two rivers extends more or less unbroken to the East-West highway and to the south to the foothills of Nassau Plateau (shown in Figure 21-2). The Study Area occupies much of the southern portion of this block, and clearing within the Study Area has the potential to significantly reduce the width of the natural connection between the northern half of the block and the extreme southern portion of the block adjacent to Nassau Plateau. Figure 21-3 depicts the loss of forest that will occur at a more localized scale due to clearing for Project infrastructure. This clearing represents roughly 30% of the entire Study Area, and does not include additional clearing that will occur outside the footprint of the Project infrastructure for commercial timbering[19]. The Study Area represents a much more significant proportion of the local forest between the Commewijne and Marowijne Rivers and Nassau Plateau than of the regional forest block, and therefore the local impacts of Project-related forest clearing will be more severe than the regional impacts of clearing. This area is currently fragmented due to ASM, but the Project related clearing will significantly reduce the amount of remaining forest between the two rivers, which is the connection between the northern and southern portions of the larger forest block described above (Figure 21-3).

Clearing of forest, whether as a result of commercial timbering or clearing to accommodate Project infrastructure, will remove existing forest and fragment remaining forest. At the local scale forest fragmentation effectively eliminates connections between previously connected forest patches, thereby creating forest edges where interior forests once occurred. Along the forest edge, tree mortality rates are higher due to factors including sudden desiccation, heat stress, and photosynthetic/respiratory distress due to dust accumulation. The open structure and changes in microclimate favor the establishment of vines and pioneer species, creating a zone of early successional species near forest edges. The abrupt, artificial boundaries of forest fragments are especially vulnerable to windstorms, which can exert strong lateral-shear forces on exposed trees (Laurence et al., 2007). Germination and seed survival have been documented to

[19] Although commercial timbering within the Study Area will not be exclusively caused by the Project, commercial timbering will occur within the Study Area. The existence of a timber Right of Exploitation does not determine whether a forest will be cleared, so it is not certain that these trees would ever have been cleared had the Merian Project not been proposed. Therefore commercial timbering is included in this impact Right of Exploitation as a cumulative impact of the Merian Project.

be lower in wind-exposed areas than protected sites (Asquith & Mejia-Chang 2005). Susceptibility to fire is higher in fragmented areas; increased fuel (dead trees) and space to allow wind and more oxygen are factors that can contribute to this effect. Various studies on edge effects from forest fragmentation fairly consistently find that edge effects generally occur within 40-60 m of an edge, but decrease rapidly further toward the interior of large forest stands. (Didham and Lawton, 1999; Kapos et al., 1993; Asquith & Mejia-Chang, 1995; Turton and Freiburger, 1997; Murcia, 1995).

Figure 21-3 Existing and Proposed Fragmentation

To minimize the fragmentation and clearing-related effects on vegetation, the Project will minimize cleared width of roads and the temporary work camp site, minimize clearing in known areas of high vegetation diversity (e.g. M6), and survey road routes prior to construction to avoid mature special-status species (e.g. M6). These measures will decrease the severity of impacts on vegetation within the Study Area, but not the likelihood that they will occur. As a result, the initial impacts of fragmentation and loss of vegetation will have high (medium severity; high likelihood) impacts on vegetation.

Mitigation

In order to further reduce the significance of the impacts on vegetation resulting from fragmentation the following mitigation is recommended:

- Surveying and re-planting Species of Concern (SOC) seedlings,
- Managing cleared and grubbed material to minimize potential fuel/ignition sources; and
- Removal of lianas as necessary to prevent “secondary felling” from the weight of large numbers of lianas growing on trees in high sun-exposure areas along edges.

Residual Impact

Implementation of the mitigation measures above will further reduce the severity of impacts on vegetation, which will reduce the impact rating to medium (low severity; high likelihood).

21.1.2 Loss and degradation of wildlife habitat from timber harvesting and clearing to accommodate construction

Wildlife habitat will be lost and/or degraded due to the same mechanisms listed above for loss and fragmentation of vegetation. These include clearing during timber harvesting, clearing remaining vegetation to construct Project infrastructure, desiccation and increased risk of blowdown along roads and timber harvest areas, increased fire risk along roads and near accumulated slash/logging debris, changes in vegetation structure and species assemblage (increased ground cover and lianas), and reduced geneflow across roads and logged areas.

Impact assessment

Construction of the access road network will fragment wildlife habitat across the north-central portion of the Study Area. Habitat fragmentation can isolate wildlife populations, which can restrict genetic transfer, access to food or shelter, and in cases where isolated populations are too small to sustain reproduction, ultimately result in extirpation. Fragmentation also increases the ratio of edge to interior habitats. Edges usually do not retain the same ecological value as interior habitats, so fragmentation usually decreases the value of the habitat that remains after disturbance. Fragmentation may also allow invasive and/or exotic species to invade currently uncolonized areas, thereby decreasing habitat value.

Forests and forest-dwelling wildlife are particularly susceptible to the effects of habitat fragmentation because their life strategies are often co-dependent, with wildlife species depending on specific tree species to meet habitat or life stage needs and forest tree species depending on specific wildlife species for dispersal.

Fragmentation, the direct impact, will certainly occur as a result of building the North Access Road, however, most of the indirect effects of fragmentation listed above for wildlife are not inevitable. The extent to which impacts to gene flow and access to resources will actually occur is contingent on individual species' ability to cross roads or disperse seeds/young across roads. Many wildlife species, including some birds and large terrestrial mammals readily cross roads (often serving as seed dispersers as they move), albeit not as readily as they traverse intact forest. As a result, the likelihood that the indirect impacts of fragmentation will actually occur varies widely for different species. In addition, much of the north-central Study Area has already been fragmented by ASM (as shown in Figure 21-3), and further fragmentation will be much less damaging in this already impacted environment than it would be in a pristine area.

Unlike vegetation, which is immobile and can be discussed in terms of direct losses of individuals within a specific transect, wildlife moves through the Study Area at will and will relocate to avoid impacted areas, so impacts on wildlife must be discussed in more general terms. Several of the special-status species identified in the biological baseline, including IUCN-listed and endemic species, would susceptible to habitat fragmentation and loss. As discussed in the baseline, many of the special-status mammals are far ranging predators that are widely distributed across Suriname and the Guiana Shield. They require large home ranges with contiguous high quality forest habitat. They likely occur on a transient basis in the Study Area currently, and further loss of habitat within the Study Area will likely cause them to generally become rarer in the immediate vicinity of the Project as they adjust their individual home ranges to avoid the newly impacted areas. Other listed mammals and birds with smaller home ranges including the white lipped peccary, black spider monkey, giant armadillo, and giant river otter would likely be displaced from heavily impacted areas but relocate to areas within the Study Area that would be less affected by Project activities. The reptiles and amphibians would be most at risk, particularly where clearing and fragmentation would affect their dry season habitats in creek forest along streams.

The same measures implemented to minimize the fragmentation and clearing-related effects on vegetation will also reduce impacts on wildlife habitat. Minimizing cleared width of roads will decrease the severity of impacts on wildlife habitat within the Study Area, but not the likelihood that they will occur. As a result, the initial impacts of sensory disturbances will have high (medium severity; high likelihood) impacts on wildlife habitat, at the local scale. Regional, or larger-scale, impacts would have much lower severity, but would still have a high likelihood of occurring.

Mitigation

Re-planting Species of Concern (SOC) seedlings during Closure and minimizing potential fuel/ignition sources will mitigate impacts on vegetation. Vegetative condition is a key factor in wildlife habitat condition, so these measures will indirectly mitigate impacts on wildlife habitat as well.

Residual Impact

Implementation of the mitigation measures above will further reduce the severity of impacts on wildlife habitat, which will reduce the impact rating to medium (low severity; high likelihood).

21.1.3 Vegetative metabolic distress

Vegetative metabolic distress will occur during Pre-Production as a result of deposition of dust on to leaves near Project infrastructure.

Impact Assessment

Project activities that require earthmoving or ground disturbance, including removal of vegetation, road traffic, extractive activities at the pits and waste rock disposal facilities, excavation of the TSF, and rock crushing and ore handling at the processing facility will have the potential to produce fugitive dust. Forest edges surrounding the proposed Project infrastructure will have a high risk of fugitive dust exposure for the duration of the Pre-Production phase. This dust will be transported naturally through wind action to adjacent vegetated areas where it will be deposited. Forested vegetation primarily located southeast of the Project will be impacted by fugitive dust, as the prevailing wind is in this direction. Air modeling shows that the wind will likely carry dust particles southeast (see Chapter 16- Air Quality and Greenhouse Gas Impacts), which will accumulate onto edge forested communities.

Broadleaf vegetation along the forested edges is most susceptible to the accumulation of dust, as its leaves have a greater surface area than narrow-leaved forested vegetation. Dust deposited on vegetation can negatively affect photosynthesis, respiration, and transpiration, and allow the penetration of phototoxic gaseous pollutants into the leaf. These impacts decrease survivability of native broadleaf species and allowing invasive and ruderal species to gain footholds in previously intact native forest stands (Farmer, 1993). The forested area within the vicinity of vegetative transects M2, M8, and U4 contains low vegetative biodiversity relative to the remainder of the Study Area, and most fugitive dust emitted from excavated or disturbed areas will be transported toward these areas due to the prevailing wind direction in the Study Area. The amount of accumulated fugitive dust will vary throughout the seasons. In the dry season more dust will be generated and it will be transported farther than during the wet season. In the wet season, wet conditions will naturally suppress dust generation and rain will flush accumulated dust off of leaves. Overall, the fugitive dust impacts to forest edges will rapidly diminish with increasing distance from the source and as the Project progresses within each phase. Effective dust control measures including watering dry and exposed surfaces and enforcing speed limits on the roadways will reduce the severity of this impact. More details regarding dust control measures that will be put in place by the Project are provided in Chapter 16 Air Quality and Greenhouse Gas Impacts. Consequently, the initial impact of fugitive dust-induced vegetative stress will be minor (low severity; medium likelihood).

Mitigation

There are no further mitigation measures available to mitigate dust-related impacts on vegetation beyond dust control measures already recommended in Chapter 17 and enforcing speed limits.

Residual Impact Rating

The residual impact rating will remain minor (low severity; medium likelihood).

21.1.4 Injury and Mortality of Wildlife

Some wildlife may be killed or injured by machinery during the Pre-Production construction process, particularly cryptic species that are more likely to hide in place rather than flee oncoming machinery or workers. These would include mostly small bodied-species such as insects, small reptiles, and perhaps some small rodents, and could also include cavity-nesting birds. In terms of impacts on special-status species, these impacts would be most severe on the herpetiles due to their limited mobility and tendency to hide rather than flee oncoming workers and equipment. Construction of the Pioneer camp will also indirectly cause the displacement of all but the most tolerant mobile wildlife species from the vicinity of the camp site. Mortality and injury of wildlife as a result of constructing the Pioneer camp will occur over a small portion of the Study Area and only affect species that are unable to avoid oncoming machinery. Therefore the impact will be minor (low severity, medium likelihood). Dislocation of mobile species (including most of the IUCN-listed and endemic mammals and birds) will occur over the same or a slightly larger area, and will also be minor (low severity, medium likelihood).

The access roads will begin conveying vehicular traffic between the various work sites and the Pioneer camp immediately upon being constructed. Increased vehicular traffic in the Study Area has a high likelihood of increasing roadkill within the Study Area. Many mammals will cross the roads mainly at night, dawn, or dusk, which will be outside normal working hours during the Pre-Production phase and will therefore limit their exposure to Project-related traffic. Access to Project roads will be controlled, so private local traffic should not enter the Study Area at night. Most birds are active during the day when traffic will occur, but they will generally fly across roads above the level where they could be struck by vehicles. Therefore potential traffic-related impacts on birds and mammals will have minor significance (medium significance; low likelihood). In contrast, amphibians and reptiles are active during the day and at night, will traverse the roads at ground level, and sometimes use roads to bask during cool mornings. During these periods they are lethargic and not able to avoid oncoming traffic. Interactions between Project-related traffic and herpetiles are therefore more likely and have the potential to kill more individuals than collisions with mammals or birds. The initial impact of wildlife injury and mortality will be moderate (low severity; high likelihood).

Mitigation

Targeted pre-disturbance surveys and relocation of herpetiles prior to disturbance will reduce mortality associated with land clearing and excavation. Speed limits will also be enforced on Project roads.

Residual Impact Rating

The residual impact rating will be minor (low severity; medium likelihood).

21.1.5 *Sensory disturbance of wildlife*

Sensory disturbance of wildlife will occur during Pre-Production due to noise and light emissions generated by the construction activities. Unnatural noise and light emissions impact wildlife by interrupting circadian rhythms, increasing mortality by attracting wildlife to well-lit hazardous areas, interfering with social vocalizations and mating activities, and increasing exposure to predation.

Impact Assessment

Human activities that will occur during the Pre-Production phases will affect diurnal and nocturnal wildlife species located within the adjacent undisturbed habitats. These effects will generally be greatest near sources of anthropogenic light and noise, but the magnitude of this impact will depend greatly on several variables including the magnitude of the anthropogenic light and noise, magnitude of the species' calls, and time of day (anthropogenic noise will be greatest during working hours and lowest during the night, whereas production of anthropogenic light will be limited to nighttime). During Pre-Production, anthropogenic noise and light will be generated from the pits, waste rock disposal facilities, camp, roads, and TSF.

During the day, noise will be the primary sensory-related impact, but it will only occur during the day and will last over a relatively short period (less than two years). Noise contours were not calculated for Pre-Production impacts because noise impacts during this phase are expected to have relatively low severity compared to impacts during Operations and are expected to be limited to the general vicinity of earthmoving and construction activities. Nevertheless, daytime noise has the potential to reduce the effectiveness of auditory cues for forage species (e.g., rodents). Forage species that rely on their sense of hearing to evade predators may be at risk of increased predation near noise sources such as heavy equipment and machinery. Increasing the susceptibility of forage species to predation may have a minor, short-term beneficial effect on predators, but if increased predation depresses forage populations to the point that their availability to predators is compromised, daytime noise will ultimately have a negative effect on predators as well. There are relatively few day-active predators that hunt by sound in the Study Area, but this category includes well-known sensitive species of concern such as jaguars and pumas (ISEC 2011).

Daytime noise will also have the potential to disrupt social species' ability to communicate. Most species of birds and primates are social, and use vocalizations to communicate across all but the shortest distances. Vocalizations play various roles for birds, including reproductive cues, establishing and defending territories, locating and communicating information on threats, and navigational information (CLO, 2007). Spider monkeys communicate access to food resources by calling (Chapman and Lefebvre, 1989). Squirrel monkeys use up to 30 different types of calls for a variety of purposes including greeting members of the social group, communicating alarm, and basic interactions between mates or parents and offspring (Lang, 2006). Effects on communication will extend over the same portions of the Study Area as effects on predation.

Nighttime noise will have the potential to affect a wider range of wildlife, because auditory cues are generally more important to nocturnal wildlife than diurnal wildlife. This is especially true in terms of predator-prey interactions because more of the large terrestrial predators in the Study Area (i.e.; wild cats) including the margay, oncilla, and ocelot are wholly or partially nocturnal than diurnal. Nighttime noise impacts will also be particularly relevant to amphibians, because many frogs and toads use calls to locate mates and establish breeding territories.

Anthropogenic light sources during the nighttime have the potential to attract and disorientate nocturnal wildlife. Increased exposure to light may attract species, cause temporary blindness, or disorientation, which could lead to increased predation, poor nesting and foraging site choices or mates, and allow collisions with artificial structures.

Insects will be affected as they are typically attracted to artificial lighting, which may cause injury or death. Many quick-flying bat species also feed on these insects which may limit the amount of insects available to more light-sensitive and slower bat species in the area, resulting in an altered ecological structure. The increase of nighttime lighting will also cause disruption to amphibians, as the light may inhibit movements and foraging, and possibly stimulate phototactic behavior leading to injury or death of a species (Longcore, 2004). Many amphibians are also insectivorous and many are nocturnal, so where swarms of insects are drawn to artificial lights, frogs and toads often congregate. These congregations frequently occur in parking lots or other areas that expose the amphibians to injury from human activities. This effect can currently be observed at night where marine toads (*Bufo marinus*) congregate to feed on moths around the security lamps at the existing exploration camp and at the security gates. To minimize the noise-related disturbance to wildlife, the Project will utilize only modern and well-maintained industrial equipment with appropriate noise mufflers. This will ensure that all noise-level specifications for major noise-causing pieces of equipment are met. As a result, the initial impacts of sensory disturbances will have moderate (low severity; high likelihood) impacts on wildlife.

Mitigation

In order to further reduce the significance of sensory disturbance to wildlife the following mitigation is recommended:

- Implementation of a wildlife awareness training programs for all workers, which will provide them with the skills to identify areas where noise and light emissions may be causing unnatural behavior or distributions, increased mortality, or other negative effects.
- Further measures (e.g., shielding lights or installing directional lighting) will be implemented if necessary to further reduce impacts based on field observations and recommendations from staff.

Residual Impact

Implementation of the wildlife awareness program (and further measures if necessary based on staff's recommendation) will further reduce the impact rating to minor (low severity; medium likelihood).

21.2 OPERATIONS IMPACTS ON TERRESTRIAL RESOURCES

The following potential impacts on biological resources are predicted to occur in the Operations Phase:

- Vegetative metabolic distres;
- Injury and mortality of wildlife; and
- Sensory disturbance of wildlife.

21.2.1 Vegetative Distress

The mechanism for vegetative metabolic distress during Operations will be identical to the mechanism during Pre-Production (i.e. deposition of dust onto leaves near Project infrastructure).

Impact Assessment

Many of the same areas that will produce dust during the Pre-Production phase including roads, pits, waste rock disposal facilities, and the processing facility will continue to produce fugitive dust during Operations. Emissions from the TSF will decline because the water spigotted into the TSF will have a damping effect on dust within the storage basin. As ore is removed and the pits deepen, their dust emissions will decrease as well due to the physical containment provided by the pit walls. These reductions, however, will be offset by increased emissions from the processing facility including crushing as the Project ramps up toward full production capacity. As a result the initial impact of fugitive dust-induced vegetative stress will remain minor (low severity; medium likelihood).

21.2.2 Injury and Mortality of Wildlife

The mechanisms for injury and mortality of wildlife to occur during Operations will be limited to roadkill, vehicular injuries, and entrapment/drowning in pits and/or the TSF. The pits and waste rock disposal facilities will be well established and functioning 24 hours and day at this point and will have virtually no habitat value, so mortality due to clearing and/or operation of heavy machinery will be negligible. Impacts on special status species during Operations will be nil because most species will have been removed or displaced from areas of high Project-related activity during the Pre-Production phase.

Impact Assessment

Impacts associated with vehicular traffic will continue largely unchanged from Pre-Production as discussed in Chapter 20.2.2 Pre-Production Phase Traffic Impacts. Increased volumes of traffic on Project roads especially at night will increase the potential for this impact to occur somewhat so the likelihood of roadkill in the Study Area will remain high. As discussed above, impacts from forest clearing and excavations will diminish significantly, but the TSF and pits may become attractive hazards to wildlife, particularly when the first pit is closed mid-way through the Operations Phase. Abandoned or idle pits will constitute new, permanent sources of water that are likely to attract wildlife, particularly during the dry season, though water is widely available in the area, so the attraction of open water is limited. This will pose minimal risk to birds and large wildlife that will be able negotiate the steep pit walls, but small wildlife such as rodents and some herpetiles will be more likely to become trapped in the pits. Spigoting at the TSF is likely to discourage wildlife activity near the dam, but along the margins of the TSF, accumulated soft tailings material may also trap terrestrial wildlife that try to walk across the TSF. As a result the initial impact of wildlife mortality will be moderate (low severity; high likelihood).

Mitigation

In order to reduce the significance of wildlife mortality during Operations, Surgold will periodically check the TSF and the pits for trapped wildlife, and opportunistically rescue animals trapped in pits and/or the TSF if possible and consistent with preserving the safety of mine staff.

Residual Impact

Implementation of the wildlife rescue program will further reduce the impact rating to minor (low severity; medium likelihood).

21.2.3 *Sensory disturbance of wildlife*

The same mechanisms for sensory disturbance that will occur during Pre-Production will persist during the Operations phase. These include interrupting circadian rhythms, increasing mortality in attractive hazardous areas, interfering with social vocalizations, interfering with mating activities, and increasing exposure to predation.

Impact assessment

The major difference in the impact of sensory disturbance between the Pre-Production and Operations phases is the temporal scope of the impact, and the magnitude of the noise-related impacts. Whereas noise and light emissions will be largely limited to daytime periods during Pre-Production, during Operations nighttime noise and light will also be generated from a larger area including the pits, processing facility, and roads because Operations activities will occur 24 hours a day. Current daytime and nighttime noise levels in the Study Area are approximately 43 dBA and 38 dBA, respectively.

Daytime noise modeling indicates that truck deliveries, drilling, blasting, excavation activities, and ground vibration levels will exceed recommended IFC noise guidelines at areas located beyond the northeastern and southwestern portions of the Industrial Zone boundary. Noise levels will exceed daytime (55 dBA) and nighttime (45 dBA) IFC Noise Guidelines within the Industrial Zone, although these guidelines are primarily based on human exposure. There are no universally accepted thresholds for noise-related impacts on wildlife, but the noise contours in Chapter 17 indicate that daytime noise will exceed current daytime noise levels by two dBA or more to a distance of at least 5 km outside the Study Area. The area of daytime noise effects is approximately 38,000 ha. The geographical footprint of nighttime noise effect was not modeled but would significantly exceed the footprint of daytime noise effects, because the difference between existing noise levels and noise levels during operations will be greater at night than during the day and this difference will be noticeable over a larger distance at night than during the day

Mitigation

Implementation of wildlife awareness training programs for all workers will provide them with the skills to identify areas where noise and light emissions may be causing unnatural behavior or distributions, increased mortality, or other negative effects. Further measures (e.g., shielding lights or installing directional lighting) can be implemented if necessary to further reduce impacts based on field observations and recommendations from staff.

Residual Impact

Implementation of the wildlife awareness program (and further measures if necessary based on staff's recommendation) will further reduce the impact rating to minor (low severity; medium likelihood).

21.3 CLOSURE IMPACTS ON TERRESTRIAL WILDLIFE

During Closure phases of the mine, Surgold will implement a Final Closure and Reclamation Plan (the Conceptual Closure plan is included in Chapter 3 and Appendix 3E). The following potential impacts on biological resources are predicted to occur in the Closure phase:

- Vegetative metabolic distress;
- Injury and mortality of wildlife; and
- Sensory disturbance of wildlife.

21.3.1 *Vegetative metabolic Distress*

The mechanism for vegetative metabolic distress during Closure will be identical to the mechanism during the first two phases (i.e.; deposition of dust onto leaves near Project infrastructure).

Impact Assessment

Many of the same areas that will produce dust during the Operations phase including roads, pits, waste rock disposal facilities, and the processing facility will continue to produce fugitive dust during Closure. The earthmoving will occur during Closure will be restorative rather than extractive, but dust will continue to be produced and transported to adjacent vegetated areas where it will continue to have the same effects discussed in Chapter 21.1.3 (Vegetative metabolic distress). Potential emissions from the TSF will increase again because spigoting will cease, the basin will dry out and the area will again function as a source of dust until it is permanently vegetatively stabilized. As a result the initial impact of fugitive dust-induced vegetative stress will remain minor (low severity; medium likelihood).

21.3.2 *Injury and Mortality of Wildlife*

The mechanisms for injury and mortality of wildlife to occur during Closure will be roadkill, vehicular injuries, and entrapment/drowning in pits. The TSF will continue to pose an entrapment hazard to large wildlife (e.g.; deer, jaguars), but within a few months after spigoting ceases smaller wildlife will probably be able to walk on it without becoming trapped. The tailings material will gradually solidify until eventually it will be capabale of supporting most wildlife. The entrapment hazard will continue to decrease as the TSF naturally re-vegetates, which will further stabilize the facility.

Impact Assessment

Impacts associated with vehicular traffic will continue largely unchanged from the impacts discussed above for Pre-Production and Production. Impacts on special status species will continue to be nil because most species will continue to avoid areas of high Project-related activity during the Pre-Production phase. The likelihood of roadkill in the Study Area will remain high. Closed or idle pits will be more available and therefore attractive to wildlife, particularly during the dry season, although it will likely take them over 20 years to fill and therefore reach their full attractive potential. As noted earlier, due to the high availability of open water in the area, the attraction is limited. Small wildlife such as rodents and some herpetiles will continue to be at risk of entrapment at the bottom of the pits or under terraces, but the hazards associated with nighttime vehicular traffic and the TSF will be diminished compared with the Operations Phase. As a result the initial impact of wildlife mortality will be minor (low severity; medium likelihood).

Mitigation

Surgold will continue to periodically check the TSF and the pits for trapped wildlife, and opportunistically rescue animals trapped in pits and/or the TSF if possible and consistent with preserving the safety of mine staff through the Closure phase.

Residual Impact

Continuing to periodically monitor the TSF and pits and rescue trapped wildlife from them if possible (as discussed above) will further reduce the impact rating to insignificant (low severity; low likelihood).

21.3.3 *Sensory Disturbance of Wildlife*

The same impact mechanisms for sensory disturbance of wildlife discussed in Chapters 15.3.1 and 15.3.2 will persist during the Closure Phase.

Impact assessment

During Closure there will be a reduction in overall noise and light impacts to the undisturbed habitats surrounding the Project infrastructure. Closure activities will be limited to a day-time shift and the extent of noise and light emissions during the night will be significantly reduced compared to full mining activities. Disruption of wildlife species will remain a concern due to the implementation of the biological monitoring program and earthmoving to rehabilitate disturbed areas. The biological monitoring program will require vehicles and staff to travel throughout the site to conduct inspections of rehabilitated / revegetated areas, and to monitor wildlife activity. Earthmoving and monitoring inspections will occur mostly during the daylight hours, and the primary impacts associated with them will be vehicular noise and human activity. This will disrupt wildlife species' circadian rhythms, social vocalizations, relocation, and interfere with their mating activities.

Mitigation

Implementation of wildlife awareness training programs for all workers will continue to provide them with the skills to identify areas where noise and light emissions may be causing unnatural behavior or distributions, increased mortality, or other negative effects. Further measures (e.g., shielding lights or installing directional lighting) will continue to be implemented if necessary to further reduce impacts based on field observations and recommendations from staff.

Residual Impact

The mitigation measures listed above will continue to reduce the impact rating to minor (low severity; medium likelihood).

21.4 POST-CLOSURE IMPACTS ON TERRESTRIAL WILDLIFE

At Post-closure, the Study Area will be fully restored with and Project-related activities in the Study Area will have ceased. The only impact on terrestrial biological resources at this stage will be residual impacts associated with the presence of the pits, which will have filled with water and become lakes. These pit lakes will have steep sides with terraced slopes, which may trap certain small herpetiles or mammals, particularly if they are attracted to the pit lakes as water sources during the dry season. This impact will only affect small terrestrial animals that are attracted to the lakes and are unable to negotiate the remnant pit slopes, and these impacts are expected to diminish over time naturally as vegetation recolonizes the slopes and the terraces disappear through natural erosive forces and subsidence/slumping. Consequently, the initial impact of during Post-closure will be insignificant (low severity; low likelihood) and no mitigation will be required.

21.5 *PRE-PRODUCTION IMPACTS ON AQUATIC BIOLOGICAL RESOURCES*

The following potential impacts on aquatic biological resources could occur during the Pre-Production Phase:

- Increases in turbidity and sedimentation;
- Degradation of water quality due to treated water discharge;
- Loss of aquatic habitat ;
- Direct mortality of aquatic organisms; and
- Degradation of water quality due to spills/accidents.

21.5.1 *Increases in turbidity and sedimentation*

Turbidity and sedimentation could increase during the Pre-Production Phase as a result of runoff from areas disturbed during timber harvesting and construction of the Project infrastructure. Increases in turbidity would occur anywhere that fine sediment destabilized through the removal of vegetation or the disturbance of soil runs off the land and into the water without sufficient controls and management. Most of the streams in the Study Area have at least some portion of their watershed that could be disturbed by some aspect of the proposed Project, so the potential exists for sedimentation and turbidity to affect most of the streams in the Study Area.

Impact Assessment

Increases in turbidity and sedimentation have separate but related impacts on aquatic wildlife. Both impacts derive from the same source; i.e. the presence of unnaturally high concentrations of fine particles in surface water bodies. As long as these particles remain suspended, they contribute to increased turbidity. Once they settle out of the water column onto the stream bottom, sedimentation occurs. An important consideration of this impact assessment is that ASM activities in the study area have already resulted in significant turbidity and sedimentation of most of the large streams in the Study Area, although some headwater streams remain relatively unimpacted.

Turbidity has a variety of physiological and behavioral impacts on the aquatic ecosystem. Turbidity decreases light penetration, which decreases primary productivity and ultimately decreases the quantity of living organisms a particular environment can support. It also reduces the photosynthetic oxygen production, which limits wildlife respiration. Compounding this effect is the tendency for fine particles to adhere to gill membranes, limiting gas exchange across the gill structure and causing further respiratory impacts. All of these phenomena affect both aquatic macroinvertebrates and fishes. Turbidity also reduces visibility, which has little relevance to most aquatic macroinvertebrates except highly mobile predatory species such as predaceous beetles and larval odonates (dragonflies and damselflies) but has a comparatively significant effect on predatory fish, many of which hunt predominantly by sight and also use vision to escape predation, locate and compete against competitors for territory, and find mates.

Sedimentation fills the spaces between gravel, cobbles, and boulders on the stream bottoms. As a result, coarse substrate becomes embedded in a matrix of fine particles. This process does not significantly impact macroinvertebrates that are tolerant of degraded conditions, including mosquitoes, midges, and some worms, because they do not rely on pinnate gill structures[20] to respire, and they mostly live either suspended in the water column or buried in fine sediment. Other crawling or clinging species with elaborate external gills, including the stoneflies, caddisflies, and mayflies, can experience respiratory difficulties as their gill filaments become fouled by fined particles. They can also lose the interstitial spaces between stones on the streambed that provide their physical habitats.

Fish are impacted by sedimentation when macroinvertebrate communities are affected because macroinvertebrates are an important prey item for predatory fish species. Sedimentation also impacts the availability of spawning habitat for many species of fish which rely on clean (i.e., un-sedimented) gravel or cobble to spawn, or for their young to find refuge from predators. Some small species of fish require sediment-free spaces between cobbles and boulders as their primary habitat throughout their lives. As described in the biological baseline, the more sensitive macroinvertebrate taxa (e.g., stoneflies, caddisflies, and mayflies) are nearly absent from the Study Area, probably as a result of previous ASM activities, so sedimentation-related impacts on macroinvertebrates are expected to be minor. The fishes from the Study Area include some species that are potentially sensitive to sedimentation, especially those that build nests, have

[20] Plumelike, with fine structures resembling a tuft or feather

adhesive eggs that require hard surfaces to attach, or are physically adapted to the occupy the spaces between stones in the streambed. Special status species in this category include *Lithoxus spp.*, *Peckoltia sp.*, and *Pseudancistrus barbatus*. Others are typical of turbid habitats and would not be significantly affected by small increases in turbidity.

The Project is expected to fully comply with the IFC effluent standard for TSS in all streams within the Study Area through the application of several measures discussed in the Water Resources Impact Assessment chapter (see Chapter 19). Compliance with these standards will minimize impacts from sedimentation on aquatic organisms within and downstream of the proposed Project, so the initial impacts due to increased sedimentation will be minor (low severity; medium likelihood).

Mitigation

In some portions of the Study Area that have not been impacted by significant ASM activity, achieving the aquatic life standard for turbidity would still allow degradation of current conditions. To mitigate impacts on these areas, the proposed Project would implement an Erosion and Sediment Control Plan that includes monitoring of receiving environment and discharge water quality and indicators that require further sediment and erosion control action. This plan would require erosion and sediment BMPs to be installed during early construction prior to construction of the permanent sediment collection facilities. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing Project related impacts on aquatic biota.

Residual Impact

The mitigation measures described above would directly address the severity of turbidity and sedimentation-related effects on streams in the Study Area and the frequency with which they could be expected to occur. Therefore the residual impact of turbidity and sedimentation would be expected to be insignificant (low severity; medium likelihood).

21.5.2 Degradation of water quality due to treated water discharge

Effluent from the Pioneer Camp's sewage treatment facility will discharge nutrients (predominantly nitrogen and phosphorous) to North North Fork A3 Creek. These discharges have the potential to cause increased algal growth and eutrophication of the receiving tributaries of A3 Creek. This is the primary impact anticipated from the Project in the Commewijne River watershed during the Pre-Production Phase. Although the TSF will be constructed and begin to function during the Pre-Production Phase, discharges from the TSF will be routed through the Treated Water Storage Pond, and discharge from the Treated Water Storage Pond will meet Project EDC discharge criteria at the evaluation points. As described in the Water Resources impact assessment (Chapter 19), TSF-impacted baseflow (seepage) is not expected to impact downstream water quality during Pre-Production.

Impact assessment

As described in the water resources baseline (Chapter 9), streams within the Study Area have historically had low concentrations of dissolved nitrogen, and dissolved phosphorous has been undetectable in recent years. Due to its naturally low dissolved concentrations in natural surface water, phosphorous is often the limiting factor in phytoplankton growth potential in streams (Litke, 2008). This is consistent with observations in the Study Area and across much of the Surinamese interior (Ouboter, 1993), where dissolved phosphorous (phosphate) concentrations are often much lower than dissolved nitrogen concentrations. Low natural nutrient concentrations (especially phosphate) would makes streams in the Study Area susceptible to eutrophication if increased nutrient loading were to occur.

Until recently dissolved phosphorous concentrations have been so low that they were undetectable downstream of the proposed treated sewage outfall (at SW-27). Phosphorous discharges would be limited to 2mg/L as per the EDC and IFC requirements. This would limit the potential for additional phosphorous loading to occur downstream of the sewage effluent outfall. The stream that would receive direct discharge from the sewage treatment facility (North North Fork A3 Creek) is very small, which naturally limits capacity of the stream to assimilate increased phosphorous especially during low flow conditions (see Chapter 19 – Water Resources Impacts.). During dry periods, instream water quality immediately downstream of the sewage outfall will be dominated by effluent discharge. This means that North North Fork A3 Creek will be highly susceptible to eutrophication due to sewage discharge.

Susceptibility to eutrophication decreases substantially with increased distance downstream of the outfall. North North Fork A3 Creek flows represent a minor portion of the overall flow in the larger watershed (A3 Creek and Las Dominicanas Creek). Sufficient assimilative capacity exists in the larger watershed, even during low flow conditions, to substantially buffer the effects of increased nutrient loads from the sewage treatment facility on the larger Las Dominicanas Creek watershed (see the Water Resources Impact Assessment, Chapter 19).

The most likely and significant biological effect of nutrient enrichment within North North Fork A3 Creek will be increased primary production characterized by increased phytoplankton and potentially cyanobacterial growth immediately downstream of the outfall. Cyanobacterial blooms currently occur in abandoned ASM pits within the Study Area that have sufficient nutrients to support them (Figure 21-4). This increased growth will likely lead to decreased dissolved oxygen concentrations as the phytoplankton and cyanobacterial growth outstrip the available nutrients, die off and decay, especially during the dry season. This impact is expected to be significant in the immediate vicinity of the outfall, but diminish in severity rapidly with increasing distance downstream. The treatment facility will also be managed to ensure Project-specific effluent criteria (i.e.; the aquatic life standards referenced in the Surface Water Impact Assessment, see Chapter 19), so the initial impacts due to increased turbidity and sedimentation will be minor (low severity; medium likelihood).

Mitigation

The Project Criteria for the protection of aquatic life do not include criteria for phosphorous, which is likely the limiting factor in algal and cyanobacterial growth in the streams within the Study Area. Project-specific discharge criteria for sewage effluent include a 2 mg/L criterion for phosphorous, which will be imposed on effluent from the sewage treatment facility, which will serve to limit the loadings to the stream system. Aquatic biological and water quality monitoring will be conducted to assess the effectiveness of mitigation measures in addressing Project related impacts on aquatic biota.

Residual Impact

Imposition of a phosphorous criteria will still allow a significant increase in dissolved phosphorous concentration and eutrophic potential to occur downstream of the sewage outfall in North North Fork A3 Creek, but the effect will be much smaller than the effect of an unregulated discharge would be and this effect is expected to decrease substantially by the time discharges reach the confluence of A3 creek and Las Dominicanas Creek. From a watershed perspective, the impacts on the Las Dominicanas Creek and the larger Commewijne River watersheds are expected to be insignificant (Severity: Low, Likelihood: Low).

Figure 21-4 Cyanobacterial bloom in abandoned ASM pit

21.5.3 Loss of aquatic habitat

Aquatic habitat will be lost within the footprints of sediment ponds and ditches in the western headwaters of Merian Creek and within the portion of A3 Creek that will be occupied by the TSF. Four headwater creeks draining the eastern side of the Study Area toward Merian Creek will be converted into sediment ponds, and the streams upstream of these ponds will be channelized and converted into ditches to convey sediment-laden water from the pits to the sediment ponds.

Impact Assessment

The sediment basins in the headwaters of Merian Creek will replace stream channels that currently drain the western portion of the Merian Creek watershed in the Study Area. These areas have been impacted by ASM activities, but the remnant channels remain in these locations. The sediment basins will eliminate most of the remnant channels, effectively removing stream habitat in these locations. SW-21 is located in the headwaters of one of the streams that will be converted to a sediment basin, and had the lowest number of fish species of the streams sampled in the Merian Creek watershed. None of the species collected at SW-21 are sensitive or in need of conservation, but there is a more diverse aquatic biological community downstream in the main channel of Merian Creek. These species may ascend the tributaries on an intermittent basis, but it is unlikely that loss of the low quality habitat that currently exists in these locations would have significant negative effects on overall habitat conditions in the larger Merian Creek watershed.

A3 Creek also had the lowest number of fish species of any stream sampled in the Commewijne Basin, and the macroinvertebrate community was comparable to the rest of the Study Area. Although there are no sensitive species known to occur in the portion of A3 Creek that would be lost when the TSF is built, there are several potentially sensitive species known to occur downstream in Las Dominicanas Creek and the Commewijne River. These include the special-status species *Corydoras oxyrhynchus*, *Loricariichthys maculates*, and potentially *Ancistrus sp.* Some areas of Las Dominicanas Creek have been impacted by ASM activities, including areas downstream of the Project that are currently limiting fish migration potential due to ponding of the stream. Nevertheless some of these species, including the potentially new-to-science *Cetopsis sp.*, are also present upstream of impacted areas which suggests that some habitat continuity still exists in Las Dominicanas Creek. These species likely ascend A3 Creek to forage during the wet season, and their fry may use a portion of A3 Creek as nursery habitat because the smaller channel and shallower water provides refuge from piscivorous fish and other predators that are more common in larger downstream habitats. The TSF will occupy nearly all of the headwaters of A3 Creek, leaving little if any of the foraging and rearing habitat that is currently present in A3 Creek intact. Loss of these habitats would have the potential to substantially decrease seasonal foraging and rearing habitat in A3 Creek.

In summary, construction of the sediment basins and the TSF will have similar impacts in the Merian Creek and Commewijne River watersheds, respectively, but the severity of these impacts will be somewhat different. Habitat conditions and the aquatic community in the headwaters of Merian Creek watershed are sufficiently degraded that loss of these habitats will not constitute a significant impact, whereas the Las Dominicanas / Commewijne River watershed still retains some habitat continuity upstream and downstream of ASM sites and loss of headwater habitat will have potentially more significant impacts. There are no practicable design measures available to minimize habitat loss from the TSF, but the sediment dams in Merian Creek headwaters may be removed or breached during Operations, depending on how quickly the North Waste Rock Disposal Facility can be rehabilitated. Early restoration of fluvial connectivity in the

Merian Creek headwaters would allow streams to return to more natural hydrologic conditions sooner. Over time the breaches are expected to allow physical habitat in the streams to recover to some degree. On balance, the initial impacts on aquatic biological resources due to habitat loss will be moderate (medium severity; medium likelihood).

Mitigation

To further mitigate impacts on physical stream habitat within and downstream of the Study Area, Surgold will work cooperatively with OGS to improve the environmental sustainability of ASM activities. This measure will be specifically targeted at reducing the high level of physical habitat disturbance associated with current ASM practices. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing Project related impacts on aquatic habitat.

Residual Impact_Rating

Although increasing the sustainability of ASM activities will not directly address the specific impacts of the proposed Project on aquatic habitat, it will reduce the cumulative impacts of the combined ASM and Project-related activities within stream channels in the Study Area. To the extent that the proposed Project will continue to displace ASM from previously impacted areas into new areas outside the Study Area and outreach through the OGS can improve conditions in these areas, the proposed mitigation has the potential to reduce the significance of cumulative impacts beyond the limits of the Study Area. This measure has the potential to continue to reduce the impact rating to minor (low severity; medium likelihood).

21.5.4 Direct mortality of aquatic organisms

Construction of the Waste Rock Disposal facilities in the western headwaters of Merian Creek and the Tailings Storage Facilities within A3 Creek will have the potential to affect all obligate stream-dwelling wildlife. Mortality of aquatic organisms during construction will arise from physical encounters with machinery and equipment, which will result in physical injury, dismemberment, and ultimately death of some organisms.

Impact_Assessment

Fish and aquatic macroinvertebrates may be killed or injured by machinery during the construction process. Macroinvertebrates are generally more susceptible to being crushed or otherwise injured by machinery due to their limited mobility, but cryptic species of fish that are more likely to hide in place rather than flee oncoming machinery or workers would also be highly susceptible to mortality during construction activities. These would include *Polycentrus schomburgkii* and *Eigenmannia sp.* in both watersheds, as well as *Sternopygus macrurus* and *Tatia gyrina* in the Commewijne watershed. Direct mortality and injury of aquatic wildlife from interactions with machinery would be limited to the physical footprint of the Project infrastructure. Initial impacts on aquatic biological resources due to habitat loss will be moderate (medium severity; medium likelihood).

Mitigation

To mitigate the effect of mortality of aquatic organisms within and downstream of the Study Area, Surgold will work cooperatively with OGS to improve the environmental sustainability of ASM activities. In addition to addressing physical habitat disturbance as described above, this measure is also intended to address the way ASM in-water work is carried out to reduce the potential for injuring and / or killing aquatic organisms. The practical value / effectiveness of this measure as mitigation depends entirely on on the extent to which it leads to positive changes in how ASM is conducted in the field. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing Project related mortality of aquatic biota.

Residual Impact

Increasing the sustainability of ASM activities will not directly address mortality associated with the proposed Project, but it will reduce the cumulative impacts of the combined ASM and Project-related in-water activities. To the extent that the proposed Project will continue to displace ASM from previously impacted areas into new areas outside the Study Area and outreach through the OGS can reduce ASM-related fish mortality in these areas, the proposed mitigation has the potential to reduce the significance of cumulative impacts beyond the limits of the Study Area. This measure has the potential to continue to reduce the impact rating to minor (low severity; medium likelihood).

21.5.5 Degradation of water quality due to spills/accidents

Transport, handling and storage of fuels and reagents during Pre-Production could impact water quality and aquatic habitat if a spill occurs. Pollutants of concern that could potentially be spilled include petroleum based products (i.e.; motor fuels, oils, lubricants, etc.) reagents, and / or cyanide. All of these materials could potentially be very harmful to water quality and aquatic habitat, depending on the volume and location of the spill.

Impact Assessment

The severity of the aquatic ecological impact of a spill would be highly dependent on several factors. One such factor is the type of pollutant released. Certain pollutants are toxic at different concentrations, have different toxicity mechanisms, and affect organisms over different time frames. For example, free cyanide mainly affects oxygen uptake in the blood. It exhibits acute negative effects on fish at concentrations as low as 5 and 7.2 µg/L and is lethal at 20-76 µg/L, but at sublethal doses cyanide is rapidly metabolized to the comparatively nontoxic thiocyanate, most of which is excreted in the urine. Rapid detoxification enables animals to ingest high sublethal doses of cyanide over extended periods without harm. Cyanide is not known to have carcinogenic properties.

Conversely, refined petroleum products have a broader spectrum of toxicity, affecting a number of different organ functions and they can be carcinogenic. Instead of rapidly breaking down, petroleum based pollutants also tend to be more persistent in the environment. Other factors that would influence the severity of a spill, but are impossible to predict, include the volume of the spill, where the spill occurs, and the time of year that the spill occurs. Table 21-2 summarizes these factors and how they would influence the severity of a spill event.

Table 21-2 Factors influencing severity of spill-related impacts on aquatic biota

Factor	Relevance
Volume of spill	Generally large spills would be more severe than small spills over the short term, although likelihood plays a significant part in determining the actual severity of small versus large spills. Small spills are more likely to occur over the course of a project than large spills, and the cumulative effect of a series of small spills may be comparable to or even exceed the severity of a single large spill.
Location of spill	Spills that occur upstream of confining structures such as the TSF in the western portion of the Study Area or the sediment basins on the east side of the Study Area would tend to be less harmful than spills in areas where no barrier to downstream dispersal exists. Outside of these areas, spills in headwater streams would also tend to be less harmful than

Factor	Relevance
	spills in the main channels of Merian, Tomulu, and Las Dominicanas Creeks because the headwaters tend to be less diverse than the main channels and the pollutants would be expected to weather, disperse, and/or be metabolized to some extent prior to reaching the main channels.
Time of year	The impact of a spill at any specific location during the wet season would tend to be less harmful than spills during the dry season. The increased streamflows during the wet season provides greater assimilative capacity than during the dry season. Higher flows during the wet season would tend to disperse spills over a greater distance and therefore dilute pollutant concentrations over the entire area of impact, although the ecological benefit of decreased concentrations would be counteracted somewhat by exposing a wider geographic area to low-level effects. This would be particularly true if a relatively large spill event occurred near the Study Area boundary because the effects of such an event would have a higher likelihood of reaching the Marowijne River, Dominicanas Creek, or the Commewijne River, all of which contain rare fishes.

Surgold will implement several measures to control spills within the Study Area. Permanent fuel storage areas will be built on impermeable bunded surfaces and oil-water separators will treat runoff from bunded areas. Where permanent impermeable bunded areas are not practicable to construct, such as at temporary fueling stations, fuel will be stored in double-hulled tanks. Reagents will be shipped mostly in solid form and stored indoors. With the application of these measures the initial impact of spills on aquatic biota will be minor (low severity; medium likelihood).

Mitigation

Surgold will implement a Spill Prevention, Control and Countermeasures Plan(SPCC). The SPCC Plan will describe measures to be implemented by Surgold and its contractors to prevent, and if necessary, contain and control inadvertent spill of hazardous material such as fuels and lubricants, using sorbent pads, containment walls, and other measures. Standard operating procedures for refueling and handling chemicals will be formalized and implemented in the field. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing indirect water-quality related impacts on aquatic biota.

Residual Impact

The measures described above will further reduce the impacts on aquatic biological resources associated with spills to insignificant (low severity; low likelihood)

21.5.6 Operations impacts on Aquatic Biological Resources

The following potential impacts on aquatic biological resources are predicted to occur in the Operations Phase:

- Degradation of water quality due to spills/accidents
- Ecological impacts due to changes in downstream water quality in the Marowijne Watershed;
- Ecological impacts due to changes in the Las Dominicanas Creek watershed; and
- Ecological impacts of changes in downstream water quality in Las Dominicanas Creek (to end of mixing zone)

21.5.7 Degradation of water quality due to spills/accidents

Impact assessment

The same vulnerabilities regarding potential spill events that would apply during Pre-Production would persist throughout Operations. Transport, handling, and storage of fuels and reagents could impact water quality and aquatic habitat if a spill occurs. The same pollutants of concern identified in Chapter 21.5.5 (Degradation of water quality due to spills/accidents) above - motor fuels, oils, lubricants, and/or cyanide - would continue to pose potential risks during Operations.

Surgold will continue to implement the same measures to control spills within the Study Area as listed above under Pre-Production, including:

- Permanent bunded fuel storage areas constructed on impermeable pads;
- Oil-water separators will treat runoff from bunded areas.
- Fuel will be stored in double-hulled tanks where permanent impermeable bunded areas are not practicable to construct; and reagents will be shipped mostly in solid form and stored indoors.

These measures will reduce the initial operational impact of spills on aquatic biota to minor (low severity; medium likelihood).

Mitigation

Surgold will implement the same mitigation measures to address spills during Operations as described above in Chapter 21.5.5 (Degradation of water quality due to spills/accidents) or Pre-Production. These measures would consist of a SPCC and implementation of standard operating procedures for refueling and handling chemicals. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in preventing spill-related impacts on aquatic biota.

Residual Impact

Similar to the Pre-Production Phase, the measures described above will further reduce the impacts on aquatic biological resources associated with spills during the Operational Phase to insignificant (low severity; low likelihood)

21.5.8 Changes in Downstream Water Quality in the Marowijne Watershed

There will be two primary sources of water quality related impacts on aquatic biota in the Merian Creek watershed during the Operational Phase of the proposed Project. These include runoff and seepage from the waste rock disposal facilities and discharge from pit pump-water. Both streams will be conveyed to sediment ponds prior to discharge to the environment.

Impact Assessment

Effluent from the waste rock disposal facilities will consist of surface runoff and near-surface groundwater that percolates through the waste material and underlying saprock. PrelGeochemical characterization have indicated low potential for metals leaching to occur in this effluent such that during low-flow conditions or drier periods the runoff and seepage would not meet Project discharge criteria. As a contingency measure, sediment pond water could be pumped to the TSF for treatment.

The sediment basins constructed in the headwaters of Merian Creek will receive turbid water from the pits and WRD runoff and seepage. As described in Chapter 21.5.1 (Increases in turbidity and sedimentation), turbidity has a variety of impacts on the aquatic ecosystem including decreases in primary productivity and biological carrying capacity, decreased oxygen production, respiratory impacts, and impacts on predator-prey interactions. Sedimentation is related to turbidity and reduces habitat availability as well as foraging opportunities for some species.

Some of the same fish species of conservation concern that inhabit the Commewijne River also inhabit the Marowijne River (e.g.; *Panaque cf dentex* and *Peckoltia sp.*) and some that are restricted to the Marowijne drainage are present both upstream and downstream of the mouth of Merian Creek (e.g.; *Cynodon meionactis* and *Geophagus harreri*). Their presence in the Marowijne, which is a much larger river system than the Commewijne River, suggests that the Marowijne River populations may be larger and more widespread than the Commewijne River populations and that they would therefore be more resilient in the Marowijne River to water quality-related impacts. The Marowijne River is also has much greater assimilative capacity than the Commewijne River and any mine discharges to the Marowijne River would have less impacts. These factors further suggest that the fishes of conservation concern in the Marowijne River would not be very susceptible to water quality-related impacts in general, and certainly less so than the Commewijne River populations.

Pit water and WRD runoff will be conveyed to the sediment ponds prior to discharge and treated to comply with Project-specific discharge standards if necessary. All discharges from the waste rock disposal facilities will comply will the Project-specific discharge criteria or be routed to a treatment facility for further treatment prior to discharge. Pit water discharges and WRD runoff will also be routed to the sediment basins to remove suspended sediment and bring the water into compliance with the Project-specific discharge criteria prior to discharge to Merian Creek. These measures will reduce the potential impacts of water quality impacts on Merian Creek to Moderate (Severity: Medium; Likelihood: Medium)

Mitigation

The Project design includes several contingency measures that would be implemented if required to further reduce the water quality-related impacts of discharges in the Marowijne River watershed. Contingency measures include: 1) water treatment within the sediment ponds , 2) anaerobic treatment to reduce nitrate concentrations, and 3) pumping water to the TSF for treatment prior to discharge.. An Adaptive Water Management plan that incorporates water quality monitoring in Merian Creek and tributaries will be implemented to detect and address changes in observed water quality through the operational life of the Project. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing water-quality-related impacts on aquatic biota.

Residual Impact

The mitigation measures described above will further reduce the biological impacts of water quality changes in the Marowijne River to Minor (medium severity; low likelihood)

21.5.9 Ecological impacts due to changes in the Las Dominicanas Creek watershed to the confluence with Tempati Creek

As described in the Chapter 19- Water Resources Impacts, operation of the Project will require changes in how water moves through the upper reaches of A3 Creek. The TSF will replace much of the South Fork of A3 Creek. Operation of the TSF will interrupt natural flows in the South Fork of A3 Creek, and reduce flows downstream of the TSF to a combination of runoff and interflow between the TSF dam and the confluence with the North Fork of A3 Creek, as well as seepage from the TSF. While significant geochemical attenuation is expected from transit through the saprolite, the seepage may contain low concentrations of aluminum, copper, and selenium as well as elevated nitrogen (ammonia and nitrate) concentrations from cyanide destruction.

For the first eight years of operations, the Treated Water Storage Pond will be located in the North Fork of A3 Creek. The Treated Water Storage Pond will discharge a relatively constant flow of treated water to the lower reaches of the North Fork of A3 Creek. Flows in the North Fork of A3 Creek will increase and likely become more controlled and less driven by the natural regime, particularly during high flow events because it will receive overflows from the Treated Water Storage Pond.

If operations continue beyond eight years, the Treated Water Storage Pond will be re-located to the South Fork of A3 Creek and the TSF will expand into the North Fork of A3 Creek, which will transpose the impacts discussed above on the two forks of A3 Creek. No significant water quality-related effects are anticipated in Tempati Creek during operations, although Tempati Creek could be used as an alternative location for the Treated Water Storage Pond. The reach of Las Dominicanas Creek downstream of A3 Creek will be exposed to the changes in flow and water quality described above, but the magnitude of these effects will be reduced due to the buffering effect of unaffected flows from Las Dominicanas Creek's southern headwaters. .

Impact Assessment

Physical stream habitat is created and maintained by streamflow and the transport of sediment through the system. Seasonal high flows are responsible for sculpting the stream channel and shaping major hydrogeomorphic features (riffles, runs, glides, pools, etc.) that comprise a stream channel. Beyond simply increasing the size of the stream and the quantity of organisms it can therefore support, high flows also flush sediment that gradually build over the dry season under low flow conditions. This flushing action naturally renews access to coarse bottom material and deep pool habitat for certain species that require these habitats on a seasonal basis. Decreasing average flows and eliminating periodic high flows in the South Fork of A3 Creek will reduce the size of the stream and increase competition for physical habitat among all taxonomic groups. It will also eliminate the natural controls on sediment accumulation within the channel, which will diminish the capacity of the stream to maintain access to deep pools and riffle habitats. The synergistic effects of these two changes will likely cause displacement of most fish species and some macroinvertebrates downstream into the mainstem A3 Creek and Las Dominicanas Creek. Most of the special status aquatic species occur downstream of the confluence of Tempati and Las Dominicanas Creeks and therefore would not be impacted by changes in flow between the North Fork and South Fork of A3 Creek, but the change in flow and/or water quality could affect *Cetopsis sp.* if it occurs in A3 Creek or in Las Dominicanas Creek downstream of A3 Creek.

There is a potential for some limited metals, as well as nitrogen resulting from cyanide destruction to be present in the TSF seepage, which could ultimately impact A3 and Las Dominicanas Creeks within the Mine Water Management Area. Depending on TSF seepage quality, lethal and sub-lethal effects on aquatic organisms in A3 Creek, above the EP-A0 compliance point, is possible. The Project, however, has identified several options for collecting and treating seepage as needed to protect the aquatic resource. These options and their predicted effectiveness are discussed in Chapter 19, Water Resources Impacts. In general terms, water chemistry impacts on macro-invertebrates will likely be more severe than on fish because they will have a greater tendency to die without relocating than fish.

Elevated nitrate concentrations downstream of the Treated Water Storage Pond may contribute to increased phytoplankton growth. As discussed in Chapter 21.5.2 (Degradation of water quality due to treated sewage discharge), phosphorous is usually the limiting nutrient factor in freshwater eutrophication potential so the effect of nitrate pollution is expected to be minor; however, there are examples of treated effluent from mines in Suriname contributing to cyanobacterial blooms (Mol, personal communication). The unnatural flow regime in A3 Creek due to transferring flows from the North and South Forks could also create barriers to fish movement, especially during low flow periods, by dewatering the South Fork ofA3 Creek and creating impassable flows in the North Fork of A3 Creek. These barriers would be in addition to the already existing migration barriers in A3 Creek, Las Dominicanas Creek, and Tempati Creek due to ASM activities. This diversion will effectively create permanent pseudo-drought conditions between the TSF and the mainstem A3 Creek.

The combination of flow abstraction and possibility of contaminated flows will create physical impacts on habitat and barriers to fish movement in both forks of A3 Creek. Impacts resulting from an increase in peak flows will likely include bank de-stabilization leading to erosion, changes in stream morphology, and changes to streambed characteristics, all of which can contribute to impacts to aquatic ecology. Bank destabilization occurs when increased flow volume and velocity undercuts the stream bank on the outside edge of curves in the stream channel to widen the channel to accommodate the additional flow. This process results in a higher streambank with little or no toe near the streambed, and ultimately leads to slumping of bank material into the stream channel. Slumping continues until the streambank reaches a naturally stable angle of repose. The material that has slumped into the stream eliminates bottom habitat within its immediate footprint, and is gradually eroded away by the stream current. This process increases turbidity and sedimentation downstream, which leads to changes in stream morphology and further habitat degradation in downstream depositional areas.

The process described above causes changes in streambed characteristics, but streambeds also change as a result of increased flow without slumping or other large scale erosional processes. In cases where the North Fork of A3 Creek's bank is armored by resilient material (compacted clay, rock, vegetative material, etc.) and is therefore resistant to erosion, the increased erosive force of the stream will deepen the stream channel by eroding the streambed itself. This process will proceed until the cross-sectional area of the stream channel reaches equilibrium with flow or the erosive process reaches a resistant layer, often consisting of bedrock or other hard non-granular material. This process is called scour, and effectively removes the cobble and gravel that many fishes and macroinvertebrates require as habitat. Coarse-grained substrate is currently rare in A3 Creek, and scouring will tend to exacerbate its rarity. The mechanism of impact is much different than what is described above for physical changes to the South Fork of A3 Creek, but the result is very similar from an ecological perspective; i.e. increased competition for remaining habitat and extirpation of individuals/species that cannot successfully compete for limited habitat resources.

The combination of physical and biochemical impacts that would occur in A3 Creek and Las Dominicanas Creek are varied and potentially significant on a local scale. A3 Creek will experience the most severe biochemical impacts because it will receive the potentially un-attenuated seepage from the TSF, treated discharge from the Treated Water Storage Pond, and experience significant changes in flow. Las Dominicanas Creek will experience physical and biochemical impacts similar to A3 Creek, but these impacts will be buffered by unaffected inputs from other tributaries. Although the potential exists for these impacts to be severe at the local scale if left unmanaged, the Project design includes several measures to avoid and minimize these impacts.

The Project includes a number of measures to mitigate these impacts including:

- Concurrent reclamation of disturbed areas and sediment and erosion control measures to attenuate runoff rates, which will directly address the flow-related impacts on Tempati Creek.
- Water in the TSF pond will be treated prior to discharge, and treated water will be stored and ultimately discharged from a Treated Water Storage Pond. Effluent from the Treated Water Storage Pond will reduce biochemical impacts from contaminated effluent as well as physical impacts on habitat from high turbidity and sedimentation downstream in Tempati and Las Dominicanas Creek.
- The process plant will include a cyanide destruction circuit to reduce cyanide concentrations in the tailings slurry discharged to the TSF, which along with additional natural degradation will negate impacts from cyanide in seepage from the TSF to A-3 Creek.
- TSF will be equipped with a seepage collection system designed to minimize the quantity of seepage reaching A3 Creek based on water quality and hydrogeological modeling results, which will further reduce impacts on A3 Creek and downstream areas in Las Dominicanas Creek.

These measures, coupled with the fact that the Study Area represents a small part of the entire Commewijne watershed will reduce these impacts to moderate (Severity - Medium; Likelihood - Medium).

Mitigation

The Project will implement additional measures which will further reduce the impacts in Las Dominicanas Creek and its tributaries in the Study Area. Discharges will be managed to approach existing peak flow conditions as closely as possible. Peak flows are the most erosive and potential physically transformative flows in a stream system, so management of peak flows will mitigate impacts on physical habit in A3 Creek. Implementation of a Sediment and Erosion Control Management Plan including BMPs to control runoff rates, streamflow and erosion monitoring to continue to improve erosion control measures will further mitigate impacts on A3 Creek, and channel improvements and erosion protection will be installed to maintain bank stability if monitoring indicates increased erosion.

Operation of the water treatment plant and groundwater collection system will be optimized to mitigate potential downstream impacts based on monitoring results. As discussed in other chapters, measures to be implemented to mitigate impacts from TSF seepage are: 1) cyanide destruction prior to discharge to the TSF, 2) treatment of the TSF water for metals and ammonia, 3) an internal drainage network to reduce the head in the TSF to limit seepage, and 4) a seepage collection system including toe drains and collection wells. Implementation of an adaptive water management program will determine if additional contingency measures are needed.

Additionally, supplemental measures may be necessary to treat remove nitrogenous byproducts of cyanide destruction from the effluent from the treated water storage pond. One such measure could be construction of an artificial wetland between the outfall from the Treated Water Storage Pond and the confluence of the North and South Forks of A3 Creek. Such wetlands have proven useful in the past for treating nitrogenous waste streams and discouraging cyanobacterial blooms at mines in Suriname (Mol, personal communication). If a wetland is constructed for the purposes of supplemental water treatment, periodic culling of vegetation from the wetland may be necessary to keep metal concentrations (particularly copper) at acceptable levels. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing Project related impacts on aquatic biota.

Residual Impact

Together these measures will further mitigate water quality-related biological impacts on A3 Creek, Tempati Creek, and Dominicanas Creek and reduce the rating of these impacts to Minor (Severity – Low; Likelihood – Medium).

21.5.10 Ecological impacts of changes in downstream water quality in Las Dominicanas Creek (to the end of the mixing zone)

As described in the Water Resources Impacts (Chapter 19), seepage from the TSF has the potential to result in elevated concentrations of a few metals and nitrogen (ammonia and nitrate) in Dominicanas Creek within the Mine Water Management Area. The analyses completed show that the Project water criteria, which are protective of aquatic life, will be met at the compliance point EP-A0. The monitoring program will confirm compliance, or indicate throught the adapative water management plan that additional contingency engineering controls are needed to further limit seepage that reaches the streams.

Impact Assessment

As stated in Chapter 21.5.5 (Degradation of water quality due to spills/accidents) the metals and nitrogen that could be present in discharges from the TSF if attenuation and the designed engineer controls are not fully effective. Surgold will implement an adaptive water quality management plan to manage any effects to aquatic life. In addition to the measures implemented by Surgold, the addition of run-off water from upstream in Las Dominicanas Creek will dilute metalsand nitrogen concentrations in the residual seepage (not captured by engineered controls) from the TSF at the confluence of Las Dominicanas and A3 Creeks, and the residual seepage will be diluted further at the confluence of Las Dominicanas Creek and Tempati Creek due to additional water abstracted from A3 Creek's watershed. The ultimate effects of these inputs will be a progressive dilution of any contaminated effluent within the mine water management area. The compliance point EP-A0 is within the Project study area. Within the Mine Water Management Area, no constituent should exceed acutely toxic concentrations for aquatic life. Water quality is therefore predicted to be sufficient to sustain aquatic life, including sensitive species and lifestages, at the end of the mixing zone.

The control measures described above in Chapter 21.5.8 (Changes in Downstream Water Quality in the Marowijne Watershed) to reduce initial water quality impacts on aquatic biota in the Las Dominicanas watershed will also reduce impacts downstream in the mine water management area by reducing pollutant concentrations in the initial discharge or limiting the seepage from discharging the stream. These measures include: : 1) cyanide destruction prior to discharge to the TSF, 2) treatment of the TSF water for metals and ammonia, 3) an internal drainage network to reduce the head in the TSF to limit seepage, and 4) a seepage collection system including toe drains and collection wells.

As described in the Aquatic Biological Resources baseline, several fish species of potential conservation interest occur downstream of the TSF in the Commewijne River. Some are also present in Las Dominicanas Creek, but the fish distribution indicates that more species of concern are present downstream in the mainstem of the Commewijne River than in its tributaries. Many of these species are presumed to be sensitive to decreased water quality, and anecdotal evidence suggests that sensitive spawning habitat for these species may be present in the Commewijne River mainstem downstream of Las Dominicanas Creek. If this is the case, impacts are already occurring due to the ASM activities that have precluded migration from the Commewijne River to the Las Dominicanas Creek. The distribution of these species is important because it suggests that as the severity of water quality decreases in a downstream direction, the sensitivity of the aquatic community to these types of impacts increases. Considering the distribution of sensitive species in Las Dominicanas Creek and the likely efficacy of the avoidance and minimization measures described above, the water quality-related impact within the mine water management area of lower Las Dominicanas Creek is likely to be moderate (Severity - Medium; Likelihood - Medium)

Mitigation

The same measures described in Chapter 21.5.9 (Ecological impacts due to changes in the Las Dominicanas Creek watershed to the confluence with Tempati Creek) to mitigate effects on water quality in the upper Las Dominicanas Creek watershed will also apply downstream of the confluence with A3 Creek. Aquatic biological monitoring will be conducted to assess the effectiveness of mitigation measures in addressing Project related impacts on aquatic biota.

Residual Impact

After application of the mitigation measures described in Chapter 19.2.5 (Degradation of Water Quality in Las Dominicanas Creek), the residual water quality-related biological impacts on lower Las Dominicanas Creek will be Minor (Severity – Low; Likelihood – Medium).

21.6 CLOSURE IMPACTS ON AQUATIC RESOURCES

The following potential impacts on biological resources could occur during the Closure Phase:

- Continued TSF seepage and sedimentation from Closure activities;
- Physical changes to the Merian Creek tributaries where the sediment basins will be constructed; and

21.6.1 *Continued TSF seepage and sedimentation*

Water will continue to seep from the TSF for a period after mining Operations cease. Mine Closure activities will include grading, amendment of growth media, and revegetation, all of which have the potential to re-disturb areas that could contribute sediment-laden runoff to surface waters.

Impact Assessment

The post-operational volume and duration of TSF seepage is discussed in the Water Resources Section. As described in that section,the source of the seepage (process water and mine tailings) will be eliminated during Closure so the volume of seepage during Closure will be less than during Operations, and it is expected to continue to decrease over time. As seepage from the tailings diminishes, continual inputs from precipitation and the resulting surface runoff will eventually constitute the entire volume of water discharged from the TSF. Initial impacts on water quality are expected to be equal to or less than impacts during Operations, and diminish with time, as the seepage will be more dominated by precipitation than from operational inputs. Water treatment and seepage collection will continue as needed to assure compliance at EP-A0 with the Project water quality criteria.

The biological impacts of sedimentation during Closure will be identical to the impacts of sedimentation described above in Chapter 18.2.1 (Increase in Soil Erosion or Topsoil Loss and Sedimentation) except that sedimentation during Closure will only last as long as necessary to re-stabilize disturbed areas. Sedimentation-related effects during this phase are therefore expected to be much less severe and occur over a shorter timeframe than comparable impacts earlier in the Project. The Closure process is essentially restorative, and is necessary to repair/restore ecological functions impaired during earlier Project phases, so there are no practicable measures to avoid or minimize the effects of the Closure Phase on water quality.

Mitigation

While earthmoving is conducted during Closure, erosion and sediment control features will be installed surrounding disturbed areas to mitigate short-term effects on water quality and aquatic habitat.

Residual Impact

The measures described above will reduce these Closure-related impacts on water quality and aquatic habitat to insignificant (Severity: Low; Likelihood: Low).

21.6.2 Changes to impacted Merian Creek tributaries

As part of the mine Closure program, the sediment basins will be breached to restore the hydraulic continuity of these streams. These streams are currently fragmented due to the in-channel excavations and diversions created by ASM activities.

Impact Assessment

Breaching the sediment basins will restore habitat connectivity from the headwaters through to Merian Creek, which will allow the streams to recover some aspects of their natural hydrology and in-stream habitats. An initial pulse of high turbidity is likely to flow through the system when the dams are breached, but the net effect of the measure on habitat conditions is expected to be positive provided that the sediment accumulated behind the dams is fully stabilized prior to the dams being breached. Although full recovery of the natural stream channel is unlikely to occur without an extensive and proactive restoration program, breaching the sediment basins is likely to provide some long-term improvement in habitat conditions in the watershed, and this improvement is likely to reverse at least some of the damage historically caused by ASM. The positive impact of this measure is expected to be Moderate (Low level of enhancement; Likelihood: high).

21.7 POST-CLOSURE IMPACTS ON AQUATIC WILDLIFE

At Post-closure the Study Area will be fully revegetated and Project-related activities in the Study Area will have ceased. There will be no Post-closure impacts on aquatic wildlife except for the residual loss of habitat within the TSF. This impact is expected to remain minor (low severity; medium likelihood) in perpetuity.

21.8 BIODIVERSITY AND CRITICAL HABITAT

Industry good practice recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. Industry good practice specifies the avoidance of impacts on biodiversity when possible and to minimize unavoidable impacts. This section describes how Surgold has integrated these principles into the design of the Project in order to comply with industry good practice.

21.8.1 *Protection and Conservation of Biodiversity*

Industry good practice relies on habitat protection as the primary mechanism for conserving biodiversity. The IFC recognizes three different types of habitats: modified, natural, and critical (IFC, 2012). Each of these habitat types is defined as follows:

- *Modified habitats*: areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition.
- *Natural habitats*: areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.
- *Critical habitat*: areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered Species (as listed by the IUCN or countries that use the IUCN guidance for listing species); (ii) habitat of significant importance to endemic and/or range restricted species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes (IFC, 2012).

The Study Area consists of a mixture of modified and natural habitats. As described in the Biological Baseline (Chapter 11), approximately 14% of the Study Area has been intensively disturbed by ASM activities and is considered modified habitat. The remainder of the Study Area is a combination of high dryland, creek, savannah, and open savannah forest. Although many of these forested areas have been disturbed by exploratory artisanal mining operations, road and trail construction, and timber harvesting in the past, most of these areas still retain a species composition that is characteristic of their respective forest types and are therefore considered Natural Habitats.

The Study Area does not contain any Critical Habitat for terrestrial species. Most of the species of conservation concern identified in the Biological Baseline

(Chapter 11), including all of the mammals and birds, are known to occur throughout Surinamese interior and are found in other parts of the Guiana Shield. Industry good practice statea that habitat known to sustain $\geq$ 10% of a global population of IUCN-listed Critically Endangered or Endangered species or $\geq$ 95% of a global population of endemic, range-restricted, or migratory/congregatory species would be considered Critical Habitat on the basis of criteria i-iii listed above (IFC 2012a), but none of these terrestrial species are Critically Endangered or Endangered, endemic to Suriname, or migratory or congregatory within the Study Areas. Therefore the Study Area would not be considered Critical Habitat for these species. The two herpetiles of conservation concern found in the Study Area have smaller ranges than the mammals and birds, but both species are known to occur outside the Study Area. *Atelopus hoogmoedi nassaui* is known to occur in several locations on and around Nassau Plateau, and it is unlikely that the Study Area supports more than 95% of the global population of *Anomaloglossus surinamensis* because similar habitats to those contained in Study Area occur elsewhere across eastern Suriname and are likely to contain this species. Two plant species, *Virola surinamensis (Rolander) Warb* and *Vouacapoua americana* are listed as Endangered or Critically Endangered by the IUCN, but both species are actually widespread in Suriname (de Wolf, personal communication) and *Vouacapoua americana* is common enough to be designated as commercial species in Suriname (CELOS, undated) so it is also unlikely that the Study Area meets the definition as Critical Habitat for these species.

According to industry good practice, designations of Critical Habitat must be made for discrete habitat units, and discrete habitat units to be delineated on an ecologically relevant scale rather than according to the Project boundary (IUCN 2012a). As described in the biological impact assessment, the Study Area is located within a large block of predominantly high dryland forest that extends from the east-west road in the north to Nassau Plateau in the south, and between the Marowijne River in the east and the Commewijne River in the west. This forest block is over 390,000 ha in size. Given the size of this forest block and the fact that it is vegetatively similar to the Study Area (i.e.; primarily high dryland forest) it is highly unlikely that significant numbers of the terrestrial species of concern are not found within this wider forest block/habitat unit, or that the Study Area meets the population thresholds required to designate it as Critical Habitat for these species.

The potential for the presence of Critical Habitat for aquatic species is slightly less clear. None of the aquatic species of concern are listed as Endangered or Critically Endangered by the IUCN; they have all been designated as species of concern due to known or potential/inferred endemicity either within the

Commewijne watershed and / or the Marowijne watershed. It is unlikely that more than 95% of the global populations of any of the aquatic species listed in Table 11-29 are present within the Study Area or that large portions of their populations would even be exposed to downstream water quality- or hydrology-related effects of the Project for the following reasons:

- All of the special fishe species captured during the field surveys for this ESIA in the Marowijne River watershed except *Potamotrygon marinae* were captured upstream of the Study Area as well as downstream, which indicates that many of these species are widespread in the Marowijne river system. Populations located upstream would not be exposed to Project-related impacts;
- *Potamotrygon marinae* which was found only downstream of the Project area is a species of freshwater stingray. Stingrays as a group are typically cryptic and therefore difficult to sample. There are no major obstacles to this species' movement in the middle Marowijne River including significant stretches of river upstream, so it is likely that this species occurs upstream of the Project as well; and
- The Commewijne River has many tributaries that have been poorly sampled or remain unsampled, and are likely to contain populations of the same fish species of concern that were collected downstream of the Project during the baseline surveys for this Project.

Although the area of the Commewijne and Marowijne Rivers that could potentially be affected by the Project are unlikely to be Critical Habitat for aquatic species based on the population- and range-related factors listed above, anecdotal evidence suggests that these species may congregate in rapids habitat located downstream of the Project Area in the Commewijne River. The presence of *Cetopsis sp.* near the Study Area boundary in Las Dominicanas Creek and the potential that this species is new to science suggests that portions of the Commewijne River could be Critical Habitat on the basis of importance to congregatory species and / or endemic species.

Development of Projects in Critical Habitats is inconsistent with industry good practice unless several factors can be demonstrated to be applicable to the Project (IFC 2012). These factors and their applicability to the Project are listed below:

- *No other viable alternatives exist with the region for development of the Project on non-critical habitat.* The Project's location is determined by the location of the gold deposit, so no other viable locations for this Project exist.

- *The Project does not lead to measureable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values.* Whether the Commewijne River actually constitutes Critical Habitat is currently unclear, but if it were to be considered as Critical Habitat the biodiversity values and ecological values relevant to designation as Critical Habitat would be the continued capacity to support spawning congregations of fishes of concern in the Commewijne River and *Cetopsis sp.* in Las Dominicanas Creek. The Project will implement a rigorous water quality management program that is designed specifically to provide water quality sufficient to support aquatic life, and includes biologically relevant standards as performance criteria. Successful application of this program would likely prevent measureable adverse impacts on the fish species of concern in the Commewijne River and Las Dominicanas Creek.
- *The Project does not lead to a net reduction in the global and/or national/population of any Critically Endangered or Endangered species over time.* None of the fish species of concern in the Marowijne or Commewijne Rivers are listed as Critically Endangered or Endangered, so the Project would not lead to reductions in populations of listed species.
- *A robust, appropriately designed, and long-term biodiversity monitoring and evaluation program is integrated into the client's management program*. Surgold has committed to implementing a biomonitoring program to include aquatic biological monitoring for the duration of the Project. Surgold has also committed to working with OGS to improve the sustainability of ASM activities in the region, which would achieve a net gain in aquatic habitat conditions in Las Dominicanas Creek and the larger Commewijne River watershed if implemented in the Project area.

21.8.2 Sustainable Management of Living Natural Resources

Provisions of industry good practice related to sustainable management of living resources are only applicable to clients engaged in production of living natural resources such as timber, animal products, etc. The Project will not produce living natural resources, so the sustainable management of living resources are not applicable to this analysis.

21.9 ECOSYSTEMS SERVICES

This ecosystem services discussion is based on the approach described in the World Resource Institute's (WRI's) *Corporate Ecosystem Services Review* (WRI, 2007), and has been tailored to be directly applicable to the proposed Project. The WRI approach is particularly applicable to this analysis because it can be scaled to apply to an entire company or a specific business unit or Project, and classifies ecosystem services according to the same four categories as the IFC's guidance. The Project-specific data inputs were taken primarily from information produced during the ecological field surveys and social surveys, stakeholder consultations undertaken for the Merian Project, and information on the proposed design and operation of the Project.

The first step in the WRI methodology is to define the scope of the ecosystem services review. For the purpose of this review, the scope was defined as the Merian Project. The second step in the WRI methodology is to identify which ecosystem services the Project is either dependent upon or has the potential to affect. This subset of ecosystem services are referred to as "priority" services—the ones most likely to be a source of risk or opportunity for the company- and become the focus of analysis in subsequent steps; the other services are screened out. Identifying priority services is critical because dependence on specific services, or impacts on those services, can represent business risks or opportunities. Identification of priority ecosystem services is therefore a key strategic exercise.

The Project Area provides numerous ecosystem services. An Ecosystem Services Review was conducted to determine whether each of the ecosystem services identified in the WRI guidance document (WRI, 2007) should be considered for elevation to a Priority Ecosystem Service based on the extent of the Project's *dependence on the service*, and the extent to which the Project has the *potential to affect the service*.

Dependence on ecosystem services was evaluated according to the following three criteria:

1. Whether the ecosystem service represents a business input;
2. Whether there are cost-effective substitutes for the service; and
3. The level to which the Project depends on services that are business inputs for which there are no cost-effective substitutes.

The Project is considered to be highly dependent only on services that provide a direct business input and for which there are no cost-effective alternatives. Table 21-3 summarizes the analysis of the Project's dependence on each of the ecosystem services identified in the WRI methodology.

Table 21-3 Project Dependence on Ecosystem Services

Ecosystem Service	*Description of Service in Project Area*	*Required as a business Input?*	*Cost-effective substitutes available?*	*Level of Dependence*
Provisioning Services				
Food	Local residents, especially from Pamaka, Tempati, and Upper Commewijne areas hunt in the forest and fish in the local streams and rivers.	No	Not applicable to services that are not business inputs.	Low
Biological Raw Materials	Local residents, especially from Pamaka, Tempati, and Upper Commewijne collect a variety of materials (primarily timber) from the forest.	Yes. Project will likely require some locally sourced materials for construction and/or operation.	Yes. Raw material can be sourced from non-local vendors, but certain raw materials (e.g., timber) would be more efficiently sourced locally, particularly in cases where small amounts are needed.	Medium
Biomass fuels	Firewood collected from the forest is used extensively in local communities.	No	Not applicable to services that are not business inputs.	Low
Fresh water	Local residents use creeks not already impacted by ASM for cooking and washing, but not as a primary source of drinking water. Local communities rely heavily on rainwater for drinking water.	Yes. Fresh water will be required as an input to the refining process.	Yes-The Project will rely on groundwater for potable needs, and a combination of treatment strategies to ensure surface water quality is sufficient for discharge to the receiving waters downstream..	High
Genetic resources	Biodiversity is critical to the resources available to local residents, e.g.; Pamaka residents refer to the forest as "their supermarket".	No	Not applicable to services that are not business inputs.	Low
Biochemicals, natural	Various traditional medicines are	No	Not applicable to services that	Low

Ecosystem Service	*Description of Service in Project Area*	*Required as a business Input?*	*Cost-effective substitutes available?*	*Level of Dependence*
medicines, pharma-ceuticals	collected from the forest by local residents, especially the Pamaka, and transients in the Tempati and upper Commewijne areas.		are not business inputs.	
		Regulating Services		
Maintenance of air quality	Forests reduce dust dispersion and provide limited assimilative capacity for airborne pollutants. High air quality is vital to overall health of area residents.	No-forests in general have a significant effect on air quality, but the limited benefit that forests within the Project Area have in terms of general air quality is not required to sustain the Project.	Not applicable to services that are not business inputs.	Low
Regulation of climate	All local communities rely to varying degrees on local agricultural production for sustenance, which is dependent on favorable climatic conditions to produce high yields.	Indirectly.- The Project is highly dependent on climate to regulate rainfall, which in turn determines availability of process water.	No-there are no cost-effective alternatives to provide adequate supplies of water or treat wastewater if climate change induces significant changes in rainfall and/or surface water supplies within the Study Area..	Medium
Regulation of water timing and flows	Natural flow regimes in the rivers and streams follow the monsoonal wet/dry season pattern. Agricultural practices have developed to depend on this pattern.	Yes. Freshwater will be required for processing operations, dust suppression and domestic water for the camp, offices and kitchen.	Yes. The Project will include runoff management in the form of sediment ponds, the TSF, concurrent reclamation and other runoff management techniques to reduce artificially increased peak runoff rates.	Low

Ecosystem Service	*Description of Service in Project Area*	*Required as a business Input?*	*Cost-effective substitutes available?*	*Level of Dependence*
Erosion control	Natural vegetation stabilizes erodible soils, especially on steep slopes. Minimizing erosion naturally maintains recruitment of forest vegetation and water quality downstream.	No-mining process will destabilize soil.	Not applicable to services that are not business inputs.	Low
Water purification / waste treatment	Naturally vegetated riparian zones provide filtration and assimilative capacity for runoff-borne contaminants.	Yes. Disturbed areas have the potential to introduce sediment, toxins, etc. to surface waters, and Project will rely in part on naturally vegetated buffers to minimize the potential for impacts on surface waters.	Yes- The Project will include runoff management in the form of sediment ponds, the TSF, concurrent reclamation and other runoff management techniques to ensure satisfactory water quality in water discharged from the Study Area. to	Medium
Disease mitigation	Maintaining natural drainage patterns minimizes breeding areas for disease vectors (e.g.; mosquitos, gastrointestinal parasites), and healthy predator (e.g. insectivorous birds) populations provide a natural check on vector populations.	Yes. Project will be dependent on the general health of workers to operate efficiently and profitably.	Yes-Project plan includes measures to manage increased incidence of disease (e.g.; sanitary measures, prophylaxis, etc.)	High
Maintenance of soil quality	High quality, fertile soil is more productive and requires fewer inputs to support healthy vegetation.	No-the Project does not require high quality soil.	Not applicable to services that are not business inputs.	Low
Pest mitigation	Pests can damage crops and harm livestock.	No- the Project is not dependent on local agricultural or animal husbandry operations.	Not applicable to services that are not business inputs.	Low

Ecosystem Service	*Description of Service in Project Area*	*Required as a business Input?*	*Cost-effective substitutes available?*	*Level of Dependence*
Pollination	Many plant species require active pollination by another species (e.g.; a bird, bat, or insect). Sustained ecological health, including stable rates of primary production, are dependent on successful pollination.	No-the Project is not dependent on the health of the local plant community.	Not applicable to services that are not business inputs.	Low
Natural hazard mitigation	Natural vegetation provides assimilative capacity for large rain events and reduces flood risks, especially in riverside communities along the Marowijne and Commewijne Rivers. Pamakan communities on islands in the Marowijne River are particularly at risk from floods, and therefore dependent on natural flood attenuation.	Partially- the Project is located on high ground outside of flood prone areas so the Project is not highly dependent on natural flood attenuation, but it could be vulnerable to small-scale landslides or slope failures resulting from destabilization due to clearing.	No-although the Project infrastructure would be located outside of high flood-risk zones, floods in low elevation areas along the road to Moengo or along the Marowijne River could disrupt operations, and flood-proofing these areas would be impracticable.	Medium
		Cultural Services		
Recreation and ecotourism	One tourist lodge is located in Atemsa, but the Project area has relatively little ecotourism and recreation infrastructure or activity compared with other areas of Suriname, particularly areas near nature reserves in the interior or along coast. The Pamaka communities and the Commewijne authority consider the area to have high potential for ecotourism in the future.	No	Not applicable to services that are not business inputs.	Low

Ecosystem Service	*Description of Service in Project Area*	*Required as a business Input?*	*Cost-effective substitutes available?*	*Level of Dependence*
Ethical and spiritual values	Local communities place a high value on spiritual connection to nature, and the forest surrounding the Project area is considered sacred.	No	Not applicable to services that are not business inputs.	Low
Educational and inspirational values	There is little evidence that the local communities place specific education or inspirational value on the Project Area except in a general spiritual sense as discussed above.	No	Not applicable to services that are not business inputs.	Low
Supporting Services				
Habitat	Natural conditions necessary to sustain species populations and protect the general health of the Project Area's ecosystems are required to maintain various provisioning, regulating, and cultural services.	Yes. Habitat is necessary to support the (animals and plants) of the Project Area's ecosystems. The Project is dependent on biological raw materials, natural regulation of water flows and water quality, and natural suppression of disease, and is therefore indirectly dependent on habitat to support these services.	No-there is no practicable alternative to provision of natural habitat to sustain entire ecosystems.	High
Nutrient cycling	Healthy, intact vegetative communities are required for effective nutrient cycling. In tropical landscapes dominated by rainforest like the Project Area, most of the nutrients present in the ecosystem are sequestered in living biomass.	Yes. Nutrient cycling is a basic process that is fundamental to overall health of any ecosystem. The Project is dependent on biological raw materials, natural regulation of water flows and water quality, and natural	No-nutrient cycling is a natural process that is fundamental to overall ecological health.	High

Ecosystem Service	*Description of Service in Project Area*	*Required as a business Input?*	*Cost-effective substitutes available?*	*Level of Dependence*
		suppression of disease, and is therefore indirectly dependent on nutrient cycling to support these services.		
Primary production	Primary production forms the energetic base of all ecosystems-without primary production, life would cease to exist.	Yes. The Project Area ecosystems, and by extension all the services they provide (including those required by the Project) are sustained by primary production.	No	High
Water cycling	All forms of life are ultimately dependent on access to water. Therefore, much like primary production, water is a fundamental requirement of a healthy ecosystem.	Yes. The Project Area ecosystems, and by extension all the services they provide (including those required by the Project) are sustained by water.	No	High

As described in Table 21-3, ecosystem services in the provisioning, regulating, and cultural categories that provide a direct business input and for which there are no cost-effective alternatives include provision of fresh water, regulation of water flow, water purification and treatment, and disease mitigation. With the exception of disease mitigation most of the ecosystem services upon which the Project is highly dependent are directly related to water. Disease mitigation is indirectly related to water resources to the extent that stagnation of running waters can contribute to disease through deterioration of water quality and increased breeding opportunities for disease vectors. The analysis clearly demonstrates that the success of the Project will be highly dependent on the ability to manage water resources efficiently. This result is consistent with the results of the overall ESIA, which identify impacts on water resources as requiring careful management.

The Project is also highly dependent on all of the ecosystem services in the supporting category. These include habitat, nutrient cycling, primary production, and water cycling. This dependence exists because the provisioning, regulating, and cultural functions upon which the Project will rely cannot function unless the ecosystem that provides them is intact and functioning. If the most basic components of the Project Area's ecosystem are not maintained, the ecosystem will collapse. The dependable supplies of fresh water that exist currently will no longer be available, natural controls on disease will disappear, and the practicability of the Project will be compromised. Although there are cost effective alternatives to the natural provision of some specific ecosystem services, there are no cost-effective alternatives to services in the supporting category because of the number of other services that they support. For example, a water treatment plant may provide a cost-effective alternative to a natural source of drinking water for a limited number of workers, but it would impracticable to rely on water treatment to provide sufficient clean water in local streams to dilute the sanitary wastestreams created by those workers indefinitely.

Ecosystem services that the Project is moderately dependent upon include biological raw materials , regulation of water timing and flows, regulation of climate, mitigation of natural hazards. Dependence on these services was rated moderate because the Project is partially, indirectly, minimally dependent on them, or because alternatives to these services exist but would be prohibitively expensive to implement.

Each of the ecosystem services identified in Table 21-3 was also evaluated to determine whether the Project would affect it. Potential to affect ecosystem services was evaluated according to three additional criteria:

1) Is the Project anticipated to affect the quality and / or quantity of the service;

2) If yes to 1 above, is the effect anticipated to be positive or negative; and

3) If yes to 1 above, is the Project anticipated to affect others' ability to benefit from the service?

The Project's impact is rated high in cases where it will have a significant, measurable, and unequivocal effect on a particular ecosystem service. Impacts that may not be significant beyond the immediate footprint of the impact, aren't directly measurable or attributable to the Project, or vary across space or time were rated medium. All other impacts are rated low. Table 21-4 summarizes the results of this analysis.

Table 21-4 Project Effect on Ecosystem Services

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
Provisioning Services				
Food	Yes-although the local communities rely on agricultural as their primary source of food, they also rely in part on fishing, hunting, and gathering NTFPs to provide food to supplement their diets. No group identified the forests or streams within the Study Area boundary as preferred hunting or fishing areas, but the Pamakas from the Marowijne River villages that they hunt and fish in the general area west of the Marowijne, which includes the Study Area.	Negative	Yes. Loss of vegetation and habitat in the areas to be cleared and disturbance of wildlife elsewhere due to increased levels of human activity will negatively affect the availability of forests fruits and game animals.	Medium
Biological Raw Materials	Yes. Most communities in the Project Area are dependent to some degree on raw materials derived from the forest. The forest within the Project Area represents a potential source of these materials. Although none of the local communities specifically identified the Project Area as a	Negative-The Project will clear significant areas of forest, rendering traditional forest products that would otherwise have been available from these areas unavailable.	Yes	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
	preferred area for collecting biological raw materials, they did indicate that forest products in general are becoming more difficult to obtain and require further trips from the villages than in the past, which means that forays into the Project Area are more likely to be necessary now than they would historically have been.			
Biomass fuels	No-although biomass fuels (predominantly firewood) are available in the Project Area, significant sources of firewood exist closer to the local communities, so it is unlikely that the local communities consider the Project Area as significant source of biomass fuels	N / A	N / A	Low
Fresh water	Yes. The Project will affect water quality and will result in changes to creek drainage basins including a significant change to A3	Negative in some areas where creeks will be redirected, but positive where ASM activities will be reduced.	No-although some freshwaters will be impacted by the Project (tributaries of the Commewijne River and ASM impacted tributaries of the Marowijne River),	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
			the areas that will be impacted were not identified as primary sources of water for local residents. Local residents use the Marowijne and Commewijne Rivers for bathing and washing and these areas would ultimately receive discharges from the Project Area, but Surgold has committed to achieving water quality sufficient for these purposes through application of a Water Management Plan.	
Genetic resources	No-although the Project will affect biological resources, the Biological Management Plan contains several measures designed specifically to prevent loss of species from the Project Area	N/A	N/A	Low
Biochemicals, natural medicines, pharmaceuticals	Yes. Most communities in the Project Area are dependent to some degree on materials derived from the forest, including traditional medicines. The	Negative-The Project will clear significant areas of forest, rendering traditional forest products that would otherwise have been available from these areas unavailable.	Yes-but only within the Study Area. Based on input received from local communities, the Study Area does not possess unique value for	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
	forest within the Project Area represents a potential source of these substances. Although none of the local communities specifically identified the Project Area as a preferred area for collecting these materials, they did indicate that forest products in general are becoming more difficult to obtain and require further trips from the villages than in the past, which means that forays into the Project Area are more likely to be necessary now than they would historically have been.		collection natural medicines, herbal remedies, etc.	
		Regulating Services		
Regulation of air quality	No-although the forest within the Project Area contributes to maintaining good air quality, air quality is not expected to deteriorate significantly as a result of Project-related clearing.	N/A	N/A	Low
Regulation of climate	No-although the forest within the Project Area	N/A	N/A	Low

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
	contributes to maintaining the climate, climatic conditions are not expected to deteriorate significantly as a result of Project-related clearing.			
Regulation of water timing and flows	Yes, although only at a very localized scale within the upper A3 Creek watershed. The Project will affect flows in the North Fork and South Fork of A3 Creek, and will reduce potential for vegetative uptake of water in cleared areas. The Project will also reduce the permeability of the Project area resulting in lower rates of infiltration and higher rates of runoff. The Project will include a number of sediment ponds as well as the Treated Water Storage Pond and the TSF that will serve as large impoundments and change the flow regimes in the adjacent creeks.	Negative. Natural flow regimes will be altered across much of the Project Area.	No-alteration of flows will occur mostly in the headwater reaches of affected watercourses, upstream of most withdrawals or consumptive human uses. Flows will return to approximately baseline conditions by the time they reach downstream users. Project has an opportunity to improve stream hydrology by reclaiming some ASM impacts	Medium
Erosion control	Yes. Clearing vegetation to construct the mine pits and other infrastructure will	Location dependent. Application of BMPs and eventually restoration of the riparian zone will	Yes. All downstream users would be potentially affected by	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
	increase erosion potential.	improve conditions in areas previously impacted by ASM. Increased erosion will negatively affect uses downstream of previously undisturbed areas, although the extent and magnitude of the effect will likely be highly variable.	increased erosion, although the effects of increased erosion in the Project Area in the mainstem of the Marowijne and/or Commewijne Rivers would likely be obscured by the magnitude of similar impacts elsewhere in their respective watersheds.	
Water purification/waste treatment	Yes. The Project will affect natural mechanisms for purifying water, especially in areas where riparian forest is impacted.	Location dependent. Application of BMPs and eventual restoration of the riparian zone will increase filtration capacity in areas previously impacted by ASM. Filtration capacity will decrease in previously undisturbed areas and affect uses downstream, although the extent and magnitude of the effect would likely be highly variable.	Yes. All downstream users would be potentially affected by changes in natural support of water quality, although the effects of increased erosion in the Project Area in the mainstem of the Marowijne and/or Commewijne Rivers would likely be obscured by the magnitude of similar impacts elsewhere in their respective watersheds.	Medium
Disease mitigation	Yes. Standing water in pits (and ultimately pit lakes) represents a potential increase in habitat for disease-carrying mosquitos.	Negative	Yes. Mosquitos are highly mobile, and increases in breeding habitat within the Project Area can translate to increased incidence of	High

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
			disease transmission for several kilometers outside the Project boundary.	
Maintenance of soil quality	No. The Project will initially remove biomass from the soil, which will decrease fertility, but the Project's restoration plan includes soil amendments to increase soil fertility and initiate vegetative regrowth.	N/A	N/A	Low
Pest mitigation	No. The Project is unlikely to introduce new pest species, or to improve conditions for existing pest species in the Project Area.	N/A	N/A	Low
Pollination	No. The Project is unlikely to prevent or discourage pollination. Although habitat availability for certain pollinators will be reduced within the Project boundary, no habitat type will be lost completely from the Project Area.	N/A	N/A	Low
Natural hazard mitigation	Yes. The Project has the potential to incrementally affect flood hazards on both the Marowijne and Commewijne	Negative	No	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
	Rivers, but the Project is located on minor tributaries of both rivers. Cumulative flood hazards at the local communities are more related to flow volumes from upstream on both rivers than from the Project Area The Project could also increase localized risks of landslides, but these risks will be limited to the immediate vicinity of Project-related excavations and will not affect local communities.			
		Cultural Services		
Recreation and ecotourism	No. Little ecotourism occurs in the Project Area and the local stakeholders have indicated a general lack of recreation opportunities in the region. The Pamaka communities and the Commewijne authority consider the area to have high potential for ecotourism in the future.	N/A	N/A	Low
Ethical and spiritual values	Yes. Local communities place a high value on spiritual connection to nature, and the forest surrounding the Project area is considered sacred. Additional land	Negative	Yes. Clearing forest will decrease the spiritual value of the Project Area for local Maroon communities, however these forests are not	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
	clearing will therefore affect the spiritual value of the Project Area to the local communities		considered as spiritually significant as other areas (e.g., the Nassau foothills) and extensive ASM has already compromised the spiritual significance of the Project Area.	
Educational and inspirational values	There is little evidence that the local communities place specific education or inspirational value on the Project Area except in a general spiritual sense as discussed above.	Negative	No. Forest in the region will still retain educational and inspirational value for the Maroons in a general sense, in spite of the site specific clearing that will occur within the Study Area	Low
		Supporting Services		
Habitat	Yes. The Project will reduce the availability of several types of habitat, especially high dryland forest, within the Study Area.	Negative	Yes. Local Maroon communities require intact wildlife habitat to support their uses of wildlife and plant products, and reducing the availability of these habitats will reduce local access to the resources these habitats support. The local Maroon communities already perceive degradation of the local wildlife-related resources due to ASM, which could be exacerbated by the Project.	Medium
Nutrient	Yes. Healthy, intact	Negative	Yes. Nutrient	Medium

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
cycling	vegetative communities are required for effective nutrient cycling. Reducing the standing stock of living vegetative biomass will reduce the capacity of the ecosystem to cycle nutrients in the cleared areas.		cycling is a basic process that is fundamental to overall health of any ecosystem. Reducing capacity to cycle nutrients reduces biological productivity, thereby reducing access to all the services provided by the ecosystem.	
Primary production	Yes. Reducing the standing stock of living vegetative biomass will reduce the overall rate of primary production in cleared areas.	Negative	Yes. Primary production is the energetic basis of any ecosystem.. Reducing primary production reduces the overall productivity of the ecosystem, thereby reducing access to all the services provided by the ecosystem.	Medium
Water cycling	Yes. The Project will affect both the quantity and quality of water available in several streams in both the Marowijne and Commewijne River catchments.	Location dependent. Application of BMPs and eventually restoration of the riparian zone will improve conditions in areas previously impacted by ASM. In areas where ASM currently occurs, benefits will occur rapidly. Increased erosion will negatively affect uses downstream of previously undisturbed areas, although the extent and magnitude of the effect will likely be highly variable, and negative effects of the Project will eventually be	Yes. The Project will affect the distribution and quality (and therefore access to) water resources.	High

Ecosystem Service	*Will the Project affect the Service?*	*Positive or Negative effect?*	*Will the Project affect other's access to benefits of Service?*	*Level of impact*
		mitigated through restorative measures during the Closure phase.		

An ecosystem service review (ESR) (WRI, 2011) was conducted to identify Priority Ecosystem Services associated with the Project. Each of the ecosystem services considered in this baseline (Table 21-3 *and* Table 21-4) was evaluated in the ESR to determine whether it should be considered for elevation to a Priority Ecosystem Service based on the following four criteria: 1) dependence of the Project on the ecosystem service; 2) potential Project impact; 3) the importance of the service to the affected community; and 4) the replaceability of the ecosystem service.

1. **Project Dependence:** The Project has a direct dependence on the service for construction, operation, or supporting worker populations. Impact ratings were taken from Table 21-3.

2. **Potential Project Impact**: The Project may result in an adverse impact on the quality or quantity of a service or impede access to the service. Impacts ratings were taken from Table 21-4.

   Note that this potential impact rating is not a determination that an impact is expected to occur or an ultimate determination of significance but, rather, an assessment of the *potential for an impact on a service to occur and the potential level of that impact***.** Potential impacts related to all phases of the Project (Pre-Production, Operations, Closure and Post-Closure) were considered.

3. **Importance to Affected Community**: Importance is rated according to the degree to which beneficiaries have the potential to be affected by the loss or degradation of a service within the unit of analysis. Importance is categorized as essential, high, moderate, or low in Table 21-5 based on the following criteria:

   - Intensity of use – e.g., daily, weekly, or seasonal use of a provisioning service; number of downstream villages reliant on erosion or flood control services, etc.;
   - Scope of use - e.g., household level versus village level; subsistence use, trade, or both;
   - Geographic proximity of the service to the beneficiary; and
   - Degree of dependence – e.g., contribution of fish or bushmeat to total protein in the diet.

Services that are rated as **Essential** or **High** importance to beneficiaries are major contributors to economic, cultural, physical, or biological wellbeing within the unit of analysis. Services that are rated as **Moderate** importance to beneficiaries provide a recognized value to beneficiaries or a supporting service to a recognized value. Services that are rated as **Low** importance have little to no significance to beneficiaries.

1. **Ecosystem Service Replaceability**: Replaceability is the existence of spatial alternatives for the same service (other sites where the same ecosystem service is also provided; e.g., medicinal plants may be harvested from a number of areas within and outside the unit of analysis). It does not refer to substituting a particular ecosystem service with a different but comparable service (e.g., the replacement of medicinal plants with medical services or the replacement of fishing with other protein sources such as livestock husbandry). Replaceability of ecosystem services is classified into one of three categories: those with many alternatives, few alternatives, and no known alternatives.

Table 21-5 documents the ESR ratings as per the above criteria. Priority Ecosystem Services are defined as:

1. Services that could have a Critical, Major, or Moderate impact from the Project AND have an Essential or High relevance to beneficiaries AND have Few or No Known Spatial Alternatives. Note that those services that have Critical, Major, or Moderate impact from the Project AND Essential relevance to beneficiaries are also considered priority services, even if spatial alternatives exist.
2. Services on which the Project is dependent such that the Project has the potential to diminish the supply of an ecosystem service to an extent sufficient to create scarcity of goods or services, either in terms of demand that cannot be met, or in terms of reduced reliability. This assessment takes into account existing (baseline) threats to the service and the extent to which these might be exacerbated by the Project.

Of the 23 ecosystem services described in Table 21-3 and Table 21-4, eight meet the thresholds to be defined as Priority Ecosystem Services (Table 21-5). These services are evaluated in detail in the impact assessment.

Services with **Critical or Major** Project impacts with **Essential** importance with **Few or No alternatives** were also considered to represent Critical Habitat (see Chapter 21.8 for the discussion on Critical Habitat).

Table 21-5 Priority Ecosystem Services (Priority Services Denoted with Green Text, Critical Services Denoted in Red Text)

Ecosystem Service	Project Dependence Low/Med/ High	Potential Impact	Importance to Affected Community	Replaceability	Priority Service (Y/N)
Provisioning					
Food	Low	Moderate	High	Many	N
Biological Raw Materials	Medium	Major	Essential	Many	Y
Biomass fuels	Low	Low	Low	Few	N
Fresh water	High	Moderate	High	Few	Y
Genetic resources	Low	Low	Low	Few	N
Biochemicals, natural medicines, pharmaceuticals	Low	Major	Medium	Many	N
Regulating					
Air quality regulation	Low	Low	High	None	N
Climate regulation	High	Low	High	None	N
Water quantity regulation / flood control	High	Moderate	Medium	None	N
Erosion control	Low	Moderate	High	None	Y
Water purification	Medium	Moderate	High	Few	Y
Disease mitigation	High	Major	Essential	Many	N
Maintenance of soil quality	Low	Low	Low	Many	N
Pest mitigation	Low	Low	Essential	Many	N
Pollination	Low	Low	Essential	Many	N
Natural hazard mitigation	Medium	Medium	Essential	Many	N
Cultural					
Recreation and ecotourism	Low	Low	Low	Many	N
Ethical and spiritual values	Low	Moderate	Essential	Few	Y
Educational and inspirational values	Low	Low	Low	Many	N
Supporting					
Habitat	High	Moderate	High	Few	Y
Nutrient cycling	High	Moderate	Medium	Few	N
Primary production	High	Moderate	High	Few	Y
Water cycling	High	Major	Essential	Few	Y

Evaluation of ecosystem services involves an interdisciplinary assessment across biological, physical, and social resources. As such, most, if not all, ecosystem services impacts are discussed in the following section but also (and in more detail) within other chapters of the ESIA as follows:

Provisioning Services

- Impacts on biological raw materials – addressed in Chapter 21 Biological Resources Impacts, Chapter 22 Land Use Impacts, and,Chapter 23 Social and Health Impacts.
- Impacts on fresh water – addressed in Chapter 19 Water Resources Impacts and Chapter 21 Biological Resources Impacts..

Regulating Services

- Impacts on erosion control – addressed in Chapter 18 Landscape and Soils Impacts.
- Impacts on water purification – addressed in Chapter 19 Water Resources Impacts and Chapter 21 Biological Resources Impacts..

Cultural Services

- Impacts on ethical and spiritual value – addressed in Chapter 23 Social and Health Impacts.

Supporting Services

- Impacts on habitat – addressed in Chapter 21 Biological Resources Impacts.
- Impacts on primary production – addressed in Chapter 21 Biological Resources Impacts.
- Impacts on water cycling – addressed in Chapter 19 Water Resources Impacts.

21.9.1 Ecosystem Services Impact Assessment Methodology

Assessment of the potential impacts of the Project on priority ecosystem services follows the impact assessment approach used in the rest of this ESIA, with some ecosystem services-specific criteria added. Specifically, the significance of impacts to ecosystem service was determined by assessing the change in service delivery (i.e., the direct, indirect, secondary, or cumulative impact of the Project on the service), which is characterized by:

- The magnitude of the impact,

- The sensitivity of the ecosystem service (in terms of resilience to impacts),
- Sensitivity of the beneficiaries of the service, and
- The likelihood that the impact will occur.

The magnitude of the impact is based on the impact ratings provided in the specific resource chapters of the ESIA **and** by considering changes in beneficiary *access* to the resource, or the *quality* and *quantity* of the good or service as used by the beneficiary. Changes in *quality* are significant when they interfere with the intended use. Changes in *quantity* are significant if they prevent or degrade a current or expected use (e.g., insufficient water for irrigation) or change the temporal or spatial reliability of supply, especially during extreme conditions.

Sensitivity of the service, in terms of resilience to change, considers current status and threats to key ecosystem services and the resilience of underlying habitats and species where this information is available. Factors considered include: 1) current levels of pressure (e.g., fishing or hunting pressure) on the resource by communities or other users inside or outside the Project Area; and 2) condition of supporting habitat for ecosystem services –e.g., baseline surface water quality or level of degradation of forest habitats in the study area.

Sensitivity of the beneficiary is assessed primarily in terms of the extent to which the beneficiary relies on the service, but it also considers whether the beneficiary has access to other services or resources that could replace the service or mitigate the effect of losing access to the service.

The likelihood that the impact will occur is defined for the ecosystem services assessment according to the same rationale that is used for the rest of the ESIA.

Table 21-5 summarizes the predicted impacts of the Project on priority ecosystem services.

21.9.2 Ecosystem Services Impact Assessment Results

Biological Raw Materials

As described in *Chapter 14 Social Baseline*, biological raw materials in the Study Area include timber and NTFPs. Most if not all of the NTFPs identified as important to the local communities are either food items or natural herbs and medicinal plants, both of which are included as separate services in this assessment. Therefore for the purposes of this impact assessment, biological raw materials are considered to be limited to timber products.

The timber currently under Right of Exploitation within the footprint of Project infrastructure will be harvested during Pre-Production, so the impact of the Project on commercial timbering operations would be negligible. The proposed Project will clear approximately 33% of the total forest within the Study Area, rendering timber products from this area unavailable for the duration of the Project's lifetime. This represents a small portion of the overall Study Area, so the magnitude of the impact is considered minor.

The capacity of the forest to provide raw materials is highly sensitive to impacts from the Project because the forest will not recover fully from the impact of being clear cut for several decades. Although approximately 20% of the total area that would be cleared is secondary or disturbed forest and would be expected to return to pre-Project conditions relatively quickly, the remaining area to be cleared is mature high dryland forest that would take significantly longer to recover. Forested land, particularly forested land along creek channels, has been cleared at an increasingly rapid pace in recent years as ASM activity has increased in response to rising gold prices. Creeks provide natural travel corridors through the forest, so the most accessible raw materials in the forests have also recently become the most rapidly exploited. Although they are not directly related to the Project, these trends nevertheless affected the forest's capacity to provide the raw materials the local communities depend on, and increase the sensitivity of the services the forest provides.

Beneficiaries of timber products are moderately sensitive to the availability of these products from the Study Area. The local communities that consume timber from the forest within and around the Study Area are not as sensitive as the forest resource within the Study Area itself, because they can harvest timber from other areas. As pressure on forest resources increases, the sensitivity of the local communities that depend on them also increases. Nevertheless, increasing pressure on the forest in general has increased the local communities' sensitivity to the availability of forest resources. Interviews with local residents reveal a general feeling of dependence on the forest as well as a sense that the forest today cannot support them as well as in the past.

Fresh Water, Water Purification, and Water Cycling

Access to clean, fresh water is critical to the survival of all of the people residing in and around the Study Area. As described in the social baseline chapter, most Pamaka households in the vicinity of the Project rely at least partially on water from local surface waters (creeks and rivers) for drinking, cooking, and washing, but no households reported using any means of water purification prior to using these water sources. This dependence on unpurified surface waters has led to health problems, especially digestive illnesses in children, and especially during the transitional period between dry and rainy seasons. The Project also requires access to fresh water for the processing operations, dust suppression and domestic water for the camp, offices and kitchen. The Project will draw its process water from the TSF impoundment and the Treated Water Storage Pond. Domestic-use water will be supplied by groundwater wells..

There are few alternatives for either the local communities or the Project to satisfy their water needs from other sources. Local people also use rain water to satisfy some of their domestic needs, but ample supplies of rainwater are only available seasonally and surface waters must be used to supplement rain water supplies during the dry season. Likewise, during Pre-Production the Project may use bottled water and rain water for some of its potable water supply. It will be dependent on surface water and use the TSF impoundment for processing water to provide a steady supply of water through the dry season.

The Project will not affect access to fresh water downstream of the Study Area boundary. There will be no interbasin transfers between the Marowijne and Commewijne Basins, and apart from minor regrading at the extreme upstream boundaries of some headwater catchments, the area of the two river basins will remain basically unchanged. Water will be exchanged between a few small creeks within the boundaries of the TSF, and some small first and second-order creeks will be eliminated within the boundaries of the pits and waste rock areas, but the effect on flows in the larger creeks and the Marowijne and Commewijne Rivers is expected to be minimal at the boundary of the Study Area.

Although the Project has little to no potential to affect the overall quantity of water available to users both within and downstream of the Study Area, the Project has much greater potential to affect water quality within the boundary of the Study Area (i.e. within the mine water management area. Water will be discharged from the Project into tributaries of both the Marowijne and Commewijne Rivers but these discharges will be treated to be protective of existing beneficial uses. As described in the Water Impacts chapter, the Project has committed to treating water flowing out of the Study Area such that the Project will have no negative effect on potability downstream.

The Project design includes an adaptive water management program, which will be designed and implemented with the intention of minimizing the overall impact of the Project on water resources and preserving existing uses of water resources within and downstream of the Study Area. The magnitude of the

Project's effect on ecosystem services related to water resources will be highly dependent on the success with which this plan is implemented. Contingencies have been identified as part of the adpative water managment plan, which would be implemented if needed based on monitoring.

Erosion Control

Erosion is a natural process, and an important factor in shaping aquatic and riparian habitats both within and downstream of the Study Area. Erosion rates vary over time in response to climatic and landscape factors. Erosion shapes the overall landscape, defines the shape of creeks and rivers, and directly influences habitat conditions especially in the riparian zone and in the aquatic environment. For example, erosion from surface runoff influences the amount of turbidity in local streams, and therefore the suitability of those streams to support aquatic life. Wind erosion shapes topography and local air quality, which in turn influences microclimate and the diversity of local vegetation communities. To the extent that the local human population is dependent on the local ecosystem for provisioning and cultural services, they are also dependent on the role erosion plays in shaping and maintaining the ecosystem that provides those services.

Erosion also has the potential to affect the Project, and the Project is dependent on controlling erosion rates to maintain the stability of various Project components. As described in the Soils Impact chapter, erosion potential generally increases as slope increases, and the Project design includes over 3,000 ha of excavations, facilities, and structures on slopes greater than 20%. Some of these areas also include soil types that are pre-disposed to erosion, which increases the risk to built structures and the Project's dependence on erosion controls. To the extent that intact natural areas (i.e.; forest) can naturally control erosion through vegetative soil stabilization, reducing runoff volume and velocity, providing windbreaks, etc., the Project will depend on these services to minimize erosion-related risks, though engineering solutions have also been included in the project design.

The local communities are located outside of the Study Area, and are therefore dependent on effective erosion control within the Study Area to minimize negative effects of uncontrolled erosion on water quality, air quality, habitat conditions, etc. Although Surgold is capable of designing, installing, and maintaining site-specific erosion controls and will integrate such measures as necessary and appropriate to address the most significant erosion-related risks with the Project footprint, there are few if any practicable, cost-effective erosion-control alternatives that provide performance comparable to natural erosion control processes at the Study Area scale. It is therefore in the interest of both the local communities and Surgold to leverage the erosion control services provided by natural vegetation and undisturbed soils / topography to minimize impacts on other ecosystem services and on overall risks to Project infrastructure.

Ethical and Spiritual Values

As described in the Social baseline and impact assessment, the local communities highly value the forest ecosystem and their relationship and interactions with it. They view the forest as part of their cultural identity, and perceive their continued access to an intact and functioning forest ecosystem as critical to their communal well-being and even to their survival.

The Project does not directly depend on the forest ecosystem in an ethical or spiritual sense, but maintaining good relations with the local communities is dependent on respecting and accommodating the local communities' cultural ties to the forest. Local hostility toward the Project would present increased business and operational risk, so the Project is indirectly dependent on maintaining the local communities' continued access to, and relationship with, the forest ecosystem within and surrounding the Study Area.

Habitat and Primary Production

As mentioned previously, supporting services such as habitat and primary production do not, by themselves, provide tangible benefits or services, but rather support and sustain other services that do provide tangible benefits to beneficiaries. For example, habitat sustains game animals, which provide food for hunters. Without primary production, the NTFPs like herbs, traditional medicines, and edible fruits would not be available to be harvested.

Both the local communities and the Project are dependent on supporting services like habitat and primary production to sustain the other ecosystem services that provide tangible benefits. Biological raw materials (i.e.; timber) would not be available to local communities to use for buildings without primary production; nor would the Project benefit from the natural erosion controls benefits associated with forest vegetation (e.g.; vegetative soil stabilization and windbreaks). The ethical and spiritual values associated with forest wildlife that are so critical to the local communities would not be supported if habitat conditions were not suitable to support the wildlife, and local goodwill toward the Project would erode if wildlife populations were to decrease as a result of habitat degradation.

As described in the preceding sections, there are few if any practicable or cost-effective alternatives to most of the priority provisioning, regulating, and cultural ecosystem services discussed in this chapter. This means that there are also few if any practicable or cost-effective alternatives to the services that support them.

21.10 RESOURCES FOR CHAPTER 21

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22.0 LAND USE IMPACTS

This chapter describes the impacts of the Merian Project on land use and ownership in the Study Area.

22.1 METHODOLOGY AND CRITERIA

Impacts on land use are evaluated qualitatively, based on comparisons of likely future conditions (as determined by the current Project description) against baseline conditions described in Chapter 5.

22.2 PRE-PRODUCTION

The following potential impacts to land use are predicted to occur in the Pre-Production phase:

- Change in land use from ASM to industrial mining due to Surgold control of the Right of Exploration land; and
- Reduction of land available for hunting and Non-Timber Forest Products (NTFP) gathering.

The Operations and Closure phases would experience the same potential impacts.

22.2.1 *Change in land use from ASM to industrial mining due to Surgold control of the Right of Exploration land.*

The Government of Suriname's policy is to formalize gold mining and improve ASM practices through implementation of the OGS. ASM, as practiced currently, creates significant and uncontrolled environmental damage, and could potentially deter individuals from accessing nearby lands (i.e., for hunting or NTFP gathering), due to perceived safety risks. The Project will restrict access to the active mine area for safety reasons. The existing Industrial Zone already limits access to much of the Mine Site area.

Impact Assessment

Pre-Production will involve the construction of a TSF and other land-intensive components, some of which will be constructed in areas already impacted by ASM. To the degree that the location of mine facilities preclude further ASM activity and damage from past ASM activity, Pre-Production will in some cases prevent further ASM-related environmental damage, particularly for downstream land uses. Pre-Production will therefore constitute a minor environmental enhancement (low enhancement, medium likelihood) to land use in the Study Area.

Mitigation

The following mitigation measures are recommended to avoid negative impacts and strengthen enhancements to land use from all phases of the Project:

- Work with the Gold Sector Organization (OGS) in their efforts to improve environmental, safety and sustainability of ASM practices.
- Reconfigure abandoned ASM sites within controlled access area to return streams to a more natural hydrologic regime to enhance natural reclamation.

Residual Impact

Implementing these mitigation measures could potentially increase the Project's land use benefits to Moderate (medium enhancement, medium likelihood).

22.2.2 Reduction of land available for hunting and NTFP gathering.

The Pre-Production Phase of the Project will take place over approximately a two-year period, during which time mine facilities will be constructed and the Mine Site prepared for day-to-day mining activity. During this phase and subsequent phases, Surgold will control access to the Mine Site.

Surgold holds a Right of Exploration for Gold and Other Minerals for a 25,916 hectares area, which is designated as Government Land by the Suriname government. The Company's 2007 application for a right of exploitation is being processed, with the expectation that it will be granted. Pre-Production activities (including access control) will be consistent with the Right of Exploration for early works and then the Right of Exploitation for mine development. All mineral exploitation activities will remain within the area defined by that agreement. Thus Pre-Production will not impact any legally defined land use or ownership rights.

Impact Assessment

Controlled access to the Mine Site has the potential to limit the amount of land available for hunting and collection of Non-Timber Forest Products (NTFPs). The area was not identified as a critical hunting and collection area during data collection, possibly due to the history of artisanal mining and exploration. Given the region's very low population and the expanse of other available forest nearby, the reduction of available land is considered to have an insignificant (low severity, low likelihood) impact on hunting and NTFP gathering. This impact may be perceived to be more severe by local residents and is discussed, assessed and mitigated in Section 23.

Mitigation

The following mitigation measures are recommended to avoid negative impacts and strengthen enhancements to land use from all phases of the Project:

- Work with the Gold Sector Organization (OGS) in their efforts to improve environmental, safety and sustainability of ASM practices.
- To mitigate potential increased competition for suitable areas for subsistence agricultural and hunting / gathering activities, Surgold will engage Pamaka stakeholders in collaboration with the Suralco Nassau Project regarding the areas of forest that will be affected by the Project. This will aim to identify stakeholder concerns and areas of forest that are significant for the collection of NTFPs or hunting. This may include giving assurances regarding specific areas of forest near to settlements
- As possible, reconfigure abandoned ASM sites within controlled access area to return streams to a more natural hydrologic regime to enhance natural reclamation.

Residual Impact

Implementing these mitigation measures would maintain the Project's insignificant impact on land use.

22.3 OPERATIONS

The impacts of the Operations phase on land use and ownership will be similar to those of the Pre-Production phase.

22.4 CLOSURE

The impacts of the Closure phase on land use and ownership will be similar to those of the Pre-Production phase.

22.5 POST-CLOSURE

Impact Assessment

During Post-closure, the TSF will have industrial controls (e.g. signs and/or berms) to assure human safety. Through time, especially as the TSF becomes naturally re-vegetated, access risk will be minimized The remaining mine areas will be revegetated and available for use by local residents immediately. Downstream ASM areas would be reconfigured and returned to more natural hydrological conditions. Some areas of the Mine Site could potentially be suitable for hunting and gathering, although pit lakes would cover some former forest land. The remnant security and lack of mineable minerals will reduce the potential for ASM. Thus, the Post-closure phase (compared to baseline conditions) will therefore constitute a minor enhancement (low enhancement, medium likelihood) to land use in the Study Area.

Mitigation

See Chapter 22.2.1.

Residual Impact

See Chapter 22.2.1.

23.0 SOCIAL AND HEALTH IMPACT ASSESSMENT

This chapter addresses the potential impacts of the Project on socio-economics and community health and safety. The Project phases in which the impact will be experienced are discussed for each impact. The analysis of each impact is discussed under the following four headings.

- Potential impact description;
- Impact assessment;
- Mitigation measures[1]; and
- Residual impact assessment.

Positive effects will be assessed first followed by negative impacts. Impacts are assessed based on the severity of the negative impact or the level of enhancement of a positive impact measured against the likelihood of the impact occurring. See Chapter 15.2 for an explanation of how severity, enhancement and likelihood measures are defined, and Chapter 15.3 for an explanation of how the overall impact rating is subsequently assessed. The assessment that follows provides the rationale for the severity or enhancement of an impact based on its duration, extent, the degree of change caused by the impact and the focus or sensitivity of receptors to the impact. The calculations behind the assessment of severity have been demonstrated for the Project phase for which the impact is anticipated to be most significant.

23.1 INCREASED EMPLOYMENT AND INCOME GENERATING OPPORTUNITY WITHIN THE MAROWIJNE AREA

23.1.1 Potential Impact Description

The Project will require up to a peak of 1,200 skilled, semi-skilled and unskilled workers. As part of its recruitment policy, Surgold has made a commitment to give preference for hiring employees within the Marowijne Area and then elsewhere in Suriname. Given that levels of advanced educational achievement and formal employment experience are low within the Marowijne Area, it is assumed that the majority of labor sourced within this area may be unskilled or semi-skilled.

This impact will begin in the Pre-Production phase and last throughout the Operations phase. During the Pre-Production period (between 2013 and 2014), Surgold will hire approximately 200 unskilled employees.

[1] Mitigation measures are actions and management plans designed to avoid or reduce negative project impacts and enhance positive impacts. For mitigation and management measures to be effective they will be contractually applied to Surgold subcontractors in addition to Surgold staff and activities.

To the extent that Surgold can hire employees who self-identify as Pamaka or are Suriname nationals that live, contribute to and visit the Marowijne Area , or whose Pamaka identity can be validated by the Pamaka Traditional Authority, it will provide Pamaka households with additional income, which can lead to improved standards of living. This additional income is likely to be spent in businesses within the Marowijne Area, promoting a multiplier effect and more widespread income generation opportunities.

In order to enhance this impact, Surgold has begun to record skills, proficiency and interest from residents within the Marowijne Area in a database, and in order to help manage any future retrenchment of employees (during the Closure phase) a Closure plan is being developed that addresses the social dimension.

It should be noted that although Surgold has indicated its willingness and desire to hire Pamaka Maroon people resident in the Marowijne Area, this may prove difficult. Capacity, experience in formal employment, formal education and certified skills in the area are limited and this may limit the potential for local people to receive employment. The local reliance on ASM as a livelihood and the perception that ASM can offer greater income than working for an industrial mine may exacerbate this issue, further limiting the number of local people eligible or willing to pursue opportunities for employment.

Any benefits received from this impact may be enhanced by Suralco's nearby Nassau bauxite mine project (approximately 40 km south of the Merian site). The opportunity for staff to be trained and work on either project will potentially increase employment capacity and wages in the area.

In addition to direct benefits from hiring people from within the Marowijne Area the Project may also offer potential economic benefits through the local procurement of goods and services.

23.1.2 Impact Assessment

The likelihood for this impact during both Pre-Production and Operations is medium given that employment will certainly be required, but local and regional (the Interior) employment will be limited by a lack of local skilled labor. Without management and enhancement measures the economic multiplier effects of this employment (wages from Surgold employment being re-invested in the local area by local people) will also be muted.

The enhancement rating for this impact during Pre-Production is low as analyzed in *Table 23-1*.

Table 23-1 Increased Employment and Income Generation Enhancement Assessment during Pre-Production

Duration	Extent	Degree of Change	Focus / Sensitivity	Overall Enhancement Rating
MEDIUM	MEDIUM	LOW	LOW	LOW
Benefits will commence during Pre-Production and increase during Operations phase however retrenchment will occur during the Closure phase and numbers of Surgold workforce will decrease.	Depending on successful implementation of enhancement measures, there is potential for benefits to be experienced throughout the local community due to the multiplier effect.	Without sufficient planning to increase local capacity the opportunities for local benefits may be reduced.	Benefits will not deliver substantial help to vulnerable groups (see Social Baseline Chapter 14) and will only benefit those that would otherwise have benefited from the Project.	

During the Pre-Production phase this impact has been assessed to have a *minor positive impact* due to a low enhancement rating and a medium likelihood. This represents the challenges that may be faced in sourcing employees from the local area.

The enhancement rating for this impact during Operations is medium as analyzed in Table 23-2.

Table 23-2 Increased Employment and Income Generation Enhancement Assessment during Production

Duration	Extent	Degree of Change	Focus / Sensitivity	Overall Enhancement Rating
HIGH	MEDIUM	MEDIUM	LOW	MEDIUM
Benefits that commenced during Pre-Production will increase during Operations and last for the Life of Mine (LoM). Retrenchment will occur during the Closure phase and numbers of Surgold workforce will decrease.	Depending on successful implementation of enhancement measures, there is potential for benefits to be experienced throughout the local community due to the multiplier effect.	Depending on successful implementation of enhancement measures, there will be opportunities for further improvements to individual and community livelihoods.	Benefits will not deliver substantial help to vulnerable groups (see Social Baseline Chapter 14) and will only benefit those that would otherwise have benefited from the Project.	

During the Operations phase this impact has been assessed as a *moderate positive impact* based on a medium enhancement and medium likelihood rating.

23.1.3 Mitigation Measures

Education and skills training

Where there are skills shortages in the local area education and skills training will be provided to residents of the Pamaka communities to increase local employment capacity. This training will be provided as part of Surgold's recruitment policy, where possible in a pre-emptive manner, in order to ensure that local capacity has been developed in advance of large scale hiring for the Operations phase. This provision of educational skills and training will help to increase the sustainability of this positive impact. Surgold will look for opportunities to work with partner organizations for this education and skills training.

Certification of Training

Successful completion of training and attainment of competency in new skills while employed with Surgold or as part of an education and skills training program will be formally recognized through a certification system. This system will also help trainees find work elsewhere at the end of employment with Surgold. In addition, on-the-job training in simple tasks will be certified by Surgold.

Coordination between Surgold and GoS

Skills and recruitment needs will be identified, where possible in consultation with Suralco and the GoS in relation to other existing and potential future industrial developments in the area. To achieve this Surgold should continue to engage relevant departments of the GoS to proactively plan for the existing development process. Training and education programs could then be developed in partnership to maximize their benefit.

Human Resources Database

A database of locally available human resources detailing skills, proficiency and education levels will be created, where possible in coordination with Suralco's Nassau project. This database will continue to be consulted to identify the maximum number of locally available candidates. In addition this resource can be used to help structure the application or expression of interest process for potential employees.

Sourcing, Procurement and Recruitment Policy

Measures will be taken to ensure that the Sourcing, Procurement and Recruitment Policy is designed to engage marginalized groups, including women, displaced ASM workers, the local youth etc., to allow the opportunity for benefits to reach a wide range of members of local communities. This will defines the objectives regarding recruitment of employees and procurement of goods and sources. This policy will be publicly available and included within stakeholder engagement activities.

Financial Management Training

Training in fiscal management will help employees, their families and affected communities to maximize the benefits they receive associated with increased household cash income. This will be provided with the aid of a relevant local partner or NGO in local languages, and will be made available to all members of employees' families.

Social Closure Planning

The retrenchment of employees during Closure and Post-closure will require careful management though an integrated Closure management plan involving social Closure planning. This should be developed prior to the completion of the Operations phase and be updated regularly; detailing how retrenched employees will be supported.

23.1.4 Residual Impact Assessment

Assuming the effective application of these management and enhancement measures by the Project team the potential positive impact is assessed as *–high* during both Pre-Production and Operations. This increase in significance results from an increase in the enhancement rating to high. The likelihood of the impact also increased to high.

23.2 INCREASED EMPLOYMENT AND INCOME GENERATING OPPORTUNITY AT A REGIONAL AND NATIONAL LEVEL

23.2.1 Potential Impact Description

As mentioned in the previous section, the Project will require a certain number of skilled, semi-skilled and unskilled workers. It is estimated that the peak requirement will be for approximately 1,200 employees, including skilled, semi-skilled and unskilled. As part of its recruitment policy, Surgold has made a commitment to favor employees at a local, regional or national level, starting within the Marowijne Area. Given that levels of advanced educational achievement and formal employment experience are low within the Marowijne Area it is assumed that the semi-skilled and skilled jobs will be filled from applicants at a regional and national level.

This impact will be experienced throughout the LoM. During the Pre-Production period Surgold will hire approximately 750 employees, an estimated 600 of whom will likely be Surinamese nationals. During Operations the total workforce is expected to be approximately 1200 employees.

If recruitment needs can be met through hiring of people at a regional or national level, it will provide additional income, which can lead to improved standards of living. This additional income is likely to be disbursed on goods and services, promoting a multiplier effect and more widespread income generation opportunities.

It should be noted that although Surgold has indicated its willingness and desire to hire at a regional or national level it is expected that some expatriate staff will be required.

Any benefits received from this impact may be enhanced by Suralco's nearby (approximately 40 km south of the Merian site) Nassau bauxite mine project. The opportunity for staff to be trained and work on either project will potentially increase employment capacity and wages.

23.2.2 Impact Assessment

The likelihood for this impact during both Pre-Production and Operations is high given that employment will certainly be required,

The enhancement rating for this impact during Pre-Production and Operations is low as analyzed in Table 23-3. This represents the relatively small numbers of employment and the requirements for some expatriate staff.

Table 23-3 Increased Employment and Income Generation Enhancement Assessment

Duration	**Extent**	**Degree of Change**	**Focus / Sensitivity**	**Overall Enhancement Rating**
MEDIUM	LOW	LOW	LOW	LOW
Benefits will commence during Pre-Production and increase during Operations phase however retrenchment will occur during the Closure phase and numbers of Surgold workforce will decrease.	Benefits will be experienced largely in urban centers such as Paramaribo due to the centralized nature of the population.	Numbers of employment are not considered significant to dictate large scale change.	Benefits will not deliver substantial help to vulnerable groups and will only benefit those that would otherwise have benefited from the Project.	

During both the Pre-Production phase and the Operations phase this impact has been assessed to have a *moderate significant positive impact* due to a low enhancement rating and a high likelihood.

This impact may be enhanced by cumulative factors including other planned industrial projects in Suriname.

23.2.3 *Mitigation Measures*

Management and enhancement measures for the previous impact will also help to enhance this impact.

Promote Mining Skills

Surgold will seek to, where possible, work with the training programs in place at higher education organizations in Paramaribo and elsewhere to promote the development of mining skills nationally.

23.2.4 *Residual Impact Assessment*

Assuming the effective application of these management and enhancement measures by the Project team the potential *positive* impact is assessed as *major.* This increase in significance results from an increase in the enhancement rating from -low to medium. The likelihood of the impact remains high.

23.3 *BENEFITS FROM COMMUNITY INVESTMENT*

23.3.1 *Potential Impact Description*

A number of infrastructure, health and socio-economic development needs have been identified in the Marowijne Area. Surgold will have the opportunity to address some of these needs through Community Investment (CI) initiatives planned in coordination with community representatives. Surgold has committed to investing in Community Investment for the Project that will benefit the Marowijne Area. Levels of investment and the duration of this investment must be defined in consultation with community representatives and the GoS but can be expected to begin in the Pre-Production stage and continue throughout the life of mine (LoM). Funding will be phased out during the Closure phase but the benefits of previous investment will likely be experienced Post-closure.

Priority investment needs will be identified in consultation with the local community and any relevant partners, including government organizations and external funders, and a commitment will be made to honor these investments, which should result in development benefits to the local community.

Currently, Surgold is working to engage relevant stakeholders concerning the methods for managing CI and requests. This includes plans to work with a committee (Community Consultation Commitee) established by the Pamaka people to define and identify priorities for investment opportunities. The Community Consultation Committee, consisting of representatives from the GoS, Surgold, Pamaka traditional leadership and other Pamaka groups will collaborate on investments for the best interest of all involved. In addition, Surgold is currently operating an Expectation and Commitment Register to record and track requests from and expectations of employees. Surgold is planning to implement the International Council of Metals and Minerals (ICMM) Mining Partnerships for Development Toolkit to structure CI, which will involve a systematic register of potential partner organizations.

Some CI initiatives are currently underway including, for example, supporting the TANA Foundation to provide child tutoring and sponsorship of high performing students and schools in the area. Surgold have also begun researching future investment opportunities, such as looking at the attributes of community based organizations for potential market ready business in order to enhance livelihood diversification and socio-economic development of vulnerable groups.

The cumulative effect of Suralco also implementing CI initiatives as part of their Nassau Project may increase the significance of this impact.

These investments will be additional to the actions taken to mitigate negative Project impacts and can therefore be considered as a positive impact to the local community.

23.3.2 Impact Assessment

The likelihood for this impact during Pre-Production and Operations is *medium*. This is based on the fact that Surgold have only recently begun planning for strategic community investment and there is not yet a definite financial commitment for future social investment. However, Surgold's managing partners have demonstrable experience of community investment in other global projects where they have a feasible mine plan and a Mineral Agreement. It is therefore likely that this experience will be replicated by Surgold for the Project.

The enhancement rating for this impact is medium as analyzed in Table 23-4.

Table 23-4 Social Investment Enhancement Assessment

Duration	**Extent**	**Degree of Change**	**Focus / Sensitivity**	**Overall Enhancement Rating**
MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
There is potential for benefits to last and increase throughout the LoM depending on successful implementation of management and enhancement measures	Benefits will be primarily experienced by the local Pamaka community.	Moderate benefits will provide opportunities for leveraging secondary benefits.	With appropriate management and enhancement measures benefits will benefit a large majority of the Pamaka community including vulnerable groups.	

This impact has been assessed as a *moderate positive impact* based on a combined evaluation of enhancement, likelihood and receptor sensitivity.

23.3.3 Mitigation Measures

To enhance the beneficial effect of this positive impact the following management measures are required. Some of these have recently been put in place by Surgold and should therefore be further developed and updated as the Project progresses.

- The Project team will develop a Community Investment Strategy that ensures investment activities are considered in a systematic manner. This will require a participatory and consultative Needs Assessment to understand the development requirements in the area and the way in which the Community Investment can be integrated into the existing development environment. The Needs Assessment could be conducted by a team experienced in this area such as a specialist consultancy, partner organization or NGO.
- The Community Investment will be targeted at helping impacted communities in the areas of health, education, livelihood diversification, food security and socio-economic development (see Social Baseline Chapter 14 Section 14.3.4 – 14.3.6 and 14.3.8). It will include targets for delivery of benefits. It will include measures to assist wider community groups as well as ensuring the inclusion of marginalized and vulnerable groups (*e.g.* due to age, gender, ethnicity and religion, please see Social Baseline Chapter 14).
- Community Investment activities will be aligned, where possible, with government, partner organization and local NGO activities to ensure that the potential positive effects are maximized and Project synergies are realized.
- As part of on-going stakeholder engagement the Project team will consult with local communities to manage expectations from the Project and the Community Investment.
- Community Investment will be designed so that community benefits are not reliant on the Project for continuation and will not require substantial upkeep, maintenance, input of human or technical resources unless this upkeep has been sourced from elsewhere. This will be crucial to enhance the sustainability of the benefits delivered by CI.
- An Investment Committee will be established with responsibility for leading strategy and decision making about community investment. Members of this committee will include representatives from the Pamaka community (established through the Community Consultation Committee), the Surgold Social Responsibility Team and local development experts may include government, NGOs and other stakeholders. Community consultation via this Investment Committee

and through the Community Platform will ensure that the development needs prioritized by the community and those identified by Surgold are aligned.

23.3.4 *Residual Impact Assessment*

Assuming the effective application of these management and enhancement measures by the Project team the potential *positive* impact is assessed as *high*. This is based on an increase in the enhancement rating from medium to high. The likelihood of the impact occurring is also increased to high.

23.4 *REDUCTION IN STANDARD OF LIVING DUE TO REDUCED PRODUCTIVITY OF INCOME GENERATING OPPORTUNITIES RELATED TO ASM*

23.4.1 *Potential Impact Description*

Surgold has prevented ASM activities from taking place within certain areas of the Project area due, for example, to safety issues. This has resulted in the loss of substantial ASM sites, such as Gowtu Bergi, from the available resource pool. Limited access routes into other potential auriferous (gold-bearing) areas and historical overexploitation of creeks by ASM workers has meant that alternative mining sites are not readily available and / or accessible. As a result, income generation from ASM is reported to have reduced substantially. This is expected to have an on-going impact during the remainder of the Pre-Production phase and through the rest of the LoM.

Based on Focus Group Discussions (FGDs,) perceptions in the local area that other potential ASM sites may not be as productive have resulted in a reluctance to proactively identify and explore / exploit new areas, further reducing income generation from ASM.

A large majority of income-generating opportunities within the Marowijne Area, including shops, bars, boat drivers and sex workers, are reliant on cash originally generated from ASM. In addition, several women from the Marowijne Area are believed to have worked at the ASM sites providing support services such as cooking and cleaning. As households lose a substantial proportion of their income, it is considered likely that businesses in the Marowijne Area would also face a substantial reduction in the income that they generate.

While Brazilian, French / British Guianese and other Surinamese migrants who originally moved into the area to practice ASM may have moved to alternative sites, for local Pamaka ASM workers the loss of auriferous areas has impacted the standard of living.

This impact may contribute to on-going out-migration from the Marowijne Area, particularly of young men in search of income generating opportunities. This out-migration of young men may contribute to other impacts such as increased vulnerability of women, children and the elderly who rely on financial and social support previously received from ASM workers.

Loss of direct and indirect income generating opportunities from ASM activities has already begun and with the continued exclusion of ASM workers from certain areas of the Project .This impact is expected to continue throughout the LoM and Post-closure.

A reduction in income from ASM activities may also contribute to several other indirect, induced or secondary impacts including a decreased community sense of safety (see Chapter *23.11*). Other indirect or induced effects of this impact are discussed in the following sections.

Decreased food security

A decrease in income generated from ASM in the Marowijne Area may result in shortages of food as households do not have sufficient alternative income streams to purchase sufficient food. Recent trends towards the consumption of purchased foodstuffs and a move away from the agriculture and the cultivation and collection of traditional food may exacerbate this impact.

A decrease in food security may be further exacerbated by the expansion of ASM workers into areas previously used for agriculture, particularly in the lower Marowijne Areas. A number of ASM workers who no longer work in the Merian Industrial Zone (IZ) have already relocated to explore / exploit alternative sites, particularly in areas of the Lower Pamaka near to Snesi Kondre. Some of these sites include current, planned or recovering agricultural areas, thereby reducing the pool of agricultural land and impacting the ability to generate sufficient food. This indirect impact has resulted in the loss of some agricultural land.

Decreased income may also increase competition for limited suitable natural resources within the local community, including land and hunting/fishing stocks, as purchased food is supplemented or replaced with food supplied by subsistence activities such as traditional hunting, fishing, gathering NTFPs or agriculture activities. This impact may also be exacerbated by reduced access to sites for collection of NTFPs and hunting due to land approbation or changes to the patterns of animals, fish and plant life both caused by the Surgold and /or Suralco Nassau projects or ASM in other areas. It should be noted that historical ASM within the current Merian IZ may also have reduced areas available for hunting / collection of NTFPs due to the large amount of clearing and disturbance that occurred due to ASM.

The issue of food security may be further exacerbated by out-migration driven by decreased levels of income from ASM. This out-migration may increase the vulnerability of the women, children and elders left behind who are unable to commit large proportions of time to subsistence activities. Without the assistance provided to them in the form of donations of food or money from ASM workers they may face food shortages, reduced access to services and decreased quality of life.

Reduced Access to Infrastructure and Services

It is possible that a decrease in income generated from ASM in the Marowijne Area throughout the LoM may result in reduced access to schooling and health services for people in the Marowijne Area as levels of income may not be sufficient to pay for items such as transportation, petrol, uniform and books. It should be noted that access to infrastructure and services was already limited when ASM was more prevalent. Information gathered during FGDs indicates that the majority of income earned by ASM miners themselves was not spent on improving standards of living or developmental activities. However, the income generated from ASM was the only significant income source and was used to contribute to rudimentary services and expenses for direct-family members such as small amounts of fuel, uniforms and school fees for children, and purchased food items for elderly.

23.4.2 Impact Assessment

The likelihood rating for this impact is high given that the impact is certain and already occurring.

The severity rating for this impact during all Project phases is medium as analyzed in Table 23-5.

Table 23-5 Reduction in Productivity of Income Generating Opportunities from ASM Severity Assessment

Duration	**Extent**	**Ability to Adapt**	**Socio-Cultural Outcome**	**Health Outcome**	**Overall Severity Rating**
HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Without mitigation and management the impact may continue throughout the LoM with a constant frequency.	A substantial percentage of the Pamaka communities rely on ASM income as a large component of household income generation.	Affected communities may be able to adapt with some difficulty if alternative livelihoods, income generating activities or viable alternative ASM sites become available.	Impact may result in secondary impacts to other livelihoods, cultural practices and access to services. It may be possible to compensate for these.	Impact may result in reduction in access to health services and shortages of food and subsistence items where affected communities can no longer afford to purchase these goods and services	

The receptor sensitivity for this impact is high as described in *Box 23-1*.

Box 23-1 *Reduction in Productivity of Income Generating Opportunities from ASM Receptor Sensitivity*

High Sensitivity
Receptors to this impact may include Project Affected People (PAPs) within the Marowijne Area that generate income from ASM activities. In addition Receptors may include household members who rely on income from ASM activities, but do not practice ASM activities.

Almost all of these receptors are understood to have livelihood sensitivity due to:

- Reliance on illegal ASM as the only widespread, available and comparatively high income generating activity within the Marowijne Area;
- Limited savings networks compared to levels of debt;
- Low levels of income related to expenditure; and
- Reduced levels of knowledge, experience and skill to participate in and pursue alternative income generating opportunities.

This impact has been assessed as a *major significant negative impact* based on a combined evaluation of severity, likelihood and receptor sensitivity.

23.4.3 *Mitigation and Management Measures*

To avoid and reduce the significance of this impact the following mitigation and management measures have been developed for adoption by the Project team.

Develop ASM Management Plan

Develop in partnership with senior management and relevant Project staff an appropriate ASM Management Plan. This plan will document Surgold's strategic objectives, methods and monitoring techniques for the management of ASM workers for the LoM. This management plan is an important step in working with local stakeholders to establish viable solutions to competition for the Merian IZ, in coordination with Traditional Authorities of the Marowijne Area. It is understood that Surgold is currently not planning on allowing any ASM activity within the Merian IZ and does not support the informal continuation of ASM within its proposed right of exploitation.

Stakeholder Engagement – Continue to Engage with ASM Stakeholders

Surgold will continue to engage ASM related stakeholders regarding their activities within the area defined by the proposed right of exploitation. This includes engagement with community members, the local artisanal mining organisation the Porknocking Commission, the traditional authority and ASM Landbosses regarding the following topics:

- The potential current and future Surgold land use requirements within the Merian Right of Exploration or Right of Exploitation outside the IZ;

- The concept of relinquishing areas of the Merian Right of Exploration in agreement with the GoS;
- The safety and security measures that will be in place to patrol and guarantee the agreed IZ; and
- Potential Community Investment (CI) initiatives that the Company is planning to help benefit Pamaka villages.

Work with Organizations to Promote ASM best practices and Improvements

In coordination with GoS, Surgold will actively seek to promote best practice amongst Pamaka ASM workers to improve the practice of small scale mining. This may include:

- Undertaking a long term engagement program related to ASM best practices and improvement;
- Working with the GoS *Ordening Goud Sector* (OGS – roughly translated as the Gold Sector Restructuring Commission, see Social Baseline Chapter 14) to regulate ASM activities, improving the practice and enhancing the sustainability of small-scale mining. This will include supporting the delivery of OGS training to Pamaka people involved in ASM through a planned program of 'Mining Schools'. Through cooperation with the OGS, Surgold will seek to promote improved environmental, health and safety sustainability of the ASM activities;
- Identifying other potential partners to deliver assistance to the traditional authority and PK Commission on an ASM formalization and improvement program; and
- Facilitating an application for a legal small-scale mining license from a Pamaka cooperative.

Local Procurement of Goods and Services

Surgold will develop a strategic Local Procurement Plan that outlines how it intends to promote the procurement of goods and services for the Project in the local area diversifying and promoting alternative livelihoods and increasing the potential for income generation.

Recruitment Policy

The Surgold recruitment policy will include measures targeted at the engagement of displaced Pamaka ASM workers ensuring they have access to the same employment opportunities with the Project as other Pamaka residents.

Education and Skills Training

Surgold will design and deliver in coordination with a relevant capacity development partner capacity development and skills training. This training will be designed to present local Pamaka inhabitants with the tools to pursue alternative income generating activities to ASM, while also increasing the skilled labor pool to serve as potential employees. In order to maximize the functionality of this program, collaboration with Suralco Nassau and the GoS will be necessary.

Agricultural and Livelihood Improvement Program

As part of their CI program Surgold will seek to partner with a relevant organization to provide an agricultural and livelihood improvement program that will improve agricultural production techniques specific to the area. This may include micro-finance measures to improve access to markets, improved seeds or other inputs. Examples include the research that Surgold have recently funded in a cassava cooperative opportunity.

Stakeholder Engagement Surrounding Limits of Deforested Areas

To mitigate potential increased competition for suitable areas for subsistence agricultural and hunting / gathering activities, Surgold will engage Pamaka stakeholders in collaboration with the Suralco Nassau Project regarding the areas of forest that will be affected by the Project. This will aim to identify stakeholder concerns and areas of forest that are significant for the collection of NTFPs or hunting. This may include giving assurances regarding specific areas of forest near to settlements.

Biodiversity and Ecological Mitigation

Implement mitigation measures that will manage disturbance impacts to local species of flora and fauna. These are discussed in Chapter 11 - Biological Resources Baseline and Chapter 12 – Aquatic Resources Baseline.

Investment in Local Service Providers

Surgold will seek to improve the provision of local services in the Marowijne Area through engagement with the GoS and other relevant partners. The provision of improved local services should be included within the CI strategy.

23.4.4 Residual Impact Assessment

Assuming the effective application of these management and mitigation measures by the Project team the significance of the potential negative impact is assessed as *Moderate*. This reduction in significance results from the reduction of the likelihood rating from high to medium. The sensitivity of the communities will, however, remain high.

23.5 TRANSMISSION OF INFECTIOUS AND COMMUNICABLE DISEASES

23.5.1 Potential Impact Description

Infectious diseases most relevant to this Project are tuberculosis (TB), food-borne illnesses, malaria, and Sexually Transmitted Infections (STIs, including HIV).

Land-disturbance activities may contribute to malaria transmission, while the worker accommodation may be a potential source for an infectious disease outbreak (e.g., TB and food-borne illnesses). The transmission of infectious diseases associated with ASM activities, namely malaria and STIs (including HIV), can be exacerbated if Project-related influx occurs at any time during the Project lifecycle.

The Project may have direct impacts on malaria or dengue fever transmission should activities inadvertently create bodies of standing water during Pre-Production, Operations and Closure. These activities may include:

- Engineering works (e.g., drainage designs) of the Moengo-Langa Tabiki road upgrade that interfere with water drainage; and
- Disturbed areas (e.g., cuts, ditches, borrow pits, pits, TSF dam, pit lakes etc.).

This impact may be exacerbated by the cumulative impact of Suralco's Nassau Project similarly producing areas of standing water allowing mosquitoes to breed.

Because the Project workforce will primarily be housed on an onsite, closed accommodation camp, worker-community interactions will be limited to local residents returning home to the Pamaka villages. Thus the Project workforce are not likely have a direct impact on infectious disease (such as STIs) transmission to the surrounding villages. However, in the rare event of an outbreak of an air-borne (e.g., TB) or food-borne illness among the workers, which can occur if the accommodations camp has unhygienic conditions, the home villages of the local workers may also become susceptible to these infectious diseases.

Because digestive tract diseases and respiratory diseases are reported to be among the top causes of morbidity in Langa Tabiki and Nason, particularly among children, an outbreak in the worker accommodation could lead to severe consequences to households in the Pamaka villages.

In the Marowijne Area, the risk of contracting malaria and STIs (including HIV) is strongly related to ASM, according to the Ministry of Health. While the incidence of malaria has been substantially reduced in the Pamaka villages, the in-migration of foreign small-scale miners from highly malaria-endemic countries, particularly from Brazil and French Guiana, are a major source of new malaria cases in the area. This maintains the parasite in the human reservoir which perpetuates the continued transmission cycle within the area. The addition of a non-local workforce during Pre-Production may increase the size of the transmission pool. It should be noted that Surgold reported that it maintains a spraying regime to limit flying, biting insects and promote worker's safety which may reduce the mosquito population.

In addition, ASM miners are at high risk for STIs (including HIV) given their association with sex workers. Because many Pamaka villagers and migrants into the area practice ASM (with estimates varying between approximately 500 and 1,500), intermittently returning to their home village for 'rest and recuperation periods', the households in the Pamaka villages near the Mine Site are susceptible to exposure to infectious diseases.

ASM activity has substantially been reduced within and near the planned Merian Mine Site due to GoS intervention in the IZ. The likelihood for an influx associated with ASM activities is considered to be low due to the removal of ASM workers from within the Merian IZ and the perceived / actual absence of other viable sites for ASM. However, ASM activities have become dispersed throughout the surrounding area and still occur within the Right of Exploration area; and thereby, can continue to pose a risk for transmission of malaria and STIs (including HIV).

23.5.2 Impact Assessment

The likelihood rating for this impact is medium given a low likelihood of increased ASM activity near the Mine Site and a rare event of an outbreak at the accommodation camp. However, the Project may have direct impacts on malaria transmission should activities inadvertently create bodies of standing water during Pre-Production, Operations and Closure.

The severity rating for this impact is medium as analyzed in Table 23-6.

Table 23-6 Transmission of Infectious Diseases Severity Assessment

Duration	Extent	Ability to Adapt	Socio-Cultural Outcome	Health Outcome	Overall Severity Rating
MEDIUM	MEDIUM	MEDIUM	N/A	HIGH	MEDIUM
Without mitigation and management impact may continue for prolonged period intermittently.	Small to moderate number of households in the Marowijne Area involved in ASM activity or formal mine work near/at the Mine Site.	PAPs may be able to adapt with some difficulty but only with a degree of support from the health services.		Impact may result in moderate to chronic illnesses which can result in loss of life unless immediate treatments or hospitalization are received.	

The receptor sensitivity for this impact is high as described in *Box 23-2*.

This impact has been assessed as a *moderate significant negative impact* during Pre-Production, Operations and Closure based on a combined evaluation of severity, likelihood and receptor sensitivity.

This impact may be enhanced by cumulative factors from other planned regional industrial projects, including the Nassau Bauxite Project.

Box 23-2 Transmission of Infectious Diseases Receptor Sensitivity

High Sensitivity

Receptors to this impact may include people in the Marowijne Area that are involved in ASM activity or formal mine work near / at the Mine Site. In addition receptors may include members living in the same household as these workers.

Almost all of these receptors are understood to have infectious disease sensitivity due to:

- High risk for malaria exists in the forest areas, where ASM camps tend to operate.
- Interaction with high risk groups for malaria and STIs (including HIV) in the ASM camps (including foreign small-scale miners and commercial sex workers).
- Low utilization rates of condom and HIV testing for STI prevention among the interior Maroon populations (according to MOH National AIDS Program).
- Existing high rates of morbidity from digestive tract diseases and respiratory diseases in Langa Tabiki and Nason, particularly among children.

23.5.3 *Mitigation and Management Measures*

To avoid and reduce the significance of this impact the following mitigation and management measures have been developed for adoption by Surgold.

Influx Management & ASM Management Plans

Develop Influx Management and ASM Management Plans (in partnership with the GoS) that proactively detail how Surgold will discourage the influx of small-scale gold mining activity into the Merian IZ, including along the Project's new North Access Road. The plans will include monitoring and evaluation criteria for influx zones and associated risks and impacts posed to the Project and affected communities on an on-going basis in order to evaluate and improve management initiatives.

Malaria Control and Prevention Program

To reduce the risk of malaria, Surgold may partner with Ministry of Health's National Malaria Program "*Looking for Gold, Finding Malaria*" which will:

- Provide permission to the MOH's Malaria Program to access the right of exploitation when requested, such as during the need to deliver free malaria treatment medications in response to a confirmed malaria incidence.
- Assist with logistics for MOH field team to access the interior areas, such as providing drivers or ATVs, lodging and food (at the expense of the MOH National Malaria Program).

- Designate a company contact person with decision-making authority to help facilitate National Malaria Program's rapid malaria control response in the event of a malaria outbreak.
- Designate a trained medical staff support onsite as the Malaria Service Delivery (MSD) point of contact for the MOH, who can be available to conduct malaria rapid diagnostic tests, and routinely report cases or alert of a potential outbreak to the MOH.

In addition, Surgold will integrate malaria control strategies into the worker H&S programs, for example:

- Provide workers with personal protection (e.g., longsleeve, inspect repellant shirts, screened indoor office and living facilities);
- Provide chemoprophylaxis to decrease risk infection for non-immune personnel (i.e., workers from non-endemic areas); and
- Provide trained medical staff support onsite who can conduct malaria rapid diagnostic tests to workers, provide effective treatment and ensure that cases are reported to MOH.

HIV Workplace Policy

Surgold may partner with the Suriname Business Council (SBC) to develop and adopt a site-specific HIV Workplace Policy for the Project that aligns with Newmont's global HIV/AIDS policy which reflects the principles of the International Labour Organization (ILO) and the World of Work Code of Practice. The collaboration with the SBC would be aimed at the development and implementation of a sustainable and consistent workplace policy for the Project on HIV prevention among all workers and their families, and mitigation of HIV impacts via care, counseling and support of workers living with the disease.

The SBC's standard HIV Workplace Policy includes the following principles:

- Ensure company ownership and sustainability of the HIV/AIDS workplace program;
- Support HIV/AIDS prevention, non-discrimination, care and support, primarily focused on workers, but also on their families and their communities;
- Monitoring and evaluation of policy;
- Provide a clear statement about non-discrimination, in particular non-discrimination based on HIV and on gender; and
- Establish procedures for addressing HIV/AIDS issues in the workplace, in particular:
    - No mandatory HIV screening of workers or job applicants;

- Ensure strict confidentiality related to HIV testing and HIV status of workers;
    - No dismissal of workers due to HIV;
    - Prevention and protection of workers living with HIV against harassment;
    - Provide education and awareness raising services to workers; and
    - Provide psycho social support and counseling for workers and their families living with HIV.

- Provide a healthy and safe environment; and
- Social dialogue: cooperation between employers, workers and their unions, and the government, and with close involvement of people living with HIV.

Surgold will engage with the MOH National AIDS Program (NAP), to identify opportunities where NAP can help strengthen the capacity of the Project staff capabilities in HIV/AIDS prevention, education and treatment; as well as, reduction of stigma and discrimination. For example:

- NAP can provide valuable input on the design of work shift for workers living with HIV that takes into account their anti-retroviral (ARV) treatment regimen (e.g., night shifts can be a barrier to taking medication).
- NAP offers worker trainings on HIV/AIDS prevention and education that have been well- received by other companies.

Worker Accommodation Standards

Surgold will design worker living quarters to prevent over-crowding and unhygienic conditions (e.g., proper sewage disposal facilities) following industry best practices, such as *Workers Accommodations: Processes and Standards* (IFC and EBRD, August 2009). Further details are included in Chapter 23.9.

Worker Health Screenings and Monitoring

Surgold will integrate hygiene training (e.g., hand washing) in worker health and safety induction programs and as a regular part of continuous trainings for workers. In addition to the established Surgold's Standard Operating Procedures for Food Preparation and Handling, Surgold will ensure all food handlers are medically screened on a routine basis (e.g., semi-annual medical exams) and vaccinated.

Surgold will also conduct regular TB screenings of workers and contractors at the Mine Site as part of Merian's Worker Medical Screening Program, while ensuring the protection of employee rights and confidentiality.

As part of the Project's Health & Safety Program, Surgold will monitor TB cases and engage with MOH's National TB Program to put in place procedures for notification.

Risk Communication Planning

Surgold will establish appropriate communication systems with local health facilities, including the Medical Mission health post in Langa Tabiki and Nason and the Regional Health Service (RGD) clinic in Moengo, and national health agencies (e.g., National Malaria Program, National TB Program) as part of an update to emergency response plans, in the rare event of an outbreak of infectious disease (e.g., malaria, TB, food-borne illness) either at the Mine Site or in the surrounding community.

23.5.4 Residual Impact Assessment

Assuming the effective application of these mitigation measures, particularly regarding the management of influx (including of potential ASM workers) into the Marowijne Area, the significance of the negative impact is assessed as *Minor*. This reduction in significance results from the reduction of the likelihood rating from low-medium to low. The severity remains high. The sensitivity of the communities to these infectious diseases will, however, remain high.

23.6 PRESSURE / OVERBURDENING OF PHYSICAL AND SOCIAL/HEALTH INFRASTRUCTURE AND SERVICES

23.6.1 Potential Impact Description

The presence of the Project may result in influx into Moengo and the transient camps near to the Merian Right of Exploration due to the perception that jobs and benefits may be granted to local people. This influx may be particularly likely due to low levels of formal employment available throughout Suriname. This influx and resultant increase in population would result in pressure or overburdening of local infrastructure and services (including health services), potentially reducing levels of availability and quality of service.

Specifically in Moengo, the Suralco Polyclinic currently provides services only to Suralco employees and supervised contractors, thus the Moengo Bureau of Public Health, Regional Health Services (RGD) clinic will receive any extra demand from other non-Project-employed newcomers (including contractors). Constraints on the clinic can potentially reduce the availability and quality of basic healthcare services to current residents in Moengo and the surrounding communities. It should be noted that the current level of service provision in Moengo is very poor. According to the Moengo RGD Clinic Director, the clinic currently has capacity to meet additional demand if the population grew. Nevertheless, availability and quality of services may become impaired if there is a substantial increase in Merian workers (contractors and direct employees) and their families moving into Moengo.

Even if the Moengo RGD Clinic plans to increase its staffing to meet increased demand, the challenge still remains in obtaining and retaining sufficient numbers of qualified health care providers, physicians and nurses, which in turn affects the quality of care.

It should be noted that Moengo is believed to be experiencing a net outflow of young residents in search of education and employment opportunities. The combined ‘pull’ of the Surgold Merian and Suralco Nassau Project may result in an increase in residents remaining in the Moengo area. This retention of residents combined with the potential influx has the potential to overburden local health infrastructure.

The residents living in the surrounding villages of Moengo may experience greater impact than those living within Moengo because of the existing challenges in accessing clinical care due to the distance.

The Project plans to have an onsite medical facility at the Mine Site likely staffed by at least a paramedic and nurse although the final decisions on staffing have not been finalized. It is not yet known what medical services will be offered. To date, Surgold has an agreement with Suralco that the Polyclinic in Moengo can assist in emergency response services. Surgold will ensure health workers hired for the onsite medical facility at the Mine Site have the qualifications and capabilities to provide primary health care and trauma care.

This impact may be exacerbated by the cumulative impact of Suralco’s Nassau Project, Moengo Minerals Kaolin Project and the Grassalco Project, which may also attract influx associated with employment opportunities.

Without effective management and mitigation measures this impact has the potential to begin in the Pre-Production phase and last throughout the LoM.

23.6.2 Impact Assessment

The likelihood rating for this impact is medium given that influx is common in mining projects and levels of services and infrastructure are low given the remoteness and lack of current influx.

The severity rating for this impact is medium as analyzed in Table 23-7.

Table 23-7 Pressure / Overburdening Of Physical and Social/Health Infrastructure and Services Severity Assessment

Duration	**Extent**	**Ability to Adapt**	**Socio-Cultural Outcome**	**Health Outcome**	**Overall Severity Rating**
MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM

Duration	Extent	Ability to Adapt	Socio-Cultural Outcome	Health Outcome	Overall Severity Rating
Without mitigation and management impact may continue for prolonged period intermittently.	A substantial percentage of the relevant communities could be affected.	Affected people may be able to adapt, with some difficulty, to levels of influx and changes in infrastructure and services.	Impact may result in secondary impacts to other livelihoods and cultural practices.	Impact may result in reduction in access to health services and shortages of food and subsistence items.	

The receptor sensitivity for this impact is high as described in *Box 23-3*.

This impact has been assessed as a ***moderate negative impact*** based on a combined evaluation of severity, likelihood and receptor sensitivity.

Box 23-3 *Pressure / Overburdening Of Physical and Social/Health Infrastructure and Services Receptor Sensitivity*

Medium Sensitivity

Receptors to this impact may include people within the relevant area who use infrastructure and services.

Some receptors are understood to be sensitive to this impact due to the poor quality and shortage of key services and infrastructure currently available in Moengo.

23.6.3 Mitigation and Management Measures

To avoid and reduce the significance of these impacts the following mitigation and management measures have been developed for adoption by the Project team.

Local Procurement and Recruitment Plan

Surgold will develop and implement a strategic Local Procurement and Recruitment Plan which geographically favors the recruitment of residents who live closest to the Marowijne Area as far as is practicable given the skill and experience requirements of different jobs. This plan will confirm the process for identifying those who self-identify as Pamaka and will require the corroboration of the local traditional governance.

This plan will specifically define and favor local applicants, businesses and service providers ahead of providers from outside the area and stipulate the processes that must be adhered to prior to appointing external staff or service provides. The requirements of this plan will apply to contractors. The Local Procurement Plan will include transparent techniques as detailed below.

Transparent Hiring Techniques

Surgold will develop, publicize and adhere to strict and transparent hiring protocols that ensure no staff are hired in an *ad hoc* manner from Moengo and other population centers; require efforts be made to identify and train local Pamaka people prior to hiring from other parts of Suriname; and that identify the Surgold Human Resources (HR) Department in Merian and Paramaribo and recruitment partners are the only groups that can hire staff. No hiring of staff will be undertaken in an *ad hoc* manner from population centers and applicants will be required to submit application forms to the Merian or Paramaribo offices. All Surgold commitments to hiring processes will also be contractually required of contractors. Short term employment of unskilled employees will involve the Human Resources database and local traditional governance to identify available labor.

Stakeholder Engagement Program

Surgold will develop an on-going and continuous program of stakeholder engagement both nationally and within Moengo and the Marowijne Area that actively informs stakeholders of Surgold's activities in Merian and how they intend to hire from within the Marowijne Area. This will include the local promotion of jobs through regular communication with Pamaka representatives such as Village Captains and by using local communication channels such as local bulletins or notice boards, radio, a local employment department near to the Merian site, and job bulletins and advertisements posted throughout the Pamaka communities.

Surgold currently is undertaking a program of storyboards to communicate to stakeholders. Storyboards are a visual communication tool and are verbally explained to villagers in the local language.

Merian Project's Health Resources

Surgold will ensure health workers hired for the onsite medical facility at the Mine Site have the qualifications and capabilities to provide primary health care and trauma care, in addition to occupational health care (e.g., worker health screenings).

If it is anticipated that a large number of the Merian workers (direct or contractors) and their families plus associated influx of income seekers will move into Moengo, then engagement with the RGD Clinic to assess potential capacity constraints will be necessary. If impact is anticipated, then consider developing an agreement with Suralco to provide families of Merian workers (direct and supervised contractors) access to primary health services at the Suralco Polyclinic as a short-term response to alleviate constraints at the RGD Clinic, such as during the Pre-Production phase. However, to fully address the anticipated impact throughout the life of the mine and Post-closure, the Project may consider identifying and supporting opportunities as part of Surgold's Community Investment Program that builds the capacity and improves the services at the RGD Clinic. The Project currently plans to house workers on Site and provide transportation to and from Paramaribo (or other home areas) in an effort to reduce potential influx to the Moengo area.

23.6.4 *Residual Impact Assessment*

Assuming the effective application of these mitigation measures by the Project team the significance of the potential negative impact is assessed as *Minor*. This reduction in significance results from the reduction of the severity ranking from medium to low, and a reduction in the likelihood rating from high to medium. The sensitivity of the receptors in Moengo will, however, remain high.

23.7 *LOSS OF CULTURAL IDENTITY, DECREASED SOCIAL COHESION AND EROSION OF TRADITIONAL CULTURAL MANAGEMENT AND LEADERSHIP SYSTEMS*

23.7.1 *Potential Impact Description*

Actual and perceived changes to the traditional livelihood practices of people in the Marowijne Area, including traditional hunting and collection of NTFPs in the Merian area, may impact the Pamaka community's 'sense of place' and cultural sense of identity.

Perceived and actual changes to the forest area and surrounding biodiversity and ecosystem caused by relocating ASM workers and the presence of Surgold and Suralco may exacerbate this impact on the Pamaka sense of place. Perceived and actual restrictions in accessing sites of cultural, livelihood and ancestral significance due to the presence of the Merian and Nassau projects may also engender feelings that the Pamaka cultural identity is being threatened.

The influx of expatriate staff and presence of a non-Pamaka workforce in the area may also contribute to this impact. In addition, differences in lifestyle and levels of development within the Marowijne Area may increase as certain members of the community work for Surgold or Suralco where they will be exposed to different (non-Pamaka and non-Surinamese) cultures and ways of life. Such differences may erode a common cultural identity within the Pamaka community.

This impact may be exacerbated by out-migration driven by decreased levels of income from ASM. This out-migration may result in the breakdown of community ties as members move to new areas.

This impact will be exacerbated by the decreased social cohesion and erosion of the traditional cultural management and leadership systems that Surgold's presence in the Marowijne Area (and the impact it has had on the reduction of available ASM sites) has had. The challenge of managing the perceived and actual socio-economic changes from the Project may place conflicting pressures on the Traditional Authority, which could undermine the traditional cultural management and leadership system.

Continued engagement with the GoS and the Traditional Authority without regard for existing tension and dynamics within Pamaka people may make the community feel isolated from decision making processes, aggravating distrust and making future community engagement more difficult. This may further undermine the traditional authority and the sense of place for the Pamaka people. The strategic approach for future development projects should help diffuse or at least not exacerbate tensions. Younger community members may feel more empowered due to increased levels of education and wealth achieved through employment with Surgold and Suralco. This may alter traditional decision making and leadership hierarchies, further fragmenting the traditional cultural management system.

In the absence of effective mitigation and management measures this impact has the potential to occur in the Pre-Production phase and last throughout the LoM.

23.7.2 *Impact Assessment*

The likelihood rating for this impact is high given that cultural change is common in mining projects and changes to livelihood practices, migration patterns and perceived restrictions on access to certain areas are likely and already occurring. In addition there are already existing tensions within the Traditional Authority that are being aggravated by the Project and there are existing disparities in levels of development within the community that are likely to be increased by the Project

The severity rating for this impact is medium as analyzed in Table 23-8.

Table 23-8 Loss of Cultural Identity Severity Assessment

Duration	**Extent**	**Ability to Adapt**	**Socio-Cultural Outcome**	**Health Outcome**	**Overall Severity Rating**
MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Without mitigation and management impact may continue for prolonged period intermittently	A substantial percentage of the Pamaka community could be affected.	PAPs may be able to adapt with some difficulty to alternative livelihood and cultural conditions.	Without mitigation and management impact likely to result in changes to livelihoods and cultural practices and quality of life.	Potential impacts on mental health and community sense of safety and well being	

The receptor sensitivity for this impact is low as described in *Box 23-3*4.

Box 234 Loss of Cultural Identity Receptor Sensitivity

Low Sensitivity Receptors to this impact may include people within the Marowijne Area who identify themselves with a strong Pamaka Maroon identity, which is connected to maintenance of the status-quo and continued practice of traditional livelihoods. This does not represent a large majority of the local community hence overall receptor sensitivity is considered low Some receptors are understood to be sensitive to this impact due to the marginalized nature of Pamaka identity within Suriname.

This impact has been assessed as a *major negative impact* based on the severity, likelihood and receptor sensitivity.

23.7.3 Mitigation and Management Measures

Stakeholder Engagement Program

Surgold will develop an on-going and continuous program of stakeholder engagement in the Marowijne Area that will actively inform stakeholders of Surgold's activities in Merian. This program will involve regular engagement with the traditional authority and regular 'roundtable' discussions with stakeholders allowing them to feedback their opinions throughout the construction and operation period. A vehicle such as the Surgold stakeholder engagement group, the Community Consultation Committee, would be suited for this activity if it can be reinvigorated and established. Stakeholders will also be provided with responses to their input to show that their views are being considered in Project planning. This type of engagement will seek to rtermove uncertaininty abou the Project and help local people to feel engaged seeking to mitigate any feelings that the Project is undermining Pamaka culture.

Stakeholder Engagement Surrounding Limits of Deforested Areas

Surgold will engage Pamaka stakeholders in collaboration with the Suralco Nassau Project regarding the areas of forest that will be affected by the Project. This will aim to identify stakeholder concerns and areas of forest that are significant for the collection of NTFPs or hunting. This may include giving assurances regarding specific areas of forest near to settlements included within the right of exploitation but outside the mine footprint.

Support Cultural Activities

Surgold will, where applicable, budgeting for support for traditional Pamaka celebrations and festivals within a Community Investment Plan. This may include the provision of presents, food, drink, and petrol during significant holidays or the Surgold CR Team attending all Pamaka festivities and celebrations to which they are invited.

Personnel Code of Conduct

Surgold will develop and implement a Personnel Code of Conduct for employees in order to reduce unplanned interactions with local communities without the support of the Community Relations (CR) Team. Camp Management Procedures will also be developed and applied, including a controlled alcohol policy, banning of unauthorized visitors to camps, and provision of recreational facilities for workers in camps. A CR administered Cultural Awareness Induction will be provided to all expatriate staff and contractors regarding local customs, traditions, religious beliefs and responsible community relations.

23.7.4 Residual Impact Assessment

Assuming the effective application of these mitigation and management measures the significance of the potential negative impact is assessed as ***minor negative impact***. This reduction in significance results from a reduction in the severity to low and the likelihood to medium. The sensitivity of receptors remains unchanged at low.

23.8 EXPOSURE OF WORKFORCE TO INSUFFICIENT OCCUPATION HEALTH AND SAFETY STANDARDS

23.8.1 Potential Impact Description

The Project will require Surgold to employ, directly and through subcontractors at peak times, approximately 1,200 employees. Mining and processing involves some inherent dangers. Without sufficient management of Health and Safety (H&S) issues the workforce may suffer injury or death.

This impact should be considered not only for Surgold staff, but also for primary and secondary subcontractors. It should be noted that the lower down in the 'subcontractor hierarchy[1]' a supplier is, the greater the potential for exposure of workers to insufficient occupational H&S standards.

Surgold will develop and comply with internal Surgold standards and described in Chapter 2, Legal and Institutional Framework. Surgold will have a series of corporate policies and standards in place outlining its commitment to the H&S of its workers that are in alignment with international best practice.

This impact could potentially occur as long Surgold has Project staff working at the Merian site, meaning in the Pre-Production phase through to mine Closure.

23.8.2 Impact Assessment

The likelihood rating for this impact is low. This is because although Suriname's constitution protects employees labor rights it has not ratified International Labour Organization (ILO) conventions relating to occupational health and

[1] Meaning the chain between Surgold contractors, their subcontractors etc.

safety. In addition H&S concerns are well documented throughout the mining industry. However the presence of Newmont corporate policies pertaining to occupation health and safety and the adoption of those policies by Surgold tempers the likelihood of this impact.

The severity rating for this impact is medium as analyzed in Table 23-9.

Table 23-9 Exposure of Workforce to Insufficient Occupation Health and Safety Standards Impact Assessment Severity Assessment

Duration	**Extent**	**Ability to Adapt**	**Socio-Cultural Outcome**	**Health Outcome**	**Overall Severity Rating**
MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH	MEDIUM
Without mitigation and management impact may continue for prolonged period intermittently	Surgold intends to hire between 900 and 1,200 people at peak periods.	PAPs may be able to adapt, with some difficulty.	Impact may result in secondary impacts to other livelihoods and cultural practices and quality of life.	Impact may result in severe health consequences	

The receptor sensitivity for this impact is low as described in *Box 23-5*.

Box 23-5 Exposure of Workforce to Insufficient Occupation Health and Safety Standards Impact Assessment Receptor Sensitivity

Low Sensitivity
Receptors to this impact may include those contracted or subcontracted to work on the Project.

Sensitive receptors may include employees who have a poor understanding of the level of national requirements for labor and H&S standards.

This impact has been assessed as a *minor negative* significant impact based on a combined evaluation of severity, likelihood and receptor sensitivity.

23.8.3 Mitigation and Management Measures

To avoid and reduce the significance of this impact the following mitigation and management measures have been developed for adoption by the Project team and subcontractors

Fitness to Work

Surgold will develop a fitness for work health risk assessment to assess the health of all personnel to be hired including specific consideration of communicable diseases that could be passed onto other workers. No worker will be denied employment on the basis of the disease testing (as long as they are fit to work), but will need to commence treatment and be non-infectious before taking up their post. Pre-placement and periodic medical examinations will be conducted at Surgold's nominated medical clinic, such as the Merian site clinic or other approved Human Resources Department (HRD) clinics, where medical examinations can be performed to the standards as specified by Newmont HRD / Health, Safety and Loss Prevention standards and the Site medical staff's requirements. Furthermore, Surgold will assume all costs associated with the company sponsored medical check-ups; and ensure that examining physicians will obtain employee permission as appropriate before conducting tests that require such permission (e.g., HIV, STD). Health screening will be mandatory but the results will not influence the appointement of staff. Health and Safety Policies

All Project staff including subcontractors will be subject to Surgold's H&S Standards and Policy including the H&S Management System.

Subcontractor Auditing

All subcontractors will be audited as necessary for adherence to the laws of Suriname and Surgold H&S standards, including provisions and testing of potable water, food storage and preparation, kitchen, waste and toilet facilities, pest control, inductions and training, fire safety and preparedness.

Actioning H&S Gaps in Subcontractor Audits

All primary and secondary subcontractor contracts will specify H&S performance and monitoring and will be required to action gaps in an agreed period.

Engagement with Workforce

All workers (including those of primary and secondary subcontractors) will have contracts that clearly state the H&S terms and conditions of their employment and their legal rights. Contracts will be verbally explained to all workers where this is necessary to ensure that workers understand their rights. This engagement will include H&S induction and training. Surgold will establish a clear grievance mechanism and H&S event reporting system to allow workers (including contractors) to report H&S events or issues.

23.8.4 Residual Impact Assessment

Assuming the effective application of Surgold H&S standards and the application of the aforementioned mitigation measures by the Project team for direct Surgold employees, primary and secondary contractors the significance of the potential negative impact is assessed as *Insignificant*. This reduction in significance results from the reduction of the severity ranking from medium to low, and a reduction in the likelihood rating from medium to low.

23.9 *EXPOSURE OF WORKFORCE TO INSUFFICIENT LABOR AND ACCOMMODATION STANDARDS*

23.9.1 *Potential Impact Description*

As stated in Chapter 23.8, the Project will require Surgold to employ up to 1,200 employees during Pre-Production and Operations, directly and through subcontractors. Details for the dates of hiring of these employees are discussed in Chapter 23.8. Without sufficient management the workforce may be exposed to unacceptable labor and accommodation standards.

As with H&S standards (*Chapter 23.8),* this impact should be considered not only for Surgold staff, but also for primary and secondary subcontractors. It should be noted that the lower down in the 'subcontractor hierarchy' a supplier is, the greater the potential for exposure of workers to insufficient labor and accommodation standards due to challenges associated with direct control and monitoring.

Surgold will have a series of corporate policies and standards in place outlining its commitment to the labor and accommodation standards that are in alignment with international best practice. However, the challenges of operating in a remote area, in a country with less complex labor laws and using primary and secondary subcontractors may result in Surgold, contractors and suppliers being underprepared to meet international requirements, placing employees at risk.

Without effective management and mitigation measures this impact has the potential to occur once employment begins, meaning in the Pre-Production phase and up to mine Closure.

23.9.2 *Impact Assessment*

The likelihood rating for this impact is low. This is because Suriname's constitution protects employees' labor rights and it has ratified International Labour Organization (ILO) conventions relating to weekly rest, equality of treatment, forced labor, labor inspection, employment services, protection of wages, employment policy, collective bargaining, child labor and labor relations[1].

The severity rating for this impact is medium as analyzed in Table 23-10.

[1] ILOLEX, Database on International Labour Standards, http://www.ilo.org/ilolex/english/newratframeE.htm

Table 23-10 Exposure of Workforce to Insufficient Labor and Accommodation Standards Severity Assessment

Duration	**Extent**	**Ability to Adapt**	**Socio-Cultural Outcome**	**Health Outcome**	**Overall Severity Rating**
MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Without mitigation and management impact may continue for prolonged period intermittently	Surgold intends to hire between 900 and 1,200 people at peak periods.	PAPs may be able to adapt, with some difficulty.	Impact may result in secondary impacts to other livelihoods and cultural practices and quality of life.	Impact may result in moderate injury or illness.	

The receptor sensitivity for this impact is low as described in *Box 23-6*.

Box 23-6 Exposure of Workforce to Insufficient Labor and Accommodation Standards Receptor Sensitivity

Low Sensitivity

Receptors to this impact may include those contracted or subcontracted to work on the Project.

Sensitive receptors may include employees who have a poor understanding of the level of national requirements for labor and accommodation standards.

This impact has been assessed as a *minor negative significant* impact based on a combined evaluation of severity, likelihood and receptor sensitivity.

23.9.3 Management and Mitigation Measures

To avoid and reduce the significance of this impact the following mitigation and management measures have been developed for adoption by the Project team and subcontractors. This impact will also be mitigated using the measures described in Chapter 23.8.3

Accommodation Standards

All accommodation will be built in adherence to international best practice, such as the International Finance Corporation (IFC) and European Bank of Reconstruction and Development (EBRD) guidelines on worker accommodations.

Labor and Accommodation Policies

All Project staff including subcontractors will be subject to Surgold's Labor and Accommodation Standards

Unions

All workers (including those of contractors and subcontractors) will be able to join unions of their choice and have the right to collective bargaining.

Subcontractor Auditing

All subcontractors will be audited on a regular basis for adherence to the laws of Suriname and Surgold standards for labor, accommodation and contracting.

Actioning H&S Gaps in Subcontractor Audits

All primary and secondary subcontractor contracts will specify labor and accommodation performance and monitoring.

Engagement with Workforce

All workers (including those of primary and secondary subcontractors) will have contracts which clearly state the labor and accommodation terms and conditions of their employment and their legal rights. Contracts will be verbally explained to all workers where this is necessary to ensure that workers understand their rights. This engagement will include induction and training. Surgold will establish a clear grievance mechanism and event reporting system to allow workers (including contractors) to report events or issues.

23.9.4 Residual Impact Assessment

Assuming the effective application of Surgold standards and the application of the aforementioned mitigation measures by the Project team for direct Surgold employees, primary and secondary contractors the significance of the potential negative impact is assessed as *insignificant*. This reduction in significance results from the reduction of the severity ranking from medium to low. The likelihood of this impact remains low.

23.10 Increase in Accidents and Injuries Along the Transportation Corridor

23.10.1 Potential Impact Description

The transportation corridor to the Mine Site involves public roads, including the East-West Highway from Paramaribo to Moengo and the Moengo to Langa Tabiki Road. The transportation corridor already currently experiences truck traffic with heavy cargo (e.g., logging trucks) and dangerous goods (e.g., gasoline trucks).

During the Pre-Production phase, the upgrade of the Moengo-Langa Tabiki Road will involve the use of heavy machinery and equipment to improve the existing road. This creates the potential for accidents and injuries involving public road users (including bicyclists and pedestrians). Unsecured construction sites (e.g., inadequate signage and barricades) and incorrect work procedures may result in increased accidents and injuries involving public road users (including community residents living or traversing near construction sites). In addition, improved conditions on the road during Operations can also lead to accidents and injuries, associated with increases in unsafe driving practices (e.g., speeding on improved paved surfaces; increased night-time driving).

During Pre-Production and Operations phases, the Project will require truck and bus transportation (i.e., tractor-trailers, dump trucks, fuel tankers, employee buses, etc.) on public roads to move workers, equipment, and materials to and from the Project sites. The Traffic and Transportation Safety Baseline (Chapter 10) estimates approximately 16 round-trip, heavy truck trips per day during the 20-month Pre-Production phase; and 33 round-trip heavy trucks per day during the Operations phase. Project Closure is expected to generate less daily truck traffic than during the Pre-Production phase.

Although anticipated Project-related heavy traffic levels during the Project lifecycle are considered insignificant relative to baseline traffic conditions (see Chapter 20 –Traffic and Transportation Safety Impacts), the type of Project traffic (i.e., truck-trailers transporting hazardous materials) and the existing road traffic safety hazards could cause significant injuries and possibly death in the event of an accident. According to the Moengo Police, vehicle accidents are most common among public road users, particularly taxi drivers, who tend to speed on the highway. Accidents involving heavy trucks typically involve the driver losing control and veering off the road, with no other vehicles involved. See Chapter 10 (Traffic and Transportation Safety Baseline) and Chapter 14 (Impact Assessment Methodology – Accidents and Injuries) for additional information on existing road traffic safety hazards along the Transportation Corridor.

In addition to increased traffic volume, stakeholders have expressed specific concerns regarding 12 hour work shifts required for truck drivers related to the potential for driver fatigue.

During Operations, hauling operations for the Project will be subcontracted out and are scheduled 24 hours per day, seven days per week, with drivers working a maximum 12-hour shift during daylight hours, but may typically be 10 hours per day. One driver will complete one round-trip in 24 hours. For late afternoon pre-loadings, drivers will park and stay overnight at The Blue Bridge in Moengo. Blue Bridge will serve as a temporary lay down for exchange of drivers and trailers.

This increase in vehicular traffic (especially trucks) along the transportation corridor increases the risk of accidents and injuries; this will particularly be the case if informal traders increase their presence around key junctions and along the road side. The road users and pedestrians along the segment of the Project's transportation route near Moengo and along the Moengo–Langa Tabiki Road have higher sensitivity to the impact because of the more limited access to emergency medical care in the area.

23.10.2 *Impact Assessment*

The likelihood rating for this impact is medium given that the impact may occur infrequently during peaks of high heavy truck traffic volume and upgrade of the Moengo-Langa Tabiki Road.

The severity rating for this impact is medium to high as analyzed below.

Table 23-11 Increase in Accidents and Injuries Severity Assessment

Duration	Extent	Ability to Adapt	Socio-Cultural Outcome	Health Outcome	Overall Severity Rating
MEDIUM	MEDIUM	HIGH	N/A	HIGH	HIGH
Without mitigation and management, the risk for accidents and injuries will be highest during Pre-Production and Operations with an intermittent frequency.	Public road users along the transportation corridor are at risk for accidents and injuries.	Those affected with irreversible damage will not be able to adapt to changes and continue to maintain pre-impact livelihood.		Impact may result in moderate to severe injuries which can result in loss of life or hospitalizations.	

The receptor sensitivity for this impact is medium as described in *Box 23-7*.

Box 23-7 Increase in Accidents and Injuries Sensitivity Receptor

High Sensitivity

Receptors to this impact include all settlements along the transportation corridor, in particular the public road users (including bicyclists and pedestrians) and informal traders along the East-West Highway and the Moengo-Langa Tabiki Road.

Some of these receptors are understood to be particularly sensitive to this impact due to:

- Unsafe driving practices and behavior, including speeding, driving under the influence of alcohol, and driver fatigue in Suriname.
- Unsafe road conditions, such as road dust reducing driver visibility, poor road drainage (water ponding), and limited right-of-ways.
- Scarcity of paths along the East-West Highway specifically designated for pedestrians (although a path network does exist in the vicinity of Moengo and some areas west of the Commewijne River).
- Existing truck traffic with heavy cargo (e.g., logging trucks) and dangerous goods (e.g., gasoline trucks).
- Limited access to emergency medical care outside of Paramaribo.
- Peak driver and pedestrian traffic during early weekday morning commute (7:00-8:30 am) and after school lets out (1:30 pm).

This impact may be exacerbated by cumulative factors including heavy truck traffic from Nassau Bauxite Project and other planned regional industrial projects.

This impact has been assessed as a *major negative impact* based on a combined evaluation of severity, likelihood and receptor sensitivity.

23.10.3 Mitigation and Management Measures

Surgold's Standard Operating Procedures (SOP) and an Emergency Response Plan (ERP) for the Merian site for worker health and safety will be relevant to the mitigation of this impact.

Control measures proposed by the Project will include the delivery of fuel in caravans to reduce the distribution of increased truck traffic along the Transportation Corridor.

To avoid and reduce the significance of this impact the following mitigation and management measures have been developed to further reduce the significance.

Traffic Management Plan

Surgold will implement and monitor the Traffic Management Plan that identifies the key traffic-related accident hotspots or high risk areas (e.g.; key road crossings with the transportation road) and proposed locally-relevant and effective protective measures. Drivers and contractors will not stop for unplanned or unauthorized breaks.

Traffic Management Mitigation

Surgold will implement the measures detailed within the Traffic and Transportation Safety Impacts (Chapter 20).

Community Awareness and Coordination on Public Safety

Prior to the commencement of use of the transportation corridor Surgold will conduct community consultations to identify potential high risk areas (areas commonly frequented by locals) and to explain the required vehicle movements. Before activities that will increase Project traffic, Surgold will inform communities regarding which areas will be partially inaccessible due to construction activities and present relevant safety signage and advice.

Surgold will engage with communities along the Transport Road corridor to raise awareness on road safety and accident prevention.

Surgold will identify local / regional / national first responders and discuss potential coordination needs to ensure first aid and emergency medical response is provided in the event of accidents.

Contractor's Health and Safety Management

Ensure hauling operations and road construction contractors adopt and implement measures for all workers to consider public safety and worker safety such as:

- Ensure Project work sites and areas are clearly marked with appropriate signage and barricades (particularly if work activities extend through the evenings);
- Avoid timing construction of the road segments that intersect with existing roads when high traffic volumes are anticipated, such as weekends and tourism periods; and
- Promote safety culture at work particularly among workers with limited prior H&S awareness to reduce risk of accidents and injuries associated with construction activities.

Driver Policy and Trainings

Employ the following policy and trainings for all drivers and contractors:

- Adopt policy where drivers and contractors will not stop for unplanned / unauthorized breaks on the journey; and
- Integrate worker fatigue and stress management program for long haul truck drivers.

23.10.4 Residual Impact Assessment

Assuming the effective application of these mitigation and management measures the significance of the potential negative impacts is assessed as *minor significant* negative *impact*. This reduction in significance results from a reduction in the likelihood from medium to low and a reduction in the severity to medium

23.11 DECREASED SENSE OF COMMUNITY SAFETY AND PSYCHO-SOCIAL WELL-BEING

23.11.1 Potential Impact Description

During Pre-Production and Operations, the presence of mine workers, including nationals from outside the local Marowijne Area, may disrupt the community cohesion and traditional way of life among Pamaka Villages (see Chapter 23.7), potentially creating stress and anxiety for some residents. Because the Project workforce will primarily be housed on an onsite closed accommodation camp, worker interactions with the surrounding Pamaka villages, ASM camps and Moengo communities will be very limited.

Nevertheless, the presence of the activities and workers at the Project site could raise the local communities' concerns and / or misconceptions around possible impacts on their health and safety. Focus group discussions in the surrounding communities of Moengo and the Pamaka communities have revealed concerns over a potential increase in crime related to the presence of workers plus associated influx and contamination of their local creeks from mine activities.

It is unclear to what extent these concerns could lead to conflict with the Project. However, there are existing tensions between the Merian Project and ASM workers. In addition, ASM workers that formerly worked in the Merian Industrial Zone and have returned to the Pamaka villages without alternative income sources may result in an increase in theft and crime within local communities. Furthermore, the reduced sense of safety may be exacerbated by the cumulative impact of Suralco's Nassau bauxite project, which will increase the presence of a large workforce in the Marowijne Area.

The potential for employment opportunities – whether at the Merian Mine, nearby ASM camps, or in the Moengo area – increases the potential for young male workers to gain cash income which is commonly associated with higher rates of alcohol and drug (marijuana and cocaine) abuse in the community.

Given that the Merian workforce will likely be comprised of Surinamese nationals with some members of local communities of Moengo and Marowijne Areas, stakeholders have raised concerns over the potential impacts to the psycho-social well-being of the workers and their households.

Personnel from the Medical Office of Labour Inspectorate have observed that workers in a stressful workplace environment compounded with long separation time (e.g., 2 weeks or more) from families due to long mine work shift schedule can exhibit mental stress and increased aggression and disruptive behavior within the household, such as domestic violence.

Given that in the Pre-Production phase the Project proposes a work shift of 12 hours per day for two weeks on and one week off, which will change to one week on one week off during Operations, as well as a closed camp policy, Merian workers are less likely to experience the potential psycho-social well-being issues due to separation time. In addition Surgold have designed the location of worker accommodation such that it will not be located near to local communities. Stakeholder engagement activities have already begun to disseminate to local communities the type of activities that are currently underway, seeking to demystify and reduce the disturbing effect of the Project.

23.11.2 Impact Assessment

The likelihood rating for this impact is low due to a closed camp policy and shorter mine work shift (one week on and one week off).

The severity rating for this impact is medium as analyzed in Table 23-12.

Table 23-12 Decrease Sense of Community Safety and Psycho-Social Well-being Severity Assessment

Duration	Extent	Ability to Adapt	Socio-Cultural Outcome	Health Outcome	Overall Severity Rating
HIGH	MEDIUM	MEDIUM	N/A	MEDIUM	MEDIUM
Without mitigation and management the impact may continue throughout the Life-of-Mine (LoM) with a constant frequency.	Small number of households within the Moengo and Marowijne Areas could be affected.	PAPs may be able to adapt, with some difficulty, but only with a degree of increased support from public safety and mental health services.		Impact may result in decreased sense of safety associated with conflict, theft, and assaults; and overall reduced psycho-social well-being.	

The receptor sensitivity for this impact is high, particularly among those new to working shift for mining companies and/or are most sensitive to reduced community safety and psycho-social well-being, as described in *Box 23-8*.

This impact may be exacerbated by cumulative factors from Nassau Bauxite Project and other planned regional industrial projects.

Box 23-8 Decrease Sense of Community Safety and Psycho-Social Well-being Receptor Sensitivity

High Sensitivity
Receptors to this impact may include some households in the Moengo and Marowijne Areas that are new to working shift for mining companies and/or are most sensitive to reduced community safety and psycho-social well-being.

Some receptors are understood to be sensitive to this impact due to:

- Limited access to public safety and/or mental health resources to address potential public safety concerns (theft, domestic violence, etc.);
- Unfamiliarity with mine shift schedule;
- Current prevalent use of alcohol and drugs among young local men;
- The prevalence of domestic violence; and
- Strong ties with Maroon traditional way of life, particularly among elderly residents in the Marowijne Area.

This impact has been assessed as a *minor negative impact* based on a combined evaluation of severity, likelihood and receptor sensitivity.

23.11.3 *Mitigation and Management Measures*

Proactive consultation and engagement could help to raise awareness and address inaccurate health risk information early on.

To avoid and reduce the significance of this impact the following mitigation and management measures have been developed for adoption by Surgold.

Worker Accommodation Standards and Worker Code of Conduct

Surgold will design accommodation camps to offer a place and appropriate times for work breaks and social interactions among workers (e.g., recreational activities, gym, social functions), some of which already exist in the exploration camp.

To prevent potential worker-community conflict at the security posts around public-access restricted areas, particularly with small-scale miners, the Project will:

- Develop and enforce a worker code of conduct (site rules) regarding respect for local communities, appropriate behavior outside of working hours, the use of alcohol/drugs, worker-community conflicts, petty crime, etc. This will be a part of internal communication plan for employee induction;
- Employ a fully-functioning culturally appropriate grievance mechanism for the local communities; and
- Raise community safety awareness on public access restrictions to mine sites, emphasizing that the purpose is to protect the health and safety of the residents.

Worker Fatigue and Stress Management Program

The Project will integrate a Fatigue and Stress Management Program as part of monitoring employees' wellbeing (for direct employees and contractors) which will ensure health workers onsite and supervisors are trained in recognizing the signs and symptoms of mental distress (e.g., disruption in sleep cycles) that could jeopardize the safety of the workers, co-workers and families. In addition, the program should nurture a workplace environment that supports rather than punishes workers for reporting conditions of mental distress, physical exhaustion, etc. with the first priority being safety and preventing accidents. Put in place, a worker grievance mechanism or similar process will also be required to allow workers to report unsafe workplace conditions (see Chapter *23.8.3*).

Stakeholder Engagement Surrounding Limits of Deforested Areas

To correct misinformation about loss of access to forest areas, which could decrease the community's sense of well-being, Surgold will engage Pamaka stakeholders in collaboration with the Suralco Nassau Project regarding the areas of forest that will be affected by the Project. This will aim to identify stakeholder concerns and areas of forest that are significant for the collection of NTFPs or hunting. This may include giving assurances regarding specific areas of forest near to settlements.

23.11.4 Residual Impact Assessment

Assuming the effective application of these mitigation measures by the Project team the significance of the potential negative impact is assessed as *insignificant*. This reduction in significance results from a reduction in the severity rating from medium to low.

23.12 INCREASE BURDEN OF CHRONIC DISEASES

23.12.1 Potential Impact Description

The growing rates of chronic diseases (heart diseases and diabetes) among the Surinamese population, including in the Moengo and Marowijne Areas, are of major concern to public health officials. While the Project can contribute to enhanced economic well-being for workers and their households during the life of the Project, this higher standard of living may contribute to greater use of alcohol and cigarettes and consumption of unhealthy foods; behavioral risk factors for many chronic diseases.

Because of the complex and multi-faceted factors that contribute to a person's risk for chronic disease (including genetics), the Project is unlikely to directly increase the burden of chronic diseases in the population. Rather, during Pre-Production and Operations, the Project can potentially contribute to behavioral risk factors for chronic diseases, such as by providing only unhealthy (e.g., high fats, high salt) food options at the Mine Site.

Major chronic diseases that impact the workforce population will also impact work productivity, a major cost to employers.

23.12.2 Impact Assessment

The likelihood rating for this impact is low given the complex and multi-faceted factors that contribute to a person's risk for chronic disease.

The severity rating for this impact is medium as analyzed in Table 23-13.

Table 23-13 Increase Burden of Chronic Diseases Severity Assessment

Duration	Extent	Ability to Adapt	Socio-Cultural Outcome	Health Outcome	Overall Severity Rating
HIGH	MEDIUM	MEDIUM	N/A	MEDIUM	MEDIUM
Without mitigation and management the impact may continue throughout the Life-of-Mine (LoM) with a constant frequency.	Small number of households within the Moengo and Marowijne Areas with workers at the Project could be affected.	PAPs may be able to adapt, with some difficulty, but only with a degree of increased support from health services.		Impact resulting in unhealthy lifestyle choices that can put workers at risk for chronic diseases.	

The receptor sensitivity for this impact is high given the growing burden of chronic diseases in the local populations as described in *Box 23-9*.

Box 23-9 *Increase Burden of Chronic Diseases Receptor Sensitivity*

High Sensitivity

Receptors to this impact include substantial portion of the workforce, including a small number of households within the Moengo and Marowijne Areas with workers at the Project.

Rates of chronic diseases (e.g., hypertension and diabetes) are increasing among the population in Suriname in urban and rural areas alike, including in the Moengo and Marowijne Areas. With a double health burden from infectious diseases as well as chronic diseases, the Marowijne Area has poorer morbidity status than the urban communities. Furthermore, the limited access to proper chronic disease management in the Moengo and Marowijne Areas put those suffering from chronic diseases at greater risk for complications from the diseases.

This impact has been assessed as a *minor negative impact* based on a combined evaluation of severity, likelihood and receptor.

23.12.3 Mitigation and Management Measures

To avoid and reduce the significance of this impacts the following mitigation and management measures have been developed for adoption by the Project team.

Healthy Food Options

The Project will seek to continue to provide healthy food options at the site canteen and promote healthy living habits

Promote Health Behavior - Exercise Room

The Project will continue to promote healthy behavior and provide an exercise room for employees at the camp.

23.12.4 Residual Impact Assessment

Assuming the effective application of these mitigation measures by the Project team the significance of the potential negative impact is assessed as *Minor*. This reduction in significance results from the reduction of the severity ranking from medium to low. It is not insignificant because the sensitivity remains high.

23.13 EXPOSURE TO ENVIRONMENTAL HEALTH HAZARDS

23.13.1 Potential Impact Description

During the LoM and Closure, Project activities that are potential sources of environmental health hazards to the public may include:

- Potential for rare accidental spillage of dangerous goods (e.g., cyanide, diesel or mill reagents) along the transport corridor;

- Potential for non-routine or uncontrolled releases from the tailings storage facility that could affect the water, flora and fauna in the Commewijne River watershed;
- Potential for leaching from the waste rock piles that could affect the water, flora, and fauna in the Marowijne River watershed;
- Improper management and disposal of hazardous materials during operation and Closure of the mine that could result in soil contamination; and
- Land-disturbing activities in the Industrial Zone and Project-related traffic along the Transport Corridor are sources of fugitive dust emissions and combustion emissions.

Possible pathways of exposure for communities to potential environmental health hazards related to the Project may include:

- Direct contact with hazardous materials in the rare event of an accident with public road users (including bicyclists and pedestrians) along the transport corridor from Paramaribo to Langa Tabiki;
- If an uncontrolled discharge occurred, the consumption of fish or contact with water from the downstream Tempati and Commewijne River area from the tailings storage facility, particularly among seasonal residents (e.g., subsistence fishermen and their households; users of the river for bathing and washing clothes);
- If an uncontrolled discharge occurred, the consumption of fish or contact with water from the downstream Marowijne River area from the waste rock piles, particularly among residents that rely on the river for cooking and washing; and
- Potential inhalation of fugitive dusts and combustion emissions among communities nearest to the Industrial Zone and the sensitive receptors (e.g., bicyclists, pedestrians, schools) along the Transport Corridor.

The likelihood for exposure to the potential environmental health hazards via the various pathways are discussed below:

- A major accident involving Project truck-trailers transporting hazardous materials is anticipated to be a rare occurrence along the Transportation Corridor (see Chapter 20, Traffic and Transportation Impact Assessment, Recommended Mitigation Measures); thus there is a low likelihood for a public road user to come into direct contact with the hazardous materials.
- The water quality impacts to the Las Dominicanas Creek from the tailings storage facility; as well as the water quality of the Merian Creek from the waste rock piles are predicted to be moderately impacted prior to mitigation (see Chapter 19, Water Resources Impacts). Potential water contaminants in the Merian Creek might include nitrates, where high

nitrate exposure can lead to a blood disorder called methemoglobinemia, particularly among infants younger than 4 months[1]. However, the Project discharge criteria requires that any effluent discharged from site contain <10 mg/L nitrate, which is protective of human health. The general level of community consumption of water from these potentially impacted creeks are likely low given there is community recognition that some creeks in the Commewijne River and the Merian Creek are already highly polluted from ASM activities.

- The impacts to aquatic biological resources related to potential surface water quality degradation (due to spills/accidents and contaminated runoff/sedimentation) prior to mitigation are anticipated to be minor (see Chapter 21, Biological Resources Impacts). In the absence of a bioaccumulation modeling assessment to predict chemical uptake in fish, this high-level impact analysis anticipates that fish tissue from these creeks is unlikely to be impacted by Project contaminants to a degree that poses a human health concern.
- Air quality (i.e., increase in fugitive dusts and combustion emissions) is anticipated to be moderately impacted prior to mitigation; thus posing a moderate exposure risk to settlements on the east of the Mine Site, along the Marowijne River and residences, schools and houses of worship along the Transportation Corridor (see Chapter 16, Air Quality and Greenhouse Gas Impacts).
- Soil contamination from spills or leaks prior to mitigation is anticipated to be minor (see Chapter 18, Landscape and Soils Impacts). Thus, the likelihood of human exposure via direct contact with soil contamination is low, particularly taking into account Project controls. The Project plans to temporarily store hazardous waste generated during the Pre-Production and Operations on site and then dispose of off-site by a licensed contractor. Furthermore, designated facilities used for the collection and temporary on-site storage of hazardous waste will include fencing, signage, roofing, lighting and lighting protection and secondary containment.

Overall, there is a low likelihood for community exposure to environmental health hazards at a level that poses a human health concern.

Impact Assessment

The likelihood rating for this impact is low given community exposure to environmental health hazards is at a level that does not pose a serious human health concern.

The severity rating for this impact is low to medium as analyzed in Table 23-14.

[1] ATSDR ToxFAQs™ for Nitrates and Nitrites, January 2011. Accessed on 15 May 2012 at http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=1186&tid=258.

Table 23-14 Exposure to Environmental Health Hazards Severity Assessment

Duration	Extent	Ability to Adapt	Socio-Cultural Outcome	Health Outcome	Overall Severity Rating
Low	Low	Medium	N/A	Medium	Medium
Exposure to potential environmental health hazards is intermittent and at low frequency.	Residents and households on the east of the Mine Site, along the Marowijne River and residences, schools and houses of worship along the Transportation Corridor.	Exposure levels are low to moderate where those affected will be able to adapt to change and maintain pre-impact quality of life and health.	N/A	Short-term exposure (e.g., to fugitive dust) may result in annoyance or minor injury that does not require hospitalization.	

The receptor sensitivity for this impact is described in *Box 23-10*

Box 23-10 Exposure to Environmental Health Hazards Sensitivity Receptor

High Sensitivity

Receptors to this impact may include subsistence fishermen and their households; and users of the river for bathing and washing clothes Commewijne River. In addition, public road users living and travelling along the transport corridor from Paramaribo to the Merian site may become exposed to fugitive emissions and releases from road construction activities and Project-related traffic, particularly pedestrians.

Some of these receptors are sensitive to exposure to environmental health hazards because of:

- Existing respiratory illness conditions, particularly among children, that put them at greater risk for health effects from exposure to fugitive dust emissions. According to Medical Mission clinic records, respiratory diseases rank as the second and third main cause of morbidity in Langa Tabiki and Nason, respectively. In addition, more than half of the household surveyed believed respiratory problems are increasing over the last few years;

This impact has been assessed as a *minor negative impact* based on a combined evaluation of severity, likelihood and receptor sensitivity.

This impact, in particular related to exposure to road traffic related emissions, may be exacerbated by the cumulative impact of other regional industrial projects that will also add heavy truck traffic along the transport corridor.

23.13.2 *Mitigation and Management Measures*

Surgold's Standard Operating Procedures (SOP), Emergency Response Plan (ERP) and standards for Occupational Health and Safety for the Merian site for worker health and safety will be relevant to this impact.

Furthermore, the following measures to manage environmental impacts will also address this impact:

- *Air Quality Mitigation Measures* - Surgold will develop and implement procedures to mitigate air quality impacts from Project related fugitive dust and combustion emission releases, including an air quality monitoring program and dust suppression measures as discussed in the Air Quality and Greenhouse Gas Impacts Chapter 16.
- *Cyanide Management* - Cyanide use for the Project will be consistent with the principles and standards of practice of the International Cyanide Management Code, to which the Merian Mine will be certified. The Cyanide Code includes principles and standards applicable to several aspects of cyanide use including its purchase (sourcing), transportation, handling, storage, use, facilities decommissioning, worker safety, emergency response, training, and public consultation and disclosure. Merian will obtain Certification within 36 months of Operations commencing.
- *Tailings and Waste Rock Management* - The tailings facility will be designed such that any discharge of water to surface waters or the groundwater from the facility meets the water quality criteria set forth by the Project as described in Chapter 19, following Environmental Design Criteria and Surgold standards. The Project discharge criteria requires that any effluent discharged from site contain <10 mg/L nitrate, which is protective of human health. In addition, seepage from TSF will be collected and treated as discussed in Physical Impacts Summary Table – Chapter 25. Treatment of effluent water prior to discharge to the environment will meet Project discharge criteria at the designated compliance points.As part of the waste rock management, Surgold will analyze waste rock for geochemcial characteristics throughout the LoM. While the testing to date does not show any concern of acid mine draiange, there is a low potential that extending management of waste rock into the decommissioning, Closure, and Post-closure phases of the mine may be required to maintain effluent quality to the levels required to protect the local environment and human health. If needed, contingency measures, such as water treatment or changes in water management will be implemented to assure protection of beneficial uses of water.
- *Hazardous Waste Management* - To prevent contamination of the land and groundwater, Surgold will develop and implement a hazardous waste management plan during Pre-Production and production. Furthermore, as part of the post-commissioning monitoring, Surgold will ensure water draining from the Mine Site and waste disposal areas are not a risk to human health.
- *Safe Transport of Hazardous Materials* - Surgold will develop and implement procedures that ensure compliance with national laws and

international requirements applicable to the transport of hazardous materials.

Following international best practices (such as the Cyanide Code), the procedures for transportation of hazardous materials, at a minimum, will include:

- Ensuring that the volume, nature, integrity and protection of packaging and containers used for transportation are appropriate for the type and quantity of hazardous material and modes of transportation involved;
- Ensuring adequate transportation vehicle specifications;
- Training employees involved in the transportation of hazardous materials regarding proper shipping procedures and emergency procedures; and
- Providing the necessary means for emergency response on call 24 hours per day.

For further details on the above measures, please see Environmental Management Plans provided in Volume IV

In addition to the environmental management measures, the following recommended measures have been developed to further reduce the significance.

Risk Communication Planning

Merian's Emergency Response Plan (ERP), will establish appropriate communication systems with local and national health facilities (e.g., Moengo Polyclinic, Medical Mission, Academic Hospital), police and leaders of potentially affected communities. The Project will collaborate with these community partners in adopting ERP procedures that may require their participation in responding to emergency situations that can impact community health and safety, such as an accidental spill of dangerous goods (e.g., cyanide) along the transportation corridor.

In the event of such an emergency, immediately notify nearby communities directly and through the community partners on what proper protective precautions to take to reduce exposure to environmental hazards.

Closure Planning

During the operations of the mine, the proposed Project will develop and adhere to an integrated mine Closure plan taking into account community health and safety. The Closure plan may include requirements that:

- All disturbed areas will be rehabilitated to natural conditions as much as possible;

- All buildings and facilities will be completely removed (including the foundations), unless specified otherwise by the Surinamese government; and / or in agreement with the local communities; and
- Post-closure monitoring of groundwater, surface water, rehabilitation, and forest areas will be required.

23.13.3 Residual Impact Assessment

Assuming the effective application of these mitigation and management measures the significance of the potential negative impacts is assessed as insignificant. This reduction in significance results from a reduction in severity from medium severity to low.

24.0 *CUMULATIVE EFFECTS ASSESSMENT*

24.1 *INTRODUCTION*

The environmental effects of individual actions can combine and interact with other activities in time and space to cause incremental or aggregate effects on the environment. The incremental or aggregate effects from seemingly disconnected actions may cause additional effects that are not apparent when assessing the actions individually. Industry good practice defines cumulative impacts as the combination of multiple impacts from existing projects, the proposed Project, and / or anticipated future projects that may result in significant adverse and / or beneficial impacts that would not be expected in the case of a stand-alone Project.

This chapter describes and analyzes the potential cumulative impacts of the Project and past, existing, or future activities on the natural environment, social and economic conditions, and community health.

24.2 *SCOPE OF THE CUMULATIVE IMPACT ASSESSMENT*

For cumulative impacts assessment (CIA) to be a useful tool to decision-makers and stakeholders, it must be limited to effects that can be meaningfully evaluated, rather than explore infinite possibilities. Three important aspects that require consideration prior to the evaluation of cumulative impacts are listed below:

- Determining the appropriate spatial boundaries for evaluation;
- The identification of relevant past, existing, and future activities for consideration; and
- Identifying the resources and / or receptors at risk or likely to experience interactions with the Project.

24.3 *SPATIAL BOUNDARIES*

For the purpose of evaluating the cumulative impacts of the proposed Project the following spatial boundaries were considered: the East-West Highway to the north; the Marowijne River to the east, the Grankreek River to the south; and the Commewijne River to the west (see Figure 9-1). This represents an area with clear natural boundaries and encompasses the social study area.

24.4 PAST, EXISTING, AND FUTURE ACTIVITIES

In the context of the Project, the following potential activities were identified as having the potential to contribute cumulative impacts.

24.4.1 *Cumulative Impacts of the Potential Nassau Plateau Bauxite Mine Project*

The proposed Nassau Bauxite Mine Project would involve a mine and a transportation road linking the mine to the existing Suralco aluminum refinery in Paranam through a road from the mine to Suhoza and a barge from suhoza to Paranam . The mine will be located in the Nassau Plateau Mountains, a densely forested hilly region in eastern Suriname, approximately 160 km southeast of Paramaribo and about 40 km to the south of the Project site.

The bauxite ore at Nassau is found on four connected plateaus ranging in elevation from 500 to 570 masl. It is estimated that the Nassau deposit contains about 43 million tonnes of bauxite ore (wet tonnes). The proposed mine would ultimately require clearing approximately 1,362 ha at the top of the Plateau, although this would be done in steps with concurrent restoration of previously mined areas. All processing, including crushing, would occur at the existing Suralco refinery in Paranam. This deposit would be sufficient to supply the Paranam refinery with bauxite for approximately 8 years.

The bauxite ore must be transported from the Nassau Plateau to the existing Suralco alumina refinery in Paranam. A combination of trucks and bargersVery are expected to be used to transport the ore. Suralco's current proposal is to construct the a Transport Road within the southern portion of the Afobaka Corridor where 35 km away from the existing Suhoza MNO Dock site on the Suriname River trucks would follow the existing MNO haul road further to the northwest toward the existing MNO Camp on the Suriname River.

Approximately 1-2 km from the Suriname River, the trucks would turn onto a still-to-be-constructed spur road from the MNO haul road to access a proposed port on the Suriname River, referred to hereafter as the Nariba Port. At the Nariba Port Site, bauxite would be loaded onto barges which would then navigate the Suriname River downstream to Suralco's existing dock at Paranam, where it would be offloaded and transported to the Paranam refinery.

Concurrent development of the Nassau Plateau bauxite mine and the proposed Project could, in combination, result in cumulative effects on air quality, water quality, wildlife movement, employment, and the potential for influx.

24.4.2 *Cumulative Impacts of the Potential Artisanal Small-scale Gold Mining and Timber Harvesting*

While gold mining in Suriname predates European contact, the current mining activities in Suriname, due primarily to an increase of gold prices, are much larger than earlier in terms of the number of people involved, gold production, and its impacts on Suriname's economy, social structure, and ecosystems. Due to its informal and quasi-legal character, estimates of the scale and intensity of small-scale gold mining is highly speculative.

Within the proposed Merian mine site, ASM gold mining continues to be active in the Tomulu, Merian, and Las Dominicanas watersheds. South of the exploitation area, ASM is active in the Brokobari Creek watershed. In the lower Paramaka Creek, there is also evidence of abandoned mined areas.

Logging in Suriname is concentrated in the more accessible northern part of the country. Over the past few decades, the 2.5 million hectare "forest belt" (a 40- to 100-km wide strip that stretches from east to west across Suriname) has been the most important timber production area. Timber extraction also occurs in a few swamp and savanna forest areas along the coastal plain. In recent years, timber harvests have expanded further to the south, into hilly and mountainous areas. Timber harvesting areas exists near the Project site. The area immediately surrounding the Project has been developed to some degree by timber harvesting.

Concurrent ASM gold mining and timber harvesting activities in the area and the development of the Project could, in combination, result in cumulative effects on water quality, wildlife movement, employment, and the potential for influx. The potential impacts associated with commercial harvesting in the immediate vicinity of the Project by a third party have been incorporated into the assessment of impacts to biological resources.

24.4.3 *Cumulative Impacts of the Potential Grankreek Hydropower Project*

In Suriname, there is an increasing demand for energy that is related to the economic development resulting in increased consumption by the residential as well as the industrial consumers. The GDP at the basic prices increased annually with almost 4% between 2001 and 2006. Currently, the demand for energy is mainly a demand for electricity and refined oil products, such gasoline and diesel. The increase demand for electricity is currently coming mainly from Paramaribo and nearby areas. According to published government reports, the demand forecasts show that non-coincidental peak load for Suriname as a whole will grow from 212 megawatt (MW) in 2007 to 503 MW in the year 2023.

To meet the increased demand for electricity, the Government of Suriname, with a grant from the Inter-American Development Bank (IDB), is studying the pre-feasibility of a small scale hydropower generation station on the Grankreek River, which is located south of the Nassau Plateau. This initiative will provide additional power capacity for the development of the interior of Suriname and help to meet the growing needs of energy in Suriname. According to the pre-feasibility bid study requirements, the study is required to move to the feasibility phase of the Project and will provide the conditions and terms for its execution, assuming that the Project is considered feasible.

The expanded availability of energy due to the proposed hydropower Project could result in increased development in the vicinity of the Nassau Plateau, including ASM, or developments by third-party mining operations on adjacent and nearby mining Right of Exploitations, leading to additional impacts on the social and natural environment in the area.

24.4.4 *Other Potential Cumulative Impacts*

Other potential accumulative impacts include the increased access to the area because of the improved roads and potential impacts on communities, increased hunting and fishing, and potential effects on rare species (e.g., species listed by CITES).

24.5 *RESOURCES AT RISK OR LIKELY TO EXPERIENCE INTERACTIONS WITH THE PROJECT*

The following resources are considered at risk or likely to experience interactions with the proposed Project:

- *Air Quality* – The development of the Project in combination with the Nassau Bauxite Project, and ASM, would result in cumulative effects on air quality of the area. However, these cumulative impacts are not permanent (roughly 8 to 20 years), primarily emit fugitive dust, and are not expected to have a significant effect on the air quality of the region.
- *Water Quality* – ASM gold mining in many of the watersheds in the Project area have caused the degradation of the water quality, increased the sediment loads of many rivers and creeks of the area, and altered stream hydrology and the associated aquatic habitats. The Merian Project, in combination with the Nassau Bauxite Project will use mining methods that will minimize or avoid the degradation of the water quality. Surgold support of OGS's efforts to improve ASM practices will lessen the cumulative impact of the Project.
- *Wildlife* – ASM gold mining activities have degraded aquatic habitat and riparian forest (creek forest) habitat across the region, including the main channel and tributaries of the Marowijne River (especially Grankreek west and south of Nassau Plateau) and the headwater tributaries of the Commewijne River. There will be little if any direct interaction between water quality impacts of the Nassau Bauxite Project and the Project

because: 1) the two projects will affect different tributaries of the Marowijne River, 2) water quality effects of both projects are expected to be assimilated rapidly in the Marowijne River's mainstem, and 3) the Nassau Bauxite Project will have little if any effect on the Commewijne River watershed. To the extent that both projects may displace ASM from within their respective boundaries, they could have significant indirect cumulative impacts if the displaced ASM activities expand into new previously un-impacted habitats in the region.

- From a terrestrial wildlife perspective, the block of forested habitat between the Project and the Nassau bauxite Right of Exploitation is becoming increasingly isolated from surrounding areas due to the cumulative impacts of villages in the east along the Marowijne River, ASM and the Project to the north, and the Nassau Bauxite Project to the south. Although no single project or activity is primarily responsible for this impact, this block of forest is surrounded by intensifying human activities on three sides and is only connected to the wider regional dry forest ecosystem in the east. The increasing isolation of this area likely limits movements of large wildlife on a regional scale.
- *Social* - The Project, in combination with the Nassau Mine, ASM, the Grankreek hydro project, and other smaller activities have the potential to cumulatively impact and benefit the local communities, primarily the Pamaka people. These projects will clearly create jobs in an area with low incomes and few employment opportunities, which offer the potential to improve the standard of living for local residents. On the other hand, these projects will likely bring in outsiders working at these projects (e.g., management and skilled employees), as well as possibly attracting people from other areas in search of jobs (e.g., influx), which could adversely affect community cohesion and strain local infrastructure and services if not properly managed.

24.6 MANAGING CUMULATIVE IMPACTS

While the Project is likely to be a major development in the region in the short-term, the possible future development of the Nassau Bauxite property, the hydropower facility, and the improvement of the roads would increase the scale of effects in the region, combined with ASM activities.

Management of potential cumulative impacts in the region will require a long-term, multi-stakeholder regional planning effort. Such planning should be done by building consensus, collaboration and partnerships between the affected and responsible parties. Key stakeholders who should be included in the process include:

- Government of Suriname particularly the District and Resort authorities;
- Residents and leaders of the region, including Maroon Villages;
- Merian, Nassau, and Grankreek Project sponsors;
- ASM Miners Associations;
- Local World Wildlife Fund (WWF) and CI NGO offices; and
- Other regional stakeholder organizations.

25.0 SUMMARY AND CONCLUSIONS

This summary chapter includes the following:

- A compilation of the impact ratings for each resource;
- A discussion of Predicted Outcomes;
- A preliminary list of proposed Environmental and Social Management and Monitoring Plans; and
- A discussion of the ESIA conclusions.

This information and supporting tables are designed to facilitate the review of this ESIA by NIMOS, other government agencies, local communities, and other stakeholders.

25.1 IMPACT RATINGS

As discussed throughout this ESIA, the significance of potential Project-related impacts are rated as one of four categories (insignificant, minor, moderate, major impacts), which are based on the severity of the impact (low, medium, and high) and its likelihood (low, medium, high), as illustrated in Figure 25-1.

	Likelihood		
Severity/ Enhancement	*Low*	*Medium*	*High*
High level of enhancement	Moderate	Major	Major
Medium level of enhancement	Minor	Moderate	Major
Low level of enhancement	Insignificant	Minor	Moderate
Low severity	Insignificant	Minor	Moderate
Medium severity	Minor	Moderate	Major
High severity	Moderate	Major	Major

Figure 25-1 Impact Rating Matrix

The impact ratings were initially based on the proposed Project, including designed engineering controls and mitigation measures to which Surgold has committed. Please note that ERM then met with Surgold to discuss the predicted impacts and recommended mitigation measures. In cases where the impact rating was more significant than minor, further mitigation measures were identified and Surgold has subsequently adopted many of these measures, which are now reflected as part of their proposed Project and evaluated accordingly.

ERM then recommended additional mitigation measures to further reduce potential Project impacts, which are reflected in a residual impact rating.

Overall, for the 61 potential resource impacts evaluated, we predict the following residual impacts:

- 5 enhancements;
- 0 major impacts;
- 3 moderate impacts;
- 26 minor impacts; and
- 27 insignificant impacts.

Summary tables of all predicted impacts are included in Table 25-1, Table 25-2 and Table 25-3.

25.2 IMPACT MITIGATION

It should be noted that the mitigation measures, requirements and suggestions included within this impact assessment chapters should not be considered the finalised approach to mitigation. It is recognised that although these are ijcluded within the ESMMP Surgold may adapt the approach as required in the spirit of the mitigation measure.

Table 25-1 Physical Impacts Summary Table

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
Air Quality							
1	**Short-term increase in fugitive dusts (PM_{10} and $PM_{2.5}$), and combustion emissions (NO_x, SO_2, and CO) released to the atmosphere**	**Pre-Production**	*Source:* · Wheel generated dust/surface disturbance during operation of diesel powered earth-moving construction equipment such as bulldozers, graders, dump trucks, etc. at the site. · Fuel combustion emissions from exhausts of non-road diesel powered earth-moving construction equipment operating at the site e.g., dozers, graders, dump trucks, etc. · Traffic to and from site: including road transportation for workers, delivery trucks, transportation of borrow material; and infrequent barge transportation for very heavy equipment. · Power generation from onsite diesel generators during construction activities at process plant and camp sites.	· Dust suppression as needed, i.e. watering disturbed areas including North Access Road. Reclaim or stabilize disturbed areas as they become available.	Minor (Severity –Low; Likelihood – Medium)	· Implement an air quality monitoring program at the mine site during Pre-Production phase to monitor relevant criteria. · Implement a concurrent rehabilitation program that minimizes the amount of land that will be disturbed at one time. · Ensure that all construction equipment and delivery trucks is maintained in accordance with manufacturer's specifications. · Implement a solid waste management plan.	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			Vulnerability: · There are permanent settlements located east of the mine site, along the Marowijne River; and residences, schools, and houses of worship along the transportation corridor.				
2	**Potential increase in fugitive dust emission concentrations (PM_{10} and $PM_{2.5}$) at the Industrial Zone boundary**	**Operations**	*Source:* · Fugitive dust from surface disturbance associated with activities such as drilling, blasting, excavation work, loading and unloading activities, material transportation via trucks on unpaved roads, wind erosion from exposed areas and stockpiles, crushing, and material handling, activities at the process plant area. · Fuel combustion emissions from exhausts of non-road diesel powered mine equipment operating at the site e.g., excavators, drills, dozers, graders, dump trucks, water trucks, etc. · Power generation from onsite power plant burning HFO (five 10.5	· Dust suppression as needed, i.e., watering disturbed areas. Reclaim or stabilize disturbed areas as they become available	Moderate (Severity – Low; Likelihood – High)	· Implement an air quality monitoring program at the mine site during Operations phase. · Increase watering of disturbed surfaces such as mine haul roads, North Access Road,stockpile area, and material transfer points during dry, low humidity, and windy conditions · Ensure that all mine equipment is maintained in accordance with manufacturer's specifications. · Rotate spigoting of tailings to maintain moisture content and/or irrigate tailings surface to minimize dust generation. · Implement a solid waste management plan and avoid open burning of wastes at the mine site.	Minor (Severity – Medium; Likelihood – Low) .

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			MWe reciprocating engine generators). · Explosive detonation. *Vulnerability:* · Air dispersion modeling shows that annual and 24-hr PM_{10} and $PM_{2.5}$ concentrations would exceed IFC ambient air quality (AAQ) guidelines at the Industrial Zone boundary; in addition, the annual and 24-hr PM_{10} would also exceed the IFC AAQ guidelines at two nearby permanent settlements (i.e.Langa Tabiki and Akaati).			· Perform regular visible dust emission checks on all active mine haul roads, stockpiles, and material transfer points.	
3	**Potential increase in exhaust emission concentrations (NOx, SO_2, CO), at the Industrial Zone boundary**	**Operations**	*Source:* · Fuel combustion emissions from exhausts of non-road diesel powered mine equipment operating at the site e.g., excavators, drills, dozers, graders, dump trucks, water trucks, etc. · Power generation from onsite power plant burning HFO (five 10.5 MWe reciprocating engine generators). *Vulnerability:* · There are permanent settlements located east of	· Use of low sulfur fuel for the new HFO power plant. · Use of HFO power plant compliant with industry good practice air quality performance standards for Thermal Power Plants – i.e., high energy efficiency reciprocating engines ($\geq$Tier 2 engines). · Use of mine equipment (drills, excavators, dump trucks, dozers, etc.) with high efficiency non-road diesel engines ($\geq$ Tier 2 engines).	Moderate (Severity – Low; Likelihood – High)	· Implement an air quality monitoring program at the mine site during Operations phase. · Ensure that all mine equipment is maintained in accordance with manufacturer's specifications. · If required, adjust or fine-tune the fuel-to-air ratio for the HFO reciprocating engines during start-up to control NOx emissions.	Minor (Severity – Medium; Likelihood – Low) .

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			the mine site, along the Marowijne River; and residences, schools. Air dispersion modeling shows that 1-hr NO_x and 24-hr SO_2 concentrations would exceed IFC ambient air quality (AAQ) guidelines at the Industrial Zone boundary, but not at the nearby permanent settlements (Langa Tabiki and Akaati,).				
4	**Short-term increase in fugitive dusts (PM_{10} and $PM_{2.5}$) and combustion emissions (NOx, SO_2, and CO), released to the atmosphere**	**Closure and Post Closure**	*Source:* · Machinery such as planters used for mine rehabilitation (wheel generated dust and combustion emissions) · Intermittent operation of vehicles / pick-up trucks used during monitoring and maintenance activities after Closure activities are complete (wheel generated dust and combustion emissions) *Vulnerability:* · There are permanent settlements located east of the mine site, along the Marowijne River; and residences, schools, and houses of worship along the transportation		Insignificant (Severity – Low; Likelihood – Low)	· Implementation of Closure and Remediation Plan	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			corridor.				
Greenhouse Gases (GHGs)							
5	**Short-term increase in greenhouse gases (CO_2 equivalents) released to the atmosphere**	**Pre-production, Closure and Post Closure**	*Source:* · Loss of aboveground and below ground biomass from deforestation of mine area (commercial tree harvesting and clearing during Pre-production). · Machinery including bulldozers, earthmoving equipment and construction machinery during Pre-Production and machinery such as planters used for mine rehabilitation (wheel generated dust and combustion emissions) · Intermittent operation of vehicles / pick-up trucks used during monitoring and maintenance activities after Closure activities are complete (wheel generated dust and combustion emissions) *Vulnerability:* · Permanent settlements located east of the mine site, along the Marowijne River, are most	· Revegetate disturbed areas as they become available.	Minor (Severity – < 25 kg CO_2e / tonne of ore processed; Likelihood – High)	· Ensure construction fleet is maintained in accordance with manufacturer's specifications. · Monitor vegetation restoration efforts	Minor (Severity – < 25 kg CO_2e / tonne of ore processed; Likelihood – High)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			vulnerable to potential global climate change effects (sea level rise, droughts, etc.) that could result from increased greenhouse gases.				
6	**Potential increase in greenhouse gases (CO_2 equivalents) released to the atmosphere**	**Operations**	*Source:* · Loss of aboveground and below ground biomass from deforestation of mine area (commercial tree harvesting and clearing). · Fuel combustion emissions from exhausts of non-road diesel powered mine equipment operating at the site e.g., excavators, drills, dozers, graders, dump trucks, water trucks, etc. · Power generation from onsite power plant burning HFO (five 10.5 MWe reciprocating engine generators). *Vulnerability:* · Permanent settlements located east of the mine site, along the Marowijne River, are most vulnerable to potential global climate change effects (sea level rise, droughts, etc.) that could result from	· Revegetate disturbed areas as they become available. · Use of HFO power plant compliant with IFC high efficiency (40-45%) and greenhouse industry good practice performance standards for new HFO-fired thermal power plants (reciprocating engines). · Use of mine equipment (drills, excavators, dump trucks, dozers, etc.) with high efficiency non-road diesel engines ($\geq$ Tier 2 engines).	Minor (Severity – < 25 kg CO_2e / tonne of ore processed; Likelihood – High)	· Ensure that all mine equipment is maintained in accordance with manufacturers' specifications. · Implement a waste management plan and avoid open burning of wastes at the mine site. · Quantify and report direct and indirect GHG emissions per IFC requirements. · Implement energy conservation measures at the process plant. Such measures include using waste heat from the HFO power plant exhaust (exhaust gas steam boilers) to (a) heat HFO storage tanks and pre-heat HFO prior to consumption in the power plant; (b) pre-heat eluate solutions to reduce diesel fuel consumption in the elution area; and (c) pre-heat carbon prior to carbon regeneration to	Minor (Severity – < 25 kg CO_2e / tonne of ore processed; Likelihood – High)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and–Proposed EMMPs	Impact Rating After Mitigation
			increased greenhouse gases.			reduce fuel consumption in carbon regeneration.	
Noise							
7	**Short-term increase in daytime and nighttime noise levels at the mine site and along the transportation corridor**	**Pre-production, Operations, Closure, and Post Closure**	*Source:* · Operation of construction equipment and vehicles at the mine site. · Operation of the diesel-powered generator set (3.3 MWe). · Movements of delivery trucks (construction and revegetation materials, supplies, etc.) and construction worker vehicles along transportation corridor. *Vulnerability:* · There are residences, schools, and houses of worship along the transportation corridor.	· All contractors on site will be required to undertake regular inspection and maintenance of all vehicles and construction equipment in accordance with manufacturer's specifications. · All construction equipment and vehicles will be operated on an as-needed basis. · Truck deliveries will be limited to day-time hours during Pre-Production, Closure and Post-closure phases.	Insignificant (Severity – Low; Likelihood – Low)	· None required – there would be little-to-no noise increase during the day; in addition, there would be little-to-no-truck delivery at nighttime (10 p.m. to 7 a.m.).	Insignificant (Severity – Low; Likelihood – Low)
8	**Potential increase in daytime and nighttime noise levels at the Industrial Zone boundary**	**Operations**	*Source:* · Surface mining operations such as drilling, blasting, and excavation activities. · Movements of dump trucks along mine haul roads. · Operation of auxiliary and support equipment such as dozers, graders, fuel trucks, and water trucks.	· The primary gyratory crusher will be enclosed in a concrete building on three sides, with the forth side partially open for access (including a roof over the top for rain protection). · The power plant will be fully enclosed, with steel/foam sandwich panel walls and roof for noise abatement, insulation, and protection for the	Minor (Severity – Low; Likelihood – Medium)	· Ensure regular maintenance of all mine equipment and haul trucks in accordance with manufacturer's specifications. · Install sound suppressive devices (such as mufflers) on mine equipment and haul trucks as necessary.	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			· Operation of the power plant, crushers, SAG Mill, and Ball Mill at the process plant area. *Vulnerability:* · Noise modeling shows that predicted daytime noise levels would exceed IFC noise guidelines of 55 dBA at the northeastern and southwestern portions of the Industrial Zone boundary, but not at the nearby permanent settlements (Langa Tabiki and Akaati). Similarly, predicted nighttime noise levels would exceed the IFC noise guidelines of 45 dBA at all portions of the Industrial Zone boundary, but not at the nearby permanent settlements.	equipment.			
Ground Vibration and Airblast Overpressure							
9	**Short-term increase in ground vibration levels at the mine site and along the transport corridor**	**Pre-production, Closure, and Post Closure**	*Source:* · Movement of delivery trucks along the transport corridor. · Operation of heavy construction equipment such as dozers and drills at the mine site during		Insignificant (Severity – Low; Likelihood – Low)	· None required	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			construction activities. · Machinery such as planters used for mine rehabilitation. · Intermittent operation of vehicles / pick-up trucks used during monitoring and maintenance activities after Closure activities are complete. *Vulnerability:* · There are permanent settlements located east of the mine site, along the Marowijne River; and residences, schools, and houses of worship along the transport corridor.				
10	**Potential increase in ground vibration and airblast overpressure levels at Industrial Zone boundary**	**Operations**	*Source:* · Blasting at the mine site. · Operation of heavy mine equipment within the mine pits and movement of dump trucks along mine haul roads. *Vulnerability:* · Modeling shows that predicted ground vibration and airblast overpressure levels would exceed recommended limits at the northeastern and southwestern portions of the Industrial Zone	· Blasting will be limited to day-time hours during Operations phase.	Minor (Severity – Low; Likelihood – Medium)	· Monitor all open pit blasts and avoid blasting during unfavorable atmospheric conditions, such as low level inversions.	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			boundary, but nearby permanent settlements (Langa Tabiki and Akaati) would not be impacted.				
11	**Potential increase in ground vibration and airblast overpressure levels along the transportation corridor.**	**Operations**	*Source:* · Movement of delivery trucks (reagents, fuel, water) and employee vehicles / company buses along the transportation corridor. *Vulnerability:* · There are residences, schools, and houses of worship along the transportation corridor.		Insignificant (Severity – Low; Likelihood – Low)	· None required	Insignificant (Severity – Low; Likelihood – Low)
Traffic and Transportation							
12	**Increased Project-related traffic volume on the Transportation Corridor (compared to baseline conditions).**	**Pre-Production, Operations, Closure and Post Closure**	*Sources* · Project Pre-Production would generate up to 16 heavy truck round-trips (Paramaribo to / from the Mine Site) per day on the Transportation Corridor. · Project operations would generate up to 33 heavy truck round-trips (Paramaribo to / from the Mine Site) per day on the Transportation Corridor. · Project Closure would generate some heavy truck round-trips (Paramaribo to / from the	· Fuel will be delivered in caravans to reduce distribution of increased truck traffic.	Insignificant (Severity – Low; Likelihood – Low)	· None. Project-related Pre-Production phase traffic would not noticeably reduce the capacity of the Transportation Corridor.	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			Mine Site) per day on the Transportation Corridor. Volume has not been estimated, but is likely less than Pre-Production phase. · Potential for decreased road capacity for non-Project traffic. *Vulnerability:* · There are residences, schools, and houses of worship along the transportation corridor.				
Land Use							
13	**Reduction of land available for hunting and NTFP gathering.** ·	**Pre-Production, Operations, Closure and Post Closure**	*Source* · Surgold will control access to the Mine Site, which will reduce the areas available for ASM or hunting and NTFP gathering. *Vulnerability* · Local residents may use the Right of Exploration area for hunting and gathering; however, other forest areas are available nearby.	· Controlled access will be consistent with the right of exploitation, and would not prevent use of adjacent lands.	Insignificant (Severity– Low; Likelihood – Low)	· Restore disturbed areas within the Project as part of mine Closure. · Work with the OGS to improve the environmental sustainability of ASM	Insignificant
14	**Change in land use from ASM**	**Pre-Production,**	*Sources* · Controlled access to mine	· Controlled access will be consistent with the right of	Minor enhancement	· Restore disturbed areas within the Project as part	Moderate enhancement

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
	to industrial mining due to Surgold control of the Right of Exploitation.	**Operations, Closure, Post Closure**	area will restrict ASM within area of controlled access including mine site and TSF area. *Vulnerability* · ASM can contribute to environmental degradation, and health / safety risks through disturbance to creek bed, banks and valleys that increase TSS loading and loss of vegetation and through the use of mercury, operation of heavy machinery.	exploitation, and would not prevent use of adjacent lands.	(Severity: Low; Likelihood – Medium)	of mine Closure. · Support OGS in their programs to improve ASM practices. · Reconfigure abandoned ASM sites within controlled access area to return streams to a more natural hydrologic regime to enhance natural reclamation.	(Enhancement – Moderate; Likelihood – Medium)
Landscape and Soils							
15	**Potential increase in soil erosion (or topsoil loss)**	**Pre-Production**	*Source:* · Vegetation clearance and grubbing. · Landscape grading and re-contouring to ensure proper drainage. · Other construction activities and earthworks. · Potential soil degradation due to erosion / storm water runoff, alterations of drainage and surface water runoff patterns	· Reclaim or stabilize disturbed areas as they become available. · Implement a concurrent rehabilitation program that minimizes the amount of land that will be disturbed at one time.	Moderate (Severity – Medium; Likelihood – Medium)	· Develop and implement a Sediment and Erosion Control Plan with soil erosion, storm water runoff, and sedimentation control measures	Minor (Severity – Low; Likelihood – Medium)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			Vulnerability: · Steep sloped areas. · Soils with high erosion potential. · Topsoil is very limited and revegetation is difficult to achieve once organic nutrients in the topsoil are lost.				
16	**Rutting and soil compaction**	**Pre-Production**	*Source:* · Heavy equipment movement. *Vulnerability:* · Soils susceptible to compaction. Once compacted these soils become difficult to re-vegetate.	· Implement a concurrent rehabilitation program that minimizes the amount of land that will be disturbed at one time.	Minor (Severity – Medium; Likelihood – Low)	· Deep rip compacted areas that are no longer in use.. · Implement an awareness education and training program. ·	Insignificant (Severity – Low; Likelihood – Low)
17	**Loss of growth media**	**Pre-Production**	*Source:* · Vegetation clearance and grubbing. · Landscape grading and re-contouring to ensure proper drainage. · Other construction activities and earthworks. *Vulnerability:* · Topsoil is very limited and vegetation is difficult to achieve once organic nutrients in the topsoil are lost.	· Implement Closure and Rehabilitation Plan.	Moderate (Severity – Low; Likelihood – High)	· Optimize sequencing to minimize duration of saprolite exposure. · Look for opportunities for reuse of grubbed material for rehabilitation (this requires active management of grub material)	Minor (Severity – Low Likelihood – Medium)
18	**Soil**	**Pre-**	*Source:*	· Bunding / secondary	Minor	· Exercise controls for	Insignificant

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
	contamination from spills or leaks	**Production, Operations, Closure(not applicable to Post-Closure)**	· Contamination from accidental spills (e.g., fuels, lubricants, and other chemical handled on site. *Vulnerability:* · Potential for soil degradation due to runoff containing hydrocarbons and other pollutants.	containment of all fuel storage · Any contaminated soil will be stored in a compacted containment cell or biocell.	(Severity – Low; Likelihood – Medium)	inspecting equipment and refueling, handling of chemicals, and Implement a Spill Prevention, Control and Countermeasures Plan(SPCC). The SPCC Plan describes measures to be implemented by Surgold and its contractors to prevent, and if necessary, contain and control inadvertent spill of hazardous material such as fuels and lubricants, using sorbent pads, containment walls, and other measures. · Implement a training module to educate employees on the SPCC Plan.	(Severity – Low; Likelihood – Low)
Water Resources – Surface Water							
19	**Degradation of water quality due to spills/accidents**	**Pre-Production Operations and Closure (not relevant for Post-Closure)**	*Sources* · Transportation, handling and storage of fuels and reagents on site could result in introduction of contaminants to surface water in the event of a spill or accident.	· Fuel storage tank farms (one for HFO, one for diesel) will be constructed within impermeable, bunded secondary containment areas. · Rain water collected from within tank farm secondary containment areas will be routed through oil-water separators prior to discharge. · Secondary containment will be provided at the tank	Minor (Severity: Low Likelihood: Medium)	· Exercise controls for inspecting equipment and refueling, handling of chemicals, and implement a Spill Prevention, Control and Countermeasures (SPCC) plan. The SPCC plan presents a system for reducing the potential for spills at the Merian Gold Project and for responding to such events as well as means to monitoring operations to confirm that	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and–Proposed EMMPs	Impact Rating After Mitigation
				farm fuel transfer areas to ensure containment of a spill, should one occur · Reagent storage will be indoors. · Transportation of fuel and reagent will be performed using trucks equipped with spill response materials and manned by staff trained in the use of the equipment.		preventative measures are in place and followed. · The SPCC will become part of the Project's Emergency Response Plan and will be supplemented by a Cyanide Management Plan, a Hydrocarbons Management Plan and a Spill Response Plan. The Spill Response Plan will include specific details regarding the steps, roles and responsibilities in the event of a spill associated with the Project.	
20	**Degradation of water quality due to discharge of treated sanitary sewage**	**Pre-Production (not relevant for other Project phases)**	*Sources* · During Pre-Production, effluent from the Pioneer Camp sewage treatment plant will be discharged to the North Fork A3 Creek. · During Pre-Production effluent from the Operations Camp and Process Plant STPs will be discharged to North Fork A3 Creek until TSF becomes operational, at which time effluent will be touted to TSF. · Effluent discharges to creek will meet Project EDC discharge criteria for sanitary effluent.	· Sewage will be treated to meet Project EDC sewage effluent discharge criteria.	Minor Severity: Low Likelihood: Medium	· Water Resources Management plan - Monitoring of STP effluent and the point of discharge during Pre-Production to confirm continued adherence to Project EDC effluent discharge standard.	Minor Severity: Low Likelihood: Medium

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			· If an upset condition occurs at the Pioneer Camp STP, discharge to the creek will be discontinued and sewage will be routed to the TSF for storage pending repair of the sewage treatment system. *Vulnerability* · North Fork A3 Creek flows represent a minor portion of the overall flow in the larger watershed (A3 Creek and Las Dominicanas Creek). Sufficient assimilative capacity exists in the larger watershed, even during low flow conditions. · Discharge to North Fork A3 Creek will be limited to short Pre-Production period. During Operations treated sewage effluent will be discharged to TSF.				
21	**Increases in TSS concentrations in streams**	**Pre-Production, Operations, Closure (not relevant for Post-**	*Sources* · During Pre-Production, clearing and grubbing, earth moving, regrading and dam and structure construction activities	· Sediment ponds will be located on impacted streams downstream of Project activities and will treat Project-site runoff to meet Project EDC discharge	Minor (Severity: Low Likelihood: Medium)	· Adaptive implementation of a Water Management Plan and Erosion and Sediment Control Plan that includes monitoring of receiving environment and	Insignificant (Severity : Low Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
		Closure)	will increase sediment in runoff to local creeks. · During Operations, exposed areas such as WRDs, material stockpiles, roads, and TSF will contribute to increased sediment in runoff from the Project. · During Closure, demolition, capping and regrading of WRDs, and regarding and stabilization of the mine pits and TSF will increase sediment in site runoff. *Vulnerability* · Merian Creek, A3 Creek and Las Dominicanas Creek are already disturbed by ASM and exhibit elevated TSS regularly and very high concentrations during precipitation events (as high as >1400 mg/L).	criteria. Investigation of potential application of flocculants and detailed design of sediment ponds are currently being finalized. · Source controls (e.g., run-on diversion dikes and swales, grading, benching, slop contouring, silt fencing, and slope stabilization / seeding) and intermediate controls (check dams, sediment traps and conveyance channels) will further reduce erosion and offsite discharge of sediment laden runoff. · Concurrent reclamation of WRDs and other disturbances will reduce the total exposed area contributing to sediment loads in runoff.		discharge water quality and indicators that require further sediment and erosion control action. · Application of BMPs during Pre-Production early construction prior to sediment ponds in place to be included in Construction Erosion and Sediment Control Plan	
22	**Changes in streamflow regime.**	**Pre-production. Operations, Closure and Post Closure**	*Sources* · Regrading of portions of the Project Area will result in a permanent change to drainage basin sizes. · Absent structural and	· Reclaim or stabilize disturbed areas as they become available · Temporary and permanent sediment control structures will provide attenuation of peak flows from the	Minor (Severity: Low Likelihood: Medium)	· Adaptive implementation of a Water Management Plan and Erosion and Sediment Control Plan that includes monitoring to assess potential erosion and continue to improve erosion control measures.	Minor (Severity: Low Likelihood: Medium)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			operational controls (sediment ponds, source controls, and intermediate controls) development of site, including loss of vegetation, compaction, and increase in impermeable surfaces, could contribute to higher rates of runoff resulting in higher average and peak flows.. · During Post-Closure, existing ASM-disturbed areas will be vegetated, restoring undisturbed conditions resulting in a decrease of average runoff and peak flows. *Vulnerability* · Most significant impacts to hydrology will occur within the Project Environmental Study Area. Impacts in both receiving creeks: Merian and Las Dominicanas Creeks downstream of the Project will show only small changes in flow regime.	drainage basin. · Sediment structures will be removed or breached during Closure or before-hand depending on phasing of Project to allow streams to return to more natural hydrologic conditions. · Implement a concurrent rehabilitation program that minimizes the amount of land that will be disturbed at one time.		· Channel improvements and erosion protection to maintain bank stability if monitoring indicates increased erosion. · Addition of root clumps or other energy dissipation in the creek channel to reduce velocities if monitoring indicates increased erosion. ·	
23	**Degradation of water quality**	**Pre-Production**	*Sources* · Discharge from the	· Discharge from TWSR will meet Project EDC effluent	Minor	· Adaptive implementation of a Water Management	Minor

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
	in Las Dominicanas Creek		Treated Water Storage Pond will impact water quality conditions in Las Dominicanas Creek. *Vulnerability* · The A3 Creek drainage basin. This comprises approximately 23 % of the Las Dominicanas watershed and <1% of the upper reaches of the Commewijne River.	limits.	(Severity: Low Likelihood: Medium)	Plan.	(Severity: Low Likelihood: Medium)
24	**Degradation of water quality in Las Dominicanas Creek**	**Production, Operations and Closure**	*Sources* · TSF-impacted baseflow (seepage) discharging to surface water in A3 Creek during drier months (such as during periods in September through November) , at the end of mining and during Closure / Post-Closure could potentially impact overall water quality in Las Dominicanas Creek. (TSF-impacted baseflow contributions not anticipated during Pre-Production phase.) · Discharge from the Treated Water Storage Pond will impact water quality conditions in Las	· Water in the TSF pond will be routed through a treatment process prior to discharge. The effluent from the Treated Water Storage Pond will meet Project EDC discharge criteria. · Process plant will include a Cyanide Destruction circuit to reduce cyanide concentrations in the tailings slurry discharged to the TSF. · TSF design includes an upstream drainage system to lower piezometric head and reduce TSF seepage. · TSF design includes a seepage collect and recovery system downgradient of TSF	Moderate (Severity: Low Likelihood: Medium)	· Adaptive implementation of a Water Management Plan and its water quality monitoring program to allow for early detection of potential water quality issues and reactive implementation of mitigative actions such as treatment modifications at the process plant and / or WTP, increased seepage collection, and modified operation of TWSR discharges.	Minor (Severity: Medium Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			Dominicanas Creek. *Vulnerability* · The TSF has the potential to impact water quality in the A3 Creek drainage basin. This comprises approximately 23 % of the Las Dominicanas watershed and <1% of the upper reaches of the Commewijne River. · Any potential impacts from the TSF seepage would be larger during dry or low-flow periods, at the end of mining and during Closure and Post-Closure when flow in the streams is dominated by groundwater contributions.	capture a portion of seepage and allow for its return to the TSF. · Based on modeling evaluation, Project is predicted to meet Project EDC instream criteria at the Study Area boundary (EP-A0).			
25 a	**Degradation of water quality in Merian Creek**	**Operations and Closure (not relevant for Pre-Production or Post-Closure)**	· Water quality in Merian Creek will be impacted by runoff and seepage from the waste rock disposal areas until reclamation of WRD is complete. · Pit-water will be pumped from a sump in each pit and discharged to small tributaries of Merian Creek	· Pit water and WRD runoff will be discharged to small Merian Creek tributaries and impounded by sediment ponds located downstream of impacted areas. · Sediment pond discharge will meet Project EDC discharge criteria. · Water quality evaluation predicts general compliance	Minor (Severity: Low Likelihood: Medium)	· Adaptive implementation of a Water Management Plan and its water quality monitoring program to allow for early detection of potential water quality issues and reactive implementation of mitigative actions such as treatment modifications at the sediment ponds relative to use of flocculants.	Minor (Severity: Medium Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			· Limited TSF-impacted seepage discharging (baseflow) to Tomulu Creek. *Vulnerability* · Potential contaminants include TSS and nitrogen and ammonia nitrogen. Merian Creek and Tomulu Creek are disturbed by artisanal and small scale mining and exhibit elevated TSS regularly and very high concentrations during precipitation events (as high as >1400 mg/L).. · Contributions from site runoff to Merian Creek make up only approximately 15% of the streamflow during low flow conditions (at Evaluation Point B0 Merian Creek above Tomulu Creek).	for Project EDC at Study Area boundary (EP-B0)		· As a contingency, if monitoring indicates that nitrate or ammonia concentrations are higher than expected in WRD seepage, treatment systems (e.g., treatment lagoons) will be added downstream from the sediment pond dams.	
25 b	**Degradation of water quality in Tomulu Creek**	**Operations**	· Water quality in Tomulu Creek will be impacted TSF quartz vein seepage and TSF saprolite seepage.	· Process plant will include a Cyanide Destruction circuit to reduce cyanide concentrations in the tailings slurry discharged to the TSF. · TSF design includes an upstream drainage system to lower piezometric head and reduce TSF seepage.	Minor (Severity: Low Likelihood: Medium)	· Adaptive implementation of a Water Management Plan and its water quality monitoring program to allow for early detection of potential water quality issues and reactive implementation of mitigative actions such as treatment modifications at	Minor (Severity: Medium Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
				· TSF design includes a seepage collect and recovery system downgradient of TSF capture a portion of seepage and allow for its return to the TSF. · Water quality evaluation predicts general compliance for Project EDC at Study Area boundary (EP-C0)		the process plant and / or WTP, and increased seepage collection.	
Water Resources – Groundwater							
26	**Degradation of groundwater quality resulting from spills or accidents**	**Pre-Production, Operations, Closure, Post-Closure.**	*Sources* · Transportation, handling and storage of fuels and reagents on site could result in introduction of contaminants to groundwater and surface water in the event of a spill or accident.	· Fuel storage tank farms (one for HFO, one for diesel) will be constructed within impermeable, bunded secondary containment areas. · Secondary containment will be provided at the tank farm fuel transfer areas to ensure containment of a spill, should one occur · Reagent storage will be indoors. · Transportation of fuel and reagent will be performed using trucks equipped with spill response materials and manned by staff trained in the use of the equipment.	Insignificant (Severity: Low Likelihood: Low)	· Exercise controls for inspecting equipment and refueling, handling of chemicals, and Implement a Spill Prevention, Control and Countermeasures (SPCC) plan. The SPCC plan presents a system for reducing the potential for spills at the Merian Gold Project and for responding to such events as well as means to monitoring operations to confirm that preventative measures are in place and followed. The SPCC plan describes measures to be implemented by Surgold and its contractors to prevent, and if necessary, contain and control inadvertent spill of hazardous material such as	Insignificant (Severity: Low Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
						fuels and lubricants, using sorbent pads, containment walls, and other measures. The SPCC plan will specify training requirements for personnel responsible for handling of fuels and reagents and for general facility staff. · The SPCC will become part of the Project's Emergency Response Plan and will be supplemented by a Cyanide Management Plan, a Hydrocarbons Management Plan and a Spill Response Plan. The Spill Response Plan will include specific details regarding the steps, roles and responsibilities in the event of a spill associated with the Project.	
27	**Changes to groundwater elevations**	**Operations, Closure and Post-Closure**	*Sources* · Pits create sink for groundwater and require pumping to keep pit clear for mining, resulting in drawdown of groundwater elevations around the pits. *Vulnerability* · Impacts will be limited to site and not expected to impact groundwater		Insignificant (Severity: Low Likelihood: Low)	· None required	Insignificant (Severity: Low Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			elevations beyond Project Area. · No current uses of groundwater in Project Environmental Study Area.				
28	**Changes in groundwater flow paths from TSF area**	**Operations, Closure and Post-Closure**	Sources · The TSF impoundment will raise groundwater levels in the TSF area resulting in changes in groundwater flow directions. *Vulnerability* · Changes in the groundwater flow paths will be limited to a local area bounded by Las Dominicanas and Tomulu Creeks and the Merian II and Maraba pits. · Changes to the flow paths will result in increases to baseflows in adjacent creeks. Increases in baseflows are not considered negative. · Some groundwater will be directed to mine pits rather to small tributaries in the vicinity of the pits. During dry conditions, baseflow in these small tributaries will be reduced.		Insignificant (Severity: Low Likelihood: Low	· If determined necessary, sediment pond and lagoon discharges might be managed to offset decreases in baseflow in small tributaries during dry conditions, · Adaptive implementation of a Water Resources Management plan that includes, water quality and biological monitoring in Las Dominicanas Creek and Merian Creek and on-going improvements to water management system to respond to observed water quality.	Insignificant (Severity: Low Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
29	**Degradation of groundwater quality downgradient of TSF**	**Operations and Closure**	*Sources* · Seepage of water through the tailings will result in seepage entering groundwater below and down-gradient of the TSF. *Vulnerability* · There is currently no use of groundwater in the area. · Seepage will comprise approximately 30% of Las Dominicanas Creek flow immediately downstream of the Project during baseflow conditions.	· Process plant will include a Cyanide Destruction circuit to reduce cyanide concentrations in the tailings slurry discharged to the TSF. · TSF seepage collection system implemented and monitored for effectiveness.	Moderate (Severity: Medium Likelihood: Medium)	· Implementation of a monitoring program that is linked to an adaptive Water Resources Management plan that includes contingency measures to be implemented as needed	Minor (Severity: Medium Likelihood: Low **)**
30	**Degradation of groundwater quality downgradient of waste rock disposal areas**	**Operations, Closure**	· Seepage of water through the waste rock disposal areas will result in seepage entering groundwater below WRDs. · Water quality in seepage could be affected by low-level leaching of metals and metalloids from waste rock and mobilization of nitrate and ammonia residues from blasting. This could affect	· Shallow impacted groundwater will be collected at sediment control structures and water will be treated to meet Project EDC discharge criteria, if determined necessary.	Moderate (Severity: Medium Likelihood: Medium)	· Detailed seepage modeling to further characterize expected groundwater seepage chemistry and support the development of tailored treatment or collection systems. · Adaptive implementation of a Water Resources Management plan including monitoring of groundwater quality at different elevations (saprolite, saprock and fresh rock) to identify	Minor (Severity: Medium Likelihood: Low)

	Impact	Phase (s)	Source of Impact and Existing Vulnerability	Project Controls	Impact Rating [a]	Further Recommended Mitigation Measures and– Proposed EMMPs	Impact Rating After Mitigation
			groundwater quality.			indicators that signify changes are required to site water management plans.	

Table 25-2 Biological Impacts Summary Table

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and–Proposed EMMPs	Residual Impact
	Terrestrial Impacts						
1	**Fragmentation and loss of vegetation from timber harvesting and clearing to accommodate construction**	**Pre-Production**	*Source*: · Loss of vegetation in roads, skid lines and areas cleared during timber harvesting · Clearing remaining vegetation to construct Project infrastructure · Desiccation and increased risk of blowdown along roads and timber harvest areas · Increased fire risk along roads and near accumulated slash/logging debris · Changes in vegetation structure and species assemblage (increased ground cover and lianas) · Reduced geneflow across roads and logged areas *Vulnerability:* · Commercial tree species · All vegetation within footprints of Project infrastructure · All disperser-dependent vegetation species · The immediate regional area is already fragmented mainly due to ASM activities.	· Implement vegetation rehabilitation and restoration plan during Closure phase · Minimize cleared width of roads and temporary work camp site · Avoid known areas of high vegetation diversity (e.g..; M6) · Survey road routes prior to construction to avoid mature special-status species (e.g.; M6)	High (Severity – Medium; Likelihood – High)	· Survey and transplant Species of Concern (SOC) seedlings · Minimize potential fuel/ignition sources · Liana removal as necessary to prevent "secondary felling"	Moderate (Severity – Low; Likelihood – High)
2	**Loss and degradation of**	**Pre-Production**	*Source*: · Loss of vegetation in roads,	· Minimize cleared width of roads and harvesting areas	Major	· Minimize potential fuel/ignition sources	Moderate

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and–Proposed EMMPs	Residual Impact
	wildlife habitat from timber harvesting and clearing to accommodate construction		skid lines and areas cleared during timber harvesting · Clearing remaining vegetation to construct Project infrastructure · Desiccation and increased risk of blowdown along roads and timber harvest areas · Increased fire risk along roads and near accumulated slash/logging debris · Changes in vegetation structure and species assemblage (increased ground cover and lianas) · Reduced geneflow across roads and logged areas *Vulnerability:* · All forest-dependent wildlife species	· Survey road routes prior to construction to avoid mature special-status species	(Severity – Medium; Likelihood – High)	· Liana removal as necessary	(Severity – Low; Likelihood – High)
3	**Vegetative metabolic distress**	**Pre-Production, Operations and Closure (not applicable Post Closure)**	*Source:* · During Pre-Production deposition of dust on to leaves near Project infrastructure. · During Operations, deposition of dust on to leaves from extractive activities at the Merian and Maraba pits, waste rock facilities, road network, processing facility (Operations only), and TSF (Closure only)	· Effective dust control measures as further described Table 25-1. · Enforce speed limits on Project roads	Insignificant (Severity – Low; Likelihood – Low)	·	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and– Proposed EMMPs	Residual Impact
			Vulnerability: · All vegetation near Project infrastructure.				
4	**Injury and Mortality of Wildlife**	**Pre-Production and Operations**	*Source:* · Lethal and sublethal injury due to crushing, collision, entanglement, etc. in roads, skid lines, and other areas where heavy machinery harvest commercial timber or construct Project facilities · Roadkill and vehicular injury · During Operations entrapment/drowning in TSF *Vulnerability:* · During Pre-Production all wildlife, but especially cavity nesting birds, small arboreal mammals, and herpetiles · During Operations all wildlife, but especially ground-dwelling herpetiles and small mammals.	· Enforce speed limits on Project roads · Minimize night driving.	Moderate (Severity – Low; Likelihood – High)	· Pre- timber harvest/construction survey and relocation of listed herpetiles (*Anomaloglossus surinamensis* and *Atelopus hoogmoedi nassaui*) · During Operations rescue animals trapped in pits and/or TSF if possible (consistent with the safety of mine staff)	Minor (Severity – Low; Likelihood – Medium)
5	**Injury and Mortality of Wildlife**	**Closure**	*Source:* · Roadkill and vehicular injury · Entrapment/drowning in pits *Vulnerability:* · All wildlife, but especially ground-dwelling herpetiles	· Enforce speed limits on Project roads Minimize night driving	Minor (Severity – Low; Likelihood – Medium)	· Rescue animals trapped in pits if possible (consistent with ensuring safety of mine staff) · Natural revegetation of pit side slopes through time will provide escape routes	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and– Proposed EMMPs	Residual Impact
			and small mammals.			· Benches in pit walls will subside, reducing potential for small animals to become trapped	
6	**Injury and Mortality of Wildlife**	**Post-Closure**	*Source:* · Entrapment/drowning in pits *Vulnerability:* · Small terrestrial wildlife species	None	Insignificant (Severity – Low; Likelihood – Low)	· None	Insignificant (Severity – Low; Likelihood – Low)
7	**Sensory disturbance of wildlife**	**Pre-Production through Closure**	*Source*: · Emissions of noise and light contribute to: · Interruption of circadian rhythms · Increased mortality in attractive hazardous areas (parking lots, security gates, etc.) · Interference with social vocalizations (in social species such as some birds and primates) · Interference with mating activities (amphibians in particular) · Increased exposure to predation/mortality *Vulnerability:* · Diurnal wildlife near Project infrastructure · Nocturnal mammals and amphibians near sources of nighttime noise and light	· Ensure noise level specifications for all major noise-causing pieces of equipment are met. · Use only modern, well maintained industrial equipment with the appropriate noise mufflers in place	Moderate (Severity – Low; Likelihood – High)	· Implement wildlife awareness training program for workers.	Minor (Severity – Low; Likelihood – Medium)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and– Proposed EMMPs	Residual Impact
8	**Sensory disturbance of wildlife**	**Closure**	*Source:* · Noise emissions from the pits, TSF impoundments, water treatment facilities, power plant, etc. · Implementation of the biological monitoring program *Vulnerability:* · Diurnal wildlife near Project infrastructure	· Ensure noise level specifications for all major noise-causing pieces of equipment are met. · Use only modern, well maintained industrial equipment with the appropriate noise mufflers in place	Minor (Severity – Low; Likelihood – Medium)	· Implement wildlife awareness training program for workers.	Insignificant (Severity – Low; Likelihood – Low)
	Aquatic Biological Impacts			·		·	
9	**Increases in turbidity and sedimentation**	Pre-Production	*Source:* · Runoff from disturbed areas from timber harvesting and construction of the Project infrastructure *Vulnerability:* · Predatory fish that hunt by sight · Fish with metabolic requirements for high water quality · Macroinvertebrates with metabolic, behavioral, or anatomical requirements for high water quality	· Sediment dams will be located on all impacted streams downstream of Project activities and will treat Project-site runoff to meet Project discharge criteria. Investigation of potential applicable flocculants and detailed design of sediment ponds is currently underway · Concurrent reclamation of WRDs will reduce the total exposed area contributing to sediment loads in runoff.	Minor (Severity – Low; Likelihood – Medium)	· Application of BMPs during early construction prior to sediment dams in place . · Development of Erosion and Sediment Control plan that includes monitoring of receiving environment and discharge water quality and indicators that require further sediment and erosion control action.	Insignificant (Severity – Low; Likelihood – Low)
10	**Degradation of water quality due to treated sewage**	**Pre-Production**	*Sources:* · Effluent from the the Pioneer and Main Camp's sewage	· Sewage will be treated to meet Project sewage effluent discharge criteria.	Minor (Severity:	· Adaptive Water Resources Management Plan - .Monitoring of sewage	Insignificant (Severity:

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and– Proposed EMMPs	Residual Impact
	discharge		treatment facility will discharge nutrients to North North Fork A3 Creek, *Vulnerability:* · Low natural nutrient load makes streams in the Study Area susceptible to eutrophication · Receiving stream (North North Fork A3 Creek) is very small and therefore has little assimilative capacity during low flow conditions. Instream water quality immediately downstream of the sewage outfall will be dominated by effluent discharge. · North North Fork A3 Creek flows represent a minor portion of the overall flow in the larger watershed (A3 Creek and Las Dominicanas Creek). Sufficient assimilative capacity exists in the larger watershed, even during low flow conditions. · Discharge to North North Fork A3 Creek will be limited to short Pre-Production period. During Operations treated sewage effluent will be discharged to TSF		Low Likelihood: Medium)	treatment plant effluent and North North Fork A3 Creek during Pre-Production to confirm continued adherence to Project and IFC effluent discharge standards. · Monitoring of water quality in receiving environment . · Potential for establishing a small pond to collect rainwater to dilute effluent prior to discharge is being explored.	Low Likelihood: Low)
11	**Loss of aquatic habitat**	Pre Production	*Source*: · Installation of Merian infrastructure in the western	· Sediment dams will be removed or breached during Operations or	Moderate (Severity –	· Support OGS' program to improve environmental sustainability of ASM	Minor (Severity –

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and–Proposed EMMPs	Residual Impact
			headwaters of Merian Creek · Impoundment of A3 Creek *Vulnerability:* · All obligate stream-dwelling wildlife within the western headwaters of Merian Creek and the footprint of the TSF	Closure, depending on phasing of Project to allow streams to return to more natural hydrologic conditions.	Medium; Likelihood – Medium)	activities, which will seek to improve regional aquatic conditions	Low; Likelihood – Medium)
12	**Direct mortality of aquatic organisms**	Pre Production	*Source*: · Installation of Merian infrastructure in the western headwaters of Merian Creek · Impoundment of A3 Creek *Vulnerability:* · All obligate stream-dwelling wildlife within the western headwaters of Merian Creek and the footprint of the TSF	· Sediment dams will be removed or breached during Operations or Closure, depending on phasing of Project to allow streams to return to more natural hydrologic conditions.	Moderate (Severity – Medium; Likelihood – Medium)	· Support OGS' program to improve environmental sustainability of ASM activities, which will seek to improve regional aquatic conditions	Minor (Severity – Low; Likelihood – Medium)
13	**Degradation of water quality due to spills/accidents**	**Pre-Production through Closure**	*Source*: · Transport, handling, and storage of fuels and reagents on site could result in introduction of contaminants to surface water in the event of a spill or accident. *Vulnerability:* · All aquatic wildlife downstream of road crossings that would be sensitive to contamination from petroleum, oils, lubricants, reagents, or cyanide.	· Fuel storage areas will be built on impermeable surfaces and bunded. · Oil-water separators will treat runoff from bunded areas. · Reagent storage will be indoors. · All fuel and reagents will be stored in double-hulled tanks.	Minor (Severity: Low Likelihood: Medium)	· Exercise controls for inspecting equipment and refueling, handling of chemicals, and Implement a Spill Prevention, Control and Countermeasures Plan(SPCC). The SPCC Plan describes measures to be implemented by Surgold and its contractors to prevent, and if necessary, contain and control inadvertent spill of hazardous material such as fuels and lubricants, using sorbent pads, containment walls,	Insignificant (Severity – Low; Likelihood – Low)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and– Proposed EMMPs	Residual Impact
						and other measures.	
14	**Changes in Downstream Water Quality in the Marowijne Watershed**	**Operations**	<u>*Source*</u>: · Runoff and seepage from the waste rock facilities and discharge from pit pump-water. <u>*Vulnerability:*</u> · All aquatic wildlife in Merian Creek and tributaries	· Pit water and WRD runoff will be discharged to small Merian Creek tributaries and impounded by small sediment ponds located downstream of impacted areas. · Sediment pond discharge will meet Project and IFC criteria for TSS.	Moderate (Severity: Medium Likelihood: Medium)	· Implement a monitoring program that is linked to the adaptie management plan that can result in implementation of contongency measures, such as nitrogen treatment lagoons , water treatment within sediment ponds, anaerobic treatment etc. · Water above chemical discharge criteria (other than TSS) will be treated to meet discharge criteria. · Implementation of an Adaptive Water Management plan that includes water quality monitoring in Merian Creek and tributaries and	Minor (Severity: Low Likelihood: Low)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and–Proposed EMMPs	Residual Impact
						changes to water management system to respond to observed water quality.	
15	**Ecological impacts due to changes in the Las Dominicanas Creek watershed**	**Operations**	*Source:* · Altered flows in receiving stream(s) could displace weaker swimming fish and invertebrates downstream · Decreased flows in receiving stream(s) could increase competition for habitat and likely displace most species · Decreased water quality in A3 creek and Las Dominicanas Creek watershed within the mine water management area could limit aquatic life *Vulnerability:* · All aquatic wildlife in Las Dominicanas Creek tributaries draining the TSF. · Fishes in Las Dominicanas Creek upstream and downstream of A3 Creek, especially *Cetopsis sp.*, *Panaqolus sp., and Peckoltia sp.*	· Concurrent reclamation and sediment and erosion control measures will attenuate runoff rates. · Establishment of temporary and permanent sediment dams will attenuate peak flows from the drainage basins during frequent rainfall events. · Sediment dams will be removed or breached during Closure or before-hand depending on phasing of Project to allow streams to return to more natural hydrologic conditions. · Water in the TSF pond will be routed through a treatment process prior to discharge. The effluent form the Treated Water Storage Pond will meet Project and IFC discharge criteria. · Process plant will include a Cyanide Destruction circuit to reduce cyanide concentrations in the tailings slurry discharged to the TSF. · TSF seepage collection	Moderate (Severity: Medium Likelihood: Medium)	· Detailed design of sediment dams such that discharge matches or approach existing peak flow conditions where feasible · Implementation of a Sediment and Erosion Control Management Plan including BMPs to control runoff rates, streamflow and erosion monitoring to continue to improve erosion control measures. · Channel improvements and erosion protection to maintain bank stability if monitoring indicates increased erosion. · Addition of root clumps to creek channel to reduce velocities if monitoring indicates increased erosion. · Implementation of a monitoring program that is linked to an Adaptive Water Management Plan that includes contingency measures to be implemented if necessary · Design of dewatering plan for TSF to mimic existing	Minor (Severity – Low; Likelihood – Medium)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and–Proposed EMMPs	Residual Impact
				system will include internal drainage networks to reduce head to the groundwater, as well as external seepage collection drains and wells		baseflow conditions as feasible i.e. constant discharge rate during dry conditions rather than intermittent pumping. · Optimizing of the operation of the Water Treatment Plant and potential groundwater collection system to mitigate potential impacts based on modeling results. · Additional supplemental measures may be necessary to treat remove nitrogenous byproducts of cyanide destruction from the effluent from the treated water storage pond. One such measure could be construction of an artificial wetland between the outfall from the Treated Water Storage Pond and the confluence of the North and South Forks of A3 Creek	
16	**Ecological impacts of changes in Downstream Water Quality in Las Dominicanas Creek downgradient of compliance point EP-A0**	**Operations**	<u>Source</u>: · TSF seepage to Tailings Creek will impact overall water quality in potential spawning areas for fish species of concern in Lower Dominicanas Creek, especially during low-flow periods in September – November (i.e.; spawning	· Completed analyses demonstrate that water quality will be protective of aquatic life at EP-A0	Moderate (Severity: Medium Likelihood: Medium)	· Implement monitoring program that is linked to the adaptive water management plan that includes contingency measures to be implemented if needed	Minor (Severity: Medium Likelihood: Low)

	Impact	Phase	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating	Further Recommended Mitigation Measures and– Proposed EMMPs	Residual Impact
			season) · Discharge from the Treated Water Storage Pond will impact water quality conditions in Las Dominicanas Creek. *Vulnerability:* · Aquatic wildlife in Las Dominicanas Creek downstream of A3 Creek, especially *Cetopsis sp.*, *Panaqolus sp., and Peckoltia sp.*				
17	**Contaminated runoff and/or sedimentation**	**Closure**	*Source*: · Operation of access road network *Vulnerability*: · All aquatic wildlife downstream of road crossings that would be sensitive to contamination from petroleum, oils, lubricants, reagents, or cyanide.		Minor (Severity – Low; Likelihood – Medium)	· Install erosion and sediment control measures at drainage points along roads. · Prepare and implement a Spill Prevention, Control and Countermeasures Planthat also addresses hazardous materials	Insignificant (Severity – Low; Likelihood – Low)
18	**Changes to impacted Merian Creek tributaries**	**Closure**	Restoration of natural or semi-natural steam channels in western tributaries of Merian Creek , improving habitat conditions		Moderate Low level of enhancement Likelihood: high	· Sediment dams will be breached to allow natural flow patterns to resume. · Restoration of impacted creeks to stabilize banks and return creeks improved conditions.	Moderate Low level of enhancemen t Likelihood: high

Table 25-3 Social Impacts Summary Table

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
	Livelihood and Socio-Economic Impacts						
1	**Pre-Production**	**Increased employment and income generation opportunities within the Marowijne Area**	*Source of Impact* · Hiring of unskilled workforce (100-300) · Multiplier effect of increased local employment · Cumulative effect of Suralco Nassau bauxite project *Vulnerability* · Lack of capacity, formal employment experience/education and certified skills may undermine the local benefit without management. Although there is a willingness to hire local Pamaka people without management measures benefits may be national level. · Competition with ASM as a livelihood perceived to be preferable.	Develop Human Resources Database Develop integrated Social Closure Plan	Minor (Enhancement – Low Likelihood – medium)	· Integrate human resources database with other industrial operations in the area (where possible) · Develop Sourcing, procurement and Recruitment Policy · Work with partner organizations to deliver Financial Management Training to employees · Education and Skills training · Certification of Training · Management of retrenchment of employees · Coordinate with Government of Suriname in relation to planning for skills training and needs in line with existing development process and related industrial developments	High (Enhancement – High; Likelihood – High)
	Operations		*New Sources of Impact* · Increased employment		Moderate (Enhancement		

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			of unskilled workforce (additional 400-500) · Cumulative effect of Suralco Nassau bauxite project *Vulnerability* · Employment opportunities for local people may be muted due to lack of eligible candidates and competition with ASM as a livelihood. Without management benefits may be experienced at a national level.		– Medium; Likelihood – Medium)		
	Closure		N / A				
	Post Closure		Retrenchment during Closure / Post -closure may undermine benefits if not correctly managed.				
2	**Pre-Production**	**Increased employment and income generation opportunities at a regional and national level**	*Source of Impact* · During construction, total workforce is expected to reach approximately 750 workers, an estimated 600 of whom will likely be Surinamese nationals. · Multiplier effect of increased local employment · Cumulative effect of	Develop Human Resources Database Develop integrated Social Closure Plan Promote mining skills through work with higher education organizations in Paramaribo and elsewhere	Minor (Enhancement – Low Likelihood – High)	· Integrate human resources database with other industrial operations in the area · Develop Sourcing, procurement and Recruitment Policy · Work with partner organizations to deliver Financial Management Training to employees · Education and Skills training · Certification of Training · Management of retrenchment of employees	Moderate (Enhancement – Medium; Likelihood – High)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			other planned projects *Vulnerability* · Lack of capacity, formal employment experience/education and certified skills may undermine the benefit without management.				
	Production		*New Source of Impact* · During operations the total workforce is expected to be approximately 1200 people.		Moderate (Enhancement – Medium; Likelihood – Medium		Moderate – High (Enhancement – Medium; Likelihood – High)
	Closure		N/A Retrenchment during Closure/ Post-closure may undermine benefits if not correctly managed.				
	Post Closure						
3	**Pre-Production** **Closure**	**Benefits from community investment**	· Community investment (CI) initiatives addressing identified socio-economic and health development needs · Cumulative impact from Nassau project CI *Vulnerability* Current CI planning is not advanced and has not involved significant	· Stakeholder engagement - Storyboards explaining how Surgold intend to partner with communities and manage CI. · Relaunching the community Platform to manage expectations and	Moderate (Enhancement – Medium; Likelihood – Medium)	· Community Investment (CI) Strategy · CI aligned to government and local partners development objectives · Stakeholder Engagement activities · Investment Committee · Community Investment Policy · Delivery of Skills and Capacity development training	Moderate-Hugh (Enhancement – Medium-high; Likelihood – High)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			participation from other stakeholders which may undermine benefits received. The sustainability of CI initiatives will scope the degree of benefits that area received Post-closure.	commitments · Use of an Expectation and Commitment register. · Partnership with TANA Foundation to provide tutoring to children in the Marowijne Area · Sponsorship of students within the Marowijne Area · Scoping of potential partner organizations.			
4	**Pre-Production** **Operation**	**Reduction in standard of living due to reduced productivity of income generating opportunities related to ASM**	· Loss of access to former ASM sites within Merian IZ · Low availability of alternative ASM sites (perceived or actual) · Local economy and local income generating opportunities highly dependent on ASM activity and revenues · Secondary impacts including reduced	Engagement with community and key members of the traditional authority and ASM livelihood group	Major (Severity – Medium-High; Likelihood – High; Receptor sensitivity – High)	· Local procurement of goods and services · Recruitment Policy · Delivery of Skills and Capacity development. · Development of ASM Management Plan that sets out the strategic management of ASM · Partner with OGS to deliver implement training for Pamaka people involved in ASM · Agricultural Improvement Program · Stakeholder engagement – engage	Moderate (Severity – Medium; Likelihood – medium; Sensitivity – high)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			food security, decreased access to infrastructure and services, decreased sense of community well being *Vulnerability* • reliance on illegal ASM as the only widespread, available and comparatively high income generating activity within the Marowijne Area; • limited savings networks compared to levels of debt; • low levels of income related to expenditure; and • reduced levels of knowledge, experience and skill to participate in and pursue alternative income generating opportunities.			with communities regarding areas of forest that will not be affected by the Merian Project · Biodiversity and Ecology mitigation · *I*nvestment in local service providers	
	Closure		*Vulnerability* ASM sites may be increasingly available Post-closure as Surgold leave the area however the				
	Post-Closure						

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			majority of auriferous areas will be exploited.				
	Impacts to Infrastructure and Services						
5	**Pre-Production** **Operations** **Closure** **Post-Closure**	**Pressure and overburdening of physical and social infrastructure and services**	· Potential Influx into Moengo and the transient camps near to the Merian Right of Exploration and Right of Exploitation by opportunistic job-seekers hoping for employment or benefits from the Project leading to increased population and overburdening on existing physical and social infrastructure and services (including health infrastructure) · Potential for impact to be exacerbated by other industrial operations in surrounding area *Vulnerability* Poor quality and shortage of key services and infrastructure currently available	Engagement with stakeholders regarding hiring practices. Workforce to work a two week rotational period before returning to their homes. Human Resources Plan in development to include requirements for hiring from specific locations (i.e. 'no hiring at the gate')	Moderate (Severity – Medium; Likelihood- Medium; Sensitivity – Medium)	· Local Procurement Plan · Transparent Hiring Techniques · Stakeholder Engagement Plan	Minor-Moderate (Severity – Low; Likelihood – Medium; Sensitivity – High)
	Socio-Cultural Impacts						

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
6	**Pre-Production** **Operations** **Closure** **Post-Closure**	**Loss of Cultural Identity in the Marowijne Area and Decreased Social Cohesion and Erosion of Traditional Cultural management and Leadership System**	· Changes (actual and perceived) to traditional livelihood practices and local physical environment due to presence of Project and relocation of ASM threatening Pamaka cultural identity and sense of place · Impact exacerbated by increase of non-Pamaka people in area · Increased out-migration caused by loss of income generation related to ASM activities may lead to loss of community ties further threatening community sense of identity · Pressure on traditional authority to manage perceived and actual socio-economic changes brought about by Project could undermine traditional cultural management and leadership system · Traditional decision	Surgold's recognition of traditional ceremonies and governance system.	Moderate (Severity – Medium; Likelihood – High; Sensitivity – Low)	· Stakeholder Engagement Plan · Stakeholder engagement – engage with communities regarding areas of forest that will not be affected by the Project · Worker Code of Conduct · Reduce unplanned worker interaction with local community	Minor (Severity – Low; Likelihood – Medium; Sensitivity – Low)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			making and leadership hierarchies altered due to shifting power balances within community brought about through presence of Project · Potential to aggravate community tensions through lack of regard for existing local political dynamics during community engagement *Vulnerability* Receptors to this impact may include people within the Marowijne Area who identify themselves with a strong Pamaka maroon identity. Some receptors are understood to be sensitive to this impact due to the marginalized nature of Pamaka identity within Suriname.				
	Labor and Workforce Impacts						
7	**Pre-Production** **Operations** **Closure**	**Exposure of workforce to insufficient occupational health and**	· Hiring of workforce including contractors and subcontractors · Use of primary and secondary	Surgold Corporate Standards	Minor (Severity – Medium; Likelihood –	· Fitness to work assessments · Health and Safety Polices · Subcontractor Auditing · Actioning H&S Gaps in Subcontractor Audits	Minor (Severity – Low; Likelihood – Low;

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
		safety standards	subcontractors *Vulnerability* Operating in a remote area and in a country with less complex labor laws		Low; Sensitivity – Low)	· Engagement with workforce	Sensitivity – Low).
	Post-Closure		**N/A – no workforce**				
8	**Pre-Production** **Production** **Closure**	**Exposure of workforce to insufficient labor and accommodation standards**	· Hiring of workforce including contractors and subcontractors · Operating in a remote area and in a country with less complex labor laws · Use of primary and secondary subcontractors *Vulnerability* Operating in a remote area and in a country with less complex labor laws	Surgold Corporate Standards and the design of the Operations Camp to meet or exceed International Standards[25]	Minor (Severity – Medium; Likelihood – Low; Sensitivity – Low)	· Adhere to best practice recommendations for accommodation standards · Apply labor and accommodation policies · Allow the formation of workers unions Subcontractor Auditing · Actioning H&S Gaps in Subcontractor Audits · Engagement with workforce	Minor (Severity – Low; Likelihood – Low; Sensitivity – Low).
	Post-Closure		**N/A - no workforce**				
	Health Impacts						
9	**Pre-Production**	**Increased transmission**	· Land disturbing	Full medical facility at	Minor	· Influx Management & ASM	Minor

[25] *Workers' Accommodations Processes and Standards: a guidance note by IFC and EBRD.*

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
	Operations **Closure**	**of infectious and communicable diseases**	activities that may inadvertently create standing bodies of water that are vector breeding grounds · Creation of the pit lake and TSF as permanent standing bodies of water · Potential for outbreak (TB and foodborne illnesses) if worker accommodation is overcrowded with unhygienic conditions *Vulnerability* • High risk for malaria exists in ASM camps. • Interaction with high risk groups for malaria and STIs (including HIV) in the ASM camps • Low utilization rates of condom and HIV testing for STI prevention among the interior Maroon populationsDengue fever rates rising in	site to reduce the opportunity for the workforce to act as vectors for disease. Design of the Operations Camp to meet or exceed International Standards[26]	(Severity – Medium-; Likelihood – Low-to-Medium)	Management Plans · Malaria Control and Prevention Program · HIV Workplace Policy · Worker Health Screenings and Monitoring · Risk Communication Planning	(Severity – Medium Likelihood – Low)

[26] *Workers' Accommodations Processes and Standards*: *a guidance note by IFC and EBRD.*

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			Suriname • Existing high rates of morbidity from digestive tract diseases and respiratory diseases in Langa Tabiki and Nason, particularly among children.				
	Post Closure		N / A				
10	**Pre-Production** **Operations** **Closure**	**Increase in accidents and injuries along the transportation corridor**	· Increase in Project-related traffic along public access roads during Pre-Production through Closure. · Risk of accidents involving community members during road upgrade *Vulnerability* · Existing road traffic safety hazards (e.g., unsafe driving practices and behavior; unsafe road conditions. · Existing truck traffic with heavy cargo (e.g., logging trucks) and dangerous goods (e.g., gasoline trucks).	All Surgold drivers and contractors will be required to comply with speed limits and driving speeds will be monitored.	Moderate (Severity – Medium-to-High; Likelihood – Medium)	· Traffic Management Plan · Community Awareness and Coordination on Public Safety · Contractor's Health and Safety Management · Drivers and contractors will not stop for unplanned / authorized breaks on the journey · Drivers Policy and Trainings	Minor (Severity – Medium; Likelihood – Low)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			· Limited access to emergency medical care outside of Paramaribo.				
	Post Closure		N/A				
11	**Pre-Production** **Operations**	**Decreased Sense of Community Safety and Psycho-Social Well-Being**	· Presence of workforce and Project activities with potential to disrupt community sense of safety and well-being *Vulnerability* • Limited access to public safety and/or mental health resources to address potential public safety concerns (theft, domestic violence, etc.). • Unfamiliarity with mine shift schedule. • Current prevalent use of alcohol and drugs among young local men. • The prevalence of domestic violence. • Strong ties with Maroon traditional way of life, particularly	Separation of worker accommodation from communities Capacity development with local police.	Minor (Severity – Medium; Likelihood – Low)	· Influx Management Plan · Stakeholder Engagement Program · Worker Accommodation Standards and Worker Code of Conduct · Worker Fatigue and Stress Management Program · Stakeholder engagement surrounding limits of deforested areas	Insignificant (Severity – Low; Likelihood – Low)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			among elderly residents in the Marowijne Area.				
	Closure		**N/A**				
	Post Closure						
12	**Pre-Production** **Operations**	**Increase Burden of Chronic Diseases**	· Provision of unhealthy food options (high-fat, high-sodium) that are risk factors for chronic diseases to workers at the Project site *Vulnerability* · Growing rates of chronic diseases among the population in Suriname, including in the Moengo and Marowijne Areas	Exercise room available to workforce.	Minor (Severity – Medium; Likelihood – Low)	· Healthy Options at Project site	Insignificant (Severity – Low; Likelihood – Low)
	Closure	**N/A**					
	Post Closure						
13	**Pre-Production** **Operations** **Closure**	**Exposure to Environmental Health Hazards**	*Source of Impact* · Potential for rare accidental spillage of dangerous goods (e.g., cyanide, diesel or mill reagents) along the	Surgold's Standard Operating Procedures (SOP), Emergency Response Plan (ERP) and standards for Occupational Health and Safety.	Minor (Severity; low-Medium, Likelihood; Low, Sensitivity; High)	· Risk Communication Planning · Closure Planning	Insignificant (Severity; Low, Likelihood; Low, Sensitivity; High)

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			transportation corridor · Air emissions from traffic and land-disturbing activities · Potential for non-routine or uncontrolled releases from the TSF and leaching from waste rock facility piles that could affect the water, flora and fauna in the downstream Commewijne River and Marowijne River areas. · Potential soil contamination from improper management and disposal of hazardous materials during the LOM. *<u>Vulnerability</u>* · Existing high burden of respiratory illness conditions in the Marowijne Area, particularly among children, that put them at greater risk for health effects from exposure to fugitive	In addition, the following measures to manage environmental impacts will also address this impact: Safe Transportation of Hazardous Materials, including Transportation Safety measures as discussed above. Cyanide Management, including the application of the Cyanide Code and Merian Certification within 36 months of Operations commencing. Tailings and waste rock management, including the collection and treatment of seepage from TSF as discussed in Physical Impacts Table.			

	Phase	Impact	Source of Impact and Existing Vulnerability	Project Sponsor Proposed Mitigation Measures	Impact Rating Considering Project Sponsor Proposed Mitigation Measures	Additional Mitigation Measures and SMMPs	Impact Rating After Mitigation or After Implementation of SMMP
			dust emissions. · Residents and households that rely on the rivers for domestic water sources and / or subsistence fish.	Treatment of effluent water prior to discharge to the environment to meet Project discharge criteria.			
	Post Closure	**Exposure to Environmental Health Hazards**	N / A – hazards have been removed				

Predicted Outcomes

The following summarizes the predicted outcomes of the Project once the mining is complete and the Closure Phase activities have been completed.

Physical Resources

- Air Quality – All emissions impacting air quality will cease by the end of the Closure Phase.
- Greenhouse Gas Emissions – All GHG emissions from the Project will be reduced to zero by the end of the Closure Phase.
- Noise and Vibration – Any noise and vibration will cease by the end of the Closure Phase and conditions should return to close to existing baseline conditions.
- Traffic – All Project-related traffic will cease by the end of the Closure Phase.
- Land Use - The Study Area will be returned to existing land use (i.e., forest)and available and accessible for NTFP collection, with the exception of the TSF, which will likely be a wetland complex, and the pit lakes.
- Landscape and Soils - Will be rehabilitated to its original landform or to a landform that approximates and blends in with the surrounding landform, although there will be three pit lakes remaining and one wetland. Disturbed areas will be stabilized to limit erosion and will reduce sedimentation as measured at the Industrial Zone boundary as compared to current ASM-impacted conditions.
- Surface Water–Surface water quality of streams draining the Mine Site in both the Commewijne and Marowijne watersheds will meet international water quality standards as established in the Merian EDC. Sediment dams will be removed once water monitoring demonstrates that TSS concentrations are similar to existing baseline conditions or better and the creeks impacted by the Project will be reconfigured to return their hydrologic regimes to more natural conditions.
- Groundwater - Groundwater elevations will return to similar levels as pre-mining conditions once the pit lakes have completely filled. Water quality will meet international water quality standards as established in the Merian EDC.

Biological Resources

- Terrestrial Habitat – Secondary forest will develop over time via natural succession on disturbed areas and should be similar to existing vegetative cover in terms of species composition. The TSF will remain a large, flat, open area, with poor natural drainage. A small open pond will form at the downstream end of the TSF and a wetland will be established around the perimeter of the pond. Higher, drier areas around the edge of the TSF may return to forest if sufficient consolidation of tailing occurs. Early in the Closure Phase, pioneer wetland species will be encouraged to colonize the exposed surface. Once established, efforts will be made to advance the development of a more mature wetland community habitat comparable with to wetland habitats found in the region. The pit lakes will become permanent water bodies.

- Wildlife – Once the Closure Phase is complete, wildlife are expected to return to the Study Area as habitats are restored and returned to existing conditions. Some new species, not currently found in the area, may begin to colonize the new habitat provided by the TSF wetland and the pit lakes.
- Aquatic Habitat - Sediment dams will be removed or breached and damage to streams from previous ASM activities will be repaired within the Project footprint where possible. These measures will return the streams to more natural hydrologic conditions, and facilitate recovery of more natural streambed characteristics and aquatic biota. The Mine Site will be reclaimed such that TSS concentrations in site runoff are reduced to approximate pre-mining conditions. Where Project-related impacts on streams overlap with historical ASM-related impacts, these measures will at least partially address legacy impacts from ASM and will therefore represent a net positive impact in terms of overall aquatic habitat as compared to existing conditions. Over time, as physical stream conditions improve, aquatic invertebrates and fish communities will recover in the Project streams and should approximate communities that existed prior to ASM activities.

Social Resources:

- Employment - Employee numbers at the Project will gradually be reduced to zero by the time of the Post-Closure Phase. The retrenchment process will be carefully managed, including giving sufficient notice of contract termination to employees. All former Project employees and participants in Surgold training programs will receive certification validating their experience and training, enabling them to seek employment in alternative industrial mining projects or other industrial sectors. Funding from Surgold for all livelihood diversification and skills training programs will terminate. The removal of funding will be carefully managed and where possible/relevant alternative funding will be sought. The outcome of these programs should leave a lasting impact of greater diversity of livelihoods practiced in the Marowijne Area, including commercialized small-scale agriculture and other entrepreneurial activities focused on supply of goods and services;

- Standard of Living - Financial Management Training for employees will be terminated, but should result in improved household financial management and savings rates amongst former Project employees, their families and potentially the wider community. Members of the Pamaka community as well as other stakeholders formerly employed or supported directly / indirectly by the Project may continue to enjoy a higher standard of living. This assumes prudent management of increased household incomes following the Financial Management Training, as well as lasting improvements to education, health and other social infrastructure and services (see below).

The following outcomes apply only to the Pamaka community, as beyond livelihood changes there are not expected to be any other long term changes to the other Social Study Areas (SSA) – (i.e., Moengo, Transportation Corridor, Tempati and Commewijne).

- Small scale mining – ASM will no longer be a primary income generator in the Pamaka community as transition to new deposits / exploration is limited. Surgold financial and technical support to OGS will terminate. Withdrawal of support will be carefully managed and if possible / appropriate alternative funding will be sought. If Surgold's work with OGS achievess its objectives, where ASM is still practiced, improved methods will be used that are more sustainable, safer and less environmentally damaging.
- Education Infrastructure - If the Community Investment Program improves educational infrastructure (renovation / extension of school buildings and teacher accommodation, school boats, teaching equipment), there will be continued improved access to primary and secondary education as well as higher educational attainment, including students who will have benefited from Merian scholarships and other efforts that Surgold is currently conducting in coordination with Education sector along the Pamaka villages.
- Health Infrastructure - If Surgold's Community Investment Program builds capacity and improves services of the local health clinics in partnership with local authorities, the communities may continue to receive the benefits (such as higher quality of care); and if medical emergency evacuation / transportation infrastructure was improved for the Project, then the community may gain better emergency response capacity (for hospital transfers or to control an outbreak);
- Social Infrastructure and Services - All funding and support given through Surgold's Community Investment Program will be terminated. Removal of funding will be carefully managed and where possible / relevant alternative funding will be sought. Availability and quality of drinking water, electricity supply, and communications infrastructure will be unchanged or improved;

- Non-Timber Forest Resources (NTFR) - Most forest areas previously restricted due to the Project will once again be accessible, with the exception of the pit lakes and TSF, however, there may be some lasting changes to the quantity and type of natural resources previously collected within these areas. Changes may be positive relative to the conditions created by ASM activities prior to the mine development.
- Community Safety - once Closure activities are complete, truck traffic and other supporting traffic will cease. The Moengo-Langa Tabiki Road will be improved from existing conditions.

25.3 *PROPOSED ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLANS*

A framework Environmental and Social Management and Monitoring Plan (ESMMP) is submitted in Volume IV of this ESIA. The ESMMP spells out Surgold's organizational structure as it relates to environmental and social management, roles and responsibilities and training requirements. The ESMMP includes a series of subplans that specifically address the management and monitoring of the following.

- Social Management
- Air Quality Management
- Biological Impact Management
- Traffic and transportation safety management
- Waste Management
- Spill Prevention and Control and Countermeasures
- Waste Rock Management
- Adaptive Water Management
- Cyanide management
- Closure and Reclamation

These Management and Monitoring subplans are included as Appendix IV.

25.4 *ESIA CONCLUSIONS*

Overall, the conclusion of this ESIA is that the impacts of the proposed Project are manageable and Pre-Production, Operations, Closure and Post-closure of the Merian Mine will not present any irreversible, unacceptable risks to people or the environment, primarily for the following reasons:

- The site is relatively remote from any permanent settlements, with Langa Tabiki being the closest village approximately 17 km to the southeast of the Merian site. This remoteness reduces the nuisance impacts that are often related to mining projects – fugitive dust, noise, vibration, traffic, and aesthetic impacts.

- Geochemical testing shows that there is very low potential for acid mine drianage and that groundwater seepage and surface drainage from the site is expected to meet international water quality standards; however, the contingency plan is for water treatment as necessary.
- Merian will be certfied under the International Cyanide Management Code for the Gold Mining Industry and will follow international best practices for the purchase, transportation, handling and storage, use in processing, decommissioning, worker safety, emergency response training, and stakeholder engagement.
- The site has already been extensively disturbed by ASM and logging, which reduces the potential for the Project to have significant effects on biological resources. There are several IUCN-listed species that are known to occur in the Project area, but most are transient species or are species common in Suriname. Surgold intends to have a net positive impact on biodiversity by working with Ordening Gould Sector (OGS) to improve the practice and sustainability of ASM in the Project area and mitigating past ASM aquatic impacts by restoring stream connectivity.
- The Project will create up to 1,200 jobs with hiring preference given to workers from Pamaka and elsewhere in Suriname. Surgold has established a Community Investment Strategy and will engage with the GoS and communities to continue investing in improving living conditions in the Project area.
- Finally, the Government of Suriname will be an equity partner and will also receive taxes and royalties, which can be used to enhance sustainable development in Suriname.

This ESIA has identified many mitigation and management measures that have either been proposed by Surgold or recommended by ERM with the intent of increasing the benefits of the Project while avoiding, minimizing, mitigating and managing any negative impacts generated by the Project. Surgold has committed to implementing these mitigation measures and the details regarding their implementation and monitoring; this commitment is documented.in an Environmental and Social Management and Monitoring Plan. Where relevant these mitigation measures may be implements using slightly different methodologies.