Sabajo Project

Draft Environmental and Social Impact Assessment

VOLUME A: PROJECT DESCRIPTION, BASELINE STUDIES AND IMPACT ASSESSMENT

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Abbreviations and Units of Measure

Abbreviation	Definition
#	number
%	percent
~	approximately
+	plus
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
°	degree
°C	degrees Celsius
µg Hg/g	micrograms mercury per gram
µg/L	micrograms per liter
µg/m³	micrograms per cubic meter
µm	micrometer or micron
µmhos/cm	micromhos per centimeter
µS/cm	microSiemens per centimeter
AAQG	Ambient Air Quality Guidelines
ABA	acid base accounting
AD	anno Domini
ADRIP	American Declaration on the Rights of Indigenous Peoples
aff.	has an affinity but not identical to
Ag	silver
AGP	acid generation potential
AIDS	acquired immunodeficiency syndrome
Al	aluminum
AL	action level
alt.	altitude
am	ante meridian
AMIRA	AMIRA International Ltd.
AN	Andesite (lithology)
ANFO	ammonium nitrate fuel oil
ANP	acid neutralization potential
ANPA	acid neutralization potential acidity titration
ANZECC	Australia and New Zealand Environmental Conservation Council
AOI	area of Influence
ARD	acid rock drainage
As	arsenic
ASM	artisanal and small scale mining
ASTM	American Society of Testing Materials
ATV	all-terrain vehicle
avg	average

Abbreviation	Definition
B	boron
Ba	barium
BAP	Biodiversity Action Plan
BATEA	best available technology economically achievable
BBS	National Herbarium of Suriname
Be	beryllium
BFA	bench face angle
BR	bedrock
BS-IBS	Black Shales / Interbedded Siltstone (lithology)
BxS	Sedimentary Breccia (lithology)
C	carbon
Ca	calcium
CaANP	carbonate acid neutralization potential
$CaCO_3$	calcium carbonate
CAI	residual carbon acid insoluble
CAP	residual carbon after pyrolysis
CAY	Herbarium of Cayenne
CBO	Community Based Organization
CCME	Canadian Council of Ministers of the Environment
Cd	cadmium
CEA Agency	Canadian Environmental Assessment Agency
CF	Cassador Fault
CFR	Code of Federal Regulations
CFZ	Cassador Fault Zone
CH_4	methane
Cl	chloride
cm	centimeter
cm/s	centimeters per second
Co	cobalt
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COPC	constituent of potential concern
Cr	chromium
CSIS	Center for Strategic International Studies
CSNR	Central Suriname Nature Reserve
C_{TOT}	total carbon
Cu	copper
DA	drainage area
db	decibel
dBA	A-weighted decibels

Abbreviation	Definition
dbh	diameter at breast height
dBL	linear (or unweighted) decibels
deg.	degree
DL	detection level
DNA	deoxyribonucleic acid
E	east
EA	environmental assessment
EAAA	ecologically appropriate areas of analysis
EBRD	European Bank for Reconstruction and Development
Eco-SSL	Ecological Soil Screening Levels (from USEPA)
EHS	Environmental, Health and Safety
ELA	Environmental Liability Assessment
ERM	Environmental Resources Management
ESIA	Environmental and Social Impact Assessment
ESMMP	Environmental and Social Monitoring and Management Plan
ETP	Effluent Treatment Plant
F	fluoride
FAO	Food and Agricultural Organization
FCC	Fertility Capability Soil Classification
Fe	iron
$Fe_{(1-x)}S$	pyrrhotite
FeAsS	arsenopyrite
FeS_2	pyrite
FPIC	Free, Prior and Informed Consent
FR	fresh rock (regolith)
g	gram
g/s	grams per second
GDP	Gross Domestic Product
GHG	greenhouse gas
GIS	Geographic Information System
GMD	Geologisch Mijnbouwkundige Dienst
Golder	Golder Associates Inc.
GoS	Government of Suriname
GPS	Global Positioning System
GRDC	Global Runoff Data Centre
H	horizontal
ha	hectare
HCO_3	bicarbonate
HCT	humidity cell test
HFC	hydrofluorocarbons
Hg	mercury
HIA	Health Impact Assessment

Abbreviation	Definition
HIRP	Health Incident Response Plan
HIV	human immunodeficiency virus
HPV	human papillomavirus
HRIA	Human Rights Impact Assessment
HSV	herpes simplex virus
IACHR	Inter-American Commission of Human Rights
IADB	Inter-American Development Bank
ICCPR	International Covenant on Civil and Political Rights
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICMM	International Council on Mining and Metals
ICOMOS	International Council on Monuments and Sites
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma mass spectrometry
ID	identification
IFC	International Finance Corporation
IGF	Intergovernmental Forum
IGSR	Institute for Graduate Studies and Research
IHME	Institute for Health Metrics and Evaluation)
ILACO	ILACO Suriname N.V.
ILO	International Labor Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRA	inter ramp slope angle
ISO	International Organization for Standardization
ISOS	International SOS
IT	information technology
IUCN	International Union for Conservation of Nature
k	hydraulic conductivity
K	potassium
KBV	Key Biodiversity Value
KC	Kleine Commewijne River
kg	kilogram
kg $CACO_3$/t	kilograms calcium carbonate per ton
km	kilometer
km^2	square kilometers
KPI	Key Performance Indicator
kWh	kilowatt hour
L	liter
L/min	liters per minute
LBB	Suriname Forest Service
L_{eq}	energy equivalent sound level
m	meter

Abbreviation	Definition
m agl	meters above ground level
m amsl	meters above mean sea level
m bgs	meters below ground surface
m/m	meters per meter
m/s	meters per second
m^2/d	square meters per day
m^3	cubic meter
m^3/sec	cubic meters per second
$m^3/sec/km^2$	cubic meters per second per square kilometers
masl	meters above sea level
max	maximum
MCL	maximum contaminant level
MEND	Mine Environmental Neutral Drainage
meq/L	milliequivalents per liter
Merian mine	Merian Gold Mine
Mg	magnesium
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/L-N	milligrams per liter as nitrogen
mg/L-P	milligrams per liter as phosphorus
min	minimum
ML	metal leaching
mm	millimeter
mm/Hg	millimeters of mercury
mm/s	millimeters per second
Mm^3	million cubic meters
Mn	manganese
Mo	molybdenum
MOH	Ministry of Health
MOP	Multi-Annual Development Plan
MPA	maximum potential acidity
MPN/100 mL	most probable number per 100 milliliters
MPOI	maximum point of impingement
Mt	megaton
mV	millivolt
MW	megawatt
MWe	megawatt electric
N	nitrogen
N/A	not available [or not applicable]
N_2O	nitrous oxide
Na	sodium
NAAQS	National Ambient Air Quality Standards

Abbreviation	Definition
NAF	non-acid forming
NAG	net acid generation test
NBS	National Biodiversity Strategy
NCD	non-communicable disease
NCV	net carbonate value
nd	no data
Newmont	Newmont Suriname, LLC
NGO	Non-Governmental Organization
NH_4^+	ammonium
NHC	National Hurricane Center
Ni	nickel
NIMOS	National Institute of Environment and Development in Suriname (Nationaal Instituut voor Milieu en Ontwikkeling in Suriname)
NIST	National Institute of Standards and Testing
NMR	National Council for the Environment (Nationale Milieuraad)
NMS	Newmont Metallurgical Services
NNP	net neutralization potential
No.	number
NO_2	nitrogen dioxide
NO_3^-	nitrate
nov.	new species
NO_X	nitrogen oxides
NP	neutralization potential
NPR	neutralization potential ratio
NTU	nephelometric turbidity unit
OAS	Organization of American States
OGS	Ordening Goudsector
OHS	Occupational Health and Safety
OS	ore stockpile
oz	ounce
P	phosphorus
PAF	potentially acid forming
PAG	peroxide acid generation
Pb	lead
PCDP	Public Consultation and Disclosure Plan
PHC	Primary Health Clinic
pm	post meridian
PM_{10}	particulate matter with mean aerodynamic diameter nominally smaller than 10 microns (µm)
$PM_{2.5}$	particulate matter with mean aerodynamic diameter nominally smaller than 2.5 microns (µm)
ppb	parts per billion
PPIA	Project's Physical Impact Area
PPL	Peak Pressure Level

Abbreviation	Definition
ppm	parts per million
PPV	Peak Particle Velocity
PS	Performance Standards
PVC	polyvinyl chloride
Q3	3rd Quarter
QA	quality assurance
QC	quality control
QH	quality-hectare
QK	quality-kilometer
Ramboll Environ	Ramboll Environ Corporation
RGB	Ministry of Spatial Planning, Land and Forestry Management
RGD	Regional Health Services (De Regionale Gezondheidsdienst)
RPD	relative percent difference
RSL	Regional Screening Levels (from USEPA)
S	sulfur
s.u.	standard units
SAP	saprolite (geologic unit)
Sb	antimony
SBB	Foundation for Forest Management and Production Control (Stichting voor Bosbeheer en Bostoezicht)
SCF	Suriname Conservation Foundation
Se	selenium
SGw	Sandstone Greywacke (lithology)
SIA	social impact assessment
SO_2	sulfur dioxide
SO_4	sulfate
sp.	species
SPLP	synthetic precipitation leaching procedure
SPS	Stichting Planbureau Suriname
SQ	quartz veins within saprolite
SR	Social Responsibility
SRD	Suriname Dollars
SSDS	Soil Survey Department Suriname
Staatsolie Company	Staatsolie Maatschappij Suriname N.V.
STI	sexually transmitted infection
STD	sexually transmitted disease
STINASU	Foundation for Nature Conservation in Suriname
S_{TOT}	total sulfur
Surgold	Suriname Gold Company, LLC
SVL	SVL Analytical, Inc.
SWTP	Sewage Water Treatment Plant
t	ton
t/d	tons per day

Abbreviation	Definition
t/y	tons per year
TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure (from USEPA)
TDS	total dissolved solids
Terrock	Terrock Consulting Engineers
the Project	the Sabajo Project
Ti	titanium
TIC	total inorganic carbon
Tl	thallium
TNM	Traffic Noise Model
TOC	total organic carbon
ToR	Terms of Reference
TR	total recoverable
TSP	total suspended particulate
TSS	total suspended solids
UDHR	Universal Declaration of Human Rights
ULSD	ultra-low sulfur diesel
UN	United Nations
UNDP	United Nations Development Program
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
UNFCCC	United Nations Framework Convention on Climate Change
UNGP	United Nations Guiding Principles
US	United States
USA	United States of America
USACE	United States Army Corps of Engineers
USD	United States Dollars
USDOS	United States Department of State
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
UTV	utility terrain vehicle
UV	ultraviolet
V	vanadium
VIDS	Association of Indigenous Village Leaders
VN	Quartz Vein (lithology)
VPSHR	Voluntary Principles on Security and Human Rights
W	west
WGS	World Geodetic System
WHO	World Health Organization
WRF	waste rock facility
WRI	World Resources Institute
wt.%	weight percent

Abbreviation	Definition
XRD	X-ray diffraction
Zn	zinc

1 INTRODUCTION

This Environmental and Social Impact Assessment (ESIA) report has been prepared by Golder Associates (Golder) on behalf of Newmont Suriname, LLC (Newmont), to assess the potential social, environmental, and health impacts for the proposed Sabajo Project (the Project). The ESIA also includes an integrated Human Rights Assessment.This assessment has been prepared in alignment with Newmont's standards, and based on the scope that was defined by the draft Terms of Reference (ToR). The ToR was submitted in August, 2017 and incorporated input from the National Institute of Environment and Development in Suriname (NIMOS) and interested stakeholders.

1.1 Overview

Newmont presently operates the Merian gold mine in eastern Suriname (Map 1-1). Newmont operates the mine on behalf of the partnership Suriname Gold Project CV, which is 75 percent (%) owned by Newmont and 25% owned by Government of Suriname (GoS) through the State owned Oil company Staatsolie.

Newmont is now considering the development of Sabajo as an extension to the Merian operation. As the owner of the Sabajo Project, Newmont holds a Right of Exploration where the Project is located (shown in Map 1-1). Previously known as Suriname Gold Company, LLC (Surgold), the company began exploration activities at Sabajo in 2009, and has completed sufficient exploration to define a basis for mining the Sabajo resource.

This document is provided to NIMOS and interested stakeholders to provide an opportunity to review, understand and comment upon the Project and its potential effects and benefits.

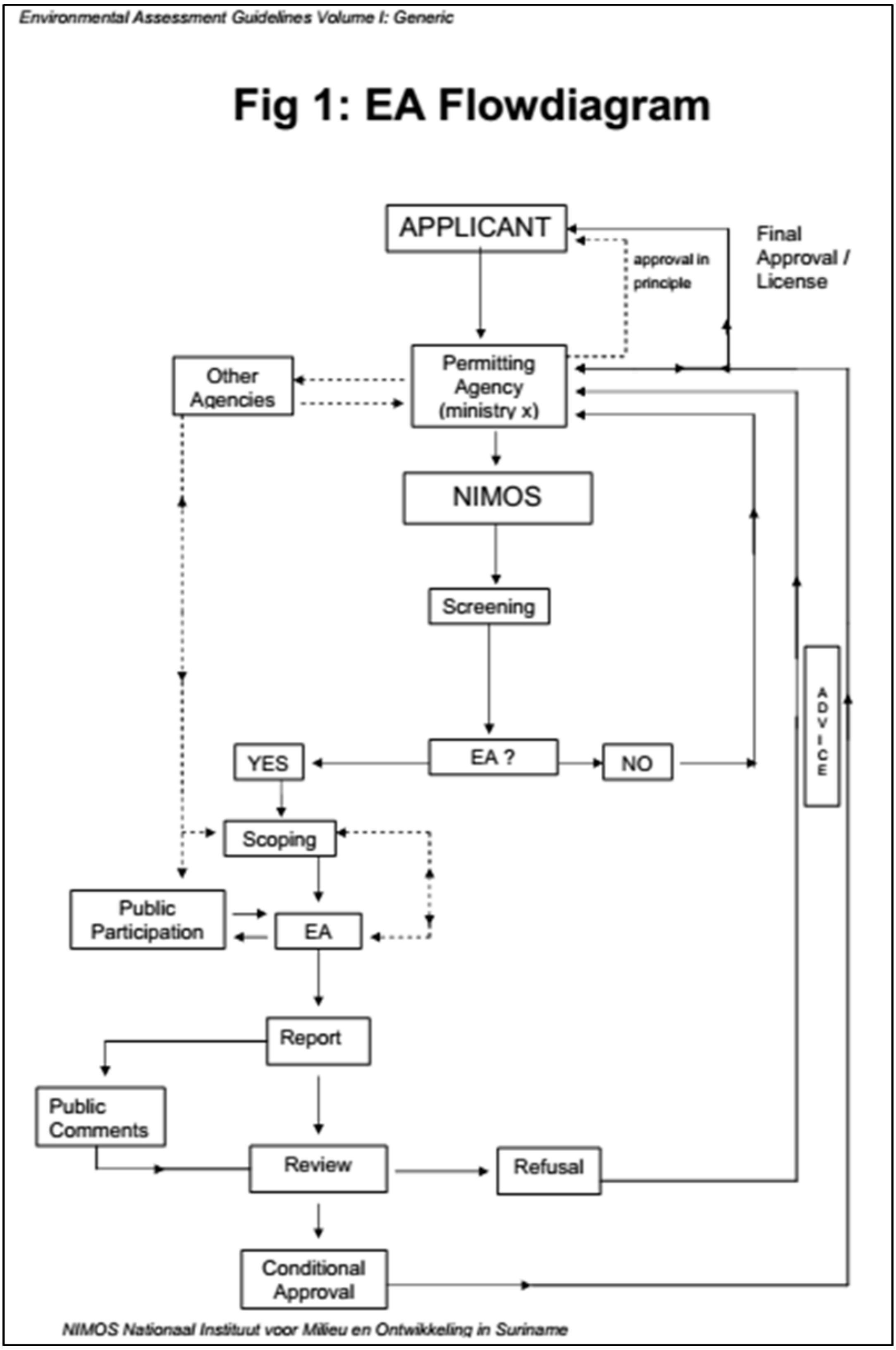
1.1.1 ESIA Phases

The preparation of the ESIA document is a culmination of a process of interaction with the Project design team, with interested stakeholders, and with NIMOS. Overall, the ESIA process is meant to inform and engage with individuals, communities, and governments who could be affected, and address relevant issues that arise, in order to inform corporate and public decision making processes regarding project investment and approval. The phases in the ESIA Process are:

- Screening, in which NIMOS decides if an ESIA is required depending on the category of the Project. This occurred in November of 2016, resulting in a definition of the Project as a Category A Project requiring an ESIA. Further details of the engagement with NIMOS are provided in Section 1.3, below.
- Scoping, in which a detailed ToR is developed, discussed, presented publicly and reviewed, then finalized to meet the needs of NIMOS and project stakeholders. Further details of the engagement for this step are also provided in Section 1.3, below.
- Impact Assessment, which involves characterizing the baseline environment by conducting field studies and describing conditions with data in a report; then considering the Project and assessing the significance of impacts, including cumulative effects between the Project and other projects. This stage also involves developing measures to reduce impacts; and
- Disclosure of Results, which completes the process, as the ESIA is presented to NIMOS and other stakeholders in a set of public meetings.

The ESIA process as mandated by NIMOS is presented in Figure 1-1.

Figure 1-1 The Suriname ESIA Process (from NIMOS)



ESIA = Environmental and Social Impact Assessment; EA = environmental assessment; NIMOS = National Institute of Environment and Development in Suriname.

GOLDER

1.1.2 ESIA Organization and Objectives

The ESIA integrates the assessment of social, environmental and health impacts within a single study. This ESIA also integrates consideration of human rights. The objectives of the ESIA, and the document sections addressing these objectives, are summarized in Table 1-1.

Table 1-1 Document Objectives and Associated Sections of the ESIA

ESIA Section Number	ESIA Section Name	Purpose / Objective
1	Introduction	■ Set the stage for the ESIA document and describe its role and context, including how stakeholders were engaged with to provide input to the Project and to the ESIA.
2	Project Description	■ Present the details of the proposed Project.
3	Analysis of Alternatives	■ Describe feasible alternatives to the Project to show how the plan for the Project was arrived at.
4	Existing Environmental and Social Conditions	■ Describe the existing environment in order to understand what exists prior to the Project, including all physical, biological and socio-economic characteristics relevant to the Project.
5	Impact Assessment	■ Assess in detail, and with a transparent approach, the environmental, human rights, social and health impacts that could occur due to the Project. ■ Set out prevention and mitigation measures to address the impacts identified. ■ Document that the Project, as planned, is or is not predicted to be compliant with regulations and relevant guidelines. ■ Describe risks or hazards that may result in effects to people, beyond the impacts that are predictable as routine.
6	Summary of Commitments and Mitigation Measures	■ Summarize in one location the commitments that Newmont is making to manage project effects (as an input to Volume B, below).
7	Conclusions	■ Provide concise conclusions as to the main effects of the Project.
Volume B	Environmental and Social Management Plans	■ Set out an overall management plan, and a process to further elaborate on the management plan, for the Project, based on the mitigation measures proposed.

the Project = the Sabajo Project; ESIA = Environmental and Social Impact Assessment.

Within the Existing Environmental Conditions (Section 4) and the Assessment of Impacts (Section 5), the following disciplines are considered:

- Physical disciplines:
  - Climate;
  - Air;
  - Noise and Vibration;
  - Terrain and soils;
  - Geochemistry;
  - Groundwater; and,
  - Surface Water.

- Biological disciplines:
  - Flora (Vegetation and habitats);
  - Terrestrial Fauna (Mammals, birds and herptiles);
  - Aquatic ecosystems; and
  - Ecosystem Services.

- Social disciplines:
  - Socio-economics;
  - Cultural resources (tangible and intangible);
  - Land Use;
  - Artisanal and small scale mining (ASM);
  - Health;
  - Legal;
  - Traffic;
  - Visual resources; and
  - Human Rights.

1.2 Legal and Institutional Framework

The Merian Mining Act granted permission to the government to enter into the Mineral Agreement on behalf of the Republic of Suriname. The Mineral Agreement is an attachment to the Merian Gold Mining Act, which was published in the Official Gazette of the Republic of Suriname (S.B. 2013 no. 162), and therefore the Mineral Agreement has force of law.

In addition to the legal requirements set out in the Merian Mineral Agreement and the International Finance Corporation's (IFC) General Environmental, Health and Safety Guidelines and the IFC's Environmental, Health and Safety Guidelines for Mining, the Project is being developed using the Newmont Corporate Standards and Guidance documents for both Social and Environmental issues. The Corporate Standards can be found at the following website: http://www.newmont.com/about-us/governance-and-ethics/policies-and-standards/default.aspx There are also several government policies that discuss sustainable development and biological resources, including the Government Declaration, the Multi-Annual Development Plan (MOP), and the National Biodiversity Strategy.

For major investments, the GoS requires that a project's environmental and social impact is taken into account and measures to mitigate such impacts are in place. All recent major investment agreements on the exploitation of natural resources between the Republic of Suriname and investors therefore contain such obligations. This is also the case for the mineral agreement between Newmont Suriname, LLC and the Republic of Suriname executed on November 22, 2013 ("the Mineral Agreement"). The Mineral Agreement imperatively prescribes that the ESIA for the Project must meet the 'IFC's General Environmental, Health and Safety Guidelines' and the 'IFC's Environmental, Health and Safety Guidelines for Mining', as described in the Mineral Agreement.

The proposed Project and the associated ESIA disclosure process will comply with the Mineral Agreement, the NIMOS process and other relevant existing legislation, including government policy documents. Responsibility for social, environmental and natural resource management is covered by several different pieces of legislation and across different government institutions.

The NIMOS ESIA guidelines serve as the primary basis for the ESIA structure and process. More detail on the legislative, regulatory and institutional requirements for the Project is provided below.

1.2.1 Legal Framework

Suriname's legislation at the national level is exercised through Laws or Acts of Parliament (*Wet*, also called *Verordening* and *Landsverordening* prior to 1975), Decrees (*Decreet*)[1], Government Decree (*Staatsbesluit*), Presidential Decree (*Resolutie*), Presidential Orders (*Presidentieel Besluit*) or Ministerial Orders (*Ministeriële Beschikking*) targeting various sectors including industry, tourism, nature conservation, etc. For the Project the most important law is the 'Act Merian Gold Project' which elevates the Mineral Agreement to the status similar to a law. Other major laws, acts, decrees, and orders concerning environmental management in Suriname are described in Table 1-2.

The Hindrance Act (*Hinderwet* 1930, 1944, and 1972) defines the permit requirements to control noise and air pollution for industrial development projects. The permits are issued and enforced by local District Commissioners (Buursink 2005; SRK Consulting 2007); however, the Act's effectiveness has been negatively impacted by outdated and inadequate regulations concerning inter alia pollution standards and waste management, and a lack of sufficient resources to conduct monitoring inspections (Buursink 2005; SRK Consulting 2007).

The Nature Conservation Act (*Natuurbeschermingswet* 1954) defines the procedures to establish and manage conservation areas and protect wildlife. According to the Act, the only allowable activities in the protected areas are activities of scientific, educational or cultural importance. Conservation areas can be established only by Presidential decree and managed by the Nature Conservation Division of the Forest Service (LBB). The Act does not provide for the protection of sensitive areas outside the established conservation areas.

The Forest Management Act (*Wet Bosbeheer* 1992) replaced the Timber Act of 1947 as the governing regulation for forest exploitation and conservation. The Act classifies forests in Suriname in three ways: permanent, temporary (maintained for the time being), or one-time exploitation forest (land intended for other future use where tree cover will be completely cleared). Resource exploitation in public forests (domain land) is allowable with a permit or forest concession granted by the Ministry of Spatial Planning, Land and Forestry Management (RGB), which issued regulations for logging, deforestation, and processing-related activities. The Forest Management Act also allows the Surinamese government to establish conservation forests.

The 2002 Environmental Act defines the rules for environmental conservation, management, and protection while promoting sustainable development. The provisions of the Act provide guidance for conducting an ESIA in Suriname including:

- Allowing for the creation and implementation of a comprehensive environmental policy and planning process.
- Establishing the importance of environmental protection and equal consideration of environmental issues with all other considerations.
- Establishing NIMOS as the Environmental Authority in Suriname.

[1] Decrees date from the period of 1980 – 1986 and have the same status as past or present Laws.

- Giving effect within Suriname to many internationally-accepted principles of Environmental Law, including the principle of precaution, the polluter pays principle and the concept of environmental impact assessment.
- Introducing and giving effect to the Environmental Impact Assessment Guidelines.
- Enshrining the principles of access to information, participation and legal protection for the Surinamese public.
- Allowing for the introduction of suitable regulations to address specific issues of environmental protection.
- Establishing a framework for enforcement of environmental legislation and regulations, together with penalties.

NIMOS published the Guidelines for Environmental Assessment (2009) (including social aspects) in Suriname and project developers are expected to comply with the spirit of the guidelines. The Guidelines also provide guidance for the Surinamese government on determining the suitability of development ESIA's. A general description of the ESIA Process has been provided above in Section 1.1.1.

There are several government policies that have been developed, which concern sustainable development and biological resources, including the Government Declaration (GoS 2015), the MOP 2017-2021 (GoS 2017), and the National Biodiversity Action Plan (BAP; GoS 2006).

The Government Declaration (Regeringsverklaring 2016-2020) (GoS 2015) mandates an efficient and effective approach to environmental management. Goals of the Government Declaration include establishing sustainable development practices through the development of a national environmental policy and integrating the environmental policy into the sectoral development policy. The Government Declaration also advocates the promoting environmental awareness and sustainable production.

A MOP is drafted every five years and submitted to Parliament for approval. The Plan, which was most recently prepared for 2017-2021, is a government policy that includes a national development strategy for sustainable development and use of biological resources as well as budgetary considerations. This plan adds to the 2016 plan (GoS 2016), which was entitled Development Strategy 2012-2016: Suriname in Transformation.

The National Biodiversity Strategy (NBS) establishes goals and strategic directions to be pursued in order to conserve and sustainably use Suriname's biodiversity and biological resources. The NBS provides a basis and a framework for the development of a BAP, which will identify the activities, tasks, outcomes, milestones, and responsible actors to implement the strategic directions, including mining.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
MINERAL AGREEMENT				
Act Merian Gold Project (S.B. 2013 no 162) and attached executed Mineral Agreement (November 22, 2013) WET van 10 september 2013, houdende toestemming tot het aangaan van een Delfstoffenovereenkomst met Suriname Gold Company LLC betreffende het gebied bekend als Merian, district Sipaliwini. S.B. 2013 no. 162 (Wet Merian Goudproject). Merian Agreement 2013	Agreement between the Republic of Suriname and Newmont Mining Corporation for the exploration and exploitation of minerals.	MNH	1. Environmental and Social Impact Statement is required. 2. All activities to comply with IFC EHS guidelines for mining	This agreement has legal authority over the Sabajo Project
GENERAL				
Kruispunt, Regerings- verklaring 2017-2021	Overall national policy statement	Government Statement		Describes the development policy of the country into which all industry and projects must fit. The developmental impacts of the Project will be compared to the requirements of this policy and efforts will be made to incorporate regional policies and strategies into any development projects that Newmont may invest in.
Ontwikkelingsplan 2012-2016 and 2017-2012	Suriname Development Strategies	Overall Development Strategy		Describes the development strategy for Suriname - efforts will be made to incorporate the strategy into any development projects that Newmont may invest in.
MINERAL RESOURCES				
DECREET van 8 mei 1986, houdende algemene regelen omtrent de opsporing en ontginning van delfstoffen (Decreet Mijnbouw) (S.B. 1986 no. 28), z.l.g. bij S.B. 1997 no. 44. (Mining Decree 1986 SB. 1986 no. 28)	1. Governs exploration and exploitation of mineral resources. 2. Article 2 stipulates that all raw materials in and above the ground, including the territorial sea, are property of the State.	MNH	1. Articles 2, 4, 16, 43, 45 are applicable to environmental protection. 2. Contains requirements for consideration of affected communities of Indigenous Peoples. 3. Several implementation regulations have been issued under this decree.	Provides legal expectations and requirements to exploit minerals nationally including consideration of environmental and social impacts.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
Staatsbesluit van 11 mei 1989 ter uitvoering van artikel 2 lid 5 van het "Decreet Mijnbouw" (S.B. 1986 n0. 28) (Besluit Mijnbouwinstallaties) Government Decree on Mining Installations S.B. 1989 no.38	Provides provisions for offshore mining installations,	MNH	1. Formulated according to: UNCLOS, SOLAS, MARPOL conventions (see Section 2.2.2 on International Agreements). 2. Chapter 3 addresses environmental protection.	Provides legal expectations and requirements to exploit minerals.
Landsverordening van 10 october 1952 betreffende het doen van boringen, G.B. 1952 no. 93 Drilling Law G.B. 1952 no. 93	Provides provisions for drilling in Suriname	Head of MNH		Provides specific requirements for drilling programs.
LAND/LAND USE				
Landsverordening van 13 juni 1973 houdende regelen betreffende de natuurlijke en regionale planning, G.B. 1973 no. 89 (Planverordening) Planning Law 1973 GB. 1973 no. 89	Provisions for national and regional planning e.g. land-use policy issues.	Minister of Planning, Planning Coordination Commission and Planning Council.	Contains the mechanism to establish Special Management Areas, to be developed as MUMAs.	Provides planning and land-use requirements.
Wet van 6 april 1956 strekkende tot vaststelling van bouwvoorschriften G.B. 1956 no. 30 z.l.g. bij S.B. 2002 no. 72 (Bouwwet) (Construction Law 1956 G.B.1 956 no.30)	Provides requirements for the construction of buildings.	Ministry of Public Works		Provides regulations and requirements to construct buildings.
Wet van 29 november 1915, tot vaststelling van een Politiestrafwet (G.B. 1915 no. 77) z.l.g. bij S.B. 1990 no. 24 (Politiestrafwet) Police Criminal Law GB. 1915 no. 77 as amended		Ministry of Justice and Police	Article 39a penalizes the disposal of waste in public places.	Provides regulations and requirements for waste disposal.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
Wet van 28 december 1959, betreffende de invoering van een nieuwe wetgeving in de West-Indische Kolonien (G.B. 1860 no. 4) z.l.g. bij S.B. 2004 no. 25 (Surinaams Burgerlijk Wetboek) Civil Code G.B. 1860 no. 4			Article 625 deals with ownership/proprietary rights as well as expropriation for the general good prior to compensation.	Provides regulations and requirements for expropriation.
AIR QUALITY AND NOISE				
WET van 27 December 1929 tot vaststelling van bepalingen omtrent het oprichten van inrichtingen, welke gevaar, schade of hinder kunnen veroorzaken G.B.1930 no. 64 z.l.g. S.B. 2001 no. 63 (Hinderwet) Hindrance Law G.B. 1930 no. 64 as amended	Controls industrial pollution (noise and air).	District Commissioners issue permits in consultation with Ministry of Health	Permits are required for industrial development projects.	Provides regulations and requirements control industrial pollution.
WATER/MARITIME				
Publicatie van 26 maart 1938, waarbij wordt afgekondigd het Koninklijk besluit van 22 februari 1938 No. 41, houdende verbodsbepalingen met betrekking tot watervergaarplaatsen in Paramaribo en voorschriften inzake verplichte aansluiting aldaar aan de waterleiding. G.B. 1938 no. 33 Water Supply Law G.B. 1938 no. 33	Contains prohibitions with respect to water wells, etc. that serve as water supply sources.	MNH, Ministry of Public Health	According to this Law the President is responsible for its implementation, but in practice the ministries assume the role.	Provides regulations and requirements for water pollution.
Decreet van 24 juni 1981, houdende vaststelling van nieuwe regels inzake het havenwezen (Decreet Havenwezen 1981) S.B. 1981 no. 86 Harbors Decree 1981 S.B. 1981 no. 86	Provisions for harbor activities.	Maritime Authority Suriname and District Commissioners, assisted by the Prosecutors office, the Police and the Ministry of Trade and Industry	Prohibits the discharge of waste, oil, and oil-contaminated water and condemned goods into public waterways and harbors.	Provides regulations and requirements for the discharge of water and oil.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
Wet van 30 juni 2004, houdende vaststelling van regels voor maritieme beveiliging (Wet Maritieme Beveiliging) S.B. 2004 no. 90 Maritime Safety Law SB. 2004 No. 90	Provisions for safety of ships and harbors.	Maritime Authority Suriname, Ministry of Trade and Industry, Maritime Safety Council		Provides regulations and requirements for ship movements.
Wet van 29 november 1915, tot vaststelling van een Politiestrafwet (G.B. 1915 no. 77) z.l.g. bij S.B. 1990 no. 24 (Politiestrafwet) Police Criminal Law GB. 1915 no.77 as amended		Ministry of Justice and Police	In terms of Article 51 the polluting of a water source or water well is liable to a fine.	Provides regulations and requirements for water pollution.
Wet van 14 oktober 1910, houdende vaststelling van een Wetboek van Strafrecht voor Suriname (G.B. no. 11 z.l.g. bij S.B. 2015 no. 44 (Wetboek van Strafrecht) Penal Code G.B. 1911 no.1 as amended		Ministry of Justice and Police	In terms of Articles 224 and 225, contamination of water resources is penalized.	Provides regulations and requirements for water pollution.
Staatsbesluit van 11 mei 1989 ter uitvoering van artikel 2 lid 5 van het "Decreet Mijnbouw" (S.B. 1986 No. 28). (Besluit Mijnbouwinstallaties) S.B. 1989 no. 38 Government Decree on Mining Installations SB. 1989 no. 38	Provisions for offshore mining installations,	MNH	It is prohibited to drain or throw overboard substances in concentrations that are hazardous to the marine environment. Protection of the marine environment should be taken into consideration during dismantling.	Provides regulations and requirements for releases to marine environments.
Landsbesluit van 12 december 1974, houdende uitvoering van artikel 13 van de Bestrijdingsmiddelenverordering 1972 („Bestrijdingsmiddelenbesluit") G.B. 1974 no. 89 Government Decree on Pesticides G.B. 1974 no. 89 as amended	To implement article 13 of the Pesticides Law	LVV, Ministry of Labour, Ministry of Public Health	Article 13 Part 2 forbids the removal or destruction of empty containers or remainders of undiluted pesticides in such a manner that water procurement areas or surface waters are polluted.	Provides regulations and requirements for pesticide disposal.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
NATURAL ECOSYSTEMS (VEGETATION, FISH, AND WILDLIFE)				
WET van 18 september 1992, houdende voorzieningen met betrekking tot het bosbeheer, alsmede de bosexploitatie en de primaire houtverwerkingssector (Wet Bosbeheer) (S.B. 1992 no. 80) Forest Management Law S.B. 1992 no.80 (replaced the Timber Law of 1947)	Provides a framework for forest management, exploitation, and related sector activities (e.g. primary processing and export) to guarantee sustainable utilization of forest resources. Provides for establishment of conservation forests.	MNH, SBB	1. Permits are required for the exploitation of public forests. 2. Currently 13 implementing resolutions have been issued under the Law 3. The Law also contains a requirement to respect the traditional rights of tribal communities.	Provides regulations and requirements for forest management.
WET van 3 April 1954, houdende voorzieningen tot bescherming en behoud van de in Suriname aanwezige natuurmonumenten (G.B. 1954 no. 26) z.g.l. S.B. 1992 no. 80. Natuurbeschermingswet 1954 Nature Conservation Law 1954 G.B. 1954 no. 26 as amended	Wildlife protection, establishment and management of protected areas. Prohibits any activities that may impact on protected areas, except for activities of scientific, educational or cultural importance.	LBB manages nature reserves with the Nature, Protection Commission in an advisory role.	1. Forms the basis for the establishment of nature reserves. 2. Several state-owned lands have been designated nature reserves by Government Decree. 3. No provision for protection of sensitive areas outside of established conservation areas.	Provides regulations and requirements for wildlife protection.
WET van 3 april 1954 houdende voorzieningen tot bescherming van de fauna en tot regeling van de jacht in Suriname (G.B. 1954 no. 25), gelijk zij luidt na de daarin aangebrachte wijzigingen bij (G.B. 1954 no. 106, zoals laatstelijk gewijzigd bij S.B. 1997 no. 33.) (Jachtwet 1954) Game Act 1954 G.B. 1954 no. 25	Protection of fauna and game management.	MNH	The Economic Offences Law is also applicable.	Provides regulations and requirements for protection of fauna and game.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
WET van 3 april 1954 houdende voorzieningen tot bescherming van de fauna en tot regeling van de jacht in Suriname (G.B. 1954 no. 25), gelijk zij luidt na de daarin aangebrachte wijzigingen bij (G.B. 1954 no. 106, zoals laatstelijk gewijzigd bij S.B. 1997 no. 33.) (Jachtwet 1954) Hunting Act 1954	1. Prohibits hunting of certain protected animals. 2. Regulates hunting and fishing.	LBB	1. Permits/licenses are required to hunt certain species. 2. Implies that Indigenous Peoples need permission to hunt and fish on State land.	Provides regulations and requirements for protection of fauna and game.
Staatsbesluit van 27 december 2002, houdende regels ter uitvoering van de artikelen 1,6,8,10,11,13,23 en 23a van de “Jachtwet 1954 no. 25, zoals laatstelijk gewijzigd bij S.B. 1997 no. 33) S.B. 2002 no. 116 (Jachtbesluit 2002) Hunting Decree 2002	Provisions for various animal species, including hunting seasons and numbers allowed,		Protection clause for Indigenous Peoples in the south of Suriname is included.	
CULTURAL HERITAGE				
Landsverordening van 16 februari 1963 houdende voorzieningen in het belang van het behoud van monumenten van geschiedenid, oudheidkunde, kunst en Surinaamse architectuur G.B. 1963 no. 23 (Verordening historische monumenten) Law on Historical Monuments GB. 1963 no. 23	Provisions for the preservation of historical monuments, art and architecture in Suriname.	Ministry of Education & Community Development		Provides regulations and requirements for preservation of cultural heritage.
Landsverordening van 7 februari 1952 houdende bepalingen tot behoud van voorwerpen welke historische, culturele en wetenschappelijke waarde hebben G.B. 1952 no. 14 Law of 7 February 1952 G.B. 1952 no. 14	Controls the export of objects that have historical, cultural and scientific value.	Ministry of Education & Community Development	A permit is required to export objects of historical, cultural and scientific value.	Provides regulations and requirements for protection of cultural heritage.

Table 1-2 Legal Framework(a) for National Environmental and Social Management in Suriname

Title	Objective(s)	Implementing Agency	Comments	Relevance
OCCUPATIONAL HEALTH & SAFETY/PUBLIC HEALTH				
WET van 8 september 1947, houdende bepalingen tot beveiliging bij de arbeid (G.B. 1947 no. 142), z.l.g. S.B. 1980 no. 116 (Veiligheidswet) Occupational Safety Law G.B. 1947 no.142 as amended	To advance safety and hygiene in enterprises so that the chance of accidents and occupational diseases can be reduced to a minimum.	Ministry of Labor	9 regulations have been issued for the implementation of this Law.	Provides regulations and requirements for health and safety in the workplace.
Decreet Arbeidsinspectie (S.B. 1983 no. 42) Labor Inspection Law S.B. 1983 no. 42	Outlines the tasks and responsibilities of the Labor Inspector.	Ministry of Labor	In cases where the safety of persons is in danger, the Inspector has the authority to close the enterprise in question.	Provides regulations and requirements for protection of cultural heritage.
De vindplaats van deze wet hebben wij niet kunnen achterhalen. Mosquito Control Law	To combat mosquitoes and other insects judged to be destructive to the health of human beings and animals.			Provides regulations and requirements for the control of mosquitos.
Publicatie van 26 maart 1938, waarbij wordt afgekondigd het Koninklijk Besluit van 22 Februari 1938 no. 41, houdende verbodsbepalingen met betrekking tot watervergaarplaatsen in Paramaribo en voorschriften inzake verplichte aansluiting aldaar aan de waterleiding G.B. 1938 no. 33 (Waterleidingsbesluit) Water Supply Law G.B. 1938 no. 33	Establishes prohibitions with respect to water wells, etc. that serve as water supply sources.	MNH, Ministry of Public Health	According to this Law the President is responsible for its implementation, but in practice the ministries assume the role.	Provides regulations and requirements for protection of water wells.

1.2.2 Regulatory Framework in Suriname

The Republic of Suriname has several Acts, bills and regulations dealing with environmental and/or natural resource management; however, there is no national law on environmental management. The Constitution of the Republic of Suriname (1987) supports the creation and improvement of "conditions necessary for the protection of nature and for the preservation of the ecological balance." As such, it provides a legal basis for a national environmental policy. A National Environmental Action Plan was compiled in 1996 and, although it has not been formally approved, some of its proposals have been implemented, such as the establishment of an institutional framework for environmental management and sustainable natural resource use.

The Nationale Milieuraad (NMR - National Council for the Environment) was established in 1997 with a mandate to advise the GoS on the development and implementation of national environmental policies. The NMR consists of a chairperson and 5-10 members representing government, private sector, Amerindian and Maroon communities, labor unions, consumer rights, and other Non-Governmental Organizations (NGOs).

Development and implementation of Suriname's environmental regulations is executed by the Nationale Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS – the National Institute for Environment and Development in Suriname). NIMOS was originally established in 1998 by Presidential Decree as an entity subordinate to the President's office, and formally reports to the NMR. NMR is currently not operational; the tasks have essentially been taken over by the Environmental Coordination Unit in the President's Cabinet. In practice, NIMOS acts as executive support for the Environmental Coordination Unit NIMOS is the main environmental management policy and advisory body and also acts as a research institute. While NIMOS had a role in the implementation of the BAP, The Environmental Coordination Unit, led by Mr Winston Lackin, is the National Focal Point for the Convention on Biological Diversity. Suriname's BAP is being managed by NIMOS.

Suriname's Government Declaration (GoS 2015) and MOP 2017-2021 (GoS 2017) specify environmental management policies and focus on objectives of the national environmental policy. In the absence of dedicated national environmental legislation, the responsibility for environmental and social issues remains widely spread between a number of agencies and departments in other ministries. These agencies and departments, and their role in environmental and social issues are described in Table 1-3.

Table 1-3 Environmental and Social Management Responsibilities of Key Institutions in Suriname

Environmental Management Aspects	Institutions							
	Ministry of Domestic Affairs	Sectoral Ministries	NIMOS	STINASU	SCF	District Commissioners	NCD (LBB)	SBB
Nature conservation and management			Facilitation of National Biodiversity Strategy	Browns- berg Nature Park	CSNR and Sipaliwini Nature Reserve		Creation of new protected areas, management, and control	Management of forests
ESIA processes		Approval of development projects and enforcement	Guidance and review of reports. Provides advice regarding environmental planning, but the final decision is still the responsibility of permitting agency.					
Industrial pollution			Technical advice; Enforcement			Permit approval	Enforcement	
Monitoring		Implementation	Supervision; Enforcement				Implementation	Implementation
Environmental Planning (Management Plans)		Participation in design and plan implementation	Coordination of design and plan implementation				Participation in design and plan implementation	
Environmental Regulations	Approval	Enforcement	Drafting and stakeholder consultation					
Forest Development							Permits approval and control of forest management plans	Monitoring of logging activities

NIMOS = National Institute for Environment and Development in Suriname; ESIA = Environmental and Social Impact Assessment; CSNR = Central Suriname Nature Reserve; STINASU = Foundation for Nature Conservation in Suriname; SCF = Suriname Conservation Foundation; NCD = Nature Conservation Division; LBB = Suriname Forest Service: SBB = Foundation for Forest Management and Production Control.

1.2.3 National Human Rights Legal Framework

Suriname is a party to several international treaties addressing human rights, including:

- International Covenant on Civil and Political Rights;
- International Covenant on Economic, Social and Cultural Rights;
- American Convention on Human Rights;
- Suriname has ratified 5 of the 8 International Labor Organization (ILO) Core Conventions, excluding C100 and C111 on discrimination and C 138 on child labor; and
- The Minamata Convention on Mercury (unsigned).

Article 105 of the 1987 Constitution enshrines protections offered in international instruments and renders them enforceable in Suriname. The government has created a commission to implement national human rights action plans (UN 2016a), as well as various national policies to combat racism, discrimination and corruption and to promote health, employment and access to basic services. While the legal framework for human rights is fairly complete, UN agencies and NGOs raise concerns about the lack of institutional capacity and financial resources to implement many of the government's human rights commitments and policies (Fund for Peace 2017).

Suriname was recently accepted (May 2017) to the Extractive Industries Transparency Initiative which addresses revenue transparency related to natural resource development; to date the country wide assessment has not been published. It is also a founding member of the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development, and a Intergovernmental Forum Mineral Policy Assessment was undertaken and published in 2017.

Suriname has been the subject of two international human rights cases over land rights of Maroon and indigenous populations (*Saramaka vs. Suriname,* 2007*; Lokono and Kaliña vs. Suriname,* 2015). In 2007, the Inter-American Court of Human Rights (IACHR) ruled that Suriname should recognize, among others, collective rights to land of the Saramaka people and that tribal peoples have the same rights as indigenous peoples under international law. Both peoples share distinct social, cultural, and economic characteristics, including a special relationship with their ancestral territories, that require special measures under international human rights law in order to guarantee their physical and cultural survival .The IACHR declared the state responsible for violating the rights to recognition of juridical personality, to collective property, to political rights, and to cultural identity, and reminded the state of its duty to adopt appropriate domestic legal provisions.

Suriname is not a party to ILO Convention No. 169 (the Indigenous and Tribal Peoples Convention), and, although the country voted in favor of the United Nations Declaration on the Rights of Indigenous Peoples, it has yet to ratify the Declaration. The Suriname legal framework does not recognize traditional (communal) land rights and has a system for managing land titling. Article 41 of the Suriname Constitution provides that natural resources should be designated for the economic, social and cultural development of the State, and that the State has the inalienable right to control such natural resources.

Suriname has a protective labor regime that controls against long hours, workplace injuries, child labor, and anti-union activities. The country passed a minimum wage law in 2015, setting the minimum wage 43% lower than the national poverty line, and only for a few sectors. Civil servants, who represent over 60% of the formal labor force, often seek second and third sources of income in the informal sector. Additionally, undocumented foreign workers do not have labor protection, which has been relevant in the artisanal mining sector, where Brazilians and, to a lesser extent, Guyanese and Chinese citizens, are established (USDOS 2013).

Labor laws and regulations prohibit discrimination regarding race, sex, gender, disability, language, sexual orientation and/or gender identity, HIV positive status or other communicable diseases, or social status. Despite these legal protections, civil society groups raise concerns about employment discrimination against indigenous peoples, Maroons, and members of the LGBT community (UN 2016b).

The minimum age for work in Suriname is not consistent with international standards by allowing children as young as ten years of age to work. The UN estimates that 6% of children aged 5-14 are involved in child labor (including children, primarily boys, working in illegal gold mines) and are deprived of education (UN 2016b). Although not present at the ASM areas that were assessed, child labor in the ASM sector is a recognized problem.

1.2.4 Corporate Requirements and Standards

Newmont Suriname is subject to the corporate requirements of its parent company Newmont Mining Corporation, which includes both environmental and social standards for all of the Newmont operations. One of the key considerations for any new project is community consultation.

Newmont has established corporate standards that outline the company's approach to its design and operations of aspects of its business that impact people and the environment and set out minimum requirements such that human health and the environment are protected. The Corporate standards are available here: http://www.newmont.com/about-us/governance-and-ethics/policies-and-standards/default.aspx. The standards address such aspects as:

- Air Emissions Management;
- Water Management;
- Waste Management;
- Waste Rock and Ore Management;
- Hazardous Materials Management;
- Closure and Reclamation Planning;
- Biodiversity;
- Stakeholder Relationship Management;
- Social Baseline and Impact Assessment;
- Local Procurement and Employment;
- Indigenous Peoples;
- Human Rights;
- Land Acquisition and Involuntary Resettlement ;
- Cultural Resources Management; and
- Community Investment and Development.

These standards are incorporated into the Project design, environmental and social management systems and monitoring programs to ensure that potential impacts are appropriately managed and mitigated.

1.3 Engagement Summary

Participation in engagement activities is an integral part of the ESIA process to ensure that the views, knowledge, and concerns of Project stakeholders are taken into account in the assessment of the potential impacts as well as in Project decisions. Stakeholder engagement activities occurred throughout the course of the ESIA with strong focus on local communities. Newmont supports an engagement approach that is tailored to each community and stakeholder group, which includes ongoing communications and distribution of project-related information.

The Sabajo stakeholder engagement program is based on:

- Newmont Mining Corporation Social Responsibility Standards (2014). http://www.newmont.com/about-us/governance-and-ethics/policies-and-standards/default.aspx
- International Council on Mining & Metals - Position Statement on Indigenous Peoples and Mining (2013). https://www.icmm.com/en-gb/members/member-commitments/position-statements

The consultation process therefore included the following:

- stakeholder identification and analysis;
- developing, with affected stakeholders,consultation activities that are culturally appropriate to each group;
- setting the program for consultation to ensure timely notification of consultation activities and to tie in with key stages in the ESIA process;
- information disclosure, specifically the provision of timely and meaningful information that is accessible to all stakeholders;
- continuous review of the approach and mechanisms for obtaining stakeholder feedback on the information disclosed; and
- receiving and documenting feedback for inclusion in the ESIA.

The fundamental principle of public consultation is for stakeholders to understand and have meaningful input to the scope and design of the Project. The Project's engagement approach complies with Newmont's Standards on Stakeholder Relationship Management and Indigenous Peoples and is consistent with the principles of Free, Prior and Informed Consent. Ultimately, the program was designed to gain agreement from potentially impacted stakeholders on the scope and approach of the ESIA process. The Project's engagements strive to provide opportunities to consult with concerned members of the public and actively seek feedback regarding the project design, potential environmental and socioeconomic effects, planned mitigation measures and monitoring plans for the various phases of the Project. All quiries are documented and all efforts are made to respond in a timely manner.

A Public Consultation and Disclosure Plan was developed for the Project and is attached as Appendix 1A to this document. This document shows that project specific community and regulatory engagement activities were first initiated by Newmont Suriname and then carried out collaboratively with the ESIA consultations throughout the ESIA process. A combination of various types of consultation techniques were used, which included face to face meetings, focus group discussions, and public meetings.

When the stakeholder engagement requirements of NIMOS and Newmont were combined, the following six rounds of engagement were planned and executed.

1.3.1 Pre-Scoping Consultation

The pre-scoping engagement activities aimed primarily to identify Project stakeholders, initiate communication with communities, present preliminary information on the Project, find out from communities how they wish to be consulted, and collect requirements related to the development of the Project. These meetings served as an open forum for communities and other stakeholders to ask questions and voice concerns on the proposed Project. Consultation occurred from October 2016 to May 2017, and a summary of the corresponding engagement activities is included in Appendix 1A.

1.3.2 Scoping Consultation

Scoping engagement consisted of a series of formal meetings included introducing the Project, the overall ESIA process, and gathering valuable information from communities and regulatory agencies (e.g., NIMOS). Four public meeting were held in four different languages to make information as easily accessible as possible. The information received from all Project stakeholders was captured in the Project ToR, and ultimately fed into the impacts that are being assessed in this ESIA document. Scoping phase consultation occurred in June 2017, and a summary of the corresponding engagement activities is included in Appendix 1A.

Following the Scoping meetings, the Project ToR was made public via the Newmont website: http://www.newmont.com/operations-and-projects/south-america/merian-suriname/reports/default.aspx.

In addition a newspaper ad was posted to remind stakeholders about the opportunity to provide feedback on the Scoping Report. To ensure that stakeholders with reduced access to internet also had the opportunity to provide additional input into the Project ToR, the Newmont SR team conducted follow up discussions by phone with key community stakeholders both to ascertain whether they felt adequately informed as well as to remind them of the possibility to comment on the Project ToR.

1.3.3 Follow-up to Scoping and Baseline Methodology Validation

The engagement meetings for validation of baseline methodologies aimed to present, discuss and gain community approval for the methods that were proposed for social baseline information collection for the Project. Nominated local research consultants for each of the baseline studies presented their proposed approach to communities in public meetings. These meetings focused on providing an open forum for communities to contribute their views on how social baseline data could be collected, on what topics and on logistics such as preferred times of the day for data collection, etc. The objective was to ensure the ESIA team is collecting the information that is most important to community stakeholders in an acceptable manner, as well as to explain data requirements to build an effective ESIA, consistent with NIMOS requirements, international best practice, and Newmont's social and environmental standards. Consultation occurred from June to September 2017, and a summary of the corresponding engagement activities is included in Appendix 1A. During all meetings, local stakeholders approved the proposed approach.

1.3.4 Baseline Results Validation

Baseline results were disclosed through engagement meetings in accordance with Newmont's commitment to provide the public with timely and meaningful information. These meetings included community presentations on the preliminary results of the baseline studies. The aim of these engagement activities was to allow communities where data had been collected to have the opportunity to review and comment on the results, in order to enable verification of the factual accuracy of findings, and also to allow stakeholders to absorb information in an easily digestible format and well ahead of the formal disclosure meetings. Consultation occurred from October to November 2017, and a summary of the corresponding engagement activities is included in Appendix 1A. The meetings were conducted by Golder and local study consultants to ensure the independent nature of the process.

1.3.5 Impact Assessment and Mitigation Validation

After a draft ESIA (this document) is complete, Engagement will be held to discuss proposed mitigation measures, and obtain input from stakeholders.

1.3.6 Formal Engagement on Completed Impact Assessment

Following ESIA completion, a full draft ESIA and a plain-language summary of the ESIA will be made publicly available. Engagement meetings will be held with communities and regulatory agencies to disclose impact assessment results for the Project. The aim of these consultation meetings is to achieve both understanding of the impacts and agreement of mitigations. Based on the comments received from NIMOS, local communities, and other stakeholders, Golder will revise the draft ESIA and complete a Final ESIA that addresses all received comments. Consultation relating to the Draft ESIA disclosure is planned to occur in March 2018 and again in May 2018 for further follow up. A summary of the planned engagement activities is included in Appendix 1A.

1.4 Acknowledgments and Contacts

This ESIA could not have been completed without the involvement and contributions of stakeholders in Paramaribo and in the Project study areas, including:

- The Kawina peoples who participated in our engagement and baseline study sessions;
- The peoples of the Carolina road communities, as listed in Section 1.3;
- The residents of communities in the Brokopondo area, including all of those noted in the engagement summary in Section 1.3;
- The Project team at NIMOS;
- The small scale miners in the area of the Project; and
- Numerous employees of Newmont Suriname.

The ESIA owes a debt of gratitude to all of these contributors.

This ESIA has been completed by a consulting team external to Newmont. The assessment team has extensive mining, natural resources assessment, and international ESIA experience combined with strong local experience provided by several well-qualified local experts. Table 1-4 identifies the key team members (external to Newmont), including the local environmental and social experts.

Table 1-4 ESIA Core Team

Name	Company	Role and Specialty Study	Years of Experience	Education
PROJECT MANAGEMENT TEAM				
Mike Brown	Golder Associates	Project Director	42 years	MBA, ME Civil Engineering, Peng
Greg Jones	Golder Associates	Project Manager	20 years	MEM Environmental Management, PMP
Mike Meyer	Meyer EPS	Senior advisor	25	PhD.
Mark Jaferllari	Golder Associates	Project Coordinator	5 years	B.Sc. Biotechnology and Chemistry, PMP
SOCIO-ECONOMICS, HEALTH AND HUMAN RIGHTS TEAM				
Linda Havers	Golder Associates	Socio-Economic and TLU Lead	>23 years	MA Anthropology
Luc Zandvliet	Triple R Alliance	Free, Prior and Informed Consent Specialist	>25 years	MA Humanitarian Assistance, MA Personnel Management and Economics
Susan Joyce	On Common Ground	Human Rights Lead	22 years	M.Sc., Development Sociology
Andrew Mason	Golder Associates	Cultural Heritage Lead	24 years	MA Anthropology
Francesca Viliani	International SOS	Health Assessment Lead	>20 years	MSc Humanitarian Affairs, MPH, Master in Public Health in Developing Countries
Kirtie Algoe	Institute for Graduate Studies & Research (Anton de Kom University)	Socio-Economic Baseline Expert	4 years	MSc Development and Policy, PhD Pending, Social Sciences
Mirella Nankoe	Institute for Graduate Studies & Research (Anton de Kom University)	Socio-Economic Baseline Expert	12 years	MSc, Cultural anthropology and sociology, PhD pending, Social change and development
Celine Duijves	Social Solutions	Cultural Resources and Small Scale Mining Specialist	>10 years	MSc Cultural Anthropology, MSc International Health
Marieke Heemskerk	Social Solutions	Cultural Resources and Small Scale Mining Specialist	>20 years	PhD Cultural Anthropology, MA History
Cheryl White	ILACO (Contractor)	Anthropologist	>10 years	MA and PhD, Anthropology
Josee Artist	Independent	Historical Narrative Lead	>20 years	MA in Cultural Anthropology / Sociology
Florence Rijsdijk	Independent	Historical Narrative Expert	>30 years	Doctoral Diploma, Business Economics
Hans Lim A Po	Lim A Po Law Firm	Legal review expert	>25 years	Degree in Civil Law; post graduate Master in International and Comparative Law
AIR AND NOISE TEAM				
Chris Madland	Golder Associates	Air and Climate Lead	>17 years	BSc Environmental Science
Andrew Faszer	Golder Associates	Noise Lead	20 years	PhD Engineering, PEng
Shareen Koenjbiharie	ILACO	Air, Noise, Traffic and Soils field support	9 years	BSc Environmental Technology

Table 1-4 ESIA Core Team

Name	Company	Role and Specialty Study	Years of Experience	Education
WATER TEAM				
Cheryl Ross	Golder Associates	Water Lead	>18 years	MSc Hydrogeology
Jay Pietraszek	Golder Associates	Surface Water Specialist	>12 years	MSc Watershed Science
David Banton	Golder Associates	Groundwater Specialist	36 years	MSc Hydrogeology
Derek Holom	Golder Associates	Groundwater Specialist	>10 years	MSc Hydrology
Rens Verburg	Golder Associates	Geochemistry Specialist	>25 years	PhD Geochemistry and Mineralogy, PGeo
BIODIVERSITY AND SOILS TEAM				
Jared Hardner	Hardner Gullison Associates	Biodiversity Lead	25 years	MSc Forest Science
Ted Gullison	Hardner Gullison Associates	Biodiversity Lead	25 years	PhD Ecology and Evolutionary Biology
Ravindra Patandin	ILACO	Project Manager – baseline components	>20 years	MSc Civil Engineering
Dirk Noordam	Independent	Soils Lead	>35 years	MSc Tropical Soil Science
Rutger De Wolf	Environmental Services & Support, Suriname	Forestry and Vegetation	5 years	M.S., Forestry
Bart De Dijn	EnvironmentalServices & Support, Suriname	Wildlife and Vegetation	>20 years	MSc., Zoology
Jan Mol	Zoology and biodiversity (Consultant – Anton de Kom University of Suriname)	Zoology and biodiversity	>25 years	PhD., Biology
Paul Ouboter	Zoology and biodiversity (Consultant – University of Suriname)	Zoology and biodiversity	>30 years	PhD., Biology
Dennis O'Leary	Golder Associates	Soils, Terrain, Seismicity and Hazards Specialist	>35 years	BA Physical Geography

ILACO = ILACO Suriname N.V.; > = greater than.

The key contacts for Newmont Suriname's Project team are listed in Table 1-5.

Table 1-5 Newmont Contacts

Key Contact Name	Key Contact Position	Contact Information
Johan Van Huyssteen	General Manager, Newmont Suriname	van 't Hogerhuysstraat 15, 4th (fourth) floor Paramaribo, Suriname S.A. Phone: (+597) 568760
Albert Ramdin	Senior Director, Government Relations, External Relations, and Social responsibility	van 't Hogerhuysstraat 15, 4th (fourth) floor Paramaribo, Suriname S.A. Phone: (+597) 568760
Cynthia Parnow	Senior ESIA Manager	Newmont Mining Corporation, 6363 South Fiddler's Green Circle, Suite 800, Greenwood Village, CO, USA Phone: (+303) 863-7114

2 PROJECT DESCRIPTION

This chapter describes the construction, operations and closure of the Sabajo Project (also referred to as the Project).

2.1 General Project Description

The Project is located in the northeastern part of Suriname, approximately 100 kilometers (km) south of Paramaribo and can be accessed by either the Afobaka Road or the Carolina Road (Map 1-1). The Project site is located in the Commewijne watershed in a largely undeveloped part of Suriname. The nearest community, approximately 37 km southwest the Project site by road, occurs at Afobaka Centrum, an administrative and business centre with a population of less than 300 people. The area immediately surrounding the Project has been modified to a significant degree by timber cutting and artisanal and small scale mining (ASM).

The proposed Project consists of the development of a gold mine with planned production of approximately 613,000 ounces (oz) of gold with removal of 140 million tonnes of waste rock. Mining will take place over 10 years and all ore will be processed at the Merian Facility located approximately 30 km to the east (Map 1-1). Exploration at the site is ongoing and will continue during operations. Additional deposits have been identified, including the Santa Barbara and Margo deposits located north and east, respectively of the Project. As there will be no processing at the site, the construction and operation of the Project requires the development of minimal supporting infrastructure, including waste rock facilities (WRFs), an ore stockpile, a camp, offices and a maintenance shop, and an approximately 30 km haul road connecting the Project with the Merian Gold Mine (Merian mine).

The description of the Project hereafter will be divided into three main components, as outlined below:

1. ***Sabajo Mine Site***- this is the operational mine area (Map 2-1) incorporating:

- six open pits (named Cassador (or “Pit 1”) and Pits 2-6) in the Sabajo Area;
- one open pit in the Margo Area;
- one open pit in the Santa Barbara Area;
- one ore stockpile in the Sabajo Area;
- two WRFs in the Sabajo Area;
- one WRF each for Margo and Santa Barbara;
- a diesel generating station (1 megawatt [MWe]);
- an effluent treatment plant (ETP) to manage seepage from the WRFs;
- one minor borrow area;
- an accommodation camp and maintenance shops;
- temporary fuel storage;
- sewage water treatment plant (SWTP);
- haul roads and other access roads; and
- landfill and waste management facilities.

2. ***Sabajo-Merian Haul Road*** – The Haul Road (Map 2-2) includes:

An approximately 30 km long and 14 meter (m) wide road to haul ore and supplies to and from the Merian mine. For safety reasons, along some of its length this road will also have a 30 m cleared buffer to each side. The road will include three bridges over creeks.

3. ***Transportation Corridor*** – The transportation corridor (Map 1-1) includes:

- use of approximately 137 km of the existing public Carolina Road from Paramaribo to Sabajo (approximately 60 km of the existing road is unpaved and will need some upgrades and maintenance); and
- use of the existing public Afobaka Road from Paramaribo to Sabajo (approximately 37 km, known as the Musa Road, is unpaved and will need some upgrades and maintenance).

Construction materials and operational supplies will mostly be imported via the Nieuwe Haven port in Paramaribo or the port in Paranam. During operations, supplies for the Project will come from the Merian mine. The final product, gold ore, will be transported from the Merian mine site's airstrip via airplane to the international airport for export to an accredited gold refinery.

The major mine components are presented in Map 2-1. The total disturbed areas of the main mine components are presented in Table 2-1.

Table 2-1 Summary of Total Disturbed Area by Major Mine Components

Mine Component	Total Area (approximate ha)
Pits	126
Waste rock facilities (WRFs)	343
Accommodation camps / staging areas	53
Haul roads (other than Sabajo-Merian Haul Road)	67
Ore stockpile	21
Water management structures (Ponds, berms)	55
Sabajo-Merian Haul Road	221
Total hectares direct disturbance (does not include fly rock buffer)	**886**
Buffer for fly rock (500 m contingency around pits)	665
Total hectares including fly rock buffer	**1,551**

ha = hectare; m = meter.

The mine life has been divided into four phases: construction, operations, closure and post-closure. Construction includes all activities required to build the mine. Operation is the phase during which the mine is transporting ore to the Merian Mill. Closure describes the phase after production during which Newmont Suriname will stabilize the site so that it can be left in a sustainable state long-term. Post closure is the phase during which Newmont Suriname no longer has responsibility of maintaining or managing the site.

Activities during these phases are summarized in the generalized Mine Schedule presented in Table 2-2. Newmont reserves the right to accelerate the indicated activities if so required for the operations of the company.

Table 2-2 Generalized Mine Schedule

Year	Activities
Early works	■ construction and improvements to access roads; and ■ commercial tree harvesting
Construction: January 2024 - December 2026	■ completion of the Camp; ■ construction of landfill; ■ construction of sediment dams, and site drainage features (ditches, ponds, site diversion channels, re-grading); construction of the main haul road between Sabajo and the Merian mine; ■ stripping of Cassador Pit area and stockpiling of saprolitic ore; and ■ construction of the water treatment facilities, power plant and supporting infrastructure.
Operations	
Years 2 to 4	■ mining of the Cassador Pit and Pit 3; and ■ establishment of North WRF.
Years 5 to 6	■ mining at Cassador Pit and Pit 5; ■ continued operation of North WRF; and ■ construction of the South WRF.
Years 7 to 9	■ mining at Cassador Pit and Pit 6; ■ continued operation of North and South WRF; ■ mining of the Santa Barbara Pit; and ■ operation of the Santa Barbara WRF.
Years 9 to 10	■ mining at Cassador Pit and Pits 2 and 4; ■ operation of North and South WRFs; ■ mining of the Margo Pit; ■ operation of the Margo WRF; and ■ beginning of closure, concurrent reclamation of WRFs.
Closure	■ capping of North, South, Margo and Santa Barbara WRFs; ■ re-grading of benches on WRFs if necessary; ■ re-vegetation of WRFs and other disturbed areas; and ■ decommissioning of buildings.

WRF = waste rock facility.

It should be noted that the following project description is based on GMining's preliminary assessment and the design elements may be subject to further optimization. Moreover, details on the design of mine infrastructure, specifications on equipment or machinery, and logistical plans for the Project are being revised and analyzed by the team.

2.2 Early Works

Exploration at the Sabajo site has been underway since 2009. An exploration camp and access roads have been constructed. The Exploration Camp is located 2 km from the mine site and will be gradually eliminated during early works as construction of a new Operations Camp progresses. The Operations Camp will cover approximately 53 hectares (ha) and eventually accommodate a maximum of 300 workers. The Exploration Camp will be used for workers during the early stages of construction. One of the first construction activities will be to commence building the Operations Camp that will serve to house the workers required during construction and will be transitioned to accommodate workers during operations.

Domestic water (e.g., that used for showering, laundry, dish-washing, etc., but excluding potable water) for the Operations Camp will be primarily sourced from the surface water streams. Another possible source includes groundwater wells. Water will be treated on-site to meet domestic water standards as necessary. Bottled water or suitably treated water will be used for potable water supply. The domestic water treatment plant will be a pre-fabricated unit and will treat water to meet the International Finance Corporation (IFC) Domestic water demand at the operations is expected to be approximately 50 cubic meters (m^3)/day.

Sewage will be treated by a pre-fabricated rotary-biological treatment system and discharged to the upper-most reaches of Creek 1 (Map 2-1), which feeds into the Kleine Commewijne River. The SWTP will be designed with a 50 m^3/day capacity. Treatment will meet discharge standards required by the IFC Environmental Health and Safety (EHS) discharge standards (IFC 2007). Solid waste generated at camp will be managed according to the Project's Waste Management Plan, which will be finalized prior to construction, and will be based on international and Newmont standards. Power will be generated by diesel generators at the beginning of early works construction, with a capacity of 600 kilowatt hours (kWh).

A small landfill within the footprint of the Southern WRF will be constructed and operated to manage domestic, non-hazardous waste from the camp and Early Works activities.

During Early Works, improvements to the Carolina Road or Afobaka Road will be completed, dependant on the access route chosen. Improvements to the road will include some clearing and grubbing of the right-of-way, installation of permanent culverts to manage runoff and the construction of a road bed suitable for the transport of heavy equipment required to construct the mine. Improvements to the Carolina Road or the parts of the Afobaka Road that are unpaved also include some clearing of vegetation to improve lines of sight and the safety of road travel for all users, potentially making a slightly wider right-of-way and surfacing of the road with laterite.

The potential impacts that will continue beyond the Early Works Phase are discussed in Impact Assessment Chapters of this Environmental and Social Impact Assessment (ESIA).

2.3 Mine Site

The proposed mine site will comprise eight open pits: Cassador, Pits 2-6 (Map 2-1) in the main Sabajo Area, and the Santa Barbara and Margo pits, located north and east, respectively from the main Sabajo Area; a processing plant; WRFs, a fuel tank farm, power generation plant; water treatment facilities; maintenance facilities; offices and worker accommodations. The mine pits and WRFs will be located in the Commewijne River watershed. Map 2-1 shows the location of the site's major components. The disturbance area includes temporary areas such as staging and laydown areas.

Mine Pits

Over the life of the Project, the mine will produce approximately 27 million tonnes of ore and 140 million tonnes of waste rock. Cassador pit will be opened first with Pit 3 opened at the end of Year 1 and operations beginning at Pit 3 in Year 2. Ultimately, the 8 pits are expected to have a maximum collective surface area of approximately 93 ha. Cassador will be the largest pit and will eventually expand over approximately 66 ha, Pits 2-6 will grow to an estimated 26 ha. Margo and Santa Barbara pits will have a maximum disturbance area of 5 ha and 28 ha, respectively. Cassador is the deepest pit at approximately 350 m. The smaller pits range in depth from 40 to 150 m.

All mining at the Project will be open-pit mining performed using a truck and shovel operation. The Sabajo site is generally composed of a thick layer of saprolite underlain by a transition layer of saprock overlying more competent bedrock (unweathered rock), which is generally referred to as fresh rock. The differences in the rock properties affect the mining methods and rates. The saprolite is a residual soil that is formed in place by chemical weathering of a parent rock. Saprolite is common in tropical environments and can be found up to depths of 100 m in the Project area. It is generally soft and can be mined without blasting although approximately 25 percent (%) of this softer saprolitic ore will be hard enough to require blasting. Blasting will be required for fresh rock and some of the harder saprolite. The hardness of the rock and ore increases through the saprock transition zone.

Blasting will be carried out using a blend consisting of 70% emulsion and 30% ammonium nitrate fuel oil to reflect the moisture present in the holes and to ensure sufficient shock energy for fragmentation in relatively low bench heights. Blasting will begin near the end of Year 2.

The pits will be constructed with a maximum average rate of vertical advance by pit stage of 14 by 5 m benches per annum for the first 6 to 7 years and a maximum of 20 to 25 by 5 m benches in last 4 to 5 years. This rate is considered achievable due to the planning of blasting two benches together in many instances. Pit slopes will be gradual through the softer rock and steepen in the harder fresh rock. A series of generic stability models were analyzed to determine slope heights and angles to achieve a minimum Factor of Safety of 1.2. For each model, both total stress analyses and effective stress analysis were performed to evaluate stability of saprolite slopes under the short-term condition and end-of-mining condition. The bench geometry is specific to the weathering profile and slope height. Final bench heights are 10 m in all weathering units. The design bench face angle (BFA) is 63° in saprolite, 68° in saprock and 80° in fresh rock. The inter ramp slope angles (IRA) recommended for the feasibility-level design of the Sabajo 2 Pit are based on the limit equilibrium analyses. Identical IRA angles were applied for the other pits. The catch bench widths were adjusted to achieve the recommended IRA required to meet minimum factor of safety criterion. The pit geometry recommendations are summarized in Table 2-3.

Table 2-3 Slope Design Configurations Summary

Material	Slope Height (m)	Bench Face Angle (BFA; deg.)	Bench Width (m)	Vertical Bench Height (m)	Inter Ramp Angle (deg.)
Saprolite	0-40	63	12.25	10	30
	40-80	63	14.55	10	27
	80-120	63	17.40	10	24
Saprock	<40 m	68	6.00	10	45
Fresh Rock	<300 m	80	6.50	10	50

Source: GMining 2017.

m = meter; deg. = degree; < = less than.

2.3.1 Waste Rock Disposal Facilities

Waste rock facility (WRF) locations (Map 2-1) have been selected to minimize truck travel distances from pits to the WRFs. WRFs heights have been restricted so as to not exceed the surrounding regional topography and to be geotechnically stable. The phasing of the opening and closing of the WRFs is dependent on the sequencing of the pit development. Pit production will begin at Cassador and the first WRF to be established will be the North WRF.

The South WRF will open in the third year of production. The Santa Barbara and Margo WRFs will become active in Years 10 and 11 respectively once these pits are mined.

Waste rock from Cassador Pit will be stored in the North WRF for the first seven years of production, after which waste rock will be diverted to the South WRF for the remaining mine life. The North WRF will consist primarily made of saprolite. The southern part of the South WRF will store potentially acid generating (PAG) waste rock.

The yearly dump plan by material type for each pit is presented in Table 2-4. The estimated WRF capacity is presented in Table 2-5.

Table 2-4 Yearly Waste Rock Plan by Material Type for each Pit (million tonnes)

Waste Tonnage	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Pit 1	10,575	16,711	18,033	18,174	17,800	17,408	14,157	9,947	3,187	127
Pit 2	-	-	-	-	-	-	2,400	4,639	737	-
Pit 3	808	1,292	71	-	-	-	-	-	-	-
Pit 4	-	-	-	-	-	-	-	-	3,715	596
Pit 5	-	-	-	244	445	-	-	-	-	-
Pit 6	-	-	-	-	-	327	-	-	-	-
Margo	-	-	-	-	-	-	-	-	-	TBD
Santa Barbara	-	-	-	-	-	-	-	-	-	TBD
TOTAL	**11,383**	**18,003**	**18,104**	**18,419**	**18,245**	**17,735**	**16,557**	**14,586**	**7,640**	**722**
Rock Type										
Saprolite	11,352	15,580	6,686	963	504	327	2,400	2,790	3,715	429
Transition Rock	32	1,613	7,104	3,372	352	-	-	1,114	0	145
Fresh Rock	-	810	4,314	14,084	17,389	17,408	14,157	10,681	3,924	148
TOTAL	**11,383**	**18,003**	**18,104**	**18,419**	**18,245**	**17,735**	**16,557**	**14,586**	**7,640**	**722**

TBD = to be determined; - = none.

Table 2-5 Estimated Waste Rock Facility Capacity

Waste Rock Facility	Elevation (m.a.g.s)	Volume (Mm^3)	Million Tonnes
North	640	52	94
South	640	144	223
Margo	640	89	145
Santa Barbara	640	43	71
Total	N/A	420	678

Mm^3 = million cubic meters; N/A = not applicable.

Waste material will be deposited at all WRFs in 10 to 20 m benches. The benches may vary in height in order to facilitate drainage toward the working crest while avoiding ponding of water on top of the WRF. The benches will be built to facilitate drainage toward the working crest of the WRF and avoid ponding at the top of the WRF. At the WRF crests the bench height will be 10 to 12 m. Depending on operational requirements, the WRFs may be operated on several benches at different elevations. WRFs will be started at the higher ground elevations to avoid pooling of runoff or seepage at the toe of the facilities.

Waste rock has been physically and geochemically characterized as part of the ESIA process. Static and kinetic leach testing has indicated a potential for leaching of metals and metalloids, specifically arsenic, antimony, cobalt and nickel and potentially thallium, under neutral pH conditions.

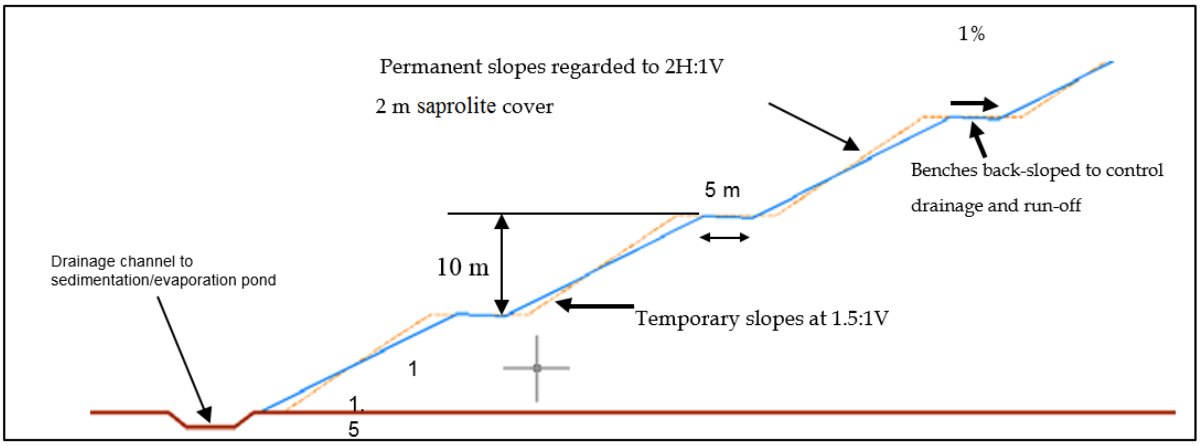
Additional characterization will be completed during final design and operations. Characterization has included analysis of Acid Rock Drainage (ARD) potential as well as the entrainment of other pollutants, such as nitrates due to blasting. The overall ARD potential of the waste rock and tailings due to sulfide oxidation is considered to be moderate. Additional testing will be completed and the water quality model will be updated during the final design phase of the Project.

Concurrent reclamation activities shall be conducted as areas of the waste disposal facility become available. Once the WRF bench has reached its final area limit, interim bench slopes of 1.5 H: 1V will be re-graded to a slope of 2H: 1V with 5 m benches sloped back to minimize erosion. The overall slope will be 2.5H: 1V. The slopes will be re-vegetated to limit erosive energy. Growth media will be used to cover the WRF faces to facilitate re-vegetation. Growth media includes saprolite and grubbed or felled vegetation. Once the growth media is placed, the available WRF face will be re-vegetated through hydro-seeding or other methods. The focus will be to return the vegetation communities as quickly as possible to a native plant community. Reclamation of these areas shall be undertaken as areas become available.

The Closure Plan (Provided in Volume B of this ESIA) requires disturbed areas to be re-contoured to final landform and re-vegetated within two years of becoming available.

Example cross-sections of the WRF facilities are provided in Figure 2-1.

Figure 2-1 Example Cross-Sections of Waste Rock Disposal Areas



H = horizontal; V = vertical; m = meter; % = percent.

2.3.2 Mining Equipment

A summary of the estimated mining fleet Is provided in Table 2-6. The manufacturer designations are shown for descriptive purposes only. Equipment from other manufacturers could be used in actual operation. All vehicles will be diesel powered.

Table 2-6 Mining Equipment

Mine Equipment	Max
Emulsion Truck	3
Shovel Sabajo - EX3600-6 (22 m^3)	2
Haul Truck - 785D	10
Dozer - D6	1
Dozer - D9	3
Grader - M16	3
Water Truck - 740B	2
Wheel Dozer - 834H	1
Loader - 980H	1
Compactor - CS-533E	1
Excavator (49 t)	1
Fuel/Lube Truck	2
Production Drill	4
Ore Loader - 992	1
Ore Haulage Truck	7
Total	**42**

m^3 = cubic meter; t = ton.

2.3.3 Labor Force

The workforce will be housed at the site in worker accommodations during both construction and operations. Construction is anticipated to start in Q3 2022 with an estimated workforce of approximately 100 Surinamese employees. The total construction force will increase as construction progresses to reach a maximum of 300 people (including mine operations and exploration groups). Of the 300 workers, all are expected to be Surinamese nationals. Once the mine begins operations, it will employ approximately 140-170 employees (with approximately half on site at any given time) and will operate 24-hours/day.

Recruitment and training for positions for operations will be based on a similar approach (i.e., priority placed on stakeholder communities).

The construction workforce will work on a fourteen days on and seven days off roster during pre-production, working 12 hour shifts. Operations staff will operate on a fourteen day and seven day rotation, working 12 hour shifts (day and night shifts will exist). Technical staff will work the same 14:7 rotation and 12 hour shifts.

Typical jobs during construction will include:

- helpers for all trades;
- camp support;
- bush cutters;
- carpenters;
- pipefitters;
- electrical technicians;

- industrial mechanics;
- industrial welders;
- riggers;
- crane operators; and
- administrative staff.

During operations, a workforce of 140 to 150 workers is estimated. An overview of general job types is as follows:

- administration;
- information technology;
- engineers;
- geologists;
- health and safety;
- environmental;
- community relations;
- surface support;
- mine operations;
- earthworks;
- mine maintenance;
- camp support;
- drill and blasting; and
- security.

2.4 Mine Infrastructure

2.4.1 Power Supply

The electrical power at Sabajo will be generated on site by an arrangement of two or three Caterpillar mobile generators C-15 and C-18 models (or similar). The arrangement will be designed to cover a 1 MW consumption and have enough standby capacity to cover in case one of the generators in the power arrangement requires maintenance. All generators will have a dual element air cleaner and silencer in order to reduce noise and emissions.

2.4.2 Borrow Sites

Borrow sites for aggregate material, laterite and sand have been identified both within the Right of Exploitation and beyond at current third-party operations. There is potential to collect the sands and/or gravels found in these piles using an excavator and dump truck operation, washing and screening the material for use in the making of lower-grade concrete required for the construction of the camp and other ancillary mine facilities and possibly dam drainage filter material.

Rock fill and the remainder of the sand requirements will be sourced from third- party quarries.

Table 2-7 lists the construction materials required by type.

Table 2-7 Construction Material Required during Pre-Production Phase

Type	Gradation (mm)	Volume (m^3)
Riprap - Plating + Sediment Ponds	-	200,000
Engineering Backfill -Sedimentation Ponds	0 to 50	1,852,168
Sand – For Sedimentation Ponds	75×10^{-6} to 4.75	200,000
Bedding	0 to 25	2,000
Aggregate	4.75 to 25	43,905

mm = millimeter; m^3 = cubic meter; - = none.

2.4.3 Fuel Storage

There will be one on-site fuel storage locations during operations. The site will be dedicated to diesel fuel with two 100 m^3 storage tanks. The diesel will be sourced from Staatsolie in Paramaribo or imported from other suppliers and delivered to the site by trucks. It is estimated that the maximum daily consumption of the diesel plant and the mining equipment will be approximately 42 m^3 per day. In order to maintain the storage reserve in the tanks, ten 30 m^3 tankers will need to be unloaded on site on a weekly basis which is sufficient for the power generation necessary at the site and for the diesel to run the mining equipment and other support vehicles.

The unloading station of the generator site will be equipped with pumps to handle the following:

- delivery of diesel fuel;
- delivery of fresh lube oil;
- loading of waste lube oil; and
- loading of sludge.

The tank farm will be replenished daily and will be designed to meet Newmont's standards specific to hydrocarbon management, including the following:

- Hydrocarbon storage tanks shall be designed and constructed above ground (i.e., not buried).
- Hydrocarbon storage facilities (tanks and piping) shall have a system to detect leaks and recover product (e.g., visual inspections, active leak detection system, annual integrity testing).
- Bulk hydrocarbon storage and transfer systems, including temporary systems, shall have a secondary containment. Where distribution piping is above ground and visible for inspection secondary containment is not required; however, the distribution piping shall be inspected and documented routinely to verify its integrity.
- The capacity of secondary containment structures shall be capable of containing a minimum of 110% of the volume of the largest tank in the containment area.
- Secondary containment shall have a typical water permeability equivalent to untreated concrete.
- Bulk tanks shall be equipped with engineered overfill/overpressure protection devices.
- Hydrocarbon use, transfer, distribution, and storage facilities shall be designed to control meteoric water, including drainage within and around containment areas.

- The areas around fuel delivery pumps and vehicle refuelling points shall be protected against spills and releases using containment and collection systems.

During pre-production fuel with be stored in smaller double-hulled tanks on paved areas designed with secondary containment.

2.4.4 Operations Camp

The mine site will include worker accommodations at the camp location (Map 2-1) with a capacity of up to 300 people. The camp will also include ancillary facilities such as kitchen and dining hall, laundry, showers and recreation or general use areas. The design of the accommodations will meet or exceed international standards (IFC and EBRD 2009).

2.4.5 Waste Management

The mine operations are expected to generate the following waste streams during construction:

- construction waste:
  - Pallets and other wood packaging materials;
  - Shipping packaging;
  - Discarded dry, non-hazardous materials;
  - Scrap metal; and
  - Scrap lumber.
- discarded office supplies;
- discarded food containers;
- putrescible food waste;
- other “household” waste;
- condemned vehicles;
- medical waste;
- solid waste: domestic solid waste or similar industrial waste (non- hazardous and hazardous) including tires, broken and used parts, unused raw concrete, reagent bags, scrap steel; and
- liquid waste: un-used chemical waste, solvents, used oil, sewage sludge and supernatant water, and waste water from maintenance shops (non-hazardous and hazardous).

Waste management will follow a hierarchy with the emphasis placed on reuse and recycling. A Waste Management Plan has been prepared to identify what material can be reused and recycled (Volume B, Environmental and Social Monitoring and Management Plan (ESMMP) for the Sabajo Project). Currently material identified for reuse include: tires (recapping) steel and wood waste if useful to location communities. Materials identified for recycling include: waste lubricants and filters, broken parts, used air filters etc., condemned vehicles, typical household recyclables, batteries, and scrap metals.

Non-Hazardous Waste

Non-hazardous waste for the Project during construction is primarily associated with packing material and surplus construction materials. The primary material types are wood (pallets), scrap steel, and cardboard. Smaller volumes of other non-hazardous waste, such as paper and organic food waste, will also be generated. As much as possible, waste will be segregated to facilitate recycling. A reputable, licensed contractor will be hired to handle final disposal of recyclable and saleable waste. The waste storage area will be constructed from impermeable materials. Waste processing and storage areas will be constructed with curbs to prevent runoff to permeable areas. Runoff and leachate will be collected and treated as needed prior to discharge to the environment. Materials that are currently recycled at the Project, includes scrap steel and other metals (aluminum, copper), plastic bottles, and specific shipping containers that can be returned to the supplier. These practices will continue into construction and operations to minimize the non-hazardous waste stream that must be managed.

For non-hazardous materials that cannot be recycled or returned to the suppliers, one or more landfills will be developed to manage the waste. The landfills will be created within the WRF areas and will be constructed and operated to be consistent with best practices, including those of the IFC. This includes aspects such as landfill siting, engineering to minimize infiltration and facilitate leachate collection if needed, tracking of waste streams, and monitoring run-off and leachate generation.

Materials that may be landfilled include tires, broken parts that cannot be recycled, typical non-recyclable waste such as foam, plastic packaging, used equipment and cloth material, un-useable wood materials, and unused concrete.

Oils and lubricants will be reused or otherwise returned to the supplier for recycling or sent to a reputable recycling facility through a trading company authorized to handle recyclable materials. Hydrocarbon-stained soil will be treated on-site using a bio-pile. A bio-pile is similar to conventional land- farming but is designed for areas that receive high amounts of precipitation, such as the Sabajo site. Aerobic microbial activity that breaks down the hydrocarbon contamination is stimulated by aerating the soil by increase air flow through the pile through slotted or perforated piping. The pile will be constructed on a bunded concrete pad and covered to reduce rainfall onto the pile.

Hazardous Waste

Hazardous material will not be disposed in the site landfill. Hazardous waste generated during the construction and operations will be temporarily stored on site and then disposed of at an approved facility by a licensed contractor. Designated facilities used for the collection and temporary on-site storage of hazardous waste will include fencing, signage, roofing, lighting, and secondary containment.

Existing management protocols are in place for materials including:

- medical waste;
- used batteries;
- used or residual oil;
- used oil filters;
- hydrocarbon impregnated materials;
- light bulbs, fluorescent tubes, and vehicle light lamps; and
- printer cartridges.

The ESMMPs included in Volume B of this ESIA provide a framework for expanding the current practices to meet the requirements of construction and operations. The management plan includes procedures for: 1) identifying hazardous waste streams, including the introduction of new ones, 2) collection, 3) temporary storage, 4) transfers to appropriate facilities, and 5) tracking and auditing of the process and ultimate disposal.

Newmont is responsible for ensuring that licensed disposal sites are being operated to acceptable standards. These requirements are incorporated in the ESMMP (Volume B) and shall be implemented, adhered to and reviewed/updated regularly or whenever changes to the system are made. The criteria for hazardous waste management have been established based on the IFC EHS Guidelines for Waste Management Facilities, and Newmont Environmental Standards.

2.5 Mine-Site Water Management

The Project will incorporate numerous structural and operational environmental controls designed to manage and minimize potential water resources, including installation and active management of sediment ponds downstream of all major disturbance areas (including construction areas, borrow areas, WRFs 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.

Water management at the mine site includes active management, and/or contingency management of the following water streams/issues:

- sediment control during construction and operations;
- pit dewatering water;
- waste rock disposal area runoff; and
- domestic waste water.

The following sections provide an overview of the site-wide water management.

2.5.1 Site Drainage and Sediment Control

Sediment management relies on: 1) run-on controls, 2) source controls near the disturbance, 3) intermediate controls, and 4) perimeter controls. Releases from the perimeter controls must meet effluent limits and achieve ambient criteria at downstream compliance points.

Conditions on site have been disturbed as a result of legacy small-scale mining such that sediment loads in the streams on the mine site have increased dramatically from since 2012 conditions (more detail is provided in Baseline Water Resources in Sections 4.6 to 4.8). The Project will apply sediment control measures prior to discharging to the receiving environment to reduce sediment loads discharging from the site. This includes development of sediment control structures/dams (sediment ponds) downstream of Project-impacted areas prior to start of major earthworks. The sediment control structures are integrated into a surface water management plan that is directed at minimizing run-on flows from undisturbed areas, so that the sediment structures can be managed. The discharges from the sediment control structures will not undergo formal treatment, though flocculants may be added to help precipitate fine clays and reduce retention time needed for total suspended solids (TSS) removal in the ponds. The sediment control plan includes in-stream sedimentation basins (with the ability to control / regulate peak flows) with the locations as shown in Map 2-3.

The details of the dam heights and volumes and associated storage volumes are included in Table 2-8.

Table 2-8 25-year/24-hour Storm Water Runoff

Erosion Control Dam	Storm Water Storage Volume (m^3)	Embankment Volume (m^3)	Embankment Height (m)
A	52,900	1,432	1.9
B	29,600	3,099	1.8
C	39,900	17,884	5.8
F	15,800	9,603	4.0
G	124,100	618	1.0
J	10,800	434	1.2
K	31,300	1,347	5.1
M	4,900	2,867	5.1
N	43,500	145	0.2
O	5,400	1,960	3.1
P	24,000	17,863	6.2
T	15,100	5,920	6.6

m = meter; m^3 = cubic meter.

2.5.2 Pit Dewatering

Pit dewatering is expected to be required at all three pits. Water will be collected in a sump and pumped to a near-by Sediment Pond and then discharged to the environment as shown in Map 2-3. Based on preliminary geochemistry data and analysis conducted to-date, the water quality of the pit dewatering is expected to meet Project discharge criteria. Pit water will be treated for TSS by routing the water through sediment ponds and then discharged to the receiving environment. Blasting will be controlled to minimize residual nitrogen in the waste rock. It is assumed that controls can be used to limit wastage to 1% or less. This level of wastage would not result in nitrogen levels in waste rock run-off or seepage that would exceed project criteria. Contingency plans for managing nitrogen have been developed in the event wastage is higher than projected as described in the ESMMP (Volume B).

Water released from the sediment control ponds will meet effluent limits at the point of discharge and ambient water quality criteria for protection of human health and the environment at a downgradient compliance point. Runoff during wet periods is anticipated to meet discharge criteria without treatment. Water quality analysis of pit water will occur during operations to confirm water quality prior to discharge to the environment. Contingency measures for water treatment will be implemented if needed to meet water quality criteria for the discharges. Areas adjacent to pits will be filled and graded to drain away from the pits. The flow diversion arrows in Map 2-3 show where runoff will be routed.

2.5.3 Waste Rock Disposal Area Runoff and Seepage

Preliminary estimates of waste rock facility seepage quality indicate a potential to exceed Project water quality standards. To prevent adverse impacts to surface water and groundwater, it is assumed that treatment of WRF seepage will be required. This assumption will continue to be evaluated as additional geochemical information becomes available and water quality predictions and/or WRF design are refined. The quality of WRF runoff is expected to be better than WRF seepage. The need for treatment of WRF runoff will be assessed once additional information are available. Map 2-3 shows the conceptual arrangement of diversion ditches, collection ditches and other conveyance features that feed the sedimentation facilities, prior to discharge to streams.

2.5.4 Effluent Treatment Plant

An ETP is planned to treat seepage from the WRFs. The discharges from the ETP will report to Creek 1 downstream of the ETP. Water released from the ETP will meet the IFC standards for effluent criteria, as well as support compliance with the Project ambient water criteria for protection of human health and the environment at the defined compliance points (Presented Volume B of this ESIA).

2.5.5 Fresh Water Supply

Water required, including for the camp, will be largely met by collection of surface water. As needed, supplemental water will be supplied by a groundwater well field. Estimated fresh water demand during operation is approximately 50 m^3/day. During construction, estimated fresh water demand is expected to double the amount for the Operation Phase. Water will be supplied from a combination of rainwater and groundwater wells. An optional source if needed is surface streams. For collected rainwater, the stored water is treated with ultraviolet (UV) system prior to delivery to the camp. For water from the creeks/surface streams, the water will be treated prior to consumption.

2.5.6 Sewage Water Treatment Plant

During operations, domestic sewage treatment will be provided by a bio-disc reactor and the sludge and effluent discharged to the WRFs. The bio-disc reactor will be the same technology used during construction. One permanent or semi-permanent sewage systems are considered during both construction and operations: Operations Camp SWTP (Mine Site). The estimated required capacity for the Operations Camp SWTP will be approximately 300 m^3 of sewage/grey water daily at maximum occupancy (200 liters/day/person), reducing to 160 m^3 of sewage/ grey water daily for the operational period after 3 years.

2.6 Transportation Corridor

As discussed in the introduction to this chapter, most of the Project's supplies will be imported to the Nieuwe Haven Port at Paramaribo or sourced from suppliers in Paramaribo. Supplies will be trucked from Paramaribo to the mine site. It is estimated that 15 to 20 trucks/day will be required to keep the mine supplied in fuel, diesel, reagents, perishables, and other supplies. During construction truck traffic is expected to reach approximately 30 trucks/day. The fuel and diesel trucking will be conducted in caravans while the other supplies will not be organized as they will come from a variety of suppliers. Generally, supplies will leave Paramaribo in the morning and make the return trip in the afternoon to maximize travel during daylight hours. The one-way trip between Paramaribo and the mine site is estimated at 4 hours.

Two access routes are being investigated as the main access for the Sabajo (and potentially the Merian) Project.

Carolina Access Route: This route starts in Paramaribo, crosses the Carolina Bridge and then passes the town of Powakka before reaching the existing private 62 km spur road from the Carolina Bridge to the Project site. The portion of this road from the Carolina Bridge to the Project will be improved if this alternative is selected as the main access road to site.

Afobaka Access Route: this route also starts in Paramaribo and continues approximately 103 km to the Afobaka Dam and then continues 37 km on the unpaved Musa Road from Afobaka to the Project site. The unpaved portion of the road will be improved if this alternative is selected as the main access route to the Project.

It is currently planned to use one of these routes for the Project but an analyses is currently underway to assess the economics of this option for the Merian mine traffic as well. The current ESIA assesses potential impacts for both the Project and Merian traffic in the event that the financial assessment indicates this is a more efficient route than the current route from Moengo that the Merian mine is currently utilizing. Based on the actual vehicle records at the Merian site, the usage presented in Table 2-9 presents the traffic likely needed if only the Sabajo specific traffic uses the access road, and Table 2-10 presents the traffic anticipated in the highest-traffic scenario, assuming the bulk of Merian traffic begins to use the road.

Table 2-9 Project Traffic Estimates: Access Road (Sabajo Traffic Only)[(a)]

Project Phase	Heavy Trucks (Fuel, Reagent and Supply Trucks)	Buses	Light vehicles
Construction (prior to completion of road to Merian)	5	3	20
Operations	10	8	10
Closure	2	2	2

a) Number of one-way trips per day.

Table 2-10 Project Traffic Estimates: Access Road (Including Merian Traffic)[(a)]

Project Phase	Heavy Trucks	Buses	Light vehicles
Construction (prior to completion of road to Merian)	5	3	20
Operations	34	25	30
Closure (and assuming closure of Merian)	0	0	6

a) Number of one-way trips per day: Includes Merian traffic starting once the Sabajo-Merian Haul Road is complete.

2.7 Sabajo-Merian Haul Road

The Sabajo-Merian Haul Road is a major earthworks project that includes an approximately 30 km long road with a rolling width of 10 to 14 m, depending on the final truck size that will be used to mine the Project (currently being evaluated are a 777 haul pack or a 785 haul pack). The current design includes a rolling width of 14.5 m with an additional clearance of 30 m on each side where necessary to ensure operational safety. It should be noted that the clearance will be determined once the in-situ field investigation have been completed. The road will be design with adequate pull out areas for safety and line of site when appropriate for sharp turns.

The road design includes the installation of three bridges, Map 2-2 shows the locations, and Map 2-4 shows the proposed cross sections. These bridges have been designed to pass the 50 year storm event of 215 mm. Table 2-11 shows the preliminary dimensions of the planned bridges.

Table 2-11 Planned Bridge Dimensions

Creek Name	KP	Dimensions	50 Year Storm Event Flow (Q50) (m^3/s)
Klein Commewijne	0+500	W = 15 m D1 = 1.50 m D2 = 2.00 m	400.2
Tempati	22+400	W = 20 m D1 = 3.00 m D2 = 4.50 m	1040.7
		W = 20 m D1 = 4.00 m D2 = 5.50 m	
Las Dominicanas	25+900	W = 10 m D1 = 1.00 m D2 = 1.50 m	166.3

m = meter; m^3/s = cubic meters per second.

The average daily traffic on the road includes approximately 10 haul trucks with a 150 tonnes payload, moving 1.5 million tonnes per year. In addition the road will be designed to carry some if not all of the Merian mine traffic as described in Section 2.6.

2.8 Project Phases

2.8.1 Pre-Production

Pre-production describes activities required to build the mine infrastructure and start-up of the pit development. Activities include:

- recruitment and training;
- opening of the borrow pits for construction materials;
- construction of sediment control structures;
- construction of Mine Infrastructure such as roads, WRFs, ore stockpiles, etc.
- preparation of the fuel tank farm;
- earthworks and surface preparation of the waste management facility; and
- construction of the main camp including offices and worker accommodations.

Pre-production activities will be done primarily with Newmont Suriname equipment but will also utilize contractor equipment when required.

Once construction earthwork activities commence, the priority will be to complete the upgrades to the access road to allow transportation of the equipment to site.

Simultaneously with the upgrading the access roads, the camp site will be cleared of vegetation and access from the construction camp to the operations camp will be established.

All major cuts will be done with Sabajo's main mining fleet (Hitachi EX-3600 BH and CAT 785D Trucks or similar). The smaller fleet will be used for the construction of the temporary sediment ponds downstream of the initial disturbed areas. Part of the smaller fleet will also be working at the camp and mill site pads assisting the construction team with miscellaneous small jobs. The contractors will mainly focus on the access roads working based from a self-sustained camp and clearing and grubbing working from the construction camp.

2.8.2 Operations

Operations are considered to begin when the Project begins shipping ore to the Merian mine. Operation activities will include:

- open-pit mining;
- waste rock management;
- operation of accommodations including treatment and delivery of potable water and sewage treatment and domestic waste management;
- transport of supplies and gold;
- routine transport of mine employees to and from Paramaribo;
- waste management;
- power generation; and
- progressive reclamation of WRFs.

2.8.3 Closure

Closure is considered to begin once the pits are no longer being mined. Closure activities will include those required to return the site as much as possible to pre-existing conditions with the exception of improvements on the areas currently impacted by ASM. Activities will also be required to ensure public safety related to the pit areas. A more detailed Conceptual Mine Closure Plan is included in Volume B of this ESIA.

Closure activities will include:

- regrading of waste rock disposal area and re-vegetation;
- pit lake management if necessary;
- any required site grading to ensure long-term site drainage conditions;
- stabilization of all slopes through re-grading and re-vegetation; and
- environmental monitoring.

2.8.4 Post-Closure

Post-closure describes the phase after all closure works are completed and the site can be left in an unmaintained but sustainable state. Activities may include environmental monitoring.

3 PROJECT ALTERNATIVES

3.1 Introduction and Methods

This section provides an overview of some of the major Sabajo Project (the Project) design alternatives that were considered through the course of Project planning and the rationale for selecting the preferred alternatives that are presented in the Project Description (see Section 2). Since the Project does not include any processing facilities, the alternatives analyses focused on the following:

- Project need and the Project versus No Project Alternative;
- transportation routes for the access road to the Project from Paramaribo; and
- routing for the Sabajo-Merian Haul Road.

These options are discussed in Sections 3.2 to 3.4.

The general approach used in all sections is a qualitative approach based on a set of criteria. Each alternative analysis will:

- Set out the goals and criteria for the project in relation to the option, in the best estimation of the Environmental and Social Impact Assessment (ESIA) team and keeping in mind stakeholder feedback received to date; an example of the goals and criteria is set out in Table 3-1.
- Rank each of the options from that closest to achieving each desired goal to the option less likely to achieve the goals presented in the table.
- State clearly the single option selected, and the reasons for that selection, or state that multiple options have approximately equal validity and may be used for the Project (if multiple options are retained for possible use by the Project, then multiple options are also to be assessed in the impact assessment).

Table 3-1 Example Criteria and Goals used in the Analysis of Access and Haul Road Alternatives

Aspect Analyzed	Criteria	Goal	Rationale
Social/Health and Safety	Safety considerations in road design	Select the route that will present the safest possible design.	Safety considerations in road design include grade, line of sight, and turning radius. These are often influenced by the existing terrain.
	Proximity to sensitive receptors	Select the route away from sensitive receptors.	Being away from sensitive receptors will decrease the chance of effects on these (and most importantly the people at these locations).
Environment	Number of stream crossings	Limit the number of stream crossings required by the road.	• Road crossings introduce the potential for degradation of aquatic habitat during construction and risks to spills or pollution during operations. Crossings that already exist or those that will cross streams that are already disturbed are preferred over crossings of pristine streams. • Clearing is considered a direct impact on potential ecological habitat. Clearing in already disturbed areas is generally preferred as this habitat is already impacted. • Roads or other linear corridors have the potential to reduce the size of habitats and restrict the movement of populations.
	Total cleared area	Limit the amount of area required for clearing.	
	Potential for habitat fragmentation	Limit the potential to fragment large areas of habitat into smaller, less sustainable areas.	
Economics	Length	Limit the length of the access road (or the part thereof that requires construction and maintenance).	There are costs associated with clearing, grading, and capping roads as well as maintenance. These increase on a per kilometer basis as do costs related to fuel consumption of trucks moving on and off site, and the accompanying production of emissions and greenhouse gases.

3.2 The Project and No Project Alternative

Table 3-2 sets out the criteria and goals for this evaluation.

Table 3-2 Criteria and Goals used in the Project / No Project Alternative Evaluation

Factor	Criteria	Goal	Rationale
Social Impact (other than direct employment)	Extent of potential impacts and benefits	Provide social benefits; minimize negative impacts	Benefits should balance impacts from the Project if the Project is to proceed.
Environmental Impact	Disturbed land in short term	Reduce disturbance	Environmental mitigation measures should balance negative effects if the Project is to proceed.
	Disturbed land in longer term	Reduce disturbance	
Economic Impact	National and local economic benefits	Employ more people at the Newmont Operations	Employment is highly valued by Suriname residents.
	Economic Feasibility	Provides the Internal Rate of Return Required by Newmont International	If the project does not provide economic benefit to the company no investment will be made

the Project = the Sabajo Project; Newmont = Newmont Suriname, LLC.

The criteria are evaluated as follows:

- **Social benefits and impacts:** these aspects are fully evaluated in the ESIA. The Project will provide added employment and procurement opportunities and will also contribute to government revenue while implementing programs for social benefit. Negative effects will also occur due to the Project and are described below (Section 5.9). In general, negative effects will be managed and mitigated and overall, the benefits associated with the project are expected to out-weigh the negative impacts.
- **Environmental benefits and impacts:** The Project is being developed in an area containing heavily disturbed landscapes as well as some intact high-quality habitats. The Project will increase the total area of disturbance in the short term because it will mine areas beyond the existing disturbance, and develop waste rock facilities and roads in presently forested areas. However, Newmont's environmental standards commit the company to no net loss of biodiversity over the life of a project and a combination of restoration of existing disturbed habitats and mine reclamation (re-vegetating lands disturbed by the Project operations) as described in the biology impact assessment (Section 5.8) will ensure that the project equalizes environmental benefits and impacts in the long term.
- **Employment Opportunities:** The Project would provide ore to the Merian operation and employ personnel in addition to those at the Merian site, resulting in new opportunities for direct employment and indirect spin-off benefits (procurement opportunities) to the public, as described in the macroeconomic assessment (Section 5.9). Project employment opportunities are estimated to outnumber the existing small-scale mining opportunities that will be displaced due to the project.
- **Economic Feasibility and benefit to Newmont:** The full economics for the Project continue to be assessed by Newmont Suriname, LLC (Newmont). The Project will only proceed if Newmont deems it to be an economical project. It is acknowledged that the economic benefits have yet to be confirmed. The Project will proceed only if it is economically feasible.

In summary, the Project would provide economic benefits to local stakeholders from jobs and procurement opportunities; its social benefits overall are expected to exceed its negative effects; and its environmental effect is neutral. Pending a final analysis of feasibility, if the project also provides sufficient economic benefits to Newmont to justify the expenditures, then the Project Alternative will be considered preferable to the No Project Alternative.

3.3 Site Access from Paramaribo

Criteria used to assess options for site access routes from Paramaribo are provided in Table 3-3.

Table 3-3 Criteria and Goals used in the Analysis of Access and Haul Road Alternatives

Aspect Analyzed	Criteria	Goal	Rationale
Social/Health and Safety	Safety considerations in road design	Select the route that will present the safest possible design.	Safety considerations in road design include grade, line of sight, and turning radius. These are often influenced by the existing terrain.
	Proximity to sensitive receptors	Select the route away from sensitive receptors.	Being away from sensitive receptors will decrease the chance of effects on these (and most importantly the people at these locations).
Environment	Number of stream crossings	Limit the number of stream crossings required by the road.	• Road crossings introduce the potential for degradation of aquatic habitat during construction and risks to spills or pollution during operations. Crossings that already exist or those that will cross streams that are already disturbed are preferred over crossings of pristine streams. • Clearing is considered a direct impact on potential ecological habitat. Clearing in already disturbed areas is generally preferred as this habitat is already impacted. • Roads or other linear corridors have the potential to reduce the size of habitats and restrict the movement of populations.
	Total cleared area	Limit the amount of area required for clearing.	
	Potential for habitat fragmentation	Limit the potential to fragment large areas of habitat into smaller, less sustainable areas.	
Economics	Length	Limit the length of the access road.	There are costs associated with clearing, grading, and capping roads as well as maintenance. These increase on a per kilometer basis as do costs related to fuel consumption of trucks moving on and off site, and the accompanying production of emissions and greenhouse gases.

Two routes were considered for use to access the Project from Paramaribo (Map 1-1):

- **Alternative 1:** The route using the Afobaka Road from Paramaribo to the Afobaka Dam, then the Musa Road from Afobaka to the Project site.
- **Alternative 2:** The route using the Carolina Road from the Powakka turn off, then across the Carolina Bridge southward to the Project site.

These routes are evaluated as follows:

- **Social/Health and Safety – road design:** Alternative 1, the Afobaka Route, includes a number of steep grades and tight turns which increase potential for traffic accidents. The Carolina Road follows less rugged terrain. Both routes ultimately intersect with the Afobaka Road, which is designed to accommodate a far higher volume of vehicles and is considered safe for the purpose of this analysis, although it has greater use by traffic. Overall, the Carolina Road is the safer option in terms of road design.
- **Social/Health and Safety – sensitive receptors:** based on an analysis by ILACO Suriname N.V. (ILACO; 2017), sensitive receptors including towns, bus stops, churches, sports fields,

monuments, muster points, and schools were mapped along each route. Alternative 1, the Afobaka Road, has 18 sensitive receptor points up to the convergence of the two routes west of Powakka. Alternative 2, the Carolina Road, has 12 sensitive receptor points up to the convergence of the two routes west of Powakka, but also has the single largest sensitive receptor, which is the town of Powakka. In summary, both routes have sensitive receptors, and one routing is not clearly better than the other in this context.

- **Cleared Area:** Both roads would need to be widened in spots and would require minimal clearing. Both routes are considered equal in this context.
- **Habitat Fragmentation:** Because the road is already cleared and in use in both cases, no substantial added habitat fragmentation occurs in either case. Both routes are considered equal in this context.
- **Length:** The lengths of the routes are: 137 kilometers (km) for Alternative 2, the Carolina Road, and 141 km for Alternative 1, the Afobaka Road. From the perspective of travel time and maintenance, therefore, the preferred choice is Alternative 2, followed by Alternative 1.

This alternative analysis has shown that both the Carolina and Afobaka roads are possible viable options for the Project. Overall the analysis slightly favors Alternative 2, the Carolina Road, due to its shorter total length and safer road design. However the two routes are similarly rated and therefore neither has yet been chosen. The option for both is included in the project description, and they have both been assessed as part of the project.

3.4 Sabajo-Merian Haul Road Routing

The criteria and goals for the Sabajo-Merian Haul Road routing are the same as those provided in Table 3-3. One added consideration is proximity to the Margo potential mining location, where an ideal routing would run close to this mine location, but not through it.

The road routing options are set out in Map 3-1. Alterative 1 is the most northern route and is the shortest distance. Alternative 2 is a central route that follows some valley-bottom terrain. Alternative 3 is the most northern and highest-altitude route. Alternative 1A was added as a hybrid of routes 1 and 2. It is important to note that for all of the routes, the Project Description assumes that during Project Operation, the road will not be open to the public. Specific criteria in relation to public use or public safety are therefore not part of the alternatives analysis.

The criteria are evaluated as follows:

- **Social/health and safety:** all of the routes can be given appropriate safe design. None of the routes passes sensitive receptors, as the area is remote. All the routes are Considered equal for road safety.
- **Sensitive social receptors:** the roads are being developed in an area with minimal access and no sensitive social receptors are present. All the routes are considered equal for health and safety in relation to receptors.
- **Stream Crossings:** The number of stream crossings for each of the three routes on the corridor map (Map 3-1) were compared. Based on this level of mapping (substantial watercourses only), four stream crossings are predicted Alternative 1, three crossings for Alternative 1A, three crossings for Alternative 2 and three crossings for Alternative 3. All options are similar, but Option 1 is preferred in this context.

- **Cleared Area:** The road is assumed to have a width of 14 meters (m), with clearing on either side, so that the maximum cleared width of the route may be up to 70 m. Based on this maximum-case assumption, the cleared area is predicted as 200 hectares (ha) for Alternative 1, 208 ha for Alternative 1A, 217 ha for Alternative 2 and 208 ha for Alternative 3. From the perspective of physical impacts, therefore, the preferred choices are Alternative 1, followed by Alternative 1A, Alternative 2, and last Alternative 3.
- **Habitat Loss:** The Alternative 1A road alignment should be avoided to protect biodiversity (Jared Hardner, Pers. Comm.). The reason for this relates to its topography, which is heterogenous and leads towards a plateau that is well documented to provide habitat for both a higher diversity of species as well as rare endemic and restricted-range species. Many of these species have not been studied in depth and therefore present great uncertainties regarding their potential rarity and vulnerability to project impacts. Areas of high species diversity and occurrence of endemic and range-restricted species are triggers for management interventions under Newmont’s Biodiversity Standard. Therefore Alternatives 2 and 3 are less preferred than Alternatives 1 and 1A in relation to the specific habitat being affected.
- **Length:** The lengths of the routes are: 28.6 km for Alternative 1, 29.8 km for Alternative 1A, 30.9 km for Alternative 3 and 31.5 km for Alternative 3. From the perspective of construction costs, travel time, and maintenance, therefore, the preferred choices are Alternative 1, followed by Alternative 1A , Alternative 2, and last Alternative 3.
- **Position relative to Margo:** If the Margo site were to be mined, Alternative 1 would need to be re-routed around it. Alternative 1A runs directly adjacent so would not need to be re-routed (it would require a very short side road). Alternatives 2 and 3 are more distant and an additional side road would need to be built. For their proximity to Margo, Alternative 1A is most preferred, Alternative 1 is next, and Alternatives 2 and 3 are least preferred.

This alternative analysis overall favors alternatives 1 and 1A equally, followed route 2 and last route 1. Route 1 and 1A are both considered acceptable. Preliminarily, Route 1A is carried forward as the chosen option for the Project. As a caveat, some detailed tangible culture studies and biological studies are proposed to occur along the route prior to construction, in order to verify the route has no un-expected issues and to fine-tune the routing.

4 SUMMARY OF BASELINE CONDITIONS

4.1 Baseline Study Areas

The study area for noise, vibration, air quality changes, and traffic, all of which occur both at the mine site and along access routes used by vehicles to and from the site (Map 4.1-1), was defined as the following:

- a 15 kilometer (km) diameter circle around the Mine location to encompass an area that could be affected by emissions, vibration, or noise from the mine;
- a 1 km buffer along the Sabajo-Merian Haul Road options for the Sabajo Project (the Project); and
- a 50 meter area encircling the potential access routes to the project to encompass areas that could be affected by traffic and dust.

The study area for soil, topography, visual aesthetics, the biological environment and water quantity and quality (Map 4.1-2) included a 2.5 km buffer area around all mine components to allow for all possible mine footprint areas to be captured and a 0.5 km buffer area around the four Sabajo-Merian Haul Road options.

The study area for social and cultural studies, which focused on people potentially affected by the Project (Map 4.1-3) consisted of communities grouped according to their potential to be impacted by the Project. These groups include the Brokopondo communities along the Afobaka road to the west of the Sabajo concession, the Kawina communities as shown on Map 4.1-3, the communities along the Carolina Road in Map 4.1-3, and the artisanal and small-scale mining areas of Santa Barbara and Margo.

4.2 Existing Environmental Conditions

4.2.1 Introduction

Because the Sabajo concession is already subject to considerable artisanal and small scale mining (ASM) activity, both current and historical, that has disturbed and potentially contaminated the environment, it is important to document the pre-existing conditions in the Sabajo Project (the Project) area. Whereas most of the baseline studies in this Environmental and Social Impact Assessment (ESIA) are focused on conditions in undisturbed areas, this section (4.2) addresses conditions in the disturbed areas.

In August 2017, Golder Associates Inc. (Golder) completed site reconnaissance surveys for the Project to assess the existing environmental conditions where ASM is occurring or has occurred, by collecting samples of soil, sediment, surface water and fish tissue for chemical analysis. The surveys supplemented an Environmental Liability Assessment (ELA) completed previously by Tetra Tech for the Sabajo (i.e., Cassador Pit) and Santa Barbara areas in October 2014 (Tetra Tech 2014a). Since that time, further ASM has occurred and continues at Santa Barbara, and ASM has begun at a new site, Margo (not included in the 2014 Tetra Tech survey). The results of the investigation are detailed in Golder's ELA Report (Golder 2018a). This section provides a summary of the existing conditions as described in these reports for Project areas of Santa Barbara, Margo, and Sabajo.

Observations during the August 2017 surveys included active ASM at Santa Barbara and Margo. Santa Barbara was the larger of the two ASM operations with multiple extraction pits, sluices, tailings areas, camps and fuel storage areas, compared to Margo which only had one large pit and sluice. Observations for both active areas also included heavy equipment, vehicles, and machine parts. No new or active ASM was observed in the vicinity of the Cassador Pit (Golder 2018a).

4.2.1.1 Summary of 2014 Environmental Liability Assessment

In October 2014, Tetra Tech prepared an ELA for the Sabajo and Santa Barbara areas (Tetra Tech 2014a). The Sabajo concession was divided into three areas for the purpose of the Tetra Tech ELA: Area A (Cassador Pit Area) located southwest of the main Sabajo Pit and northeast of the Sabajo West Pit; Area B (Brian's Pit) located south of the Santa Barbara Pit; and Area C (Santa Barbara North) located west and northwest of the Santa Barbara Pit. A summary of the Tetra Tech findings is presented herein (Tetra Tech 2014a).

Tetra Tech evaluated the areas for impacts to the environment as a result of ASM activities. The ELA included screening for chemical contamination in soil, water and fish tissue; documentation of unregulated mining and camp areas; photographic documentation of general waste; calculation of land disturbance; evaluation of damage to pre-existing infrastructure; and estimation of costs of damage and loss of resource.

The ELA results indicated that impacts to the environment had occurred as a result of ASM activities within the industrial area. These impacts included, but were not necessarily limited to, hydrocarbon and mercury releases to the environment, surface water impacts from nearby land disturbances, increases in land disturbance area and extensive industrial and domestic waste.

Tetra Tech documented multiple hydrocarbon carbon releases within their assessment area. The surface area at each release site was measured to determine the superficial impact, but the vertical extents of the impacted areas were not determined during their assessment. Hydrocarbon impacts were associated with diesel fuel and petroleum oil products.

Tetra Tech documented mercury impacted soils through field screening and laboratory analysis of soils in the ASM areas. Screening concentrations were highest in the rock crushing / sluice box areas with values decreasing with increased distance (typically 15 to 20 meters [m]) from these areas. Laboratory results for soil samples indicated the highest concentrations of mercury were measured in Area A, which had soil mercury concentrations ranging from 40.3 milligrams per kilogram (mg/kg) to 69.3 mg/kg.

Total mercury values for fish showed higher than average values for samples collected from ASM areas, specifically from samples collected in the Cassador Pit area. Fish samples collected in other ASM areas did not show as high a concentration of total mercury when compared against one another. Fish tissue samples collected from the Cassador Pit area consisted of species of cichlid and tetra.

Total arsenic was detected at two ASM water sampling locations at concentrations of 0.0038 milligrams per liter (mg/L) and 0.0504 mg/L. The United States Environmental Protection Agency (USEPA) has established an arsenic maximum contaminant level for drinking water of 0.01 mg/L. The water sample with an arsenic concentration that exceeded the USEPA drinking water criterion was collected from the tailings pond associated with the Cassador Pit. Water sample results indicated that dissolved and total mercury were commonly detected at both ELA and baseline monitoring locations. In addition to the elevated arsenic and mercury concentrations measured at ASM sampling locations, dissolved and total manganese were also measured at elevated concentrations when compared to the baseline monitoring locations.

Remote sensing analysis of Quickbird (2010 and 2012) and LiDAR (2014) imagery by Tetra Tech indicated that a 64.65 hectare (ha) increase in land disturbance had occurred within the industrial areas as a result of ASM activities within the Cassador Pit area. Imagery and data used to determine the extent of disturbance at Santa Barbara indicated an increase of 24.74 ha over a 2-year period. Land disturbance for the purpose of the ELA was defined as a change from forested to cleared land.

Tetra Tech concluded that the majority of the land disturbance was attributed to mining activities such as pit excavations, dam building, road building, and deforestation for the camp areas which were characterized by house/structures and large quantities of waste. The waste consisted of industrial waste such as metal drums, heavy equipment, machinery, and small engines (generators and pumps), as well as domestic waste items such as broken furniture, food and drink containers, clothing and miscellaneous personal items.

4.2.2 2017 ELA Sampling and Data Collection Methods

The August 2017 site reconnaissance survey included sample collection of soil, sediment, surface water and fish tissue from 15 August to 18 August 2017. Sampling locations are shown on Map 4.2-1 to 4.2-4. Sampling was completed by Golder field leads with the assistance of Newmont Suriname, LLC. (Newmont) and ILACO Suriname N.V. (ILACO) staff. The sampling program was mainly focused at the Santa Barbara and Margo sites, with fewer sampling locations at the Cassador Pit area (i.e., Sabajo area) on request by Newmont. The following sections include a summary of methods used for the survey. Additional details are provided in Golder (2018a).

4.2.2.1 Soil Sample Collection

Forty-four (44) soil samples were collected from 15 to 17 August 2017 (33 at Santa Barbara, 6 at Margo, and 5 at Sabajo). Soil sampling locations at Santa Barbara and Margo were determined in the field based on visual observation of land disturbance. Samples were collected in areas of excavation and sluicing and from tailing piles, tailing washouts, fuel storage areas, fuel disposal areas and debris piles.

Soil samples collected at the Cassador Pit were sampled at the approximate locations previously sampled by Tetra Tech (2014a). Sample locations were determined from Global Positioning System (GPS) coordinates provided in the 2014 Tetra Tech ELA. Photographs of sampling locations and descriptions of samples collected were recorded during each sampling event (Photo 4.2-1).


Photo 4.2-1 Examples of Soil Sample Collection Areas, Santa Barbara (Samples SB-S-1 and SB-S-5, Respectively)

Soil samples were collected from 0 to 0.15 m below ground surface using a shovel, which was rinsed with distilled water and wiped with individually packaged alcohol wipes between each sampling location. Samples were then placed in labelled Ziploc bags (triple bagged) and stored in coolers for laboratory analysis for contaminant screening (i.e., mercury and petroleum hydrocarbons) and chemical analysis.

4.2.2.2 Water Sample Collection

Four water samples were collected on 16 and 17 August 2017 (2 at Santa Barbara and 2 at Margo). Samples were collected in active ASM areas, which included the following:

- 2 Santa Barbara Samples – One from active sluicing runoff and one from an accessible stream; and
- 2 Margo Samples – One from surface runoff downstream of tailings pond and one from a makeshift tailings pond.

Photographs of sampling locations, descriptions of samples collected, and field water quality measurements (i.e., temperature, pH, specific conductance, turbidity, oxidation-reduction potential and dissolved oxygen) were recorded during each sampling event (Photo 4.2-2). All surface water samples were collected using a modified USEPA Method 1669 “Clean Hands/ Dirty Hands” sampling procedure (USEPA 1996).

Following collection, samples were filtered, appropriate laboratory-supplied preservatives were added, and the preserved samples were kept cool in storage prior to laboratory chemical analysis.

Photo 4.2-2 Examples of Water Sample Collection Areas, Santa Barbara and Margo (Samples SB-SW-2 and MAR-SW-2, Respectively)

4.2.2.3 Sediment Sample Collection

Six sediment samples were collected from 15 to 18 August 2017 (3 at Santa Barbara, 2 at Margo, and 1 at Sabajo). As with surface water, samples from Santa Barbara and Margo were collected from an accessible stream, sluicing runoff, tailings ponds, and overland flow downstream of the tailings pond, in active ASM areas. Samples were considered sediment samples since they were collected below standing water and were completely saturated. The sediment sample collected in the Sabajo area was collected downgradient of the Cassador Pit in an area of overland runoff. Photographs of sampling locations and descriptions of samples collected were recorded during each sampling event (Photo 4.2-3).

Photo 4.2-3 Examples of Sediment Sample Collection Areas, Santa Barbara and Margo (Samples SB-SED-1 and MAR-SED-1, Respectively)

Sediment samples were collected from 0 to 0.15 m below sediment surface using a shovel, which was rinsed with distilled water and wiped with individually packaged alcohol wipes between each sampling location. Samples were then placed in labelled Ziploc bags (triple bagged) and stored in coolers for laboratory analysis for contaminant screening (i.e., mercury and petroleum hydrocarbons) and chemical analysis.

4.2.2.4 Fish Tissue Sample Collection

Fish tissue samples were collected by Golder on 16 August 2017. Twenty-eight small forage fish were collected with a hand net in a stream located in the Santa Barbara area. Fish were sorted in the field by gross visual identification. Fish samples were triple bagged, labelled, and kept frozen until submission for laboratory chemical analysis and fish classification. Photographs of sampling locations and descriptions of samples collected were recorded during each sampling event (Photo 4.2-4). Subsequently, more fish were caught about 2 kilometers (km) downstream of Santa Barbara in the Kleine Commewijne watershed and were also analyzed.

Photo 4.2-4 Example of Fish Collection Area and Fish Sample, Santa Barbara (Samples SB-F-1 and SB-F-1A, Respectively)

4.2.2.5 Analysis of Changes in Land Disturbance

Areas of land disturbance at Santa Barbara, Sabajo, and Margo were digitized from August 2017 satellite images and these areas were compared to areas calculated in 2014 by Tetra Tech (2014a).

4.2.3 Results

For reference, laboratory analysis results were compared to regulatory criteria from a number of jurisdictions (e.g., USEPA, Canadian Council of Ministers of the Environment [CCME], Health Canada, etc.). Detailed results are included in Golder (2018a), however a summary is provided in the following sections.

4.2.3.1 Soil

Screening Criteria and Standards

Soil quality analytical results were compared to the following USEPA criteria in the absence of any in-country standards or guidance:

- Toxicity Characteristic Leaching Procedure (TCLP) – to determine if soil waste possesses the characteristic of toxicity and may be considered a hazardous waste (USEPA 2009a);

- Regional Screening Levels (RSL) for industrial land use – to determine if potentially significant levels of contamination are present to warrant further investigation and evaluate whether contaminant concentrations in soil may present elevated levels of risk to workers who may be engaged in future mining activities (USEPA 2016); and
- Ecological Soil Screening Levels (Eco-SSL) – to identify those contaminants of potential concern in soils for ecological receptors (i.e., plants, soil invertebrates, mammals and birds) (USEPA 2005). The Eco-SSL were also used in the Tetra Tech (2014a) ELA.

The comparison of soil metal concentrations to these standards was done as a screening tool to identify constituents of potential concern. Applicability of these standards to the Project site is not implied.

Analytical Results

Soil sample results are summarized in Table 4.2-1. For each area (i.e., Santa Barbara, Margo and Cassador Pit), this table includes the number of determinations, range of concentrations (i.e., minimum, maximum and median)[1] and the frequency of detection for each metal analyzed in soil samples (i.e., mercury [Hg], arsenic [As], barium [Ba], copper [Cu], cadmium [Cd], chromium [Cr], lead [Pb], selenium [Se] and silver [Ag]). The complete soil data set is available in Golder (2018a). A summary of exceedances of the reference standards listed above by area is presented in Table 4.2-2. Results are discussed below:

- Mercury was detected in 35 of the 44 samples analyzed. Of these, one sample (from Margo) exceeded the TCLP criterion of 4 mg/kg. Mercury concentrations in all soil samples (including the one from Margo) were below the USEPA RSL. Arsenic concentrations were typically below detection in the Santa Barbara samples. When detected, arsenic concentrations exceeded the USEPA RSL. It is notable that for ten samples, the arsenic reporting limit (i.e., 12.5 mg/kg) was above the USEPA RSL (3 mg/kg) and therefore compliance would not be assessed. Arsenic was present in the six Margo samples at concentrations ranging from 9 to 999 mg/kg. Arsenic concentrations exceeded all reference standards in 5 of the 6 samples.
- Cadmium was detected in 29 of the 39 samples analyzed. Some exceedances of USEPA Eco-SSL for mammals and birds were measured in both Santa Barbara and Margo samples. Cadmium concentrations in all samples were below the cadmium TCLP and USEPA RSL criteria.
- Chromium was detected in all 39 samples submitted for laboratory analysis. Eleven samples exceeded the TCLP criterion of 100 mg/kg. Most samples exceeded the USEPA Eco-SSL for mammals and birds.
- Selenium was detected in one Margo sample at a concentration of 1 mg/kg thereby exceeding the USEPA Eco-SSL for plants.
- Barium, lead and silver concentrations were below all reference standards in all samples.

[1] Non-detect concentrations were assumed equal to the analytical reporting limit in the calculation of median concentrations. For some parameters, analytical reporting limits were variable between samples.

Table 4.2-1 Summary of Soil Metal Results

	Parameter[a]							
	Mercury	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Reporting Limit(s)[b]	0.033	2.5 and 12.5	1	0.2 and 1		0.8	0.5	0.5 and 2.5
Santa Barbara								
No.	33	33	33	33	33	33	33	33
Min.	<0.033	<2.5	<1	<0.2	17	<0.8	<0.5	<0.5
Max.	0.81	18	35	2.1	150	6.2	<0.5	<2.5
Median	0.07	2.5	7.5	0.46	53	3.3	-	-
% ND	24%	94%	3%	27%	0%	27%	100%	100%
Margo								
No.	6	6	6	6	6	6	6	6
Min.	<0.033	7	1	<0.2	58	3.4	<0.5	<0.5
Max.	6.3	999	9.8	1.7	183	7.3	1.1	<0.5
Median	0.20	246	4.5	0.44	90	5.2	0.5	-
% ND	17%	0%	0%	17%	0%	0%	83%	100%
Cassador Pit								
No.	5	-	-	-	-	-	-	-
Min.	0.04	-	-	-	-	-	-	-
Max.	0.47	-	-	-	-	-	-	-
Median	0.10	-	-	-	-	-	-	-
% ND	0%	-	-	-	-	-	-	-

Source: Golder (2018a)

a) Results in milligrams per kilogram (mg/kg) dry weight for all metals with the exception of mercury which is presented in units mg/kg wet weight.

b) Arsenic, cadmium and silver reporting limits elevated for some samples due to dilution prior to analysis.

% ND = frequency of non-detect values; No. = number; min. = minimum; max. = maximum; < = less than; - = not analyzed.

USEPA TCLP criteria exceedances were reported for mercury and arsenic at Margo, and chromium at both Margo and Santa Barbara (Table 4.2-2). These corresponded to samples collected in areas near sluice outwashes and an unmarked drum suggesting a potential for soils in the vicinity of ASM activities to fail the TCLP test. ELA sampling targeted areas of ASM disturbance. Additional sample collection and analysis would be required to determine the amount of soil that may be classified as hazardous.

USEPA RSL exceedances were only reported for arsenic at Santa Barbara and Margo (Table 4.2-2).

USEPA Eco-SSL limits for cadmium and chromium were exceeded at Santa Barbara and Margo for many soil samples. Arsenic exceeded the USEPA Eco-SSL for plants, mammals and birds at all but one sampling location at Margo. A single exceedance of the selenium USEPA Eco-SSL for plants was measured at Margo (Table 4.2-2). It is worth noting that the USEPA Eco-SSL criteria were not derived to enforce regulatory action but rather to identify those contaminants of potential concern in soils that may require further evaluation in a baseline ecological risk assessment.

No exceedances were measured in the Sabajo (Cassador Pit) area samples, which were only analyzed for mercury content. Mercury concentrations in these samples were significantly lower than the values previously reported by Tetra Tech (2014a).

Additionally, based on preliminary screening, ten soil samples were submitted for laboratory analysis of petroleum hydrocarbons (i.e., benzene, toluene, ethylbenzene, xylenes, diesel, gasoline and lube oil). Hydrocarbon concentrations were typically below detection in most samples with none exceeding USEPA criteria.

Table 4.2-2 Summary of Soil Parameter Exceedances for USEPA Reference Standards

		Parameter[a]							
		Mercury	**Arsenic**	**Barium**	**Cadmium**	**Chromium**	**Lead**	**Selenium**	**Silver**
		mg/kg	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Reporting Limit(s)[b]		0.033	2.5 and 12.5 [c]	1	0.2 and 1		0.8	0.5	0.5 and 2.5
Reference Standards for Screening Evaluation									
TCLP Limit		4	100	2000	20	100	100	20	100
USEPA Soil RSL		46	3	220,000	980	1,800,000	800	5,800	5,800
USEPA Eco SSL	Plants		18		32		120	0.52	560
	Soil Invertebrates			330	140		1,700	4.1	
	Birds		43		0.77	26	11	1.2	4.2
	Mammals		46	2,000	0.36	34	56	0.63	14
Santa Barbara Exceedances of Reference Standards									
TCLP Limit		0	0	0	0	**8**	0	0	0
USEPA Soil RSL		0	**2**	0	0	0	0	0	0
USEPA Eco SSL	Plants		0		0		0	0	0
	Soil Invertebrates			0	0		0	0	
	Birds		0		**4**	**27**	0	0	0
	Mammals		0	0	**16**	**23**	0	0	0
Margo Exceedances of Reference Standards									
TCLP Limit		**1**	**5**	0	0	**3**	0	0	0
USEPA Soil RSL		0	**6**	0	0	0	0	0	0
USEPA Eco SSL	Plants		**5**		0		0	**1**	0
	Soil Invertebrates			0	0		0	0	
	Birds		**5**		**2**	**6**	0	0	0
	Mammals		**5**	0	**4**	**6**	0	**1**	0
Cassador Pit Exceedances of Reference Standards									
TCLP Limit		0							
USEPA Soil RSL		0							

Source: Golder (2018a)

a) Results in milligrams per kilogram (mg/kg) dry weight for all metals with the exception of mercury which is presented in mg/kg wet weight.

b) Arsenic, cadmium and silver reporting limits elevated for some samples due to dilution prior to analysis.

c) Reporting limit for some samples higher than USEPA RSL.

TCLP = Toxicity Characteristic Leaching Procedure; USEPA = United States Environmental Protection Agency; RSL = Regional Screening Levels; Eco-SSL = Ecological Soil Screening Levels.

4.2.3.2 Sediment

Screening Criteria and Standards

For screening purposes, sediment quality analytical results were compared to the CCME Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 2001) to determine the possibility of adverse effects on biota in aquatic systems.

Analytical Results

Sediment sample results are summarized in Table 4.2-3. Exceedances of reference guidelines are summarized in Table 4.2-3. Results are summarized below.

- Mercury was detected in four of the six samples analyzed, with CCME guidelines exceedances observed in one sample from Santa Barbara and another from Sabajo.
- Arsenic was detected in three of the five samples analyzed, with CCME guidelines exceedances observed in all three samples (one from Santa Barbara and two from Margo).
- Cadmium was detected in the two Margo samples at concentrations above CCME guidelines.
- Chromium was detected in all five samples analyzed, with CCME guidelines exceedances observed in three samples (one from Santa Barbara and two from Margo).

Table 4.2-3 Summary of Sediment Metal Results

	Parameter[a]							
	Mercury	**Arsenic**	**Barium**	**Cadmium**	**Chromium**	**Lead**	**Selenium**	**Silver**
	mg/kg	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Reporting Limit	0.033	2.5		0.2			0.5	0.5
Santa Barbara								
No.	3	3	3	3	3	3	3	3
Min.	<0.033	<2.5	1.09	<0.2	7.3	1.4	<0.5	<0.5
Max.	0.29	57	49.2	<0.2	42.4	6.0	<0.5	<0.5
Median	0.15	2.5	16.9	<0.2	24	1.5	<0.5	<0.5
% ND	33%	67%	0%	100%	0%	0%	100%	100%
Margo								
No.	2	2	2	2	2	2	2	2
Min.	<0.033	366	0.96	0.62	44.4	4.7	<0.5	<0.5
Max.	0.07	940	4.75	1.56	82.9	7.6	<0.5	<0.5
Median	0.05	653	2.86	1.09	63.7	6.2	<0.5	<0.5
% ND	50%	0%	0%	0%	0%	0%	100%	100%
Cassador Pit								
No.	1	-	-	-	-	-	-	-
Min.	0.193	-	-	-	-	-	-	-
Max.	0.193	-	-	-	-	-	-	-
Median	0.193	-	-	-	-	-	-	-
% ND	0%	-	-	-	-	-	-	-

Source: Golder (2018a)

a) Results in milligrams per kilogram (mg/kg) dry weight for all metals with the exception of mercury which is presented in units mg/kg wet weight.

% ND = frequency of non-detect values; No. = number; min. = minimum; max. = maximum; < = less than; - = not analyzed.

In summary, Santa Barbara sediment samples collected downgradient of an active sluice exceeded at least one of the limits for mercury, arsenic and chromium. Both Margo samples, collected in and downgradient of the tailings pond, exceeded guideline limits for arsenic, cadmium and chromium. The Sabajo sediment sample, collected downgradient of the Cassador Pit, was found to exceed CCME guidelines for mercury. None of the samples with reported exceedances were collected in areas where fish were observed.

Additionally, based on preliminary screening, one sediment sample from Santa Barbara was submitted for laboratory analysis of petroleum hydrocarbons (including benzene, toluene, ethylbenzene, xylenes, diesel, gasoline and lube oil). All analyzed parameters were below detection.

Table 4.2-4 Summary of Sediment Parameter Exceedances for CCME Reference Standards

	Parameter[a]							
	Mercury	**Arsenic**	**Barium**	**Cadmium**	**Chromium**	**Lead**	**Selenium**	**Silver**
	mg/kg	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Reporting Limit	0.033	2.5		0.2			0.5	0.5
Reference Standards for Screening Evaluation								
ISQG	0.17	5.9	NV	0.6	37	35	NV	NV
PEL	0.486	17	NV	3.5	90	91.3	NV	NV
Santa Barbara Exceedances of Reference Standards								
ISQG	**1**	**1**	-	0	**1**	0	-	-
PEL	0	**1**	-	0	0	0	-	-
Margo Exceedances of Reference Standards								
ISQG	0	**2**	-	**2**	**2**	0	-	-
PEL	0	**2**	-	0	**1**	0	-	-
Cassador Pit Exceedances of Reference Standards								
ISQG	**1**	-	-	-	-	-	-	-
PEL	0	-	-	-	-	-	-	-

Source: Golder (2018a)

a) Results in milligrams per kilogram (mg/kg) dry weight for all metals with the exception of mercury which is presented in units mg/kg wet weight.

ISQG = Interim Sediment Quality Guideline; PEL = Probable Effects Level; NV = No value; - = not analyzed.

4.2.3.3 Water

Analytical Results

The four water samples collected were tested for pH, total suspended solids, alkalinity, and dissolved and total metals (including mercury). Water quality results are summarized in Table 4.2-5:

Table 4.2-5 Water Quality Results

Parameter	Fraction[a]	Unit	MAR-SW-01 (ASM Tailings Pond Runoff)	MAR-SW-02 (ASM Tailings Pond)	SB-SW-01 (ASM Sluice Runoff)	SB-SW-02 (In-stream)
Date			17/08/2017	17/08/2017	15/08/2017	16/08/2017
FIELD PARAMETERS						
pH		pH	-	-	-	7.07
Conductivity		µS/cm	-	-	-	162.5
Turbidity		NTU	-	-	-	24.3
Temperature		°C	-	-	-	28.7
Oxygen Reduction Potential		mV	-	-	-	0.4
Dissolved Oxygen		mg/L	-	-	-	5.03
GENERAL CHEMISTRY						
pH		pH	6.27 H	4.59 H	5.28 H	6.4 H
Specific Conductance		µmhos/cm	42.5	53.6	24.7	32.3
Total Dissolved Solids (TDS)		mg/L	22 H	27 H	<100 H	52 H
Total Suspended Solids (TSS)		mg/L	635 H	638 H	22,400 H	16 H
Hardness (Calculated)		mg/L $CaCO_3$	4.3	0.9	1	4.3
MAJOR IONS						
Total Alkalinity		mg/L $CaCO_3$	3	<1	<1 H	7.5
Bicarbonate		mg/L $CaCO_3$	3	<1	<1 H	7.5
Carbonate		mg/L $CaCO_3$	<1	<1	<1 H	<1
Chloride		mg/L	7.24	10.3	3.94	3.14
Fluoride		mg/L	<0.1	<0.1	<0.1	<0.1
Sulfate		mg/L	2.53	1.97	0.96	<0.3
Calcium	D	mg/L	0.921	0.36	0.315	1.88
Magnesium	D	mg/L	1.04	0.21	0.24	1.03
Sodium	D	mg/L	3.49	5.26	2.48	1.96
Potassium	D	mg/L	<0.5	0.73	<0.5	1.15
DISSOLVED METALS						
Aluminum	D	mg/L	<0.08	<0.08	<0.08	<0.08
Antimony	D	mg/L	<0.003	<0.003	<0.003	<0.003
Arsenic	D	mg/L	<0.003	<0.003	<0.003	<0.003
Barium	D	mg/L	0.0032	0.0033	0.0048	0.0046
Beryllium	D	mg/L	<0.0002	<0.0002	<0.0002	<0.0002
Boron	D	mg/L	<0.04	<0.04	<0.04	<0.04
Cadmium	D	mg/L	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	D	mg/L	<0.006	<0.006	<0.006	<0.006
Cobalt	D	mg/L	<0.006	<0.006	<0.006	<0.006
Copper	D	mg/L	<0.001	0.0011	<0.001	0.00101

Table 4.2-5 Water Quality Results

Parameter	Fraction[a]	Unit	MAR-SW-01 (ASM Tailings Pond Runoff)	MAR-SW-02 (ASM Tailings Pond)	SB-SW-01 (ASM Sluice Runoff)	SB-SW-02 (In-stream)
Iron	D	mg/L	0.268	<0.1	<0.1	2.56
Lead	D	mg/L	<0.003	<0.003	<0.003	<0.003
Manganese	D	mg/L	0.0492	0.0196	0.0126	0.0853
Mercury	D	mg/L	<0.0002	0.00161	<0.0002	<0.0002
Molybdenum	D	mg/L	<0.008	<0.008	<0.008	<0.008
Nickel	D	mg/L	<0.001	<0.001	<0.001	<0.001
Selenium	D	mg/L	<0.003	<0.003	<0.003	<0.003
Silver	D	mg/L	<0.0001	<0.0001	<0.0001	<0.0001
Thallium	D	mg/L	<0.001	<0.001	<0.001	<0.001
Zinc	D	mg/L	<0.01	<0.01	<0.01	<0.01
TOTAL METALS						
Aluminum	TR	mg/L	2.48	0.71	117	0.2
Antimony	TR	mg/L	<0.003	<0.003	<0.003	<0.003
Arsenic	TR	mg/L	0.0274	0.0138	<0.003	<0.003
Barium	TR	mg/L	0.0049	0.0045	0.184	0.0227
Beryllium	TR	mg/L	<0.0002	<0.0002	<0.0016	<0.0002
Boron	TR	mg/L	<0.04	<0.04	<0.04	<0.04
Cadmium	TR	mg/L	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	TR	mg/L	0.014	<0.006	0.565	<0.006
Cobalt	TR	mg/L	<0.006	<0.006	<0.006	<0.006
Copper	TR	mg/L	0.0027	0.0011	0.0453	<0.001
Iron	TR	mg/L	20.9	3.73	270	9.07
Lead	TR	mg/L	<0.003	<0.003	0.0536	<0.003
Manganese	TR	mg/L	0.0528	0.0207	0.174	0.165
Mercury	T	mg/L	<0.0002	0.0017	0.00152	<0.0002
Molybdenum	TR	mg/L	<0.008	<0.008	<0.008	<0.008
Nickel	TR	mg/L	0.001	<0.001	0.0217	<0.001
Selenium	TR	mg/L	<0.003	<0.003	<0.003	<0.003
Silver	TR	mg/L	<0.0001	<0.0001	0.000119	<0.0001
Thallium	TR	mg/L	<0.001	<0.001	<0.001	<0.001
Zinc	TR	mg/L	<0.01	<0.01	0.037	<0.01
NUTRIENTS						
Ammonia as N		mg/L	0.503	0.157	0.079	0.104
Nitrate/Nitrite as N		mg/L	<0.05	0.146	0.423	<0.05
Phosphorus	D	mg/L	0.05	0.09	<0.05	<0.05

a) Fraction: D = dissolved; T = total; TR = total recoverable
Data Qualification: H – analytical hold time exceedance

ASM = artisanal and small scale mining; mg/L = milligrams per liter; N = nitrogen; $CaCO_3$ = calcium carbonite; <= less than; NTU = nephelometric turbidity unit; µS/cm = microSiemens per centimeter; µmhos/cm = micromhos per centimeter; °C = degrees Celsius; mV = millivolt.

The two surface water samples from Santa Barbara were collected from a watercourse (stream) and from water flowing out of an active sluice. Fish were observed at the watercourse in Santa Barbara where one of the samples was collected.

The two surface water samples from Margo were collected from a tailings pond at the bottom of the sluice and from overland flow downgradient of the base of the tailings pond dam.

Water quality results are discussed in Section 4.8 (baseline water quality).

4.2.3.4 Fish

Screening Criteria and Standards

Fish tissue mercury concentrations were compared to the Health Canada criteria of total mercury for commercially-sold fish (Health Canada 2007).

Analytical Results

Twenty-eight (28) small forage fish (17 hatchetfish and 11 tetra fish) were collected by Golder field staff, from a stream located on the southern portion of the Santa Barbara active ASM area (i.e., at the same location as one of the sediment and surface water samples). Additionally, two wolf fish were collected from the Kleine Commewijne watershed, about 2 km downstream of the Santa Barbara ASM area, by ILACO field staff.

Mercury was detected in all fish tissue samples analyzed (three fish could not be analyzed due to the small sizes) at concentrations ranging from 0.19 to 0.98 micrograms mercury per gram (µg Hg/g) fish. Mercury concentrations in 9 (4 hatchetfish and 5 tetra fish) of the 28 small forage fish tissue samples exceeded the Health Canada criterion for total mercury content in commercially-sold fish. Hatchetfish and tetra are small forage fish that are found swimming as schools in small streams. These fish are unlikely to be consumed by humans.

In the previous ELA completed by Tetra Tech (2014a), hatchetfish were collected in in the vicinity of SB-F-1A (PFIS-02). Tetra Tech reported a total mercury concentration in fish tissue sample PFIS-02 of 0.63 mg/kg (i.e., µg Hg/g fish). This value was based on a composite sample of four hatchetfish collected from this location. The total mercury concentration reported by Tetra Tech for the composited hatchetfish tissue sample at PFIS-02 is similar to the average total mercury concentration for SB-F-1A (0.47 µg Hg/g fish) reported by Golder (2018a).

Mercury concentrations in the wolf fish were 0.58 µg Hg/g and 0.75 µg Hg/g. Both wolf fish tissue samples also exceeded the Health Canada criterion for mercury content in commercially-sold fish. Wolf fish is a predatory species of fish that could be consumed by people.

4.2.4 Existing Disturbance from Aerial Imagery

Based on an analysis of satellite imagery, the area disturbed to date by ASM activities at Sabajo, Santa Barbara and Margo is calculated to have increased to 423 ha as of August 2017, primarily due to a large added disturbance area at Santa Barbara since 2014 (Golder 2018a). The increased impact is, in part, due to extensive runoff of eroded materials/tailings downstream from excavated areas. A summary of the areas disturbed for Sabajo, Santa Barbara and Margo and the trend in these disturbances over time is provided in Table 4.2-6.

Table 4.2-6 Summary of Land Disturbance based on Aerial Surveys, August 2017

Location	Area of Disturbance in 2012 (ha)[(a)]	Area of Disturbance in 2014 (ha)[(a)]	Area of Disturbance in 2017 (ha)
Sabajo	43	65	66
Santa Barbara	90	114	348
Margo	0	0	9
Total	**113**	**179**	**423**

a) Source: Tetra Tech (2014a)

ha = hectare.

4.2.5 Uncertainties

The existing environmental conditions for Sabajo, Santa Barbara, and Margo ASM areas described in this section are current as of August 2017, as ASM is ongoing at Santa Barbara and Margo sites. Over the course of the 5-day site visit in August 2017, ASM operations were fluid and active sluices changed from day to day. Additionally, due to the large area disturbed at Santa Barbara, active ASM and the presence of workers, not all areas of the Site could be accessed by Golder in August of 2017, and observations could not be made in close proximity to the camps due to the presence of workers (Golder 2018a).

Mercury concentrations in samples collected by Golder (2018a) at the Sabajo (Cassador Pit) area were significantly lower than the values previously reported by Tetra Tech (2014a). The variation in the analytical data reported in 2014 and 2017 may be attributable to multiple factors. One factor could be the heterogeneity of the soil in the Cassador Pit area. It is possible that a soil sample collected only a few feet away from the original sampling location could have significantly different results. Furthermore, since the original soil samples collected by Tetra Tech were relatively shallow, any earthworks that may have taken place at the Cassador Pit could easily have distributed the soils in this area.

4.3 Regional Climate

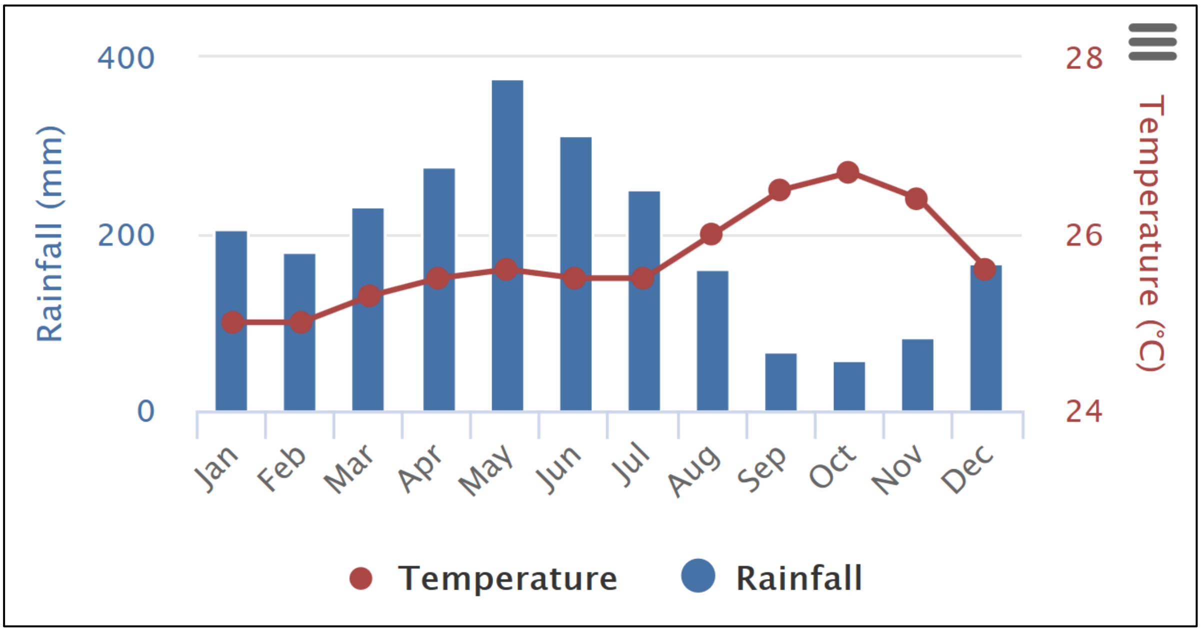
4.3.1 Introduction: The Climate of Suriname

Suriname is an area where both northeast and southeast trade winds may occur. Trade winds are very steady winds that usually blow from the same direction and with the same force every day. Where they converge in the “equatorial trough”, they cause an uplifting of the air, which causes clouds to condense and rain to fall if sufficient moisture is available. The equatorial trough, which is influenced by variations in the general circulation of the air, is the most decisive factor in creating the climate of Suriname (ERM 2013).

In general, Suriname has a tropical climate influenced by year-round trade winds from the northeast with four distinct seasons:

- short rainy season: mid-December to mid-February;
- short dry season: mid-February to mid-April;
- long wet season: mid-April to mid-August; and
- long dry season: mid-August to mid-December.

Figure 4.3-1 Average Monthly Temperature and Rainfall for Suriname from 1901 to 2015



Source: The World Bank Group, 2017.
°C = degrees Celsius; mm = millimeter.

The long-term, annual mean rainfall in Suriname (1901 – 2015) varies between approximately 1,450 millimeters (mm) at low-lying areas such as Coronie to 3,000 mm in the mountainous regions such as Tafelberg, and overall averages 2,379 mm for the period of record.

The monthly rainfall shows a seasonal cycle, which is caused by the meridional movement of the Inter-tropical Convergence Zone. The higher rainfall in certain parts of the interior results when moist winds are forced up over the mountain slopes to higher, colder altitudes where the water condenses (orographic rains). In Suriname, the monthly rainfall is typically highest in May-June and lowest in

September-October. Sibibusi (heavy thunderstorms) normally occur in July and August, but can also occur between September and November.

Mean air temperature is 26.2 to 28.2 degrees Celsius (°C) with January being the coldest month and September and October being the warmest months. The relative humidity is high to very high (80 to 90 percent [%]). The occurrence of hurricanes in Suriname is very rare.

4.3.2 Methods

4.3.2.1 Sabajo Climate Data Collection

The climate summary provides the meteorological data collected at the Newmont Suriname, LLC. (Newmont) Sabajo Project (the Project) site from 11 November 2011 through 31 December 2016. The meteorological (met) station is located approximately 50 meters (m) north of the entrance to the Sabajo site and was installed and configured to collect data in accordance with the Sabajo Mine Exploration Camp Meteorological Monitoring Station Installation and Operations Report (December 16, 2011). Ramboll Environ Corporation (Ramboll Environ) supported the monitoring program during the period of record by reviewing and archiving data completion of one annual on-site calibration, technical support for operations and data collection, and preparation of an annual report.

The met station is used to monitor and collect local weather data in support of permitting activities and will provide baseline meteorological data necessary for a site-specific evaluation and comparison to historical data. The quality assurance goals and objectives have been identified so that data will meet project goals and provide quality representative meteorological data for the Sabajo site. The location of the monitoring station with respect to the overall project site development can be seen in Map 4.3-1.

The station was originally installed on 8 to 11 November 2011 and is configured to collect ambient data in 15-minute, 60-minute, and 24-hour output tables for the following parameters:

- horizontal and vertical wind speed;
- horizontal wind direction and wind direction standard deviation;
- temperature;
- humidity;
- solar radiation;
- barometric pressure;
- pan evaporation; and
- precipitation.

An annual quality assurance calibration procedure was conducted by Ramboll Environ on 25 March 2016 using National Institute of Standards and Testing (NIST) certified sensors. At the time of the calibration, all sensors were operating within project accuracy goals and routine maintenance was performed to ensure continued sensor accuracy and continued operation. In 2017, the battery malfunctioned in March and was not reinstalled until August 2017. For this reason the data collected in early 2017 is deemed as unreliable. The calibration performed in December 2017 has corrected the issues and regular maintenance will be conducted going forward.

4.3.2.2 Monitoring Station Configuration

Based on the project requirements, technical knowledge was used in selecting a site that would allow the instruments to function under optimum conditions with the surrounding area and would be representative of met conditions at the site.

The met station is a 10 m three-sided aluminum lattice tower equipped with a lightning protection system and Campbell Scientific Inc. CR1000 data logger enclosed in a weather proof enclosure attached to the tower. Sensors on the tower are located at 2 and 10 meters above ground level (m agl). In addition, a precipitation sensor is located at 1 m agl and a 25.4 centimeters (cm) deep by 102.6 cm wide cylindrical stainless steel evaporation pan and float sensor are located on a concrete pad; both in close proximity to the tower. The station is configured to measure the following parameters:

- average (avg), maximum (max) and minimum (min) 10 m horizontal wind speed;
- 10 m horizontal wind direction;
- 10 m wind direction standard deviation;
- avg, max, and min 10 m vertical wind speed;
- avg, max and min 2 m ambient temperature;
- avg, max and min 2 m ambient relative humidity;
- avg, max and min 2 m solar radiation;
- avg, max and min station barometric pressure;
- total precipitation;
- avg, max, and min pan evaporation rate; and
- min battery voltage.

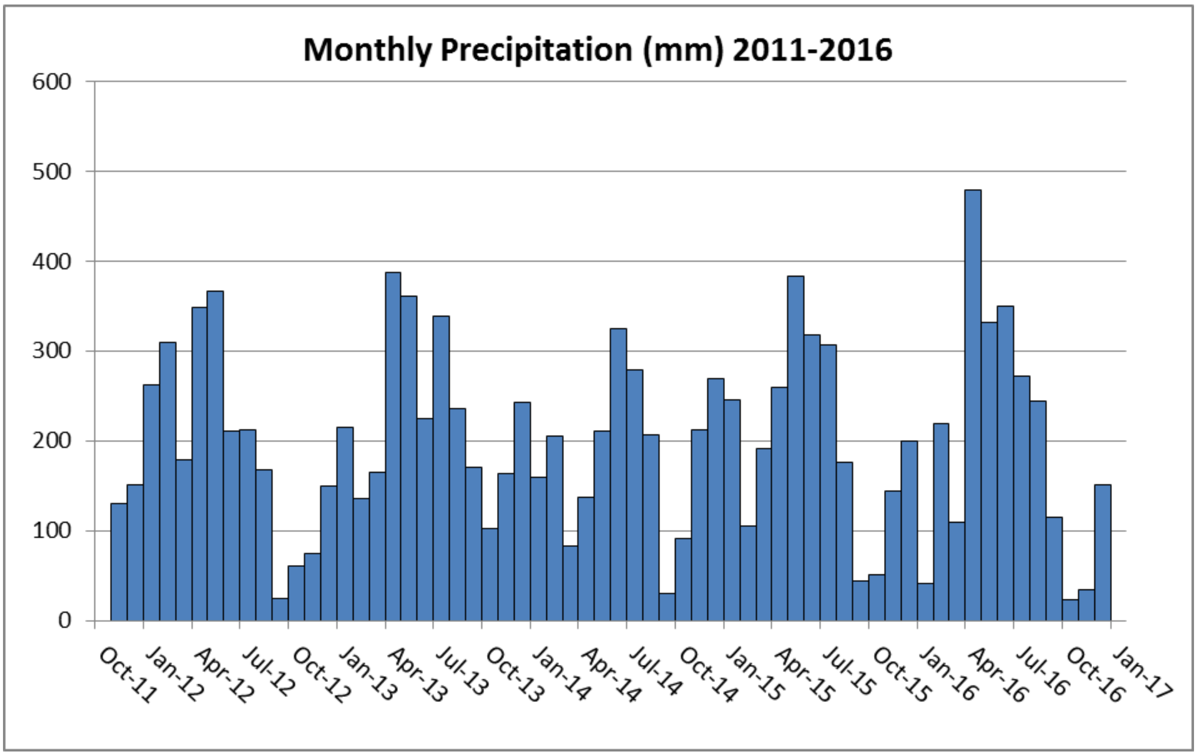
All data is recorded to the CR1000 in 15-minute, 60-minute, and 24-hour (midnight to midnight) output tables. The station is powered by a 12 Amp Hour battery and 20 watt solar panel. A 6 foot chain link fence was installed around the site after the installation was completed, with access provided by an east-facing gate entrance.

4.3.3 Results

4.3.3.1 Precipitation

Figure 4.3-2 shows the precipitation record for the Sabajo site from 2011 to December 2016. Average annual precipitation at Sabajo ranges from a minimum of 2,209 mm in 2015 to a maximum of 2,740 in 2013. Overall average precipitation at Sabajo is 2,422 mm for the period of record. The average annual precipitation at Sabajo from 2010 to 2016 is very similar (less than a 1% difference) to the annual average precipitation at Merian (2,382 mm) and within the range measured at the regional gauges.

Figure 4.3-2 Sabajo Project Monthly Total Recorded Precipitation from 2011 to 2016

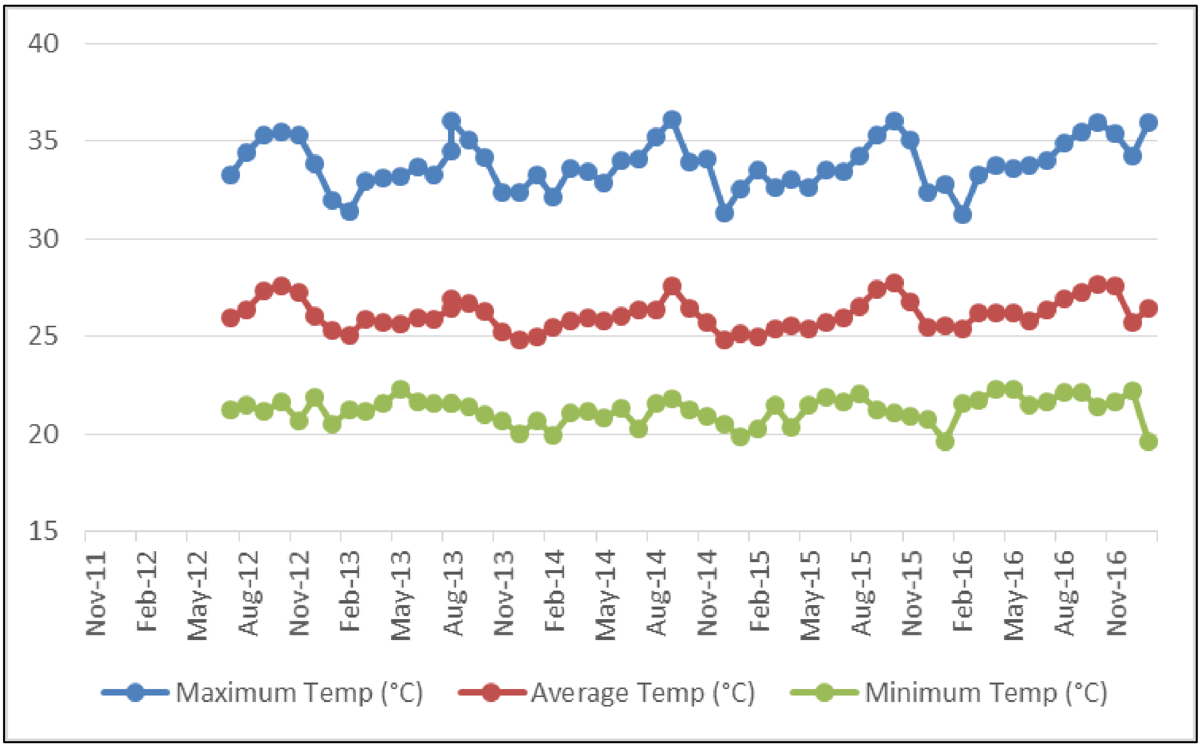


mm = millimeter.

4.3.3.2 Temperature

Figure 4.3-3 shows the temperature record for the Sabajo site from 2011 to December 2016. Average monthly temperature at Sabajo ranges from 27.7 °C in October to 24.8 °C in January. Maximum temperatures ranged from 31.3 to 36.1 °C in the dry months from August through October. Low temperatures ranged from 19.6 to 22.3 °C usually in the dry months although low nighttime temperatures were recorded in the wet seasons also.

Figure 4.3-3 Sabajo Project Monthly Recorded Temperatures from late 2011 to 2016

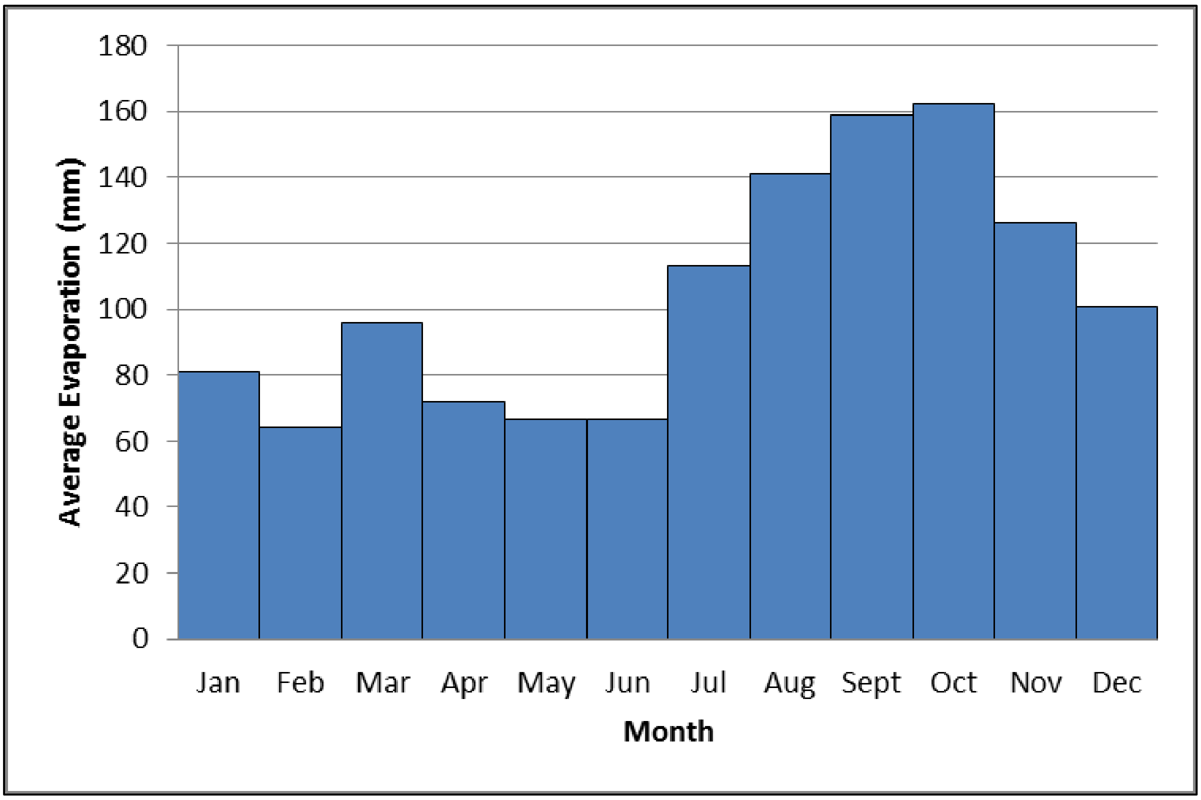


°C = degrees Celsius.

4.3.3.3 Evaporation

A summary of the evaporation data collected from November 2011 to December 2016 is presented in Figure 4.3-4. Annual average evaporation is 1,248 mm. It should be noted that this is approximately 15% less than the average evaporation at Merian (Table 4.3-1), with most of the decreases occurring in the wetter months of January, February, and April to June.

Figure 4.3-4 Sabajo Project Average Monthly Evaporation from 2011 to 2016



mm = millimeter.

Table 4.3-1 Sabajo-Merian Comparison of Monthly Average Evaporation

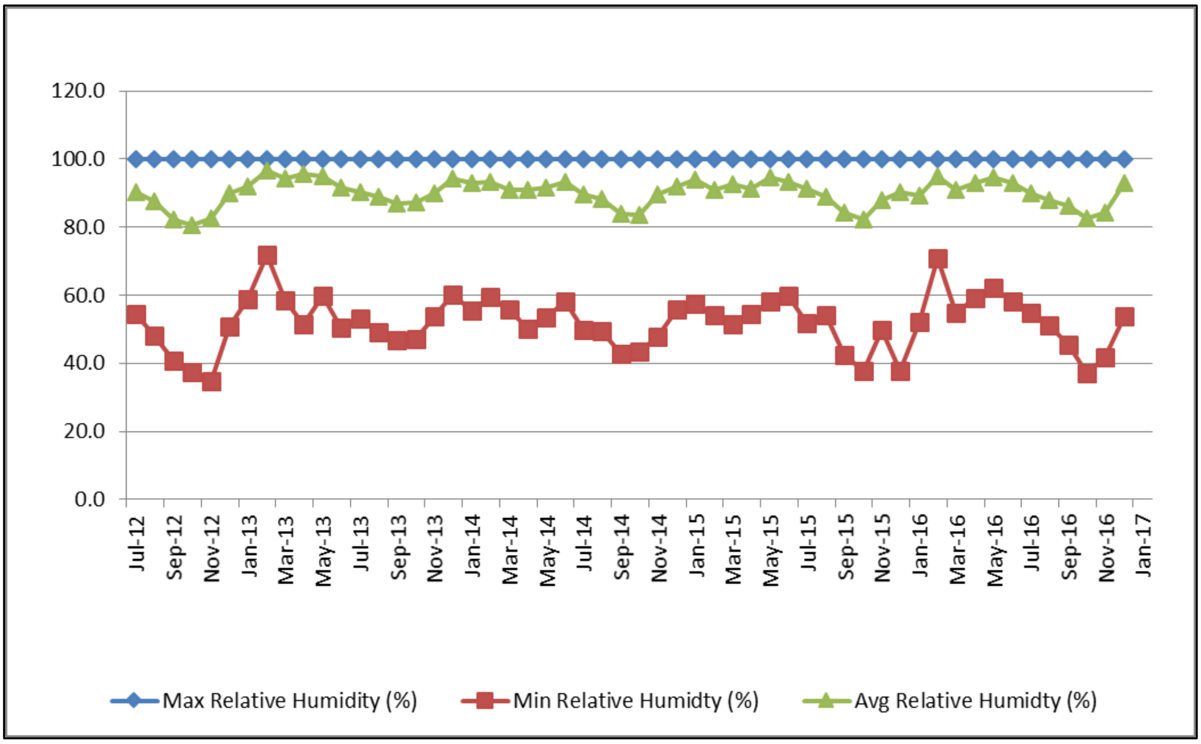
Month	Average Evaporation (mm)	Merian Average Evaporation (mm)	Percent Difference
Jan	81	112	28%
Feb	64	103	38%
Mar	96	93	-3%
Apr	72	124	42%
May	67	104	36%
Jun	67	119	44%
Jul	113	126	10%
Aug	141	155	9%
Sept	159	152	-4%
Oct	162	153	-6%
Nov	126	115	-10%
Dec	101	116	13%
TOTAL	**1248**	**1472**	**15%**

mm = millimeter; % = percent.

4.3.3.4 Humidity

A summary of the relative humidity data collected between November 2011 to December 2016 is presented in Figure 4.3-5. As expected, the relative humidity is consistently at a high percentage due to the amount of rainfall received at the site. Average relative humidity ranges from 80 to 85% in the long dry season (August through December). Minimum humidity ranges from 35 to 72%, with the lowest values being observed in the dry seasons, however maximum humidity measured was 100% during all seasons.

Figure 4.3-5 Sabajo Project Monthly Relative Humidity Data from 2011 to 2016



% = percent.

4.3.3.5 Barometric Pressure

As expected due to the low elevation, the barometric pressure was close to sea level pressure (760 millimeters of mercury [mm/Hg]) with pressure decreases mainly due to passing low pressure weather systems. Average barometric pressure over the period of record ranged from 750 to 755 mm/Hg. Minimum barometric pressure ranged from 701 to 751 mm/Hg. Maximum barometric pressure ranged from 757 to 782 mm/Hg (Table 4.3-2).

Table 4.3-2 Sabajo Barometric Pressure Observations

Month	Maximum 1-Hour Average Barometric Pressure (mm/Hg)	Minimum 1-Hour Average Barometric Pressure (mm/Hg)	Average Barometric Pressure (mm/Hg)
January	756.8	750.7	753.55
February	786.6	749.7	753.36
March	781.8	700.9	749.61
April	756.6	748.7	752.65
May	769.2	725.6	752.18
June	765.1	740.3	751.2
July	760.1	743.7	751.68
August	767	731.6	750.37
September	755.8	749.5	753.23
October	755.1	747.3	751.67
November	754.7	747.7	751.24
December	754.7	748.5	752.15
2016 Annual	786.6	700.9	751.91

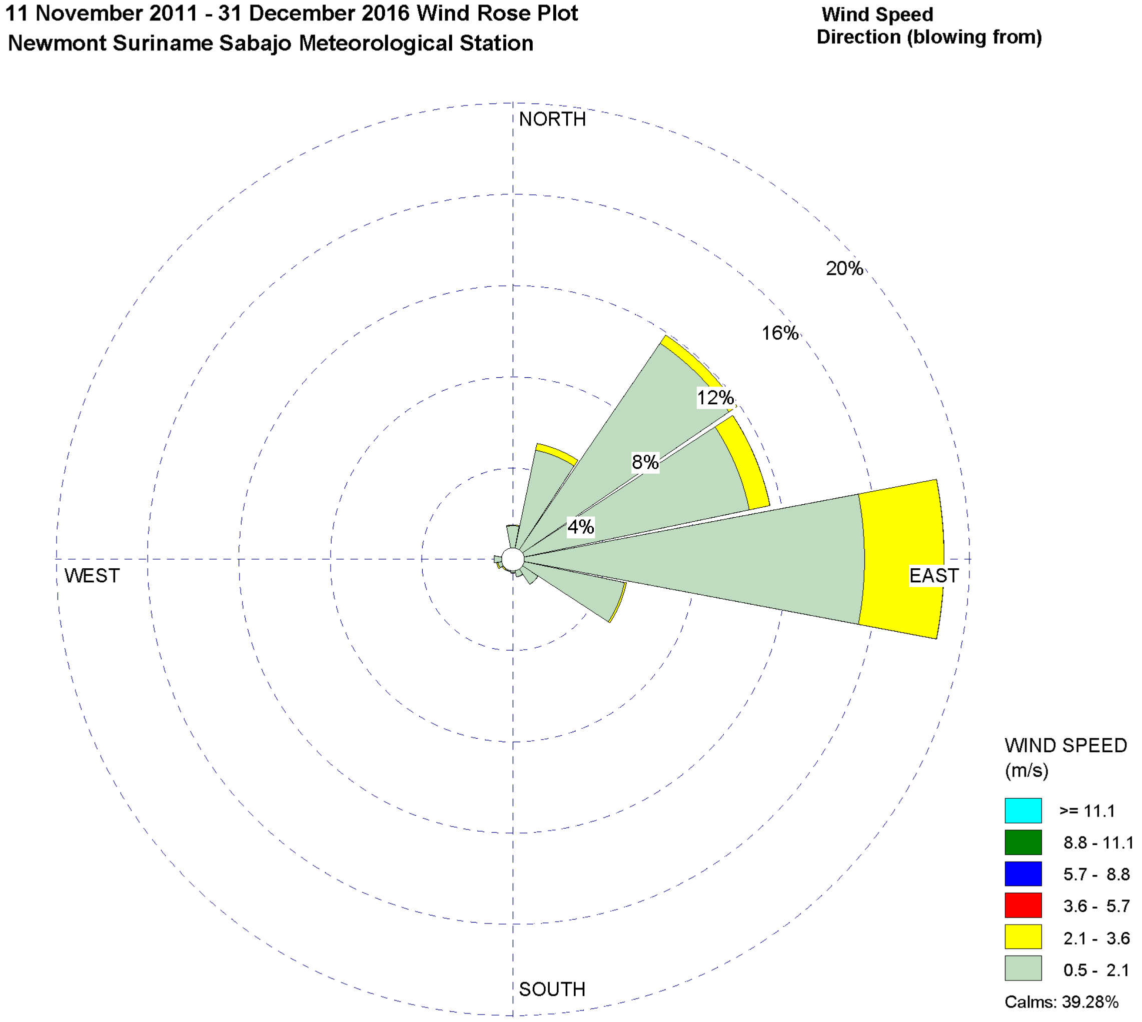
mm/Hg = millimeters of mercury.

4.3.3.6 Wind Speed and Direction

Wind data was characterized by approximately 94% of winds blowing from the east and northeast. This pattern may be due to the orientation of the immediate topography at the site, in conjunction with coastal-influenced weather patterns. A visual presentation of wind speed and wind direction for the monitoring period is presented a wind rose diagram (Figure 4.3-6). The wind rose diagram demonstrates that this site was not exposed to extreme wind conditions, but instead incremental mild winds, almost entirely out of the east and northeast.

The average wind speed at the 10 m level for the duration of monitoring period was 0.86 meters per second (m/s). The maximum hourly average wind speed recorded during the period of record was 4.4 m/s. The elevated wind gusts were, on almost every occasion associated with a rain-producing storm event out of the east. The wind data from the site demonstrates that overall the site experiences very little wind and most measureable wind is associated with storms that travel from east to west. Thirty nine percent of the wind speed was recorded as calm (less than 0.5 m/s), 55% was recorded between 0.5 and 2.1 m/s and all recorded wind speeds were below the 5.7 to 8.8 m/s wind class.

Figure 4.3-6 Sabajo Wind Rose Diagram



% = percent; m/s = meters per second; >= = greater than or equal to.

4.4 Geomorphology, Terrain and Soils

4.4.1 Introduction

This section provides a summary of baseline conditions for geomorphology, terrain and soils. Geomorphology is the study of landforms, their processes, form and sediments at the earth's surface. Terrain refers to the physical characteristics of the natural features of an area, i.e., its landforms, vegetation and soils (Whittow 2000). Soil refers to the natural medium that plants grow in; they are a natural body consisting of layers (soil horizons) that are composed of weathered mineral materials, organic material, air and water. Soil is the end product of the combined influence of climate, topography, organisms (flora, fauna and human) on parent materials (original rocks and minerals) over time.

Activities associated with the Sabajo Project (the Project) will result in soil disturbance and could potentially modify geomorphology or terrain conditions. In order to perform an assessment of the potential effects of the Project on geomorphology, terrain and soil resources caused by Project activities, it is important to understand existing baseline conditions.

To describe baseline conditions, a study area was defined (Section 4.1, Map 4.1-2). Existing information including a 1:100,000 scale reconnaissance soil map conducted by Soil Survey Department Suriname (SSDS; 1977), geology maps and reports (GMD 1977; Bosma et al. 1984; Kroonenberg et al. 2016), and terrain and geomorphology reports and maps (O'Herne 1966, 1969) were initially used to ascertain the general characteristics of the Project study area. Following a review of this data, a reconnaissance field visit was conducted on July 26 and 27, 2017 followed by field investigations on 7-9 August and again on 14-19 August 2017 by ILACO Suriname N.V. (ILACO) to collect site-specific data within or adjacent to the Project study area. This methodology is a similar approach to describing baseline conditions as was used for the Merian Gold Mine (Merian mine) Environmental and Social Impact Assessment (ESIA). The Merian mine is located approximately 30 kilometers (km) east of the Project, and has similar elevations, topography and soil conditions as the Project study area.

The methods and results of the geomorphology, terrain and soil field program are described in detail in the Baseline Report: Geomorphology and Soils Report (ILACO 2017a), and are summarized in this section of the ESIA.

4.4.2 Project Physical Impact Area

The Project study area includes the Project's Physical Impact Area (PPIA) which was specifically targeted for baseline data collection because it is most likely to be disturbed as a result of the Project. This includes mine pits, waste rock facilities, ore stockpile areas, campsite and facility areas, and the Sabajo-Merian Haul Road. The PPIA within the Sabajo Concession is shown in Map 4.1-2. Not all of the PPIA will necessarily be disturbed by the Project, as discussed in the impact assessment.

4.4.3 Methods

The Baseline Report (ILACO 2017a) builds primarily on information contained in the existing soil map for Suriname (SSDS 1977). Additional field data was collected in order to characterize and refine soil map units previously described and mapped for the PPIA. The field survey was conducted in accordance to guidelines developed by the Soil Survey Division Staff (1993) and Food and Agricultural Organization (FAO; 1977).

4.4.3.1 Site Selection

Transects

Using the existing soil map (SSDS 1977) to assess landscape and soil patterns, 11 areas within the PPIA were chosen within which to locate transects used to characterize baseline geomorphology and soil conditions. These transects, or catina sequences, were laid out so that they crossed the major elements within their respective landscapes (e.g., valley, footslope, slope and hill top). Several survey sample sites were planned for each transect with a planned depth of 120 centimeters (cm) for each soil pit.

Representative Profile Sites

Representative soil profiles, used to characterize major soil units were chosen in the field in order to survey all major local soil types, and was based partly on accessibility (Map 4.4-1). These sites were described in more detail than the transect sites and samples were collected for later laboratory analysis. Profiles were sampled and described using FAO (1977) methods and terminology.

4.4.3.2 Soil Sample Collection and Analysis

Soil sample collection for analysis was conducted at two site types, road cut sites and pollution sites.

At road cut sites, sampling was conducted to assist in describing and classifying the major soil types, and to assist with the characterization of soil quality. At each road cut site, composite topsoil samples were collected. Composite samples were taken from the 0 to 20 cm topsoil layer in forested areas adjacent to each site. Analysis included measures for soil physical characteristics (soil moisture, bulk density, permeability) and soil quality (pH, organic matter, total nitrogen (N) and phosphorus (P), exchangeable cations, base saturation, particle size). Samples were analyzed at the soil laboratory of the University of Suriname. Analyses are described in Annex 2 of the Baseline Report (ILACO 2017a).

Selected transect sites included sampling for the determination of baseline levels of soil contaminants for comparison against levels found in areas with existing artisanal and small scale mining (ASM). The sample sites were situated in undisturbed areas away from ASM and were assumed to be unaffected by ASM. Composite sampling was conducted at the physiographic positions typically affected by ASM activities: lower hill slope, footslopes and creek valley. At each location a 40 by 40 meters (m) area was selected within which 15 subsamples, collected between 0 and 20 cm, were taken. The samples were sent for analysis by Eurofins Analytico in the Netherlands. These analyses are also described in Annex 2 of the Baseline Report (ILACO 2017a).

4.4.3.3 Soil Mapping

The soil map provided as part of this report is a subset of the Reconnaissance Soil Map of Northern Suriname (SSDS 1977). A new legend, containing modified descriptions of the original soil map units, was developed. It was based on results of the soil survey and includes FAO (2014) equivalent soil subgroups for selected soil map units.

Note that the original 1:100,000 reconnaissance level soil mapping (SSDS 1977) did not adhere to FAO (1977, 2014) standards and more closely resembled a surficial geology map in that soil subgroups were not described. The original mapping contained soil map unit descriptions with information including: landscape position (e.g., plateau, valley bottom), drainage (e.g., well, poorly), and textural information (e.g., sand, gravelly clay). The soil map interpretations for this report include FAO classifications for the original soil map units when sufficient data for such interpretations was available. No new soil mapping was undertaken for this project and the Soil Survey Department Suriname (SSDS; 1977) soil mapping is unaltered with the exception of the legend.

4.4.3.4 Soil Characterization

The soil descriptions from the field survey were used to test the veracity of the SSDS (1977) soil map units delineated and described in the reference soil map. When possible, soil map units were classified according to rules laid out by FAO (1977, 2014).

The Land Suitability Classification System used in this report was based on the FAO system for land evaluation (FAO 1977) and modified by Melitz (1978) and Melitz and Alderlieste (1978) for application in Suriname. The classification system is broken down into three land use types: annual crops, perennial crops and livestock (cattle) pasture and ratings split into four classes: highly suitable, moderately suitable, marginally suitable and not suitable. The suitability class of a soil profile is determined by the lowest or most limiting rating, but in cases where there are more than three minimum ratings, the suitability class is set at one class below the lowest rating. The results of this evaluation were applied to the re-interpreted reference soil map (SSDS 1977).

For a detailed description of the Land Suitability Classification System and the Fertility Capability Soil Classification System (FCC) developed by Sanchez et al. (2003), refer to the Baseline Report (ILACO 2017a).

4.4.4 Results

Representative soil profiles were established at six road cut locations. A total of 30 soil horizon samples were collected for soil property characterization and soil classification. Samples for determining soil moisture, bulk density and permeability were only collected at three of the road cut locations, due to high gravel content.

Prior to the field survey, five transect locations were eliminated due to a lack of access at the time of the survey, leaving six locations. The Sabajo-Merian Haul Road transects were among the locations not surveyed. Within the six remaining transects, a total of 37 soil survey sites were described. Of the 37 sites, 20 were surveyed to full depth (120 cm) due to high gravel content or the presence of stones. The average depth of the other 17 survey locations was approximately 80 cm. In total, 38 undisturbed sites were sampled for physical characterization. Composite samples for the ASM pollution study were collected at five sites along two transects. The locations of sample sites and transects are presented in Map 4.4-1.

4.4.4.1 Bedrock Geology

The Sabajo Concession is situated in the Marowijne Greenstone Belt within the Precambrian Guiana Shield (Bosma et al. 1984; Kroonenberg et al. 2016). Bedrock is predominantly of the Paramaka and Rosebel Formations. The Paramaka Formation is comprised of phyllites and metacherts, among others; the Rosebel Formation is composed of quartz sandstone and conglomerates. Apatoe Dolerites form two parallel dykes within the Sabajo-Merian Haul Road, which corresponds to the Narrow and Steep Low Ridge landscape unit, while much of the eastern part of the road corridor crosses through terrain developed on metagraywackes and phyllites of the Armina Formation.

4.4.4.2 Geomorphology and Terrain

Regional Context

The Guiana Shield has been shaped over billions of years by tectonic movements, weathering, denudation and sedimentation under a range of historic climate regimes. Physical and chemical processes, acting on the landscape since the Cretaceous Period, have determined its current form (Noordam 1993).

Sabajo Concession and Potential Sabajo-Merian Haul Road

The highest point in the region within and adjacent to the Sabajo Concession is found at the Adelaarstop at an elevation of 399 meters above sea level (masl). Most of the surrounding land is much lower and comprises hill land and ridges with elevations between 25 and 100+ masl. The steepest slopes exceed 50 percent (%; SSDS 1977).

The landforms and landscape units found in the Sabajo Concession and near the Sabajo-Merian Haul Road are presented in Figures 2 and 3 of the Baseline Report (ILACO 2017a). Four landform units are mapped within the concession (SSDS 1977), including: undulating and rolling lowland, hilly and steeply dissected low and moderately high land, narrow and steep low ridges, and mountainous land.

The Sabajo Concession has a northwest-southeast running central zone mapped as "hilly and steeply dissected low and moderately high land" with "undulating and rolling lowland" to the north and south of this zone. These units are defined by differences in elevation, degree of dissection and slope gradient. The latter landform is less dissected and has a lower drainage density and lower slope values than the first. Elevations are typically between 25 and 75 masl. Narrow and steep low ridges are found in the northeast portion of the Sabajo Concession and also bisecting the Potential Project Access Road. This landform follows a roughly south-north path and has an elongated form, but the unit does not clearly contrast with the landscape surrounding it.

The majority of the Sabajo-Merian Haul Road will traverse the "hilly and steeply dissected low and moderately high land" (Map 4.4-1).

4.4.4.3 Soil Map Units

Regional Context

The regolith in which the soils of the Guiana Shield have developed is typically deep and intensively weathered. The soils have been eroded several times, coinciding with drier stages, which occurred during glacial periods of the Pleistocene. After denudation events, soil formation processes often had to start over again on the newly exposed regolith (De Boer 1972; King et al. 1964; Kips and Snel 1979; Noordam 1993).

Sabajo Concession and Sabajo-Merian Haul Road

The soil map of the Sabajo Concession and surrounding region is shown in Map 4.4-1. Table 4.4-1 contains a legend with the original and re-interpreted descriptions of selected SSDS (1977) soil map units along with FAO (2014) equivalent soil subgroups. The landscape and soil map units from the SSDS (1977) reconnaissance survey did not always show strong correlation with field observations and the description of some soil units required modification to match site conditions. The table contains brief descriptions of each major soil map unit found in the Sabajo Project Physical Impact Area and those bisected by the Sabajo-Merian Haul Road. For detailed descriptions of map units, and how FAO classifications were derived, please refer to the Baseline Report (ILACO 2017a).

The majority of the Sabajo Project Physical Impact Area (footprint) is located in the Donderbari landscape unit (1,103.9 hectares [ha]; 71.2%) where most of the field work was concentrated (Table 4.4-2). Approximately 280 ha (18.0%) occurs within the Tibiti landscape unit. Most of the remaining area is contained in two landscape units; Tempati, located within the mine area and the road corridor (94.8 ha; 6.1%) and Compagnie, located in two areas along the south border of the mine area (66.8 ha; 4.3%). The Sabajo-Merian Haul Road bisects the Donderbari (approximately [~]14.3 km), the Lucas (~0.8 km), the Tempati (~12.8 km) and the Tibiti (~1.9 km) landscape units.

Table 4.4-1 Soil Map Unit Legend for Major Soil Subgroups Found Within the Project Physical Impact Area and Crossed by Sabajo-Merian Haul Road[a]

Landform	Landscape Unit	Landscape Position	Map ID Number	SSDS Description	Re-interpreted Descripiton	FAO Classification[b]
Undulating and rolling low land (steepest slope 2-16%; 10-100 masl	**Tibiti**	Plateau and hill top	**43**	(Moderately) well and imperfectly drained sandy (clay) loam, often over sandy clay; locally gravelly clay	nd	Same as number 44[d]
		Plateau and slope	**44**	Moderately well and imperfectly drained sandy (clay) loam and (sandy) clay, locally with gravelly surface	nd	*Moderately well drained:* Acric Xanthic FERRALSOL (Clayic)[c] Acric Xanthic FERRALSOL (Loamic)[c] *Imperfectly drained:* Albic Dystric STAGNOSOL (Loamic)[c] Albic Dystric STAGNOSOL (Arenic)[c] Acric Xanthic FERRALSOL (Clayic, Gleyic) Acric Xanthic FERRALSOL (Gleyic, Loamic)
		Valley bottom and footslope	**46**	Poorly drained sand, sandy loam to clay	nd	Dystric Oxygleyic GLEYSOL (Loamic)[d] Dystric Fluvic Oxygleyic GLEYSOL[d]
	Compagnie	Plateau and slope	**47**	Imperfectly drained sand, sandy (clay) loam and clay, often gravelly	Well drained slightly gravelly to gravelly clay loam over slightly gravelly silty clay; silty saprolite in subsoil >100 cm	Acric FERRALSOL (Alumic, Amphi-Loamic, Dystric, Vetic)
		Valley bottom, footslope and depression	**48**	Poorly drained sandy loam, often gravelly	Imperfectly to poorly drained loam and clay, often quartz gravelly	Dystric Oxygleyic GLEYSOL (Epi-Loamic)
Hilly and steeply dissected low and moderately high land (steepest slope 16-30+%; 10-300 masl)	**Tempati**	Hilltop	**64**	Well drained gravelly clay	nd	Same as 67[c]
		Slope	**65**	(Moderately) well drained gravelly clay	nd	Same as 68[c]
		Valley bottom and footslope	**66**	Poorly drained loam to clay	nd	Dystric Oxygleyic GLEYSOL (Loamic)[d] Dystric Fluvic Oxygleyic GLEYSOL (Clayic)[d]

Table 4.4-1 Soil Map Unit Legend for Major Soil Subgroups Found Within the Project Physical Impact Area and Crossed by Sabajo-Merian Haul Road[a]

Landform	Landscape Unit	Landscape Position	Map ID Number	SSDS Description	Re-interpreted Descripiton	FAO Classification[b]
Hilly and steeply dissected low and moderately high land (steepest slope 16-30+%; 10-300 masl)	**Donderbari**	Hilltop	**67**	Well drained very gravelly clay, locally iron- stone at the surface	Well drained gravelly clay, occasionally very gravelly clay	Pisoplinthic FERRALSOL (Alumic, Clayic, Dystric, Vetic) Humic Pisoplinthic FERRALSOL (Alumic, Clayic, Dystric, Vetic)
		Slope	**68**	Well drained very gravelly clay	Well drained gravelly clay, occasionally very gravelly clay	Humic FERRALSOL (Clayic, Dystric, Vetic) Humic Pisoplinthic Xanthic FERRALSOL (Clayic, Dystric, Vetic)
		Valley bottom and footslope	**69**	Poorly and imperfectly drained clay, locally very gravelly	Valley bottom: Poorly drained loam and clay loam over clay, loam layers have variable quantities of fine, medium and coarse sand	Dystric Oxygleyic GLEYSOL (Loamic)
					Locally: Soils with heterogeneous textures and sand fractions in subsequent layers	Dystric Fluvic Oxygleyic GLEYSOL (Abruptic, Epi-Loamic)
					Lower footslope: Imperfectly and poorly drained, white to light gray loam and clay loam	Albic Dystric STAGNOSOL (Loamic)
					Locally: Poorly drained fine, medium and coarse loamy sand	Albic Dystric STAGNOSOL (Arenic)
Narrow and steep low ridges (steepest slope 25-50+%; 10-100 masl)	**Lucas**	Ridge and slope	**72**	Excessively to well drained gravelly clay, locally ironstone and stones at the surface	nd	Pisoplinthic FERRALSOL (Alumic, Clayic, Dystric, Vetic)[c]

a) Only major soil map units within the Mine Physical Impact Area and Sabajo-Merian Haul Road are described.

b) Classification based on field data unless otherwise noted. Following are the FAO subgroups associated with each site: NS01 - Pisoplinthic FERRALSOL (Alumic, Clayic, Dystric, Vetic), NS02 - Humic FERRALSOL (Alumic, Clayic, Dystric, Vetic), NS03 - Humic Pisoplinthic FERRALSOL (Alumic, Clayic, Colluvic, Dystric, Vetic), NS04 - Humic Pisoplinthic FERRALSOL (Alumic, Clayic, Dystric, Vetic), NS05 - Acric Pisoplinthic FERRALSOL (Alumic, Amphi-Loamic, Dystric, Vetic), NS06 - Humic Pisoplinthic Xanthic FERRALSOL (Alumic, Clayic, Dystric, Vetic).

c) Classification based on Sanchit 1972.

d) Classification based on professional opinion of local soil scientist and described as “likely” in the Baseline Report (ILACO 2017a).

ID = identification; SDSS = Soil Survey Department Suriname; FAO = Food and Agricultural Organization; masl = meters above sea level; > = greater than; + = plus; cm = centimetre; % = percent; nd = no field data.

Table 4.4-2 Soil Map Unit Area and Linear Summaries for the Project Physical Impact Area and the Sabajo-Merian Haul Road

Landscape Unit	Soil Map Unit	Project Physical Impact Area		Sabajo-Merian Haul Road	
		Area (ha)	Proportion (%)	Linear Distance (m)	Proportion (%)
Tibiti	**43**	109.4	7.1	826	2.8
	44	142.8	9.2	952	3.2
	46	27.2	1.8	91	0.3
Compagnie	**47**	43.8	2.8	-	-
	48	23.0	1.5	-	-
Tempati	**30**	0.4	<0.1	60	0.2
	64	39.1	2.5	5467	18.4
	65	42.9	2.8	5609	18.8
	66	12.3	0.8	1662	5.6
Donderbari	**67**	462.8	29.8	5496	18.5
	68	561.9	36.2	6786	22.8
	69	79.2	5.1	1996	6.7
Lucas	**72**	6.1	0.4	828	2.8
Totals		**1551.1**	**100.0**	**29773**	**100.0**

% = percent; ha = hectare; m = meter; <= less than; - = not applicable.

4.4.4.4 Soil Analysis

Simplified results of chemical and physical analyses are presented in this section. For detailed results, please refer to the Baseline Report (ILACO 2017a).

Most profiles show an increase in clay percentage with depth, usually followed by a gradual decrease. Most soils contain iron gravel and occasionally also quartz gravel. The textural class of the Donderbari landscape unit sample sites all are clay, sometimes with a very high clay content. The samples from the Compagnie landscape unit are mostly clay loam textures with silt in the saprolite layer. A few soil horizons are slightly gravelly (2% to 15%), but most are either gravely (15% to 50%) or very gravely (50% to 90%).

There is little variation between samples for many of the soil chemical parameters. All soils are acid, have a very high aluminum saturation and a very low base saturation. All contain low to fair quantities of organic matter, and have a low cation exchange capacity value. All soils are very low in primary weatherable minerals, and thus have low nutrient capacity reserves. Virtually all nutrient reserves are found in the upper portion of the soil profiles, which is the only source for nitrogen and for much of the phosphorus (P) and sulfur. Total P is typically fair, but available P is low. In general, sampled soils are high in acidity and low in fertility.

Bulk density ranges between 1.29 and 1.46 grams per cubic centimeter. Total porosity is around 50%. Both are considered normal for this region, although Melitz & Alderlieste (1978) found higher bulk densities and lower porosity values for sandy loam and clay loam soils in the Nassau area. Available moisture is fair, ranging between 11% and 21%. Air capacity is low to high (greater than 3% to greater than 5%). Permeability is typically high, which is expected for well drained profiles.

4.4.4.5 Land Suitability and Fertility Capability Soil Classification

The results of Land Suitability and Fertility Capability Classification are presented in Table 4.4-3. For a discussion on how ratings were derived, consult the Baseline Report (ILACO 2017a).

Table 4.4-3 Land Suitability and Fertility Capability Ratings by Soil Map Unit

Landscape Unit	Soil Map Unit	Overall Land Suitability Rating			Fertility Rating (FCC)
		Annual Cropping	Perennial Cropping	Pasture (cattle grazing)	
Tibiti	43	marginally suitable	moderately suitable-marginally suitable[d]	moderately suitable	Laek
	44	marginally suitable	moderately suitable-marginally suitable[d]	moderately suitable	Laek
Compagnie	47	marginally suitable-not suitable[c]	marginally suitable	moderately suitable	Caekr (Caekr >30% if steep)
Tempati	64	not suitable	marginally suitable	moderately suitable-marginally suitable[b]	Caekr
	65	not suitable	marginally suitable	moderately suitable-marginally suitable[b]	Caekr (Caekr >30% if steep)
Donderbari	67	not suitable	marginally suitable	moderately suitable-marginally suitable[b]	Caekr
	68	not suitable	marginally suitable-not suitable[c]	moderately suitable-marginally suitable[b]-not suitable[c]	Caekr (Caekr >30% if steep)
Lucas	72	not suitable	marginally suitable-not suitable[c]	moderately suitable-marginally suitable[b]-not suitable[c]	Caekr (Caekr >30% if steep)
Creek Bottom/ Foot-slopes[a]	46, 48, 66, 69	not suitable	not suitable	not suitable	Legk or SLegk

a) The Landscape Suitability Ratings of these Soil Map Units are independent of landscape unit so they have been grouped for simplicity.

b) Dependent on gravel and stone content (rating decreases with higher contents).

c) Dependent on slope gradient (rating decreases with higher slope values).

d) Dependent on drainage class (rating decreases with wetter drainage).

FCC = Fertility Capability Soil Classification; >= greater than; % = percent.

Most of the soils in the study area are unsuitable for annual cropping. The exceptions are soil map units 43 and 44 of the Tibiti Landscape Unit, which have marginal suitability, and map unit 47 of the Compagnie Landscape Unit, which has marginal suitability for sites with lower slope gradients.

For perennial crop production most soils are marginally, or marginally to moderately suitable. The exceptions are for soil map units associated with creek bottoms and footslopes (46, 48, 66, 69), and for the steepest parts of soil map unit 68 in the Donderbari Landscape Unit and unit 72 in the Lucas Landscape Unit, which are all unsuitable.

Finally, the ratings for cattle production for soil map units in the Project access management area and those that bisect the Sabajo-Merian Haul Road, are typically the highest of the three suitability indices, indicating that for the most part this region, based solely on these map ratings, is best suited as grazing land. Most of the area is either moderately or moderately to marginally suitable. The exceptions are for soil map units associated with creek bottoms and footslopes (46, 48, 66, 69), and for the steepest parts of soil map unit 68 in the Donderbari Landscape Unit and unit 72 in the Lucas Landscape Unit, which are all unsuitable.

Major constraints for the creek bottom and footslope soils are flooding hazard and poor drainage, which limits oxygen availability and creates problems with accessibility and rideability. Hill and slope soils are typically constrained by nutrient availability, buffer capacity and aluminum toxicity. High slope values and high gravel contents of found in many of the soil map units are an additional constraint on agricultural activities.

4.4.5 Future Work

Following the soils work to date, some added work prior to construction is recommended:

- There is uncertainty in the soil map units and assigned subgroups in areas not visited during the field program due to a lack of access. Although this is adequate for the impact assessment, further fieldwork and associated report updates, prior to any soil disturbance in these regions, is recommended to verify our conclusions.
- There is uncertainty in baseline soil chemistry levels used for comparison with ASM sites, due to having only two sets of clustered sites. Further fieldwork and associated report updates, prior to any soil disturbances in these regions, is recommended to verify our conclusions.
- There is uncertainty associated with using soil mapping based on 1:100,000 scale mapping completed in 1977. At this scale and considering the amount of time since any map updates have been completed, there is a level of uncertainty with respect to mapping accuracy at any given location. However, this level of detail is felt to be appropriate for an ESIA, so no further work is proposed at this time.

4.5 Geochemistry

4.5.1 Introduction

4.5.1.1 Program Overview

This section describes the components and the results of the mine waste geochemical characterization program. The goal of the geochemical characterization program is to characterize the acid rock drainage and metal leaching (ARD/ML) potential of mine materials (i.e., waste rock and ore). Typically, a geochemical characterization program will begin with static testing followed by kinetic testing, if deemed appropriate. The objective of static testing is to describe the bulk chemical characteristics of a material. These tests are designed to evaluate the potential of a material to leach metals[1] and/or generate acid. If static testing indicates an ARD/ML potential, kinetic testing is typically conducted to verify whether the various ARD/ML potentials identified will indeed be realized over time. Kinetic tests are also used to determine reaction rates and to evaluate metal leaching, both short and long-term.

The baseline geochemical characterization program for the Sabajo Project (the Project) has included static and kinetic testing of drill core samples representative of waste rock and ore, primarily from the Sabajo deposit. Based on the results of testing completed to date, this report presents our current understanding of the ARD/ML potential of mine materials. The geochemical characterization program is ongoing and, therefore, refinement of the current conceptual model of the behavior of mine materials may be appropriate as additional information becomes available. For example, because geochemical characterization to date has focused on the Sabajo deposit, additional data collection will be required prior to mine operations to confirm the geochemical behavior of materials from the Santa Barbara and Margo deposits. Although, due to the close proximity of these deposits, the geochemical behavior of waste rock and ore from the three deposits is expected to be consistent, this assumption must be verified. In addition, kinetic testing, which was initiated in 2017, is ongoing. Data gaps and uncertainties are discussed in the uncertainty section (Section 4.5.5).

An understanding of the site geology is fundamental to the selection of samples for geochemical characterization as well as the interpretation of analytical results. For this reason, a brief description of the site geology is presented in this section. Geo-environmental information from similar deposits is also included, as these data provide additional insights into the possible environmental behavior of the Sabajo deposit.

4.5.1.2 Site Geology

The ore body is located along a shear zone known as the Cassador shear zone. The footwall consists of dacite and the hanging wall is composed of graphitic and variably brecciated mudstones, siltstones, sandstones and greywackes. The entire sequence is overlain by a greenstone package consisting of mafic to felsic volcanics intermixed with volcaniclastic units and sedimentary sequences including marls (Newmont 2015).

The regolith (i.e., the layer of unconsolidated rocky material covering the bedrock) consists of Saprolite (SAP) underlain by a transition layer of Saprock (SR) overlying more competent material, which is referred to as “Fresh Rock” (FR). Saprolites form in high-rainfall environments where extensive chemical weathering results in decomposition of the parent rock. The distribution of Saprolite (~30 percent [%] to 40%), Saprock (~10%) and Fresh Rock (~50% to 60%) is similar for

[1] The term metal refers to both metals and metalloids.

waste rock and ore (Figure 4.5-1). The geologic mapping units identified for the Project are shown in Table 4.5-1 and Figure 4.5-1. The table also includes the relative percentages of each mapping unit for waste rock and ore. Saprolite, Saprock and Fresh Rock are distributed across Andesite (AN), Black Shales/Interbedded Siltstone (BS/IBS), Sedimentary Breccia (BxS), Dacite (DA), Sandstone Greywacke (SGw), and Quartz Vein (VN). Almost 80% of the waste rock consists of (in decreasing order) Sandstone Greywacke, Dacite and Andesite, whereas the ore is mainly (83%) composed of Quartz Vein and Sandstone Greywacke.

Based on mineralogical analysis by x-ray diffraction (XRD) of 11 drill hole composite samples of saprolite, saprock and fresh rock (Newmont 2011), all materials contain quartz and muscovite. The carbonate minerals ankerite and dolomite were present in fresh rock in quantities ranging from 2 to 7 weight percent (wt.%), while one saprock/fresh rock sample contained 2 wt.% siderite. Pyrite was found (at 1 wt.%) in one saprock/fresh rock sample and two fresh rock samples. Other minerals included a variety of aluminosilicates (albite – fresh rock; chlorite – fresh rock; kaolinite - saprolite) and iron oxides (goethite and hematite – saprolite). Minerals present in individual samples included plagioclase and rutile. The 11 drill core composite samples were from the Santa Barbara (6 samples) and Sabajo (5 samples) deposits collected during the early exploration phase of Sabajo.

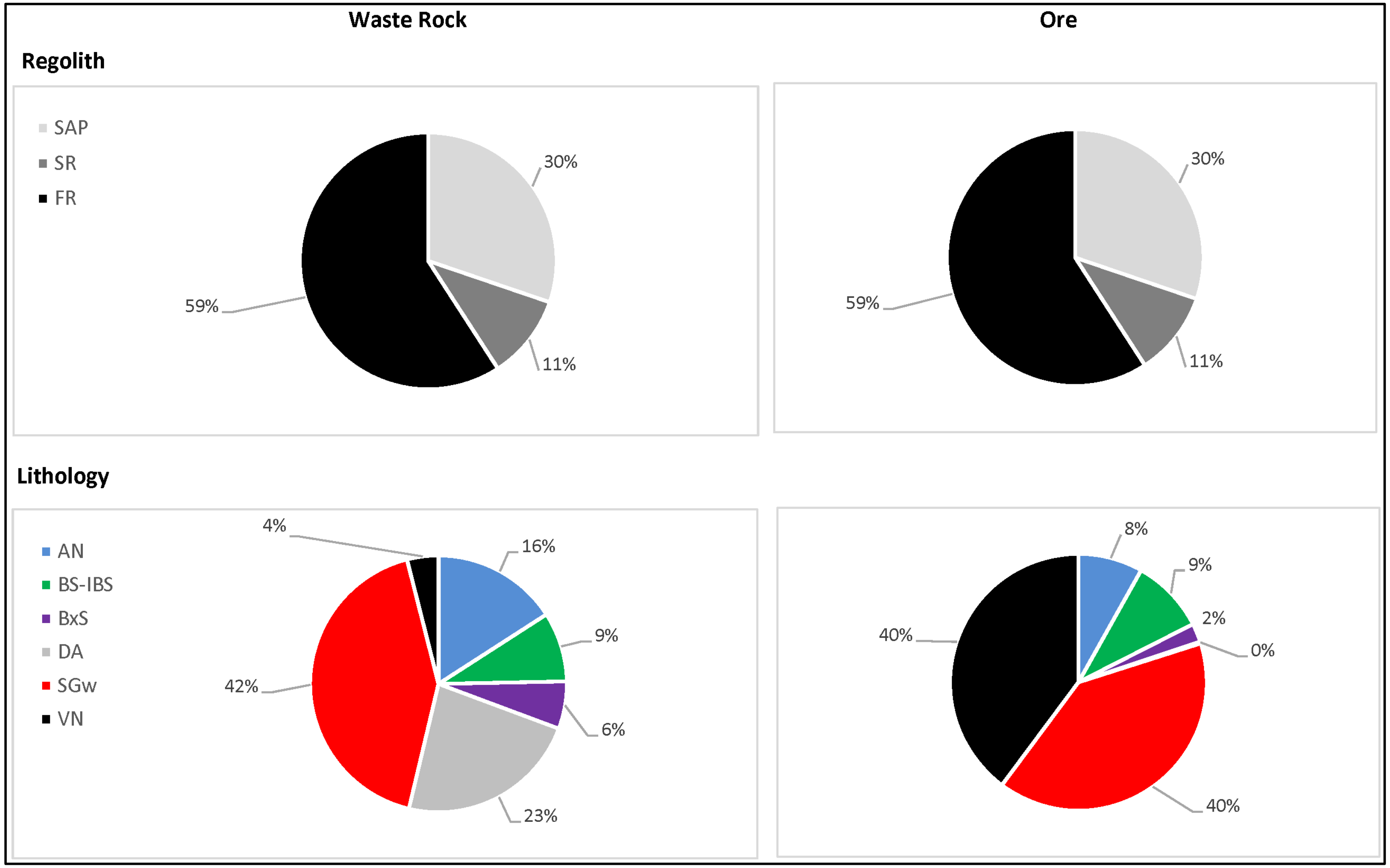
Gold mineralization occurs in intensively-silicified breccias associated with pyrite [FeS_2], arsenopyrite [FeAsS] and pyrrhotite [$Fe_{(1-x)}S$]. The mineralization is controlled by structures often parallel to the basal dacite unit and along fault splays that cross the sedimentary hanging wall package, reaching the base of the overlaying greenstone unit.

Table 4.5-1 Sabajo Deposit - Waste and Ore Distribution by Material Type

		Waste Rock				Ore			
		Lithology				Lithology			
		ALL	SAP	SR	FR	ALL	SAP	SR	FR
		100%	40%	12%	48%	100%	30%	11%	59%
Regolith	AN	**16%**	7%	1%	7%	**8%**	3%	1%	4%
	BS-IBS	**9%**	4%	1%	4%	**9%**	4%	1%	5%
	BxS	**6%**	1%	1%	4%	**2%**	1%	0.2%	1%
	DA	**23%**	8%	3%	12%	**0%**	0.2%	0.0%	0%
	SGw	**42%**	19%	6%	17%	**40%**	14%	5%	21%
	VN	**4%**	1%	0.4%	3%	**40%**	8%	3%	29%

Notes:
Lithology:
SAP = Saprolite; SR = Saprock; FR = Fresh Rock.
Regolith:
AN = Andesite; BS-IBS = Black Shales / Interbedded Siltstone; BxS = Sedimentary Breccia; DA = Dacite; SGw = Sandstone Greywacke; VN = Quartz Vein; % = percent.

Figure 4.5-1 Waste Rock and Ore Distribution by Lithology and Regolith



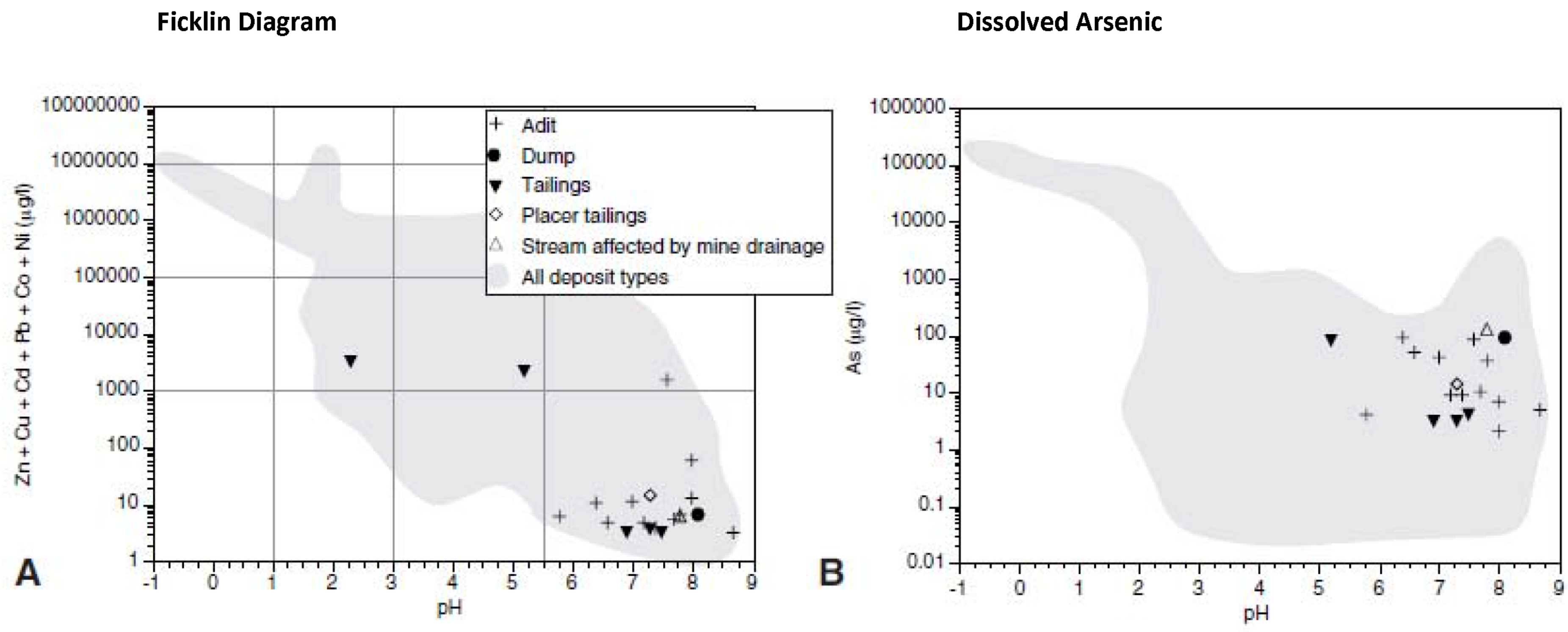
SAP = Saprolite; SR = Saprock; FR = Fresh Rock; AN = Andesite; BS-IBS = Black Shales / Interbedded Siltstone; BxS = Sedimentary Breccia; DA = Dacite; SGw = Sandstone Greywacke; VN = Quartz Vein;% = percent.

4.5.1.3 Geo-Environmental Information

Economic geologists have long recognized unifying principles between various ore deposit types. The use of data from analogue sites is a powerful tool in the prediction of future water qualities (i.e., the geo-environmental approach). A geo-environmental model of a mine deposit is defined as "*a compilation of geologic, geophysical, hydrologic, and engineering information pertaining to the environmental behaviour of geologically similar mineral deposits (1) prior to mining, and (2) resulting from mining, mineral processing and smelting*." (Seal et al. 2002). The key elements of the geo-environmental model include deposit type, deposit size, host rock, wall-rock alteration, mining and ore processing method, deposit trace element geochemistry, primary and secondary mineralogy, topography and physiography, hydrology, and climatic effects. Geo-environmental models are compilations of empirical data that are best used as guidelines for the potential range of environmental impacts at a site (Seal et al. 2002).

Ficklin diagrams are a tool used in geo-environmental assessments. The traditional Ficklin plot is a scattergram in which the sum of the base metals zinc (Zn), copper (Cu), lead (Pb), cadmium (Cd), cobalt (Co), and nickel (Ni) is plotted against pH. Figure 4.5-2 (reproduced from Plumlee et al. 1999) is a Ficklin plot presenting observed water qualities for low sulfide gold quartz vein deposits such as the Sabajo deposit. The gray shading in this figure represents the range of water qualities observed for all deposit types. Data from low sulfide gold quartz vein deposits are superimposed on the shaded area. This figure demonstrates that a wide range of water qualities can be encountered at low sulfide gold quartz vein deposits; however, drainage chemistry is often characterized by circum-neutral pH, due to the presence of carbonate minerals. Metal concentrations are typically low. Drainage from these deposits often contains arsenic [As], due to the presence of arsenopyrite. As shown in Figure 4.5-2, arsenic has been measured in mine waters from these deposits at microgram per liter (µg/L) to 100 µg/L concentrations. In Figure 4.5-2, the low-pH waters occur in association with tailings, likely due to the enrichment of sulfide in this material. For the same reason, acidic drainage from ore stockpiles is sometimes observed.

Figure 4.5-2 Ficklin Diagram and Dissolved Arsenic - Low Sulfide Gold Quartz Vein Deposits



Source: Reproduced from Plumlee et. al. (1999)

Zn = zinc; Cu = copper; Cd = cadmium; Pb = lead; Co = cobalt; Ni = nickel; As = arsenic; µg/L = micrograms per liter; % = percent.

4.5.2 Geochemical Characterization Program

4.5.2.1 Overview

Geochemical characterization of waste rock and ore for the Project has included the following:

- mineralogical analysis;
- chemical composition analysis;
- acid base accounting (ABA);
- short-term leach testing; and
- kinetic leach testing (i.e., humidity cell [HCT] testing).

These data are available from three primary sources, as described below and summarized in Table 4.5-2.

- **Mineralogy Database**: Mineralogical analysis results are available for 74 Sabajo deposit samples, distributed as follows (sample number in parentheses): saprolite (28), saprock (7), and, fresh rock (39). This data set includes the five Sabajo samples from Newmont Suriname, LLC (Newmont; 2011) discussed in Section 4.5.1.2.
- **Exploration Assay Database**: The Newmont Sabajo exploration database includes chemical composition data (i.e., metals and sulfur and carbon species by Leco furnace) for drill core samples classified by material type (i.e., waste rock and ore), regolith (i.e., SAP, SR and FR) and lithology (i.e., AN, BS, BxS, DA, IBS, SGw and VN). Chemical assays were typically performed on drill core samples approximately 1 meter in length. The number of elemental and Leco furnace determinations are shown in Table 4.5-2[2]. In this report, these data are referenced as the **exploration** dataset.
- **Environmental and Social Impact Assessment (ESIA) Baseline Data**: In 2017, 48 samples of Sabajo drill core representative of waste rock and ore were collected for geochemical characterization. Sample analysis included ABA and short-term leach testing. These samples were used to prepare eight composite samples (i.e., seven waste rock and one ore) for kinetic (i.e., HCT) testing. Composite waste rock HCT samples were analyzed for the following: ABA, chemical composition, short-term leach testing and mineralogy. In this report, these data are referenced as the **ESIA baseline** dataset.

The exploration data were used as the basis for the selection of samples for the ESIA baseline geochemical characterization program, as described in the next section.

[2] The number of analyses associated with a single lithology are shown. Results for drill core samples that spanned two lithologies were excluded from the dataset.

Table 4.5-2 Project Geochemistry Data Set

	Data Source		
	Mineralogy Database	**Exploration Database**	**ESIA Baseline**
DEPOSIT			
Sabajo	x	x	x
Santa Barbara[e]	x	-	-
	Number of Samples/Determinations		
DATA TYPES			
Mineralogy			
X-ray diffraction (XRD) analysis	74	-	7 HCT Comp. [b,c]
Chemical Composition			
Elemental analysis (4-acid digest)	-	19,290	7 HCT Comp. [b,c]
Leco sulfur and carbon	-	2,312	Note d
Acid Base Accounting			
Modified Sobek	-	-	48
NCV (ASTM Method 1915-09)	-	-	48 + 7 HCT Comp. [b,c]
PAG [a]	-	-	48 + 7 HCT Comp. [b,c]
Short-Term Leach Testing			
SPLP	-	-	48 + 7 HCT Comp. [b,c]
PAG [a]	-	-	48 + 7 HCT Comp. [b,c]
Kinetic Testing			
HCT	-	-	8

Notes:
a) PAG is included in two categories due to chemical analysis of test leachates.
b) HCT Comp = composite samples prepared for humidity cell testing (7 waste rock and one ore).
c) No analysis of ore composite sample.
d) Included as part of NCV analysis.
e) Santa Barbara mineralogy results presented in Newmont (2011)
ASTM = American Society of Testing Materials; HCT = humidity cell test; NCV = net carbonate value; PAG = peroxide acid generation; SPLP = synthetic precipitation leaching procedure; ESIA = Environmental and Social Impact Assessment.

4.5.2.2 ESIA Baseline Sample Selection

The geochemical characterization program included testing of 48 waste rock and ore samples which were obtained from Sabajo drill core. Sample selection criteria included the following:

- **Regolith**: Representation of all regoliths. Sample distribution considered the relative proportion of each regolith in waste rock and ore (i.e., FR >SAP >SR).
- **Lithology**: Representation of all lithologies. The number of samples per lithology ranged from 4 to 10.
- **Total Sulfur, Carbon and Arsenic Concentrations**: Sample selection targeted a range of sulfur, carbon and arsenic concentrations. Because sulfur, carbon and arsenic determinations were only available for some samples, sample selection was biased toward areas of the deposit where these data were available.
- **Spatial Representation**: Sample selection considered spatial representation across the deposit in all directions (i.e., x, y and z).
- **Waste Rock and Ore**: The 48 samples included 46 waste rock and 2 ore samples. The primary focus of the characterization program was the behavior of waste rock, as this material will be stockpiled on site. Because ore processing will occur at the Merian Operation, only a nominal number of ore samples were selected.

Composite samples for kinetic testing were prepared using 41 of the 48 individual samples. Seven waste rock samples and one ore composite sample were prepared. Composite samples were representative of a single regolith (FR or SAP) and targeted a range of sulfur and arsenic concentrations. The waste rock composite samples typically include samples from each lithology, mixed in the approximate relative proportions expected to be present in the waste rock facilities.

4.5.2.3 Analytical Methods

This section describes the analytical testing methods used to characterize the ARD/ML potential of ore and waste rock. Analytical testing for the Project was performed by Newmont Metallurgical Services (NMS) in Denver, Colorado.

4.5.2.3.1 Static Test Methods - Chemical Composition and Mineralogy

Characterization of a material's chemical composition is fundamental to understanding its environmental behavior. The results from solid-phase chemical analysis can be used to infer which elements are of potential environmental concern, although it should be understood that a high concentration of a particular element does not necessarily imply that this element will indeed be mobilized in concentrations that may lead to environmental impacts. Mineralogical analysis is performed to determine the relative abundance of the major mineralogical components in a material. In combination with the bulk chemical characteristics, the mineralogical information can be used to explain and predict the ARD/ML potential of the materials tested. Mineralogical findings, specifically the absence or presence of sulfide and carbonate mineral phases, are considered in the interpretation of ABA results.

The analytical methods used were as follows:

- **Elemental Chemical Composition** – Characterization of the elemental composition of a sample is typically a two-step process that includes an acid digestion to release elements into the solution phase followed by analysis of the elements in the resulting digestion. Elemental analysis was conducted by 4-acid digestion followed by inductively coupled plasma (ICP) analysis. The 4-acid digestion produces near-total solid phase elemental results (MEND 2009).
- **Mineralogical Analysis** – Mineralogical analysis was performed by XRD.

4.5.2.3.2 Static Testing Methods - Acid Base Accounting and Acid Generation Potential

Acid base accounting is conducted to predict the acid generation characteristics of a material and is based on the relative difference between the net acid generation potential and net acid neutralization potential of the material. Methods commonly used for ABA analysis include the Sobek Method (Sobek et al. 1978) and the American Society of Testing Material (ASTM) Method E1915-09 (ASTM 2009).

Newmont follows ASTM Method E1915-09, developed initially by Newmont, to determine the potential for a mine waste material to generate or consume acid. A net carbonate value (NCV) is determined from the difference between the acid neutralization potential (ANP) and the acid generation potential (AGP) of the material, and is typically expressed in units of percent carbon dioxide (% CO_2).

The ANP of a material is either determined from the total inorganic carbon (TIC) concentration or by titration. TIC is determined by one of two methods: 1) the difference between the total carbon and the residual carbon after reaction with hydrochloric acid (i.e., C_{TOT} – CAI), or 2) estimated from the residual carbon after pyrolysis (CAP). ANP determined by titration, referred to as the acid neutralization potential acidity titration (ANPA) in ASTM 1915-09, includes a correction for the neutralization potential consumed by the oxidation and hydrolysis of iron.

The AGP of a material is calculated from its sulfide sulfur content, determined as the difference between total and residual sulfur after pyrolysis. AGP can also be derived from the total sulfur content.

Maximum potential acidity (MPA) is the term often used to describe when AGP is determined from total sulfur.

Based on the calculated NCV, one of eight classifications, ranging from highly acidic to highly alkaline, is assigned to the material (Table 4.5-3). The detailed NCV calculations are shown in the table footnotes.

Determination of the following parameters was performed for the Newmont ABA:

- Total Sulfur (S_{TOT});
- Total Carbon (C_{TOT});
- Residual Carbon Acid Insoluble (CAI);
- Residual Carbon and Sulfur from pyrolysis (CAP and SAP)[3];
- Acid Neutralization Potential Acidity Titration (ANPA); and
- Paste pH.

In addition to ABA analysis, the peroxide acid generation (PAG) test was also performed to estimate ARD potential. The PAG test, developed by Newmont, is similar to the AMIRA International Ltd. (AMIRA) net acid generation (NAG) test (AMIRA 2002). It is a shake test conducted on a small amount of finely ground material using 15% hydrogen peroxide, overnight. The final pH of the sample is measured to determine if there is excess reactive pyrite in the sample.

Table 4.5-3 Newmont Protocol for Waste Classification by Net Carbonate Value

NCV Classification	Abbreviation	Criteria for Classification (% CO_2)	Secondary Criteria (% CO_2)
Highly Acidic	HA	NCV ≤ -5	
Acidic	A	-5 <NCV ≤ -1	
Slightly Acidic	SA	-1 <NCV ≤ -0.1	
Neutral	N	-0.1 <NCV <0.1	ANP ≥ 0.1 or AGP ≤ -0.1
Inert	I	-0.1 <NCV <0.1	ANP <0.1 and AGP >-0.1
Slightly Basic	SB	0.1 ≤ NCV <1	
Basic	B	1 ≤ NCV <5	
Highly Basic	HB	5 ≤ NCV	

Notes:

NCV = AGP + ANP (units% CO_2)

NCV = 22.7 (AGP + ANP) (units kg $CaCO_3$/t)

ANP = ANPA, 3.67 (C_{TOT} - CAI), or 3.67 CAP (units% CO_2)

AGP = -1.37 (S_{TOT} - SAP) (units% CO2)

NCV = net carbonate value; AGP = acid generation potential; ANP = acid neutralization potential; ANPA = acid neutralization potential acidity titration; C_{TOT} = total carbon; S_{TOT} = total sulfur; CAI = residual carbon acid insoluble; SAP = saprolite; ≤ = less than or equal to; ≥ = greater than or equal to; < = less than; > = greater than;% CO_2 = percent carbon dioxide; kg $CaCO_3$/t = kilogram calcium carbonate per ton.

A pH below 4.5 indicates an acid generating material. The solutions are filtered and assayed for dissolved analytes to determine the soluble minerals in the samples.

A possible limitation of the single-stage PAG test is its ability to accurately predict the acid generation potential of samples with high sulfur contents. As noted above, the PAG test is similar to the AMIRA NAG test. The single addition NAG test may not reliably reflect the acid forming potential of sulfidic samples (>1 wt.% S) with high contents of readily available neutralizing minerals (AMIRA 2002). With

[3] The ASTM method calls for an ignition temperature of 550 °C; however, an ignition temperature of 650 °C is sometimes used. Analytical results presented in this report are for a temperature of 550 degrees Celsius.

a single addition test, only partial sulfide oxidation may be achieved and, therefore, a number of NAG stages may be required to fully oxidize all sulfide and consume any available ANP. As a consequence, for samples with sulfide contents greater than 1 wt.%, a sequential NAG test is recommended to determine the ARD potential of the sample. This test involves multiple hydrogen peroxide additions.

4.5.2.3.3 *Static Testing Methods - Short-Term Leach Tests*

Leach testing is conducted to characterize the metal leaching potential of a waste material. The results of short-term leach tests tend to be sensitive to the methodology used (e.g., solid to solution ratio, nature of the lixiviant, grain size reduction). Therefore, although these leach tests provide an estimation of which metals are most likely to leach from a particular material, leachate metal concentrations will exhibit variability related to the specific test methodology used and may not be representative of field-scale conditions.

The Synthetic Precipitation Leaching Procedure (SPLP) (USEPA Method 1312, USEPA 1994) was used to characterize the leaching potential of waste rock and ore. This test simulates the short-term interaction between meteoric water and fresh mine waste. This test is performed at a 20:1 solution to solid ratio. The resultant liquid phase is the separated, filtered, and analyzed for pH and other parameters.

4.5.2.3.4 *Kinetic Test Methods – Humidity Cell Testing*

For samples with reactive sulfides, kinetic testing results provide the best indication of field-scale leaching, particularly over the long term. Because the mobility of many metals increases as conditions become more acidic (i.e., pH decreases), the duration of kinetic testing must be long enough to overcome the “lag time” to ARD formation (i.e., long enough to exhaust available neutralization potential).

Eight HCTs were initiated in 2017 to evaluate the weathering behavior of waste rock and ore. HCTs are conducted in the laboratory to accelerate weathering reactions on finely crushed materials. Testing is being performed in accordance with ASTM D5744-13^{E1} (Option B) (ASTM 2013). The humidity cell test is a small column kinetic leaching method using 1 kilogram (kg) of material at nominal ¼ inch particle size for samples derived from drill core. A water flush of 1 liter (L) is applied, followed by a wet and dry cycle and weekly flushing of the material to accelerate the weathering reactions. The solutions are filtered and assayed for dissolved analytes to determine the soluble minerals in the weathered samples and to estimate lag times to acid generation. Testing is typically conducted for a minimum 20-week period, but testing may need to be extended for materials with an uncertain ARD potential or slow-reacting materials. Early flush results can indicate the presence of readily-soluble minerals such as acid salts. Later results are indicative of long-term conditions and are used to estimate release rates of sulfates and metals.

HCT testing is ongoing. Due to the transient nature of the leachate compositions, the results are not presented in this report.

4.5.3 Geochemical Characterization Results

This section presents a factual summary of the results of the geochemical characterization program. Data interpretation, including an overall assessment of the ARD/ML potential of waste rock and ore based on the collective interpretation of all data, is presented in Section 4.5.4.

4.5.3.1 Chemistry and Mineralogy

Mineralogy database results for the Project are summarized in Table 4.5-4. This table shows the minimum and maximum concentrations as well as the frequency of occurrence for minerals identified in Sabajo drill core samples selected from the exploration database.

- **Carbonate Minerals**: Ankerite and dolomite are the primary carbonate minerals in the deposit. Calcite and siderite are also present, but occur at lower frequency and concentrations. Carbonate mineral occurrence is higher in the fresh rock compared to the saprolite and saprock.

  Calcite and dolomite are more effective sources of neutralization potential than ankerite and siderite. Fe-Mn carbonates (i.e., siderite and ankerite) are not effective acid neutralizers because the ferrous iron or manganese that is released when these carbonates dissolve eventually oxidizes, hydrolyzes, and precipitates in the form of Fe-Mn hydroxide minerals. Therefore, the alkalinity contribution from Fe-Mn carbonate dissolution is counteracted by the acidity that is generated by the eventual precipitation of the Fe-Mn hydroxide.

- **Sulfide Minerals**: Pyrite is the primary sulfide mineral in the deposit. Although the ranges of pyrite concentrations measured in samples from the three regoliths are similar, the frequency of pyrite occurrence is higher for the fresh rock samples compared to the saprock and saprolite samples. Arsenoypyrite was identified in one of the 39 fresh rock samples.
- **Iron Oxides**: Iron oxides (hematite and goethite) are present in the saprolite and saprock samples but are absent in the fresh rock samples, as expected based on the weathered nature of the shallow units.
- **Other**: Paragonite (a mica mineral similar to muscovite) was identified in one saprolite and one fresh rock sample. This mineral may provide some buffering capacity.

Average chemical concentrations of selected parameters in waste rock samples from the exploration assay database are shown in Figure 4.5-3. Total carbon, total sulfur and three major elements (aluminum [Al], calcium [Ca] and iron [Fe]) are presented in Figure 5.4-3A. Consistent with the mineralogy results, average total sulfur (indicative of sulfide content) and total carbon (indicative of carbonate content) concentrations are highest in the fresh rock and lowest in the saprolite, as follows:

- Total Sulfur: FR (0.57 wt.%) >SR (0.50 wt.%) >SAP (0.15 wt.%); and
- Total Carbon: FR (2.0 wt.%) >SR (0.89 wt.%) >SAP (0.42 wt.%)

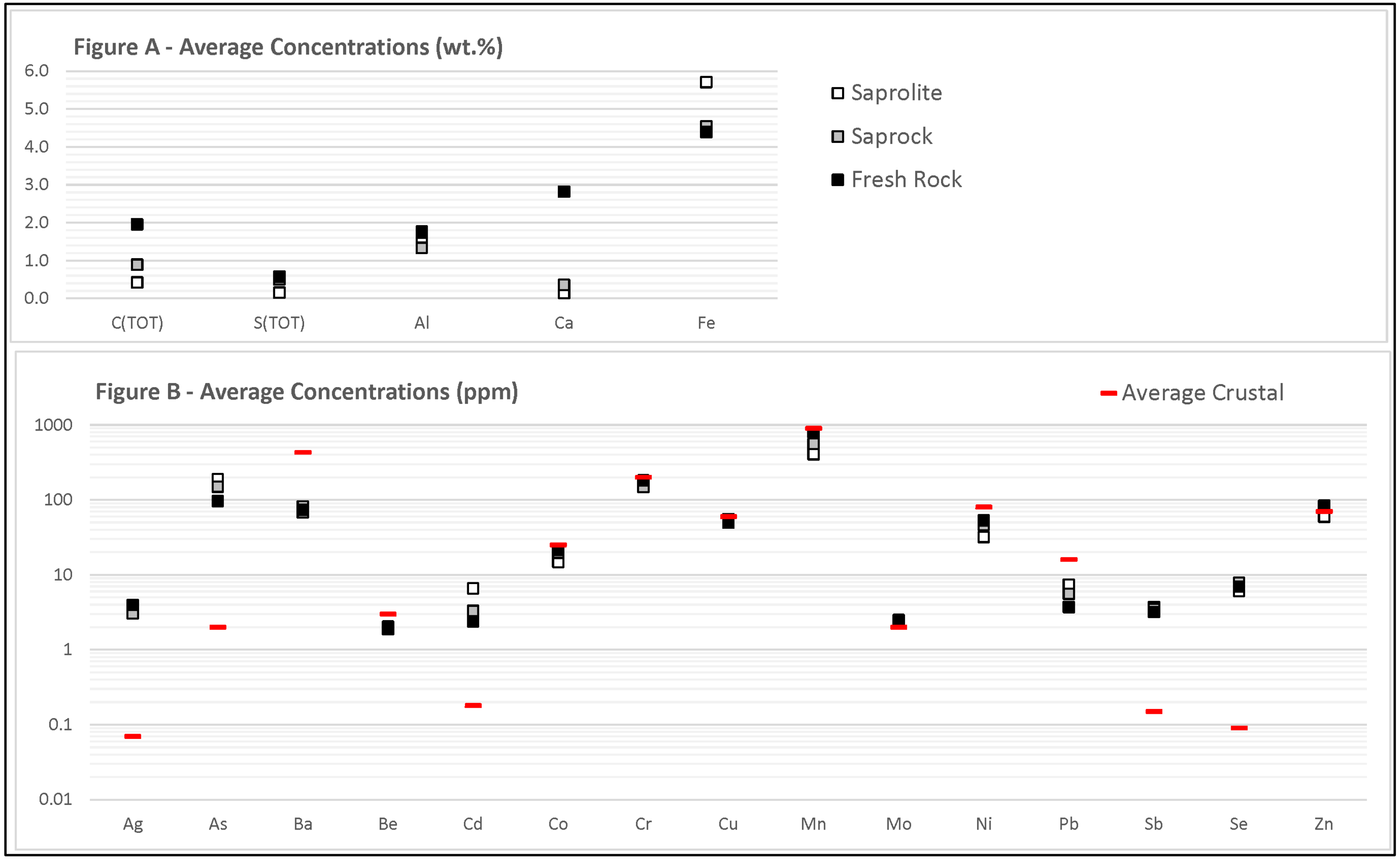
In Figure 4.5-3B, average metal concentrations are compared to the average crustal abundance of these elements in the earth's crust (Smith and Huyck 1999). Average elemental concentrations for the following parameters are higher than average crustal abundance concentrations: silver (Ag), As, Cd, molybdenum (Mo), antimony (Sb), selenium (Se), and Zn. This comparison is made as a tool in identifying possible parameters of environmental concern, which was further evaluated through leach testing (Section 4.5.3.3). It should be noted that some of the identified exceedances may be an artifact of analytical reporting limits. The assay database reporting limits appear to be variable. At times, for some parameters, the analytical reporting limit may have exceeded the average crustal abundance value.

Table 4.5-4 Mineralogy Database

	Mineral	Saprolite (28 Samples)			Saprock (7 samples)			Fresh Rock (39 samples)		
		Occurrence (% of Samples)	Min	Max	Occurrence (% of Samples)	Min	Max	Occurrence (% of Samples)	Min	Max
Carbonates	Calcite	0%	-	-	0%	-	-	21%	0.4	14
	Ankerite / Dolomite	4%	1.2	1.2	0%	-	-	87%	2.0	49
	Siderite	0%	-	-	14%	2.0	2.0	3%	3.2	3.2
Sulfides	Pyrite	21%	0.3	2.3	71%	0.5	2.5	100%	0.5	3.8
	Arsenopyrite	0%	-	-	0%	-	-	3%	2.4	2.4
Other	Goethite	68%	0.6	13.2	29%	3.3	3.9	0%	-	-
	Hematite	39%	0.6	8.7	29%	1.0	4.7	0%	-	-
	Kaolinite	79%	0.4	34.8	29%	10	14	0%	-	-
	Muscovite / Sericite	100%	3.5	51.8	100%	8.7	30	100%	12	33
	Paragonite	4%	7.1	7.1	0%	-	-	3%	12	12
	Plagioclase	7%	11	11	29%	1.9	24	13%	5.9	18
	Chlorite / Chinochlore	14%	0.7	38	57%	2.0	36	97%	0.9	32
	Quartz	100%	10	95	100%	31	85	100%	29	79
	Rutile	96%	0.4	2.0	86%	0.3	1.1	92%	0.3	1.3
	Albite	0%	-	-	0%	-	-	10%	5.5	13

% = percent; Min = minimum; Max = maximum.

Figure 4.5-3 Exploration Assay Database Results



C = carbon; S = sulfur; Al = aluminum; Ca = calcium; Fe = iron; Ag = silver; As = arsenic; Ba = barium; Be = beryllium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Mn = manganese; Mo = molybdenum; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Zn = zinc; TOT = total; wt.% = weight percent; ppm = parts per million.

4.5.3.2 Acid Base Accounting

The acid generation potential of a sample is determined based on the ratio of ANP and AGP.

Acid generation capacity is estimated from the total sulfur or sulfide sulfur content of a sample. Total sulfur versus sulfide sulfur concentrations in ESIA baseline samples are shown in Figure 4.5-4[4]. As expected, sulfur concentrations are highest in the fresh rock samples and lowest in the saprolite samples (excluding the one saprolite sample with anomalously high total sulfur). Average total sulfur concentrations for the ESIA baseline samples are consistently higher than the average concentrations for the exploration database (Table 4.5-5), suggesting that the ESIA baseline data set may be biased high with respect to overall acid generation potential.

Because most sulfur is present as sulfide (Figure 4.5-4), for this study, total sulfur is used to estimate AGP to ensure a conservative approach in the assessment of ARD potential.

ANP was determined using multiple methods: 1) bulk neutralization potential (NP) by titration (i.e., ANPA), and 2) carbonate ANP (CaANP) calculated from TIC concentrations estimated in two ways:

- the difference between total carbon (C_{TOT}) and residual carbon acid insoluble (CAI), referred to as $CaANP_{CAI}$; and
- the pyrolysis method (CAP), referred to as $CaANP_{CAP}$.

Average ANP values by regolith for each of the three ANP methods are shown in Figure 4.5-5. Irrespective of the method of determination, average ANP values for the saprolite and saprock samples are low. This observation is consistent with the general absence of carbonate minerals in these weathered materials, as determined by mineralogical analysis. Average ANP values for the fresh rock samples are higher, consistent with the presence of carbonate minerals.

ANP values determined using the three methods yielded variable results. For example, $CaANP_{CAI}$ versus ANPA is shown in Figure 4.5-5. At low ANP values, $CaANP_{CAI}$ values are consistently significantly higher than ANPA values; however, at high ANP values, the opposite trend is observed. As discussed previously, carbonate minerals that contain iron and/or manganese do not contribute to buffering capacity since subsequent hydrolysis of the iron and manganese tends to generate acidity. Ankerite and siderite are included in the TIC analysis and, therefore, if these minerals are present, the CaANP determinations will likely overestimate the neutralizing capacity of the material. The ANPA method is designed to exclude any contribution to ANP from iron carbonate minerals. It is, therefore, unexpected that at low ANP values, ANPA is higher than $CaANP_{CAI}$. The same trend is observed at low ANP values when ANPA is compared to $CaANP_{CAP}$ (i.e., ANPA >$CaANP_{CAP}$).

For this study, the lowest measured ANP value for each sample was used to estimate ANP to ensure a conservative approach in the assessment of ARD potential. In general, the ANP of the saprolite is expected to be low to very low, while ANP is present in meaningful quantities in the fresh rock samples. The ANP of the saprock is expected to be intermediate to the saprolite and fresh rock.

Paste pH versus PAG pH values are shown in Figure 4.5-6. Paste pH values ranged from 2.8 to 9.3 while PAG pH values ranged from 2.3 to 10.8. Consistent with their low neutralization capacity, the saprolite and saprock samples generally yield low pH values whereas the fresh rock samples generally yielded higher pH values. The alkaline paste pH values (i.e., values greater than 8.5) may be attributable to the presence of paragonite.

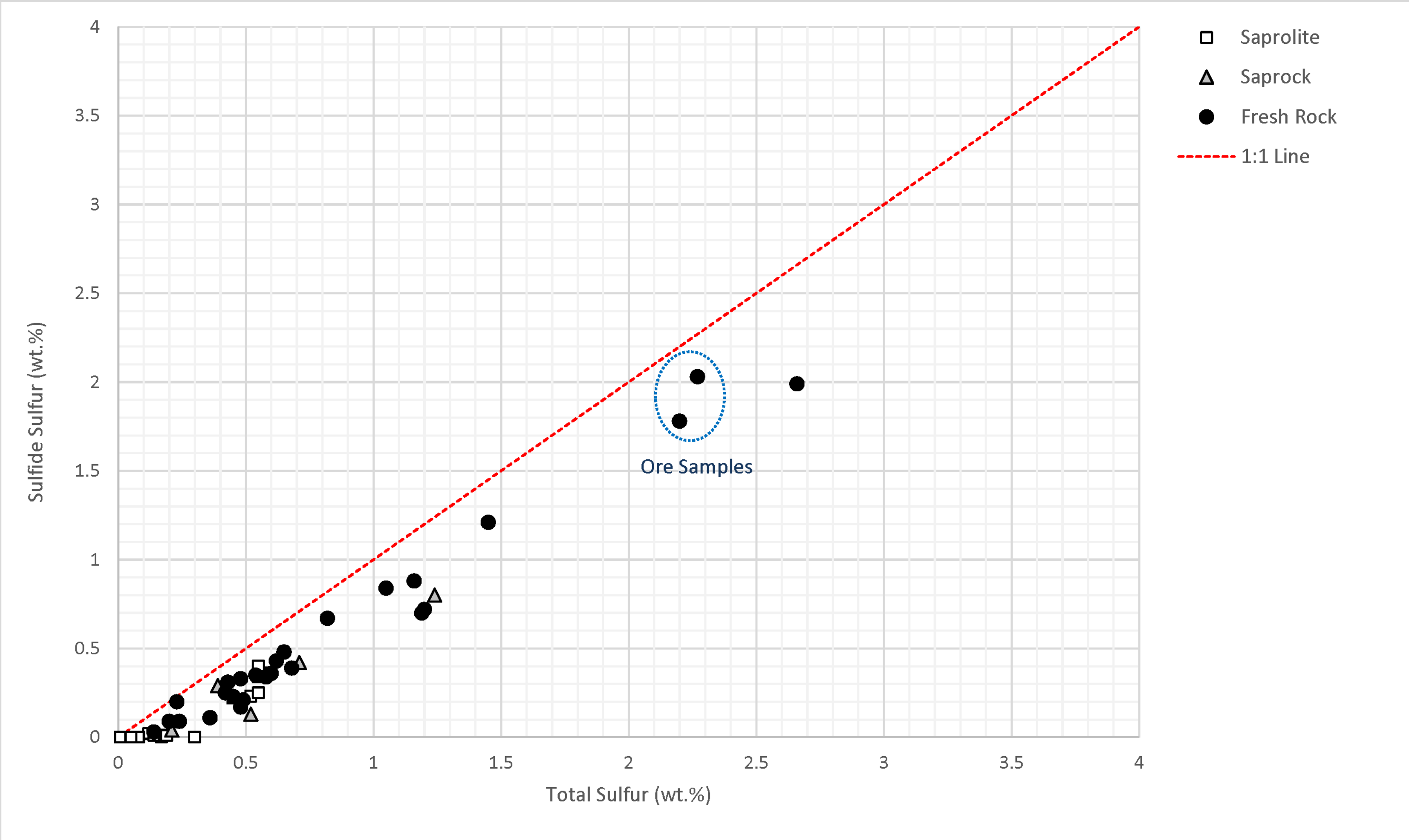
[4] This figure does not include a saprolite sample with 11 wt.% total sulfur.

Table 4.5-5 Assay Database versus ESIA Baseline Samples Total Sulfur Concentrations

Regolith	Total Sulfur (wt.%)							
	Exploration Assay Database				ESIA Baseline Samples			
	No.	Avg.	Min.	Max	No.	Avg.	Min.	Max
Saprolite (SAP)	367	0.15	0.005	11	17	0.88	0.01	11
Saprock (SR)	81	0.50	0.005	2.2	5	0.61	0.21	1.2
Fresh Rock (FR)	1032	0.57	0.005	4.4	24	0.71	0.14	2.7

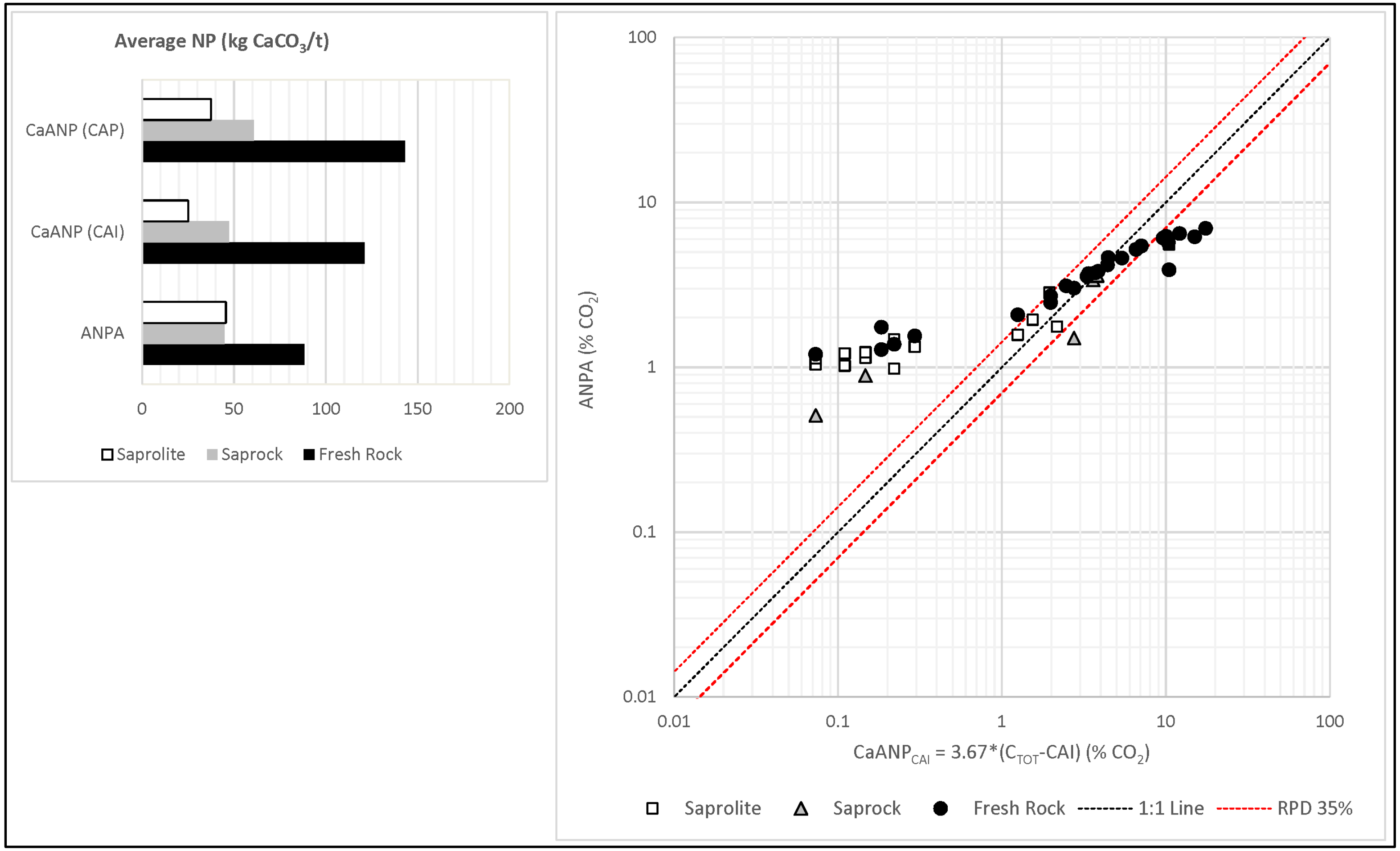
No. = number; Avg. = average; Min. = minimum; Max. = maximum; ESIA = Environmental and Social Impact Assessment; wt.% = weight percent.

Figure 4.5-4 Total Sulfur vs. Sulfide Sulfur



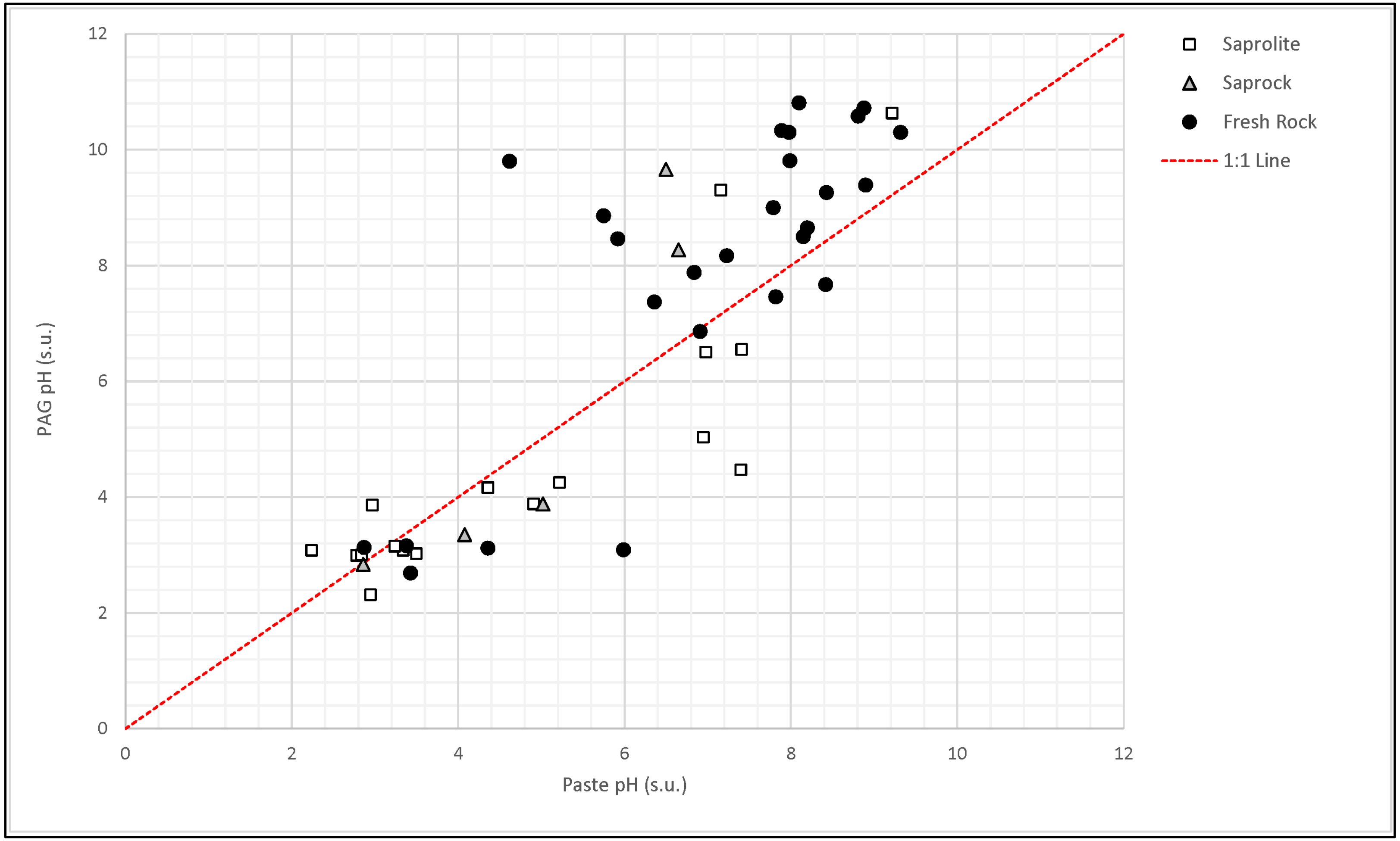
wt.% = weight percent.

Figure 4.5-5 Acid Neutralization Potential Determination Results



NP = neutralization potential; CaANP = carbonate acid neutralization potential; ANPA = acid neutralization potential acidity titration; C_{TOT} = total carbon; RPD = relative percent difference; CAI = residual carbon acid insoluble; kg $CaCO_3$/t = kilogram calcium carbonate per ton;% CO_2 = percent carbon dioxide;% = percent.

Figure 4.5-6 Paste pH vs. Peroxide Acid Generation pH



PAG = peroxide acid generation; s.u. = standard unit.

4.5.3.3 Static Leach Testing

Static leach testing was conducted using the SPLP method. In addition, the leachates generated from the PAG test were analyzed. As mentioned previously, the results of leach tests tend to be sensitive to the methodology used. Therefore, although leach tests provide an estimation of which metals are most likely to leach from a particular material, leachate metal concentrations will exhibit variability related to the specific test methodology used and may not be representative of field-scale conditions.

The parameter suite for all baseline leach tests is shown in Table 4.5-6. Reporting limits are provided for all analytes present at concentrations below the reporting limit in one or more samples. Some metals were analyzed using both ICP and inductively coupled plasma mass spectrometry (ICP-MS), with the latter yielding lower reporting limits. Because the ICP-MS results are considered more accurate, these are the results that are presented and discussed.

Baseline static leach test results (i.e., SPLP and PAG) are summarized in Table 4.5-7. The SPLP leach test is designed to mimic the interaction between rainwater and a solid material. This test is used to assess the environmental stability of a waste material following short-term contact with meteoric water. This test does not, however, provide information on metal leaching during prolonged weathering. The results of the PAG test, a more aggressive test designed to mobilize metals present in association with sulfide mineralization through the use of a hydrogen peroxide solution, are considered a “worst-case” representation of the interaction between waste rock and water that infiltrates the waste rock facilities. Leach test results, in association with water balance and facility design information, are used to estimate mine water qualities. Table 4.5-7 includes the Project water quality standards for comparison. Exceedances of these standards are identified by shading and bold type. Results for selected parameters are shown in Figures 4.5-7 to 4.5-15 (i.e., sulfate (SO_4), Al, As, Co, Cu, Fe, Mn, Ni, and Zn). For reference, these figures include the following:

- **Analytical reporting limits**: Analytical reporting limits are specific to each parameter and leach test. The analytical reporting limits for each parameter associated with each of the three leach tests (i.e., SPLP and PAG) are shown in the figures. Reporting limits are only shown if the parameter was reported as below detection in one or more leachates.
- **Lowest Project water quality standard** (Table 4.8-3): The Project water quality standards are presented in Section 4.8 and include three types of standards: effluent, drinking water, and aquatic life. For each parameter, the lowest of these three standards is shown in the leach test result figures. For hardness-dependent aquatic life criteria, a hardness value of 10% as calcium carbonate ($CaCO_3$) is assumed.

ESIA baseline sample SPLP and PAG leachate pH values are shown in Figure 4.5-16. For most samples, PAG pH values were lower than SPLP pH values. Leachate pH ranges by test type were as follows: SPLP (3.0 to 9.7) and PAG (2.3 to 10.8).

Sulfate was analyzed in SPLP leachates and ranged in concentration from 2 to 590 mg/L. Samples with a total sulfur content of less than approximately 0.4 wt.% consistently yielded sulfate concentrations below 100 mg/L. Sulfate concentrations in SPLP leachates generally increased with decreasing leachate pH (Figure 4.5-7). The magnitude of the sulfate concentrations in samples containing reactive sulfide minerals may be interpreted to indicate the relative degree of sulfide oxidation. The trend of decreasing pH with increasing sulfate concentration is consistent with an increased presence of acid-generating sulfide minerals in lower-pH samples.

Table 4.5-6 Baseline Leach Tests Parameter Suite

		Leach Test		
		SPLP	PAG	HCT
48 Samples		x	x	
7 HCT Composite Samples		x	x	x
Parameter	Unit			
General Chemistry				
pH	s.u.	x	x	x
Total Dissolved Solids (TDS)	mg/L	50	-	x
Specific Conductance	µmhos/cm	x	-	x
Hardness	mg/L as $CaCO_3$	x	-	x
Major Ions				
Calcium (Ca)	mg/L	x	-	x
Magnesium (Mg)	mg/L	x	x	x
Potassium (K)	mg/L	x	-	x
Sodium (Na)	mg/L	x	x	x
Alkalinity	mg/L as $CaCO_3$	10	-	10
Acidity	mg/L as $CaCO_3$	x	-	x
Chloride (Cl)	mg/L	x	-	x
Fluoride (F)	mg/L	0.02	-	0.02
Sulfate (SO_4)	mg/L	x	-	x
Metals				
Silver (Ag)	mg/L	0.0001	0.0005	0.0001
Aluminum (Al)	mg/L	0.001	x	0.001
Arsenic (As)	mg/L	0.001	0.002	0.001
Boron (B)	mg/L	0.002	0.02	x
Barium (Ba)	mg/L	x	x	x
Beryllium (Be)	mg/L	0.0009	0.001	0.0009
Bismuth (Bi)	mg/L	0.05	-	0.05
Cadmium (Cd)	mg/L	0.0001	0.0002	0.0001
Cobalt (Co)	mg/L	0.001	0.0001	0.001
Chromium (Cr)	mg/L	0.0004	0.002	0.0004
Copper (Cu)	mg/L	0.0015	0.01	0.0015
Iron (Fe)	mg/L	0.05	0.01	0.05
Gallium (Ga)	mg/L	0.05	-	0.05
Mercury (Hg)	mg/L	0.1	0.1	-
Lithium (Li)	mg/L	10	0.01	10
Manganese (Mn)	mg/L	x	0.003	x
Molybdenum (Mo)	mg/L	0.0002	0.0004	0.0002
Nickel (Ni)	mg/L	x	0.0002	x
Lead (Pb)	mg/L	0.0007	0.001	0.0007
Sulfur (S)	mg/L	x	-	x
Antimony (Sb)	mg/L	0.0005	0.0004	0.0005
Scandium (Sc)	mg/L	0.05	-	0.05
Selenium (Se)	mg/L	0.0007	0.002	0.0007
Silicon (Si)	mg/L	0.05	-	0.05
Tin (Sn)	mg/L	0.05	-	0.05
Strontium (Sr)	mg/L	x	-	x
Titanium (Ti)	mg/L	x	-	x
Thallium (Tl)	mg/L	0.0008	0.0003	0.0008
Vanadium (V)	mg/L	0.0003	0.003	0.0003
Zinc (Zn)	mg/L	0.0025	0.002	0.0025
Nutrients				
Nitrite as Nitrogen (NO_2-N)	mg/L-N	0.04	-	0.04
Nitrate as Nitrogen (NO_3-N)	mg/L-N	0.02	-	0.02
Ammonia as Nitrogen (NH_3-N)	mg/L-N	x	-	-
Phosphate as Phosphorus (PO_4-P)	mg/L-P	0.02	-	0.02

SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation; HCT = humidity cell test; $CaCO_3$ = calcium carbonate; µmhos/cm = micromhos per centimeter; s.u. = standard unit; mg/L = milligrams per liter; mg/L-N = milligrams per liter as nitrogen; mg/L-P = milligrams per liter as phosphorus.

Table 4.5-7 Baseline Leach Test Result Summary

		Project Water Quality Standards [1]			SPLP [2] 48 Samples 7 Composites			PAG [2] 48 Samples 7 Composites		
		Legal Effluent	Drinking Water	Aquatic Life	MIN	MAX	% ND	MIN	MAX	% ND
Acidity	mg/L as $CaCO_3$				-19	522	0%	-	-	-
Alkalinity	mg/L as $CaCO_3$				<10	59	33%	-	-	-
Specific Conductance	µmhos/cm				25	756	0%	-	-	-
Hardness	mg/L as $CaCO_3$				6	218	0%	-	-	-
pH	s.u.	6 - 9		6.4 - 8.4	**3.0**	**9.7**	-	**2.3**	**10.8**	-
Silver (Ag)	mg/L		0.18	0.0001	<0.0001	**0.003**	64%	<0.0005 [3]	**0.006**	80%
Aluminum (Al)	mg/L		37	0.087	<0.001	**42**	4%	0.01	**13**	0%
Arsenic (As)	mg/L	0.1	0.01	0.15	<0.001	**0.4**	22%	<0.002	**0.9**	25%
Boron (B)	mg/L		7.3	5	<0.002	0.1	9%	<0.02	0.03	98%
Barium (Ba)	mg/L		2	0.04	0.002	**0.2**	0%	0.002	**0.1**	0%
Beryllium (Be)	mg/L		0.004	0.0001	<0.0009 [3]	**0.004**	95%	<0.001 [3]	<0.001 [3]	100%
Bismuth (Bi)	mg/L				<0.05	<0.05	100%	-	-	-
Calcium (Ca)	mg/L				2	50	0	-	-	-
Cadmium (Cd)	mg/L	0.05	0.005	0.0004	<0.0001	**0.03**	60%	<0.0002	**0.006**	69%
Cobalt (Co)	mg/L		0.35	0.1	<0.001	**3.7**	33%	<0.0001	**1.0**	24%
Chromium (Cr)	mg/L	0.1	0.1	0.01	<0.0004	**0.1**	80%	<0.002	**0.1**	5%
Copper (Cu)	mg/L	0.3	0.2	0.0686	<0.0015	**3.7**	36%	<0.01	**2.6**	49%
Iron (Fe)	mg/L	2	26	1	<0.05	**98**	69%	<0.01	**222**	27%
Gallium (Ga)	mg/L				<0.05	0.14	93%	-	-	-
Mercury (Hg)	mg/L	0.002	0.002	0.0008	<0.0001	<0.0001	100%	<0.0001	<0.0001	100%
Potassium (K)	mg/L				0.14	6.3	0%	-	-	-
Lithium (Li)	mg/L				<10	54	85%	<0.01	0.02	85%
Magnesium (Mg)	mg/L				0.27	31	0%	0.07	20	0%
Manganese (Mn)	mg/L		0.88	0.3	0.001	**18**	0%	<0.003	**13**	27%
Molybdenum (Mo)	mg/L		0.18	3.2	<0.0002	0.003	51%	<0.0004	0.02	7%
Sodium (Na)	mg/L				1.8	14	0%	0.3	7.6	0%
Nickel (Ni)	mg/L	0.5	0.73	0.007	0.0008	**7.2**	0%	<0.0002	**1.6**	2%
Lead (Pb)	mg/L	0.2	0.015	0.003	<0.0007	**0.02**	60%	<0.001	**0.4**	53%
Sulfur (S)	mg/L				1.2	192	0%	-	-	-
Antimony (Sb)	mg/L		0.006	0.24	<0.0005	0.002	76%	<0.0004	**0.01**	38%
Scandium (Sc)	mg/L				<0.05	0.06	98%	-	-	-
Selenium (Se)	mg/L		0.05	0.005	<0.0007	0.003	78%	<0.002	**0.02**	15%
Silicon (Si)	mg/L				<0.05	4.3	7%	-	-	-
Tin (Sn)	mg/L				<0.05	<0.05	100%	-	-	-
Strontium (Sr)	mg/L				0.006	0.2	0%	-	-	-
Titanium (Ti)	mg/L				0.001	0.03	0%	-	-	-
Thallium (Tl)	mg/L		0.002	0.007	<0.0008	**0.008**	91%	<0.0003	**0.004**	84%
Vanadium (V)	mg/L				<0.0003	0.02	64%	<0.003	0.1	15%
Zinc (Zn)	mg/L	0.5	5	0.02	<0.0025	**5.6**	7%	<0.002	**2.2**	5%
Total Dissolved Solids (TDS)	mg/L		2,000		<50	840	15%	-	-	-
Chloride (Cl)	mg/L			230	0.05	8.7	0%	-	-	-
Fluoride (F)	mg/L		4		<0.02	0.9	2%	-	-	-
Nitrite as Nitrogen (NO_2-N)	mg/L-N		1		<0.04	0.3	56%	-	-	-
Nitrate as Nitrogen (NO_3-N)	mg/L-N		10	13	<0.02	<0.02	100%	-	-	-
Ammonia as Nitrogen (NH_3-N)	mg/L-N				0.36	0.8	0%	-	-	-
Phosphate as Phosphorus (PO_4-P)	mg/L-P				<0.02	<0.02	100%	-	-	-
Sulfate (SO_4)	mg/L		1,500		1.7	589	0%	-	-	-

Notes:

ND = non detect

TDS only analyzed in 15 of 55 SPLP leachates

Mercury not analyzed in the 7 composite sample PAG leachates

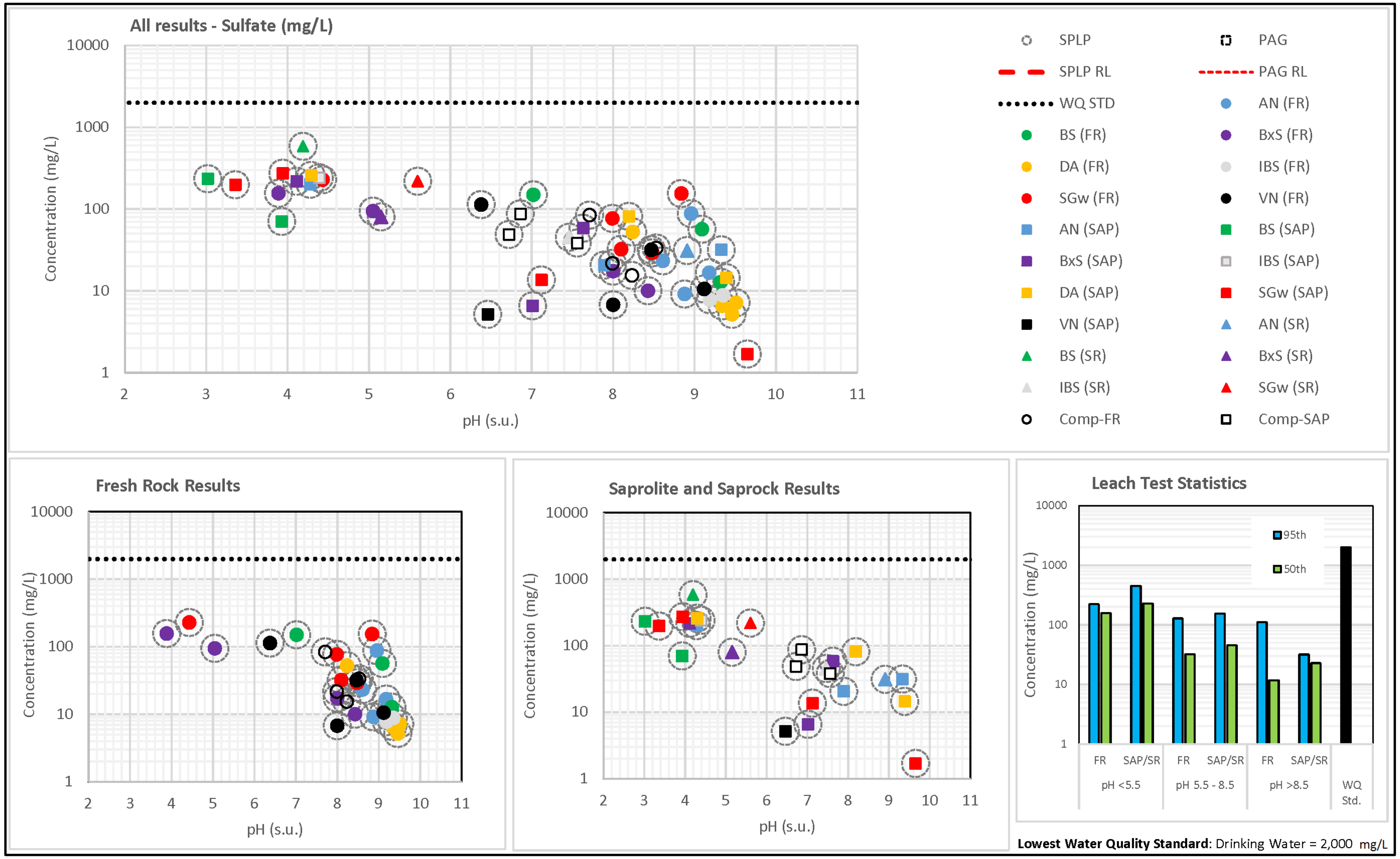
1) Shading identifies lowest Project water quality standard.

2) Shading and bold type identify exceedances of lowest Project water quality standard.

3) Analytical reporting limit higher than lowest Project water quality standard.

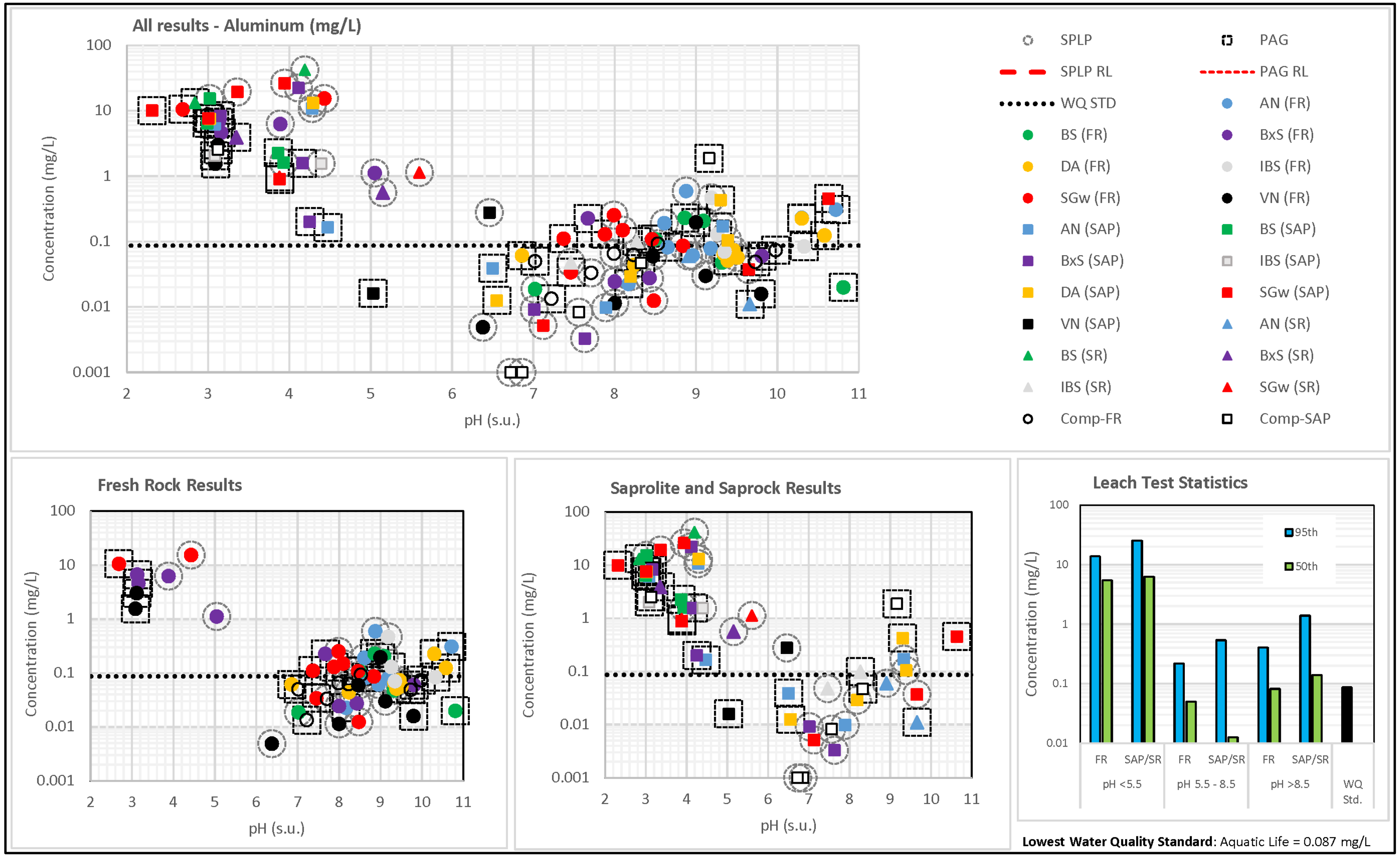
SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation; HCT = humidity cell test; MIN = minimum; MAX = maximum; $CaCO_3$ = calcium carbonate; µmhos/cm = micromhos per centimeter; s.u. = standard unit; mg/L = milligrams per liter; mg/L-N = milligrams per liter as nitrogen; mg/L-P = milligrams per liter as phosphorus; < = less than;% = percent.

Figure 4.5-7 Static Leach Test Results - Sulfate (mg/L)



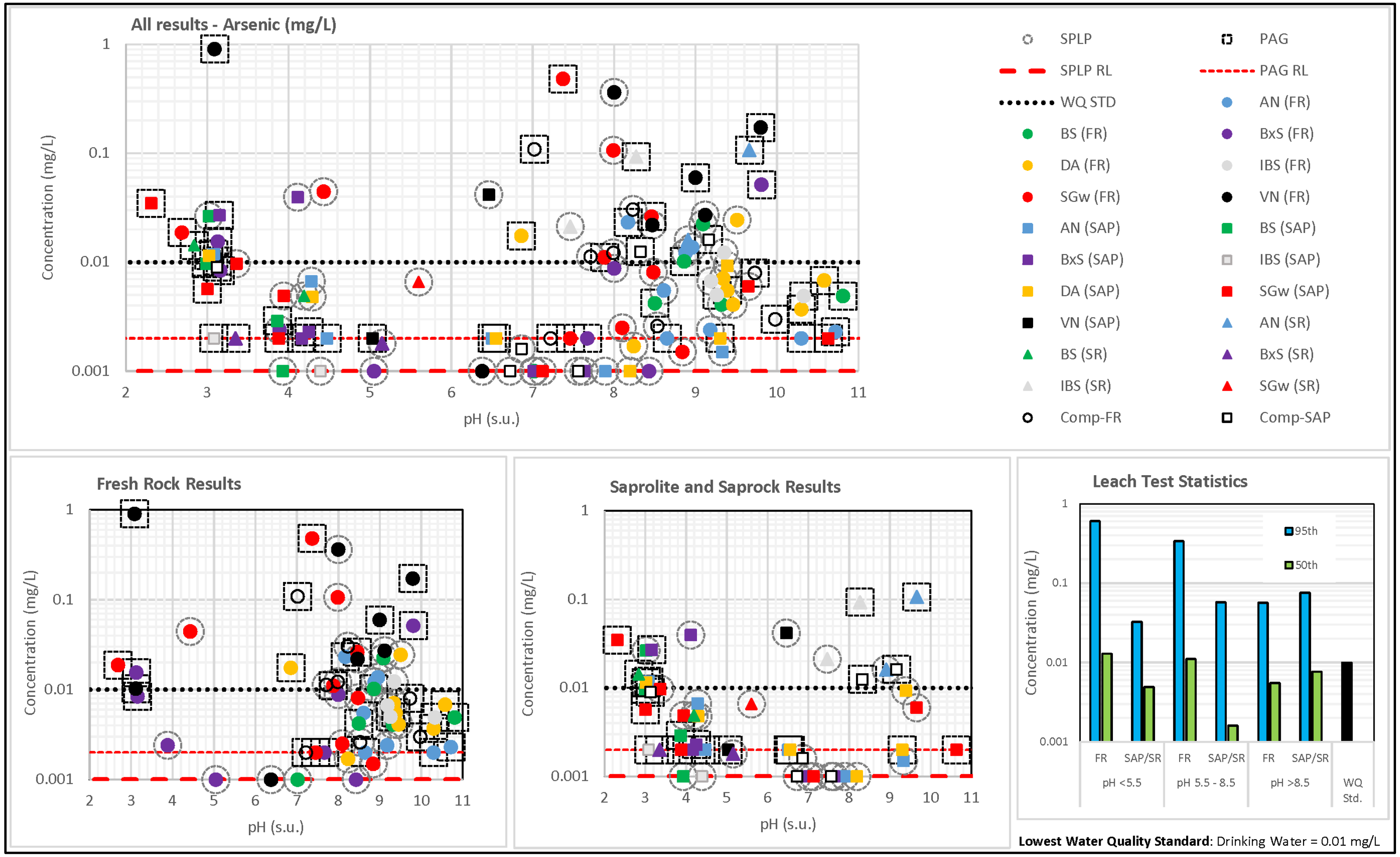
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-8 Static Leach Test Results - Aluminum (mg/L)



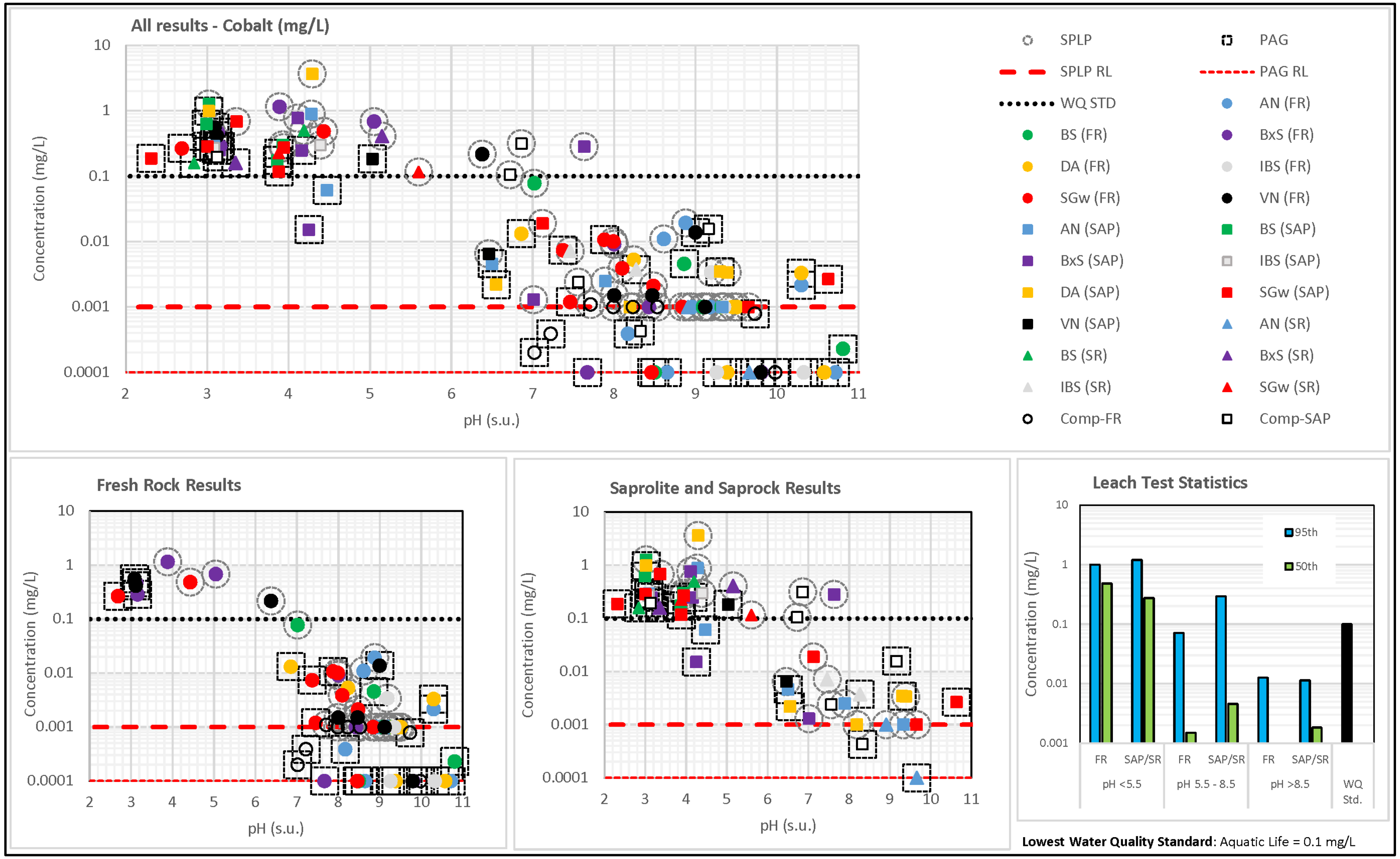
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-9 Static Leach Test Results - Arsenic (mg/L)



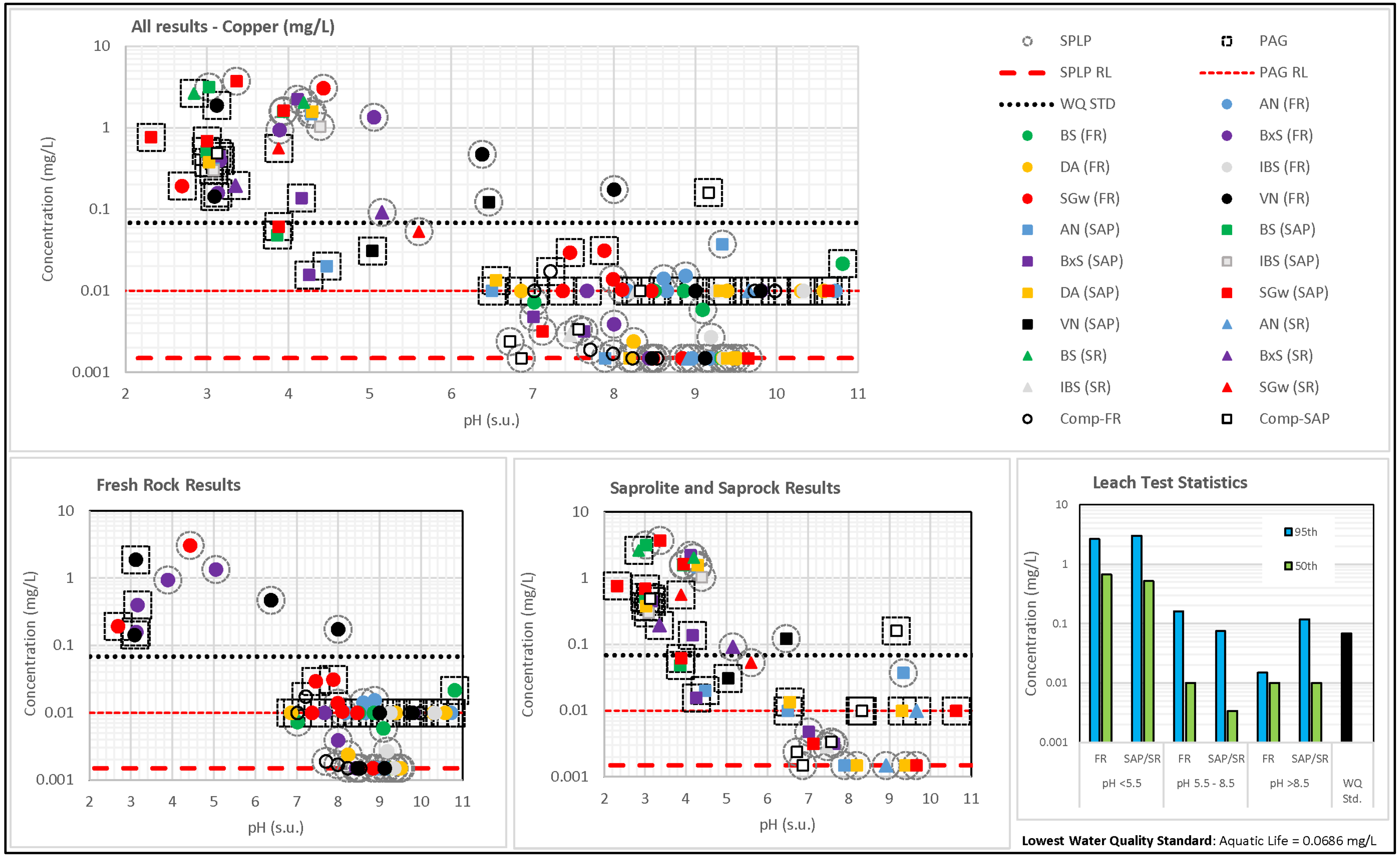
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-10 Static Leach Test Results - Cobalt (mg/L)



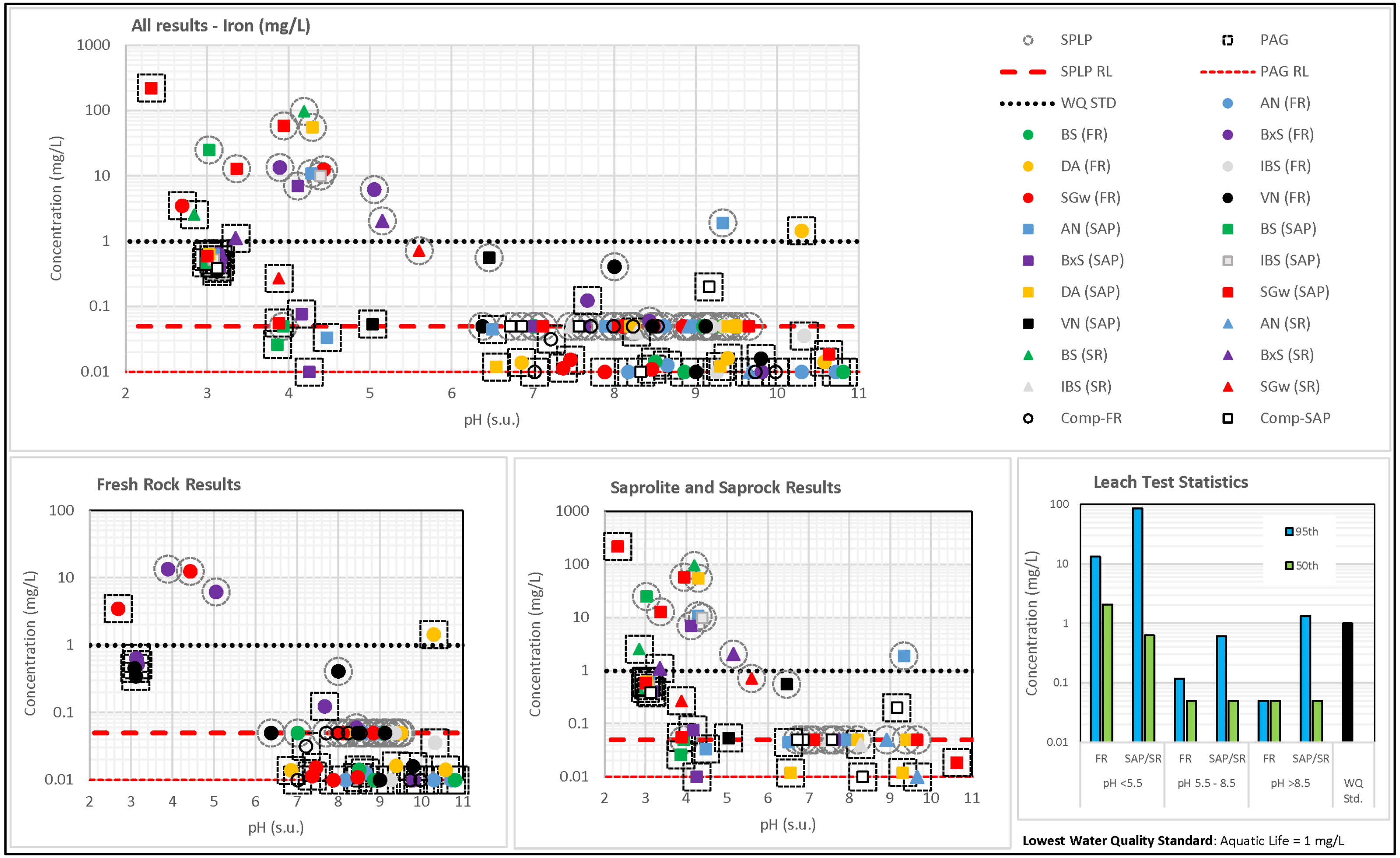
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-11 Static Leach Test Results - Copper (mg/L)



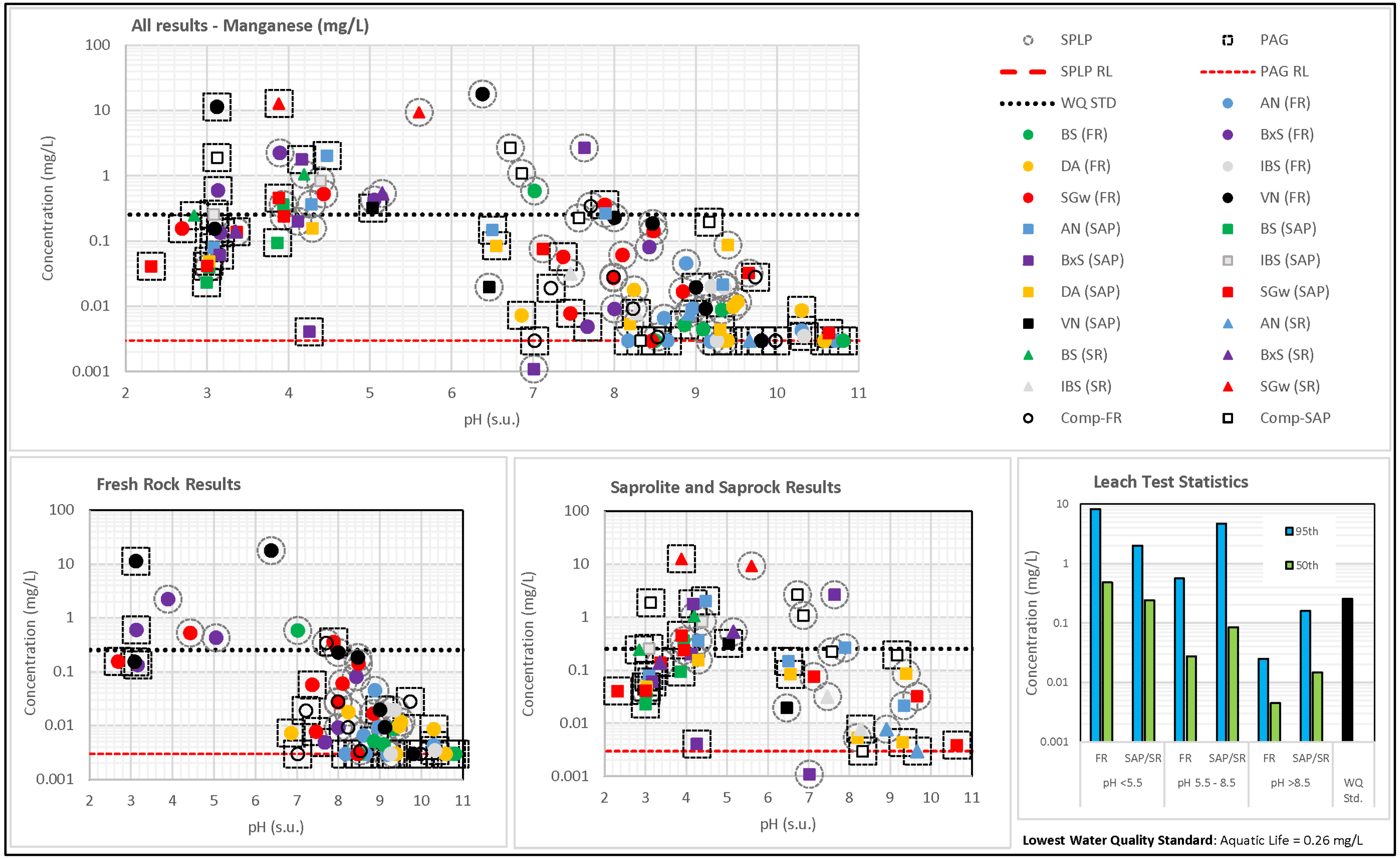
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-12 Static Leach Test Results - Iron (mg/L)



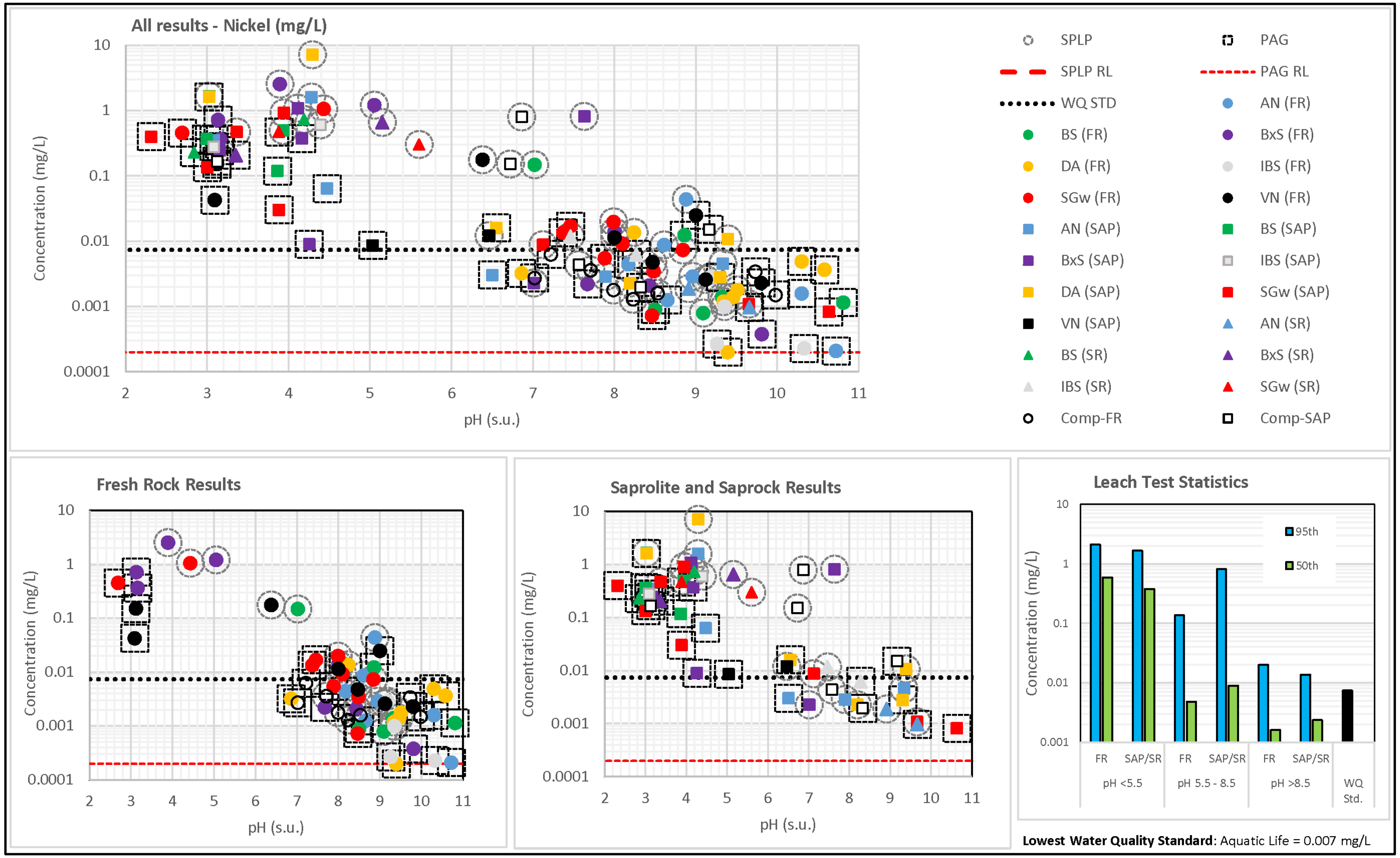
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-13 Static Leach Test Results - Manganese (mg/L)



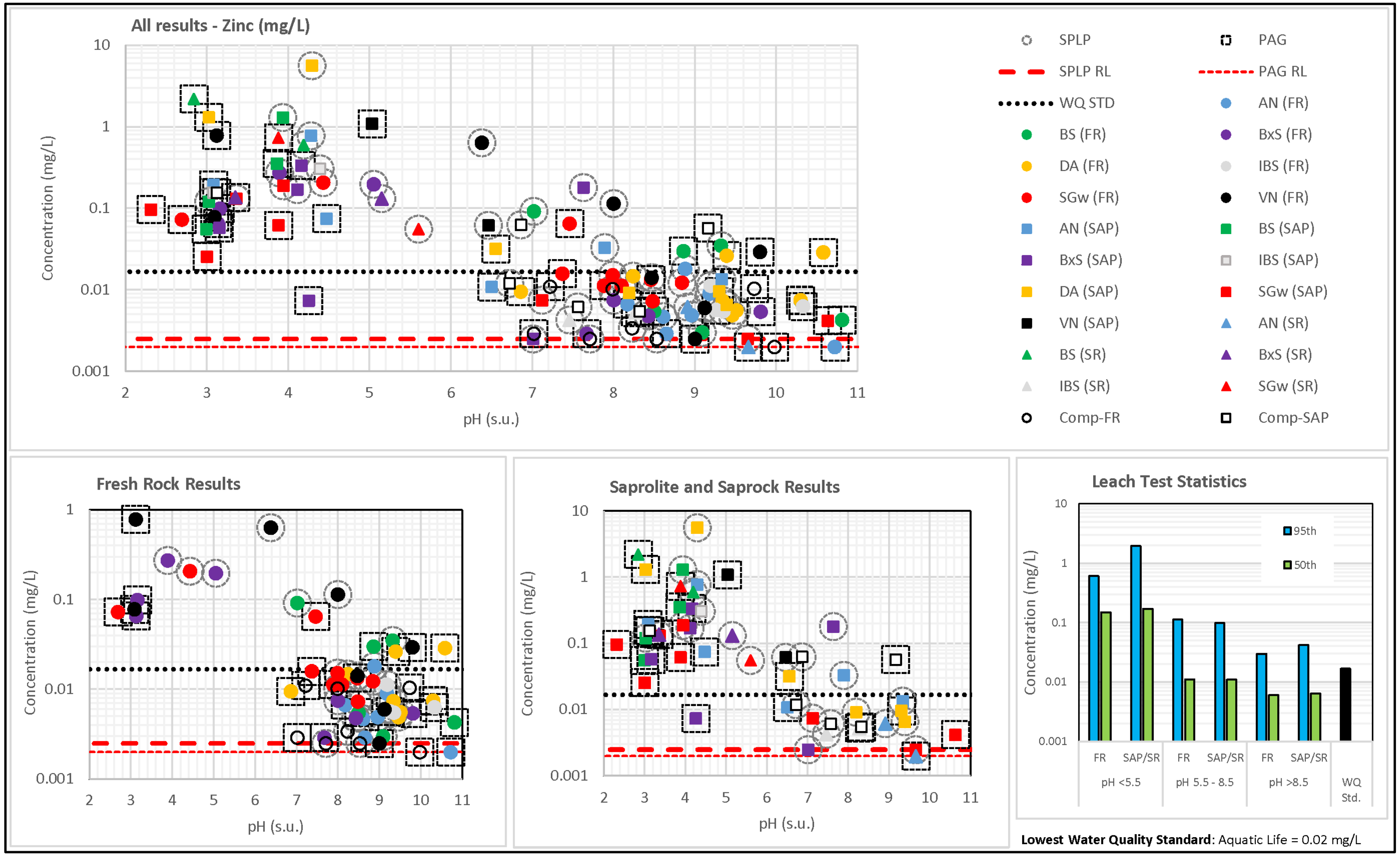
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-14 Static Leach Test Results -Nickel (mg/L)



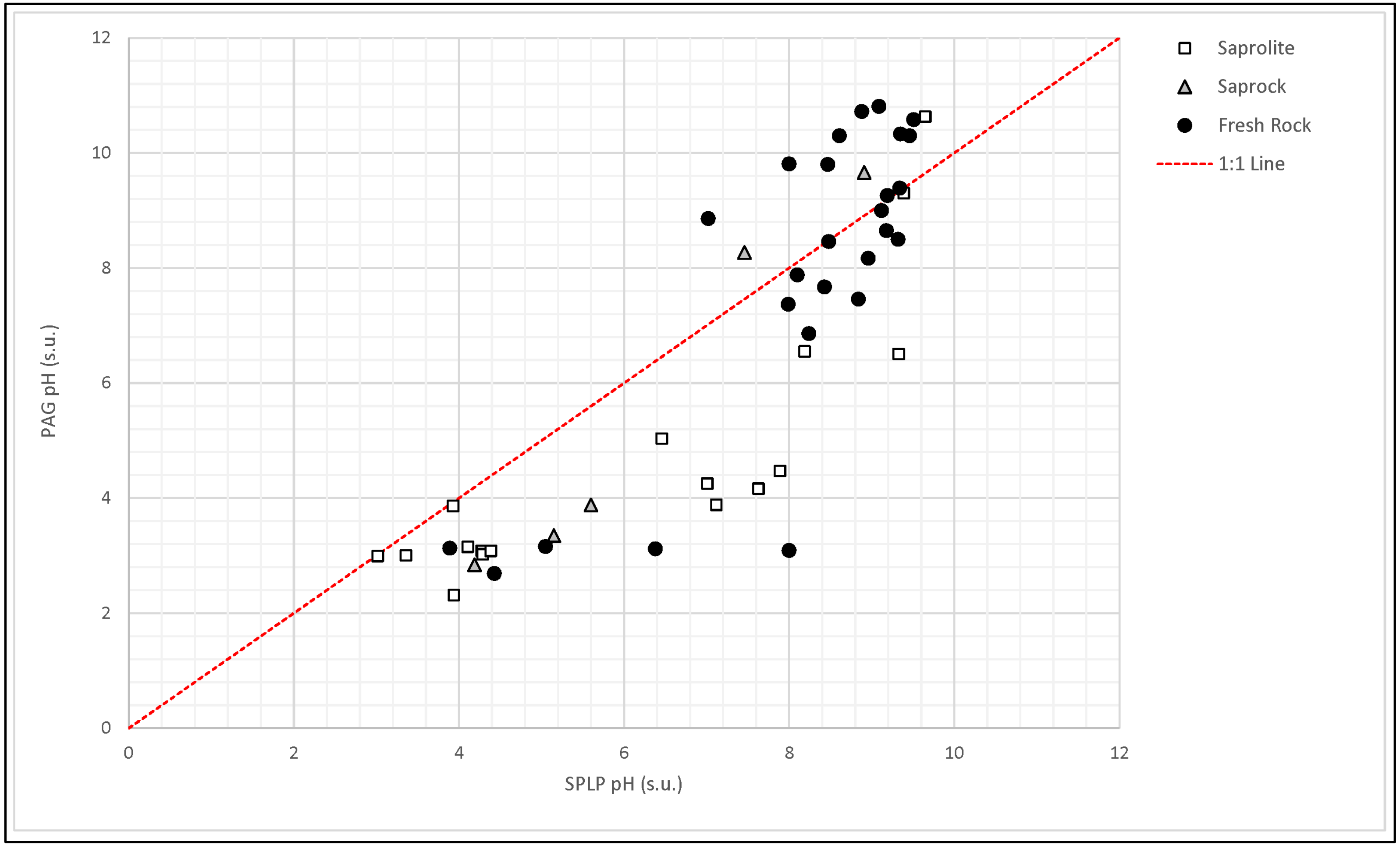
mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-15 Static Leach Test Results - Zinc (mg/L)



mg/L = milligrams per liter; SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation.

Figure 4.5-16 SPLP pH vs. PAG pH



SPLP = synthetic precipitation leaching procedure; PAG = peroxide acid generation; s.u. = standard unit.

As discussed in Section 4.5.3.2, paste pH values ranged from 2.8 to 9.3 and generally increased with increasing depth; saprolite and saprock samples generally yielded lower paste pH values than fresh rock samples. Leachate pH is important to consider when evaluating trace metal leaching and mobility; the mobility of many trace metal is pH dependent and often increases with increasingly acidic conditions.

Leachate metal concentrations versus pH for selected parameters are shown in Figures 4.5-8 to 4.5-15. The following trends were observed (not all parameters are included in the figures):

- increasing metal concentration trends with decreasing pH: Ag, Cu, Cd, Co, Fe, Mn, Ni, Zn, and Ba (PAG leachates);
- "U" shaped curve characteristic of a metal hydroxide control on metal solubility: Al;
- increasing concentration trend with increasing pH: Sb; and
- no obvious pH dependency: As, Ca, Cr, Mo, Pb, Se, and Ba (SPLP leachates).

The leach test results are generally consistent with geochemical principles that dictate that aqueous cationic species (i.e., species having a positive charge in dissolved form, such as Cd, Co, Cu, Zn) tend to become more soluble when conditions become more acidic, while anionic species (i.e., species having a negative charge, such as Mo, Sb, As, Se) tend to become less soluble in acidic environments or show little effect from pH.

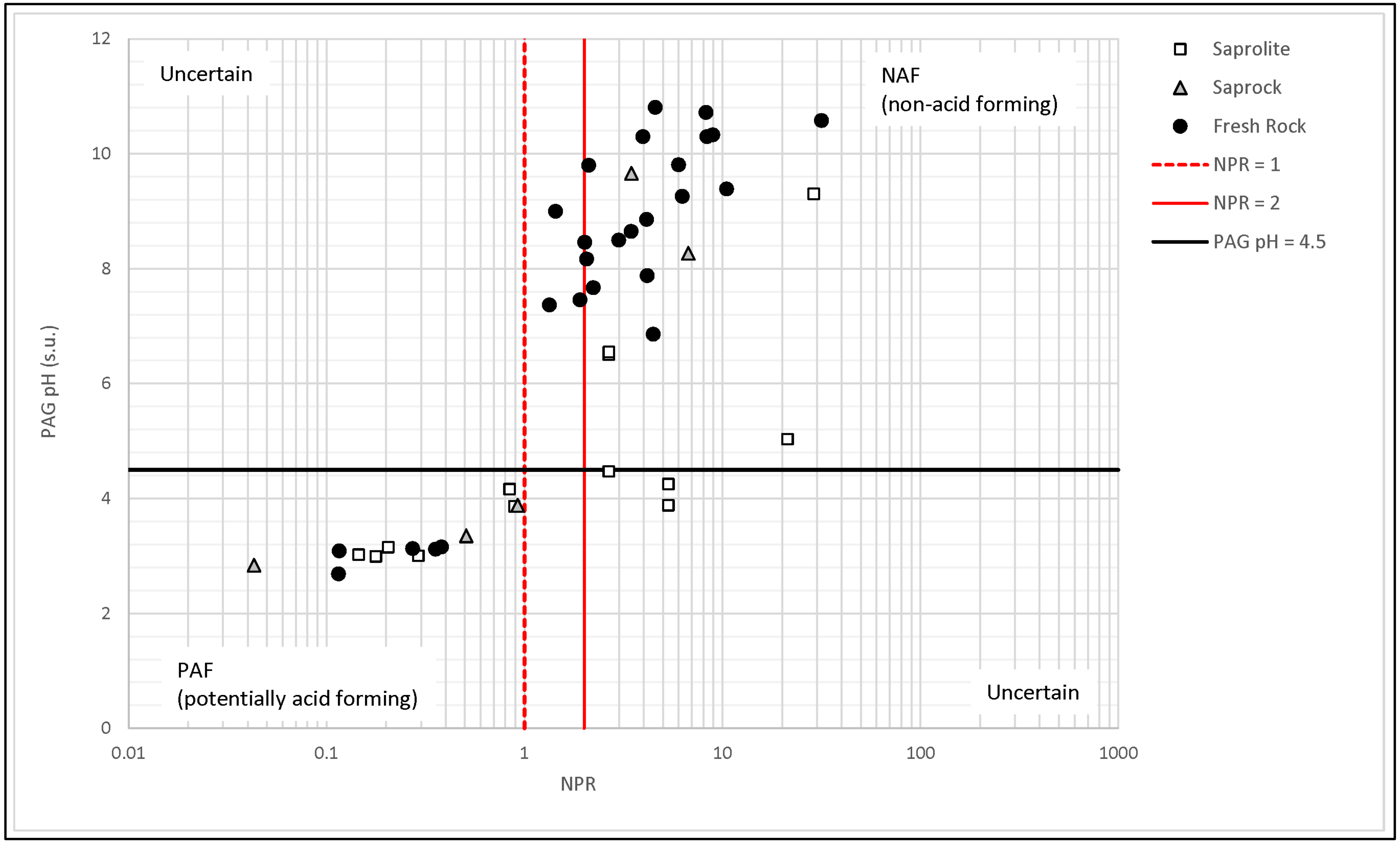
In addition to leachate concentration trends with pH, the following tendencies were observed in static test leachates:

- Generally increasing leachate concentrations with increasing total sulfur (solid phase) for the following parameters: Ca (SPLP)[5], Mo (PAG), Sb (PAG), Se (PAG), and sulfate (SPLP). Mo, Sb, and Se concentrations were often at or below detection in SPLP leachates. These trends suggest that Mo, Sb and Se occur in association with sulfides.
- Increasing leachate arsenic concentrations with increasing total arsenic (solid phase), for both PAG and SPLP leachates (Figure 4.5-17). The highest arsenic leachate and solid phase concentrations were typically associated with fresh rock samples, rather than saprolite or saprock. In particular, SGw and vein lithologies tended to dominate higher arsenic concentrations (leachate >0.01 mg/L and solids >400 ppm), while DA samples clustered more predominantly at mid to low concentrations of both solid and leachate arsenic.
- A positive correlation between SPLP sulfate leachate concentrations and the following parameters: Cu, Al, Ca, Cd, Co, Cr, Fe, Mn, Ni, and Zn.
- Fresh rock leachate pH values were most often circum-neutral to alkaline, even for higher sulfur samples; only one of eight fresh rock samples with a total sulfur concentration of greater than 1 wt.% yielded a pH <5 (both SPLP and PAG). As noted earlier, PAG pH values may be biased high for high sulfur content samples due to incomplete sulfide oxidation during the PAG test.

The highest antimony leachate concentrations were most often associated with fresh rock samples, rather than saprolite or saprock. This trend was present to a lesser degree for molybdenum as well.

[5] Calcium and sulfate concentrations were only measured in SPLP leachates.

Figure 4.5-17 Static Leach Test Results – Solid vs. Leachate Arsenic



PAG = peroxide acid generation; NPR = neutralization potential ratio.

- Unlike arsenic and antimony, the highest leachate concentrations of zinc, lead, nickel, iron, chromium, cobalt, cadmium, aluminum, and copper were often found in saprolite, sometimes saprock, and to a much lesser degree in fresh rock.

The observed relationships between dissolved metal concentrations and pH, total sulfur, and leached sulfate support the observation that fresh rock represents a potential source of reactive sulfide minerals. Metals associated with sulfide minerals that occur as cationic aqueous species generally correlate with sulfate SPLP leachate results, consistent with a common origin in the form of reactive sulfide minerals. The higher concentrations of sulfate and cationic metals (Cu, Al, Ca, Cd, Co, Cr, Fe, Mn, Ni, and Zn) and lower pH values in leachates from saprolite and saprock are consistent with these materials having undergone a higher degree of weathering, including sulfide oxidation. These results contrast with anionic metal leachate concentrations (As, Sb, Se, Mo), of which higher concentrations were often found in fresh rock leachates, with no obvious pH dependency.

Leach test results were compared to the lowest water quality standard. This comparison was done to identify constituents of potential concern (COPC) for informational purposes only. The potential for mine water discharges to result in exceedances of groundwater or surface water quality standards is evaluated as part of the water quality impact assessment (Section 5.7). In Figures 4.5-7 to 4.5-15, the lowest water quality standards are included as black dotted lines. Exceedances of water quality standards can be summarized as follows:

- **Arsenic**: Exceedances of the drinking water standard of 0.01 mg/L were observed in leachates from both leach tests (i.e., SPLP and PAG) across a wide range of pH values (i.e., from acidic to alkaline) (Figure 4.7-9).
- **Cobalt, Copper, Iron and Manganese**: Exceedances of the lowest Project water quality standards were typically measured under circum-neutral to acidic pH conditions with the potential for exceedances increasing as pH decreases (Figures 4.7-10 to 4.7-13).
- **Aluminum, Chromium, Barium, Nickel and Zinc**: Exceedances of the lowest Project water quality standards were observed in leachates from both leach tests (i.e., SPLP and PAG) across a wide range of pH values (i.e., from acidic to alkaline). The highest leachate concentrations were measured under acidic conditions (Figures 4.5-8, 4.5-14 and 4.5-15 for aluminum, nickel and zinc, respectively).
- **Selenium and Antimony:** Exceedances of the lowest Project water quality standards were only observed in the PAG leachates. For antimony, a few exceedances of the drinking water standard of 0.006 mg/L were measured under neutral to alkaline pH conditions. For selenium, exceedances of the aquatic life criterion of 0.005 mg/L were measured across a wide range of pH values (i.e., from acidic to alkaline).
- **Cadmium, Lead, Silver and Thallium:** Exceedances of Project water quality standards were measured in a few leachates. For lead, exceedances were more common for the PAG leachates compared to the SPLP leachates, whereas the opposite was true for thallium. It is notable that the analytical reporting limit for silver in PAG leachates was above its water quality criterion.
- **Beryllium:** Beryllium was detected in a few SPLP leachates at concentrations above the lowest Project water quality standard. Beryllium was consistently below detection in PAG leachates. It is notable that the SPLP and PAG analytical reporting limits for beryllium (i.e., 0.0009 mg/L and 0.001 mg/L, respectively) are higher than the aquatic life criterion for beryllium.

4.5.4 Data Interpretation

4.5.4.1 Evaluation of Acid Generation Potential

A number of criteria have been proposed to characterize the acid generation potential of a sample using ABA results. The most common approaches are those based on the use of the neutralization potential ratio (NPR = ANP/AGP) and the net neutralization potential (NNP = ANP – AGP). For several reasons, no single ANP/AGP or NNP value has been identified to have universal applicability in terms of predicting acid generation. The actual threshold values for a particular solid are material-specific, and depend on many factors, including the amounts and types of acid generating and neutralizing materials, their morphology, grain size, crystallinity, chemical composition, the mineral paragenesis, textural aspects, and the site-specific exposure conditions.

Guidelines for evaluation of acid generation potential of mine wastes presented by the MEND Program (MEND 2009) are summarized in Table 4.5-8. These guidelines were applied in the evaluation of ABA results. In addition to NPR, PAG pH values were considered. A PAG pH value of 4.5 is typically applied as the threshold between acid generating (pH <4.5) and non-acid generating (pH >4.5). Parallel to this evaluation, Newmont classifies the samples based on the results of the NCV analysis (see Table 4.5-3). The NCV classifications were compared to the NPR and PAG pH criteria. Consistent with the calculation of NPR values, AGP and ANP for NCV calculation were based on total sulfur and the minimum measured ANP value. The AGP used for the calculation of NCV is typically based on sulfide sulfur.

NPR versus PAG pH is shown in Figure 4.5-18. The MEND NPR criteria of 1 and 2 and a PAG pH value of 4.5 are superimposed on this figure. Approximately 35% of all samples are classified as potentially acid forming (PAF) (i.e., NPR <2 and PAG pH <4.5). This group includes more than half of the saprolite and saprock samples and approximately 20% of the fresh rock samples. Approximately 50% of the samples are classified as non-acid forming (NAF), including most of the fresh rock samples. The remaining samples (~15%) are classified as uncertain. The uncertain saprolite samples (i.e., three samples in lower right “uncertain” quadrant) all have low total sulfur concentrations (<0.01 to 0.17 wt.%), and they may, therefore, be NAF. For very low sulfur content samples, classification based on NPR is of limited value as the absence of sulfide minerals means that these samples do not have acid generating potential. The uncertain fresh rock samples (i.e., the three samples in upper left “uncertain” quadrant) have total sulfur contents ranging from 0.7 to 2.7 wt.%. For these samples, it is possible that the single addition PAG pH values are biased high. It should also be noted that the same may be true for samples with a sulfur content greater than 1 wt.% S currently classified as NAF based on their PAG pH being greater than 4.5.

The ARD potential classification of the samples based on the results of NCV analysis is shown in Figure 4.5-19. Over half of the samples (67%) are classified between neutral and basic, with the remaining samples classified as either slightly acidic (27%) or acidic to highly acidic (6%). The NCV results are in general agreement with the classification based on NPR. NCV samples classified as basic (i.e., HB, B or SB) or acidic (i.e., HA, A, or SA) are typically also classified by MEND as unlikely and likely to generate ARD, respectively. Most of the NCV samples classified as inert or neutral are classified by MEND as acid generating or uncertain. In general, the MEND classification results in an overall slightly higher ARD potential than the classification based on the NCV method.

Kinetic testing is ongoing to verify whether the various ARD potentials identified from the static testing will indeed be realized over time. The HCT program includes kinetic testing of eight composite samples (seven waste rock and one ore). In general, when sulfides are present in saprolite and saprock, these materials are expected to be acid generating due to their low neutralization potential.

Static test results further suggest that most of the fresh rock may be non-acid generating due to the presence of carbonate minerals. Sequential PAG testing may be required to resolve and/or refine the classification for some of the fresh rock samples that contain higher than approximately 1 wt.% S.

Table 4.5-8 Acid Rock Drainage Classification Criteria

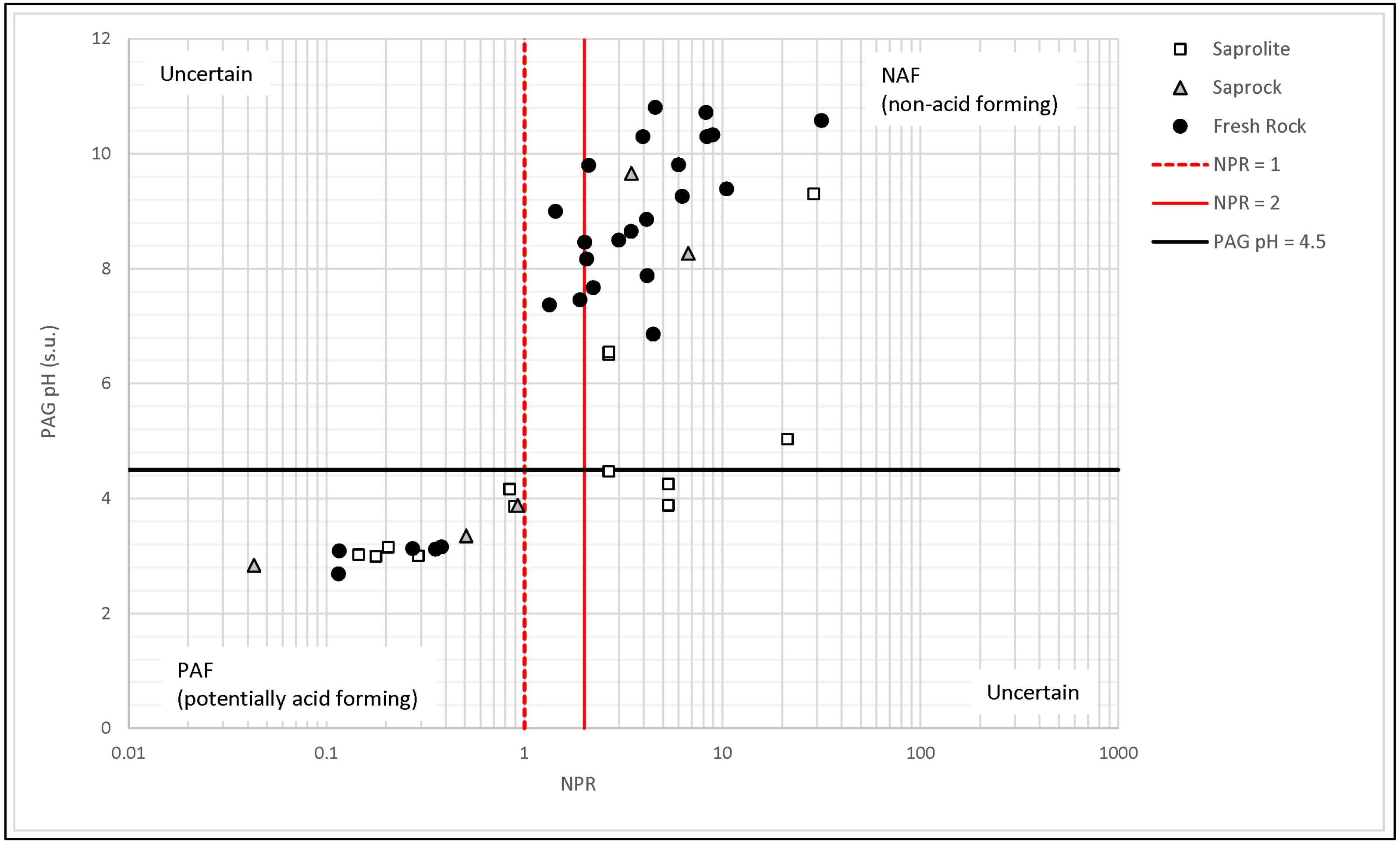
Potential for ARD Classification	Criteria	Comments
PAF - ARD likely	NPR <1	Likely acid generating, unless sulfide minerals are non-reactive. Kinetic testing required to estimate the lag time to ARD.
Uncertain - ARD potential uncertain	1<NPR <2	Possibly acid generating if ANP is insufficiently reactive or is depleted at a rate faster than sulfides.
NAF - low ARD potential	NPR >2	Not potentially acid generating unless significant preferential exposure of sulfides along fractures planes, or extremely reactive sulfides in combination with insufficiently reactive ANP.

Notes:

Source: Adapted from MEND (2009)

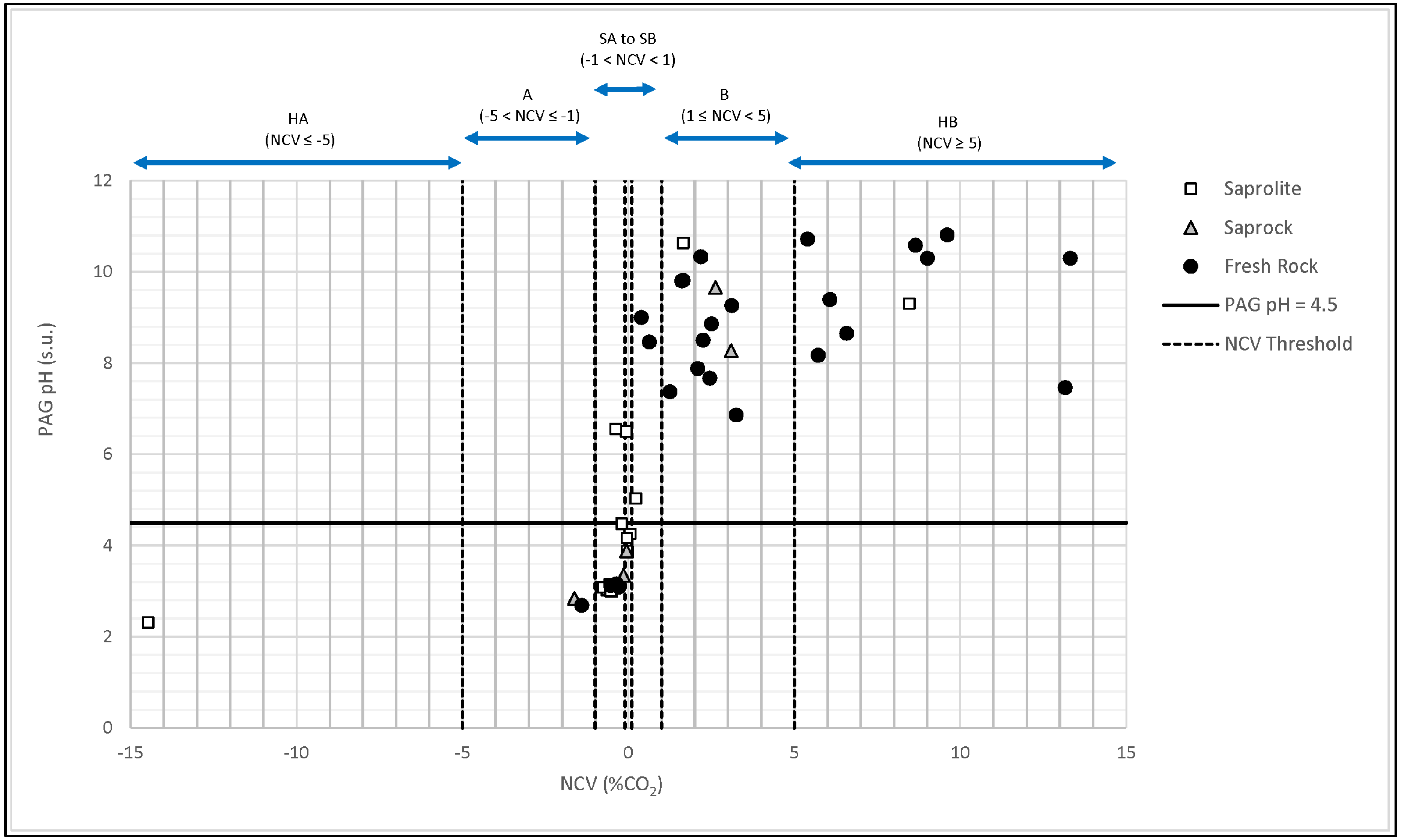
NPR = neutralization potential ratio; PAF - potentially acid forming; NAF - non-acid forming; ARD = acid rock drainage; ANP = acid neutralization potential; < = less than; > = greater than.

Figure 4.5-18 Neutralization Potential Ratio vs. Peroxide Acid Generation pH



PAG = peroxide acid generation; NPR = neutralization potential ratio.

Figure 4.5-19 Net Carbonate Value vs. Peroxide Acid Generation pH



NCV = net carbonate value; PAG = = peroxide acid generation; < = less than; ≤ = less than or equal to; ≥ = greater than or equal to; HA = highly acidic; A = acidic; SA = slightly acidic; SB = slightly basic; B = basic; HB = highly basic; CO_2 = carbon dioxide.

4.5.4.2 Evaluation of Metal Leaching

Static leach test results indicate that pH will be a primary control on the degree of metal leaching. To identify potential COPCs, leach test statistics (i.e., 50^{th} and 95^{th} percentile) were calculated by regolith (i.e., fresh rock and combined saprock and saprolite) for all parameters with project water quality standards. Statistics were calculated over three pH ranges: <5.5 (acidic), 5.5 to 8.5 (circum-neutral), and >8.5 (alkaline; Table 4.5-9).

Based on the results of the static leach tests, the following constituents are identified as COPCs based on their potential to exceed Project water quality standards:

- **Arsenic**: Leach testing indicates a potential for mobilization of arsenic from both fresh rock and saprolite/saprock under acidic, neutral and alkaline conditions. Because leachate concentrations generally increase with increasing solid phase arsenic concentration, total arsenic concentration may be considered as a criterion for material segregation.
- **Aluminum, Chromium, Barium, Nickel and Zinc**: Leach testing indicates a potential for mobilization from both fresh rock and saprolite/saprock under acidic, neutral and alkaline conditions. With the exception of barium, the highest leaching potential is observed under acidic conditions.
- **Cobalt, Copper, Iron, and Manganese**: Leach testing indicates a potential for mobilization of these metals from both fresh rock and saprolite/saprock, particularly under acidic conditions.
- **Antimony, Beryllium (possibly), Cadmium, Lead, Selenium, Silver and Thallium**: Leach testing indicates some potential for mobilization of these metals. The leaching potential of beryllium is uncertain due to its elevated reporting limits (i.e., analytical reporting limits above the lowest Project water quality standard).

In summary, arsenic is a primary element of concern due to its potential to leach from all rock types under all pH conditions. Under circum-neutral pH conditions, other elements with leaching potential include aluminum, chromium, barium, nickel and zinc. If acidic conditions are established, several additional metals have the potential to exceed water quality criteria in mine waters.

Table 4.5-9 Leach Test Statistics Summary

Parameter	Lowest Water Quality Standard (mg/L)	Lowest Water Quality Standard Type	Percentile	Saprolite / Saprock			Fresh Rock		
				<5.5	5.5 - 8.5	>8.5	<5.5	5.5 - 8.5	>8.5
Sulfate (SO_4) (mg/L)	1,500	DW	50th	227	46	23	157	32	12
			95th	448	154	32	223	129	111
Aluminum (Al) (mg/L)	0.087	A	50th	6	0.01	0.14	5	0.05	0.08
			95th	25	0.54	1.4	14	0.22	0.40
Antimony (Sb) (mg/L)	0.006	DW	50th	0.0004	0.0005	0.0005	0.0005	0.001	0.001
			95th	0.0005	0.003	0.004	0.001	0.006	0.005
Arsenic (As) (mg/L)	0.01	DW	50th	0.005	0.002	0.008	0.013	0.011	0.006
			95th	0.03	0.06	0.08	0.6	0.3	0.06
Barium (Ba) (mg/L)	0.04	A (H)	50th	0.03	0.01	0.05	0.07	0.01	0.02
			95th	0.1	0.2	0.1	0.1	0.2	0.2
Beryllium (Be) (mg/L)	0.0001	A (H)	50th	0.001	0.0009	0.001	0.001	0.0009	0.001
			95th	0.001	0.001	0.001	0.001	0.001	0.001
Boron (B) (mg/L)	5	A	50th	0.02	0.02	0.02	0.02	0.02	0.02
			95th	0.07	0.03	0.04	0.05	0.03	0.03
Cadmium (Cd) (mg/L)	0.0004	A (H)	50th	0.0006	0.0001	0.0002	0.0009	0.0002	0.0002
			95th	0.008	0.0007	0.0002	0.003	0.0009	0.002
Chromium (Cr) (mg/L)	0.01	A (H)	50th	0.02	0.0004	0.007	0.02	0.0004	0.007
			95th	0.1	0.008	0.02	0.06	0.02	0.03
Chloride (Cl) (mg/L)	230	A	50th	1.4	1.4	1.3	1.3	1.3	1.4
			95th	2.1	2.5	6.8	7.9	1.5	2.1
Cobalt (Co) (mg/L)	0.1	A	50th	0.3	0.005	0.002	0.5	0.002	0.001
			95th	1.2	0.3	0.01	1.0	0.07	0.01
Copper (Cu) (mg/L)	0.0686	A	50th	0.5	0.003	0.01	0.7	0.01	0.01
			95th	3.0	0.07	0.1	2.7	0.2	0.01
Fluoride (F) (mg/L)	4	DW	50th	0.2	0.1	0.1	0.5	0.1	0.1
			95th	0.5	0.2	0.1	0.9	0.2	0.1
Iron (Fe) (mg/L)	1	A	50th	0.6	0.1	0.1	2.1	0.1	0.1
			95th	86	0.6	1.3	13	0.1	0.1
Lead (Pb) (mg/L)	0.003	A (H)	50th	0.002	0.001	0.001	0.003	0.001	0.001
			95th	0.06	0.01	0.01	0.004	0.002	0.002
Manganese (Mn) (mg/L)	0.3	A (H)	50th	0.2	0.09	0.01	0.5	0.03	0.005
			95th	2.0	4.7	0.2	8.2	0.6	0.03

Table 4.5-9 Leach Test Statistics Summary

Parameter	Lowest Water Quality Standard (mg/L)	Lowest Water Quality Standard Type	Percentile	Saprolite / Saprock			Fresh Rock		
				<5.5	5.5 - 8.5	>8.5	<5.5	5.5 - 8.5	>8.5
Mercury (Hg) (mg/L)	0.0008	A	50th	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
			95th	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Molybdenum (Mo) (mg/L)	0.18	DW	50th	0.001	0.0003	0.002	0.001	0.001	0.001
			95th	0.01	0.005	0.004	0.01	0.01	0.008
Nickel (Ni) (mg/L)	0.007	A (H)	50th	0.4	0.01	0.002	0.6	0.005	0.002
			95th	1.7	0.8	0.01	2.1	0.1	0.02
Selenium (Se) (mg/L)	0.005	A	50th	0.003	0.001	0.001	0.004	0.001	0.002
			95th	0.009	0.003	0.004	0.01	0.009	0.006
Silver (Ag) (mg/L)	0.0001	A	50th	0.0005	0.0005	0.0005	0.0005	0.0001	0.0005
			95th	0.003	0.001	0.0006	0.0006	0.0005	0.0007
Thallium (Tl) (mg/L)	0.002	DW	50th	0.0005	0.0008	0.0006	0.0003	0.0008	0.0003
			95th	0.004	0.002	0.0008	0.0008	0.0008	0.0008
Zinc (Zn) (mg/L)	0.017	A (H)	50th	0.2	0.01	0.006	0.15	0.01	0.006
			95th	1.9	0.1	0.04	0.6	0.1	0.03

DW = drinking water; A = aquatic life ; A (H) = hardness-dependent aquatic life; < = less than; > = greater than; mg/L = milligrams per liter.

4.5.5 Uncertainties

This section presents a preliminary evaluation of the ARD/ML potential of mine materials based on the available results from a geochemical characterization program. This geochemical testing program is currently ongoing. As additional information becomes available, the conceptual model presented herein will be updated. Current data gaps and uncertainties include the following:

- **Spatial Representation**: The ESIA baseline samples were all collected from Sabajo drill core. Although the geochemical behavior of waste and ore from the Santa Barbara and Margo deposits is expected to be similar, geochemical investigation of these deposits is required to verify this assumption. The ESIA baseline samples were also obtained primarily from the center of the Sabajo deposit, due to the availability of sulfur, carbon and arsenic assay data. Additional sample collection from the perimeter of the Sabajo deposit may be necessary.
- **ANP Estimation**: Accurate estimation of ANP is fundamental to estimation of ARD potential. ANP is a measurement of the amount of alkaline or basic material in a rock or soil. There are many minerals capable of acid neutralization; however, their reaction mechanisms and rates vary widely. Effective ANP is defined as "*the acid neutralization that can neutralize internal and external acidity inputs sufficiently to maintain near-neutral pH drainage*" (MEND 2009). For Sabajo, effective ANP includes only the contribution from calcite and dolomite. The Fe-Mn carbonates that are present will not provide effective ANP.

  ANP determinations by multiple methods have resulted in a range of estimated ANP values. Additional evaluation is required to determine the most appropriate and accurate method to estimate effective ANP. A correlation between ANP and total carbon will need to be determined to relate ANP estimates to the larger waste rock total carbon assay database.

  Sequential PAG testing for high-sulfur content samples is recommended to reduce uncertainty in ARD classification.
- **Kinetic Testing**: As noted earlier, kinetic testing is ongoing. Kinetic test results are required to verify ARD potential and evaluate long-term metal leaching potential.
- **Ore**: The ESIA baseline program included only two ore samples due to the limited availability of this material. Additional characterization of ore may be warranted.

4.6 Groundwater

4.6.1 Introduction and Background

This section summarizes the results of the baseline hydrogeologic investigation and presents a conceptual hydrogeological model of the Sabajo Project (the Project) area. The model provides the basis for identifying the potential short and long-term impacts to groundwater flow and quality that may occur during development and operation of the Project at Sabajo. This baseline assessment does not include an evaluation of the Margo and Santa Barbara artisanal and small scale mining (ASM) areas because hydrogeological information was not available at the time of this assessment (this is addressed further in the data gaps subsection). Given the information collected as part of the Sabajo groundwater baseline assessment, and the similar site setting for Sabajo, Margo and Santa Barbara pits, the potential impacts can be identified. Additional hydrogeological data will be collected in the three planned mining areas prior to development of any mining activities. The hydrogeologic baseline assessment for Sabajo includes data from the following sources:

- climate information from the Merian Gold Mine (Merian mine) weather station;
- geological information from the Newmont Suriname, LLC. (Newmont) exploration program of the Sabajo deposit;
- geological information from the drilling and installation of monitoring wells and test wells in the area of the proposed main Sabajo pit, the north waste rock facility (WRF) and the ore stockpile (OS) area in 2016 and 2017;
- slug tests in the monitoring wells to provide hydraulic properties of the geological units;
- pumping tests in the test wells to provide information on hydraulic parameters and aquifer boundaries;
- water quality sampling of the monitoring wells and test wells to characterize baseline groundwater quality; and
- discrete and continuous groundwater level measurements in the monitoring wells and test wells from December 2016 to September 2017 to examine the change in water levels with time.

4.6.2 Method

Hydrogeologic investigations were conducted in late 2016 and 2017 by Newmont and Golder Associates Inc. (Golder) according to the Hydrogeological Characterization Work Plan (Golder 2017a). The objective of the hydrogeologic investigations was to assess the nature and occurrence of groundwater in the vicinity of the proposed Sabajo Pit, WRFs and OS at the Project site to develop a conceptual hydrogeologic model of the Project area. The hydrogeologic field investigation consisted of the following:

- borehole drilling followed by either test well or monitoring well installations;
- permeability testing using the monitoring wells;
- pumping tests at two test wells to characterize hydraulic conductivity and boundary conditions for the geological units;
- groundwater quality sampling; and
- groundwater level monitoring at monitoring wells and test wells to characterize groundwater elevations, flow directions, hydraulic gradients and seasonal fluctuation in groundwater level.

Additional details regarding each component of the field investigation program are provided below. Map 4.6-1 shows the locations of the monitoring wells and test wells. Well construction details are summarized in Table 4.6-1.

Table 4.6-1 Well Construction Details

Well ID	Well Type	Northing (Survey)	Easting (Survey)	Ground Surface Elevation (m amsl) (Survey)	Screened Geologic Unit	Top of Saprock (m bgs)	Top of Bedrock (m bgs)	Total Well Depth Including Filter Pack (m bgs)	Top of Screen (m bgs)	Bottom of Screen (m bgs)	Monitored Interval		Top of Bentonite (m bgs)	Bottom of Bentonite (m bgs)	Borehole Radius (mm)	PVC Casing Inside Radius (mm)
											Top of Filter Sand (m bgs)	Bottom of Filter Sand (m bgs)				
SP-MW-01-SQ	Monitoring Well	562,357	743,181	66.39	Saprolite Quartz Vein	68.0	70.7	65.9	54.9	64.0	47.9	65.9	Unknown	47.9	60.96	25.4
SP-MW-02-SR	Monitoring Well	563,183	741,536	52.95	Saprock	1.6	4.0	30.0	13.8	29.0	11.0	30.0	8.0	11.0	60.96	25.4
SP-MW-02-BR	Monitoring Well	563,171	741,528	53.05	Cassador Fault	1.2	31.5	61.0	39.7	61.0	38.0	61.0	35.0	38.0	60.96	25.4
SP-TW-01-SR	Test Well	562,368	743,205	65.90	Saprock	69.5	80.5	81.0	70.9	80.0	67.9	81.0	66.0	67.9	100.01	50.8
SP-TW-01-BR	Test Well	562,348	743,191	66.49	Cassador Fault	58.0	69.8	124.5	99.4	123.8	95.8	124.5	88.0	95.8	79.38	50.8
SP-MW-01-BR	Monitoring Well	562,370	743,174	66.63	Cassador Fault	62.9	63.0	158.0	135.8	151.0	134.0	158.0	132.0	134.0	60.96	25.4
WRD-MW-01-SR	Monitoring Well	561,651	741,865	28.06	Saprock	27.0	34.6	41.8	27.2	33.2	25.8	35.2	24.1	25.8	60.96	25.4
WRD-MW-01-SQ	Monitoring Well	561,654	741,866	27.92	Saprolite Quartz Vein	27.0	34.6	18.0	10.0	16.0	9.0	18.0	8.0	9.0	60.96	25.4
OS-MW-01-SR	Monitoring Well	563464	743280	-	Saprock	17.5	22.3	28.0	18.0	27.0	17.0	28.0	16.0	17.0	60.96	25.4

Notes:

Shaded cells represent estimated coordinates based on handheld GPS

ID = identification; PVC = polyvinyl chloride; GPS = Global Positioning System; m amsl = meters above mean sea level; m bgs = meters below ground surface; mm = millimeter; - = not available.

In general, the monitoring wells were drilled and installed with a coring rig using PQ-sized drill casing (122.6-millimeter [mm] outside diameter). The test wells were first drilled using a coring rig, followed by over-reaming with tri-cone bit. The monitoring wells were completed using 2-inch (50 mm) diameter polyvinyl chloride (PVC) screen and casing. The test wells were completed using 4-inch (102 mm) diameter PVC well screen and casing. For all wells, the final well completion depths and screened intervals were selected based on the core logs and drilling observations.

Hydraulic testing was conducted in the monitoring wells and test wells to estimate the hydraulic conductivity of the monitored intervals. The hydraulic testing consisted of slug tests (i.e., falling-head or rising-head tests) and pumping tests. Results from the hydraulic testing are summarized in Table 4.6-2.The data collected in 2016 and 2017 has identified the hydrogeologic units at the site, which include:

- alluvium (in-situ and reworked from ASM);
- saprolite and/or quartz veins within saprolite (SQ);
- saprock (SR); and
- bedrock (BR) and Cassador Fault (CF).

Geological cross-sections depicting the stratigraphy across the site are presented in Maps 4.6-2 and 4.6-3.

Groundwater levels were measured in the monitoring wells and test wells using electronic pressure transducers and electric water level tapes to determine changes in groundwater level with time. Table 4.6-3 presents the dates of the manual water level readings. Table 4.6-4 presents the dates and locations of the continuous groundwater level readings (i.e., pressure transducer data).

Groundwater quality samples were collected from the monitoring wells using either temporary sampling pumps, peristaltic pumps (with dedicated tubing), or dedicated bladder pumps. A water quality sample was collected from each test well at the end of the constant rate pumping test. Table 4.8-2 in Section 4.8 (Water Quality) summarizes the groundwater quality samples collected during the field investigation. Groundwater quality is discussed in Section 4.8.

Precipitation data for the site has been obtained from the weather station located at Merian mine; these data are presented in Section 4.3 (Climate Summary).

Table 4.6-2 Hydraulic Testing Results

Hydrogeologic Unit	Geologic Description	Thickness (m)	Hydraulic Properties				Hydraulic Behavior
			No. of Tests	Hydraulic Conductivity Range (cm/s)[a]	Hydraulic Conductivity Geomean (cm/s)[a]	Transmissivity (m^2/d)	
Alluvium (native and reworked)	In-situ and reworked alluvial materials found in stream valleys, consisting of sand to coarse gravel-sized quartz vein fragments in a silty to fine sand matrix.	<5 m (estimated)	N/A	1×10^{-7} to 1×10^{-2}	N/A	No data	Unconfined, hydraulic continuity with surface water
Saprolite / Saprolite Quartz Veins	Saprolite: Formed from the deep chemical weathering and oxidation of the underlying bedrock and comprised primarily of fine-grained soil particles (silt and fine sand).	1 to 90	89	2×10^{-7} to 1×10^{-4}	9×10^{-6}	No data	Unconfined
	Saprolite Quartz Veins: Relict features from the weathering of the underlying bedrock containing intruded quartz veins. Higher density occurrences of quartz veins are typically found near the epithermal deposits and were observed in several coreholes near the Sabajo pit.	Disseminated throughout Saprolite (typically <1 to 10 cm thick)	4	9×10^{-5} to 1×10^{-4}	1×10^{-4}	No data	Unconfined. Hydraulic continuity with surface water where outcrops in/near stream channels
Saprock	Transition zone of partially weathered or oxidized rock. Saprock is characterized as having properties of weak rock and displays the primary textural features found in the underlying bedrock.	1 to 35	7	5×10^{-5} to 4×10^{-4}	2×10^{-4}	3.5 to 10	Semi-confined to confined with some hydraulic continuity with surface water where subcrops in/near stream channels.
Bedrock / Cassador Fault	Bedrock: Sequence of volcanic (i.e., dacite and andesite) and sedimentary (i.e., graywacke, sandstone, and siltstone) rocks.	>80	65	1×10^{-7} to 3×10^{-3}	9×10^{-5}	No data	Confined. Low permeability in unfractured bedrock. Moderately permeable in fractured bedrock. Limited hydraulic continuity with surface water.

Table 4.6-2 Hydraulic Testing Results

Hydrogeologic Unit	Geologic Description	Thickness (m)	Hydraulic Properties				Hydraulic Behavior
			No. of Tests	Hydraulic Conductivity Range (cm/s)[a]	Hydraulic Conductivity Geomean (cm/s)[a]	Transmissivity (m^2/d)	
Bedrock / Cassador Fault (Continued)	Cassador Fault: A zone of carbonaceous fine-grained sedimentary rock (siltstone to mudstone) and typically has a fractured halo and fine-grained gouge zone of 5 to 10 m. The total width of the fault zone at Sabajo is estimated to be about 100 to 150 m, based on geologic cross-sections. The footwall rock is composed predominantly of dacite and the hanging wall rocks are composed mostly of sedimentary rocks and andesite.	>80	5	1×10^{-5} to 2×10^{-5}	1×10^{-5}	1.5 to 4.6	Confined, moderately permeable in fractured zone with preferential flow/continuity along strike of fault and with fractured bedrock in hanging wall.

Notes:

Light shaded cells based on range in hydraulic conductivity values for silt to silty sand (Freeze and Cherry 1979)

Dark shaded cells represent values from the Merian Project hydrogeological investigation (Golder 2013), because lithologies are similar and no Sabajo data are available.

a) Range of results from pump tests and slug tests

No. = number; N/A = not applicable; m = meter; cm = centimeter; m^2/d = square meters per day; cm/s = centimeters per second; >= greater than; <= less than.

Table 4.6-3 Manual Groundwater Level Measurements

Well ID and Date of Measurement							
SP-TW-01-BR	**SP-TW-01-SR**	**SP-MW-01-BR**	**SP-MW-01-SQ**	**SP-MW-02-BR**	**SP-MW-02-SR**	**WRD-MW-01-SQ**	**WRD-MW-01-SR**
22 June 2017	23 June 2017	2 December 2016	23 June 2017	19 June 2017	19 June 2017	1 December 2016	1 December 2016
23 June 2017	24 June 2017	9 June 2017	24 June 2017	20 June 2017	20 June 2017	9 June 2017	9 June 2017
24 June 2017	25 June 2017	23 June 2017	25 June 2017	21 June 2017	21 June 2017	19 August 2017	19 August 2017
25 June 2017	26 June 2017	24 June 2017	26 June 2017	22 June 2017	22 June 2017	27 September 2017	27 September 2017
26 June 2017	27 June 2017	25 June 2017	27 June 2017	4 July 2017	4 July 2017	-	-
27 June 2017	28 June 2017	26 June 2017	28 June 2017	19 August 2017	10 August 2017	-	-
28 June 2017	29 June 2017	27 June 2017	29 June 2017	27 September 2017	19 August 2017	-	-
1 July 2017	30 June 2017	28 June 2017	30 June 2017	-	27 September 2017	-	-
2 July 2017	1 July 2017	29 June 2017	1 July 2017	-	-	-	-
3 July 2017	2 July 2017	2 July 2017	2 July 2017	-	-	-	-
19 August 2017	19 August 2017	19 August 2017	4 July 2017	-	-	-	-
-	-	27 September 2017	10 August 2017	-	-	-	-
-	-	-	19 August 2017	-	-	-	-
-	-	-	27 September 2017	-	-	-	-

ID = identification;- = no measurement.

Table 4.6-4 Pressure Transducer Records

Well ID	File Start	File End
SP-MW-01-BR	23 June 2017	26 June 2017
SP-MW-01-BR	12 August 2017	27 September 2017
SP-MW-01-SQ	23 June 2017	26 June 2017
SP-MW-01-SQ	30 June 2017	27 September 2017
SP-MW-02-SR	10 August 2017	27 September 2017
SP-TW-01-BR	23 June 2017	23 June 2017
SP-TW-01-BR	26 June 2017	29 June 2017
SP-TW-01-SR	23 June 2017	23 June 2017
SP-TW-01-SR	24 June 2017	26 June 2017
SP-TW-01-SR	30 June 2017	3 July 2017
WRD-MW-01-SQ	3 July 2017	3 July 2017
WRD-MW-01-SQ	18 August 2017	19 August 2017
WRD-MW-01-SR	3 July 2017	3 July 2017
WRD-MW-01-SR	19 August 2017	27 September 2017

Notes:

Pressure transducer currently (as of October 2017) deployed in the following wells: SP-MW-01-SQ, SP-MW-02-SR and WRD-MW-01-SR

ID = identification.

4.6.3 Hydrogeologic Units

The hydrogeologic units described below are the water-bearing strata or geological structures that transmit groundwater in the Project area. Each hydrogeological unit has distinct properties; specifically geology, hydraulic parameters and groundwater flow and water quality.

Alluvium / Reworked Material

Unconsolidated materials are found primarily in stream valleys at the site. The unconsolidated materials include native alluvial deposits consisting of sand and silt, and similar materials that have been reworked by ASM activities. Alluvium was not encountered in any of the coreholes drilled as part of this investigation. The in-situ and reworked alluvial materials are estimated to range in thickness from 1 to 4 meters (m) based on visual observations in areas of ASM. The estimated width of the alluvial deposits ranges from less than 40 to 300 m.

Saprolite/Saprolite with Quartz Veins (SQ)

Saprolite is formed from deep chemical weathering and oxidation of the underlying volcanic and sedimentary bedrock and is primarily composed of fine-grained soil particles (clay, silt and fine sand). Saprolite was observed in each of the coreholes and was typically identified as a reddish-brown to yellow-brown clayey silt with iron and manganese oxide staining or mottling. Weathering has resulted in a saprolite profile that extends on average 50 to 60 m below the ground surface. The saprolite sequence across the site exhibits local variation in thickness ranging from less than 1 to over 90 m, based on corehole information and geologic cross-sections from Newmont.

Maps 4.6-2 and 4.6-3 show the saprolite thicknesses across the site. The thinnest areas of saprolite are generally found in stream valleys and other low-lying areas where erosion has removed the thick saprolite soils. The thickest sequences of saprolite are generally found in upland areas and the proposed main Sabajo pit area.

The prominent geologic structures within the saprolite are relict fabric, foliation, or bedding that were present in the original unweathered rock, including remnant quartz veins that are associated with the ore bodies. Quartz veins have also been encountered in other areas of the Project site, including the WRF. The quartz veins in the saprolite may be relatively intact or broken and rubbly with a gravelly appearance. Higher density occurrences of quartz veins are typically found near the ore body within the main pit and along strike of the Cassador Fault Zone (CFZ) and were observed in several coreholes near the Sabajo Pit (SP-MW-02-BR, SP-TW-01-BR, SP-MW-01-SQ) and WRF (WRD-MW-01-SQ). Within the saprolite, the quartz veins were typically observed to be disseminated and saccharoidal (i.e., granular with a “sugary” texture) with a halo of white clay, and ranged in thicknesses of less than 1 to 10 centimeters (cm). Within the underlying saprock and fresh rock, the quartz veins were observed to be more massive, ranging in thickness from less than 1 to more than 1 m.

Saprock (SR)

A transition zone of partially weathered or oxidized rock, commonly referred to as saprock, occurs below the saprolite and overlying bedrock (Maps 4.6-2 and 4.6-3). Saprock is characterized as having properties of weak rock and displays the primary textural features found in the underlying bedrock. Quartz veins extend through the saprock between overlying saprolite and underlying fresh bedrock. Based on corehole logs, the saprock thickness at Sabajo is estimated to range from less than 1 m to more than 35 m, where thicker occurrences of saprock are found in the Pit 1 area. The saprock is generally encountered at an elevation of +50 meters above mean sea level (m amsl) to -40 m amsl.

Bedrock (BR)/Cassador Fault Zone (CFZ)

Bedrock underlies the saprock and contains zones of both weathered and fractured and unfractured rock. The bedrock consists of a sequence of volcanic (i.e., dacite and andesite) and sedimentary (i.e., graywacke, sandstone, siltstone and black shales) rocks. Based on available well logs and corelogs, the top of fresh unweathered bedrock was generally encountered at an elevation of +20 to -50 meters above mean sea level (m amsl). Observations during core logging of boreholes in the Sabajo pit area suggests that the bedrock is generally more fractured in the upper 20 to 30 m of the bedrock surface and associated with the CFZ.

The CF is a regional shear zone that runs through the proposed Sabajo pit and generally trends northwest-southeast and dips steeply to the northeast between about 60 to 75 degrees. The CF is identified as a zone of carbonaceous fine-grained sedimentary rock (siltstone to mudstone) and typically has a fractured halo and fine-grained gouge zone of 5 to 10 m. The total width of the fault zone at Sabajo is estimated to be about 100 to 150 m, based on geologic cross-sections. The footwall rock is composed predominantly of dacite and the hanging wall rocks are composed mostly of sedimentary rocks (i.e., sandstone, mudstones and interbedded black shales) and andesite.

4.6.4 Hydraulic Characteristics

The hydraulic characteristics of the hydrogeologic units are presented in Table 4.6-2. In total there were 16 tests conducted: 14 slug tests were performed in five monitoring wells to determine the hydraulic conductivity (K) of the near-borehole materials in the screened zone; and two constant-rate pumping tests were conducted in the two test wells to determine transmissivity (T), storativity (S), and hydraulic boundary conditions of the screened zones in the test wells.

The overall hydraulic conductivity range was estimated to be 1×10^{-5} to 4×10^{-4} centimeters per second (cm/s), with the highest hydraulic conductivity observed in the saprock at the WRF location and the lowest hydraulic conductivity observed in the Cassador Fault bedrock at the northwest end of the main Sabajo Pit. The geometric means hydraulic conductivity for the saprolite quartz veins within saprolite and the saprock were very similar at 1 to 1.5 x 10^{-4} cm/s; whereas the average hydraulic conductivity for the fractured bedrock was an order-of-magnitude lower at 1.4 x 10^{-5} cm/s.

Constant-rate pumping tests were conducted in the saprock (SP-TW-01-SR) and the fractured bedrock within the Cassador Fault Zone (SP-TW-01-BR); hydrographs of the pumping tests are presented in Figures 4.6-1 and 4.6-2, respectively. Pumping test details are provided in the hydrogeologic field investigation report (Golder 2018b). Based on the results of the testing, the transmissivity of the saprock is estimated to range from 3.5 to 10 square meters per day (m^2/d) and the Cassador Fault bedrock transmissivity is estimated to range from 1.5 to 4.6 m^2/d. Storativity was not estimated from the pumping tests because the critical time assumption (u) was not met (Golder 2018b). Drawdown in SP-TW-01-BR after 3 days of continuously pumping approximately 4.5 liters per minute (L/min) was approximately 43 m. Drawdown in the bedrock monitoring well located about 28 m to the north from the test well was about 3.5 m after 3 days of pumping, compared to maximum drawdowns of about 0.14 and 0.15 m in the saprolite quartz vein and saprock monitoring wells, which are located 14 to 25 m to the northwest and southeast from the test well, respectively. The observation well response to pumping the bedrock test well indicates limited hydraulic connection between the fractured bedrock and the overlying saprolite quartz vein and saprock, as indicated by the limted drawdown in these shallower units. The testing suggests preferential groundwater flow within the hanging wall fractured bedrock network associated with the CFZ.

4.6.5 Groundwater Elevations, Hydraulic Gradients and Flow Paths

Groundwater Flow

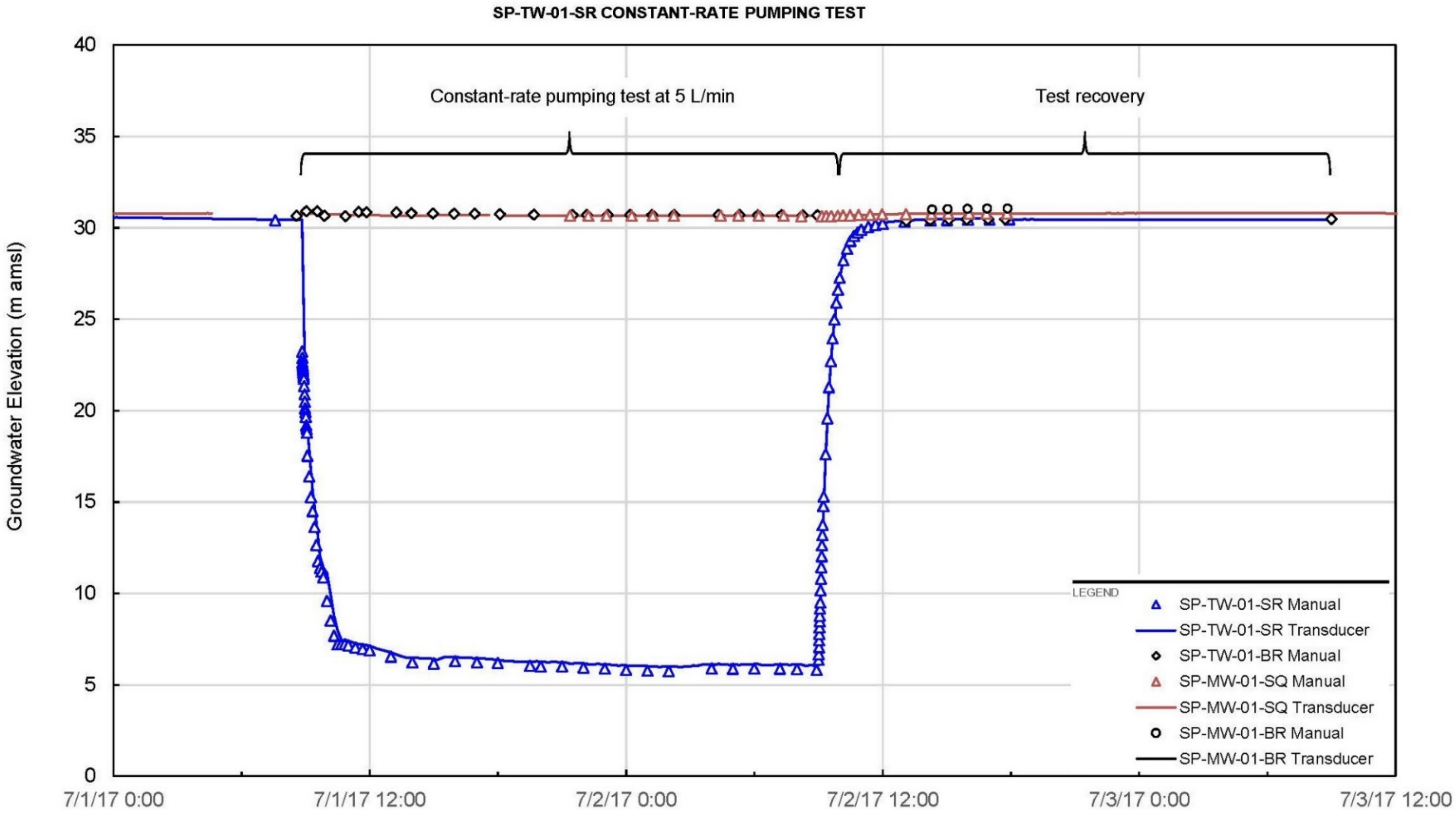
Groundwater levels have been measured periodically in the monitoring wells and test wells completed at site since they were installed to evaluate groundwater level response to precipitation, and other external influences (e.g., atmospheric and earth tides). The depth to groundwater ranged from less than a meter in the lowland areas (OS area) to more than 36 meters below ground surface (m bgs) in the upland areas (Sabajo Pit area). Groundwater elevations and schematic groundwater flow directions at the end of the long wet season (August 2017) are presented in Map 4.6-4.

Figures 4.6-3 to 4.6-5 show changes in groundwater levels in the Sabajo Pit area and the WRF area. Each figure depicts water levels measured in wells completed at different depths and in different hydrogeologic units (i.e,. saprolite quartz vein system, saprock, and bedrock). These figures also show daily precipitation observed at the Merian mine weather station.

Groundwater levels in the saprolite quartz vein system at the SP-MW-01 location show influences from precipitation events, where water level rises of 1 to 3 cm were observed in response to infiltration of precipitation (Figure 4.6-4). The saprock monitoring well completed at the SP-MW-02 location showed less response to precipitation. The figure shows that in August 2017; the rate of groundwater level decrease reduced following a period of increased precipitation indicating the overlying materials are of relatively low permeability.

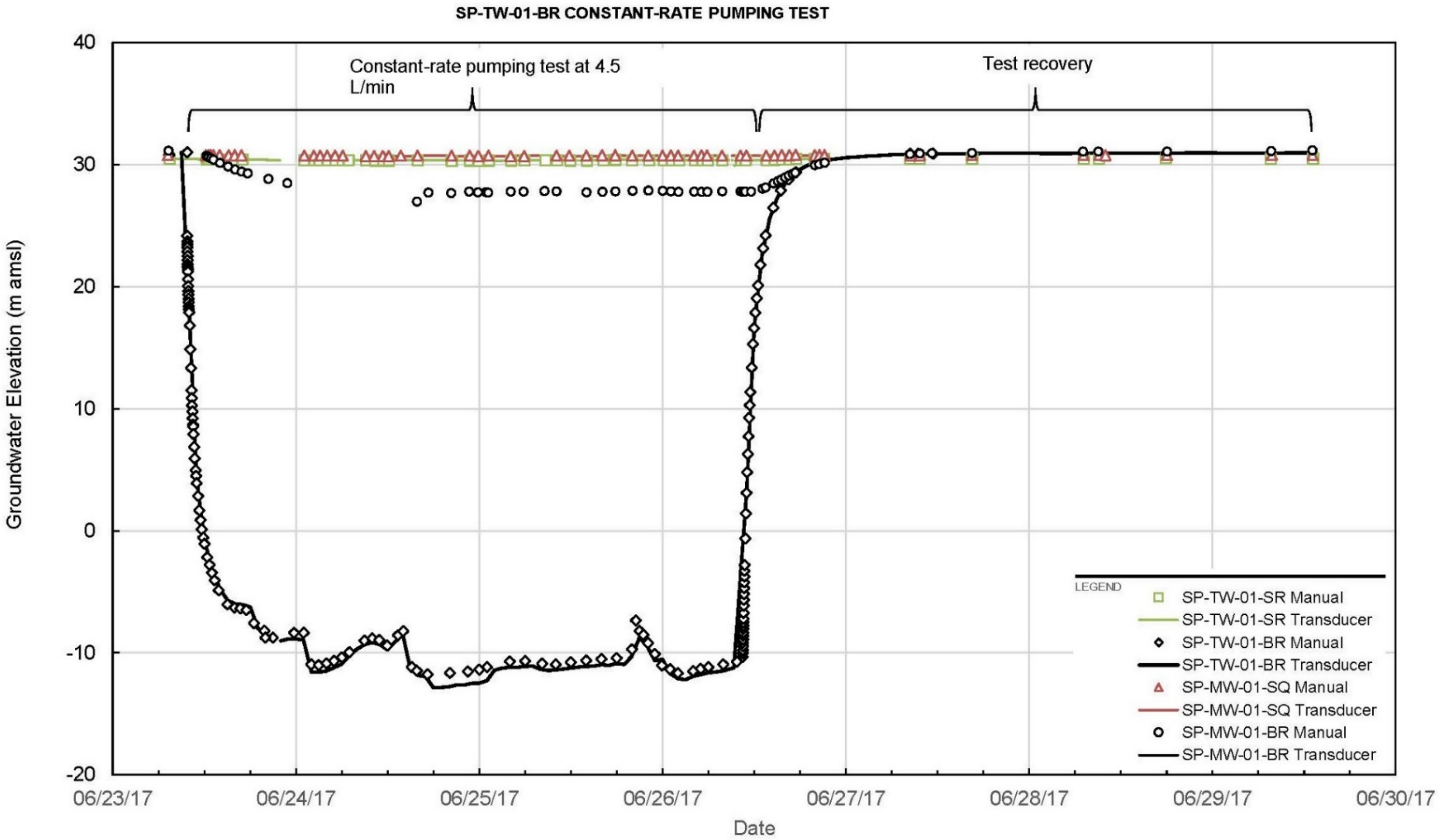
In the WRF location and close to the valley floor, continuous water level monitoring shows that the water levels in the saprock responded immediately by about 3 to 15 cm to precipitation (the monitored interval in the saprock is about 26 to 35 m bgs at this location). This indicates that the near surface geological units at this location are of moderate to high permeability.

Figure 4.6-1 SP-TW-01-SR Constant-Rate Pumping Test



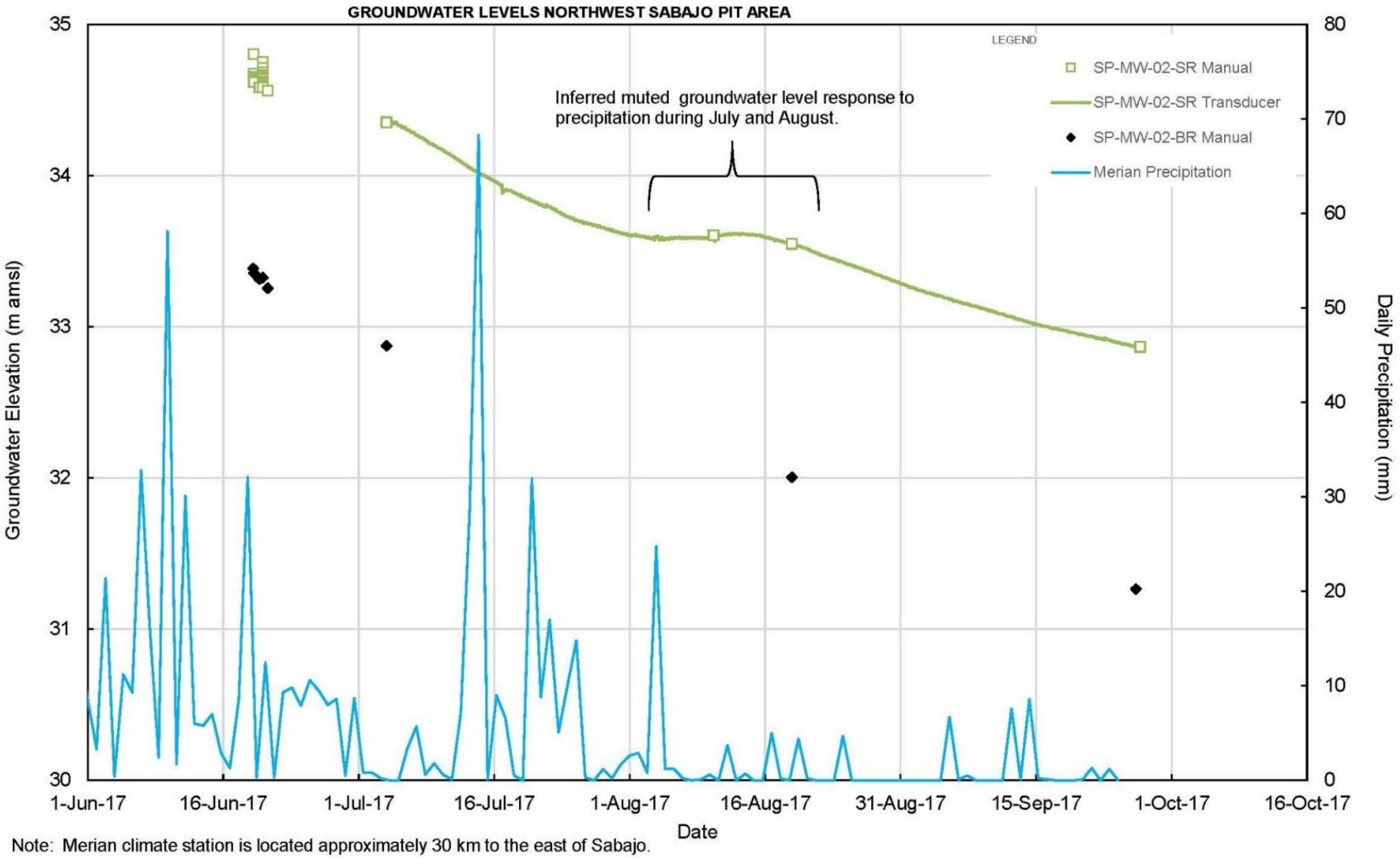
L/min = liters per minutes; m amsl = meters above mean sea level.

Figure 4.6-2 SP-TW-01-BR Constant-Rate Pumping Test



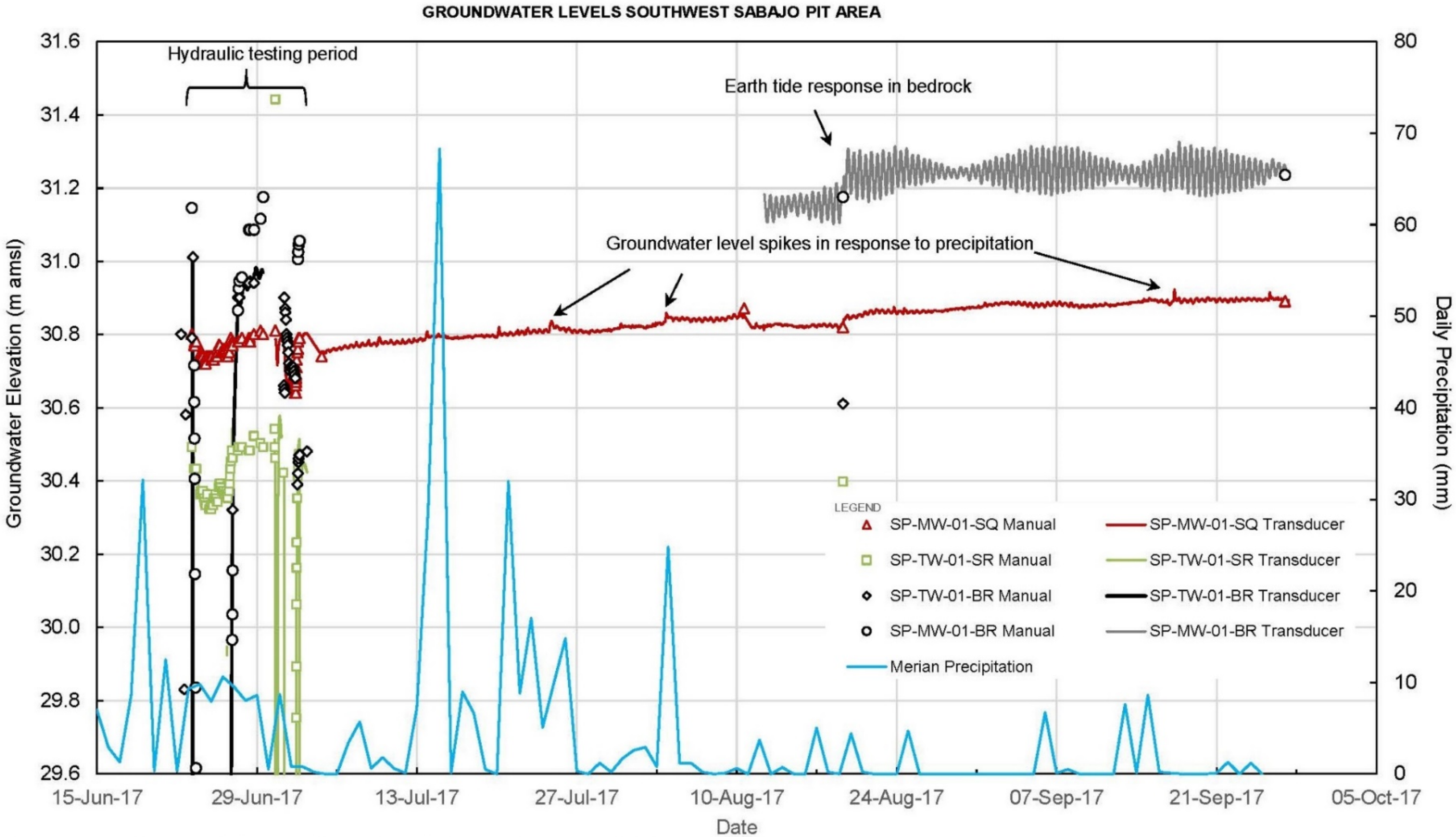
L/min = liters per minutes; m amsl = meters above mean sea level.

Figure 4.6-3 Groundwater Levels Northwest Sabajo Pit Area



m amsl = meters above mean sea level; mm = millimeter; km = kilometer.

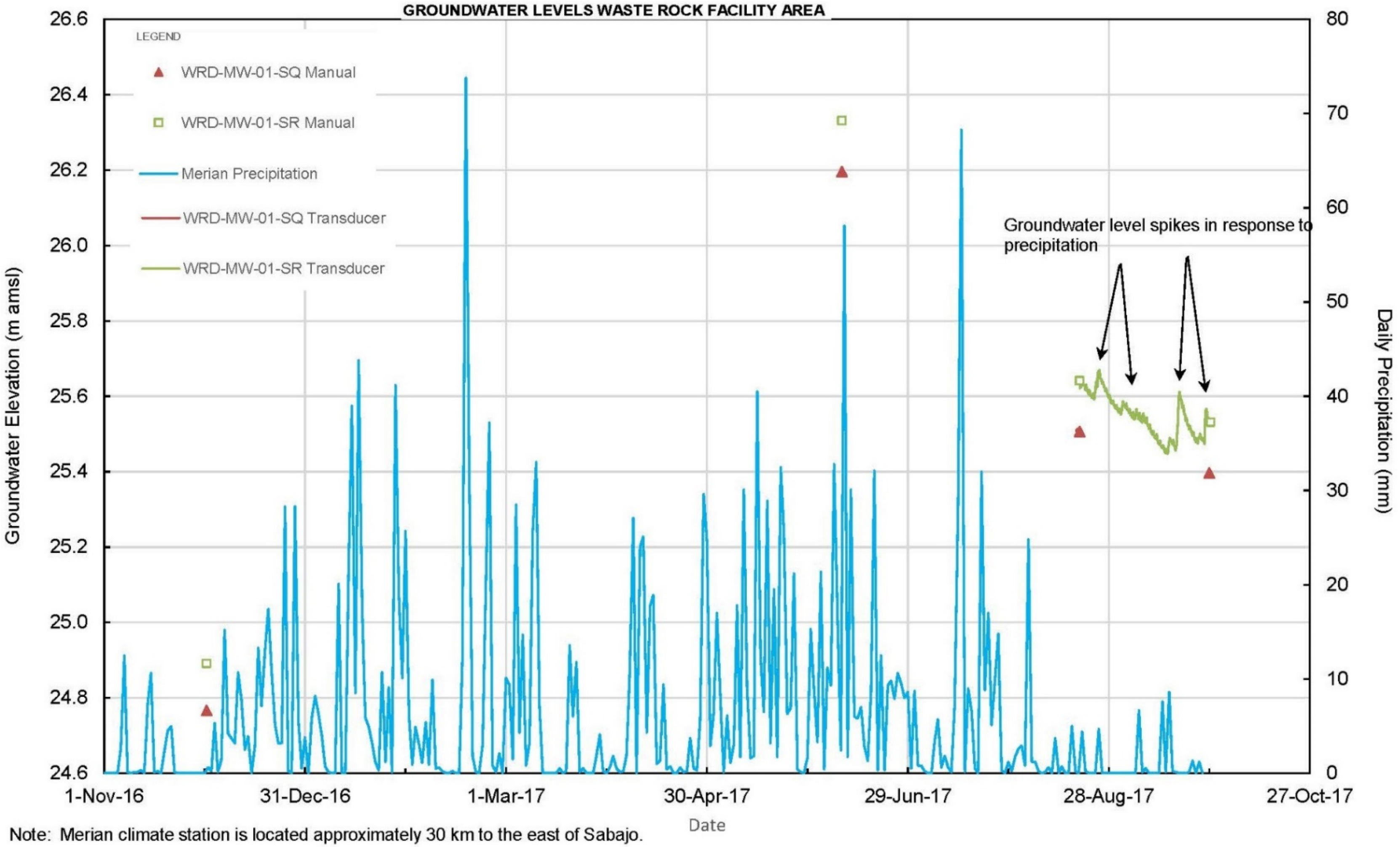
Figure 4.6-4 Groundwater Levels Southwest Sabajo Pit Area



Note: Merian climate station is located approximately 30 km to the east of Sabajo.

m amsl = meters above mean sea level; mm = millimeter; km = kilometer.

Figure 4.6-5 Groundwater Levels Waste Rock Facility Area



Note: Merian climate station is located approximately 30 km to the east of Sabajo.

m amsl = meters above mean sea level; mm = millimeter; km = kilometer.

Groundwater levels in the saprolite quartz vein system in the Sabajo Pit area (SP-MW-01-SQ; Figure 4.6-4) increased by about 10 cm from late June to late September 2017 in response to precipitation. In the WRF area, groundwater levels in the saprolite quartz vein system and saprock increased by about 1.4 m (Figure 4.6-5) from December 2016 to June 2017. During this period of time, about 1.1 m of precipitation was recorded at the Sabajo climate station. From June to September 2017, groundwater levels declined by nearly 2 m in the saprock and bedrock at the SP-MW-02 location and by about 1 m in the saprock and saprolite quartz veins at the WRF location.

Short-term diurnal fluctuations in continuous water level readings (1 to 10 cm) were observed in the CF monitoring well at the Sabajo pit (i.e., SP-MW-01-BR; Figure 4.6-4); these diurnal fluctuations are attributed to earth tides, indicating that the bedrock groundwater system is a rigid, confined hydraulic unit with low storativity.

Map 4.6-4 presents groundwater elevation contours and schematic groundwater flow directions. Shallow groundwater flow (i.e., within the upper 150 m of the subsurface) generally mimics surface topography, where higher groundwater elevations are observed in upland areas (i.e., hills) and lower groundwater elevations are observed in lowland areas (i.e., valley bottoms and streams). A groundwater divide is inferred to exist near the surface water divide toward the western end of the study area (shown as a dark blue line). Overall, groundwater flows away from the hills and converges in major stream drainages.

Hydraulic Gradients

The hydraulic gradient is the change in groundwater elevation over a distance along a groundwater flow line. It represents the slope of the water table (unconfined aquifer) or the piezometric surface (confined aquifer). For a given value of hydraulic conductivity, a steeper hydraulic gradient indicates a greater volume of groundwater flow per unit cross-sectional area of the hydrogeologic unit.

The horizontal component of hydraulic gradient across the groundwater study area is variable, reflecting the topographic conditions, variations in hydraulic conductivity, and thickness of the hydrogeologic units. The horizontal hydraulic gradients among the different hydrogeologic units were not evaluated as part of this baseline study due to the sparsity of data (both number of wells and number of common hydrogeologic units to evaluate); however, the horizontal gradient of the shallow groundwater ranges from about 0.005 to 0.033 meters per meter (m/m). The steeper horizontal gradient occurs where the topographic relief is higher, and the shallower gradients occur where the topographic relief is low.

The vertical component of hydraulic gradient was evaluated at each location where multiple wells were constructed. A downward (negative) component of hydraulic gradient indicates groundwater is flowing downward from a shallow hydrogeologic unit to deeper ones, and generally reflects flow from infiltration at the surface. An upward (positive) component of gradient indicates that groundwater is flowing from deeper units under greater pressure head toward shallower units, and generally reflects flow from bedrock toward the saprolite surface and eventually discharging to surface water. Table 4.6-5 presents a summary of vertical components of hydraulic gradients observed during August and September 2017. These data indicate that the vertical components of hydraulic gradient in the Project area are relatively low but vary in terms of upward and downward flow paths. Groundwater flow is upward in the relatively low-lying area at WRD-MW-01 from the saprock to the saprolite and both upward and downward flow the upland areas of the proposed Sabajo Pit (upward at SP-MW-01 and downward at SP-MW-02). The apparent upward component of groundwater flow could be a result of structural control on the deeper groundwater flow paths or could be a result of the horizontal hydraulic gradient in this area, because the distance between well pairs was between 14 and 25 m at this location. The downward component of flow observed at the SP-MW-02 is near the groundwater divide, where recharge is expected to occur.

Table 4.6-5 Vertical Hydraulic Gradients

Location	Distance between Well Pairs (m)	Date	Vertical Component of Hydraulic Gradient (m/m)
Bedrock and Saprock			
SP-TW-01-SR / SP-TW-01-BR	25	08-19-17	0.008
SP-MW-02-BR / SP-MW-02-SR	13	08-19-17	-0.060
Bedrock and Saprolite			
SP-MW-01-BR / SP-MW-01-SQ	14	08-19-17	0.004
Saprolite and Saprock			
WRD-MW-01-SQ / WRD-MW-01-SR	3	08-19-17	0.008
SP-MW-01-SQ / SP-TW-01-SR	24	08-19-17	-0.026

Notes:
Positive values represent an upward component of hydraulic gradient
Negative values represent a downward component of hydraulic gradient
m = meter; m/m = meters per meter.

4.6.6 Conceptual Model of Groundwater Conditions

Shallow groundwater flow at Sabajo generally mimics the surface topography, where groundwater flows away from recharge areas on hilltops and ridges to converge and discharge in the valley bottoms to surface water and as evapotranspiration from phreatic vegetation. Based on measured groundwater elevations, groundwater levels at the site range from about 19 to 36 m amsl, with lower groundwater elevations found in valley bottoms (i.e., OS and WRF areas) and the higher groundwater elevations found in upland areas (proposed Sabajo Pit area). Groundwater levels at individual wells over the period of record have fluctuated from less than 20 cm to more than 2 m.

Groundwater at Sabajo occurs within the alluvium, saprolite/saprolite quartz veins, saprock, and fractured bedrock. The dominant groundwater flow paths are expected to be within the quartz vein system, saprock, and (to a lesser degree) the fractured bedrock, which have relatively higher hydraulic conductivities compared with the unfractured bedrock and saprolite. Although saprolite was not tested during the Sabajo hydrogeological investigation, testing at Merian has shown that groundwater flow through saprolite is minor because of its low permeability. Groundwater flow in unfractured bedrock is also relatively minor because of the very low permeability (absence of fractures).

Groundwater within the CFZ is interpreted to flow preferentially within the fractured rock network associated with the hanging wall. There appears to be limited vertical hydraulic connection to the overlying saprock and saprolite quartz vein system.

Downward components of hydraulic gradient were observed from saprolite quartz veins to saprock and from sapock to bedrock in the upland areas and near the watershed boundary to the west, where recharge is expected to occur. In the lowland areas, and upward component of groundwater flow was observed from saprock to saprolite quartz veins, where groundwater discharge to streams is expected to occur. At the southwest end of the main Sabajo Pit, an apparent upward component of hydraulic gradient was observed from bedrock to the overlying saprock and saprolite quartz veins, suggesting a structural control on deeper groundwater flow paths.

Measurements show an increase in groundwater levels in the saprock and possibly saprolite quartz veins in the WRF area in response to precipitation indicating that the near surface materials are moderately permeable, likely because of the presence of quartz veins within the saprolite. Where the saprolite is thick and quartz veins are absent, interaction between surface water and groundwater is expected to be minor due to the low permeability of the saprolite.

4.7 Surface Water

4.7.1 Introduction

This section provides an overview of the baseline surface water hydrologic setting of the area within and immediately downgradient of the Sabajo Project (the Project). This report should be read in conjunction with similar reports describing the climate and the hydrogeology of the area. Specifically, this section describes the site hydrologic setting including discussion of streamflows, site runoff (i.e., total water yield) and baseflows for creeks downstream of the Project in the concession area (Map 4.7-1).

Site-specific data collected at Sabajo during the current baseline monitoring period (2017) and during earlier water quality sampling rounds (2010 to 2016) were used to characterize baseline conditions. Additionally, a Baseline Hydrology Report for the Merian Gold Mine (Merian mine; Golder 2012a) and the data from that report is also used to characterize site hydrology at Sabajo. The Merian mine is located approximately 30 kilometers (km) east of the Project. The elevations, topography and precipitation patterns are similar between the sites, meaning the streamflow patterns are also likely similar. In addition, the land-uses (i.e., prior to mining at Merian) appear to be similar, specifically in regard to small scale mining operations at each site. Therefore the streamflow rates, patterns and general site conditions described in the Merian mine Baseline Hydrology report can be related to Sabajo, as detailed in the sub-sections below.

4.7.2 Site Conditions

4.7.2.1 Precipitation

This section provides a brief overview of site precipitation, because precipitation patterns are the primary control on streamflow. A more complete description of site climate is provided in Section 4.3. The climate of Suriname is characterized by two short and two long wet and dry seasons. The short wet season runs from December to January (2 months) followed by the short dry season from February to March (2 months). The long wet season generally runs from April to July (4 months) and the long dry season from August to November (4 months; ERM 2012). A detailed climate report was completed for the Merian Project in 2012 (Golder 2012b). That report used Merian site data and long-term records from nearby weather stations to document precipitation conditions at the location of the Merian mine. The long-term mean annual precipitation at the Merian mine was estimated to be 2,382 millimeters (mm) and the long-term mean annual precipitation among the regional gauges varied from 2,166 to 2,544 mm.

Precipitation data from the Sabajo site are available from 2012 to 2016 (Tetra Tech 2013a, 2015a and 2016a). Over this period, the annual precipitation totals ranged from 2,209 mm to 2,740 mm and averaged 2,422 mm. The average annual precipitation at Sabajo from 2010 to 2016 is very similar (within 2 percent [%]) to the annual average precipitation at Merian (2,382 mm) and within the range measured at the regional gauges.

Recent data suggests Sabajo may be slightly wetter than the Merian Project as the 2012 to 2016 precipitation at Merian Project averaged approximately 2,238 mm, or 6% less than measured at Sabajo. This difference may be attributed to localized spatial variability during storm events, gauge discrepancies, etc. and not necessarily indicative of consistent, long-term differences between the two sites.

Limited precipitation data are available from Sabajo during 2017 due to equipment malfunction. As streamflows measured at the Sabajo monitoring stations in 2017 are generally similar to the historical flow measurements (Section 4.7.3), this suggests that the climatic conditions during 2017 were consistent with previous years. Furthermore, the precipitation data collected at the Merian mine between April and July 2017 were within approximately 10% to 15% of the long-term average for those months. This suggests that the absence of climate data at Sabajo does not affect the quality of the baseline data presented in this ESIA.

4.7.2.2 Hydrologic Setting

The Project Site elevation ranges from approximately 30 to 80 meters above sea level (masl), at a latitude of approximately 5 degrees north and a longitude of approximately 55 degrees west. The forest canopy, in upland areas in particular, is dense and the ground surface is covered with dense vegetation and litter, although soils are thin and water is not retained. Hillslopes are moderately steep with typical slopes of approximately 30% to 50%. Valley bottoms are generally wide and flat.

There are two primary unnamed drainages on the Site (Map 4.7-1). One flows predominantly west and the other flows predominantly east within the Project area (Map 4.7-1). Downstream, both drainages trend north and merge approximately 5 km north of the Project exploitation concession boundary and eventually flow in the Commewijne River near the village of Java, which is approximately 35 km north of Sabajo. There are a series of small tributary streams that flow into the unnamed creeks in the vicinity or downgradient of the Project site. Perennial flow has been observed at all of the surface water monitoring stations (i.e., active and inactive) shown on Map 4.7-1.

Monitoring stations have been established on many of the streams within or immediately down–gradient of the Sabajo hills (Section 4.7.2.4). The Santa Barbara area is approximately 2 km north (downgradient) of Sabajo hills. The Margo area is approximately 2 km east of Sabajo hills and a portion of that area drains to Sabajo monitoring station CSW-10 (Map 4.7-1). All are within the same concession area.

4.7.2.3 Small Scale Mining

The surface water hydrology and drainage network on and immediately downgradient of the Sabajo Site is strongly influenced by artisanal and small scale mining (ASM) operations. ASM activities involve excavation of alluvium and saprolite soils containing quartz sand and gravel, and is primarily focused in or near stream channels.

ASM practices typically involve dredging up soils and sediments using track excavators with a particular focus on alluvium derived from quartz vein deposits and possibly quartz veins that are exposed at ground surface. Material is dug from large pits then washed and run through sluice boxes using hydraulic pumps. Waste material is spread across the floodplain. The end result is that vegetation is removed from valley bottoms, the valley bottoms are widened, and remnant pit excavations and a large amount of disturbed sediment is left (stockpiled) in the floodplain. ASM activities have been shown to increase sediment loads and suspended sediment concentrations, stream turbidity, and heavy metal concentrations (Mol and Ouboter 2004). The impacts of ASM activities on streamflows have not been fully quantified but may include increased runoff from areas where vegetation has been removed, and dampening of peak flows due to increased storage on the floodplains resulting from the prevalence of pit excavations (Golder 2012a).

Visual observations indicate that ASM has occurred across a large part of the Sabajo Site. The most significant disturbance is in the main Sabajo Pit area and downstream in an area known locally as Santa Barbara. Visual observations made during a hydrologic reconnaissance in April 2017 suggest that the majority of the stream channels on and in the vicinity of the site have been disturbed to some degree in the past. The past disturbances have likely altered stream hydrology, as discussed above, but also limits access into the channels. Most of the disturbed stream channels consist of very soft alluvial sediments that cannot be safely accessed, which was the key limitation to the number of stream gauges that could be installed during the baseline monitoring period (Section 4.7.4).

A large complex of ASM workings (Santa Barbara mining area) is located north of Sabajo hills, which has extensive disturbance and mining activities are ongoing (as of mid-2017). Monitoring station CSW-01 is located within the historical (and current) ASM operations of the Santa Barbara area.

4.7.2.4 Surface Water Monitoring Network

Eight surface water monitoring stations are part of the active (i.e., monitoring was conducted at these stations in 2017) baseline hydrologic monitoring program: six are located in the vicinity of the Project facilities and two are located on Tempati Creek. There are four active monitoring stations on the west drainage at Sabajo (CSW-01, CSW-05, CSW-06, CSW-07) and two active monitoring stations on the east drainage (CSW-09 and CSW-10; Map 4.7-1). Four other monitoring stations near the Site have been monitored historically but were not included in the 2017 monitoring events. Historical streamflow and water quality data (Section 4.8) from these stations are included in this baseline.

The sites on Tempati Creek are located approximately 15 km east of the Site. Due to their remote location, these two sites, which are described below, were accessed once in April 2017 (Map 4.7-1).

Surface water has been monitored at Sabajo since September 2010. Prior to 2017, monitoring was conducted on an annual to semi-annual basis. Monitoring frequencies were increased to approximately every other month between April and September 2017. Monitoring includes water quality sampling and manual streamflow measurements during sample collection. The manual streamflow measurements were generally made from bridges and consisted of a combination of visual estimates and manual measurements. Similar flow measurement procedures were used during the baseline monitoring period at all sites except CSW-07 (Section 4.7.3.2). The surface monitoring network is summarized in Table 4.7-1.

4.7.3 Summary of Measured Streamflows at Sabajo

4.7.3.1 Historical Streamflows

The streamflows for all measured sampling locations between September 2010 and August 2017 are shown in Figure 4.7-1. The measured flows vary widely between sites, as flows ranged from less than 0.001 cubic meters per second (m^3/sec) to over 10 m^3/sec. This variability between sites is largely a function of the differences in drainage areas (Table 4.7-1). Sites with large drainage areas (CSW-01, CSW-09 and CSW-10) generally have higher flows than sites with moderate drainage areas (CSW-06 and CSW-07) and sites with small drainage areas (CSW-05, CSW-02 and CSW-03). The observed variability in flows at individual stations across sampling dates is likely due seasonal fluctuations in rainfall. Typically, the highest flows are measured during the long wet season (April to July), although the April 2017 measurements were relatively low because of the dry conditions preceding and during that site visit. ASM activities have affected streamflow measurements at certain sites (e.g., CSW-01) due to channel diversions, etc. (Tetra Tech 2016a). Overall, the measured flows should be considered generalized approximations as measurement procedures were estimated in some instances due to site safety and access issues (except at CSW-07), particularly at higher flow rates.

Flow measurements were normalized by drainage area to calculate unit-discharge rates over time (Figure 4.7-2). Most of the unit-discharge flows range between 0.001 cubic meters per second per square kilometers (m^3/sec/km^2) and 0.2 m^3/sec/km^2. When the average unit-discharge rate at each site is calculated, the average site values range between 0.02 m^3/sec/km^2 and 0.06 m^3/sec/km^2. The unit-discharges at the Project are similar to the unit-discharges measured during the baseline monitoring period at Merian Project, which generally ranged from 0.002 to 0.1 m^3/sec/km^2 with peaks as high as 0.5 to 1 m^3/sec/km^2 during individual storm events (Golder 2012a).

Table 4.7-1 Surface Water Monitoring Station Details

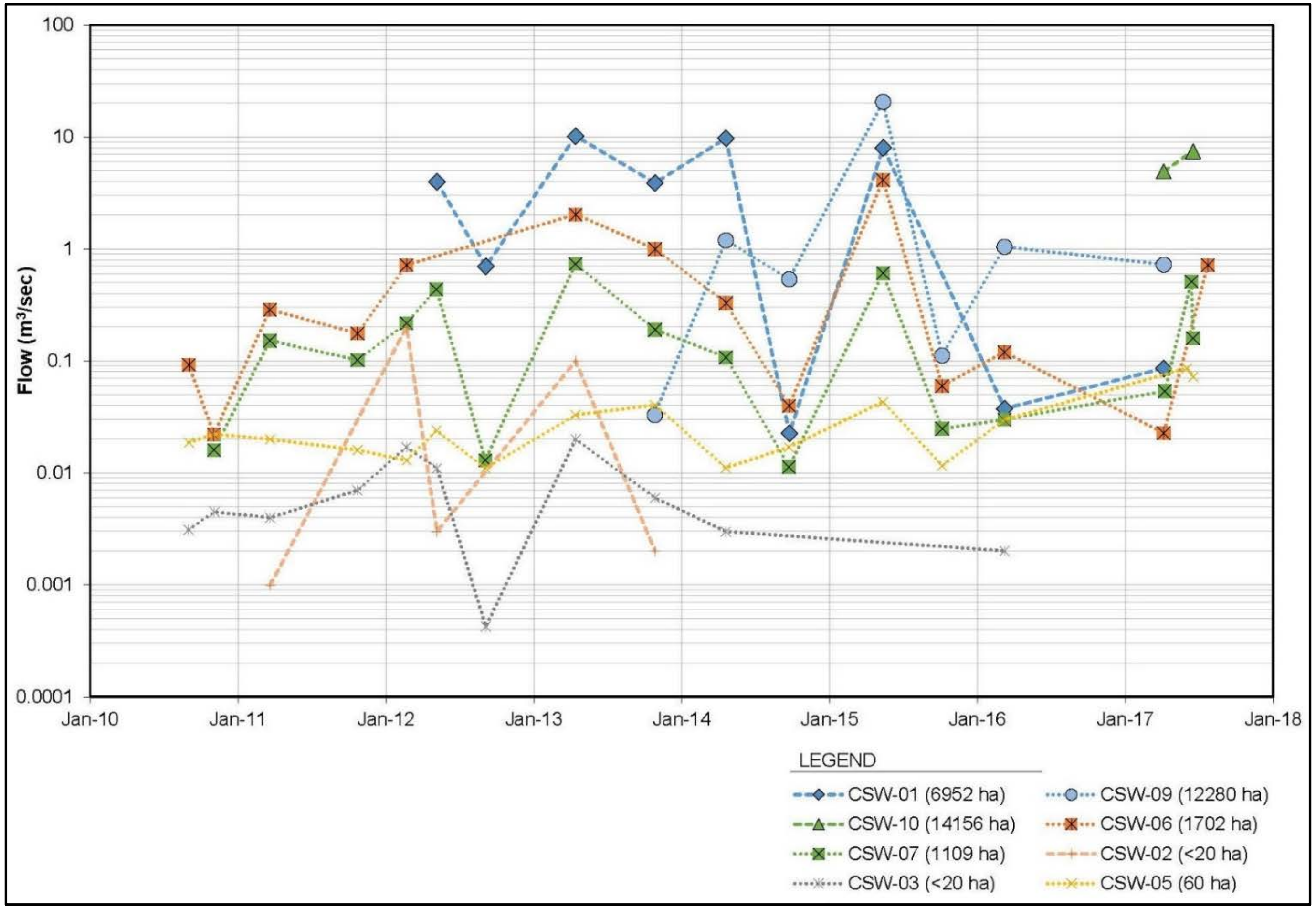
Site	Easting (m)	Northing (m)	Drainage Area (ha)	Status	Description
CSW-01	741,901	567,729	6,952	Active 2010-Present	Furthest downgradient location on western drainage, within Santa Barbara area, heavily impacted by ASM
CSW-05	739,939	565,332	60	Active 2010-Present	Western drainage, site is on a small tributary drainage outside of all proposed project facilities, impacted by ASM
CSW-06	741,060	565,777	1,702	Active 2010-Present	Western drainage, upgradient of CSW-01 but below all proposed Sabajo area project facilities on the west side of the Project, impacted by ASM
CSW-07	740,469	563,395	1,109	Active 2010-Present	Western drainage, stream gauge installed (Section 4.7.3.2), negligible to no ASM impacts
CSW-09	743,641	562,059	12,280	Active 2010-Present	Eastern Drainage, up-gradient of CSW-10. Immediately downgradient of proposed Sabajo pits and waste rock storage facilities, impacted by ASM
CSW-10	743,957	564,886	14,156	Active 2017-Present	Furthest downgradient location on eastern drainage, upstream ASM disturbances are evident
CSW-02	742,999	567,302	<20	Inactive 2010-2013	Small tributary on eastern drainage, Site disturbed by ASM and not monitored after 2013
CSW-03	742,346	566,068	<20	Inactive 2010-2016	Inaccessible after 2016, impacted by ASM
CSW-04	739,890	565,194	N/A (no flow data for site)	Inactive 2010-2011	Duplicate station to CSW-05
CSW-08	743,558	563,852	N/A (no flow data for site)	Inactive 2010-2012	Small tributary on eastern drainage, inaccessible after 2012, impacted by ASM
TSW-01	763,716	565,683	N/A (no flow data for site)	Active April 2017	Furthest downgradient monitoring station on Tempati Creek, upstream ASM disturbances are evident
TSW-02	759,970	560,192	N/A (no flow data for site)	Active April 2017	Up-gradient monitoring station on Tempati Creek, located near the temporary "fly camp", negligible to no ASM impacts

Notes:

1. X (Easting) and Y (Northing) coordinates are UTM Zone 21N, WGS 1984 datum
2. Drainage areas (DA) for active stations determined from site elevation models, DA for CSW-02 and CSW-03 could not be accurately determined, DA for CSW-04 and CSW-08 are not applicable because no flow data are available for these sites.
3. The location of CSW-01 has shifted slightly over time because the station is located in an actively disturbed portion of the Santa Barbara ASM area.
3. CSW-06 was moved downstream approximately one kilometer from its original location in April 2013 because of its close proximity to proposed project facilities at that time and after access to this area was made possible by logging operations.

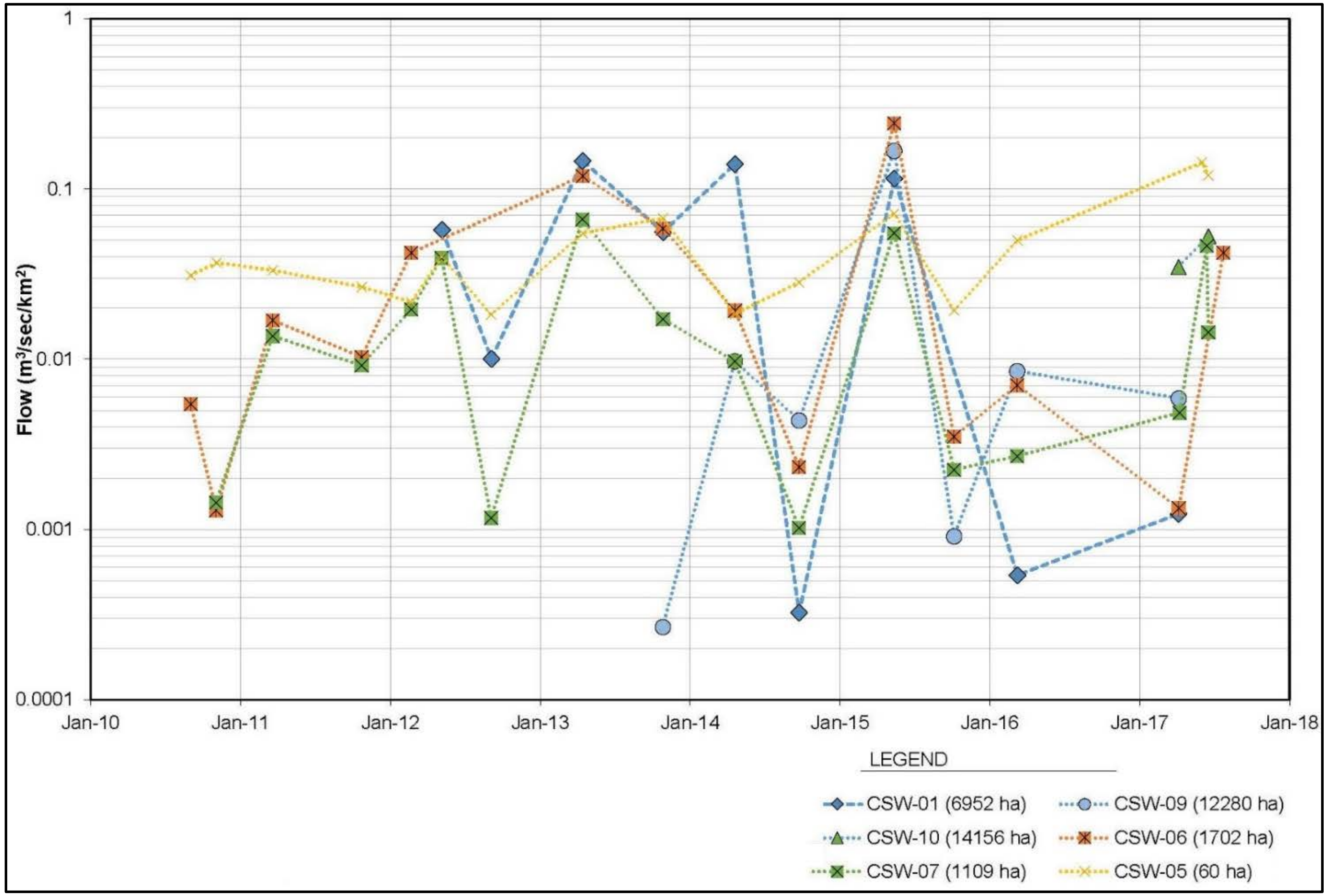
the Project = the Sabajo Project; ASM =artisanal and small scale mining; UTM = Universal Transverse Mercator; WGS = World Geodetic System; m = meter; ha = hectare; N/A = not available; <= less than.

Figure 4.7-1 Manual Streamflow Measurements at All Sites (2010-2017)



Notes:
Drainage areas are shown in parenthesis (in hectares [ha]).
m^3/sec = cubic meters per second; < = less than.

Figure 4.7-2 Manual Unit-Discharge Streamflow Measurements at All Sites (2010-2017)



Notes:

Drainage areas are shown in parenthesis (in hectares [ha]).

$m^3/sec/km^2$ = cubic meters per second per square kilometer; < = less than.

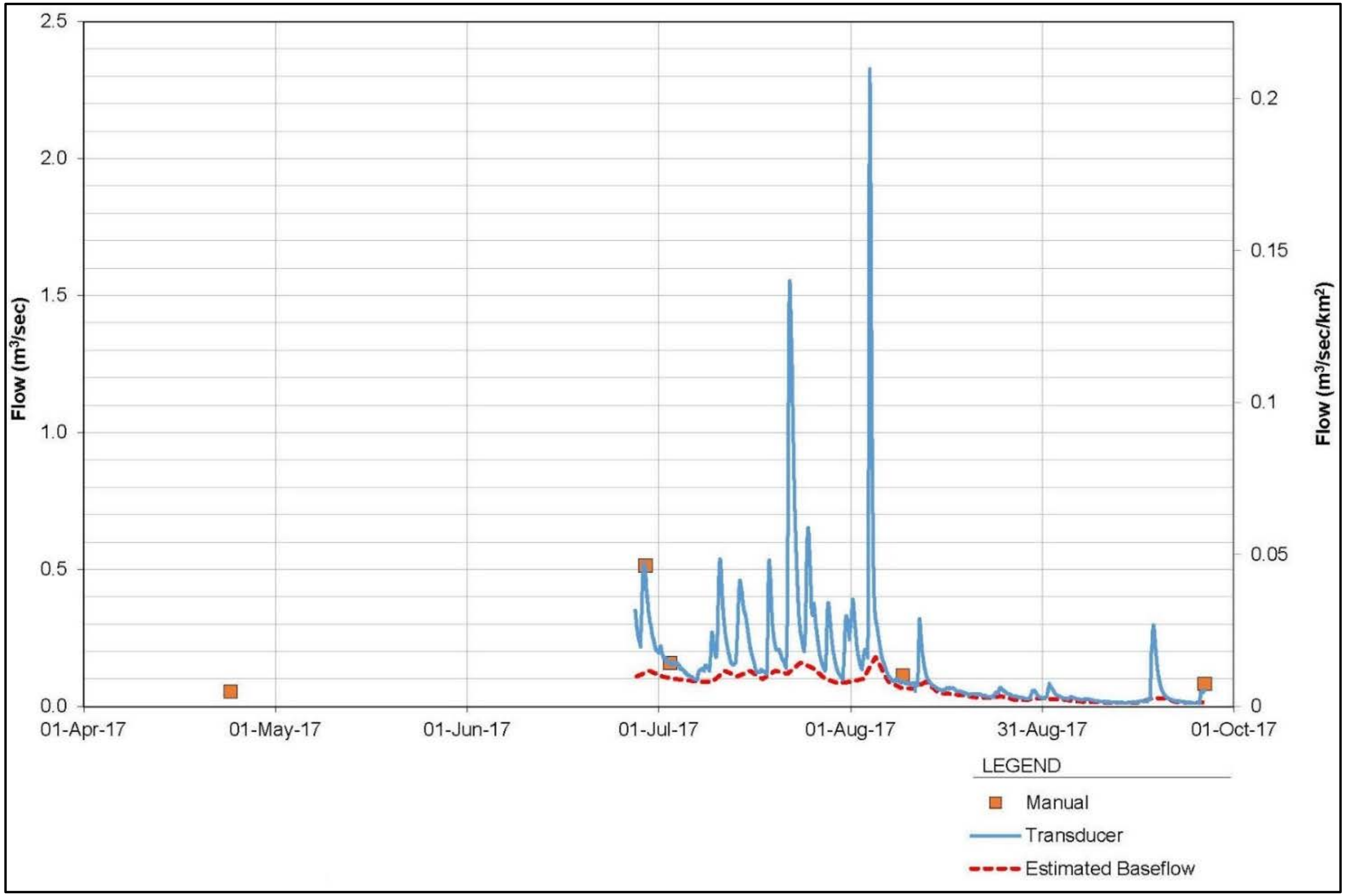
4.7.3.2 CSW-07 Stream Gauge

An automated stream gauge was installed at CSW-07 in June 2017 and near continuous flow data are available at this station from June 2017 to September 2017. The automated station consists of a pressure transducer and data logger to record stream stage, which is converted to flow rates using a rating curve. The rating curve was developed from manual flow and channel survey measurements. The manual flow measurements were used to develop the lower portion of the rating curve (i.e., for flows within the range of the manual measurements), while the upper portion of the curve (peak flows) was determined from a simplified one-dimensional hydraulic model built from channel cross-section and profile gradients measured in the field. Once the flow rates were calculated from the rating curve, baseflows at CSW-07 were estimated following standard baseflow separation procedures used by Barnes (1939).

The hydrograph at CSW-07 shows short-term peaks during wet season storm events and then quick recession to baseflow or near baseflow levels (Figure 4.7-3). The largest storm events occurred between mid-July and early August. There are only a few smaller storm events after early August, indicative of dry season conditions, and the flows generally remained low from mid-August to the end of the period of record (26 September 2017). During the dry season, outside of the small storm events, the total streamflow rates were essentially equal to baseflow, indicating that all of the flow is generated from groundwater discharge during the dry season.

The 2017 measured flows at CSW-07 fall within the range of the historical measurements (Figure 4.7-1), but the peak flows measured during storm events are considerably higher than any of the manual measured flow rates (Figure 4.7-3). Streamflows at CSW-07 ranged from 0.01 m^3/sec (dry season baseflow) to 2.3 m^3/sec/km^2 (wet season peak flow). This range in flow corresponds to unit-discharge rates of 0.001 to 0.2 m^3/sec/km^2 (Figure 4.7-3). Similar unit-discharges were measured during the baseline monitoring period at Merian Project (Section 4.7.3). The streamflow rates at CSW-07 translate to monthly total water yields of 6.3 centimeters (cm), 3.1 cm and 0.8 cm for July, August and September, respectively. The estimated baseflows ranged from 0.01 m^3/sec (0.001 m^3/sec/km^2) to 0.2 m^3/sec (0.01 m^3/sec/km^2). The monthly baseflow yields were 2.7 cm, 1.5 cm and 0.4 cm for July, August and September, respectively. Both the total water yields and baseflow yields fall within the ranges measured during baseline monitoring at Merian (Section 4.7.5; Golder 2012a).

Figure 4.7-3 CSW-07 Hydrograph - 2017



m^3/sec = cubic meters per second; m^3/sec/km^2 = cubic meters per second per square kilometer.

4.7.4 Summary of Baseline Streamflow at Merian Mine

A baseline hydrology report was prepared for the Merian mine (Golder 2012a), in support of the Merian ESIA. A baseline summary report for the Merian Project is included in the Sabajo baseline for comparison purposes. Streamflows were measured at Merian at four locations for up to a 12-month monitoring period (actual period of record varied between sites). The gauge locations were selected to provide a range of drainage areas, in order to allow for examination of variations in unit-discharges for different basin sizes. The drainage areas ranged from 126 hectares (ha) to 8,800 ha, roughly similar to the drainage areas at the Sabajo sites (Table 4.7-1). The recorded total precipitation during the 12-month baseline monitoring period was approximately equal to the long-term average, but wetter than average conditions were recorded during the fall low-flow season.

Streamflow in the study area for the Merian mine showed wide variability between sites in relation to drainage area differences and seasonal variability related to precipitation patterns. The dry-season low flows ranged between approximately 0.002 and 0.004 $m^3/sec/km^2$. The wet-season (April to July) low flows typically ranged between approximately 0.007 and 0.01 $m^3/sec/km^2$. The monthly total water yields ranged from approximately 1.1 cm in September 2011 to 10.7 cm in January 2012. The average total annual water yield measured on site from September 2011 to August 2012 was 72.3 cm. The total water yields from Merian were similar to those measured at CSW-07 at Sabajo: the average July total water yield at Merian was 4.7 cm compared to 6.3 cm at CSW-07 and the average September total water yield at Merian was 1.1 cm compared to 0.8 cm at CSW-07.

For the available period of record, the Merian monthly total water yields ranged from 14% to 63% of the respective monthly precipitation, with an annual average of 33%. The 63% ratio was measured in August 2012; there was uncertainty in the total water yield estimate for this month. If the August 2012 value is excluded, then the monthly rainfall/total water yield ratios ranged from 14% to 42% and the annual average was 30%.

Merian baseflows also varied in response to precipitation. The average monthly baseflow yields ranged from 0.6 cm in September to 2.2 cm in June. The 12-month average baseflow was 18.2 cm, which is inferred to equal the groundwater recharge rate based on the available data. The baseflow yields from Merian were also similar to those measured at CSW-07 at Sabajo: the average July baseflow yield at Merian was 2.2 cm compared to 2.7 cm at CSW-07 and the average September baseflow yield at Merian was 0.6 cm compared to 0.4 cm at CSW-07.

4.7.5 Regional Hydrology

Regional stream gauge data were also compiled for the Merian mine baseline report (Golder 2012a). The regional streamflow gauges in Suriname are located primarily on larger rivers, which have much larger drainage areas than the streams of interest on the Sabajo Site. Furthermore, only mean monthly streamflows are available at several of the gauges. As a result, the regional gauges are useful for providing only general estimates of total annual and monthly water yields that can be extrapolated to the Sabajo Site. In addition, hydrologic impacts related to ASM operations may be more pronounced in smaller drainages (i.e., like those at Merian and Sabajo) than in larger drainages.

Streamflow data were compiled from nine regional stream gauges. Two of these gauges are located in French Guyana; the other seven are in Suriname. Most of the gauges had less than 10 years of available data, collected during the 1970s and early 1980s. The drainage areas ranged from 5,150 square kilometers (km^2) to 63,700 km^2; the two largest drainage areas are on the Marowijne River (GRDC 2017). Because the basin areas vary widely between the gauges and the drainage areas at the Sabajo Site are much smaller than at the regional gauges, the unit-discharge comparisons are most useful for estimating site runoff (i.e., water yield).

The regional stream gauges showed high variability in monthly total water yields, exceeding 30 cm during the wettest months on record. Typically there was approximately 10 to 15 cm of runoff per month during the wet season and less than 5 cm per month during the dry season. Among all the gauges the mean annual total water yield ranged from 54.5 cm (Nickerie River) to 124.3 cm (Sinnamary River) and the average annual total water yield among the gauges was 84.5 cm. For all the regional gauges, the standard deviation of the mean annual water yield averaged 20.1 cm, or approximately 25% of the mean.

In addition, the United States Army Corps of Engineers conducted a water resources assessment of Suriname, which included the Commewijne River (USACE 2001). The report listed the total catchment area of the Commewijne River at 6,600 km^2 and the mean annual flow at 169 m^3/sec; which translates into a unit discharge of 0.026 m^3/sec/km^2 and an annual total water yield of 81 cm. The USACE report does not provide any details about the precise location of the stream gage or period of record used to establish the mean annual flow.

4.8 Water Quality

4.8.1 Introduction and Background

This section describes baseline water quality based on the results of surface water (2010 to 2017) and groundwater (2016 to 2017) quality monitoring. Baseline water quality was characterized to support evaluations of possible short- and long-term impacts to water quality that may occur during development and operation of the Sabajo Project (the Project). The monitoring results also define existing impacts to water quality from artisanal and small scale mining (ASM) activities in the Project area.

As described in Section 4.7, the routine surface water quality monitoring network was established in 2010 and includes ten stations in the vicinity of the Sabajo and Santa Barbara deposits (CSW-01 to CSW-10; Map 4.7-1). The routine baseline data set includes data from two monitoring periods, referred to as the historical and recent monitoring periods, as described below:

- **Historical**: Surface water monitoring conducted by Tetra Tech between September 2010 and December 2016 at up to nine monitoring locations (CSW-01 to CSW-09; Tetra Tech 2011a,b,c, 2012a,b,c, 2013b,c, 2014b, 2015b,c,d, 2016b). Over the period of monitoring, some locations were removed from the monitoring network due to changing site conditions such as inaccessibility due to changes in ASM activities.
- **Recent**: Surface water monitoring conducted by Golder Associates Inc. (Golder) between April and September 2017 at six monitoring locations (i.e., CSW-01, CSW-05, CSW-06, CSW-07, CSW-09 and CSW-10). These sites, which are in the vicinity of the Santa Barbara and Sabajo deposits, were selected for continued monitoring to ensure that in each of the sub-basins where Project facilities will be located, there is a downstream monitoring location. Monitoring location CSW-05 is located outside the Project physical impact area.

Site details and the period of record for each monitoring location are shown in Table 4.8-1. The historical and recent monitoring periods included collection and analysis of samples for up to 15 and 4 monitoring events, respectively.

In association with the April 2017 routine surface water monitoring event, samples were also collected from two locations on Tempati Creek (i.e., TSW-01 and TSW-02 shown in Map 4-7-1). These stations were established to characterize baseline water quality in the vicinity of the proposed road crossing. Due to the remoteness of these locations, samples were only collected on one occasion. Additional water quality monitoring will be conducted prior to operations.

Additional details on the site locations, including the degree of existing ASM disturbance at each site, is provided in the baseline hydrology section (Section 4.7). Based on visual observations, the degree of disturbance from ASM activities, as presented in Table 4.7-1 (and repeated in Table 4.8-1), is summarized below:

- **Heavily impacted by ASM**: CSW-01.
- **Impacted by ASM (includes sites where upstream disturbances are evident):** CSW-02, CSW-03, CSW-04, CSW-05, CSW-06, CSW-08, CSW-09, CSW-10 and TSW-01.
- **Negligible to no impacts by ASM**: CSW-07 and TSW-02.

Table 4.8-1 Surface Water Monitoring Period of Record Summary

		Monitoring Locations									
		CSW-01	**CSW-02**	**CSW-03**	**CSW-04**	**CSW-05**	**CSW-06**	**CSW-07**	**CSW-08**	**CSW-09**	**CSW-10**
Site Details	**Area**	Santa Barbara	Santa Barbara	Between Sabajo and Santa Barbara	Outside Project physical impact area		Between Sabajo and Santa Barbara	Sabajo	Sabajo	Sabajo	Between Sabajo and Santa Barbara
	Nearest Mine Facility	Pit	Pit and WRF		None	None		WRF	WRF	Pits and WRF	
	Drainage	Western	Eastern	Eastern	Western	Western	Western	Western	Eastern	Eastern	Eastern
	ASM Impacts?	Yes - High	Yes	Yes	Yes	Yes	Yes	No to Negligible	Yes	Yes	Yes
	Description	Furthest downgradient station - Creek 1	Small tributary to Creek 2	Tributary to Creek 2	Small tributary to Creek 1	Small tributary to Creek 1	Creek 1 downgradient of Sabajo facilities	Creek 1	Small tributary to Creek 2	Creek 2 immediately downgradient of Sabajo facilities	Furthest downgradient station - Creek 2
	Date	**Monitoring Events**									
Historical - Tetra Tech	Sep-10	x	x	x	x	x	x	x	x	x	
	Nov-10	x		x	x	x	x	x	x	x	
	Apr-11	x	x	x	x	x	x	x	x	x	
	Nov-11	x		x		x	x	x	x	x	
	Mar-12	x	x	x		x	x	x		x	
	May-12	x	x	x		x	x	x	x	x	
	Sep-12	x		x		x	x	x	x	x	
	Apr-13	x	x	x		x	x	x		x	
	Nov-13	x	x	x		x	x	x		x	
	May-14	x		x		x	x	x		x	
	Oct-14	x				x	x	x		x	
	May-15	x		x		x	x	x		x	
	Oct-15	x		x		x	x	x		x	
	Mar-16	x		x		x	x	x		x	
	Sep-16	x		x		x	x	x		x	
Current -	Apr-17	x				x	x	x		x	x
	Jun-17	x				x	x	x		x	x
	Aug-17	x				x	x	x		x	x
	Sep-17	x				x	x	x		x	x
	Total	**19**	**6**	**14**	**3**	**19**	**19**	**19**	**6**	**19**	**4**

Golder = Golder Associates Inc.; ASM = artisanal and small scale mining; WRF = waste rock facility.

In addition to routine sampling, targeted surface water samples were collected in association with two Environmental Liability Assessments (Tetra Tech 2014a; Golder 2018a) that Newmont Suriname, LLC (Newmont) conducted to document and measure existing disturbance and contaminant concentrations from ASM activities. In May 2014, Tetra Tech collected water samples for chemical analysis from areas affected by ASM. Five samples were collected from mine pits and tailings ponds in the Santa Barbara and Sabajo areas. In September 2017, Golder collected four surface water samples from disturbed areas in the vicinity of the Margo and Santa Barbara deposits.

As discussed in Section 4.6, groundwater monitoring and test wells were installed in late 2016 and 2017. All wells are located in the vicinity of the Sabajo deposit, the focus of the hydrogeologic investigation. Well completions by geologic unit are as follows (number of wells in parentheses): saprolite quartz vein (2); saprock (4); and, bedrock within the Cassador Fault Zone (3). Well depths range from approximately 10 to 150 meters below ground surface (m bgs). Well details and the period of monitoring at each well are shown in Table 4.8-2.

Table 4.8-2 Groundwater Monitoring Well Details and Period of Record Summary

Well ID	Well Type	Screened Geologic Unit	Mid-Point Screen (m bgs)	Monitoring Events					
				Dec-16	Apr-17	Jun-17	Aug-17	Sep-17	Total
WRD-MW-01-SQ	Monitoring Well	Saprolite Quartz Vein	13	x	x		x	x	4
SP-MW-01-SQ	Monitoring Well	Saprolite Quartz Vein	59			x	x	x	3
SP-MW-02-SR	Monitoring Well	Saprock	21			x	x	x	3
OS-MW-01-SR	Monitoring Well	Saprock	23	x	x				2
WRD-MW-01-SR	Monitoring Well	Saprock	30	x	x		x	x	4
SP-TW-01-SR	Test Well	Saprock	75						0
SP-MW-02-BR	Monitoring Well	Cassador Fault	50			x	x	x	3
SP-TW-01-BR	Test Well	Cassador Fault	112			x			1
SP-MW-01-BR	Monitoring Well	Cassador Fault	143	x	x	x	x	x	5

ID = identifier; m bgs = meters below ground surface.

4.8.1.1 Project Water Quality Standards

Water quality standards serve as the basis for the assessment of potential Project impacts to groundwater and surface water resources due to the proposed Project. The Project water quality standards are based on the standards for the Merian Operation. The original development of these standards is presented in Meyer and Montoya (2011) and the current standards are presented in Newmont (2018). Project water quality standards are shown in Table 4.8-3 and include the following:

- **Effluent Limits (Column A)** – Effluent limits are equivalent to the International Finance Corporation (IFC) effluent guidelines (IFC 2007a). Constituent concentrations in mine effluents should remain below these guidelines, which IFC states are applicable to site runoff and treated effluents to surface waters for general use. IFC notes that these guidelines should be achieved, without dilution, at least 95 percent of the time. Effluent guidelines are applicable to total metal[1] concentrations (as opposed to dissolved metal concentrations). Because the Project will not use cyanide, IFC effluent guidelines for cyanide species are excluded from Table 4.8-3. Table 4.8-3 includes an effluent limit for total coliforms, which is equivalent to the IFC limit for treated sewage discharges (IFC 2007b).
- **Drinking Water (Column B)** – Constituent concentrations in groundwater at the point of compliance should not exceed drinking water standards. Project drinking water standards include

[1] The term metal refers to both metals and metalloids.

the United States Environmental Protection Agency (USEPA) primary standards (i.e., maximum contaminant levels [MCLs]), which are protective of human health (USEPA 2009b). Drinking water standards are applicable to total metal concentrations. Groundwater compliance points are defined in the Environmental and Social Monitoring and Management Plan (ESMMP), Volume B of the ESIA.

- **Aquatic Life (Column C)** - Constituent concentrations in surface water at the point of compliance should not exceed aquatic life standards. For most metals, aquatic project water quality standards are applicable to the dissolved metal concentration. The following aquatic water quality standards are applicable to the total recoverable (TR) or total metal concentration: aluminum (TR); selenium (total); and, iron (total). As identified in Table 4.8-3, some aquatic life standards are hardness dependent (i.e., barium [Ba], beryllium [Be], cadmium [Cd], chromium [Cr], lead [Pb], manganese [Mn], nickel [Ni] and zinc [Zn]). In Table 4.8-3, aquatic standards are shown based on a hardness of 10 milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$). The aquatic life standard for dissolved copper shown in Table 4.8-3 (i.e., 0.0686 mg/L) has been adopted by the Merian Operation based on site-specific toxicity testing as described in GEI Consultants (2017).

Aquatic life has been selected as the applicable surface water standard for the Project since this is the primary beneficial use of surface water in the Project area.

As will be discussed in this Section, some exceedances of the Project water quality standards have been measured during the baseline monitoring period. Therefore, it is anticipated that for some analytes, project-specific standards will be established for the Project prior to operations that will replace the standards presented in Table 4.8-3. The Project may also choose to implement site-specific standards due to site-specific conditions using accepted scientific practices (.e.g., the approach that has been used to adopt a new copper standard for the Merian Operation).

Table 4.8-3 Project Water Quality Standards

Standard Type		Legal Effluent		Drinking Water		Aquatic Life
Applicability		Mine Effluent		Groundwater		Surface Water
Dissolved or Total Metals[a]		Total Metals		Total Metals		Dissolved Metals[b]
Parameter	**Units**	**Column A**	**Source[a]**	**Column B**	**Source[a]**	**Column C**
pH	s.u.	6 - 9	IFC[c]			6.4 - 8.4
Temperature	°C	<3 degree change	IFC[c]			
Total Suspended Solids (TSS)	mg/L	50	IFC[c]			
Total Dissolved Solids (TDS)	mg/L			2,000		
Nitrate as N	mg/L			10	MCL	13
Nitrite as N	mg/L			1	MCL	
Ammonia as N	mg/L-N					2.5[d]
Sulfate	mg/L			1,500		
Aluminum	mg/L			37		0.087
Antimony	mg/L			0.006	MCL	0.24
Arsenic	mg/L	0.1	IFC[c]	0.01	MCL	0.15
Barium	mg/L			2	MCL	0.04
Beryllium	mg/L			0.004	MCL	0.0001
Boron	mg/L			7.3		5
Cadmium	mg/L	0.05	IFC[c]	0.005	MCL	0.0004
Chromium (Total or VI)	mg/L	0.1	IFC[c]	0.1	MCL	0.01
Chloride	mg/L					230
Chlorine	mg/L			4	MCL	0.011

Table 4.8-3 Project Water Quality Standards

	Standard Type	Legal Effluent		Drinking Water		Aquatic Life
	Applicability	Mine Effluent		Groundwater		Surface Water
	Dissolved or Total Metals[a]	Total Metals		Total Metals		Dissolved Metals[b]
Parameter	**Units**	**Column A**	**Source[a]**	**Column B**	**Source[a]**	**Column C**
Cobalt	mg/L			0.35		0.1
Copper	mg/L	0.3	IFC[c]	0.2		0.0686[e]
Fluoride	mg/L			4	MCL	
Iron	mg/L	2	IFC[c]	26		1
Lead	mg/L	0.2	IFC[c]	0.015	AL	0.003
Manganese	mg/L			0.88		0.3
Mercury	mg/L	0.002	IFC[c]	0.002	MCL	0.0008
Molybdenum	mg/L			0.18		3.2
Nickel	mg/L	0.5	IFC[c]	0.73		0.007
Selenium	mg/L			0.05	MCL	0.005
Silver	mg/L			0.18		0.0001
Thallium	mg/L			0.002	MCL	0.007
Zinc	mg/L	0.5	IFC[c]	5		0.02
Biological Oxygen Demand (BOD)	mg/L	50	IFC[c]			
Chemical Oxygen Demand (COD)	mg/L	150	IFC[c]			
Oil and Grease	mg/L	10	IFC[c]			
Phenols	mg/L	0.5	IFC[c]			
Total Coliforms	MPN/100 mL	400	IFC			

Notes:

Water quality standards based on Merian Operation standards.

Project water quality standards may be revised if baseline concentrations exceed standards. Project water quality standards may also be adjusted due to site-specific conditions using accepted scientific practices.

a) Sources:

IFC = International Finance Corporation (IFC 2007a [most parameters] and IFC 2007b [coliform])

IFC (2007a) cyanide species standards not included in table since there will be no cyanide use in the Project area.

MCL = maximum contaminant level, United States Environmental Protection Agency (USEPA) drinking water standards (USEPA 2009b)

AL = action level, USEPA drinking water standards (USEPA 2009b)

For standards without a specific source referenced see Meyer and Montoya (2011)

b) Dissolved metals with the exception of aluminum (total recoverable), iron (total) and selenium (total). Grey shading identifies aquatic standards that are hardness dependent. A hardness of 10 mg/L as calcium carbonate is assumed.

c) IFC guidelines should be achieved, without dilution, at least 95 percent of the time.

d) Based on USEPA (1999). Assumes a pH of approximately 6.7 and a temperature of 29 °C.

e) Site specific value based on site-specific testing (GEI Consultants 2017)

N = nitrogen; s.u. = standard units; mg/L = milligrams per liter; MPN/100 mL = most probable number per 100 milliliters; °C = degrees Celsius; mg/L-N = milligrams per liter nitrogen; <= less than.

4.8.2 Water Quality Monitoring Program

4.8.2.1 Constituents and Laboratory Analysis

As discussed above, the historical surface water quality monitoring program was conducted between September 2010 and December 2016 with a total of up to 15 sampling events at each monitoring location. The analytical suite for these samples included general chemistry parameters (e.g., pH, total dissolved solids [TDS], total suspended solids [TSS]), some major ions[2], dissolved metals[3], total metals[4], nutrients, total cyanide, total organic carbon (TOC) and field parameter measurements.

The recent surface water quality monitoring program was conducted between April and September 2017 with a total of 4 sampling events. Therefore, samples were collected during both the wet and dry seasons. As described in Section 4.7.2.1, the long wet season generally runs from April to July and the long dry season from August to November. The analytical suite for these samples included general chemistry parameters, major ions, dissolved and total metals[5], nitrogen species, organics and field parameter measurements. Four rounds of groundwater quality monitoring were conducted between December 2016 and September 2017. The analytical suite for samples included general chemistry parameters, dissolved and total metals[6], nutrients, organics and field parameter measurements.

All surface water and groundwater samples were analyzed by SVL Analytical, Inc. (SVL) in Kellogg, Idaho, United States of America (USA). Dissolved metal samples were filtered with a 0.45 micrometer (µm) filter prior to analysis. Following measurement of elevated arsenic concentrations in some monitoring wells during initial sampling rounds, selected samples were filtered in the field with both a 0.45 µm and 0.10 µm filter prior to analysis. Analysis of groundwater samples following filtration with a 0.10 µm filter was conducted to confirm that arsenic was present in the dissolved fraction and not associated with colloidal or particulate material that passes the 0.45 µm filter.

SVL metal reporting limits for the historical and recent monitoring periods are shown in Table 4.8-4. For a few parameters (i.e., Be, Cd, copper (Cu), and Ni), reporting limits for the recent monitoring period are an order of magnitude lower than the historical monitoring period. These changes are due to a change in the method of analysis from inductively coupled plasma (ICP) to analysis by inductively coupled plasma mass spectrometry (ICP-MS).

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[2] Major ion parameter suite: Alkalinity, chloride (Cl), sulfate (SO_4), potassium (K) and sodium (Na). Ca and magnesium (Mg) were not included in major ion analysis.

[3] Dissolved metal parameter suite: aluminum (Al), antimony (Sb), arsenic (As), Be, boron (B), Cd, Cr, cobalt (Co), Cu, iron (Fe), Pb, Mn, molybdenum (Mo), Ni, selenium (Se), silver (Ag), vanadium (V) and Zn.

[4] Total metal parameter suite: iron (Fe), Mn and mercury (Hg).

[5] Dissolved and total metal parameter suite: Al, Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Se, Ag, titanium (Tl), V and Zn.

[6] Same parameter suite as surface water monitoring.

Table 4.8-4 Recent and Historical Monitoring Period Analytical Reporting Limits

	Reporting Limit (mg/L)	
	Historical	Recent
Aluminum	0.08	0.08
Antimony	0.003 (a)	0.003
Arsenic	0.003 (b)	0.002
Barium	NA	0.002
Beryllium	0.002	0.0002
Boron	0.04	0.04
Cadmium	0.002	0.0002
Chromium	0.006	0.006
Cobalt	0.006	0.006
Copper	0.01	0.001
Iron	0.6	0.1

	Reporting Limit (mg/L)	
	Historical	Recent
Lead	0.0075	0.003
Manganese	0.004	0.008
Mercury	0.0002	0.0002
Molybdenum	0.008	0.008
Nickel	0.01	0.001
Selenium	0.001 / 0.003	0.003
Silver	0.005	0.0001
Thallium	NA	0.001
Vanadium	0.005	NA
Zinc	0.01	0.01

Notes: All values shown are mg/L
a) Lower reporting limit (0.0012 mg/L) for some samples.
b) Lower reporting limit (0.002 mg/L) for some samples.
c) Some reporting limits for December 2016 groundwater samples differed from the standard current monitoring reporting limits.
NA = not analysed; mg/L = milligrams per liter.

4.8.2.2 Quality Assurance / Quality Control

Quality Assurance / Quality Control (QA/QC) refers to the techniques and procedures used to evaluate data quality (i.e., accuracy and precision). Historical surface water monitoring QA/QC protocols are described in the Tetra Tech reports (Tetra Tech 2011a,b,c, 2012a,b,c, 2013b,c, 2014b, 2015b,c,d, 2016b). The recent QA/QC program included the following components: collection and analysis of field quality control samples (i.e., blanks and duplicates); review of laboratory QA/QC data (i.e., blanks, duplicates, matrix spikes and control samples); assessment of sample holding times; comparison of dissolved and total metal concentrations, and, calculation of charge balance errors. A detailed description of the QA/QC program for the recent monitoring program and the results of data validation are described in the baseline water quality data report (Golder 2018c). No results were rejected based on the QA/QC assessment.

4.8.3 Surface Water Quality

The complete surface water quality data set is provided in the baseline water quality data report (Golder 2018c). This report includes tables that compare all baseline water quality results to Project water quality standards. For the recent monitoring results, the tables also include any data qualifiers applied based on the results of the QA/QC evaluations. Selected results and a summary of baseline exceedances of Project water quality standards are discussed in the sub-sections below.

4.8.3.1 Routine Monitoring Results (Stations CSW-01 to CSW-10)

Surface water quality results are summarized in Table 4.8-5. This table shows the number of samples (including duplicates) and the maximum and minimum concentrations measured at each monitoring location during the period of record.

Table 4.8-5 Routine Surface Water Monitoring – Summary Statistics

Parameter	Fraction[b]	Unit	All Surface Water Stations		CSW-01			CSW-02			CSW-03			CSW-04			CSW-05		
			2010 - 2017		2010 - 2017			2010 - 2013			2010 - 2016			2010 - 2011			2010 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
FIELD PARAMETERS																			
pH		pH	4.4	7.8	18	5.0	6.8	5	5.8	6.7	13	4.6	5.9	3	5.2	6.0	18	4.5	6.2
Specific Conductance		μS/cm	11	297	18	22	153	5	11	158	13	16	65	3	33	37	18	22	48
Turbidity		NTU	<DL	1,000	18	35	1,000	5	28	690	13	0	82	3	11	29	18	3.0	51
Temperature		°C	24	33	18	25	30	5	25	28	13	24	30	3	25	26	18	27	33
Oxygen Reduction Potential (ORP)		mV	56	213	4	83	156	0	-	-	0	-	-	0	-	-	4	88	122
Dissolved Oxygen (DO)		mg/L	0.93	10	18	3.0	10	5	1.3	7.5	13	1.7	10	3	5.1	6.2	18	4.1	9.7
GENERAL CHEMISTRY																			
pH		pH	5.6	7.2	4	6.5	6.8	0	-	-	0	-	-	0	-	-	4	6.3	6.8
Specific Conductance		μmhos/cm	23	57	4	29	40	0	-	-	0	-	-	0	-	-	4	31	34
Total Dissolved Solids (TDS)		mg/L	15	170	20	22	170	6	72	112	15	15	71	3	24	128	20	16	144
Total Suspended Solids (TSS)		mg/L	<DL	1,420	20	12	844	6	10	1,420	15	<5	24	3	5.0	<10	20	<5	32
Hardness		mg/L $CaCO_3$	2.3	9.4	4	4.0	5.5	0	-	-	0	-	-	0	-	-	3	4.6	4.9
MAJOR IONS																			
Total Alkalinity		mg/L $CaCO_3$	<DL	43	20	2.0	11	6	6.5	43	15	<1	6.5	3	9.7	13	20	5.8	11
Bicarbonate		mg/L $CaCO_3$	<DL	43	20	2.0	11	6	6.5	43	15	<1	6.5	3	9.7	13	20	5.8	11
Carbonate		mg/L $CaCO_3$	<DL	<DL	20	<1	<1	6	<1	<1	15	<1	<1	3	<1	<1	20	<1	<1
Chloride		mg/L	2.2	12	20	2.6	5.6	6	4.0	12	15	2.6	6.5	3	3.6	3.9	20	2.5	4.3
Fluoride		mg/L	<DL	<DL	4	<0.1	<0.1	0	-	-	0	-	-	0	-	-	4	<0.1	<0.1
Sulfate		mg/L	<DL	2.0	20	0.39	1.9	6	<0.3	2.0	15	<0.3	0.88	3	0.67	0.90	20	0.45	1.6
Calcium	D	mg/L	1.0	3.5	4	1.5	1.8	0	-	-	0	-	-	0	-	-	3	1.6	1.7
Magnesium	D	mg/L	0.56	2.3	4	1.0	1.3	0	-	-	0	-	-	0	-	-	3	1.1	1.2
Sodium	D	mg/L	2.1	3.8	4	2.5	3.5	0	-	-	0	-	-	0	-	-	3	2.1	2.6
Potassium	D	mg/L	<DL	1.1	4	0.57	1.1	0	-	-	0	-	-	0	-	-	3	<0.5	0.52
Calcium	TR	mg/L	<DL	<DL	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Magnesium	TR	mg/L	<DL	<DL	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Potassium	TR	mg/L	<DL	2.2	16	<0.5	1.1	6	0.56	2.2	15	<0.5	0.80	3	<0.5	0.69	16	<0.5	0.72
Sodium	TR	mg/L	<DL	8.7	11	2.2	3.4	6	3.3	8.7	11	2.0	3.5	3	2.5	3.1	12	2.1	2.8
DISSOLVED METALS																			
Aluminum	D	mg/L	<DL	0.38	20	<0.08	0.18	6	<0.08	0.16	15	<0.08	0.25	3	<0.08	<0.08	20	<0.08	<0.08
Antimony	D	mg/L	<DL	0.008	20	<0.0012	<0.003	6	<0.0012	<0.003	15	<0.0012	<0.003	3	<0.0012	<0.0012	20	<0.0012	<0.003
Arsenic	D	mg/L	<DL	0.043	20	<0.002	<0.003	6	<0.002	<0.003	15	<0.002	<0.003	3	<0.002	0.002	20	<0.002	<0.003
Barium	D	mg/L	<DL	0.007	4	0.005	0.007	0	-	-	0	-	-	0	-	-	4	<0.002	0.003
Beryllium	D	mg/L	<DL	<DL	20	<0.0002	<0.002	6	<0.002	<0.002	15	<0.0002	<0.002	3	<0.002	<0.002	20	<0.0002	<0.002
Boron	D	mg/L	<DL	0.046	20	<0.04	<0.04	6	<0.04	<0.04	15	<0.04	<0.04	3	<0.04	<0.04	20	<0.04	<0.04

Table 4.8-5 Routine Surface Water Monitoring – Summary Statistics

Parameter	Fraction[b]	Unit	All Surface Water Stations 2010 - 2017		CSW-01 2010 - 2017			CSW-02 2010 - 2013			CSW-03 2010 - 2016			CSW-04 2010 - 2011			CSW-05 2010 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Cadmium	D	mg/L	<DL	<DL	20	<0.0002	<0.002	6	<0.002	<0.002	15	<0.0002	<0.002	3	<0.002	<0.002	20	<0.0002	<0.002
Chromium	D	mg/L	<DL	<DL	20	<0.006	<0.006	6	<0.006	<0.006	15	<0.006	<0.006	3	<0.006	<0.006	20	<0.006	<0.006
Cobalt	D	mg/L	<DL	0.008	20	<0.006	0.007	6	<0.006	0.008	15	<0.006	0.006	3	<0.006	<0.006	20	<0.006	0.006
Copper	D	mg/L	<DL	0.001	20	<0.001	<0.01 [a]	6	<0.01	<0.01	15	<0.001	<0.01 [a]	3	<0.01	<0.01	20	<0.001	<0.01
Iron	D	mg/L	0.060	7.5	20	0.17	1.6	6	0.16	2.4	15	0.27	7.5	3	0.84	0.90	20	0.071	1.2
Lead	D	mg/L	<DL	<DL	20	<0.003	<0.0075	6	<0.0075	<0.0075	15	<0.0075	<0.0075	3	<0.0075	<0.0075	20	<0.003	<0.0075
Manganese	D	mg/L	0.013	0.44	20	0.032	0.38	6	0.036	0.27	15	0.013	0.056	3	0.10	0.20	20	0.070	0.33
Mercury	D	mg/L	<DL	0.0005	20	<0.0002	0.0003	6	<0.0002	<0.0002	15	<0.0002	0.0005	3	<0.0002	<0.0002	20	<0.0002	0.0002
Molybdenum	D	mg/L	<DL	<DL	20	<0.008	<0.008	6	<0.008	<0.008	15	<0.008	<0.008	3	<0.008	<0.008	20	<0.008	<0.008
Nickel	D	mg/L	<DL	0.010	20	<0.001	0.010	6	<0.01	<0.01	15	<0.01	<0.01	3	<0.01	<0.01	20	<0.001	<0.01 [a]
Selenium	D	mg/L	<DL	0.004	20	<0.001	<0.003	6	0.001	0.004	15	<0.001	<0.003	3	<0.001	<0.001	20	<0.001	<0.003
Silver	D	mg/L	<DL	0.0001	20	<0.0001	<0.005	6	<0.005	<0.005	15	<0.0001	<0.005	3	<0.005	<0.005	20	<0.0001	<0.005
Thallium	D	mg/L	<DL	<DL	4	<0.001	<0.001	0	-	-	0	-	-	0	-	-	4	<0.001	<0.001
Vanadium	D	mg/L	<DL	0.005	16	<0.005	0.005	6	<0.005	<0.005	15	<0.005	<0.005	3	<0.005	<0.005	16	<0.005	<0.005
Zinc	D	mg/L	<DL	0.025	20	<0.01	0.013	6	<0.01	<0.01	15	<0.01	<0.01	3	<0.01	<0.01	20	<0.01	<0.01
TOTAL METALS																			
Aluminum	TR	mg/L	<DL	3.4	4	0.45	3.4	0	-	-	0	-	-	0	-	-	4	<0.08	<0.08
Antimony	TR	mg/L	<DL	<DL	4	<0.003	<0.003	0	-	-	0	-	-	0	-	-	4	<0.003	<0.003
Arsenic	TR	mg/L	<DL	0.007	4	<0.003	0.007	0	-	-	0	-	-	0	-	-	4	<0.003	0.003
Barium	TR	mg/L	0.005	0.024	4	0.009	0.016	0	-	-	0	-	-	0	-	-	4	0.005	0.024
Beryllium	TR	mg/L	<DL	<DL	4	<0.0002	<0.0002	0	-	-	0	-	-	0	-	-	4	<0.0002	<0.0002
Boron	TR	mg/L	<DL	<DL	4	<0.04	<0.04	0	-	-	0	-	-	0	-	-	4	<0.04	<0.04
Cadmium	TR	mg/L	<DL	<DL	4	<0.0002	<0.0002	0	-	-	0	-	-	0	-	-	4	<0.0002	<0.0002
Chromium	TR	mg/L	<DL	0.007	4	<0.006	0.007	0	-	-	0	-	-	0	-	-	4	<0.006	<0.006
Cobalt	TR	mg/L	<DL	<DL	4	<0.006	<0.006	0	-	-	0	-	-	0	-	-	4	<0.006	<0.006
Copper	TR	mg/L	<DL	0.006	4	0.002	0.006	0	-	-	0	-	-	0	-	-	4	<0.001	<0.001
Iron	TR	mg/L	0.90	118	20	2.9	20	6	4.1	64	15	0.93	118	3	2.3	3.3	20	2.1	4.9
Lead	TR	mg/L	<DL	<DL	4	<0.003	<0.003	0	-	-	0	-	-	0	-	-	4	<0.003	<0.003
Manganese	TR	mg/L	0.014	0.60	20	0.054	0.60	6	0.069	0.53	15	0.014	0.053	3	0.10	0.19	20	0.079	0.36
Mercury	T	mg/L	<DL	0.0005	20	<0.0002	0.0005	6	<0.0002	<0.0002	15	<0.0002	0.0004	3	<0.0002	<0.0002	20	<0.0002	0.0003
Molybdenum	TR	mg/L	<DL	<DL	4	<0.008	<0.008	0	-	-	0	-	-	0	-	-	4	<0.008	<0.008
Nickel	TR	mg/L	<DL	0.004	4	0.001	0.004	0	-	-	0	-	-	0	-	-	4	<0.001	0.001
Phosphorus	TR	mg/L	<DL	0.74	16	<0.05	0.74	6	<0.05	0.069	15	<0.05	0.22	3	<0.05	<0.05	16	<0.05	0.050
Selenium	TR	mg/L	<DL	<DL	4	<0.003	<0.003	0	-	-	0	-	-	0	-	-	4	<0.003	<0.003
Silver	TR	mg/L	<DL	<DL	4	<0.0001	<0.0001	0	-	-	0	-	-	0	-	-	4	<0.0001	<0.0001
Thallium	TR	mg/L	<DL	<DL	4	<0.001	<0.001	0	-	-	0	-	-	0	-	-	4	<0.001	<0.001

Table 4.8-5 Routine Surface Water Monitoring – Summary Statistics

Parameter	Fraction[b]	Unit	All Surface Water Stations 2010 - 2017		CSW-01 2010 - 2017			CSW-02 2010 - 2013			CSW-03 2010 - 2016			CSW-04 2010 - 2011			CSW-05 2010 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Vanadium	TR	mg/L	<DL	<DL	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Zinc	TR	mg/L	<DL	0.029	4	<0.01	0.025	0	-	-	0	-	-	0	-	-	4	<0.01	<0.01
NUTRIENTS																			
Ammonia as N		mg/L	<DL	1.2	20	<0.03	0.36	6	0.26	1.2	15	<0.03	0.24	3	0.13	0.17	20	<0.03	0.23
Nitrate/Nitrite as N		mg/L	<DL	0.31	20	0.066	0.30	6	<0.05	0.22	15	<0.05	0.16	3	0.056	0.12	20	<0.05	0.26
Phosphorus	D	mg/L	<DL	<DL	4	<0.05	<0.05	0	-	-	0	-	-	0	-	-	3	<0.05	<0.05
CYANIDE AND ORGANICS																			
Diesel		mg/L	<DL	<DL	2	<0.1	<0.1	0	-	-	0	-	-	0	-	-	2	<0.1	<0.1
Lube Oil		mg/L	<DL	<DL	2	<0.5	<0.5	0	-	-	0	-	-	0	-	-	2	<0.5	<0.5
Gasoline		mg/L	<DL	<DL	2	<0.1	<0.1	0	-	-	0	-	-	0	-	-	2	<0.1	<0.1
Cyanide (total)		mg/L	<DL	0.011	16	<0.01	<0.01	6	<0.01	<0.01	15	<0.01	<0.01	3	<0.01	<0.01	16	<0.01	<0.01
Total Organic Carbon		mg/L	2.3	21	11	3.4	13	6	10	21	11	3.1	13	3	2.4	3.2	12	2.3	5.2

Notes:
Lighter text is for results below detection limits.
a) Some results at ppb levels (i.e., concentration measured below higher reporting limit).
b) Fraction: D = dissolved; TR = total recoverable; T = total
<DL = less than analytical detection limit; min = minimum; max = maximum; °C = degrees Celsius; mV = millivolt; N = nitrogen; ppb = parts per billion; µS/cm = microSiemens per centimeter; µmhos/cm = micromhos per centimeter; NTU = nephelometric turbidity units; mg/L = milligrams per liter; $CaCO_3$ = calcium carbonate; <= less than; - = not available.

Table 4.8-5 Routine Surface Water Monitoring – Summary Statistics (Continued)

Parameter	Fraction[b]	Unit	All Surface Water Stations		CSW-06			CSW-07			CSW-08			CSW-09			CSW-10		
			2010 - 2017		2010 - 2017			2010 - 2017			2010 - 2012			2010 - 2017			2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
FIELD PARAMETERS																			
pH		pH	4.4	7.8	19	4.5	7.1	18	4.4	7.8	5	4.4	6.8	18	4.6	7.0	4	6.4	6.9
Specific Conductance		µS/cm	11	297	19	19	45	18	21	50	5	24	60	18	23	297	4	45	58
Turbidity		NTU	<DL	1,000	19	8	524	18	0	51	5	14	283	18	5.8	1,000	4	21	85
Temperature		°C	24	33	19	25	32	18	24	29	5	24	32	18	25	28	4	26	29
Oxygen Reduction Potential (ORP)		mV	56	213	5	56	186	4	86	190	0	-	-	4	85	213	4	84	183
Dissolved Oxygen (DO)		mg/L	0.93	10	19	3.9	9.9	18	0.93	10	5	3.0	6.9	18	5.2	10	4	6.7	7.3
GENERAL CHEMISTRY																			
pH		pH	5.6	7.2	5	5.9	6.6	4	5.6	6.4	0	-	-	4	6.4	7.2	4	6.7	7.1
Specific Conductance		µmhos/cm	23	57	5	23	34	4	25	31	0	-	-	4	43	55	4	41	57
Total Dissolved Solids (TDS)		mg/L	15	170	23	20	126	24	20	92	7	24	124	21	34	138	4	42	62
Total Suspended Solids (TSS)		mg/L	<DL	1,420	23	<5	198	24	<5	17	7	<5	58	21	<5	314	4	9.0	32
Hardness		mg/L $CaCO_3$	2.3	9.4	5	2.6	4.5	4	2.3	3.9	0	-	-	4	5.4	9.1	4	6.2	9.4
MAJOR IONS																			
Total Alkalinity		mg/L $CaCO_3$	<DL	43	23	2.1	12	24	1.2	14	7	1.2	13	21	3.6	22	4	8.5	17
Bicarbonate		mg/L $CaCO_3$	<DL	43	23	2.1	12	24	1.2	14	7	1.2	13	21	3.6	22	4	8.5	17
Carbonate		mg/L $CaCO_3$	<DL	<DL	23	<1	<1	24	<1	<1	7	<1	<1	21	<1	<1	4	<1	<1
Chloride		mg/L	2.2	12	23	2.6	5.0	24	2.2	4.7	7	3.0	4.6	21	2.3	5.6	4	3.8	4.6
Fluoride		mg/L	<DL	<DL	5	<0.1	<0.1	4	<0.1	<0.1	0	-	-	4	<0.1	<0.1	4	<0.1	<0.1
Sulfate		mg/L	<DL	2.0	23	<0.3	1.1	24	<0.3	1.0	7	<0.3	1.1	21	0.56	1.6	4	0.82	1.0
Calcium	D	mg/L	1.0	3.5	5	1.2	1.6	4	1.0	1.4	0	-	-	4	2.3	3.5	4	2.2	3.5
Magnesium	D	mg/L	0.56	2.3	5	0.63	1.1	4	0.56	0.94	0	-	-	4	1.3	2.2	4	1.5	2.3
Sodium	D	mg/L	2.1	3.8	5	2.2	2.9	4	2.3	2.7	0	-	-	4	2.9	3.7	4	2.8	3.8
Potassium	D	mg/L	<DL	1.1	5	<0.5	0.50	4	<0.5	<0.5	0	-	-	4	<0.5	0.67	4	<0.5	0.59
Calcium	TR	mg/L	<DL	<DL	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Magnesium	TR	mg/L	<DL	<DL	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Potassium	TR	mg/L	<DL	2.2	18	<0.5	0.72	20	<0.5	0.62	7	<0.5	1.2	17	<0.5	0.67	0	-	-
Sodium	TR	mg/L	<DL	8.7	13	2.0	3.3	15	2.1	3.1	7	2.6	3.2	12	1.9	3.8	0	-	-
DISSOLVED METALS																			
Aluminum	D	mg/L	<DL	0.38	23	<0.08	0.28	24	<0.08	0.38	7	<0.08	0.38	21	<0.08	0.38	4	<0.08	<0.08
Antimony	D	mg/L	<DL	0.008	23	<0.0012	0.008	24	<0.0012	<0.003	7	<0.0012	<0.003	21	<0.0012	<0.003	4	<0.003	<0.003
Arsenic	D	mg/L	<DL	0.043	23	<0.002	<0.003	24	<0.002	<0.003	7	<0.002	0.043	21	<0.002	0.004	4	<0.003	0.003
Barium	D	mg/L	<DL	0.007	5	0.004	0.006	4	0.005	0.006	0	-	-	4	0.005	0.007	4	0.004	0.005
Beryllium	D	mg/L	<DL	<DL	23	<0.0002	<0.002	24	<0.0002	<0.002	7	<0.002	<0.002	21	<0.0002	<0.002	4	<0.0002	<0.0002
Boron	D	mg/L	<DL	0.046	23	<0.04	<0.04	24	<0.04	0.046	7	<0.04	<0.04	21	<0.04	<0.04	4	<0.04	<0.04

Table 4.8-5 Routine Surface Water Monitoring – Summary Statistics (Continued)

Parameter	Fraction[b]	Unit	All Surface Water Stations 2010 - 2017		CSW-06 2010 - 2017			CSW-07 2010 - 2017			CSW-08 2010 - 2012			CSW-09 2010 - 2017			CSW-10 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Cadmium	D	mg/L	<DL	<DL	23	<0.0002	<0.002	24	<0.0002	<0.002	7	<0.002	<0.002	21	<0.0002	<0.002	4	<0.0002	<0.0002
Chromium	D	mg/L	<DL	<DL	23	<0.006	<0.006	24	<0.006	<0.006	7	<0.006	<0.006	21	<0.006	<0.006	4	<0.006	<0.006
Cobalt	D	mg/L	<DL	0.008	23	<0.006	0.007	24	<0.006	0.007	7	<0.006	0.008	21	<0.006	<0.006	4	<0.006	0.006
Copper	D	mg/L	<DL	0.001	23	<0.001	<0.01 [a]	24	<0.001	<0.01 [a]	7	<0.01	<0.01	21	<0.001	<0.01 [a]	4	<0.001	0.001
Iron	D	mg/L	0.060	7.5	23	0.37	1.8	24	0.70	1.5	7	0.39	1.1	21	0.060	1.4	4	0.62	0.94
Lead	D	mg/L	<DL	<DL	23	<0.003	<0.0075	24	<0.003	<0.0075	7	<0.0075	<0.0075	21	<0.003	<0.0075	4	<0.003	<0.003
Manganese	D	mg/L	0.013	0.44	23	0.027	0.076	24	0.014	0.44	7	0.022	0.089	21	0.013	0.16	4	0.027	0.14
Mercury	D	mg/L	<DL	0.0005	23	<0.0002	0.0004	24	<0.0002	0.0003	7	<0.0002	<0.0002	21	<0.0002	0.0005	4	<0.0002	<0.0002
Molybdenum	D	mg/L	<DL	<DL	23	<0.008	<0.008	24	<0.008	<0.008	7	<0.008	<0.008	21	<0.008	<0.008	4	<0.008	<0.008
Nickel	D	mg/L	<DL	0.010	23	<0.001	<0.01 [a]	24	<0.001	<0.01 [a]	7	<0.01	<0.01	21	<0.001	<0.01 [a]	4	<0.001	0.001
Selenium	D	mg/L	<DL	0.004	23	<0.001	<0.003	24	<0.001	<0.003	7	<0.001	<0.003	21	<0.001	<0.003	4	<0.003	<0.003
Silver	D	mg/L	<DL	0.0001	23	<0.0001	<0.005	24	<0.0001	<0.005 [a]	7	<0.005	<0.005	21	<0.0001	<0.005 [a]	4	<0.0001	0.0001
Thallium	D	mg/L	<DL	<DL	5	<0.001	<0.001	4	<0.001	<0.001	0	-	-	4	<0.001	<0.001	4	<0.001	<0.001
Vanadium	D	mg/L	<DL	0.005	18	<0.005	<0.005	20	<0.005	<0.005	7	<0.005	<0.005	17	<0.005	<0.005	0	-	-
Zinc	D	mg/L	<DL	0.025	23	<0.01	0.025	24	<0.01	0.021	7	<0.01	<0.01	21	<0.01	0.011	4	<0.01	<0.01
TOTAL METALS																			
Aluminum	TR	mg/L	<DL	3.4	5	0.22	0.53	4	0.17	0.40	0	-	-	4	0.12	0.40	4	0.22	0.61
Antimony	TR	mg/L	<DL	<DL	5	<0.003	<0.003	4	<0.003	<0.003	0	-	-	4	<0.003	<0.003	4	<0.003	<0.003
Arsenic	TR	mg/L	<DL	0.007	5	<0.003	<0.003	4	<0.003	<0.003	0	-	-	4	<0.003	<0.003	4	<0.003	<0.003
Barium	TR	mg/L	0.005	0.024	5	0.006	0.008	4	0.006	0.007	0	-	-	4	0.006	0.009	4	0.007	0.010
Beryllium	TR	mg/L	<DL	<DL	5	<0.0002	<0.0002	4	<0.0002	<0.0002	0	-	-	4	<0.0002	<0.0002	4	<0.0002	<0.0002
Boron	TR	mg/L	<DL	<DL	5	<0.04	<0.04	4	<0.04	<0.04	0	-	-	4	<0.04	<0.04	4	<0.04	<0.04
Cadmium	TR	mg/L	<DL	<DL	5	<0.0002	<0.0002	4	<0.0002	<0.0002	0	-	-	4	<0.0002	<0.0002	4	<0.0002	<0.0002
Chromium	TR	mg/L	<DL	0.007	5	<0.006	<0.006	4	<0.006	<0.006	0	-	-	4	<0.006	<0.006	4	<0.006	0.006
Cobalt	TR	mg/L	<DL	<DL	5	<0.006	<0.006	4	<0.006	<0.006	0	-	-	4	<0.006	<0.006	4	<0.006	<0.006
Copper	TR	mg/L	<DL	0.006	5	<0.001	0.002	4	<0.001	<0.001	0	-	-	4	<0.001	0.002	4	<0.001	0.003
Iron	TR	mg/L	0.90	118	23	2.2	6.6	24	1.4	6.9	7	0.90	4.0	21	1.2	37	4	2.4	3.5
Lead	TR	mg/L	<DL	<DL	5	<0.003	<0.003	4	<0.003	<0.003	0	-	-	4	<0.003	<0.003	4	<0.003	<0.003
Manganese	TR	mg/L	0.014	0.60	23	0.028	0.29	24	0.018	0.53	7	0.024	0.085	21	0.037	0.20	4	0.054	0.18
Mercury	T	mg/L	<DL	0.0005	23	<0.0002	0.0004	24	<0.0002	0.0003	7	<0.0002	<0.0002	21	<0.0002	0.0005	4	<0.0002	<0.0002
Molybdenum	TR	mg/L	<DL	<DL	5	<0.008	<0.008	4	<0.008	<0.008	0	-	-	4	<0.008	<0.008	4	<0.008	<0.008
Nickel	TR	mg/L	<DL	0.004	5	<0.001	0.002	4	<0.001	0.002	0	-	-	4	0.001	0.002	4	0.001	0.002
Phosphorus	TR	mg/L	<DL	0.74	18	<0.05	0.050	20	<0.05	<0.05	7	<0.05	<0.05	17	<0.05	<0.05	0	-	-
Selenium	TR	mg/L	<DL	<DL	5	<0.003	<0.003	4	<0.003	<0.003	0	-	-	4	<0.003	<0.003	4	<0.003	<0.003
Silver	TR	mg/L	<DL	<DL	5	<0.0001	<0.0001	4	<0.0001	<0.0001	0	-	-	4	<0.0001	<0.0001	4	<0.0001	<0.0001
Thallium	TR	mg/L	<DL	<DL	5	<0.001	<0.001	4	<0.001	<0.001	0	-	-	4	<0.001	<0.001	4	<0.001	<0.001

Table 4.8-5 Routine Surface Water Monitoring – Summary Statistics (Continued)

Parameter	Fraction[b]	Unit	All Surface Water Stations		CSW-06			CSW-07			CSW-08			CSW-09			CSW-10		
			2010 - 2017		2010 - 2017			2010 - 2017			2010 - 2012			2010 - 2017			2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Vanadium	TR	mg/L	<DL	<DL	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Zinc	TR	mg/L	<DL	0.029	5	<0.01	0.029	4	<0.01	0.010	0	-	-	4	<0.01	0.015	4	<0.01	<0.01
NUTRIENTS																			
Ammonia as N		mg/L	<DL	1.2	23	<0.03	0.13	24	<0.03	0.23	7	0.049	0.32	21	<0.03	0.13	4	<0.03	0.090
Nitrate/Nitrite as N		mg/L	<DL	0.31	23	<0.05	0.17	24	<0.05	0.24	7	<0.05	0.18	21	0.10	0.31	4	0.15	0.27
Phosphorus	D	mg/L	<DL	<DL	5	<0.05	<0.05	4	<0.05	<0.05	0	-	-	4	<0.05	<0.05	4	<0.05	<0.05
CYANIDE AND ORGANICS																			
Diesel		mg/L	<DL	<DL	2	<0.1	<0.1	2	<0.1	<0.1	0	-	-	2	<0.1	<0.1	2	<0.1	<0.1
Lube Oil		mg/L	<DL	<DL	2	<0.5	<0.5	2	<0.5	<0.5	0	-	-	2	<0.5	<0.5	2	<0.5	<0.5
Gasoline		mg/L	<DL	<DL	2	<0.1	<0.1	1	<0.1	<0.1	0	-	-	2	<0.1	<0.1	2	<0.1	<0.1
Cyanide (total)		mg/L	<DL	0.011	18	<0.01	<0.01	20	<0.01	<0.01	7	<0.01	<0.01	17	<0.01	0.011	0	-	-
Total Organic Carbon		mg/L	2.3	21	13	4.1	11	15	5.4	14	7	3.4	16	12	2.9	8.2	0	-	-

Notes:

Lighter text is for results below detection limits.

a) Some results at ppb levels (i.e., concentration measured below higher reporting limit).

b) Fraction: D = dissolved; TR = total recoverable; T = total

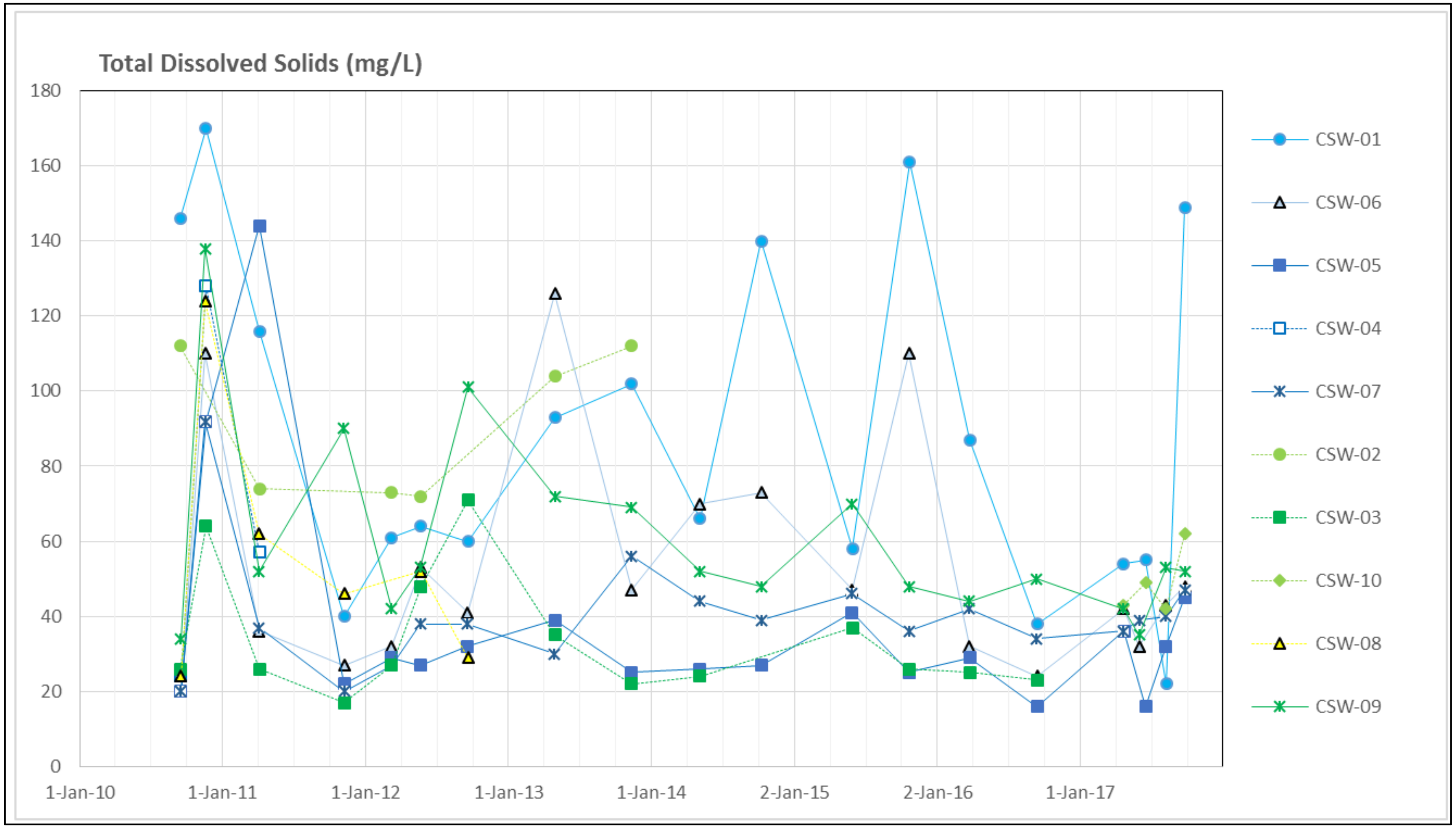
<DL = less than analytical detection limit; min = minimum; max = maximum; °C = degrees Celsius; mV = millivolt; N = nitrogen; ppb = parts per billion; µS/cm = microSiemens per centimeter; µmhos/cm = micromhos per centimeter; NTU = nephelometric turbidity units; mg/L = milligrams per liter; $CaCO_3$ = calcium carbonate; <= less than; - = not available.

Surface water quality, based on the results of routine monitoring at stations CSW-01 to CSW-10, is described as follows:

- **pH**: Field measured pH values exhibit a large range from acidic to circum-neutral conditions (i.e., from 4.4 to 7.8 s.u.). At individual monitoring locations, pH is often temporally variable. For example, the entire range of pH values (i.e., 4.4 to 7.8 s.u.) has been measured over the period of record at CSW-07. Acidic field pH values (i.e., pH values <5.0 s.u.) have been measured at most monitoring locations including CSW-01, CSW-03, CSW-05, CSW-06, CSW-07, CSW-08 and CSW-09. With the exception of CSW-10, average pH values at all stations range from 5.1 to 6.1 s.u. The average pH at CSW-10 is 6.7 s.u.
- **Alkalinity**: Average[7] alkalinity concentrations range from approximately 2 to 17 mg/L as $CaCO_3$. Alkalinity concentrations are typically lowest at CSW-03 and highest at CSW-09. The highest alkalinity measured in a single sample was at CSW-02 (43 mg/L as $CaCO_3$).
- **Total Dissolved Solids (TDS):** Average TDS concentrations range from approximately 30 to 90 mg/L. TDS concentrations are most variable, and often the highest, at CSW-01, ranging from 22 to 170 mg/L over the period of record (Figure 4.8-1). At this station, the highest TDS concentrations are typically measured in October and November. CSW-01 is the most heavily disturbed monitoring station by ASM.
- **Hardness:** Calcium and magnesium concentrations were not measured during the historical monitoring period. The recent monitoring data indicates low hardness levels at all surface water locations (<10 mg/L as $CaCO_3$). Aquatic water quality standards that are hardness based are therefore low.
- **Total Suspended Solids (TSS):** TSS concentrations are highly variable among sites (Figure 4.8-2). Average TSS concentrations at six of the monitoring locations are less than 20 mg/L (i.e., CSW-03, CSW-04, CSW-05, CSW-07, CSW-08 and CSW-10). At these six locations, maximum TSS concentrations have remained below 60 mg/L. The highest TSS concentrations are measured at CSW-01 and CSW-02. The ranges of TSS concentrations measured at these stations, which are both in areas disturbed by ASM, are highly variable. Some of the samples at these stations were likely collected with active ASM activities occurring in relatively close proximity to the sampling locations, which likely explains the variability in TSS.
- **Sulfate:** Sulfate concentrations are low at all surface water monitoring locations (average sulfate concentrations range from 0.4 to 1.0 mg/L).

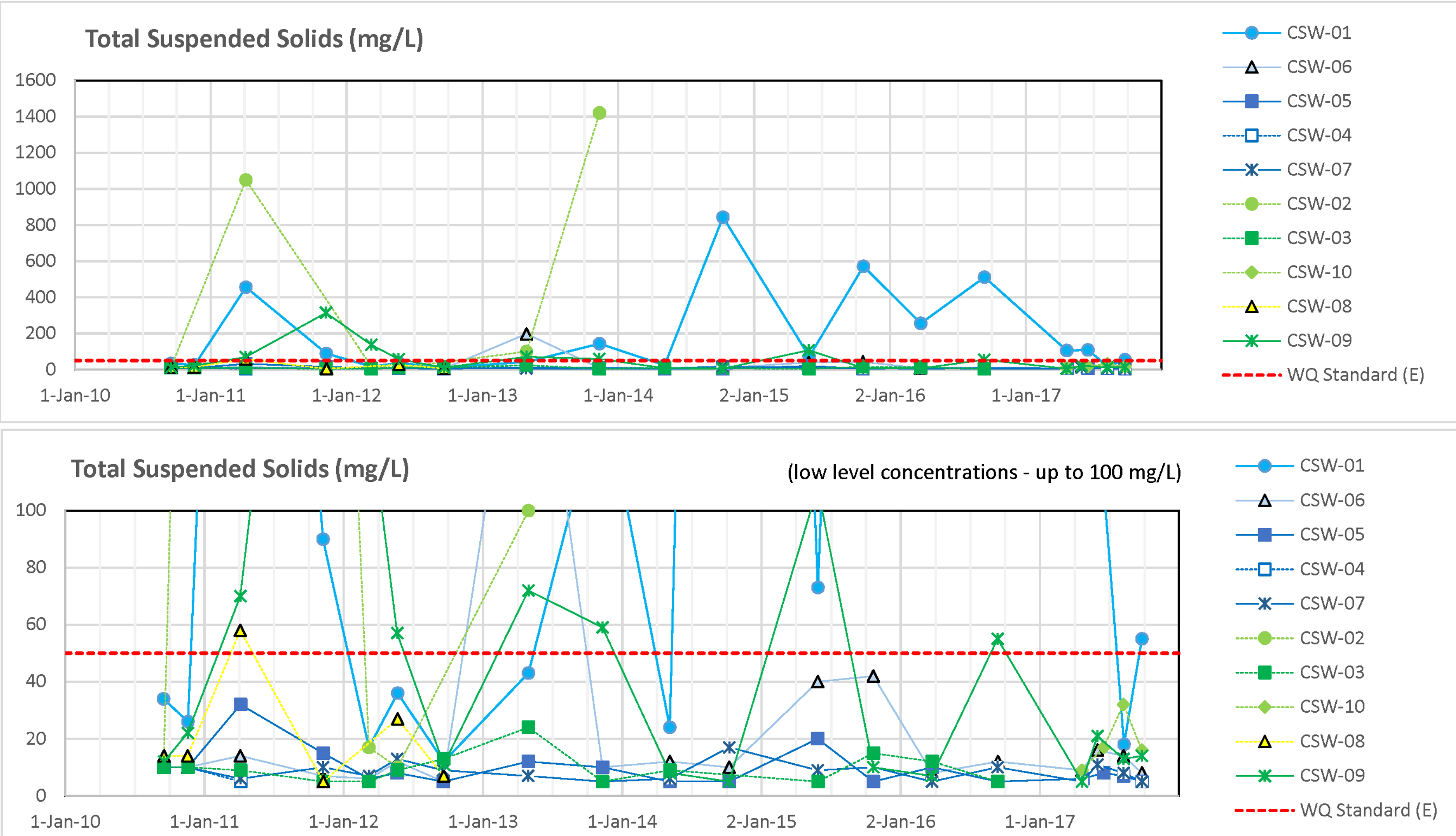
[7] Non-detect concentrations assumed equal to the analytical reporting limit in the calculation of average concentrations.

Figure 4.8-1 Surface Water Total Dissolved Solids Concentrations



Note: Non-detect concentrations shown at the reporting limit.
mg/L = milligrams per liter.

Figure 4.8-2 Surface Water Total Suspended Solids Concentrations



Note: Non-detect concentrations shown at the reporting limit. Water Quality (WQ) Standard = Effluent guideline of 50 mg/L (not to be exceeded 95% of time)
mg/L = milligrams per liter; % = percent.

- Metals:
  - **Aluminum (Al):** Dissolved aluminum concentrations in surface water range from below detection (<0.08 mg/L) to 0.4 mg/L. Dissolved aluminum has been consistently below detection at the following locations: CSW-04, CSW-05 and CSW-10. With the exception of CSW-01, total recoverable aluminum concentrations have been below 1 mg/L. At CSW-01, the maximum measured total recoverable aluminum concentration was 3.4 mg/L.
  - **Arsenic (As):** With the exception of three samples collected at CSW-08 in 2010 and 2011, dissolved and total recoverable arsenic concentrations have been low (<0.007 mg/L) or below detection at all locations. Between 2010 and 2011, dissolved arsenic was measured at CSW-08 at concentrations ranging from approximately 0.02 to 0.04 mg/L. Dissolved arsenic then declined to below detection and remained below detection until September 2012 when monitoring at this location stopped.
  - **Barium (Ba):** Barium (total recoverable and dissolved) is present in surface water at low concentrations (typically <0.01 mg/L).
  - **Copper (Cu) and Nickel (Ni):** Dissolved and total recoverable copper and nickel concentrations are low in surface water.
  - **Iron (Fe) and Manganese (Mn):** Iron and manganese are consistently detected in surface water samples. Average dissolved iron concentrations range from approximately 0.5 to 1.4 mg/L. Average dissolved manganese concentrations range from approximately 0.02 to 0.14 mg/L.
  - **Mercury (Hg):** Total and dissolved mercury concentrations are typically below detection in surface water. When detected, mercury concentrations are low (i.e., maximum measured concentration of 0.0005 mg/L).
  - **Zinc (Zn):** Total recoverable and dissolved zinc are typically below detection in surface water. When detected, concentrations are low (<0.03 mg/L).
  - **Non-Detect Metals**: The following metals have been at or below detection in both the dissolved and total fractions of all routine surface water samples collected over the period of record (reporting limits presented in Table 4.8-4): beryllium (Be), cadmium (Cd), molybdenum (Mo), lead (Pb), thallium (Tl) and vanadium (V). With the exception of a single dissolved sample detection, antimony (Sb) and boron (B) have been below detection in both the dissolved and total fractions of all surface water samples. Dissolved antimony and boron were detected at concentrations close to their respective reporting limits in a single sample collected from CSW-06 (April 2017) and CSW-07 (April 2013), respectively. With the exception of isolated total fraction detections at CSW-01 (up to 0.007 mg/L), dissolved and total recoverable chromium (Cr) have been at or below detection in all surface water samples.
  - Cobalt (Co), selenium (Se) and silver (Ag) have consistently been below detection in the total fraction of all surface water samples. These parameters have been detected on occasion at low levels in the dissolved fraction samples as follows:
    - Co: Detected at concentrations up to 0.008 mg/L between 2010 and 2012 at multiple stations (i.e., CSW-01, CSW-02, CSW-03, CSW-05, CSW-06, CSW-07, and CSW-08).
    - Se: Detected at concentrations up to 0.004 mg/L at CSW-02 between 2010 and 2011.
    - Ag: Detected at concentrations of less than 0.001 mg/L at three stations in September 2017 (CSW-07, CSW-09 and CSW-10).
- **Nitrogen**: With the exception of CSW-02, ammonia concentrations have remained below 0.4 milligrams per liter nitrogen (mg/L-N) at all surface water monitoring locations. Ammonia

concentrations have consistently been higher at CSW-02 relative to the other locations, ranging from 0.3 to 1.2 mg/L-N. Nitrate plus nitrite concentrations have also remained below 0.4 mg/L-N at all surface water monitoring locations.

- **Cyanide**: With the exception of a single detection, cyanide was below detection in all historical surface water samples. Cyanide (0.011 mg/L) was measured just above the reporting limit in a single sample collected from CSW-09 in November 2011. This single historical sampling event is uncharacteristic as cyanide was below detection in all samples at all locations (i.e., 117 analytical measurements with no cyanide detected) and there has been no use of cyanide in the Project area by Newmont and based on the ASM baseline report, none of the ASM groups are using cyanide. The isolated reportable cyanide measurement is likely a laboratory error. As there are no plans to use cyanide at the Sabajo operations, cyanide was not part of the recent monitoring analytical suite.
- **Organics**: Hydrocarbons (i.e., diesel, lube oil and gasoline) were analyzed in the surface water samples collected in June and August 2017. All measured parameters were below detection. It is notable that hydrocarbon samples were typically analyzed outside of recommended holding times due to the inability to deliver the samples to SVL in less than14 days.
- **Total Organic Carbon (TOC)**: TOC was analyzed in the historical surface water samples. Average TOC concentrations at surface water monitoring locations ranged from approximately 3 to 16 mg/L. The highest TOC concentrations were consistently measured at CSW-02.

4.8.3.2 Routine Monitoring Comparison to Project Water Quality Criteria

Routine monitoring results were compared to Project aquatic life water quality standards (Table 4.8-3) and exceedances identified (Table 4.8-6). Exceedances are summarized below:

- **pH:** Exceedances of the aquatic life pH standard (i.e., 6.4 to 8.4) were routinely measured at all surface water monitoring locations. Field measured pH values are often below the lower limit of 6.4.
- **Aluminum:** Exceedances of the aquatic life criterion for aluminum of 0.087 mg/L (dissolved and/or total recoverable fraction) were measured on occasion at most monitoring locations (i.e., CSW-01, CSW-02, CSW-03, CSW-06, CSW-07, CSW-08, CSW-09 and CSW-10).
- **Iron:** Total recoverable iron concentrations consistently exceeded the aquatic life criterion of 1 mg/L at all surface water monitoring locations. On occasion, dissolved iron concentrations also exceeded the aquatic life criterion at most stations.
- **Manganese:** Exceedances of the aquatic life criterion for manganese were measured on occasion at the following locations: CSW-01, CSW-02, CSW-04, CSW-05, CSW-07 and CSW-09.
- **Silver:** Single exceedances of the aquatic life criterion for silver of 0.0001 mg/L were measured at CSW-07, CSW-09 and CSW-10.
- **Zinc:** Exceedances of the aquatic life criterion for zinc were measured on occasion at the following locations: CSW-01, CSW-06, CSW-07 and CSW-09.

The following aquatic life water quality standards are hardness dependent: barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), lead (Pb), manganese (Mn), nickel (Ni) and zinc (Zn). As noted earlier, hardness concentrations are low in surface water resulting in low aquatic life limits. With the exception of barium and manganese, analytical reporting limits for these parameters sometimes exceeded the aquatic life criteria. An accurate assessment of compliance with aquatic life standards cannot be made when results are reported as below detection and the analytical reporting limit is above the aquatic life standard.

Table 4.8-6 Routine Monitoring Summary of Surface Water Project Water Quality Exceedances

Parameter	Aquatic Life Water Quality Standard (Table 4.8-3)	Monitoring Locations									
		CSW-01	CSW-02	CSW-03	CSW-04	CSW-05	CSW-06	CSW-07	CSW-08	CSW-09	CSW-10
pH (Field)	6.4 - 8.4	16	4	13	3	18	14	17	5	12	1
Aluminum (D)	0.087 mg/L	10	4	5			8	7	2	5	
Aluminum (TR)	0.087 mg/L	4					4	4		4	4
Iron (D)	1 mg/L	10	5	7		1	11	5	1	2	
Iron (TR)	1 mg/L	19	6	13	3	19	19	19	4	19	4
Manganese (D)	0.26 mg/L [(a)]	4	3		1	7		4		1	
Silver (D)	0.0001 mg/L							1		1	1
Zinc (D)	0.02 mg/L [(a)]	2					1	2		1	

Note:

Number of times an exceedance was measured in primary samples shown in table. Duplicate results excluded from evaluation.

a) Aquatic criterion is hardness dependent. Value shown is for a hardness of 10 mg/L as $CaCO_3$.

b) Drinking water standards are not applicable to surface water. Comparison is for reference only.

D = dissolved; TR = total recoverable; mg/L = milligrams per liter; $CaCO_3$ = calcium carbonate.

4.8.3.3 Tempati Creek Monitoring Results (Stations TSW-01 and TSW-02)

In April 2017, water quality samples were collected from two locations (i.e., TSW-01 and TSW-02) on Tempati Creek. Tempati Creek pH was circum-neutral (pH approximately 6.5 s.u.) and specific conductance (~30 microSiemens per centimeter [µS/cm]) and TDS concentrations (~40 mg/L) were low. Total alkalinity was approximately 7 mg/L as $CaCO_3$.

Dissolved and total metal concentrations were low and often reported as below detection. Iron, manganese and aluminum (total recoverable fraction only) were the only metals detected at concentrations above 0.01 mg/L. Nitrogen concentrations were low in Tempati Creek. Ammonia and nitrate (plus nitrite) were measured at concentrations up to 0.05 and 0.1 mg/L-N, respectively.

The water quality results from Tempati Creek are provided in Golder (2018c).

4.8.3.4 Tempati Creek Comparison to Project Water Quality Criteria

Tempati Creek monitoring results were compared to Project water quality standards (Table 4.8-3) and exceedances identified. Exceedances are summarized below:

- **Aluminum**: Total recoverable aluminum exceeded the aquatic life standard of 0.087 mg/L at TSW-01.
- **Iron**: Total recoverable iron exceeded the aquatic life standard of 1 mg/L at TSW-01 and TSW-02.

4.8.3.5 Supplemental Water Quality Results

In August 2017, water samples were collected at two locations in the vicinity of ASM activities at each of the Santa Barbara and Margo deposits. The water samples represent different types of sampling locations in areas affected by ASM:

- SB-SW-01: active sluicing runoff;
- SB-SW-02: stream sample downstream of ASM activity;
- MAR-SW-01: surface runoff downstream of tailings pond; and
- MAR-SW-02: a makeshift tailings pond.

The water quality results from these locations are presented in Golder (2018c). Water sample pH values were not measured in the field; however, pH was measured at the laboratory. Laboratory pH values were near neutral at two locations (i.e., MAR-SW-01 and SB-SW-02) and acidic at the other two locations (4.6 and 5.3 s.u. at MAR-SW-02 and SB-SW-01, respectively). Laboratory pH values were therefore lowest in the samples collected closest to ASM activity. Specific conductance ranged from approximately 25 to 50 µS/cm. At the Margo sampling locations, TSS concentrations were approximately 640 mg/L whereas at the Santa Barbara sampling locations, TSS ranged from 16 mg/L (SB-SW-02) for the in-stream sample to 22,400 mg/L (SB-SW-01) in active sluice runoff. Alkalinity concentrations were low at all locations ranging from below detection (<1 mg/L as $CaCO_3$) to 8 mg/L as $CaCO_3$.

Dissolved metal concentrations were generally low with many metals reported as below detection. Dissolved iron concentrations ranged from below detection to 2.3 mg/L. Dissolved manganese concentrations were similar at all stations ranging from 0.01 to 0.08 mg/L. Dissolved mercury was detected at MAR-SW-02 (0.002 mg/L).

Similar to the routine monitoring stations at Sabajo, aluminum, iron, and manganese were all present in the total recoverable fraction. Total recoverable arsenic (up to 0.03 mg/L) was present in the Margo samples. Total mercury was detected at low levels (i.e., 0.002 mg/L) in the two samples collected in closest proximity to ASM activities (i.e., MAR-SW-02 and SB-SW-01). Due to the elevated TSS concentration of sample SB-SW-01 (active sluice runoff), a number of metals were present at higher concentrations in this sample compared to the other Santa Barbara and Margo samples and also the routine monitoring location samples (e.g., Cr, Cu, Pb and Ni).

In May 2014, water quality samples were collected from pits (samples PCSW-01 and PCSW-03) and tailings ponds (samples PCSW-02, PCSW-04 and PCSW-05) associated with ASM. Samples were also collected from the main existing pit at Sabajo in 2010 (labelled as Cassador Pit) and 2016 (labelled as Sabajo Pit). Water quality results are presented in Golder (2018c).

The TDS concentrations of all samples were low, ranging from below detection (<20 mg/L) to 34 mg/L. Many dissolved metals were below detection in all samples. Dissolved arsenic was detected in one of the tailings pond samples at a concentration of 0.05 mg/L. Dissolved mercury was detected in most samples at low concentrations (i.e., up to 0.0004 mg/L). Nitrogen species concentrations were low in all samples. Ammonia and nitrate (plus nitrite) concentrations ranged from below detection to 0.8 mg/L-N.

4.8.3.6 Supplemental Water Quality Comparison to Project Water Quality Criteria

Supplemental monitoring results were compared to Project water quality standards (Table 4.8-3) and exceedances identified (Table 4.8-7). Results were compared to aquatic life and drinking water standards for reference only. With the exception of once location (i.e., SB-SW-02), the supplemental samples are not representative of surface water or groundwater. Therefore, surface water and groundwater Project water quality standards are not applicable.

Exceedances are summarized below:

- **pH:** Exceedances of the aquatic life pH standard (i.e., 6.4 to 8.4) were routinely measured at the supplemental monitoring locations. Field measured pH values were often below the lower limit of 6.4 defined for both standards.
- **Aluminum:** Total recoverable aluminum exceeded the aquatic life standard of 0.087 mg/L at all Santa Barbara and Margo monitoring locations (all of which were sampled in 2017). At SB-SW-01, total recoverable aluminum also exceeded the drinking water standard of 37 mg/L.
- **Arsenic:** Dissolved arsenic exceeded the drinking water standard of 0.01 mg/L in one of the ASM tailings pond samples (i.e., PCSW-02). Total recoverable arsenic exceeded the drinking water standard in both Margo area water samples.
- **Barium:** Dissolved barium exceeded the aquatic life standard in one water sample from Santa Barbara and one water sample from Margo.
- **Chromium**: Total recoverable chromium exceeded the drinking water standard of 0.1 mg/L in the active sluice runoff sample (SB-SW-01) that had very high TSS.
- **Iron:** Total recoverable iron exceeded the aquatic life criterion of 1 mg/L in all Margo and Santa Barbara water samples and samples PCSW-03 (pit sample) and PCSW-05 (tailings pond sample). In the stream sample from Santa Barbara (i.e., SB-SW-02), dissolved iron also exceeded the aquatic life criterion. Total recoverable iron exceeded the drinking water standard at SB-SW-01.
- **Lead:** Total recoverable lead exceeded the drinking water standard of 0.015 mg/L in the active sluice runoff sample (SB-SW-01) that had very high TSS.

- **Manganese:** Dissolved manganese exceeded the aquatic life criterion in some ASM pit and tailings pond samples**.** Manganese (dissolved and total recoverable fractions) exceeded the drinking water standard of 0.88 mg/L in one tailings pond sample.
- **Mercury:** Dissolved mercury exceeded the aquatic life criterion of 0.0008 mg/L in the Margo tailings pond sample (MAR-SW-02).

Supplemental monitoring results were also compared to mine effluent standards. Exceedances are shown in Table 4.8-7 and included the following parameters: TSS; iron (total recoverable and dissolved fractions); and chromium (total recoverable fraction).

In summary, exceedances of Project water quality criteria were more common in the water samples collected in 2017 from the Margo and Santa Barbara ASM affected areas compared to the ASM pit and tailings pond samples collected between 2010 and 2016.

Table 4.8-7 Supplemental Surface Water Monitoring Summary of Project Water Quality Exceedances

Parameter	Type[a]	Water Quality Standard (Table 4.8-3)	MAR-SW-01	MAR-SW-02	SB-SW-01	SB-SW-02	Cassador Pit[c]	PCSW-01	PCSW-03	Sabajo Pit [c]	PCSW-02	PCSW-04	PCSW-05
			17-Aug-17	17-Aug-17	15-Aug-17	16-Aug-17	17-Sep-10	6-May-14	7-May-14	13-Sep-16	6-May-14	7-May-14	7-May-14
			Margo Area		Santa Barbara Area		ASM Pit [b]				ASM Tailings Pond [b]		
			Tailings Pond Runoff [b]	Tailings Pond [b]	Active Sluice Runoff [b]	Stream							
Surface Water and Groundwater Standards (Reference Only)													
pH	A	6.4 - 8.4	x [d]	x [d]	x [d]		x	x	x	no measurement	x	x	x
Aluminum (TR)	A	0.087 mg/L	x	x	x	x							
Aluminum (TR)	D	37 mg/L			x								
Arsenic (D)	D	0.01 mg/L									x		
Arsenic (TR)	D	0.01 mg/L	x	x									
Barium (D)	A	0.038 mg/L [e]		x	x								
Chromium (TR)	D	0.1 mg/L			x								
Iron (D)	A	1 mg/L				x							
Iron (TR)	A	1 mg/L	x	x	x	x			x				x
Iron (TR)	D	26 mg/L			x								
Lead (TR)	D	0.015 mg/L			x								
Manganese (D and TR)	D	0.88 mg/L										x	
Manganese (D)	A	0.26 mg/L [e]								x	x	x	
Mercury (D)	A	0.0008 mg/L		x									
Mine Effluent Standards													
Total Suspended Solids (TSS)	E	50 mg/L	x	x	x				x				
Iron (D)	E	2 mg/L				x							
Iron (TR)	E	2 mg/L	x	x	x	x			x				x
Chromium (TR)	E	0.1 mg/L			x								

a) Type of water quality standard: A (aquatic life); D (drinking water); E (mine effluent).
b) Aquatic life and drinking water standards are not applicable to mine waters. Comparison is for reference only.
c) Cassador Pit and Sabajo Pit are both samples from the main pit at Sabajo.
d) Laboratory measured pH value.
d) Aquatic criterion is hardness dependent. Value shown is for a hardness of 10 mg/L as $CaCO_3$.
D = dissolved; TR = total recoverable; mg/L = milligrams per liter; ASM = artisanal and small scale mining; $CaCO_3$ = calcium carbonate.

4.8.3.7 Surface Water Quality Summary

Water quality monitoring has been conducted over a 7-year period (2010 to 2017) at a number of locations in the vicinity of the Santa Barbara and Sabajo deposits. Because all but two of these stations (i.e., CSW-07 and TSW-01) have been impacted by ASM activities, and water quality at CSW-07 and TSW-01 is not unique, it is not possible to characterize ASM "impacted" versus "non-impacted" water quality. Surface water quality results for all stations are summarized below. A short discussion of likely impacts from ASM is presented at the end of this section.

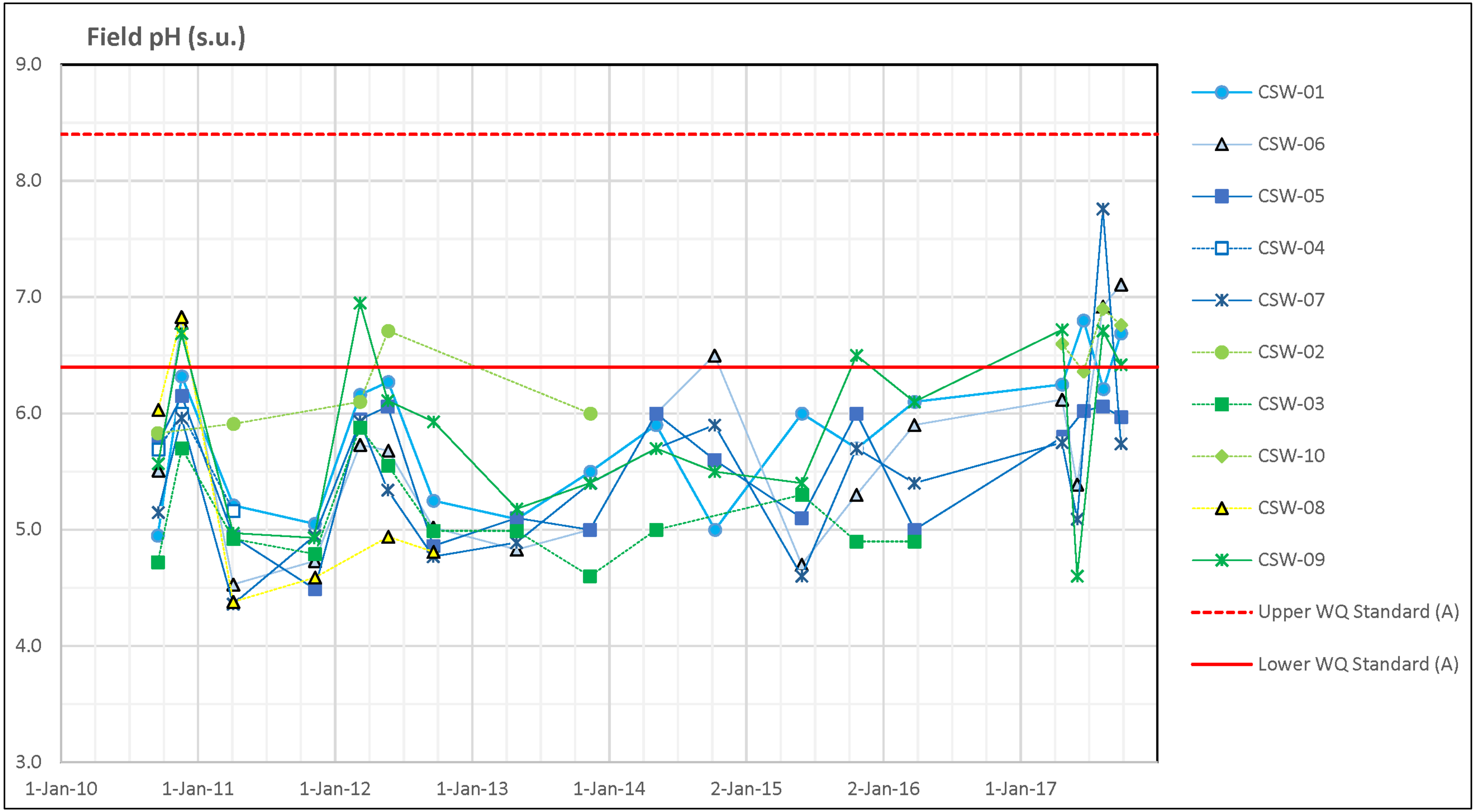
In summary, site surface water quality is characterized as follows:

- **TDS:** Surface water TDS concentrations are consistently below 170 mg/L at all monitoring locations (Figure 4.8-1). TDS concentrations exhibit temporal variability. For those monitoring locations with the longest baseline monitoring period (i.e., CSW-01 to CSW-09), the ratio of maximum to minimum TDS concentrations ranges from 1.6 (CSW-02) to 9.0 (CSW-05). Consistent seasonal trends in TDS concentrations are not apparent.
- **pH and Alkalinity**: Surface water pH values range from acidic to circum-neutral (Figure 4.8-3). At many sites, field pH values have exhibited a high degree of variability, with the difference between the highest and lowest pH values exceeding 1.5 pH units (i.e., CSW-01, CSW-05, CSW-06, CSW-07, CSW-08 and CSW-09). The acidic pH values measured at most monitoring sites, on occasion, are likely due to the presence of naturally occurring organics. It is notable that field measured pH values at site CSW-07, a site where ASM activity is negligible, have ranged from 4.4 to 7.8, consistent with a natural cause of low pH values (i.e., organic acids). Surface water alkalinity concentrations are low with most monitoring locations reporting maximum total alkalinity concentrations of less than 20 mg/L as $CaCO_3$.
- **Major Ions**: Compositional diagrams (Piper plots) facilitate the identification of water types and show changes in major ion chemistry through time. Piper plots present the relative concentrations of major cations (calcium, magnesium and sodium) and anions (chloride, sulfate and bicarbonate) in milliequivalents per liter (meq/L). A Piper plot was generated using the software program AquaChem (Waterloo Hydrogeologic 1999) for all recent surface water quality monitoring results (Figure 4.8-4). A charge balance criterion of less than 10% was applied to all data included in plotting. This resulted in exclusion of monitoring location CSW-07 from the Piper plot. Surface waters in the Project area are characterized by low sulfate and calcium concentrations. Sodium and bicarbonate are the dominant cation and anion in most surface water samples. Samples from stations CSW-01, CSW-05, CSW-06, TSW-01 and TSW-02 are all classified as Na-Mg-Ca-HCO_3-Cl type. Samples from CSW-09 and CSW-10 generally have slightly more calcium and magnesium than the other monitoring stations. Three mine water samples were included in the Piper plot for comparison. Chloride is the dominant anion in the samples collected from the Margo (MAR-SW-01 and MAR-SW-02) and Santa Barbara (SB-SW-01) areas as part of the Environmental Liability Assessment (Golder 2018a). Samples from these monitoring locations are classified as Na-Cl type.
- **Metals**: Dissolved metal concentrations are generally low in surface water samples and often below detection. Dissolved manganese and iron are consistently measured in surface water (Figure 4.8-5). Dissolved arsenic is typically below detection; however, on occasion it has been detected at some monitoring locations at low levels (i.e., up to 0.04 mg/L at CSW-08). Other metals are detected on occasion, but typically at low levels.
- **Nutrients**: Nitrogen species (i.e., ammonia and nitrate) concentrations are consistently low at most monitoring locations (i.e., <0.5 mg/L-N). The one exception is CSW-02 where ammonia concentrations were consistently higher than the other monitoring locations with maximum concentrations on the order of 1 mg/L. Monitoring at this location ceased in 2014.

As noted earlier, there are only two routine monitoring locations that are classified as not affected by ASM (i.e., CSW-07 and TSW-02). Based on the results of supplemental targeted monitoring and the routine monitoring program, the following potential impacts to area water quality in association with ASM activities are identified:

- **Total Suspended Solids (TSS):** ASM activities involve land disturbance in the vicinity of stream channels. These activities have the potential to increase TSS, as evidenced by the erratic trends in TSS observed at CSW-01, the monitoring location where ASM disturbance is greatest (Figure 4.8-2). An increase in TSS results in an increase in total metal concentrations.
- **Mercury:** ASM activities may involve the use of mercury. Mercury was detected at low levels in water samples collected in 2017 from a tailings pond and sluice associated with ASM. Mercury concentrations are generally below detection in site streams. On occasion, dissolved mercury has been detected at concentrations up to 0.0005 mg/L in site streams (Figure 4.8-6), but is still below all Project water quality standards. It is notable, that when mercury is detected, it is detected in multiple samples from the same sampling event. This trend suggests possible inaccuracy in the mercury measurements. In September 2016, the highest mercury concentration was measured at CSW-07, a site classified as not affected by ASM based on visual observations.
- **Organics:** The 2017 Environmental Liability Assessment (Golder 2018a) documented diesel and gasoline impacts to water from ASM. When analyzed, organics were below detection at all routine surface water monitoring locations. However, qualitative field observations during sampling rounds when organics samples were not collected suggest the potential periodic presence of organics in surface water below ASM activities. Specifically, oil sheens were visible near CSW-01 in May 2017 during a period when there was active ASM upstream.
- **Arsenic:** Total arsenic was present in water samples collected in association with ASM activities at the Margo site in 2017. Soils data for this area indicate the presence of elevated arsenic concentrations (Golder 2018a). ASM activities may affect arsenic concentrations in area streams. Arsenic concentrations in surface water are shown in Figure 4.8-7.

Figure 4.8-3 Surface Water pH (Field Measured)



Note: Water Quality (WQ) Standard = Aquatic Life limit of 6.4 to 8.4.

Figure 4.8-4 Surface Water Piper Plot (some mine water samples included for comparison)

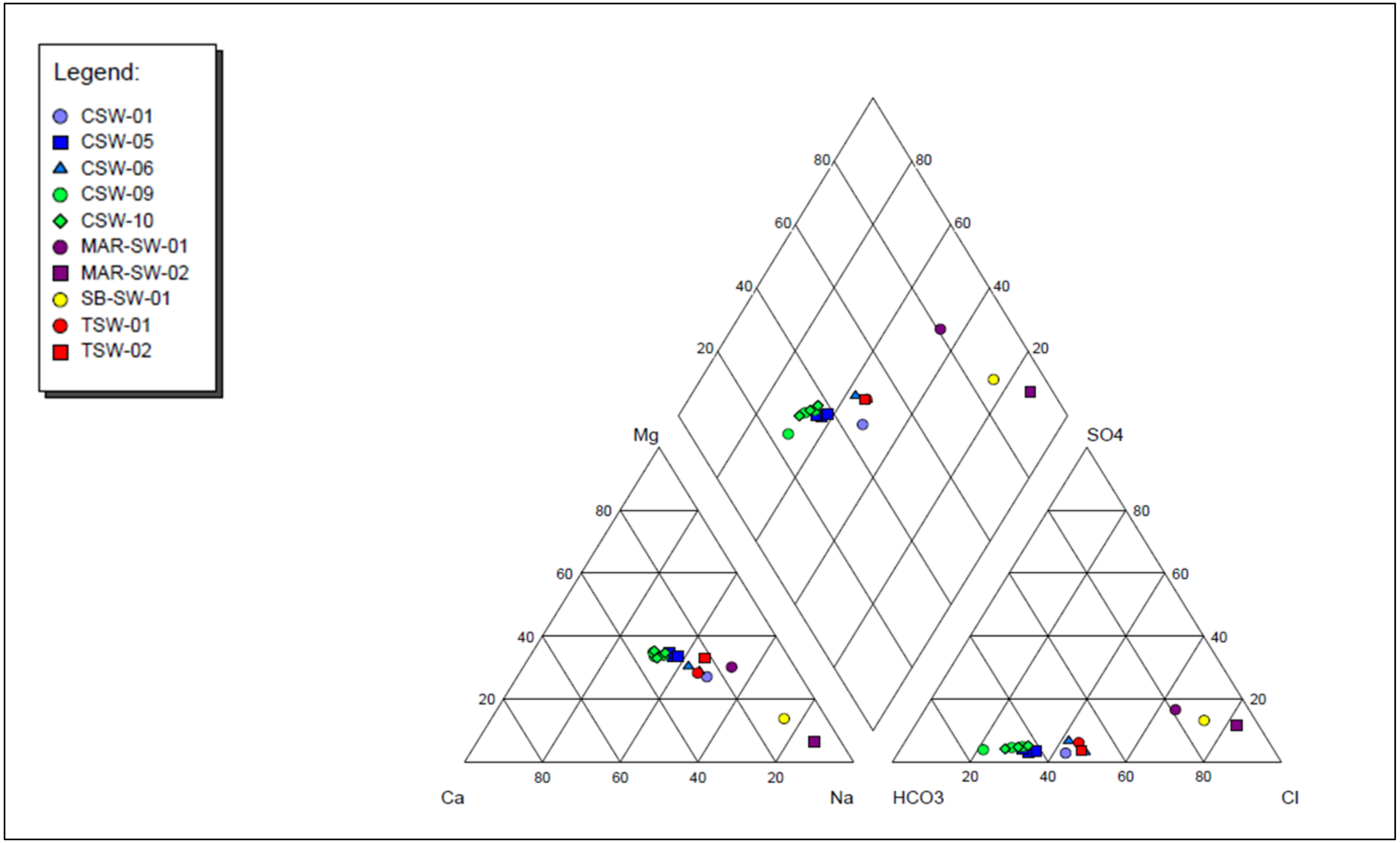
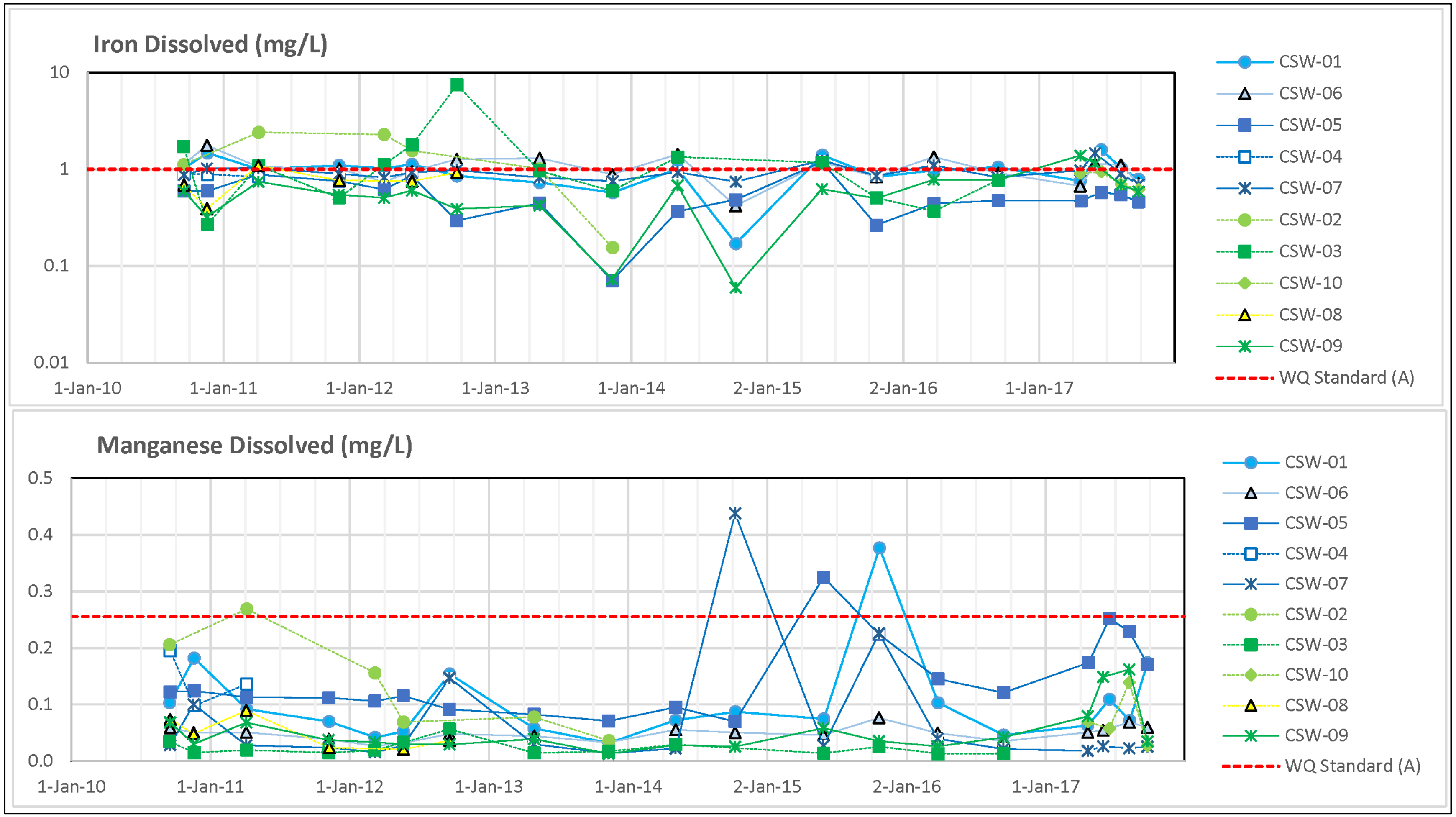
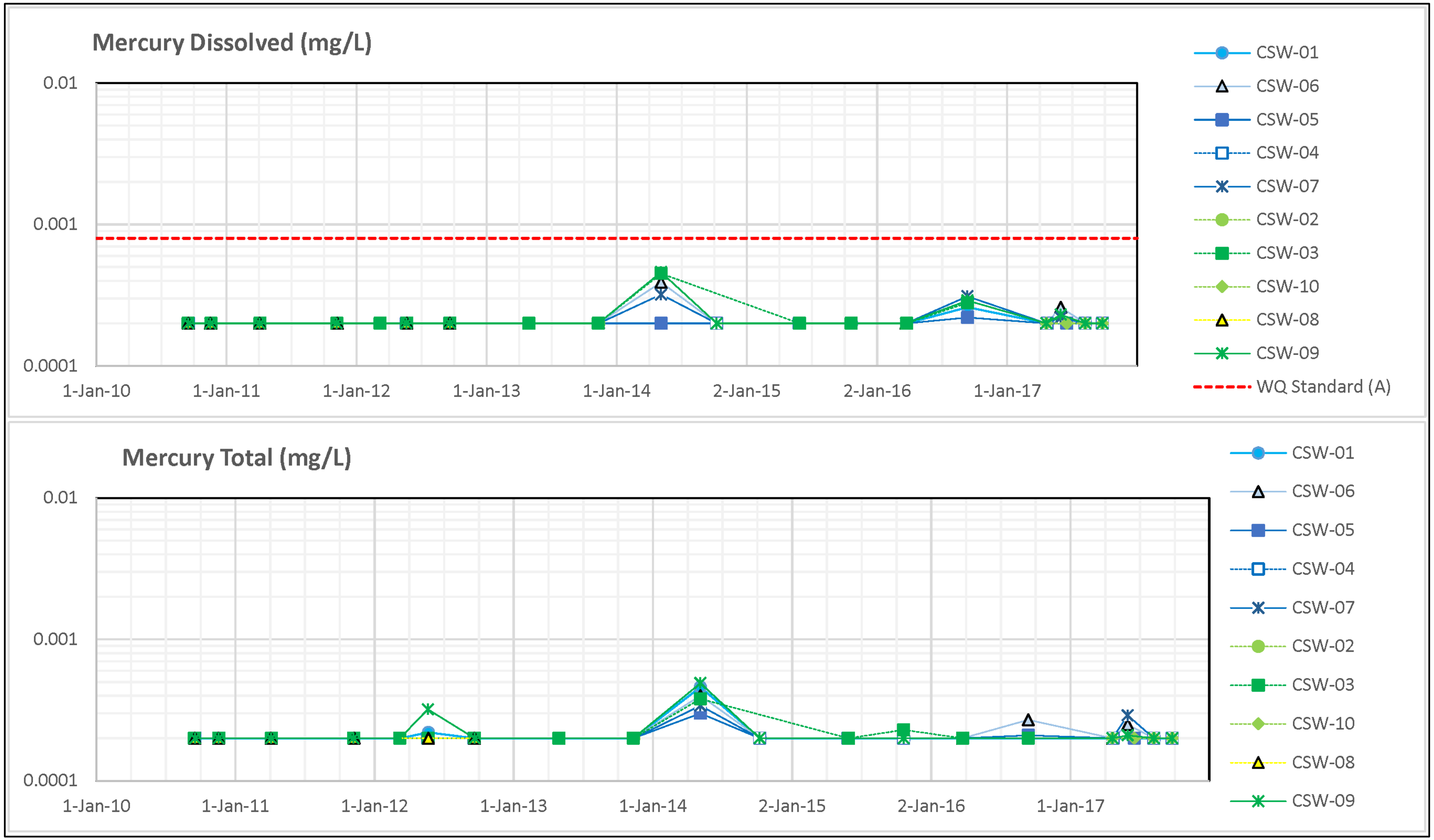


Figure 4.8-5 Surface Water Dissolved Iron and Manganese Concentrations



Note: Non-detect concentrations shown at reporting limit. Water Quality (WQ) Standards = 1 mg/L iron (Aquatic Life) and 0.26 mg/L manganese (Aquatic Life at a hardness of 10 mg/L as $CaCO_3$). mg/L = milligrams per liter; $CaCO_3$ = calcium carbonate.

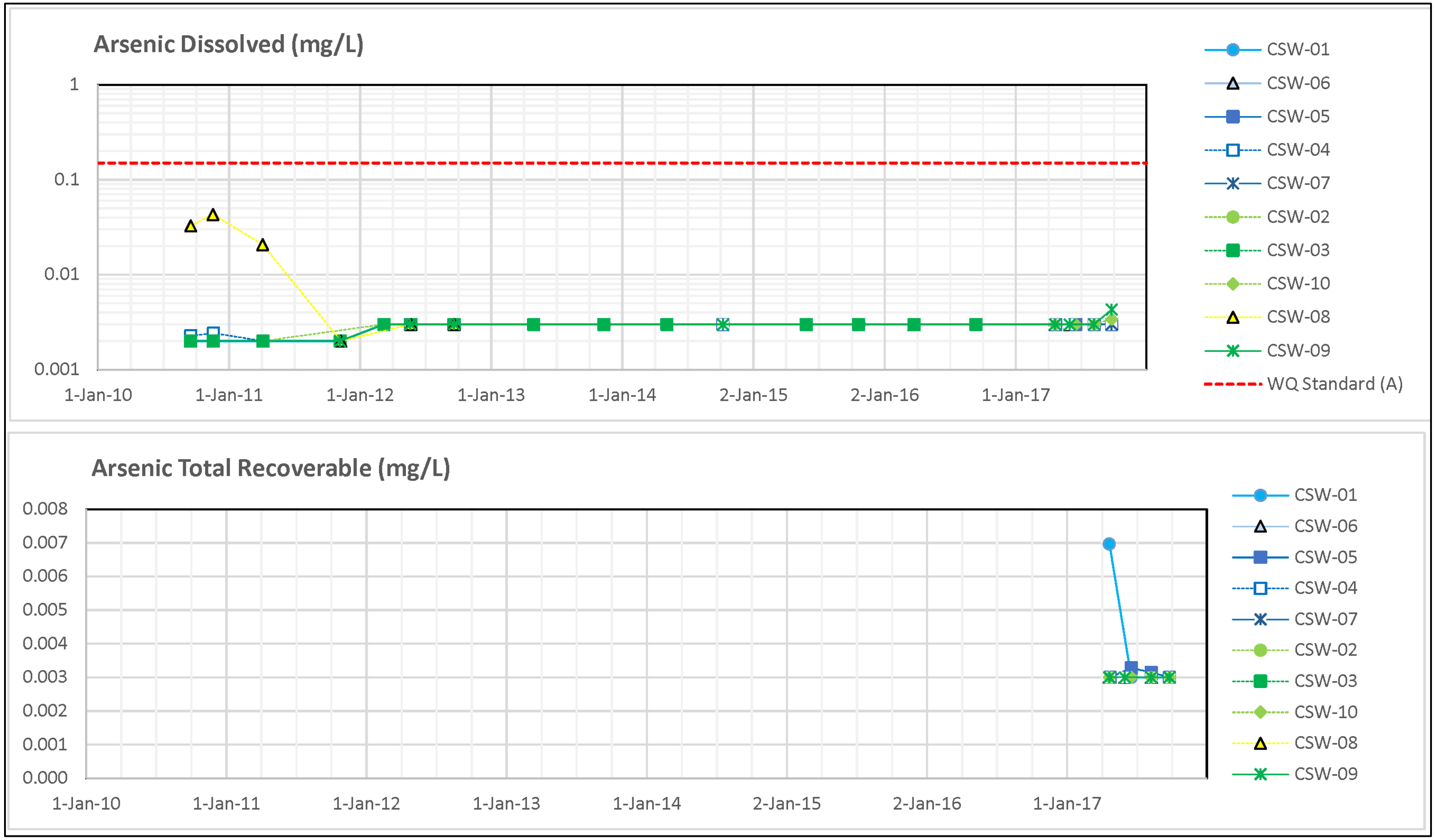
Figure 4.8-6 Surface Water Mercury Concentrations



Note: Non-detect concentrations shown at the reporting limit. Water Quality (WQ) Standard = Aquatic Life standard of 0.0008 mg/L.

mg/L = milligrams per liter.

Figure 4.8-7 Surface Water Arsenic Concentrations



Note: Non-detect concentrations shown at the reporting limit. Water Quality (WQ) Standard = Aquatic Life standard of 0.15 mg/L.
mg/L = milligrams per liter.

4.8.4 Groundwater Quality

The complete groundwater quality data set is provided in the baseline water quality data report (Golder 2018c). Selected groundwater results are discussed in this section.

Groundwater quality results are summarized in Table 4.8-8. In this table, the number of samples (including duplicates) and the maximum and minimum concentrations by geologic unit (i.e., saprolite quartz vein, saprock and bedrock within the Cassador Fault Zone) are shown.

- **pH**: Groundwater field measured pH values range from acidic (4.6 s.u.) to circum-neutral (6.9 s.u.). The pH values measured in the saprolite quartz vein wells demonstrated the most variability ranging from 4.6 to 6.6 s.u. The saprock well pH values ranged from 5.6 to 6.8 s.u. The Cassador Fault well pH values were the most consistent, ranging from 6.0 to 6.9 s.u.
- **Total Dissolved Solids (TDS):** Groundwater TDS concentrations range from approximately 40 to 380 mg/L. The highest TDS concentrations (i.e., >270 mg/L) were measured in two of the Cassador Fault wells (i.e., SP-MW-01-BR and SP-TW-01-BR). TDS concentrations were lower in the third Cassador Fault well (i.e., approximately 100 mg/L at well SP-MW-01-BR). TDS concentrations in the saprock wells range from approximately 50 to 270 mg/L and from 40 to 100 mg/L in the saprolite quartz vein wells.
- **Alkalinity**: Alkalinity concentrations are variable ranging from approximately 10 to 340 mg/L as $CaCO_3$. The highest alkalinity concentrations (i.e., >200 mg/L as $CaCO_3$) were measured in two of the Cassador Fault wells (i.e., SP-MW-01-BR and SP-TW-01-BR). Alkalinity concentrations were lower in the third Cassador Fault well (i.e., approximately 50 to 80 mg/L as $CaCO_3$ at well SP-MW-01-BR). Alkalinity concentrations in the saprock wells range from approximately 20 to 130 mg/L and from 10 to 70 mg/L in the saprolite quartz vein wells.
- **Sulfate:** Groundwater sulfate concentrations range from 2 to 44 mg/L. Sulfate concentrations in the saprock wells spanned this entire range. The lowest (2 mg/L) and highest (~40 mg/L) sulfate concentrations were measured in two of the saprock wells (i.e., wells OS-MW-01-SR and SP-MW-02-SR). The range of sulfate concentrations measured in the saprolite quartz vein and Cassador Fault wells were similar (i.e., approximately 3 to 30 mg/L).
- Metals:
  - **Aluminum (Al):** Dissolved aluminum was typically below detection in groundwater (<0.08 mg/L). Total recoverable aluminum concentrations ranged from below detection to almost a milligram per liter.
  - **Arsenic (As):** Dissolved and total recoverable arsenic concentrations in the saprolite quartz vein and saprock wells were low ranging from below detection (<0.003 mg/L) to 0.006 mg/L. Arsenic concentrations were elevated in two of the Cassador Fault wells (i.e., SP-MW-01-BR and SP-TW-01-BR) ranging from 1.1 to 1.7 mg/L. For the sampling event that included sample filtration using both a 0.10 μm and 0.45 μm filter, dissolved arsenic concentrations were essentially equal indicating that the arsenic is present in the dissolved fraction and not associated with colloids. The maximum arsenic concentration in the third Cassador Fault well was 0.015 mg/L (i.e., well SP-MW-02-BR).
  - **Barium (Ba):** Barium is present in groundwater at concentrations ranging from approximately 0.01 to 0.07 mg/L.
  - **Copper (Cu) and Nickel (Ni):** Dissolved and total recoverable copper and nickel concentrations are low in groundwater. When detected, copper and nickel are present at low (<0.01 mg/L) levels.

- **Iron (Fe):** Dissolved iron concentrations in groundwater range from below detection (<0.1 mg/L) to 8 mg/L. Dissolved iron concentrations were highest in the Cassador Fault wells (SP-MW-01-BR and SP-MW-02-BR) ranging from 0.5 to 8 mg/L. Dissolved iron concentrations are lower in the saprolite quartz vein wells (below 0.4 mg/L) compared to the saprock wells.
- **Manganese (Mn):** Dissolved manganese concentrations in groundwater range from 0.01 to 1 mg/L. Similar to iron, dissolved manganese concentrations were highest in the Cassador Fault wells ranging from 0.5 to 1 mg/L. Dissolved manganese concentrations were less than 0.5 mg/L in the saprolite quartz vein and saprock wells.
- **Zinc (Zn):** Dissolved zinc concentrations in groundwater range from below detection (<0.01 mg/L) to 0.05 mg/L.
- The following metals were below detection in both the dissolved and total fractions of all groundwater samples collected over the period of record: antimony (Sb); cadmium (Cd); chromium (Cr); cobalt (Co); lead (Pb); mercury (Hg); selenium (Se); thallium (Tl); and, vanadium (V).
- Dissolved molybdenum and silver were below detection in all saprolite quartz vein and Cassador Fault well samples. These metals are detected on occasion at low levels (up to approximately 0.01 mg/L) in the saprock well samples.

- **Nitrogen**: Nitrogen concentrations were low in groundwater samples. Ammonia concentrations ranged from below detection (<0.03 mg/L-N) to 0.9 mg/L-N. Nitrate plus nitrite concentrations ranged from below detection (<0.05 mg/L-N) to 0.3 mg/L-N.
- **Cyanide**: When analyzed, cyanide was below detection in all samples.
- **Organics**: When analyzed, organics (i.e., diesel, lube oil and gasoline) were below detection in all samples.

Arsenic, iron and manganese concentrations are generally highest in the Cassador Fault wells. Field personnel noted the smell of hydrogen sulfide during sampling of well SP-MW-01-BR. The presence of these metals is therefore likely associated with high mobility under reducing conditions.

A Piper plot of groundwater samples is shown in Figure 4.8-8. A charge balance criterion of less than 10% was applied to all data included in plotting. Groundwater major ion composition is different than the major ion composition of surface water. Groundwater in the Cassador Fault wells at the southeast end of Pit 1 (i.e., SP-MW-01-BR and SP-TW-01-BR) is classified as Ca-Mg-HCO_3 type. These are the wells where elevated arsenic concentrations have been measured. The major ion signature of the Cassador Fault well located at the northwest end of Pit 1 (SP-MW-02-BR) is typically classified as Na-HCO_3. The dominant cations in bedrock groundwater therefore range from calcium and magnesium to sodium. Sodium is the dominant cation in the saprolite quartz vein groundwater samples. The major ion composition of the quartz vein wells is typically classified as Na-HCO_3-SO_4 type (i.e., wells SP-MW-01-SQ and WRD-MW-01-SQ). The plot shows that the saprock major ion chemistry is somewhat intermediate to bedrock and quartz vein major ion chemistry. Sodium is often the dominant cation; although the cation signature of some samples is dominated by calcium. Bicarbonate is typically the dominant anion with variable amounts of sulfate.

Table 4.8-8 Groundwater Monitoring - Summary Statistics

Parameter	Fraction [(a)]	Unit	All Groundwater Stations		Quartz Vein (SQ)			Saprock (SR)			Bedrock (BR)		
			2016 - 2017		2016 - 2017			2016 - 2017			2016 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
FIELD PARAMETERS													
pH		pH	4.6	6.9	7	4.6	6.6	7	5.6	6.8	7	6.0	6.9
Specific Conductance		µS/cm	47	634	7	47	151	7	80	374	6	63	634
Turbidity		NTU	0	250	7	3.4	250	7	2.5	152	8	0	35
Temperature		°C	25	29	7	26	29	7	25	28	8	26	29
Oxygen Reduction Potential (ORP)		mV	-143	192	7	19	192	7	-102	131	8	-143	98
Dissolved Oxygen (DO)	D	mg/L	0.17	7.5	7	0.26	7.5	7	0.17	1.6	8	0.31	6.0
GENERAL CHEMISTRY													
pH		pH	5.7	8.3	7	5.7	7.5	7	6.5	7.6	9	7.0	8.3
Specific Conductance		µmhos/cm	47	617	7	47	146	7	77	361	9	141	617
Total Dissolved Solids (TDS)		mg/L	38	382	8	38	104	10	49	267	10	97	382
Total Suspended Solids (TSS)		mg/L	5.0	65	8	<5	26	10	<5	65	10	5.0	27
Hardness		mg/L $CaCO_3$	0.89	118	8	0.89	19	10	3.1	29	10	6.9	118
MAJOR IONS													
Total Alkalinity		mg/L $CaCO_3$	8.3	337	8	8.3	67	10	17	131	9	49	337
Bicarbonate		mg/L $CaCO_3$	8.3	337	8	8.3	67	10	17	131	9	49	337
Carbonate		mg/L $CaCO_3$	<DL	5.7	8	<1	<1	10	<1	<1	9	1.0	5.7
Chloride		mg/L	3.6	7.9	8	4.4	7.6	10	4.7	7.9	10	3.6	5.6
Fluoride		mg/L	<DL	0.48	8	<0.1	0.15	10	<0.1	0.42	10	0.10	0.48
Sulfate		mg/L	2.0	44	8	2.8	26	10	2.0	44	10	4.9	31
Calcium	D	mg/L	0.66	64	7	0.66	13	7	2.1	13	9	4.3	64
Magnesium	D	mg/L	0.21	28	7	0.21	4.5	7	0.72	4.6	9	1.6	28
Sodium	D	mg/L	6.6	70	7	6.6	18	7	9.8	70	9	14	39

Table 4.8-8 Groundwater Monitoring - Summary Statistics

Parameter	Fraction [a]	Unit	All Groundwater Stations		Quartz Vein (SQ)			Saprock (SR)			Bedrock (BR)		
			2016 - 2017		2016 - 2017			2016 - 2017			2016 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Potassium	D	mg/L	<DL	3.3	7	<0.5	<0.5	7	<0.5	3.3	9	0.53	1.4
Calcium	TR	mg/L	2.2	60	1	2.2	2.2	3	8.0	22	1	60	60
Magnesium	TR	mg/L	0.83	25	1	0.83	0.83	3	2.1	6.9	1	25	25
Potassium	TR	mg/L	<DL	0.79	1	<0.5	<0.5	3	<0.5	0.79	1	0.77	0.77
DISSOLVED METALS													
Aluminum	D	mg/L	<DL	0.17	8	<0.08	<0.08	10	<0.08	0.17	10	<0.08	<0.08
Antimony	D	mg/L	<DL	<DL	8	<0.003	<0.003	10	<0.003	<0.003	10	<0.003	<0.003
Arsenic	D	mg/L	<DL	1.7	8	<0.003	0.004	10	<0.003	0.006	10	<0.003	1.7
Barium	D	mg/L	0.009	0.064	7	0.010	0.031	7	0.009	0.047	9	0.011	0.064
Beryllium	D	mg/L	<DL	<DL	8	<0.0002	<0.0002	10	<0.0002	<0.0002	10	<0.0002	<0.0002
Boron	D	mg/L	<DL	0.055	8	<0.04	<0.04	10	<0.04	0.055	10	<0.04	<0.04
Cadmium	D	mg/L	<DL	<DL	8	<0.0002	<0.0002	10	<0.0002	<0.0002	10	<0.0002	<0.0002
Chromium	D	mg/L	<DL	<DL	8	<0.006	<0.006	10	<0.006	<0.006	10	<0.006	<0.006
Cobalt	D	mg/L	<DL	<DL	8	<0.006	<0.006	10	<0.006	<0.006	10	<0.006	<0.006
Copper	D	mg/L	<DL	0.003	8	<0.001	0.002	10	<0.001	0.003	10	<0.001	0.002
Iron	D	mg/L	<DL	8.0	8	<0.1	0.36	10	<0.1	4.0	10	<0.1	8.0
Lead	D	mg/L	<DL	<DL	8	<0.003	<0.0075	10	<0.003	<0.0075	10	<0.003	<0.0075
Manganese	D	mg/L	0.009	1.0	8	0.024	0.45	10	0.009	0.50	10	0.52	1.00
Mercury	D	mg/L	<DL	<DL	8	<0.0002	<0.0002	10	<0.0002	<0.0002	10	<0.0002	<0.0002
Molybdenum	D	mg/L	<DL	0.011	8	<0.008	<0.008	10	<0.008	0.011	10	<0.008	<0.008
Nickel	D	mg/L	<DL	<DL	8	<0.001	<0.01	10	<0.001	<0.01	10	0.002	<0.01
Selenium	D	mg/L	<DL	<DL	8	<0.003	<0.003	10	<0.003	<0.003	10	<0.003	<0.003
Silver	D	mg/L	<DL	0.0001	8	<0.0001	<0.0001	10	<0.0001	0.0001	10	<0.0001	<0.0001
Thallium	D	mg/L	<DL	<DL	7	<0.001	<0.001	7	<0.001	<0.001	9	<0.001	<0.001

Table 4.8-8 Groundwater Monitoring - Summary Statistics

Parameter	Fraction [a]	Unit	All Groundwater Stations		Quartz Vein (SQ)			Saprock (SR)			Bedrock (BR)		
			2016 - 2017		2016 - 2017			2016 - 2017			2016 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Vanadium	D	mg/L	<DL	<DL	1	<0.005	<0.005	3	<0.005	<0.005	1	<0.005	<0.005
Zinc	D	mg/L	<DL	0.045	8	<0.01	0.016	10	<0.01	0.015	10	<0.01	0.045
TOTAL METALS													
Aluminum	TR	mg/L	<DL	0.86	8	<0.08	0.49	10	<0.08	0.86	10	<0.08	0.73
Antimony	TR	mg/L	<DL	<DL	8	<0.003	<0.003	10	<0.003	<0.003	10	<0.003	<0.003
Arsenic	TR	mg/L	<DL	1.7	8	<0.003	<0.003	10	<0.003	0.005	10	<0.003	1.7
Barium	TR	mg/L	0.010	0.069	7	0.010	0.034	7	0.012	0.048	9	0.012	0.069
Beryllium	TR	mg/L	<DL	0.0002	8	<0.0002	<0.0002	10	<0.0002	<0.0002	10	<0.0002	0.0002
Boron	TR	mg/L	<DL	0.048	8	<0.04	<0.04	10	<0.04	0.048	10	<0.04	<0.04
Cadmium	TR	mg/L	<DL	<DL	8	<0.0002	<0.0002	10	<0.0002	<0.0002	10	<0.0002	<0.0002
Chromium	TR	mg/L	<DL	<DL	8	<0.006	<0.006	10	<0.006	<0.006	10	<0.006	<0.006
Cobalt	TR	mg/L	<DL	<DL	8	<0.006	<0.006	10	<0.006	<0.006	10	<0.006	<0.006
Copper	TR	mg/L	<DL	0.009	8	<0.001	0.002	10	<0.001	0.009	10	<0.001	0.008
Iron	TR	mg/L	0.12	8.8	8	<0.1	0.50	10	0.12	5.0	10	0.14	8.8
Lead	TR	mg/L	<DL	<DL	8	<0.003	<0.0075	10	<0.003	<0.0075	10	<0.003	<0.0075
Manganese	TR	mg/L	0.027	1.0	8	0.027	0.47	10	0.040	0.49	10	0.54	1.01
Mercury	T	mg/L	<DL	<DL	8	<0.0002	<0.0002	10	<0.0002	<0.0002	10	<0.0002	<0.0002
Molybdenum	TR	mg/L	<DL	0.011	8	<0.008	<0.008	10	<0.008	0.011	10	<0.008	<0.008
Nickel	TR	mg/L	<DL	<DL	8	<0.001	<0.01	10	<0.001	<0.01	10	0.001	<0.01
Phosphorus	TR	mg/L	<DL	0.60	1	<0.05	<0.05	3	<0.05	0.16	1	0.60	0.60
Selenium	TR	mg/L	<DL	<DL	8	<0.003	<0.003	10	<0.003	<0.003	10	<0.003	<0.003
Silver	TR	mg/L	<DL	0.001	8	<0.0001	<0.0001	10	<0.0001	0.001	10	<0.0001	<0.0001
Thallium	TR	mg/L	<DL	<DL	7	<0.001	<0.001	7	<0.001	<0.001	9	<0.001	<0.001
Vanadium	TR	mg/L	<DL	<DL	1	<0.005	<0.005	3	<0.005	<0.005	1	<0.005	<0.005

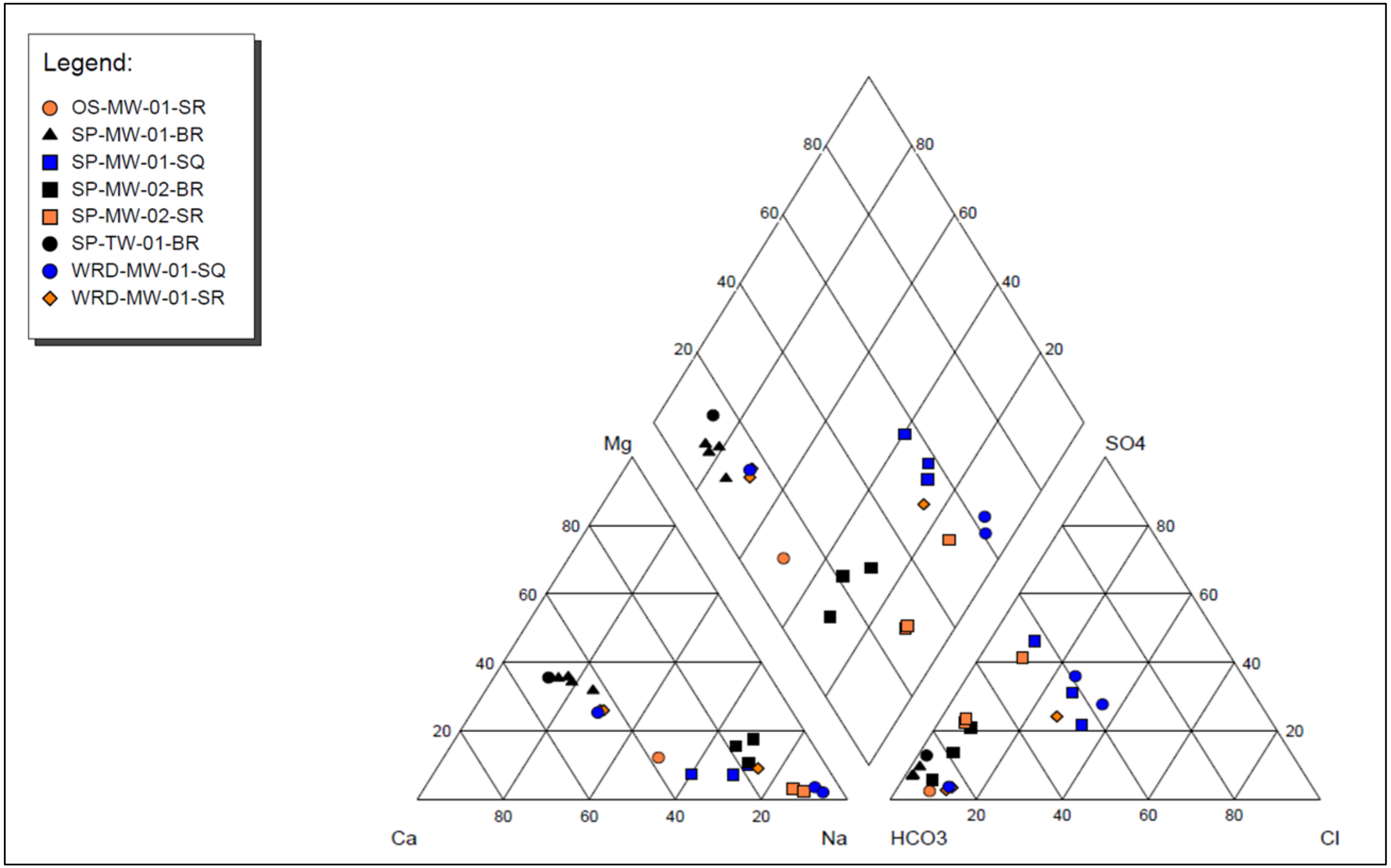
Table 4.8-8 Groundwater Monitoring - Summary Statistics

Parameter	Fraction [a]	Unit	All Groundwater Stations		Quartz Vein (SQ)			Saprock (SR)			Bedrock (BR)		
			2016 - 2017		2016 - 2017			2016 - 2017			2016 - 2017		
			Min	Max	Count	Min	Max	Count	Min	Max	Count	Min	Max
Zinc	TR	mg/L	<DL	0.11	8	<0.01	0.018	10	<0.01	0.014	10	<0.01	0.11
NUTRIENTS													
Ammonia as N		mg/L	<DL	0.88	7	<0.03	0.18	7	<0.03	0.60	9	0.035	0.88
Nitrate/Nitrite as N		mg/L	<DL	0.30	8	<0.05	0.17	10	<0.05	0.30	10	<0.05	0.14
Phosphorus	D	mg/L	<DL	0.34	7	<0.05	0.05	7	<0.05	0.25	9	<0.05	0.34
CYANIDE AND ORGANICS													
Diesel		mg/L	<DL	<DL	2	<0.1	<0.1	2	<0.1	<0.1	3	<0.1	<0.1
Lube Oil		mg/L	<DL	<DL	2	<0.5	<0.5	2	<0.5	<0.5	3	<0.5	<0.5
Gasoline		mg/L	<DL	<DL	2	<0.1	<0.1	2	<0.1	<0.1	3	<0.1	<0.1
Cyanide (total)		mg/L	<DL	<DL	1	<0.01	<0.01	3	<0.01	<0.01	1	<0.01	<0.01
Total Organic Carbon		mg/L	-	-	0	-	-	0	-	-	0	-	-

a) Fraction: D = dissolved; TR = total recoverable; T = total

<DL = less than analytical detection limit; °C = degrees Celsius; mV = millivolt; N = nitrogen; µS/cm = microSiemens per centimeter; µmhos/cm = micromhos per centimeter; NTU = nephelometric turbidity units; mg/L = milligrams per liter; $CaCO_3$ = calcium carbonate; <= less than; - = not available.

Figure 4.8-8 Groundwater Piper Plot



Ca = calcium; Na = socium; MG = magnesium; SO_4 = sulfate; Cl = chloride; HCO_3 = bicarbonate.

GOLDER

4.8.4.1 Groundwater Comparison to Project Water Quality Criteria

Groundwater monitoring results were compared to Project drinking water quality standards (Table 4.8-3) and exceedances identified (Table 4.8-9). All of the exceedances were measured in wells completed in the Cassador Fault (i.e., bedrock wells), as summarized below:

- **Arsenic:** Dissolved and total recoverable arsenic concentrations exceeded the drinking water standard in all Cassador Fault wells. As noted earlier, dissolved arsenic results for groundwater samples filtered with a 0.45 µm and 0.10 µm filter were similar, indicating that the arsenic is present in the dissolved fraction. Maximum arsenic concentrations (i.e., milligram per liter levels) are orders of magnitude higher than the drinking water standard of 0.01 mg/L.
- **Manganese**: Dissolved and total recoverable manganese exceeded the drinking water standard in one of the Cassador Fault wells (i.e., SP-MW-01-BR). Maximum manganese concentrations (i.e., approximately 1 mg/L) were only slightly higher than the drinking water standard of 0.88 mg/L.

No exceedances of Project drinking water standards were measured in the saprolite quartz vein or saprock wells.

Table 4.8-9 Groundwater Summary of Drinking Water Exceedances

Parameter	Drinking Water Quality Standard (Table 4.8-3)	Monitoring Well							
		Saprolite Quartz Vein		Saprock			Cassador Fault		
		WRD-MW-01-SQ	SP-MW-01-SQ	SP-MW-02-SR	OS-MW-01-SR	WRD-MW-01-SR	SP-MW-01-BR	SP-MW-02-BR	SP-TW-01-BR
No. of Samples		4	3	3	2	4	5	3	1
Arsenic (D)	0.01 mg/L						5	1	1
Arsenic (TR)	0.01 mg/L						5	1	1
Manganese (D)	0.88 mg/L						4		
Manganese (TR)	0.88 mg/L						4		

Note: Number of times exceedance measured in primary samples shown in table. Duplicate results excluded from evaluation.
D = dissolved; TR = total recoverable; mg/L = milligrams per liter.

4.8.4.2 Groundwater Baseline Dataset

As noted earlier, the focus of the hydrogeologic baseline investigation was the area surrounding the main Sabajo Pit (Pit 1). Groundwater quality in the vicinity of the Margo and Santa Barbara Pits has not been characterized. Additional well drilling and sampling in these areas will be completed prior to mining to characterize baseline conditions.

4.9 Noise and Vibration

4.9.1 Introduction

The Sabajo Project (the Project) activities will emit noise into the environment. These Project noise emissions have the potential to cause an increase in noise levels. Change to existing baseline noise levels was identified as a concern by local stakeholders.

Before performing an assessment on the potential change in noise due to the Project, it is important to understand existing baseline noise levels. A field program to measure baseline noise levels in the Project area was undertaken by ILACO Suriname N.V. (ILACO). The results of the baseline field program are described in detail in the document *Noise Baseline Study Sabajo Project Environment and Social Impact Assessment* (ESIA*;* ILACO 2017b) and are summarized in this section of the ESIA.

4.9.2 Method

Suriname has no regulatory standards for noise pollution. In the absence of Suriname-specific guidance, existing baseline noise levels were measured in general accordance with the International Finance Corporation (IFC) *General Environmental, Health, and Safety Guidelines: Environmental Noise Management* (IFC 2007c).

Existing baseline noise levels were measured at (Figure 4.9-1):

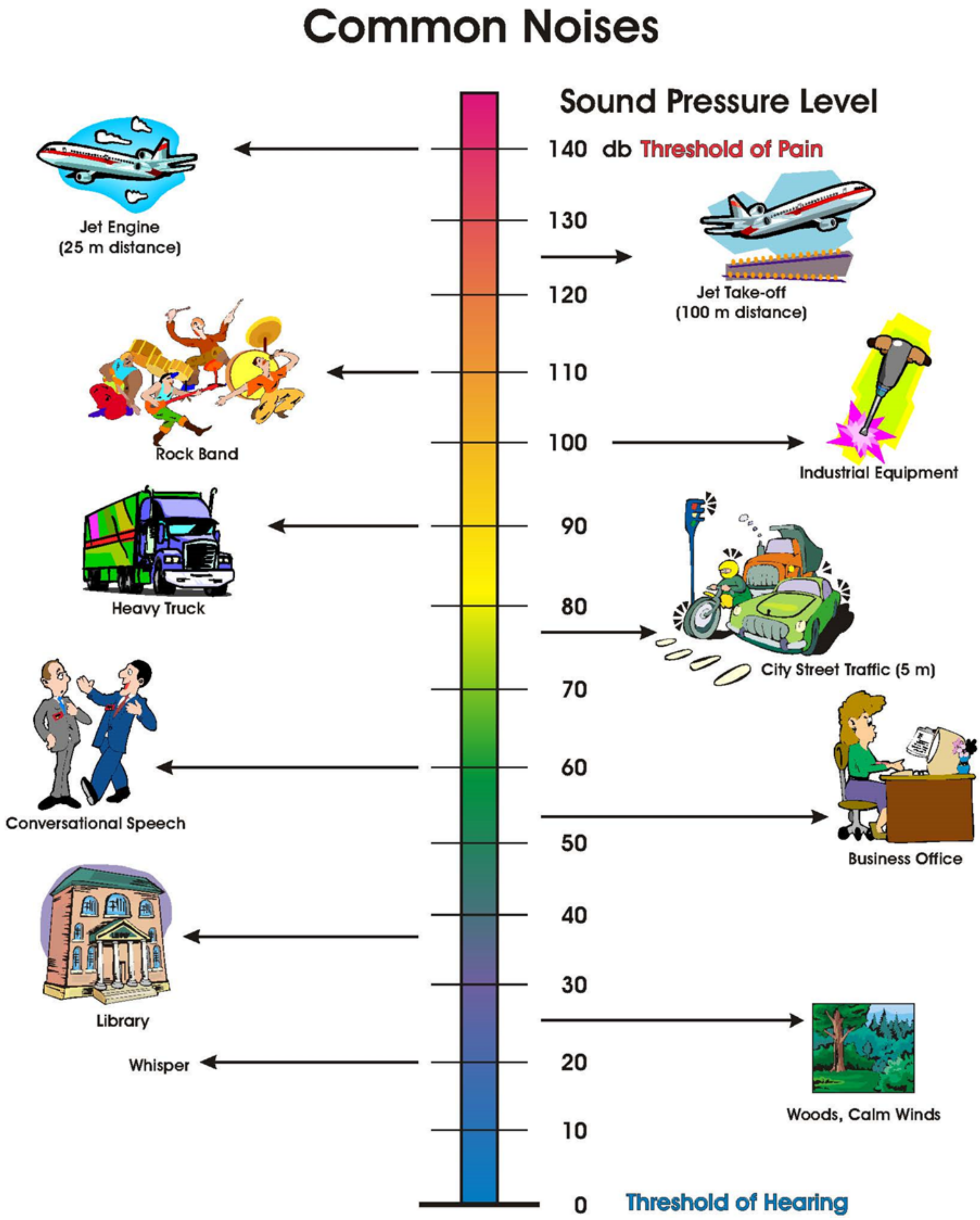
- five locations within the area proposed for Project mining;
- one location along the route of the proposed Sabajo-Merian Haul Road;
- six locations along Carolina Road;
- three locations along Afobaka Road; and
- one location near the junction of Carolina Road and Afobaka Road.

Existing baseline noise levels were measured once during the wet season (i.e., 30 May to 9 July 2017) and once during the dry season (15 September to 24 September 2017) as per the Terms of Reference (Golder 2017b) that was approved by the National Institute of Environment and Development in Suriname. At most locations, existing baseline measurements were only collected during the IFC-defined daytime period (i.e., 07:00 to 22:00), since Project activities and associated noise effects are expected to be greatest during the daytime. However, existing baseline noise levels were measured during the IFC-defined night time period (i.e., 22:00 to 07:00) at some locations within the area proposed for Project mining, since Project activities in this area are expected to be continuous 24 hours per day.

At each location, existing baseline noise levels were measured with a Type I Svantek Svan 957 sound level meter. The duration of individual measurements was selected so as to capture representative conditions. Measurement durations typically ranged between 9 minutes and 18 minutes. In accordance with the IFC guideline, existing baseline noise levels were characterized using the energy equivalent sound level (L_{eq}) in A-weighted decibels (dBA). Following the conclusion of the field program, existing baseline noise levels were compared to recommended limits set out in the IFC guideline.

To support the assessment of potential Project noise effects, multiple measurements were combined to obtain daytime and nighttime noise levels that are representative of the existing baseline environment in the proposed Project mining area and along the Sabajo-Merian Haul Road. In addition, measurements along Carolina Road and Afobaka Road were used, in combination with the United States Department of Transportation (USDOT) Traffic Noise Model (TNM), to develop computer models of existing baseline noise levels at various distances from these roads. To provide context to the results, Figure 4.9-1 shows examples of noise levels.

Figure 4.9-1 Examples of Noise Levels



db = decibel; m = meter.

4.9.3 Results

4.9.3.1 Access Corridor

Table 4.9-1 presents raw measurements of existing baseline noise levels collected during the ILACO field program and a short description of observed noise sources along the Afobaka and Carolina Roads.

Table 4.9-1 Results from Baseline Noise Field Program along the Transportation Corridors

Measurement Location	Project Area	Description of Measurement Location	Description of Major Noise Sources	Existing Baseline Noise Level [L_{eq}, dBA]				IFC Guideline Value [L_{eq}, dBA]	
				Rainy Season		Dry Season			
				Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)
N-1	Afobaka Road	Forested area; 4 m from Musa Road	Birds, insects, rustling leaves, occasional falling tree branches	47.3	N/A[a]	68.7	N/A[a]	55	45
N-2	Afobaka Road	Forested area; 1 m from junction of Musa Road and Afobaka Road	Road traffic, birds, insects, rustling leaves	66.4	N/A[a]	56.0	N/A[a]	55	45
N-3	Afobaka Road	Developed area with low vegetation; 4 m from junction of Afobaka Road and Bronsweg Road	Road traffic	62.8	N/A[a]	61.8	N/A[a]	55	45
N-4	Afobaka Road / Carolina Road	Developed area with low vegetation; 3 m from junction of Afobaka Road and Powakka Road	Road traffic	68.1	N/A[a]	65.5	N/A[a]	55	45
N-5	Carolina Road	Developed area with white sand; 26 m from Carolina Road	Road traffic, people talking, playing music, pets, children playing	43.5	N/A[a]	43.9	N/A[a]	55	45
N-6	Carolina Road	Forested area; 4 m from Carolina Road	Road traffic, insects, birds	58.5	N/A[a]	58.5	N/A[a]	55	45
N-7	Carolina Road	Forested area; 3.7 m from Carolina Road	Insects, birds, road traffic	66.9	N/A[a]	65.8	N/A[a]	55	45
N-8	Carolina Road	Forested area; 3 m from Blakawatra Road	Birds, insects, road traffic	45.1	N/A[a]	49.5	N/A[a]	55	45
N-9	Carolina Road	Forested area; 6 m from Casipora Road	Insects, birds, road traffic	40.2	N/A[a]	37.6	N/A[a]	55	45
N-10	Carolina Road	Forested area; 4.5 m from Louis Stugerweg Road	Birds, insects, road traffic	52.9	N/A[a]	58.8	N/A[a]	55	45

a) Nighttime measurements were not collected at this location.

b) This measurement location is far from the nearest residential receptor and so baseline noise levels are compared to both the residential and industrial guidelines from the IFC.

Project = the Sabajo Project; IFC = International Finance Corporation; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter; N/A = not available.

Typical traffic for Afobaka Road and Carolina Road is shown in Table 4.9-2.

Table 4.9-2 Typical Traffic for Afobaka Road and Carolina Road

Road	Average Traffic Volume (06:00 to 18:00)					
	Cars	Cargo Trucks	Buses	Large Trucks	Logging Trucks	Motorbikes
Afobaka Road	534	292	392	78	38	25
Carolina Road	880	181	219	7	21	124

In general, noise was caused by road traffic, natural sources (e.g., birds, insects, frogs, rustling leaves), and human sources (e.g., talking, playing music, generators, mobile phones, slamming doors).

Measurements from N-1, N-2, N-3, and N-4 were used, in combination with typical baseline traffic counts from Table 4.9-2, to develop and calibrate a TNM model of existing baseline noise levels at various distances from Afobaka Road. Similarly, measurements from N-4, N-5, N-6, N-7, N-8, N-9, and N-10 were used, in combination with typical baseline traffic counts from Table 4.9-2, to develop and calibrate a TNM model of existing baseline noise levels at various distances from Carolina Road. Because the TNM models were calibrated to match the maximum measured baseline noise levels, they are considered conservative (i.e., tending to overestimate existing baseline noise levels for most locations along Afobaka Road and Carolina Road). The TNM models were focused on the IFC-defined daytime period, since it Project traffic on Afobaka Road and Carolina Road will be confined almost exclusively to the daytime period.

For Afobaka Road and Carolina Road, Table 4.9-3 compares model predictions to baseline noise measurements. As discussed previously, the model predictions agree quite well with the maximum baseline measurements and overestimate noise levels at the other measurement locations. In other words, the models are conservative. Table 4.9-4 presents baseline noise level model predictions at various distances from Afobaka Road and Table 4.9-5 presents similar model predictions for Carolina Road.

Table 4.9-3 Afobaka Road and Carolina Road Existing Baseline Noise Levels: Comparison of Measurements and Model Predictions

Road	Measurement Location	Existing Baseline Noise Level [L_{eq}, dBA]	
		Daytime (07:00 to 22:00)	
		Range of Measurements	Model Prediction
Afobaka Road	N-1	47.3 to 68.7	68.7
	N-2	56.0 to 66.4	70.7
	N-3	61.8 to 62.8	68.7
	N-4	65.5 to 68.1	69.3
Carolina Road	N-4	65.5 to 68.1	68.4
	N-5	43.5 to 43.9	61.7
	N-6	58.5	67.8
	N-7	65.8 to 66.9	67.9
	N-8	45.1 to 49.5	68.4
	N-9	37.6 to 40.2	66.8
	N-10	52.9 to 58.8	67.5

L_{eq} = energy equivalent sound level; dBA = A-weighted decibels.

Table 4.9-4 Representative Modeled Existing Baseline Noise Levels for Afobaka Road

Distance from Road [m]	Representative Existing Baseline Noise Level [L_{eq}, dBA]	IFC Guideline Value [L_{eq}, dBA]
	Daytime (07:00 to 22:00)	Daytime (07:00 to 22:00)
15	64.8	55
50	57.5	55
100	50.2	55
200	43.6	55
300	40.1	55

IFC = International Finance Corporation; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter.

Table 4.9-5 Representative Modeled Existing Baseline Noise Levels for Carolina Road

Distance from Road [m]	Representative Existing Baseline Noise Level [L_{eq}, dBA]	IFC Guideline Value [L_{eq}, dBA]
	Daytime (07:00 to 22:00)	Daytime (07:00 to 22:00)
15	63.9	55
50	56.9	55
100	50.7	55
200	44.1	55
300	39.9	55

IFC = International Finance Corporation; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter.

It is important to understand that existing noise levels along Afobaka Road and Carolina Road are not unusual. The USDOT acknowledges that *"Levels of highway traffic noise typically range from 70 to 80 dBA at a distance of 15 metres from the highway"* (USDOT 2017).

It is also important to understand that existing noise levels measured along Afobaka Road and Carolina Road will not result in hearing damage. Sleep disturbance is the primary health effect associated with exposure to noise levels in the range measured along Afobaka Road and Carolina Road; however, sleep disturbance is typically only an issue during the nighttime period and the existing noise levels were measured during the daytime period. Because of reductions in traffic volume, it is likely that existing noise levels are substantially lower during the nighttime period than during the daytime period.

4.9.3.2 Sabajo Area

Table 4.9-6 presents raw measurements of existing baseline noise levels collected during the ILACO field program and a short description of observed noise sources in the Sabajo Area.

Measurements from N-12A, N-12B, N13, N-14A, and N-14B were logarithmically averaged to obtain daytime and nighttime noise levels that are representative of the existing baseline environment in the proposed Project mining area. Similarly, measurements from N-11 were logarithmically averaged to obtain a daytime noise level that is representative of the existing baseline environment along the proposed Sabajo-Merian Haul Road. A representative nighttime noise level for the haul road was obtained by scaling from the mining area (i.e., by assuming that the difference between daytime and nighttime noise levels is the same along the haul road as in the mining area). Table 4.9-7 presents daytime and nighttime noise levels that are representative of the existing baseline environment in the proposed Project mining area and along the proposed Sabajo-Merian Haul Road.

Table 4.9-6 Results from Baseline Noise Field Program in the Sabajo Area

Measurement Location	Project Area	Description of Measurement Location	Description of Major Noise Sources	Existing Baseline Noise Level [L_{eq}, dBA]				IFC Guideline Value [L_{eq}, dBA]	
				Rainy Season		Dry Season			
				Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)
N-11	Sabajo-Merian Haul Road	Forested area; 2 m from edge of haul road	Birds, insects	52.4	N/A[(a)]	43.3	N/A[(a)]	55 / 70[(b)]	45 / 70[(b)]
N-12A	Project mining area	Santa Barbara ASM area – adjacent to entry road	Ongoing mining (e.g., generators and pumps), insects, birds, people talking, ringing mobile phones, playing music	59.0	N/A[(a)]	52.9	N/A[(a)]	55 / 70[(b)]	45 / 70[(b)]
N-12B	Project mining area	Santa Barbara ASM area – adjacent to campsite	Playing music, people talking, birds, insects	47.6	N/A[(a)]	40.4	N/A[(a)]	55 / 70[(b)]	45 / 70[(b)]
N-13	Project mining area	Cassador Pit small scale mining area	Birds, insects	38.6	N/A[(a)]	31.3	N/A[(a)]	55 / 70[(b)]	45 / 70[(b)]
N-14A	Project mining area	Sabajo site – adjacent to camps	Daytime: people talking, slamming doors, generator, birds, insects Nighttime: insects, frogs	48.2	49.1	44.7	50.2	55 / 70[(b)]	45 / 70[(b)]
N-14B	Project mining area	Sabajo site – approximate centre of site	Daytime: people talking, people walking by, slamming doors, generator, playing music and television, light vehicle traffic, back-up alarms Nighttime: insects, frogs, ringing mobile phones, snoring	52.5	48.5	44.0	42.3	55 / 70[(b)]	45 / 70[(b)]

a) Nighttime measurements were not collected at this location

b) This measurement location is far from the nearest residential receptor and so baseline noise levels are compared to both the residential and industrial guidelines from the IFC

Project = Sabajo Project; IFC = International Finance Corporation; ASM = artisanal and small scale mining; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter; N/A = not available.

Table 4.9-7 Representative Existing Baseline Noise Levels: Project Mining Area and Sabajo-Merian Haul Road

Project Area	Representative Existing Baseline Noise Level [L_{eq}, dBA]		IFC Guideline Value [L_{eq}, dBA]	
	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)	Daytime (07:00 to 22:00)	Nighttime (22:00 to 07:00)
Project mining area	51.4	48.4	55 / 70[a]	45 / 70[a]
Sabajo-Merian Haul Road	49.9	46.9	55 / 70[a]	45 / 70[a]

a) This location is far from the nearest residential receptor and so baseline noise levels are compared to both the residential and industrial guidelines from the IFC
Project = Sabajo Project; IFC = International Finance Corporation; Leq = energy equivalent sound level; dBA = A-weighted decibels.

4.9.4 Uncertainties

The field program adequately characterized existing baseline noise levels across the study area. No additional baseline data collection is required or proposed for the Project.

Representative existing baseline noise levels along Afobaka Road and Carolina Road were established using noise measurements, baseline traffic counts, and the TNM modelling algorithm. There is uncertainty inherent in this approach, since measured noise levels are highly sensitive to the specific traffic volume and environmental conditions that prevailed at the time of the measurement. There is additional uncertainty in the way the TNM algorithm accounts for attenuation as road noise propagates into the environment. To address these uncertainties, the models have been calibrated to match the maximum measured baseline noise levels. As such, the models are considered conservative (i.e., tending to overestimate existing baseline noise levels for most locations along Afobaka Road and Carolina Road). Because of the modelling conservatism, the representative existing baseline noise levels presented in Table 4.9-5 and Table 4.9-6 are appropriate inputs to the assessment of Project noise effects along Afobaka Road and Carolina Road.

Representative existing baseline noise levels for the proposed Project mining area and along the proposed Sabajo-Merian Haul Road were established by logarithmically averaging multiple measurements. There is uncertainty inherent in this approach, since measured noise levels are highly sensitive to the specific environmental conditions that prevailed at the time of the measurement. That being said, the magnitude of the uncertainty is small enough to not materially impact the conclusions of the noise assessment. In other words, the representative existing baseline noise levels presented in Table 4.9-3 are appropriate inputs to the assessment of Project noise effects in the mining area and along the Sabajo-Merian Haul Road.

4.10 Existing Air Quality

Air quality in the Environmental and Social study area of the Sabajo Project (the Project) is generally influenced by natural and anthropogenic sources, such as:

- dust blown by wind during the dry season;
- artisanal and small scale mining (ASM);
- logging activities;
- dust created by driving vehicles on unpaved roads;
- exhaust gases from vehicles; and
- fuel combustion (wood and hydrocarbons) for home cooking.

The current impacts of these activities on air quality are generally localized and do not contribute substantially to regional degradation of air quality.

4.10.1 Air Quality Sampling

No historical ambient air quality data are available for the study area. Newmont Suriname, LLC (Newmont) established an air monitoring program at the Mine Site and along the Carolina Transportation Corridor in August 2017 to obtain baseline data.

Sampling was conducted at five locations:

- the Stichting voor Bosbeheer en Bostoezicht (SBB) station along the Carolina Transportation Route near Powakka;
- in the community of Redi Doti;
- in the community of Casipora;
- inside the proposed Cassador Pit; and
- at the location of the future haul road.

Additional monitoring was conducted in the communities of Redi Doti and Casipora to ensure that the effects of the potential project could be compared at these locations, as this was a concern identified during the scoping meetings conducted in June of 2017 (see Public Consultation and Disclosure Plan; Appendix 1A). The site locations were selected to provide the most representative ambient air concentrations near activities related to the Project. In addition, they provided ease of access and required security for the monitoring equipment at each site. Map 4.10-1 presents a map of the selected sampling locations. No monitoring was conducted along the Afobaka road as this transportation route is paved and it was assumed that dust emissions from traffic would be negligible.

The following constituents were included in the sampling program:

- total suspended particulate (TSP) matter;
- particulate matter less than 10 microns mean aerodynamic diameter (PM_{10});
- particulate matter less than 2.5 microns mean aerodynamic diameter ($PM_{2.5}$);
- nitrogen dioxide (NO_2); and
- sulfur dioxide (SO_2).

Meteorological data was obtained from the Sabajo weather station as well as from other instrumentation in the field to accurately characterize weather conditions during each sampling event.

The ambient air sampling program was conducted over the course of two mobilizations. The first mobilization was conducted from August 2017 through October 2017, which is generally considered the long "dry" season. The drier portions of the year were targeted, as during this time there is typically an elevated amount of background particulate matter in the ambient air. Target constituents measured during the both mobilizations included TSP, PM_{10}, $PM_{2.5}$, NO_2, and SO_2.

The second mobilization was conducted from 14 December 2018 through 4 February 2018 during the short "wet" season. The sampling equipment was reassembled at each of the same three locations utilized during the first mobilization.

Additional monitoring was conducted in Redi Doti and Casipora in November and December 2017, and again in January 2018, in response to community concerns.

As expected, no major air pollution sources were identified during sampling (first and second mobilizations) at the Cassador Pit or the haul road locations, indicating that ambient baseline conditions were sampled. During the first mobilization, infrequent vehicle traffic was also observed on the Carolina Road (Transportation Corridor) at the SBB site.

Sampling was conducted during all mobilizations for a 4 day period at each of the locations. This varies slightly from the United States Environmental Protection Agency (USEPA) monitoring schedule of one day of monitoring every three days due to logistical limitations. However, for the purposes of the baseline monitoring period, the data collected at all locations was statistically similar and it can be considered that the results represent baseline conditions.

The instrument used to collect the particulate air quality data was a Dust Profiler manufactured by Aeroqual (www.aeroqual.com) due to its portable nature. (Photo 4.10-1).This instrument is designed to provide continuous particulate measurement of PM_{10}, $PM_{2.5}$, and TSP. It uses an optical particle counter to count and classify particulate matter according to size. The instrument then converts the size distribution into a mass measurement. The data is collected using a software program that takes continuous measurements and then averages them to provide hourly data.

NO_2 and SO_2 were sampled during both mobilizations using the Aeroqual SO_2 and NO_2 sampling meters. Each sample was collected over a 4-day period concurrent with the other ambient monitoring.

Tables 4.10-1 to 4.10-6 present a detailed summary of the results of all constituents measured during September/October and December 2017 at the Redi Doti, Casipora, the Carolina Road (SBB) site, the Cassador Pit, and the future Sabajo-Merian Haul Road location, respectively. The tables also show the observed weather conditions during each sampling event.

Table 4.10-1 through Table 4.10-6 also present summaries of the resultant data of all constituents. These were compared to the World Health Organization (WHO) Ambient Air Quality Guidelines (WHO 2005).

Photo 4.10-1 Air Monitoring Equipment

The tables present data based on the maximum results obtained for each target analyte during both mobilizations for comparison to the published standards and guidelines. Based on the monitoring results, there were no target analytes that exceeded the WHO Ambient Air Quality Guidelines for 24-hour average concentrations for particulates.

Table 4.10-1 Measurement Results of Air Quality Constituents at Station SBB1, 2017

Date	TSP (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	NO_2 (ppm)		SO_2 (ppm)	Weather Conditions
	24-hr	24-hr	24-hr	24-hr	1-hr Maximum	24-hr	
10/2/2017	8	5	3	-	-	0.0	Sunny
10/3/2017	12	10	7	-	-	0.0	Sunny
10/4/2017	14	11	9	0.0	0.0	0.0	Sunny
10/5/2017	15	10	7	0.0	0.0	0.0	Sunny
01/24/2018	4	3	3	0.0	0.0	0.0	Rainy
01/25/2018	6	5	3	0.0	0.0	0.0	Rainy
01/26/2018	22	20	23	0.0	0.0	0.0	Rainy
01/27/2018	36	30	12	0.0	0.0	0.0	Sunny
01/28/2018	28	19	13	0.0	0.0	0.0	Sunny
01/29/2018	9	8	7	0.0	0.0	0.0	Sunny

TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns aerodynamic diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns aerodynamic diameter; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; µg/m³ = micrograms per cubic meter; ppm = parts per million; hr = hour; - = no valid data collected.

Table 4.10-2 Measurement Results of Air Quality Constituents at Station SBB2, 2017

Date	TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 (ppm)		SO_2 (ppm)	Weather Conditions
	24-hr	24-hr	24-hr	24-hr	1-hr Maximum	24-hr	
10/5/2017	13	9	6	0.0	0.0	0.0	Sunny
10/6/2017	16	10	6	0.0	0.0	0.0	Sunny
10/7/2017	22	13	7	0.0	0.0	0.0	Sunny
10/8/2017	35	19	8	0.0	0.0	0.0	Sunny
10/9/2017	28	16	7	0.0	0.0	0.0	Sunny
10/10/2017	13	10	7	0.0	0.0	0.0	Sunny
01/29/2018	65	35	19	0.0	0.0	0.0	Sunny (bit rainy)
01/30/2018	66	37	19	0.0	0.0	0.0	Sunny
01/31/2018	61	32	15	0.0	0.0	0.0	Sunny & Cloudy
02/01/2018	12	11	9	0.0	0.0	0.0	Rained
02/02/2018	9	8	7	0.0	0.0	0.0	Sunny
02/03/2018	17	8	5	0.0	0.0	0.0	Sunny
02/04/2018	12	6	3	0.0	0.0	0.0	Sunny

TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns aerodynamic diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns aerodynamic diameter; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $\mu g/m^3$ = micrograms per cubic meter; ppm = parts per million; hr. = hour.

Table 4.10-3 Measurement Results of Air Quality Constituents at Redi Doti Station, 2017

Date	TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 (ppm)		SO_2 (ppm)	Weather Conditions
	24-hr	24-hr	24-hr	24-hr	1-hr Maximum	24-hr	
10/18/2017	15	10	5	0.0	0.0	0.0	Sunny
10/19/2017	12	9	6	0.0	0.0	0.0	Sunny
10/20/2017	29	23	17	0.0	0.0	0.0	Sunny
10/21/2017	24	20	15	0.0	0.0	0.0	Sunny
11/26/2017	6	6	4	-	-	0.0	Sunny & Cloudy
11/27/2017	7	6	4	-	-	0.0	Sunny & Cloudy
11/28/2017	7	6	4	-	-	0.0	Sunny & Cloudy
11/29/2017	9	7	4	-	-	0.0	Sunny & Cloudy
11/30/2017	8	7	4	-	-	0.0	Sunny
01/10/2018	7	5	4	-	-	0.0	Sunny
01/11/2018	7	5	4	-	-	0.0	Sunny
01/12/2018	8	6	4	-	-	0.0	Sunny
01/13/2018	7	6	5	-	-	0.0	Sunny
01/14/2018	5	5	4	-	-	0.0	Sunny
01/15/2018	6	6	4	-	-	0.0	Sunny

TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns aerodynamic diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns aerodynamic diameter; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $\mu g/m^3$ = micrograms per cubic meter; ppm = parts per million; hr. = hour; - = no valid data collected.

Table 4.10-4 Measurement Results of Air Quality Constituents at Casipora Station, 2017

Date	TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 (ppm)		SO_2 (ppm)	Weather Conditions
	24-hr	24-hr	24-hr	24-hr	1-hr Maximum	24-hr	
10/21/2017	14	10	7	0.0	0.0	0.0	Sunny
10/22/2017	10	7	5	0.0	0.0	0.0	Sunny
10/23/2017	6	5	4	0.0	0.0	0.0	Sunny
10/24/2017	7	7	5	0.0	0.0	0.0	Sunny
11/22/2017	5	4	3	-	-	0.0	Sunny & Cloudy
11/23/2017	8	7	6	-	-	0.0	Sunny & Cloudy
11/24/2017	9	7	5	-	-	0.0	Sunny & Cloudy
11/25/2017	9	8	6	-	-	0.0	Sunny & Cloudy
11/26/2017	8	7	5	-	-	-	Sunny & Cloudy
01/05/2018	34	27	21	-	-	0.0	Cloudy
01/06/2018	18	17	15	-	-	0.0	Cloudy & Rainy
01/07/2018	14	14	12	-	-	0.0	Sunny
01/08/2018	8	7	6	-	-	0.0	Rained
01/09/2018	4	3	2	-	-	0.0	Rained
01/10/2018	4	4	3	-	-	0.0	Rained

TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns aerodynamic diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns aerodynamic diameter; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $\mu g/m^3$ = micrograms per cubic meter; ppm = parts per million; hr. = hour; - = no valid data collected.

Table 4.10-5 Measurement Results of Air Quality Constituents at Cassador Pit Station, 2017

Date	TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	NO_2 (ppm)		SO_2 (ppm)	Weather Conditions
	24-hr	24-hr	24-hr	24-hr	1-hr Maximum	24-hr	
08/13/2017	48	27	10	-	-	-	Sunny
08/14/2017	10	6	3	-	-	-	Sunny
08/15/2017	9	8	6	-	-	-	Sunny
08/16/2017	11	9	6	-	-	-	Sunny
08/17/2017	9	8	6	-	-	-	Sunny
08/18/2017	11	9	6	-	-	-	Sunny
08/19/2017	10	8	6	-	-	-	Sunny
09/28/2017	9	8	7	-	-	-	Sunny
09/29/2017	10	9	7	-	-	0.0	Sunny
09/30/2017	12	11	6	-	-	0.0	Sunny
10/24/2017	6	6	4	0.0	0.0	0.0	Sunny
10/25/2017	6	5	4	0.0	0.0	0.0	Sunny
10/26/2017	9	9	6	0.0	0.0	0.0	Sunny
12/17/2017	4	4	2	-	-	0.0	Cloudy
12/18/2017	4	4	2	-	-	0.0	Rainy & Sunny
12/19/2017	3	2	1	-	-	0.0	Rainy & Cloudy
12/20/2017	4	3	2	-	-	0.0	Rainy & Cloudy
12/21/2017	5	5	3	-	-	0.0	Cloudy
12/22/2017	6	6	4	-	-	0.0	Cloudy
12/23/2017	8	8	4	-	-	0.0	Cloudy

TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns aerodynamic diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns aerodynamic diameter; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $\mu g/m^3$ = micrograms per cubic meter; ppm = parts per million; hr. = hour; - = no valid data collected.

Table 4.10-6 Measurement Results of Air Quality Constituents at Sabajo-Merian Haul Road Station, 2017

Date	TSP (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	NO_2 (ppm)		SO_2 (ppm)	Weather Conditions
	24-hr	24-hr	24-hr	24-hr	Hourly Max	24-hr	
10/14/2017	11	10	8	-	-	0.0	Sunny
10/15/2017	9	9	7	0.0	-	0.0	Sunny
10/16/2017	9	8	6	0.0	0.0	0.0	Sunny
10/17/2017	8	7	5	0.0	0.0	0.0	Sunny
10/18/2017	12	11	6	0.0	0.0	0.0	Sunny
12/13/2017	9	9	7	-	-	0.0	Rainy
12/14/2017	16	16	12	-	-	0.0	Rainy
12/15/2017	15	14	11	-	-	0.0	Rainy & Sunny
12/16/2017	14	11	8	-	-	0.0	Rainy & Cloudy
12/17/2017	12	7	4	-	-	0.0	Rainy & Cloudy

TSP = total suspended particulate; PM_{10} = particulate matter less than 10 microns aerodynamic diameter; $PM_{2.5}$ = particulate matter less than 2.5 microns aerodynamic diameter; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; µg/m³ = micrograms per cubic meter; ppm = parts per million; hr. = hour; N/A = not available; - = no valid data collected.

Air quality measurements for SO_2 and NO_2 were conducted during the same monitoring period as the particulate monitoring with the following exceptions: NO_2 was not measured during the August, December and January campaigns in any locations as there was instrument malfunction. However, during the period when the instrument was working, there were no measured concentrations for NO_2 at the level of detection for the monitoring instrument, as would be expected in an area where there is limited vehicular traffic or other sources. During all monitoring events the measured SO_2 concentrations were 0.0 parts per million (ppm), with the exception of instrument malfunction on 21 December 2017 at the Cassador Pit where a measurement of 0.5 micrograms per cubic meter (µg/m³) was measured with no apparent source. As such this data point was qualified as non-representative of baseline. The baseline concentrations for both NO_2 and SO_2 are considered to be 0.0 µg/m³.

Overall, pollutant concentrations obtained from all locations are representative of good air quality in the study area and the surrounding communities, as expected from a generally undeveloped area.

4.10.2 Greenhouse Gases

Greenhouse gases (GHGs) are gases that warm up the earth's atmosphere by absorbing solar radiation reflected from the earth's surface. The five main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Scientific evidence indicates a trend of increasing global temperature over the past century due to an increase in GHG concentrations in the atmosphere caused by human activities, particularly fossil fuel combustion. The resulting increase in GHG concentrations in the atmosphere have likely increased the amount of heat that is retained by Earth's atmosphere, thus contributing to increased global temperatures. There is concern that such increase in global temperatures could have many consequences for the environment. The significance of these consequences is no longer a subject of debate, such that there is general consensus in the scientific community that these consequences will occur more quickly and could potentially have adverse effects on human health and the environment. Such effects may include human health problems from exposure to extreme heat and declining air quality, reduction in agricultural production, and severe flooding from frequent heavy downpours and sea-level rise.

Due to the potential effects of global warming from human activities, Newmont has committed to monitoring GHGs and publicly reporting the results since 2012.

In Suriname, there are currently no policies, laws, or measures in place to reduce or mitigate the effects of GHG emissions. The Republic of Suriname (2016) reported a 2008 estimate of GHG emissions for Suriname, which indicated approximately 6.4 megaton (Mt) of CO_2 equivalents were emitted annually or a total of 0.02 percent (%) of the global emissions (Republic of Suriname 2016).

4.11 Biodiversity Baseline Studies

Biodiversity baseline studies conducted for the Sabajo Project (the Project) conform to methods described in:

- *Good Practices for the Collection of Biodiversity Baseline Data.* 2015. Multilateral Financing Institutions Biodiversity Working Group (https://www.hg-llc.com/publications/); and
- Newmont's Biodiversity Management Standard and its Guidance note.

Results of the baseline studies allow Key Biodiversity Values (KBVs) to be identified. The types of KBVs covered in Newmont's Biodiversity Management Standard, plus the specific KBVs identified for the Project are described in Section 5.8. KBVs then become the focus of the impact assessment.

4.11.1 Landscape Context

The Guiana Shield – broadly considered as the region of northeastern South America bounded by the Orinoco and Amazon Rivers, and the Atlantic Ocean - contains one of the largest regions of intact lowland tropical forest remaining on Earth, and features high diversity and endemism of flora and fauna (Kelloff and Funk 2004; Hammond 2005; Hollowell et al. 2005).

The Project footprint, including the Sabajo-Merian Haul Road, is drained by the upper Commewijne River, specifically its two main branches, the Tempati Creek in the east and the Little Commewijne River in the west. The Sabajo mining area and the western portion of the Sabajo-Merian Haul Road will be located in the catchment of the upper Kleine Commewijne River (also referred as Little Commewijne River), and the eastern portion of the road in the Tempati Creek catchment (see Maps 4.11-1, 4.11-2 and 4.11-3 that show the Project footprint and study area in relation to the two drainages and terrestrial habitats). The upper Commewijne Catchment is mostly covered with lowland *terra firme* rainforest (dry land; i.e., not flooded; De Dijn *et al.*, in press) interspersed mostly with seasonally flooded forests.

The Project's area of influence does not have significant topographic relief from the surrounding landscape (in contrast, for example, to areas to the immediate south starting with Adelaar's Peak at 1,309 meters above sea level (masl), and rising to the Nassau Plateau at 1,870 masl). As a result, unique vegetation communities or major habitats for endemic and / or range-restricted terrestrial species would not typically be expected to occur here.

The Upper Commewijne River Catchment has a long (40 years) history of extensive mechanized logging and gold mining (Photo 4.11-1). The extensive gold mining is especially damaging to the streams and riparian (stream-side) forest (De Dijn and Landburg 2017). The upper Kleine Commewijne River and its main tributaries are severely disturbed by artisanal and small scale mining (ASM). Smaller forest creeks (SAB3, SAB1) and some headwater streams (SAB6upstream) are still in relatively good condition (areas disturbed by ASM and intact riparian areas are clearly visible in Map 4.11-1).

Photo 4.11-1 Creek bed after informal mining near Santa Barbara (Credit: Hardner 2015)

The current map of International Union for Conservation of Nature (IUCN) designated Key Biodiversity Areas indicates there are none within the Project's footprint, or its likely area of influence (Map 4.11-4) – the closest being Brownsberg Nature Park and Nassau Mountain. No protected areas are within the Project's footprint or likely area of influence. Brownsberg Nature Park (IUCN Category II) and Copi (IUCN Category IV) are the closest (Map 4.11-5).

4.11.1.1 Detailed Field Studies

Detailed field studies undertaken by taxonomic specialists included mapping of major habitat types and surveys of major taxonomic groups: birds, mammals, amphibians and reptiles, fish, and plants. Following is a summary of baseline methods and results.

In order to plan the fieldwork for the baseline studies, a reconnaissance trip was taken 26 to 27 April 2017. The objective of the trip was to gain an understanding of the vegetation, water bodies, soils, and human disturbance in the general area.

This information was then used to conduct a preliminary mapping of terrestrial and aquatic habitats, which subsequently formed the basis for locating sampling sites for the terrestrial habitat and aquatic ecology baselines. The study area comprised the proposed Project footprint plus a buffer for non-footprint direct effects such as from water quality and noise (see Map 4.1-2). Field surveys focused within this approximately 188 square kilometer study area, however some control sites were outside of it.

Sites for the habitat/vegetation baseline were located to sample the main natural forest types in the study area, as well as to capture areas of current and future disturbance from small-scale miners and Newmont respectively, including within the Project footprint. Aquatic sites were located to sample the Tempati and Kleine Commewijne drainages, and included control sites and sites downstream from the Project footprint. Poor accessibility in the eastern part of the study area limited the fieldwork that was possible in the Tempati drainage. To the greatest extent possible, the habitat/vegetation preliminary habitat mapping and sampling sites formed the basis for bird, mammal and flora baseline surveys.

The following sections report methodology and results for terrestrial and aquatic habitats, and for flora, birds, mammals and amphibians/reptiles.

4.11.2 Methods

4.11.2.1 Terrestrial Habitats Methods

Study sites

Plots were installed at 14 sites in the accessible western half of the Sabajo study area. Plots were located to sample:

- within or adjacent to the footprint of the proposed Sabajo mine and transportation corridor between the Sabajo and Merian concessions;
- the main natural habitat/vegetation communities in the study area; and
- the heavily disturbed, man-made habitat in the study area, which includes sites disturbed by logging, road-building, and ASM.

Plot locations are shown in Maps 4.11-2 and 4.11-3. Geo-coordinates and a brief description of the locations are presented in Table 4.11-1. No transects or plots were installed in the main valley of the Tempati Creek due to its inaccessibility.

Table 4.11-1 Locations and Descriptions of Sites in the Sabajo Study Area (June to July 2017)

Location code	Geo-coordinates (UTM 21 N; WGS 84) incl. altitude	Landform, topography, drainage	Vegetation and soil	Disturbance history
A1	0738781 m E 0563031 m N 54 m alt.	Broad depression / low undulating land, part marshy	Medium stature lightly disturbed forest on loamy soil	Light disturbance: logging (not recent)
AF1	0739275 m E 0563509 m N 61 m alt.	Small creek valley, encased by fairly steep-sloped, low hills	Medium-tall stature lightly disturbed swamp-marsh forest	Light disturbance: eroded soil from road flows into creek
C1	0743104 m E 0564330 m N 49 m alt.	Broad depression / low undulating land, mostly marshy	Medium-tall stature lightly disturbed forest on sandy soil	Light disturbance: logging (not recent)
C2[(a)]	0744252 m E 0572496 m N 30-35 m alt.	Low undulating land, from marshy to dryland	Medium-tall stature lightly disturbed forest on loamy soil	Light disturbance: logging and field camp construction
E1	0750550 m E 0563694 m N 89 m alt.	Hilltop/slope	Tall stature lightly disturbed forest on lateritic soil with thick duricrust	Light disturbance in plot; heavier disturbance in surrounding area: recent logging
F1	0742044 m E 0565949 m N 88 m alt.	Hillslope	Tall stature lightly disturbed forest on lateritic soil with duricrust	Light disturbance: logging (not recent) and lines for mining exploration
F2	0741574 m E 0563530 m N 60 m alt.	Base of hill; dry	Ruderal / pioneer vegetation	Heavily disturbed area: recent informal mining disturbance
F3	0741640 m E 0563547 m N 57 m alt.	Riparian area; wet	Ruderal / pioneer vegetation	Heavily disturbed area: recent informal mining disturbance
F6	0745985 m E 0562927 m N 49 m alt.	Near-riparian area; dry	Ruderal / pioneer vegetation	Heavily disturbed area: older informal mining disturbance
F7	0740804 m E 0563009 m N 83 m alt.	Hilltop/slope hill	Tall stature forest on lateritic soil	Light disturbance: logging (not recent)
F8	0741024 m E 0563202 m N 65 m alt.	Hillslope	Roadside vegetation with low stature secondary forest	Disturbed: old, continuing disturbance due to logging, associated road building and maintenance
F9	0743185 m E 0562552 m N 52 m alt.	Riparian area; largely wet	Ruderal / pioneer vegetation and a strip of secondary forest	Heavily disturbed area: recent informal mining disturbance
F4	0741280 m E 0565402 m N 42 m alt.	Riparian area; part wet	Ruderal / pioneer vegetation	Heavily disturbed area: recent informal mining disturbance
F5	0749470 m E 0563012 m N 74 m alt.	Hilltop/slope	Tall stature forest on lateritic soil with duricrust	Lightly disturbed

a) This location was not assessed in similar way as other plots; basic observations on mature trees only were recorded opportunistically during a reconnaissance of the road to Kleine Commewijne (Downstream of Santa Barbara).

UTM = Universal Transverse Mercator; WGS = World Geodetic System; E = east; N = North; alt. = altitude; m = meter.

Methodology

Fieldwork was conducted during June - July 2017. Eight 0.1 hectares (ha; 200 meter [m] x 5 m) plots were installed in the sites located in natural vegetation (A1, AF1, C1, C2, E1, F1, F5, and F7). Smaller 0.025 ha (50 m x 5 m) plots were installed at six sites in disturbed vegetation (F2, F3, F4, F6, F8, and F9). Smaller plots were appropriate for disturbed vegetation because of the simpler vegetation communities present and the smaller patch sizes that the vegetation occupied.

A variety of field observations and measurements were taken to characterize the general habitat where each plot was located, including measures of land form/meso-topography, drainage/hydrology, climate, soil, vegetation structure, and disturbance history. See Appendix 4A, Table 4A-1 for a description of all variables recorded. The vegetation within each plot was characterized by estimating height and measuring diameter at breast height (dbh) for trees greater than or equal to (≥) 10 centimeters (cm) dbh and liana stems ≥2 cm dbh. Large trees and lianas were identified by a treespotter in the field. Tree vernacular names were recorded and subsequently linked to scientific names to the greatest extent possible. Understory plants were identified in the field to the extent possible. Vouchers were taken if fertile plant material was found in the field. The vouchers were transferred to the National Herbarium of Suriname (BBS) for identification, and also to the French Guiana Herbarium of Cayenne (CAY) for more definitive identification by senior experts.

Data analyses

Basic statistics including observed species richness, species diversity (alpha; Krebs 1989), and structural maps were calculated for each plot. A variety of statistical techniques including Non-metric Multidimensional Scaling analysis and a Cluster analysis (see Legendre and Legendre 1998) were used to compare and contrast the habitat and vegetation variables from the 14 sites. These comparisons provided the basis to distinguish distinct habitat/vegetation types, and then with the aid of maps and satellite imagery, map these habitats across the study area.

4.11.2.2 Aquatic ecosystems Methods

Study sites

Sampling sites were located in the two main branches of the Commewijne River, the Tempati Creek and the Kleine Commewijne River, in the upper Commewijne River watershed (Map 4.11-1).

The middle section of the Tempati Creek was sampled (site TEM1) in the high-water season, reached by boat from the village Java at the junction of the Tempati and Kleine Commewijne River (Map 4.11-6; Table 4.11-2). In the low-water season the Tempati was sampled further upstream, close to the Merian Concession (TEM2), and accessed by a new road to the north of the Merian Concession.

The upper Kleine Commewijne River (KC) was sampled only in the low-water season; it was sampled at the logging concession of TAKT NV.

The other sampling sites are located close to the two future mine pits of Sabajo and Santa Barbara and include the large stream SAB5. This stream and the stream immediately to the east, SAB6, are two tributaries of the Kleine Commewijne River that were sampled at two localities associated with, respectively, a northern road (the downstream sites SAB5 and SAB6) and a southern road (the upstream sites, SAB5upstr and SAB6upstr). Two smaller streams near the Sabajo Camp were sampled: the stream SAB1 crossing the road to the camp and an ephemeral rainforest creek SAB3 located slightly to the east of the camp. Another stream crossing the future Sabajo-Merian Haul Road was sampled where it crossed the southern road (SAB11).

Table 4.11-2 Locations and Descriptions of Sites in the Sabajo Study Area

Location code	Geo-coordinates	Locality	Ecological habitat	Disturbance history
TEM1	05.30447N 54.61958W	Middle Tempati	Small river	Moderate (upstream)
TEM2	05.09.002N 54.36.501W	Upper Tempati near Merian	Large stream	Informal mining in tributaries
KC	05.10.554N 54.47.756W	Kleine Commewijne at TAKT NV	Small river	Upstream informal mining (S. Barbara)
SAB1	05.08.999N 54.36.494W	Small creek at road crossing near camp	Small stream	Upstream informal mining
SAB3	05.10300N 54.80638W	Seasonal / ephemeral forest creek	Very small, ephemeral forest creek	None
SAB5	05.10671N 54.79928W	Medium stream at northern road crossing	Large stream	Informal mining
SAB5u	05.05.052N 54.48.144W	SAB5 upstream at southern road	large to medium-sized stream	Informal mining
SAB6	05.11019N 54.78188W	2nd stream crossing northern road	Medium-sized stream	Informal mining
SAB6u	05.08898N 54.75888W	SAB6 upstream at southern road crossing	Medium-sized stream	Informal mining
SAB11	05.08809N 54.78025W	Small stream crossing southern road	Small forest creek	Informal mining down and upstream

N = north; W = west; S = south.

Methodology

Stream sampling took place in two periods, 11 to 16 July 2017, representing the high-water rainy season conditions, and 20 to 27 September 2017, representing low-water dry season conditions.

Global Positioning System (GPS) coordinates were recorded for each sampling site, followed by a visual assessment and photographic documentation of physical disturbance, water quality measurements (temperature, dissolved oxygen, conductivity, pH, Secchi transparency and turbidity), and samples of the biotic communities of plankton, aquatic invertebrates and fishes. Water temperature and dissolved oxygen were measured with a YSI Ecosense DO200A meter; conductivity was measured with a YSI Ecosense EC300A meter; pH was measured with an YSI Ecosense PH10A meter and turbidity was measured with a LaMotte 2020 meter. Secchi transparency was assessed with a Secchi disc.

Fishes and macro-invertebrates were identified and counted in the laboratory. Fish were weighed to the nearest 1 gram (g). Identifications were made to the lowest taxonomic level possible. For fish and macro-crustaceans this usually meant to species.

Data analyses

Numbers and wet mass of each individual fish species in a sample were converted to proportions of the total sample to quantitatively assess differences among streams and to compare the present data with catches in other surveys (e.g., Mol and Van der Lugt 2012). Proportions (in biomass or numbers) of total sample belonging to *i*th species (p_i) were used to calculate species diversity for each stream with the Shannon-Wiener index $H = -\sum(p_i)*(\ln p_i)$ (Krebs 1989). Evenness (*J*), which quantifies unequal representation of species (dominance, uncommonness) against a hypothetical community in which all species are equally common, was calculated as $J = H/H_{max}$, where H_{max} is the maximum possible diversity in a community with *S* species (i.e., $H_{max} = \ln S$) (Krebs 1989).

4.11.2.3 Flora Methods

Study sites

Botanical surveys were carried out at the 14 sites where plots were installed for the habitat/vegetation study (see above). Surveys were carried out within and in the vicinity of the plots, and then were extended by collecting fertile plants in the areas between the sites.

Methodology

Fieldwork was conducted from 26 August to 2 September 2017 during the dry season.

Herbarium vouchers (preferably with reproductive material) were collected and processed for those subcanopy species for which positive identifications were not possible in the field. This included terrestrial herbs, shrubs, treelets, vines and lianas with branches and fertile parts at reachable height, accessible epiphytes and bark climbing species. In contrast, unidentified tree seedlings, saplings and juveniles were not vouchered. Instead, their vicinity was searched in order to find material that could help with formal identification needed to complete the species list for the tree canopy layer. Materials helpful in this regard included fallen fruits, flowers, leaves and fresh fallen branches from the tree crown layer, and sometimes fallen or logged mature trees. Two hundred and sixteen plant vouchers were collected, prepared, and pressed on site. A complete set of samples was given to the National Herbarium of Suriname reference collection at BBS – University of Paramaribo. A second duplicate set was sent to the CAY reference collection. Some single samples from BBS were sent on loan to other institutions for an in-depth identification process by relevant experts.

4.11.2.4 Birds Methods

Study sites

Bird surveys were carried out at 13 of the 14 plots installed for the habitat/vegetation study. All 13 plots were surveyed for birds on at least one day during each site visit by the bird survey team.

Methodology

Bird surveys were conducted from 6 to 12 July and 10 to 16 October 2017, during Suriname’s long rainy and dry seasons, respectively.

Birds were surveyed using the ten-species or MacKinnon list technique (MacKinnon and Phillips 1993; Herzog et al. 2002; MacLeod et al. 2011). Under this methodology, an observer walks slowly through targeted habitats or areas and lists individual birds as they are encountered. The resulting complete list is subsequently divided into ten-species sampling units, which are used to derive estimates of diversity and community similarity. For further explanation of this technique, see Herzog et al. (2016).

Ten-species lists were generated for each of the 13 sites that were visited. Individuals encountered elsewhere in the concession, including in the base camp and at random points along roads, were tallied separately to provide data for estimation of total bird species richness in the entire concession area. When plots were located close to sharp habitat boundaries, individuals in adjacent habitats were not counted. To avoid overrepresentation of highly conspicuous species (e.g., toucans, Screaming Piha) in the dataset, birds more than 200 m away were not counted.

Data analyses

All diversity and community similarity statistics were derived using EstimateS (Colwell 2013). Both abundance-based (Chao 1) and incidence-based (Chao 2) diversity estimators were derived for each transect separately and for the concession area as a whole. Diversity estimates were based on extrapolation of rarefaction curves to a hypothetical maximum of 500 samples, with the upper abundance limit for rare species set at two (to reflect the fact that many bird species in tropical forest are rarely observed). Community similarity (Chao's estimator for Chao's Sørensen abundance-based similarity index; Chao et al. 2005) was calculated for all pairwise transect combinations. Community similarity was also estimated for forest versus secondary and slope/hilltop versus valley/marsh transects, based on pooled samples from transects classified as such (see above).

4.11.2.5 Mammals Methods

Study sites

Small mammals were surveyed at 3 sites for 6 days each. These sites were a subset of those established for the habitat/vegetation study. The three sites are:

- Sites A1 and AF1 were combined because of their close proximity; A1 had medium tall, lightly disturbed forest on sandy or loamy soil in an undulating broad depression; AF1 had medium-tall, lightly disturbed swamp-marsh forest in a narrow creek valley.
- F2 was not surveyed directly because the road to the site was blocked by a treefall. Instead small mammals were surveyed nearby F2 along an adjacent road.
- F5 was tall, lightly disturbed forest on lateritic soil in hilly terrain.

Camera traps were set at 4 sites for approximately 5 weeks in the Kleine Commewijne watershed of the Sabajo study area. These sites were also a subset of those established for the habitat/vegetation study. The four sites were:

- AF1 (described above);
- C1 was medium-tall, lightly disturbed forest on sandy soil in a broad depression of low-lying, undulating land that was mostly marshy;
- E1 had tall, lightly disturbed forest with lateritic soil on slopes and hilltops; and
- F8 was disturbed roadside vegetation with low, secondary forest on hilly slopes.

See Map 4.11-3 for a map of the study sites.

Methodology

The mammal baseline study for the Project was conducted from 12 to 29 September 2017.

To sample bats, mesh mist nets were set in the forest along transects and in clearings near the forest edge. Aluminum box-style Sherman traps were placed on the ground and in trees for rats and mouse opossums (Lim and Pacheco 2016). Wire box-style National traps were set for larger opossums at the base of large trees with vines. Large mammals observations were documented by (i) the baseline survey team during fieldwork (ii) by interviewing mining staff about any mammal encounters they had, and (iii) camera traps that were set from 27 August to 30 September 2017.

Large mammals are easier to identify than small mammals because large mammals are better known and have fewer species. In general, visual confirmation of species is possible for large mammals by sightings or photographs (Emmons and Feer 1997). In contrast, some groups of small mammals need more detailed examination including comparison of museum voucher specimens and analysis of Deoxyribose Nucleic Acid (DNA). In order to document the small mammal diversity of the Sabajo area, and to ensure scientific veracity, a reference collection of small mammals was made for this study and was deposited at the University of Suriname's National Zoological Collection of Suriname and the Royal Ontario Museum. The specimens will be available to the international community for research. The use of wild mammals for research in this study followed the guidelines of the American Society of Mammalogists (Sikes et al. 2016).

Data analyses

Baseline data derived from the mammal surveys included the estimation of species diversity and relative abundance of mammals. Biodiversity measures such as species accumulation curves, estimated species richness, species diversity indices, and shared species between sites were computed using EstimateS Version 9 (Colwell 2013).

4.11.2.6 Amphibians and Reptiles Methods

Study sites

A total of 4 transects and 13 localities (pots) were included in the surveys (Map 4.11-1). As mentioned above, the eastern portion of the proposed Sabajo-Merian transportation corridor was inaccessible in 2017.

Methodology

This study used standard protocols for herpetological fieldwork in Suriname. Surveys were performed from 18 to 24 July (rainy season) and from 10 to 16 October (dry season).

The field sampling of amphibians and reptiles involved:

- visual and aural (call) surveys of species during both night and day;
- collections of species that require further identification in the lab;
- at each location, recording/sampling along a trail of ca. 0.3 to 0.5 kilometers (km) in length or at single location (pot) along the road; and
- digital photographic documentation of amphibian and reptile species observed (if possible).

Data analyses

Shannon-Wiener Index, Simpson's Diversity Index, and Simpson's Evenness index, were calculated for amphibians at each survey location. Sample sizes were insufficient to calculate these indices for reptiles.

4.11.3 Field Study Results

4.11.3.1 Terrestrial Habitats

Complete raw habitat survey data are presented in Appendix 4A, Table 4A-2. Habitat pictures from each site are presented in Appendix 4A, Figure 4A-1. Complete raw vegetation survey data are presented in Appendix 4A, Table 4A-3.

The 8 large (0.1 ha) habitat/vegetation plots located in dense, mature natural forest documented (Table 4.11-3):

- 131 large tree species and 27 large liana taxa;
- High variation in the density of large tree stems and lianas, ranging from 44 stems/0.1 ha in plot F7 to 89 in plot E1 for trees, and 14 in plot E1 to 33 in plot A1 for lianas;

- High variation in large tree and liana species/taxon richness, ranging from 15 species in plot A/F1 to 41 in plot C2 for trees, and from 8 in plot E1/F5 to 15 in plot C1 for lianas; and,
- High variation in large liana and tree species diversity (Fisher alpha scores), ranging from ~7 in plot A/F1 to ~44 in plot C2 for trees, and from ~5 in plot F5 to ~12 in plot C1.

The 3 small (0.025 ha) plots in creek forest (plot M1) and heavily disturbed ruderal/secondary vegetation (plots B5 and B6) documented (Table 4.11-4):

- 7 large tree species and 6 large liana taxa;
- Low density of large tree stems, ranging between 0 - 3 stems/0.1 ha at the heavily disturbed plots with ruderal vegetation, and slightly higher (5 stems/0.1 ha) in secondary forest;
- Low large tree species richness, ranging from between 0 and 2 species at the heavily disturbed plots and 5 at the secondary forest plot;
- A density of large liana stems between 0 and 4 stems/0.1 ha at the heavily disturbed plots, and 6 at the secondary forested plot; and
- Low large liana taxon richness, ranging from between 0 and 3 taxa at the heavily disturbed plots, and 3 at the secondary forest plot.

Small plot sizes and the partially treeless character of the vegetation at two of the plots (B5 and B6) meant that it was not possible to calculate robust estimates of species diversity for disturbed vegetation.

Appendix 4A presents a number of descriptive statistics for the plots, including:

- Table 4A-4 showing the relative abundance of all mature tree families in the plots;
- Table 4A-5 showing the relative abundance of all mature liana families within the plots;
- Table 4A-6 showing the number of liana stems, per taxon, per plot;
- Table 4A-7 showing the number of tree stems, per taxon, per plot; and
- Table 4A-8 showing the openness of plot segments.

Table 4.11-3 Diversity of Large Trees and Lianas in 8 Large Plots[a] in Mainly Natural Vegetation in the Sabajo Study Area in 2017

Plot	Density/abundance: No. of stems/0.1 ha		Observed richness: No. of species or taxa/0.1 ha		Richness index: Fisher's alpha	
	Trees	Lianas	Trees	Lianas	Trees	Lianas
A/F1	54	17	15	9	6.87	7.75
A1	60	33	29	13	22.09	7.91
C1	61	30	20	15	10.36	11.93
C2	68	-	41	-	43.66	-
F1	54	32	31	10	30.28	4.99
F7	44	21	26	9	26.70	5.96
F5	55	19	32	8	31.98	5.2
E1	89	14	40	8	27.94	7.75
Total			131	27		

a) 0.1 ha in relatively undisturbed forest
ha = hectare; No. = number.

Table 4.11-4 Diversity of Large Trees and Lianas in 6 Small Plots[a] in Mainly Disturbed Vegetation in the Sabajo Study Area in 2017

Plot	Density/abundance: No. of stems / 0.025 ha		Observed richness: No. of species or taxa/0.025 ha	
	Trees	Lianas	Trees	Lianas
F8	5	6	5	3
F9	3	4	2	3
F6	0	0	0	0
F4	0	0	0	0
F3	0	0	0	0
F2	0	0	0	0
Total			7	6

a) 0.025 ha in ruderal non-forests vegetation (all plots except F8) and secondary forest (F8) ha .

ha = hectare; No. = number.

A Typology for Habitats/Vegetation for the Project Area

The results of the Non-metric Multidimensional Scaling and Cluster analyses incorporating mature tree and liana data, understory plants, and plants from non-forest environments yielded similar groupings of the 14 plots. These findings, along with the abiotic, structure and disturbance measurements form the basis of a habitat/vegetation typology for the Project study area. Five habitat/vegetation types were recognized in forested areas that were (seasonally) flooded or waterlogged, and three in forested areas that do not flood or become waterlogged for prolonged periods of time. The habitat/vegetation types are presented in Table 4.11-5. Appendix 4A, Figure 4A-1 presents vegetation profiles for each vegetation types, and Appendix 4A, Figure 4A-2 presents data on the relative importance of tree families for each habitat/vegetation type.

Table 4.11-5 Terrestrial Habitat/Vegetation Typology for the Sabajo Study Area

Type	Habitat Description	Vegetation Description	Location
Lowland Forrest (~0-400 m alt.)			
Flooded (poorly drained / waterlogged)			
Marsh forest in floodplain	Tall forest in wide valleys – terraces of major creeks; deep soil that seasonally floods (at least large part of soil seasonally waterlogged)	Hydrophytic palms *Euterpe oleracea* and *Socratea exorrhiza* present; Lecythis corrugata very abundant (many large individuals) in marshy parts. drier parts with typical high dryland tree species.	**Type C2** Floodplain of the Kleine Commewijne and major tributaries
		Hydrophytic trees expected abundant not yet studied	Floodplain of the Tempati and major tributaries
Creek forest	Tall forest in narrow creek valleys, encased by lateritic hills; deep sandy / loamy soil that is mostly flooded / waterlogged perennially	*Euterpe oleracea* very abundant, as well as many other hydrophytic trees, such as *Tabebuia insignis* and *Pterocarpus officinalis*. Understory with abundant *Monotagma spicatum* and *Geonoma baculifera*, rich in epiphytes and scandent herbs with epiphytic tendencies	All smaller creek valleys, not destroyed due to small-scale mining activities
Wet savanna forest on sandy soil (with xeric aspect)	Tall forest in wide depressions with creeks; deep, flooded / water-logged white / bleached sand soil	Tall hydrophytic palm *Euterpe oleracea* abundant, and locally also the understory palm *Elaeis oleifera*. Typical white sand savanna forest trees present such as *Licania divaricata*.	**Type C1** Local depression(s) in the landscape (certainly 1 in the northeastern part of the Sabajo Concession; possibly another one in the southeast)

Table 4.11-5 Terrestrial Habitat/Vegetation Typology for the Sabajo Study Area

Type	Habitat Description	Vegetation Description	Location
Marsh forest on loamy soil	wide depression with creeks; deep, loamy soil (large part flooded / water-logged in rainy season)	Hydrophytic palm *Euterpe oleracea* present; *Lecythis corrugata* abundant. Some typical high dryland forest trees also present (at drier spots). Understory very rich in palms and Marantaceae.	**Type A** Large depression at the southern margin of the Sabajo Concession.
Dryland (well drained)			
Dry mountain savanna forest on duricrust (xeric to meso-xeric?)	Dolerite ridges with shallow soil over (possibly intact) duricrust	Fairly small-medium sized trees of families Myrtaceae and Euphorbiacae should be present / abundant alongside other xerophytes. (not yet studied.)	Two (maybe 3) isolated dolerite ridges in the landscape, in the central part of the study area (between the Sabajo Concession and the Tempati Creek)
High dryland forest (mesic)	Tall forest on low hills and slopes of taller hills; soil deep, but gravely / rocky (probably no duricrust in the soil)	Large tree families Lecythidaceae, Mimosaceae and Caesalpiniaceae are co-dominant; many other families are also represented. Many of these trees present: *Bocoa prouacensis*, *Lecythis idatimon*, *Eschweilera* sp. ("bergi manbarklak"), *Hirtella obidensis*, *Excellodendron barbatum*, *Catostemma fragrans*, and *Virola michelii*. Young *Oenocarpus* spp. palms, adult *Astrocaryum paramaca* and *Attalea microcarpa* palms often present / abundant in the understory.	**Type F** Low hills and slopes of tall hills
	Tall forest, often with high (large) tree density, on tops of tall hills with shallower, more gravely / rocky soil (probably underlain by compromised duricrust)	Same as previous but hardwood trees such as *Bocoa prouacensis* more numerous. These trees also present: *Aniba megaphylla*, the palm *Oenocarpus* sp. (new species), and cf. *Oxandra asbeckii.*	**Type E** Tops of taller hills
Disturbed Vegetation (all altitudes)			
Young secondary vegetation (ruderal vegetation and young secondary forest)	(Largely) treeless 'open' vegetation on non-flooded / waterlogged soil	No or hardly any mature trees, but often abundant young pioneer trees such as *Cecropia* cf. *peltata, C. sciadophylla,* and *Goupia glabra.* Much of the ground covered with the fern *Pityrogramma calomelanos*, the lycopod *Lycopodiella cernua*, and the herbs *Chelonanthus alatus*, *Miconia racemosa*, *Solanum subinerme*, *S. jamaicense*, *Spermacoce* cf. *oligodontha, Comolia* sp., *Hyptis lanceolata*, and *Lindernia* sp. At these drier locations *Palicourea guianensis* and *Sabicea* spp. were recorded.	Entire study area Drier parts of areas affected by small-scale mining; also dry roadsides
	(Largely) treeless 'open' vegetation on (seasonally) flooded / water-logged soil	Same as previous, but hydrophytic herbs more abundant, such as *Fimbristylis* sp., *Xyris fallax*, and the very abundant *Ludwigia octovalvis.*	Entire study area Wetter part of areas affected by small-scale mining; also roadsides near creek crossings
Older secondary forest	Forest with a low or irregular canopy (mostly on well-drained soil)	Large trees tend to be typical secondary forest trees such as *Inga* spp.	Probably entire study area, but very patchy, at roadside locations intensively used in the past by loggers

m = meter; alt. = altitude; ~ = approximately.

Based on the typology described in Table 4.11-5 a provisional map of the terrestrial habitats/vegetation of the study area was developed (Map 4.11-2).

The extent of each habitat type is shown in Table 4.11-6. High dryland forest is the dominant vegetation type, comprising more than 50 percent (%) of the 18,782 ha study area. Note that here "high" refers to the size of trees and not elevation. The four seasonally flooded forest types together comprise 34.7% of the area, while 6.3% of the vegetation has been disturbed by ASM.

Table 4.11-6 Extent of Different Habitat/Vegetation Types in the Project Study Area

Habitat/vegetation type	Area (ha)	% of Total
High dryland forest	10,757.8	57.3%
Marsh Forest in Floodplain (Kleine Commewijne)	1,642.9	8.7%
Marsh Forest in Floodplain (Tempati)	1,218.0	6.5%
Marsh Forest on Loamy Soil	1,622.4	8.6%
Creek Forest	1,498.1	8.0%
Secondary Forest / Disturbance	1,174.9	6.3%
Wet Savannah Forest on Sandy Soil	527.5	2.8%
No data	296.3	1.6%
Dry Mountain Savannah Forest on Duricrust	43.7	0.2%
Total	18,781.7	100%

Note: The two types of disturbed vegetation are combined
% = percent; ha = hectare

Main differences from the Merian Project area are less high dryland forest, less savanna forest and more marsh forest (ERM 2013).

Biodiversity Values of Note

Features of note include wet savanna forest habitat on sandy soil, which had a large population of the palm *Elaeis oleifera*, a species of conservation interest (see Flora results below); in high dryland forest on tall hills with shallow soil, at least in the central part of the study area, the new-to-science and likely restricted range endemic palm *Oenocarpus* sp. was present, also a species of conservation interest.

4.11.3.2 Aquatic ecosystems

Appendix 4B presents descriptive information on the ten sampling sites. Appendix 4B, Figure 4B-1 contains photos that illustrate the range of conditions sites sampled for this study, while Appendix 4B, Table 4B-1 presents habitat characteristics and water quality data.

Phytoplankton/zooplankton Communities

Appendix 4B, Table 4B-2 presents qualitative and quantitative information on phytoplankton communities sampled for this study. The streams in and around the Sabajo Consession yielded 40 algae species. The algae belong to the following groups: Cyanobacteria, Chlorophyta, Charophyta, Bacillariophyta, Rhodophyta and Euglenophyta. No algae were observed in the samples of the Kleine Commewijne River, Tempati Creek and SAB6upstream. In the samples SAB6 and SAB11 few algae were observed. The phytoplankton communities of the streams SAB1, SAB5 and SAB5upstream were rich in species with 24, 17 and 5 algae species respectively. The small creek near the Sabajo camp (SAB1) had some noteworthy algae species, including desmids, diatoms, *Nitella* and *Batrachospermum*. Few zooplankton species were found in the samples, mainly rotifers and rhizopods. Based on the phytoplankton composition of the streams, SAB5 is somewhat eutrophic or rich in nutrients, the stream near the Sabajo camp SAB1 is mesotrophic, while the other streams are more oligotrophic.

Macroinvertebrates

Appendix 4B, Table 4B-3 presents quantitative information on phytoplankton communities sampled for this study. The study yielded 800 macro invertebrates comprising 80 species, collected in the two sampling periods (July and September 2017). Most specimens were collected in the upper Tempati (TEM2; 253 specimens in 17 species) in the dry season, while the small stream SAB7 had the most species (but less specimens) in the rainy season (148 specimens in 23 species) (Table 4.11-7). The upper reach of the stream SAB6 (SAB6upstream) had a high Shannon Wiener Diversity Index (2.60) in the dry season, while SAB11 had the lowest Shannon Wiener Index (0.98; rainy season). Sampling conditions in Kleine Commewijne River were difficult and resulted in a low number (4) of specimens.

Table 4.11-7 Summary of Aquatic Macro-Invertebrate Surveys

Site	Sampling period	Total number of specimens	Number of species	Diversity (*H*)
TEM1	J	27	10	1.61
TEM2	S	253	17	1.92
KC	S	4	3	1.04
SAB1	S	32	9	1.66
SAB3	J	46	10	1.72
SAB5	J	23	10	2.07
	S	8	4	1.21
	J+S	31	13	2.24
SAB5upstr	S	83	8	1.34
SAB6	J	36	11	1.96
	S	7	4	1.28
	J+S	43	13	2.13
SAB6upstr	J	46	11	1.65
	S	54	19	2.6
	J+S	100	27	2.68
SAB11	J	33	5	0.98
SAB7	J	148	23	2.27

Note: Total number of specimens, total number of species and Shannon-Wiener species diversity (H) of macro-invertebrates collected in the Tempati (TEM1 and TEM2, respectively), Kleine Commewijne River (KC) and streams in and near the Sabajo Concession (Upper Kleine Commewijne River Catchment) during surveys in July (J) and September (S) 2017.

Fishes

Appendix 4B, Table 4B-5 presents quantitative information on fish communities sampled for this study. Surveys documented 71 species of fish at the ten sampling sites. Fish species richness (number of species) and diversity was highest in the Tempati (Table 4.11-8). The number of fish species seen was less that the 105 observed during the Merian Environmental and Social Impact Assessment (ESIA; ERM 2013). The upper Tempati (TEM2) had some fish species (*Lithoxus*, *Hypostomus*) that appeared to benefit from gravel substrate in a short reach of the stream originating from gold mining. The fish community of the Kleine Commewijne River had relatively many *Eigemannia* glass knifefishes, a feature which Mol and Ouboter (2004) associated with a high suspended sediment concentration (high turbidity, low transparency) which favour fishes that are not visually-oriented (e.g., knifefishes and catfishes).

There are no settlements in the study area and sport fishing was not observed. Large food fish species are present in the larger streams Tempati, upper Kleine Commewijne and its main tributary SAB5. Semi-commercial fishing has been observed in the village Peninica (Java) at the junction of the Tempati and Kleine Commewijne River (J. Mol, personal observations). This concerned the collecting of ‘swamp fishes’ (the erythrinids walapa and pataka, the cichlids krobia and datrafisi, the catfish kwikwi, etc.) in dry-season pools in the floodplain of the lower Tempati Creek and lower Kleine Commewijne River. It is possible that some sport fishing occurs on the lower Tempati Creek and lower Kleine Commewijne River.

Table 4.11-8 Summary Results for Fish Communities

Site (sample period)	Number / Mass	Total number of specimens / mass (g)	No. of species	Diversity (*H*)	Evenness (*J*)
TEM1 (J)	N	226	43	3.29	0.88
	M	11,135	-	2.28	0.61
TEM2 (S)	N	179	36	3.03	0.85
	M	6,564	-	1.2	0.34
KC (S)	N	297	30	2.67	0.79
	M	11,106	-	0.81	0.24
SAB1 (S)	N	140	16	2.5	0.9
	M	263	-	1.45	0.52
SAB3 (J)	N	38	6	1.54	0.86
	M	10	-	1.61	0.9
SAB5 (J+S)	N	142	22	2.28	0.74
	M	6,495	-	0.41	0.13
SAB5upstr (S)	N	64	17	2.5	0.88
	M	172	-	2.01	0.71
SAB6 (J+S)	N	165	24	2.21	0.7
	M	145	-	2.7	0.85
SAB6upstr (J+S)	N	121	20	2.25	0.75
	M	284	-	1.86	0.62
SAB11 (J)	N	90	16	2.18	0.79
	M	87	-	2.05	0.74

Note: Including number of specimens, wet mass (g), number of species, diversity and evenness of fish communities in the two collection periods, 11-16 July 2017 (J) and 20-27 September 2017 (S).

N = number; M = mass; g = gram; No. = number; - = not applicable.

Stream integrity

The results of the baseline data can be summarized using expert judgement to derive a qualitative measure of stream integrity (Table 4.11-9) that includes stream morphology, water quality, phytoplankton, aquatic macroinvertebrate and fish communities. The basis of this approach is to compare observed/measured data from the surveys to what would be expected in a pristine stream of the same size and geomorphological setting. For example, a large number of species (including large-sized species) of fishes is expected in a large to medium-sized stream (Tempati, Kleine Commewijne, SAB5) whereas only few, small-sized fishes are expected in a tiny ephemeral forest creek (SAB3). Observations like needlefishes in nuptial colors contribute positively to the condition of the stream, while the presence of numerous fish lice on the anyumara of SAB5 contribute negatively.

Table 4.11-9 Qualitative Subjective assessment of the Integrity of the Streams In and Near the Sabajo Concession and Streams Crossing the Sabajo-Merian Haul Road

Watershed	Site	Stream morphology	Water quality	Phyto-plankton	Aquatic invertebrates	Fishes	Overall Quality
Middle and upper Tempati and upper Kleine Commewijne	TEM1	+	+	ND	o	+	+
	TEM2	--	-	-	+	-	-
	KC	-	--	-	-	-	--
Unnamed streams in the upper Kleine Commewijne River Catchment	SAB1	-	-	+	+	+	+
	SAB3	+	+	ND	o	+	+
	SAB5	-	--	-	o	-	-
	SAB5u	--	-	+	o	-	--
	SAB6	-	--	--	o	-	--
	SAB6u	-	+	o	+	+	+
	SAB11	-	+	o	+	-	-

Note: Based on on-site characteristics of (1) stream morphology (presence of gold miner ponds, fine sediments or gravel on the streambed, riparian vegetation), (2) water quality (turbidity/Secchi, conductivity, DO, pH), phytoplankton (Nitella, desmids, Euglenophyta, Cyanobacteria), (3) aquatic macro-invertebrates (Ephemeroptera, Trichoptera, Plecoptera, Nemoptera) and (4) fishes (colors, parasites, diversity, abundance of knifefishes etc). Variables are assessed as indicative of pristine (+), moderately disturbed (-) or severely disturbed (--) conditions; ND = No Data available; o = no opinion.

Biodiversity Values of Note

No macroinvertebrates or fish species new to science or threatened according to the IUCN Red List were documented in the baseline.

Although it is known to occur in the Upper Tempati Catchment (Mol and Van der Lugt 2012, photograph in Mol 2012), a rare, enigmatic cetopsid catfish (*Cetopsis* sp), was not collected during the present survey. This species is previously known in Suriname from only two specimens collected during baseline studies for the Merian ESIA in a tributary of Tempati Creek.

The Commewijne River contains three endemic fish species. Two species (*Peckoltia* sp and *Panaqolus* sp) are only known from a single specimen each collected during studies, unrelated to this ESIA, in the blackwater Mapane Creek that is outside the study area. The third endemic is a *Corydoras* species (aff. oxyrhynchus) that was collected at the junction of the Kleine Commewijne River and Tempati Creek for this study.

In July, a slender plar'plari species (*Ageneiosus ucayalensis*) was collected in the middle Tempati; this species was previously known in Suriname only from the Corantijn River (Mol 2012); it has never been caught by the authors and is not known from the Commewijne River (Mol 2012). A second interesting species is *Piabucus dentatus*; this elongated characin is seldom caught in Suriname (the baseline survey team catch a single specimen every 2 years) but proved relatively abundant in the upper Commewijne River (sites TEM2, SAB5 and SAB6).

4.11.3.3 Flora

The floristic survey identified 370 vascular plant species belonging to 105 plant families: 72 Dicotyledon families, 17 Monocotyledons, 17 Fern and related families (pteridophytes) (Appendix 4C, Table 4C-1 presents a complete list of the species that were documented by the floristic survey). Species accumulation curves suggest that a considerable number of additional species remain undocumented in the study area (Appendix 4C, Figure 4C-1). This finding is also supported by the Merian Project ESIA results, where 613 species of plant were recorded (ERM 2013).

The number and proportion of species by life form are shown in Table 4.11-10. Trees represented nearly a third of species documented in the study area, while herbs, shrubs and treelets together accounted for 46.3% of species.

Table 4.11-10 Number and Proportion of Plant Species by Life Form

Life form	No. of species	Relative importance (% total species)
Trees	112	30.4%
Herbs	102	27.6%
Shrubs & treelets	69	18.7%
Lianas (woody climbers)	32	8.7%
Epiphytes	19	5.1%
Vines	5	1.4%
Understory palms	9	2.4%
Tree ferns	5	1.4%
Tree palms	5	1.4%
Stemless palms	3	0.8%
Saprophytes	2	0.5%
Climbing palm	1	0.3%
Miscellaneous	5	1.4%

% = percent; No. = number.

Biodiversity values of note

In the course of floristic surveys the following four species potentially new to science were documented:

- *Anathallis* aff. *ciliolate* (Orchidaceae), a herbaceous epiphyte, found in High Dryland Forest
- *Lundia* sp. nov (Bignoniaceae), a liana, found in High Dryland Forest
- *Oenocarpus* sp. nov (Arecaceae), a tree palm, found in High Dryland Forest
- *Clidemia* sp. *nov. ? (affine Hirta ?)* (Melastomataceae), a shrub found in High Dryland Forest

These species require further study to resolve their taxonomy and better understand their distribution.

The floristic survey also documented some plant species of economic importance. Of particular note was the American oil palm *Elaeis* aff. *oleifera* (Kunth) Cortés (Arecaceae), a stand of which was located in Wet Savannah Forest on Sandy Soil.

According to a Guianas palm specialist, the Suriname and French Guiana populations belong to a different sub-species than those from central Amazon basin and Central America. When this taxonomic group is revised, the Guianan populations may be classified as *Elaeis oleifera subsp. guianensis* (de Granville pers. com. 2017), a distinct Guianese strain of the American Oil Palm. This sub-species represents a genetic resource of potential economic importance for oil palm, which is planted extensively in plantations in tropical regions around the world. In addition to the oil palm, a number of economically important timber species were documented in the study area, two of which are classified as globally endangered by IUCN (*Virola surinamensis* IUCN Endangered; *Vouacapoua americana* IUCN Critically Endangered). Two species of trees are protected by Suriname forestry law: *Dipteryx odorata* and *Copaifera guyanensis.*

The floristic survey also documented other species of lesser conservation interest based on considerations of economic potential, endemism, and degree of threat. Appendix 4C, Table 4C-2 presents a short list of these species. All of these species of note may be suitable candidates for management during construction and incorporation into restoration and reclamation programs. This is particularly the case when dense populations of these species present.

4.11.3.4 Birds

Species Richness and Diversity

Field surveys documented 249 species of birds on the 13 sites visited in the Project study area (Table 4.11-11; see Appendix 4D, Table 4D-1 for a complete list of species observed in the Project area). These results, supplemented by observations elsewhere in the study area, suggest that the complete resident avifauna of the study area comprises between 300-350 species. For comparison, the Merian ESIA (ERM 2013) documented 237 bird species. Estimates of species richness were higher for forest plots (193 observed species) than for those in secondary habitats (155 observed species), while species richness estimates were similar for dryland forest (191 observed species) and seasonally inundated forest (189 observed species) (Appendix 4D, Figure 4D-1).

Community (taxonomic) similarity was high between transects in forest and those in secondary vegetation, and between transects on dryland (slopes and hilltops) and those in marsh or creek valley situations (Appendix 4D, Figure 4D-2).

Table 4.11-11 Sampling Effort and Observed Species Richness for Birds in the 13 Study Plots

Location Code	Landscape aspect	Structure	Number of ten-species samples	Number of species
A1	Slope/Hilltop	Forest	12	74
AF1	Valley/Marsh	Forest	9	60
C1	Valley/Marsh	Forest	11	67
E1	Slope/Hilltop	Forest	14	91
F1	Slope/Hilltop	Forest	21	119
F2 & F3	Valley/Marsh	Secondary	9	67
F4	Valley/Marsh	Secondary	7	55
F5	Slope/Hilltop	Forest	18	110
F6	Valley/Marsh	Secondary	18	90
F7 & F8	Slope/Hilltop	Forest	13	81
F9	Valley/Marsh	Secondary	16	90

In general, comparing transects in forest and secondary habitats indicates more overlap in species composition and smaller differences in estimated diversity than expected. This was not due to widespread invasion of forest habitats by secondary forest species (or vice versa), but rather, the rarity or absence of many forest bird species due to the pervasive degradation of forest, which was evident virtually everywhere surveyed. The forest avifauna was notably lacking understory and canopy mixed-species foraging flocks; antbirds that have obligate associations with army ants; and large-bodied frugivores that disperse seeds of rainforest trees, such as tinamous, guans, and curassows. There was also a scarcity of birds of prey, terrestrial insectivores, and large parrots. These observations were consistent between the July and October surveys. All of the aforementioned species groups should be common in extensive lowland forest in Suriname and are indicative of a healthy, functioning forest ecosystem. That they are evidently so rare in Sabajo is an indication that the area has experienced at least moderate ecological disruption as a result of small-scale logging and mining activity, signs of which were ubiquitous throughout the survey area.

Biodiversity values of note

Despite the widespread degradation of habitat in Sabajo, a few notable bird species were observed. Of particular significance was an observation of Harpy Eagle (*Harpia harpyja*; IUCN Near Threatened) during the October survey. Of the 249 species observed during the two survey periods, 34 are endemic to the Guiana Shield. The majority of these, such as the Guianan Warbling-Antbird (*Hypocnemis cantator*) are forest species that persist in Sabajo. The proportion of endemics in the study area (~13.7%) was roughly equal to that found in less disturbed lowland forest areas of the Guiana Shield (O'Shea *in press*), suggesting that forested habitats in Sabajo retain value for regional endemic birds. Most of the endemic species encountered are readily found in lowland forests of the Guiana Shield and have broad geographic ranges within this area.

4.11.3.5 Mammals

Species Richness and Diversity

Bats: 29 species of bats (n=196 individuals) were caught in mist nets in the Project area (Table 4.11-12), which is similar to the 25 species noted during the Merian ESIA (ERM 2013). The most common was Seba's short-tailed fruit bat (*Carollia perspicillata*), a species that is the primary seed disperser of a pioneering shrub in the pepper plant genus *Piper*. Estimated total bat species richness based on netting data suggest that the bat survey is not complete and 55 species of bats may occur in the study area (see Appendix 4E, Figure 4E-1 for species accumulation curves for bats).

Terrestrial small mammals: the trapping success rate for small mammals was very low with 385 trap nights required to catch a single individual. The low capture rate is typical of the Guianas (Lim and Banda 2013) and perhaps can be attributed to the poorer soil quality of the older and more eroded Guiana Shield. Cuvier's terrestrial spiny rat (*Proechimys cuvieri*) was the only species of rat caught in Sherman traps (n=7 individuals). At up to 0.5 kg in weight, it is an important prey species for many nocturnal predators. The larger National wire traps captured just one of the common tropical opossum (*Didelphis marsupialis*). This species is an opportunistic omnivore that has a wide diet ranging from fruits to insects and carrion. Capture rates were too low to estimate total small terrestrial mammal species richness. See Appendix 4E, Table 4E-1 for a complete list of small mammals captured in the study area.

Large mammals: 25 species of large mammals (monkeys, carnivores, rodents, sloths, anteaters, armadillo, deer, peccaries, and tapir) directly observed during baseline surveys and/or observed by mine staff on site and/or photographed by camera traps (see Appendix 4E, Table 4E-2 for a complete list of large mammals documented in the study area). In 210 camera trap nights, 57 mammals were photographed. The red-rumped agouti (*Dasyprocta leporina*) was the most commonly photographed species and represented 40% of photos. The next commonest was the long-nosed armadillo (*Dasypus* spp.), but Kappler's long-nosed armadillo (*Dasypus kappleri*) and the nine-banded armadillo (*Dasypus novemcinctus*) could not be differentiated in the photos. The collared peccary (*Tayassu tajacu*) was the third most frequently photographed mammal. In total 11 species of large mammal were photographed. Estimated total large mammal species richness for the Project site based on these data suggest that 14-15 species are potentially present and photographable. Another 14 species were identified visually either by the baseline survey team or by Sabajo mine staff. Mine staff most frequently identified rumped agouti (*Dasyprocta leporina*), collared peccary (*Tayassu tajacu*), red brocket deer (*Mazama americana*), and golden-handed tamarin (*Saguinus midas*).

Table 4.11-12 Biodiversity Values for Mammals from the Sabajo Environmental Assessment in Suriname

Type of mammal	Site	Individuals	Species	Net/trap-nights	Estimated average richness	Shannon diversity index
Bats	A1/AF1	35	15	85	27.4	2.2
	F2	87	19	62	32.4	2.2
	F5	74	19	80	24.2	2.5
	Total	196	29	227	55.4	2.58
Rats and Opossums	A1/AF1	1	1	1056	-	-
	F2	2	2	984	-	-
	F5	5	1	1038	-	-
	Total	8	2	3078	-	-
Large Mammals in Camera Traps	AF1-0	18	8	35	14.4	1.8
	AF1-C4	1	1	35	-	-
	C1-C2	11	4	35	5.8	1.0
	E1-C1	14	4	35	3.8	1.3
	E1-ESS1	5	3	35	5.0	1.0
	F8-C3	8	3	35	3.6	0.9
Total		57	11	210	14.5	1.8

- = sample size too small to calculate

Biodiversity Values of Note

The mammal surveys did not document any species considered as Endangered or Critically Endangered by the IUCN Red List, although several species assessed at lower threat levels were documented (IUCN has assessed the giant anteater, lowland tapir, and the Guiana spider monkey as Vulnerable, and the jaguar as Near Threatened). Other mammals of conservation interest include the relatively rare, large carnivorous greater false vampire bat (*Vampyrum spectrum*), which was caught in a net set in a highly disturbed area. Four of the 8 species of primates that occur in Suriname were observed during the field survey, indicating that some species of large mammals sensitive to hunting pressure are still resident in the Sabajo area.

4.11.3.6 Amphibians and reptiles

Species Richness and Diversity

Complete species lists from fieldwork are presented in Appendix 4F for transects (Table 4F-1) and pots (Table 4F-2). Fourty-three species of amphibians (all Anura) and 17 species of reptiles (12 lizards, 2 snakes, 1 turtle and 2 caimans) were found (Table 4.11-13 and 4.11-14). This compares with 61 species noted during the Merian ESIA (ERM 2013). ASM had significantly disturbed most creek valleys. As a consequence, in most areas the survey team found an amphibian fauna typical of disturbed open areas with stagnant pools or swamps. Only two transects in relatively undisturbed forests showed a richer herpetofauna (Transects 1 and 2). Transect 1 was the richest with 21 species of amphibians, followed by Pot 4 (18 species) and Pot 3 (16 species). Transect 3 was the poorest locality with only 1 amphibian species.

Table 4.11-13 Species Richness of Amphibian and Reptile Communities at Sabajo Mining Area Transects and Additional Observations

Taxonomic Group	Transect 1		Transect 2		Transect 3	Transect 4		Additional observations (R)
	R	D	R	D	R	R	D	
AMPHIBIANS	21	0	14	0	1	8	0	0
REPTILES	3	4	5	4	1	0	0	7
Lizards	2	3	3	4	1	0	0	6
Snakes	1	1	2	0	0	0	0	0
Turtles	0	0	0	0	0	0	0	1
Crocodilians	0	0	0	0	0	0	0	0

Note: R – rainy season; D – dry season.

Table 4.11-14 Amphibian and Reptile Species Found at Sabajo Mining Area Localities (Pot's)

Taxonomic Group	Pot number																				
	1		2	3		4		5		6		7		7b		8 and 9		10	14	15	16
	R	D	R	R	D	R	D	R	D	R	D	R	D	R	D	R	D	R	D	D	D
Amphibians	13		5	16		18		14		8		7		9		10		3	5	2	8
Reptiles	0	1	0	0	0	1	0	1	1	1	1	0	0	0	2	0	1	0	0	1	0
Lizards	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0
Snakes	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Turtles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0

Note: R – rainy season; D – dry season.

Biodiversity Values of Note

All amphibian and reptile species were either assessed by IUCN as Least Concern or have not had IUCN conservation assessments published yet. The frog *Osteocephalus cabrerai* is a rare species over most of its distribution range including Suriname. The specimen from Sabajo is only the second found in Suriname. In a swampy forest area near basecamp (Pot 4) a species of *Anomaloglossus* (a small terrestrial frog) was heard with a call different from known *Anomaloglossus* species. This could indicate the occurrence of an *Anomaloglossus* species new to science. Although the call was recorded it was not possible to catch any individuals. At Transect 1 a *Scinax* species (a tree frog) was collected that could not be identified. It may be a species new for Suriname.

4.11.3.7 Ecosystem Services

Ecosystem services are the benefits that people derive from ecosystems, and are generally considered in three categories: *provisioning*; *regulating*, *cultural*, and *supporting*. Ecosystem service benefits to local communities and users of the Sabajo area were evaluated as part of the Cultural Resources Survey and ASM Survey (see Section 4.12 for details on methodology). In general, the surveys did not identify significant ecosystem services meriting treatment as Key Biodiversity Values, and therefore are not treated in the impact assessment and mitigation plan.

Local communities

The survey of cultural resources of local communities indicates ecosystem services of importance in proximity to villages. Both women and men collect non-timber forest products, including medicinal plants, construction materials, plants and plant parts to fabricate crafts and utensils, and edible fruits and plants (e.g., palm fruits). Sabajo is located within the traditional area of the Kawina people, however, their current land and resource use is concentrated around Java, beyond the Project's area of influence.

Artisanal and Small Scale Miners

The survey of small-scale gold miners in the study area revealed limited use of local provisioning services. Of the 16 surveyed small-scale operations, 10 reported getting all their fish and meat exclusively from Paramaribo. In four camps, one or more inhabitants hunted occasionally; once or twice a month or even less. Only in one camp, the researchers encountered an active hunter, going out at least weekly. Most gold miners who also hunt are Kawina people. Reported game included tapir (*Tapirus terrestris*), agouti (*Dasyprocta sp.*), paca (*Cuniculus paca*), deer (*Mazama americana*), peccary (*Tayassu pecari* and *Pecari tajacu*), and forest birds such as the Black Curassow (*Crax alector*). Occasionally people also find turtles or armadillos. In five camps people fished occasionally, and in two other camps fishing occurred more regularly. Most caught fish include Anjoemara (*Hoplias aimara*), piering, koebi, Tiger fish (*Hoplia malabaricus*), Krobia (*Cichlasoma bimaculatum* and *Krobia guianensis*). Like fish and meat, vegetables are mostly obtained from Paramaribo, although there is some limited garden planting around camps. Water for consumption is generally derived from wells or rainwater.

4.12 Social Baseline Summaries

Several social and community studies were undertaken to describe socio-economic, health, and cultural baseline features in the Sabajo Project (the Project) Area of Influence (AOI). The Brokopondo and Carolina communities are discussed due to their potential to be affected by Project traffic transporting people and goods to the Project area. The Project Access road has not been selected at the time of writing and thus studies were undertaken with both clusters of communities. There are two dimensions to how the Kawina people may be affected by the Project: one is that the Sabajo Project is situated on the traditional lands of the Kawina Maroon Tribe. The other issue is that the Kawina traditional communities as listed in Table 4.12-1, share the same watershed as the Sabajo Project. Artisanal and small scale mining (ASM) worksites are also present in the Project AOI and in the Project concession area.

Studies focused on stakeholder groups and communities that have the potential to be affected by the Sabajo Project, including its proposed access routes. A special study on ASM located on the proposed mine site has also been included. Table 4.12-1 displays AOI communities and stakeholder groups that were involved in the various studies:

Table 4.12-1 AOI Communities and Stakeholder Groups

Kawina Communities	Brokopondo Communities	Carolina Communities	Artisanal and Small-Scale Mining Areas
Gododrai	Afobaka Centrum	Redi Doti	Santa Barbara
Java	Asigron	Casipora	Margo
Moismoiskondre	Balingsoela	Powakka	km 34
Pennenica	Brokopondo Centrum	Philipus Kondre (Klein Powakka)	Area of Polaco
Kawina residents in Paramaribo	Boslanti	Pierre Kondre Kumbasi	
	Compagnie Kreek		
	Drepada		
	Tapoeripa		

Note: The four traditional Kawina communities (Gododrai, Java, Moismoiskondre, and Pennenica) are intermittently occupied.

This section provides summary information from each of these baseline studies:

- ‘Socio-Economic Baseline ‘Sabajo Project’’ (IGSR 2017);
- ‘Socioeconomic and Cultural Resources Survey: Carolina Communities’ (Social Solutions and ILACO 2017a);
- ‘Small-scale Mining Survey’ (Social Solutions and ILACO 2017b);
- ‘Cultural Resources Survey’ (Social Solutions and ILACO 2017c);
- ‘A Historical Narrative of Traditional Lands around the Newmont Sabajo Project’ (Artist and Rijsdijk 2017);
- ‘Tangible Heritage’ (Social Solutions and ILACO 2017d); and,
- ‘Baseline Health Status: Suriname’ (ISOS 2017).

4.12.1 Socio-Economics

4.12.1.1 Methodology

Two studies were conducted to describe socio-economic conditions in communities in the Project's AOI (Map 4.1-3). The Socio-Economic Baseline 'Sabajo Project' Final Draft Report (IGSR 2017) has been drawn upon for the discussion of baseline conditions in the Brokopondo communities and the Kawina population. The study involved a review of publicly available information such as government statistical reports and websites, and relevant publications. Primary data were also obtained, and included: a household survey to build profiles of the "Brokopondo communities"; global positioning system (GPS) mapping to link households to survey data; interviews with key informants and focus group meetings (e.g., traditional authorities, women, youth, land user groups). Primary data collection on the Kawina population was sourced completely from focus group meetings[1]. The Brokopondo communities (Afobaka Centrum, Asigron, Balingsoela, Boslanti, Brokopondo Centum, Compagnie Kreek, Drepada, and Tapoeripa) are located nearest to the Project. The Kawina currently live in Paramaribo but maintain a presence in their traditional communities: Java, Pennenica, Moismoiskondre and Gododrai. The Institute for Graduate Studies and Research (IGSR) report was also referenced in the discussion of macroeconomic conditions in Suriname, and was updated where necessary.

The Socioeconomic and Cultural Resources Survey (Social Solutions and ILACO 2017a) conducted for the Environmental and Social Impact Assessment (ESIA) has been drawn upon for the discussion of baseline conditions in the "Carolina Communities": Powakka, Philipus Kondre (Klein Powakka), Redi Doti, Casipora, and Pierre Kondre Kumbasi. The survey was conducted by desktop review and analysis, secondary sources verification and interviews with select key informants. Research procedures adhered to professional ethical standards for social science research. The review of secondary sources focused on studies discussing natural resources, Non-Timber Forest Products, language use, as well as a land use map and management plan for the user area. Data analysis also used the raw data set (community questionnaire and household survey) from the 2015 N.V. Energie Bedriiven Suriname baseline survey for the listed communities. Prior to data collection, the proposed research and methodology was discussed with the Association for Indigenous Village Heads in Suriname[2] (VIDS) who act as key contact with the Carolina target communities. Four consultation meetings with representatives (one or more members of traditional authorities and one or more individuals with specific knowledge about the village) of the five communities were held to verify written records and fill gaps in secondary source information.

4.12.1.2 National Economic and Social Context

Suriname is a country with a population of nearly 541,000, on the northeast South American continent. Most (i.e., around 90 percent [%]) of the population resides in Paramaribo (241,000), or in communities along the coastline. The remaining 10% of the population resides inland in a number of smaller communities with populations of several hundred each. Much of the population in inland villages are of Amerindian or Maroon decent.

According to the Human Development Report Suriname is categorized as having achieved high human development (UNDP 2015). With its rank of 0.714 in 2014 and the position of 103 out of 188 countries and territories, the human development index in Suriname can be by and large compared

[1] As a result of this approach, demographic information on the Kawina is limited. In addition, publicly available demographic information on the Kawina was not found.

[2] Dutch name: Vereniging van Inheemse Dorpshoofden in Suriname

with Guyana and Belize (ibid). This rank, however, is still below the average (0.748) of Latin America and the Caribbean (ibid).

The World Bank classified Suriname as an upper middle-income country in 2016 (World Bank 2018). For decades it has been among the best performing economies in the Caribbean, but this has changed in the past few years with increasing inflation rates and currency depreciation due to economic decline. The situation has worsened to such an extent that international financial institutions, such as the International Monetary Fund, are currently supporting the Government financially to stabilize the economy (ibid).

The economy of Suriname is dominated by mineral development and exportation, and government investment. In the past, the mineral sector contributed roughly a third of total national Gross Domestic Product (GDP). Strong commodity prices in the early 2000s led the Surinamese economy to grow from nearly $[3]1 billion in 2000 to around $5 billion in 2014 (CSIS 2017). By 2016, with falling commodity prices and exports, the national GDP had fallen to $3.6 billion (World Bank 2017).

With recent shifts in commodity prices and reduced production of aluminum, the mineral sector's GDP contribution has fallen to about 18% in 2016 (SPS 2017a). The sector is dominated by petroleum production at a state-owned[4] oil refinery, and gold mining at the Merian and Rosebel mines. Government investment in other sectors (e.g., construction, service provision) represents approximately 22% of national GDP contributions (SPS 2017a).

The Surinamese economy shrank by 2.7% in 2015 and approximately 10% in 2016 due to a combination of factors: declining exports from the mineral sector due to the reduced price of gold and oil, cessation of the bauxite/aluminum sector in 2016, and declining government investment in the face of budget deficits (SPS 2017a estimate). The economy is expected to continue to shrink by another 0.2% in 2017. Increased gold exports, improved gold prices and government investment in forthcoming projects are expected to stimulate economic growth by about 2.5% annually between 2018 and 2021 (IGSR 2017).

With recent declines in mineral revenues, the Government has been operating at a deficit, drawing upon the international reserve (valued at $350 United States Dollars [USD] as of 2016) to make up shortfalls. Government revenues declined by 9% in 2015, while expenditures increased to about 10%. The Government's budget deficit as a percentage of GDP increased from 2.7% in 2012 to around 11% in 2015 (IGSR 2017). National Government revenues amounted to $457 million in 2016. Of this, about 75% ($341 million) comes from taxes, while the remaining 25% ($116 million) comes from other non-tax, non-grant-based sources. Revenue from mining in specific amounted to $75.9 million (17% of total revenue), of which $26.4 million (35%) came from royalty payments[5]. Large and medium-scale mining operations contributed three quarters ($57.7 million) of this total, while ASM contributed the remaining quarter ($18.2 million). Government expenditures in the same year were approximately $572 million, resulting in an annual deficit of $115 million (Republic of Suriname 2017).

The national inflation rate is high and peaked at 50% to 60% in 2016 as a result of the falling exchange rate ($1 USD: $7.44 Suriname Dollars (SRD), October 2017), recent increases in the gasoline tax and growing tariffs on utility prices. Though the inflation rate has begun to drop, it still

[3] All dollar ($) values presented in this section are $USD. Where values have been converted from $SRD, a $1 USD : $7.44 SRD exchange has been applied.

[4] State Oil Company Suriname NV (Staatsolie)

[5] The remainder comes from corporate, wage, sales and other taxes, import duties, statistical and consent fees, and other non-tax-based sources.

remains high at 30.4% in 2017 (IMF 2017). High inflation rates have led to reduced purchasing power of wage earners and people living on fixed incomes (GoS 2017).

The nation's ratio of exports to imports has improved in recent years, growing from 71% in 2015 to 92% in 2016. This is largely due to the inflation- and tax-driven reduction in the purchasing power of consumers, whose demand for consumer goods has historically constituted about 42% of total imports. Mineral (gold and aluminum) and petroleum exports made up 88% of the total national exports from 2005 to 2015. With declining global commodity prices and the cessation of bauxite mining and aluminum production in 2015, mineral exports declined to 69% of total exports in 2016. The market price of gold rose by 8% in 2016 and the export volume increased by 2.4% with production at the Merian Gold Mine (Merian mine). This in turn increased the export value of gold by approximately $79.4 million USD, representing 61% of total national exports in 2016.

4.12.1.3 Regional and Local Setting

The Sabajo Project is located in Para District in northeast Suriname. The closest communities (about 15 kilometers [km] from the Project in a straight line) are located in Brokopondo District. Communities are grouped as follows:

Kawina Community

The Kawina people are a mix of Amerindians and Ndyuka Maroons and have inhabited and used the Commewijne River area for more than 200 years. After escaping from slavery most of the Kawina came to the area and remained there for decades. Others went further to the Tapanahony River area but later they also returned to the Commewijne River area because the conditions for agriculture and logging were more favorable. Before the Interior War (1986-1992), the four Kawina villages (Pennenica, Java, Moismoiskondre, Gododrai) in the Commewijne River area were fully populated. The Interior War caused the destruction of the villages and the inhabitants were forced to flee to Paramaribo. After the war ended the Kawina people unsuccessfully attempted to rebuild the villages resulting in few returning to live in them permanently. The Kawina's efforts to return to their traditional villages are hampered by difficult or limited access to the area and a lack of infrastructure. Today, some Kawina maintain plots for vegetable growing and hold various celebrations at the villages as well as reside at the villages intermittently.

Brokopondo Communities

The 'Brokopondo communities' discussed in the social baseline reports are select communities in the District of Brokopondo that are located along the southern part of the Brokopondo to Afobaka Road. The majority of people living in this area are Maroon[6]. The Maroon (or African descendants that escaped slavery) are further self-identified as being of Saramaka or Saakiiki tribes. The villages of Asigron, Balingsoela and Drepada have been historically Saramaka, and the villages of Boslanti, Tapoeripa and Compagnie Kreek are historically Saakiiki. Afobaka Centrum is divided into two areas with both Saakiiki and Saramaka residents. The Saakiiki villages in the AOI were established in the 1960s and are referred to as 'transmigration' communities as they were relocated to their current location due to the flooding of their original villages for the construction of the Afobaka hydropower dam. The Saramaka communities are historically from the region and have been granted Indigenous Peoples status by the Inter-American Court of Human Rights, as have all Maroon tribes. The Government of Suriname (GoS) has not officially recognized this designation to date.

[6] There are six Maroon Tribes in Suriname: Ndyuka, Saramaka, Paramaka, Kwinti, Aluku and Matawai.

Carolina Communities

Since pre-Columbian times, the Lokono co-existed with the Kaliña Indigenous groups living in the same area. Historic records suggest that the Lokono and Kaliña Indigenous peoples moved into the present-day east Para region in the early 17th century to keep at a distance from the coastal area plantations. Casipora and Pierre Kondre Kumbasi are the oldest Indigenous communities in this area. Pierre Kondre Kumbasi and Redi Doti are Kaliña communities while Powakka, Philipus Kondre and Casipora are Lokono communities.

Similar to the Maroon tribes, all Indigenous groups (or Amerindians) in Suriname have been recognized by the Inter-American Court on Human Rights as Indigenous Peoples.

Both Brokopondo and Carolina communities are discussed due to their potential to be affected by Project traffic transporting people and goods to the Project area. The Project Access road has not been finalized and thus studies were undertaken with both clusters of communities.

Socio-economic information on these communities is discussed in relation to:

- local economy and employment;
- land use;
- demographics;
- housing, infrastructure and services; and,
- government.

4.12.1.4 Local Economy and Employment

Kawina Communities

The majority of Kawina people (approximately 500 people) reside in Paramaribo, after leaving their traditional communities during the civil war. Today, few inhabit traditional Kawina communities (i.e., Gododrai, Java, Moismoiskondre, and Pennenica). Some return to the communities to tend to agricultural plots, however no major economic activities occur in or around the communities. A number of Kawina men work in ASM; as the Kawina are dispersed in Paramaribo, information about of their employment status as a group is not known. Each of the four Kawina communities has a community forest and income is earned through logging activities. The majority of traditional Kawina authorities receive an income from the government through government employment or a stipend for their position as traditional authorities (IGSR 2017).

Brokopondo Communities

Collectively, the population of the six Brokopondo communities within the study area is 2,536. This includes the population of Afobaka Centrum at approximately 500. The population of Brokopondo Centrum, is unknown due to the transient nature of the population and is not included in this total. Both Afobaka and Brokopondo centrums are government service centers with shops and some level of agricultural activity and do not have a traditional village structure. The other Brokopondo communities are rural Maroon villages with the following populations: Asigron: 237, Balingsoela: 604, Boslanti: 195, Compagnie Kreek: 347, Drepada: 147 and Tapoeripa at 506. Agriculture and ASM are the main economic activities in the Brokopondo communities. The prevalence of each activity varies by community. About 50% of the population practices agriculture. Of those that do, most (75%) are women. The main crops that are cultivated by the respondents of the household survey are cassava (81%), banana (65%), rice (52%), leafy vegetables (72%), and root vegetables such as yams (86%). Most of them (56%) sell their surplus, while others (44%) use it for their own consumption. Logging plays a smaller role as an income-generating activity in Brokopondo communities, representing the primary economic activity for just 1% of households.

Hustling[7], handicrafts, fishery, cattle breeding, government service work, and processing of agricultural crops are all dominant aspects of the rural economy. These activities differ in importance by community. Handicraft production is one of the more important activities in Asigron and Tapoeripa; fishing in Boslanti, Victoria, Balingsoela, and Tapoeripa; cattle breeding in Asigron, and processing of agricultural crops in Asigron, Balingsoela, and Compagnie Kreek.

Approximately 50% of the population aged 15 and over in Brokopondo communities are employed, with the remaining being either unemployed (23%) or not active in the labor force (27%). This varies greatly between communities, with Compagnie Kreek and Drepada having the lowest proportion of the population employed (37% and 28%, respectively) of the Brokopondo communities, and Asigron having the highest (65%). Nearly half of all households have a monthly income of under $135 USD ($1,000 SRD). Less than 10% of households have a monthly income of greater than $335 USD ($2,500 SRD). The remaining 40% have monthly incomes between these values.

Educational attainment levels are low in the Brokopondo communities, but not atypical of the interior populations. Approximately 20% of the population does not have any formal schooling. Nearly half (43%) have completed or partially completed primary school as their highest level of education, while another quarter of the population has either completed or partially completed secondary schooling. A small number of people in Balingsoela and Tapoeripa have obtained partial or complete post-secondary education. Those that continue onto high school or to post- secondary education are likely residing in Paramaribo and do not necessarily return to their village after completion. This group is under-represented in the household survey because they were not residing in the community when the survey was undertaken. Nonetheless, there are evident barriers to achieving more than primary school education.

Carolina Communities

Many people in the communities along the Carolina road live and work in Paramaribo during the week, and return to their villages for the weekend. For most communities, agriculture remains the most important economic activity. Produce is either sold as-is or as processed products (e.g., cassava bread) at the Paramaribo market. Agriculture is practiced most intensively in Pierre Kondre Kumbasi, where 6 out of 10 surveyed households reported using land for commercial agriculture or livestock. In this community, the average size of the commercial plots was also much larger than in the other communities, and none of the households involved in commercial crop production planted on an area smaller than 1 ha. Pineapple production is a major agricultural activity for this village. In Powakka and Redi Doti, a somewhat smaller portion of households are involved in commercial agricultural or livestock production (28.2% and 34.4%, respectively). While there are households in these communities that used quite large commercial plots of up to 6 hectares (ha), there are also households that reported planting on just 75-80 square meters (0.0075-0.008 ha). In Casipora, only one household reported using land (0.75 ha) for commercial agricultural or livestock production.

Tourism is another important source of income for some in Carolina communities. Tourism-related work is often largely associated with Jodensavanne and the Blaka Watra recreational resort. These locations are popular tourist attractions, and are located near Casipora and Redi Doti. Redi Doti also features holiday apartments. In Powakka, there are two recreational swimming places. These places are visited by both Suriname and foreign tourists, mostly on weekends and during school holidays.

[7] Reselling goods and performing odd jobs for cash.

Members of the Carolina Road communities make a living by selling items to tourists, cooking, life guarding, or cleaning.

Other employment opportunities taken up by residents of the Carolina communities includes work with construction contractors, timber processing companies and IAMGOLD. Some residents still participate in logging, holding logging rights in community forests or working with timber processing firms in the region. Some community forests (e.g., Powakka) have, however, been logged to the point that few commercial wood stands are left, discouraging further forestry activity. Hunting and fishing is not widely practiced by residents of the Carolina Road Communities, though a small number of individuals derive some level of income from these activities.

As of August 2017, over half of individuals aged 15 years and older (54%) in the Carolina communities had not been involved in any cash earning activities in the past six months. For those that have worked, the most common cash earning activity is self-employed agricultural worker (12.3%). Other areas of employment include government service (4%); mining and minerals (i.e., Staatsolie and Newmont Suriname, LLC [Newmont]) (3%); cleaning (3%); tourism (2%); security (2%); and construction (including painting and welding) (1.5%). Smaller numbers of people are employed as taxi drivers, fishermen, hunters, gardeners and handymen.

Nearly a third of adults in the Carolina communities have not completed an elementary education. Of the remaining two thirds that have completed an elementary education, only 3% possess high school-level education.

4.12.1.5 Land Use

Kawina Communities

Tribal communities do not have formal rights to the land they traditionally lived on and used. The Kawina's traditional communities are now largely unoccupied, with many of those self-identifying as Kawina residing in Paramaribo. Following the destruction of these communities during the Interior War, limited land use has occurred in and around these communities. Each community does, however, have an associated community forest. Logging in these forests is intended to provide some income to the Kawina. Some Kawina have also begun to use land in their traditional communities for agricultural purposes, returning from Paramaribo on weekends to plant, tend to, and harvest crops. There is strong interest among Kawina in rebuilding these villages and some wish to take up permanent residence, thus suggesting that Kawina have maintained their cultural connection to these places. The Kawina are acknowledged as having customary land tenure and rights in the area of the proposed Sabajo Project (Artist and Rijsdijk 2017). Kawina land use in the area of the proposed project is primarily associated with ASM (see Section 4.12.2 for further information).

Brokopondo Communities

Agriculture is the primary land use for the six Brokopondo communities included in the study. Plots are associated with individual households, and are largely tended to by the female members of the household, and youth. Agricultural plots are seldom within the community itself, instead being located in adjacent areas. About a third of plots are located more than 1 km away from the community.

Lands around these communities are also used for hunting and fishing. Hunting and fishing is not a dominant land use for these communities and is conducted by a limited number of individuals and largely for personal consumption. Fishing activities typically occur within the community or within 500 meters and hunting activities typically occur greater than 1 km away from the community.

Tourism and recreation (e.g., boat trips, camping, resorts) are other prevalent land use activities in the area, particularly near Afobaka Centrum and Lake Afobaka. Some ASM occurs in Compagnie Kreek, Boslanti, Drepada and Tapoeripa, but the extent of these activities are not fully defined at this time.

Carolina Communities

Amerindian peoples moved into the present-day east Para region in the early 17th century. In the early years of colonization, Indigenous groups who had been living in the coastal area fled upriver to escape efforts of plantation owners to enslave them. Some Indigenous groups settled in the area now known as “Carolina”, Casipora and Pierre Kondre Kumbasi are the oldest Indigenous communities in this area (settled somewhere between 1875 and 1928). Pierre Kondre Kumbasi and Redi Doti are Kaliña communities, while Powakka, Philipus Kondre (Klein Powakka) and Casipora are Lokono communities.

The Indigenous communities do not have formal rights to the land they traditionally live on and use. Due to historic migratory movements, many individuals and families that originate from the listed villages live in Paramaribo during the week. Community members who live elsewhere but contribute to the village and participate in events have equal rights to participate in community decision making processes.

All communities have community forest concessions for the purpose of timber production, though not all are exploited and some commercial forest stands no longer contain any productive timber. Commercial agriculture is mostly performed on land assigned by the traditional authorities. Both women and men collect forest products, including medicinal plants, construction materials, plants to fabricate crafts and utensils, and edible fruits and plants (e.g., palm fruits). There is some degree of commercial agriculture, primarily pineapple production in all of these communities. Commercial agriculture is practiced most intensively in Pierre Kondre Kumbasi. Tourism activities near these communities are associated with the *Jodensavanne historical site and medicinal healing well* in Redi Doti, and the *Blaka Watra* resort near Casipora.

4.12.1.6 Demographics

Kawina Communities

It is estimated that there is a population of about 500 Kawina people today. The Kawina in Paramaribo have access to secondary and post-secondary education located in the city. Based on anecdotal evidence, the Kawina living in Paramaribo would therefore potentially have the necessary education for skilled employment. The Kawina who are based in Paramaribo are not a homogeneous community and they live amongst other cultures and have intermarried with other ethnic groups. It is therefore challenging to speak about a unique culture as families are made up of many cultures. As the Kawina mainly live in an urban context, their daily lives may be less intertwined with rituals and taboos associated with their land (i.e., sacred creeks, rivers and forests). Results of focus group sessions, however, suggest that Kawina do get together as a group for celebrations and cultural events. Based on interviews, only a few community members live permanently in the villages at present and some villages are completely abandoned.

Brokopondo Communities

While all communities have had some in-migration and out-migration that has led to ethnic diversification, the majority of people living in the area are Maroon. Household respondents reported that Christianity was the dominant religion in the communities[8] of Balingsoela, Victoria, Compagnie

[8] Information on the dominant religion in Asigron was not reported.

Kreek, Drepada, and Tapoeripa while the traditional religion (Winti) is the dominant religion in the community of Boslanti.

In the Brokopondo communities a fairly large number of registered individuals are not currently residing in the village. These individuals are primarily female (53% or all registered residents who reside outside their home villages[9]). In some villages like Tapoeripa and Drepada, nearly three-quarters of all households have at least one household member residing outside the village. These are mostly children who have left for further education or spouses who have left for work. The villages of Asigron, Balingsoela, and Compagnie Kreek also have a sizeable portion of the population (between 11% to 16% of the total surveyed population) who reside outside the village. The majority of these individuals are children of respondents who have left to further their education. As previously discussed, the Brokopondo villages only have primary schools and pursuance of further education is obtained in Brokopondo Centrum or Paramaribo.

Respondents who were born outside of the respective villages make up between 11% to 23% of the population in the Brokopondo communities. These individuals who have moved to the Brokopondo communities do so for a variety of reasons such as relationship ties, schooling, and jobs. It is uncertain whether these are people moving from other villages or from a larger center. Most households in the villages are typical nuclear families with a mother, father and children or are female headed households (mother with children). Of the households surveyed, 43% had completed primary education, 23% had completed secondary education level, and 20% did not finish their schooling. Few people residing in the Brokopondo villages have gone on to tertiary education (post-secondary), with only two respondents in Tapoeripa indicating that they have reached completion. Those pursuing further education must go to schools in the Brokopondo Centrum or Paramaribo and once completed, may choose not to return to their villages.

At the household level, approximately 50% of the Brokopondo population is employed while an estimated 23% is unemployed. Employment in this context includes farming and informal sector employment. Close to 50% of households report an earned monthly income below SRD 1000, Thirty percent earn between SRD 501-1000, and 20% earn below SRD 500. Among the Brokopondo communities, the village of Asigron has the highest percentage of employment (65%) and the village of Victoria has the highest percentage earning greater than SRD 2500 (10%). The village of Boslanti has the largest proportion of the population (39%) earning the lowest income tier (less than SRD 500). Monthly income was estimated and should be viewed with caution as households do not take in regular monthly income due to the nature of their economic activities. Table 4.12-2 presents the income, employment and economic activities by Brokopondo Village.

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[9] This gender breakdown does not include the village of Tapoeripa as gender breakdown of household members not currently living in this village was not reported.

Table 4.12-2 Income, Employment and Economic Activities by Brokopondo Village

Village	Income	Percentage Employed	Major economic activities
Asigron	7% <SRD 500 About 32% SRD 500-1000 17% SRD 1001-1500 5% >SRD 2500	65%	Hustling, Non-governmental, agriculture
Victoria	35% <SRD 500 25% SRD 501-1000 10% >SRD 2500	50%	Agriculture, Small scale gold mining, Hustling
Balingsoela	About 32% SRD 500-1000 17% <SRD 500 7% >SRD 2500	56%	Small scale gold mining Non-governmental, Hustling
Boslanti	39% <SRD 500 29% SRD 500-1000 2% >SRD 2500	53%	Hustling, Other, Small scale mining
Compagnie	18% <SRD 500 42% SRD 501-1000 9.5% >SRD 2500	37%	Hustling, Small scale gold mining Other
Drepada	19% <SRD 500 41% SRD 501-1000 3% >SRD 2500	38%	Small scale gold mining, Non-governmental, Hustling.
Tapoeripa	24% <SRD 500 29% SRD 501-1000 5%>SRD 2500	47%	Small scale gold mining, Non-governmental, Hustling.

Source: IGSR 2017.
% = percent; < = less than; > = greater than.

Note: Income data reported may exceed the employment percentage. In the majority of villages, a greater percentage of people have reported income than the percentage actually employed.

Economic activities undertaken by the Brokopondo communities do not require formal education and therefore there is no correlation between income and education in these communities. While there is no notable difference between sexes for incomes between SRD 501-1000, the proportion of male respondents earning higher than SRD 2500 is seven times greater than that of females in the Brokopondo communities, likely due to their dominance in the mining and logging employment.

Carolina Communities

The five Carolina communities have a total estimated population of 1,653. The villages are broadly dispersed and houses are typically built some distance from the road. The villages which are in the AOI are Powakka and Philipus Kondre (Klein Powakka)[10] (population: 1,268), Redi Doti (population 167), Pierre Kondre Kumbasi (population 69), and Casipora (population 149)[11]. The largest group of community members are men ages 18 and older (581), followed by women (474), boys younger than 18 years (334) and girls (262). Improved access to the area due to road and bridge upgrading and a recent electrification scheme has reduced the need to leave the villages and migrate to the city for work or school and several families have even returned to live permanently in the Indigenous communities. Other contributing factors that have contributed to this re-migration is the current national crisis and high living expenses in Paramaribo.

[10] Powakka and Philipus Kondre were surveyed under one name and from the 2015 Energie Bedriiven Suriname dataset; it is not possible to distinguish between the two.

[11] All populations for Carolina Road communities are extrapolated based on figures stated during community consultations.

In current times, the Indigenous villages consist of three groups of people: people who are registered in the village and live there; people who are registered in the village but live elsewhere during the week; and people who are not registered in the village but live there. With the exception of Pierre Kondre Kumbasi, the villages consist predominantly of permanently inhabited households (in the range of 80-98%). In Pierre Kondre Kumbasi, only approximately 33% of the village is made up of permanently inhabited households. Community members who live elsewhere but contribute to the village and participate in events have a right to participate in community decision making.

4.12.1.7 Housing, Infrastructure and Services

Kawina Communities

The Kawina's traditional communities near the Project are largely unoccupied, with those self-identifying as Kawina mostly residing in Paramaribo. Following the Interior War, limited infrastructure has been maintained or developed due to limited access from the destruction of the main bridge during the war. There is some evidence of recently constructed structures, but they are not connected to physical infrastructure (e.g., water, electricity, sanitation). Similarly, there are no medical, protective or educational services providers in the area.

Brokopondo Communities

Nearly all Brokopondo households are connected to public electricity free of charge. Water in some communities is sourced from a combination of public and private taps; however, the water from these taps is often not potable or clean for household use. Other households collect rainwater or take water from nearby waterbodies. Such water must first be boiled before it is safe for drinking. Many households note that water pollution is an issue in communities, and fear that ASM activities have led to mercury contamination in waterbodies. Most Brokopondo households make use of toilets with flushing water connected to a septic tank. Others make use of open field sanitation and/or a public latrine. About two thirds of houses are constructed with wooden walls and the remainder are built with cement bricks. Where present, flooring is typically made of cement (61%) or wood (29%).

Most communities have some level of primary education provided within the community, though most students must travel to Brokopondo Centrum or Paramaribo to complete primary school or have access to secondary and post-secondary education. Brokopondo Centrum also has a vocational center.

Public security threats and dispute resolution in Brokopondo communities are typically resolved through the traditional authority. Crime is not observed to be a major issue in these communities; however, police are involved for more serious crimes such as homicide or armed robbery. The Ministry of Justice and Police and the Suriname Police Force have police offices/checkpoints in the resort of Kwakoegron, in the villages of Klaaskreek and Brokopondo Centrum, and along the Afobaka Road.

Medical services are available through the Medical Missions in communities and medical clinics in Brokopondo Centrum (see Section 4.12.6 for further information).

Carolina Communities

Primary schooling is available to children from Carolina communities in Powakka and Redi Doti. A school bus transports children from Casipora and Pierre Kondre Kumbasi. None of the Carolina communities have a secondary school, with school busses transporting older children to Paranam. Medical services are available at the Medical Mission Primary Health Care (PHC) clinics in Powakka and Redi Doti. People in Casipora and Pierre Kondre Kumbasi typically use the clinic in Redi Doti, while inhabitants of Philipus Kondre travel to Powakka.

The Carolina communities are not connected to the public drinking water distribution network of the Suriname Water Company. Powakka features a stand-alone, free of charge water system, which was installed by the Service for Water Provision of the Ministry of Natural Resources. Villagers have water taps on their plot, not in the home. Management of this system will soon be taken over by Suriname Water Company. The water in these communities is currently unfiltered and not suitable for drinking by World Health Organization (WHO) standards. Redi Doti and Pierre Kondre Kumbasi rely on a shared stand-alone water system. The filtration equipment for the system is broken, meaning that river water is pumped unfiltered to outdoor taps for each household and must be boiled before drinking.

In Casipora, there are several hand pumps that are connected to underground wells. The hand pumps divert the water to a tap near households. For those households without a tap nearby, rainwater and creek water are the main source of household water. The village of Casipora has sent a request to Suriname Water Company to be connected to the national water distribution network. Philipus Kondre relies on about 23 hand pumps, which are connected to wells. The pumps generally work well, but in the dry season the water sometimes has an odor. Some households in Philipus Kondre have connected a water pressure regulator pump to the hand pumps, to pump the well water directly into water storage bins. The village is seeking funds to extend the drinking water supply system.

Houses in these communities also rely on rainwater collected from their roof tops. In the dry season relatively more households rely on the water trucks from the Ministry of Natural Resources. Water trucks provide drinking water to rural areas that are not connected to the Suriname Water Company system. The trucks do not service Casipora because this village has sufficient access to water in the dry season.

For sanitation, just over half of households in the Carolina communities use outhouses or latrines. Forty-two percent of households use a flush toilet with a septic tank, and another 5.5% use a flush toilet with surface drainage outside the compound. There are some differences among the target communities in terms of the most common sources of sanitation. For example, in Redi Doti three quarters of households reported using a flush toilet with septic tank, versus only one third of households in Powakka have them. In Powakka, latrines are most commonly used.

The Carolina communities are recently connected to the public electricity grid of the Energy Company of Suriname. Consulted community members suggested that the presence of 24/7 electricity allows children to study in the evening hours. Moreover, more people have started small businesses, for example selling popsicles and juice.

4.12.1.8 Government

Kawina Communities

The Ndyuka are represented by a Granman, which is the highest authority of a tribe and is appointed and installed by the tribe. The Granman of the Kawina communities is the Granman of the Ndyuka's Granman Velanti. The Granman is assisted by a number of “Head Kapiteins” (Head Captains - one for each lo, see Section 4.12.3) and Kapiteins. A Kapitein is head of a village and is assisted by Basjas and a number of important people such as elderly men and heads of matrilineal lines. The Basja has the executive power. When religious issues play a role in matters of governance (which is often the case) the priests also function as fellow-governors. The Surinamese government is informed about appointment of captains and other traditional authorities. The government endorses the appointment officially and provides the Granman with a stipend. Kawina communication with government is through the Ministry of Regional Development. Although they largely reside in Paramaribo, they still maintain a traditional authority, which is headed by the Ndyuka Granman, and have weekly meetings. The Granman or a captain will never take a decision without holding a krutu (meeting). If there is a krutu, the community communicates invitations through a local radio station, Radio Koyeba. Only for serious crimes (e.g., suicide, manslaughter) are the official authorities in Paramaribo involved. Otherwise, traditional authorities play a role in dealing with offences.

Each village takes care of its own governance for day to day affairs. Family affairs are settled between families. In each bere[12] the elderly participate in meetings and decision-making processes with the captains. Each village usually also has a council of elders. Each osu (a matrilineal kinship group of individuals with common ancestors, Section 4.12.3) is represented in the council. The council discusses the case and suggests a solution or provides advice to the captain.

The Kawina maintain community forests as defined by the 1992 Forest Management Act[13]. The Act provides for the grant of community forest permits at the discretion of the Minister in charge of forest management, and subject to any conditions the Minister may impose. The community forest permits are revocable forestry concessions that convey limited and restricted use rights.

Brokopondo Communities

The Ministry of Regional Development is responsible for regional governance, decentralization and the development of the interior. The commissioner's offices of the respective districts are governed by the Director of Regional Development. The Regional Body Act (SB 1989/44) regulates the relationship between the State and the districts (SPS 2013). The regional government has been assigned to the District Councils, Resort Councils and District administrations. These bodies are responsible for the formulation of regional plans and the corresponding budgets according to the Regional Authorities Act[14] and which form part of the national planning. The financial support for the districts is strongly dependent on the central government.

The district administration is the executive organ of the district and is subject to the control of the District Council. The District administration consists of the District Commissioner (appointed by the central government), who is both chairperson and member of the Council. The remaining members are also appointed by the Government and one representative per ministry, preferably one who has their residence in the district. Execution of the daily management of the district is the main task of the district administration. The District Councils and Resort Councils[15] are not executive agencies but supervisory bodies. The District Commissioner's office is situated in Brokopondo Centrum. For the performance of the administrative tasks, the District Commissioner has an administrative office available in all six administrative areas[16] with civil servants. The administrative office is led by an administrative officer who performs the duties together with the civil servants.

Each Brokopondo community is governed by a traditional authority that may be comprised of both women and men Basjas (deputy leader) and Kapiteins (clan head / village leader). The Granman is also a member of the District administration. At present, there is an ongoing dispute about who is the overall clan leader (Granman) for the Saramaka villages since the previous leader passed away in

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[12] One of several units that forms a lo (matrilineal clan).

[13] "Forest areas, situated around community lands, and assigned as Community Forest to the benefit of tribal communities living in villages or settlements, with the purpose to provide for food and forest products for communities own consumption, as well as for the commercial use of wood, collection of non-timber forest products and for agricultural purposes". Either the Kapitein or a village committee is set up to oversee management of community forests.

[14] WRO, S.B. 1989, no. 44, as last amended by S.B. 2005, No. 28, Arts 51 to 56.

[15] Resorts are under the authority of Resort councils which consists of members of local communities in the relevant areas.

[16] Kwakoegron, Marchallkreek, Klasskreek, Centrum, Bronsweg, and Sarakreek.

2014. Positions of Traditional Authority have historically been appointed and last for life. In recent times, however, many villages are choosing to elect their leadership, which may increase their legitimacy for some, especially younger, people. In some instances, there has been disagreement about who is the legitimate village authority. For instance, in Tapoeripa there is a Kapitein, who has been accepted by the GoS, and receives compensation from the District Commissioner through a stipend, however he has not been accepted by the community and has not been inaugurated according to village traditions and therefore does not have decision making authority within the village. Similarly, in Drepada, there is currently no Kapitein as the former has died and there has not been a process to select new leadership. Community members report that this can be problematic as this creates a vacuum where decisions cannot not be made and it leads to heightened tension and confusion. In addition, many of the villages report that there is very little contact between the District Commissioner, who is the representative of the GoS and the traditional authorities. The District Commissioners are responsible for assigning logging and mining concessions while the traditional leadership parcels out land for the community to farm and live on. At times, there has been conflict over concessions provided to people from outside the community on land that has been historically under community tenure. All Saramaka captains meet periodically about issues of common concern. While the traditional authority is not yet recognized by the Constitution of Suriname, the Ministry of Regional Development, on behalf of the Government, provides a compensation for traditional authority.

Carolina Communities

Lokono and Kaliña Indigenous groups do not have a *Granman* or paramount chief in contrast to most Maroon tribal groups. Village leaders (Kapitein) and their administrative assistants (Basja) have been historically appointed (typically for life), however this tradition is transforming and more often a democratic process is being used to select leadership. The most recent leaders were elected in Powakka and Redi Doti. Women are also just as likely to hold leadership positions as men in the villages and the roles and responsibilities are the same for both genders. In addition, people who originate from the villages, however who may live in Paramaribo or beyond, but still contribute to the villages have equal right to participate in community decision making processes, including the selection of village leadership. Decision-making processes in the village are typically based on consensus. Traditional authorities across Suriname and Para are organized through membership to coordinating organizations (such as VIDS) and the villages in the Para region have organized to work together on issues such as security, specific problems, or joint-activism when they perceive injustices. One example has been by coordinating roadblocks in order to demand connection to the national grid to access electricity for their communities.

4.12.2 Small-Scale Mining

This summary provides an overview of ASM activities in and around the Sabajo Project. The information is summarized from the ASM baseline study (Social Solutions and ILACO 2017b) that was conducted as part of the ESIA. The study describes the history of ASM in the Sabajo area, population and demographics, ASM operation, ASM economic management, land bosses and service providers, and existing relations between Newmont Suriname and the small-scale gold miners. The Kawina Ndyuka has a special focus as they have historically lived in the Commewijne watershed area and have a history of resource use along the Little Commewijne Creek and its tributaries, which traverse the Sabajo Project (Artist and Rijsdijk 2017).

4.12.2.1 Methodology

The ASM survey was conducted according to a mixed method approach that combined mapping of the ASM operations[17], a census of workers in mining camps, structured interviews with equipment owners and structured yet more conversational (i.e., qualitative) interviews with selected ASM stakeholders and Newmont staff. The consultant also made observations[18] and conducted short informal interviews with mining service providers to obtain general area information.

Fieldwork was conducted in the different ASM zones of the Sabajo area[19] and adhered to professional ethical standards for social science research. Existing written sources are scarce and hence most information in this ASM study was obtained from interviews. Maps from the Suriname National Archives were reviewed for evidence of historic settlements and mining activities in or near the Sabajo area as well as books about Ndyuka history and culture. As much as possible, data obtained from interviews were verified through interviews with other people and with archival data and literature.

For socio-economic field data collection, the consultant used three different research instruments:

1) Area observation sheets were used to characterize the four different mining zones referred to as “Santa Barbara”, “Margo”, “Km 34” and “Polaco area”.
2) A simple survey form was used to list all inhabitants associated with each one of the ASM operations, including non-working members such as wives of workers and children. Another questionnaire was used for interviews with the equipment owners. These questions focused primarily on the types of equipment used and economic management of the operations.
3) Qualitative interviews were conducted with persons with a specific role in, or knowledge about, the ASM sector in the Sabajo area. Target persons for these interviews included traditional authorities, land boss(es), and Kawina individuals with a long history of ASM in the Sabajo area.

Over the course of the fieldwork, researchers identified a total of 18 separate ASM operations across the four mining zones. Seven of these operations belonged to Brazilian equipment owners, six were run by Kawina equipment owners, and the remaining operations belonged to other Surinamese nationals. Following the fieldwork, findings were presented and discussed with small scale miners to verify accuracy and solicit additional insights.

4.12.2.2 History of Artisanal and Small Scale Mining at Sabajo

The history of ASM in the Project area dates back to the 1880-1910 gold rush. Some of the present-day Kawina small scale miners began ASM activities in the Sabajo area in 1993. They left the area in 1995 due to the high costs of bringing in fuel and supplies but returned in 2009 with improved access associated with newly developed logging roads. In the meantime, an individual had established himself as a land boss[20] in the area.

[17] We define as an ASM Operation: a firm performing ASM activities in one location, and which is owned by one equipment owner or joint venture, with one shared budget. One ASM operation can own multiple pieces of mining equipment and different teams of workers.

[18] Observations in mining camps included, for example, sleeping arrangements, type of sanitary facilities and drinking water source, presence of armed guards, amount of planting around the camps. Observations in work areas served to check on the type of equipment, and workers’ safety and protection. Observations in cabarets served to verify reports of the number of sex workers.

[19] The term mining zone is used to refer to a concentration of ASM within the larger Sabajo area. Hence Santa Barbara and Margo are different mining zones.

[20] A land boss is a de facto concession owner, typically someone claiming traditional presence or customary rights in the area, to whom an ASM operation pays a percentage of proceeds.

In 2010, a year after Newmont Suriname first obtained exploration rights in the Sabajo Area, it became unsafe for Newmont to continue its exploration activities due to the number of ASM operators and the company asked the GoS for assistance in evicting the gold miners. Most miners left in 2011 and the last group left in 2014. Since 2014, ASM operators have occasionally been asked to leave when they start mining again in places they are not allowed to go and/or when they are affecting Newmont's operations (e.g., water quality, roads). While Newmont regained exploration rights over the Santa Barbara area in 2017, the company currently works alongside the ASM operators for the drilling program work and regularly engages with them as part of the ongoing community relations program[21].

4.12.2.3 Demographics

Small scale mining in the Sabajo concession area is carried out by an estimated 198 individuals. This number includes individuals who take percentage shares from gold miners but may not permanently be present in the area. Almost all those directly involved in ASM (93%) reside in Paramaribo when not actively mining, while the remainder stay either in the bush around the mining area, or with family members in other communities. Of the total ASM workforce, only 10% is female. Women typically work in supportive roles such as food preparation and hospitality (i.e., 15 individuals), or as commercial sex workers in "cabarets" (i.e., 13 individuals). There was one female equipment owner.

About 71% (140 individuals) of small scale miners studied operate in the Santa Barbara area. The majority (80% [112]) of these are gold workers. Equipment owners and land bosses make up smaller portions of the Santa Barbara ASM population (9% [15] and 1% [2], respectively). Other miscellaneous workers make up the remainder of the ASM population in this area (9% [12]). Margo is home to the next largest group of small scale miners in the Sabajo concession area, where 35 individuals (18% of small scale miners) are employed as either gold workers (32 individuals) or equipment owners (3 individuals). There are several other ASM operations of lesser scale at Km 34 (6 gold workers, 1 equipment operator), Polaco (6 gold workers, 1 equipment operator), and along the road to the Sabajo base camp (9 other miscellaneous workers).

Of the total 198 miners in the Sabajo Concession Area, 21 are Kawina. Most of these (86% [18]) work in the Santa Barbara area, while the remainder (14% [3]) work around Margo. Around half (52% [11]) of Kawina small scale miners are employed as gold workers, while most of the remainder (38% [8]) are equipment owners. The two land bosses employed in ASM in Santa Barbara also claim to be of Kawina decent. It is noteworthy that nearly half of the equipment owners are Kawina, and that non-Kawina equipment owners are largely Brazilians who make payments to a Kawina land boss. The Kawina feel that the areas that they mine are within Kawina lands, and so believe that they are not required to make payments to land bosses, and that they cannot be evicted by other small-scale miners.

Educational achievement in the ASM population is low. Most (87%) had no more than some level of elementary education, though more than a third (39%) had not actually completed elementary school. Individuals who had studied further had completed middle school (6%), lower technical education (5%) or lower vocational training (<1%, i.e., 1 individual). Of those with completed technical education, areas of study include truck driving licenses (1 individual), excavator operation certificates (3 individuals), construction diplomas (2 individuals), and certificates related to electrical and mechanical trades (4 individuals).

[21] Dries Hugo, Security Manager Suriname, and Otto Sloane, Security Manager South America, 23 July 2017.

4.12.2.4 Land Bosses

Though not legal under Surinamese law, the system of land bosses is a commonly accepted practice in ASM areas in Suriname and acts to informally regulate and govern these areas. Land bosses are typically people who claim either formal (i.e., concession title) or informal (ancestral/tribal) rights to the land where ASM is taking place. Gold miners pay concession fees that typically corresponds to 10% of earnings. Of the two land bosses in the Project area, the more influential land boss cannot claim rights on either ground. This individual's status as land boss is based on being the first Surinamese person in Santa Barbara, and on a non-verified concession title claim for the Santa Barbara flood plain area (he is related to Kawina more indirectly, through marriage). This individual also brought Brazilian equipment owners to the area and trained them in ASM. Unlike Kawina small scale miners in the Santa Barbara area, other miners make payments to the land boss for their permission to mine the area. In mining zones other than Santa Barbara, ASM equipment owners do not make payments to land bosses because they are Kawina, or because they do not accept and challenge the legitimacy of *any* land rights claim. Some have also not yet been visited by someone claiming to be a land boss, and so do not make any payments. Payments made to land bosses do not extend to or benefit Kawina communities as a whole or entity, rather staying with the individuals. Research revealed an uneasy relation between the Kawina traditional authorities and Kawina mining equipment owners, mostly due to the use of communal grounds for personal gain. The traditional authorities have little control over ASM activity at Sabajo.

4.12.2.5 Equipment and Service Providers

Small-scale gold miners at Sabajo have highly mechanized operations, with nearly all operations using excavators that are either owned or, less commonly, rented. Thirteen hammer mills and 14 sluicing systems were active at the ASM operations in the Sabajo area. Although all equipment owners reported the use of mercury to extract gold from the ore, nearly all did not use mercury retort to reduce the quantity of mercury vapor. The use of toxic substances other than mercury is rare. Consulted ASM equipment owners estimated the average value of their machinery at roughly $100,000 USD.

There are a limited number of ASM service providers in the Sabajo Project area. One store located along the road to the basecamp sells basic groceries and user items. There are also four cabarets that employ a number of commercial sex workers.

4.12.2.6 Economics

Small scale mining as it is currently practiced in Suriname requires substantial financial investment. Not only does the equipment owner need to buy the processing equipment (e.g., hammer mill or hydraulic set), an excavator is also indispensable. Fuel is the largest variable expense, with between 3,000 to 8,000 liters of diesel consumed per excavator per week. When working with an excavator, the gold workers receive 20% of mining earnings, while the equipment owner retains 80% to cover the expenses and make an income. Assuming six day work weeks, average earnings for gold workers would be 17.8 grams (g) of gold per month, equating to $570 USD per month. Inclement weather, equipment malfunctions and other operational challenges are frequent, however, resulting in lower real earnings for gold workers estimated at half this value (i.e., $288 USD per month). ASM equipment owners may make over $1,100 USD per month, but must often use a portion of this to cover debts taken on to finance the purchase of equipment. Equipment owner debts ranged from approximately $2,000 USD to $200,000 USD, with an average of $63,000 USD. Given these expenses, gold miners indicated that they need to find at least 18 grams of gold per barrel of fuel[22] to

[22] Gold miners typically express the profitability of a work location in grams of gold per barrel of fuel. Fuel expenses are the highest variable expenses.

break even. When they are unable to break even, gold miners may borrow additional money, buy fuel for the next mining cycle on credit, and/or not pay the workers for that cycle to keep the operation going. Failure to timely pay debts, in turn, results in an additional fine or confiscation of the items that have been placed as collateral. Based on interviews in many other ASM areas, it can be assumed that persons working in the ASM sector sell their gold to one of the certified gold shops in Paramaribo.

4.12.2.7 Small Scale Mining in the Local Context

Food for the camps is primarily obtained from Paramaribo. Some individuals hunt and fish and in many camps people plant some basic food crops to supplement the diet. The majority of ASM operations obtained drinking water from a well, and others relied on rain and/or creek water. Most camps created some sort of sanitary facility in the forest (typically, a large hole with wooden beams across) and others relied on the forest floor. Garbage is disposed of by digging holes in the ground that is then sometimes burned or covered with sand. For medical services, ASM workers would travel to Paramaribo or French Guiana. Emergency cases rely on the Newmont health post at the base camp. The vast majority (94%) of ASM workers did not have health insurance. For protection against theft and violent assault, some ASM operations have hired armed security services, either continuously or only on high risk days. Quoted expenses for such services ranged from 10 g Gold (~ USD 320)/pp/day to USD 3,000-5,000/month.

The ASM have virtually no relation or contact with the surrounding Afobaka communities. As most small scale miners live outside the project area and supplies are mostly sourced from Paramaribo, few economic benefits stay in the project area.

4.12.3 Cultural Practices and Intangible Values

4.12.3.1 Methods

This section summarizes the results of two studies of the cultural context of AOI communities. While the socioeconomic portions of the Socioeconomic and Cultural Resources Survey (Social Solutions and ILACO 2017a) have been described further above in Section 4.12.1.1, the cultural portions are summarized below The Intangible Heritage baseline for the Brokopondo communities (Social Solutions and ILACO 2017c) consisted of information gathered from focus group interviews and desktop review. The consultant conducted focus groups with men, women, and youth as well as individual or two-person interviews. Desktop review using information from the National archives and existing studies focused on cultural places and customs and was used to complement and verify information gathered through interviews. The author’s personal knowledge of Ndyuka and Saramaka culture was also used to supplement the focus group interviews and desktop review. Research procedures adhered to professional ethical standards for social science research. Methods validation meetings were conducted in the six target communities along the Afobaka Road. The consultant explained the upcoming study and the methods used and obtained informed consent from the participants.

4.12.3.2 Brokopondo and Kawina

4.12.3.2.1 Tribal Identity

The Ndyuka are one of six Maroon groups in Suriname. Anthropologist Richard Price estimated their 2014 numbers at 26,000 in the Suriname interior and another 30,000 individuals in Paramaribo and environs (Price 2013). The traditional living areas of the Ndyuka in Suriname include the Tapanahony River (named: Ndyuka River), Cottica/Moengo regions, and the Sarakreek (NDY: Saakiiki). Inhabitants of this latter region mostly moved to Brokopondo, north of the lake when the hydropower dam was built. In addition, smaller concentrations of Ndyuka live along the Lawa, Marowijne, and Commewijne Rivers.

The Saramaka (also: Saamaka, Saramacca) are one of the six Maroon groups in Suriname. Price estimated their 2014 numbers at 28,500 in the Suriname interior and another 29,000 individuals in Paramaribo and environs (Price 2013). The Saramaka Maroons have traditionally lived along the Suriname River, where most of their communities are still situated – both north and south of the lake.

The project area is located entirely in the Commewijne River watershed; in the triangle between the Bigi Anu Creek/ Little Commewijne River and its tributary, the Tempati Creek. This general area has historically been used by people who refer to themselves as "Kawina", meaning "Commewijne" in Ndyuka[23]. Among people who call themselves "Kawina", one can distinguish people from the lower Commewijne River - who are mostly Indigenous mixed with Creoles - and people from the upper Commewijne River, who are ethnically predominantly Ndyuka[24]. The latter group considers itself as a sub-group within the Ndyuka tribe and, as described earlier, falls under the traditional authority of the Ndyuka Granman.

The Saakiiki *people* are a subset of Ndyuka Maroons who settled in the Saakreek (Sarakiiki) region in the late 18th century. Several Saakiiki communities were resettled north of the Brokopondo lake when the hydropower dam was built in 1964; mostly along the Suriname River. Even though these communities (Tapoeripa, Compagnie Kreek and Boslanti) do not have a centuries' long presence in the area, they do claim territorial rights to the land around the communities they were forced to move to. The Saakiiki in the communities north of the hydropower lake presently fall under the Ndyuka Granman.

4.12.3.2.2 Leadership Structures and Appointment

The different Maroon groups have a comparable traditional authority structure, with the Granman (paramount chief) as head of the tribal group, and Kapiteins (clan heads/village leader) as main authorities in the villages. The Granman and Kapiteins are assisted by Basjas (administrative assistants).

Politics and religion are interwoven in most Maroon groups, with the Granman and Kapiteins being central persons in communicating with the ancestors and the outside world. In recent years, many villages have chosen to elect their leadership instead of appointing them for life as has been historically done which may increase their legitimacy for some, especially younger people. The change in process has sometimes resulted in disagreement in determining the legitimate village authority. Identifying the current successor of the overall clan leader (Granman) for the Saramaka Tribe is one example of these succession disputes. When the legitimacy is questioned, the process can be drawn out for a number of years and can create a leadership vacuum where decisions are not made and confusion can arise.

[23] Both Kawina traditional authorities and other Kawina individuals mentioned in focus groups and personal interviews that Kawina people, mostly men, historically used this general area for logging, fishing and hunting. During such trips, men built temporary shelters in the forest. One Kawina gold miner, Mr. Misidjang, reported that his grandparents lived some years in a settlement (*kampu*) along the Bigi Anu Creek (pers. com, R. Misidjang, 05-08-17). They called this place Lemiki bong (Lemon tree). Mr. Misidjang found it difficult to estimate the exact distance from this Santa Barbara, but estimated it at about 2-3 km. The family fished, hunted and planted in this location, but moved when their children grew older and they wanted to send them to school. There is no evidence that there have been larger permanent villages in this area.

[24] There does not seem to be a clear land mark that divides the upper Commewijne River area from the Lower Commewijne River. In the small-scale mining study one respondent reported that everything from Gododrai southward is Upper Commewijne (Mr. Francis and Mr. Misidjang, pers. com. 19/07/17). According to another respondent in this study, everything down river from Cassiwinica is lower Commewijne (Jopoi, gold equipment owner, pers. com. 031117).

4.12.3.2.3 Tribal, Clan and Family Structures

Suriname's Maroon societies have a largely matrilineal descent structure, with heritage and family relations being traced to the organizational units of *Oso, Mamapikin, Bee, Lo* and *Nási*[25]. For Maroon individuals, these kinship lineages are very important in determining who is to be trusted, who will assist in times of need, who one associates with, and who are suitable marriage candidates. In order to understand the various communities, it is important to be aware of these lineages. Insight into these relationships will help determine whether the interests of different groups in a community are represented and if one group does not benefit at the expense of others. The physical structure of the village is not necessarily the most important unit that Maroon individuals will associate with. The lineage or *lo* is more important, which may have consequences for the distribution of benefits in the communities. Consultation with individuals suggests that the *lo* plays a less important role in individual's lives when they live in the city, where their daily social circle includes a larger diversity of people[26]

4.12.3.2.4 Religion

Religion is central to Ndyuka and Saramaka daily life. Among the target Afobaka communities, villages can be roughly categorized as Christian (missionized) villages and non-Christian villages, where the traditional Winti religion is dominant. In reality, the divide is less strict; inhabitants of Christianized communities take part in Winti rituals, and in Non-Christianized communities one finds Christened people who may not obey certain traditional cultural codes.

The Winti religion is animist and polytheistic, and ancestral spirit veneration plays an important role. The three-tiered hierarchy of higher and lower Gods plays a crucial role in every aspect of Ndyuka and Saramaka life, though perhaps less so for individuals who have been converted to Christianity. Each village, or each lineage, has a number of active mediums (lukuman or obiaman) who may be consulted for divination or remedial action. Breaking the rules and taboos that have been imposed by the various deities will upset their ancestral spirits. Avenging, ancestral spirits (kunu) must be appeased when a wrong is committed, through libations and sacrifices as directed by religious practitioners (priests and mediums) to prevent the wrath from happening.

Due to historic differences in missionary activity, all Saramaka communities in the sample were "Christian" (Roman Catholic, Moravian, and Apostolic) and all Ndyuka communities were "non-Christian". Living in a Christian community, or identifying as Christian does not mean that all villagers are Christian or that all traditions related to the Winti religion are abandoned. In some cases, conversion to Christianity is done in combination with Winti beliefs. "Non-Christian" communities typically have both a church and burial sites for those who are Christians and those who adhere to the Winti religion. Interviews with respondents from "Christian" communities reported that the church does not interfere with the traditional beliefs and taboo beliefs, and people still respect their traditions. Individuals who are Christian partake in many traditional rites and ceremonies, including libations and spiritual possession. In comparison to the "Christian" Saramaka communities, traditional cultural expressions seem more strongly maintained and appear more important in Ndyuka non-Christian communities. Places of spiritual worship also seem better maintained and more central to community

[25] In brief these organization units are defined as follows:
Oso-'house' including mother and children belonging to the same matrilineage and mother's spouse.
Mamapikin-family members that share a common grandmother or great grandmother'
Bee-descendants of a common mythical ancestor
Lo-sub group within the larger tribal group or (matri) clan
Nasi-Motherclan
[26] For example, not one of the six women in the Kawina focus group was married to a Kawina man, simply because they had met someone else.

life and taboos (e.g., menstrual taboos) appear more important. The Ndyuka generally seem to use charms, amulets, and fetishes to protect themselves from evil more than the Saramaka do.

4.12.3.2.5 Shrines, Places of Worship

The two ancestral shrines of most significance are the Mortuary and the ancestor pole/flag pole. Without these two structures, a settlement is not considered a real ancestral "village" but a kampu (camp), regardless of the number of inhabitants and layout. In addition, the majority of villages have one or more shrines and ritual places. Such ritual places are also found in the old Kawina villages and are still used. Community members reported that there are specific places in the forest where you may not go; but in many cases, one only recognizes such a place upon approach. For all communities, the burial sites are special places that must be preserved and maintained. If a person passes away, the family decides at what burial place will be used.

All communities reported one or more locations with special sacred significance. Sacred trees include: Kankantrie (Ceiba pentandra), Katu (SAR) or Nkatu (NDY) (Moraceae Ficus), and Kwatakama (Parkia spp.). Generally, it was recommended that if one encountered such a tree during road planning and building, the road should go around it. Various snakes (Boa Constrictor, Anaconda, Boa Spp.) are considered sacred animals.

4.12.3.2.6 Rites of Passage, Rituals and Celebrations

Maroons have rites of passage during the most important transitions in their lives. These include rites of passage around important life events such as celebrations around the transition to adulthood for girls and boys, and rituals during marriage, pregnancy, childbirth and death. The size of the event depends on the character of the community (incl. the dominant religion), on the position of the individual, the preference of the family and of the financial situation. Maroons living outside their traditional village still attach value to these rituals and celebrations.

Important rituals are libation to call upon ancestral spirits, and *sweli* - consultation of an oracle and sacred bundle to investigate the supernatural cause of an accident, illness or death. *Tap yari* is an annual party to celebrate the closing of the past year and the beginning of the current year. Every village has its own *tap yari* but the day of celebration is mutually agreed among other villages. This leads to a sequence of *tap yari* celebrations that usually occur in the first three months of the year.

4.12.3.2.7 Taboos

Taboos are in place that establish rules, norms and restrictions that should be followed in order to avoid bad fortune for the individual and community. These include acceptable behavior for women during menstruation, the sanctity of animals of importance (i.e., not harming the boa constrictor), taboo days in which one is not allowed to perform heavy physical labor, and the protection from pollution with respect to the use of sacred waterbodies (i.e., creeks and rivers) or forests. When people violate the taboos willingly, bad things may happen to them, including death. When people violate the taboos unknowingly or coincidentally, the consequences are not as severe. Still, if one is aware, it would be good to perform certain rituals to beg pardon for such violations. Such rituals typically involve libation and may take place either in the community or at the location where the incident took place.

4.12.3.2.8 Traditional and Spiritual Healers

In times of illness, community members rely on a combination of Medical Mission Primary PHC clinics, *dresiman* and/or *obiaman*, traditional herbal remedies prepared in a special bowl (*patu*), and home remedies. In all consulted communities, there was at least one dresiman, and often also obiaman, traditional midwives, and other specialized healers. For some treatments, such as vaccinations of babies and infants, villagers exclusively rely on the Medical Mission PHC clinics, and today childbirth rarely takes place without certified health workers. The Medical Mission clinics are not opposed to consultations with traditional healers and there are even cross-referrals (IADB 2006).

4.12.3.2.9 Visiting the Community: Protocol for Visitors

Outsiders visiting the community for formal/professional reasons are expected to arrange their visit through the traditional authorities preferably 1-3 weeks in advance. When arranging community meetings, it is important that representatives of different community sections and/or different clans are represented. For large meetings in an official setting (e.g., signing of an agreement, handing over a present), bringing a bottle of *sopi* (strong liquor) for libation is good practice.

A day in advance of the visit, visitors should make contact with the *Kapitein* to confirm if the visit is still feasible. Rituals and festivities can cause a last minute change of plans. When visiting the village, although there is no dress code, one should wear appropriate clothes. When entering the village outsiders should announce the arrival to the *Kapitein* or to the person who was assigned as contact person by the *Kapitein.* Visitors can ask for a guide to walk them through the village or to take to specific locations in the village. More generally, when visiting and communicating with traditional communities, outsiders should be aware of the importance of tangible and intangible heritage and the value attached to these cultural resources.

4.12.3.3 Carolina Communities

4.12.3.3.1 Indigenous Identity

Archeological research suggests that pre-Columbian Indigenous groups travelled through the Amazon flood plains along the Rio Negro and the Orinoco River valley to the Northern shores of the South American continent. These early Orinoco cultures influenced Indigenous cultures throughout the Caribbean region and it is plausible that the present-day Lokono have their origins among these groups. Since pre-Columbian times, the Lokono co-existed with the Kaliña Indigenous groups in the same areas. The Kaliña Indigenous peoples came from the North, from the Caribbean region. Not much is known about the exact location of the early Lokono and Kaliña communities.

Historic records suggest that the Lokono and Kaliña Indigenous peoples moved into the present-day East Para region in the early 17th century, to keep at a distance from the plantations that were established in the coastal area. Casipora and Pierre Kondre Kumbasi are the oldest Indigenous communities in this area. Pierre Kondre Kumbasi and Redi Doti are Kaliña communities, while Powakka, Philipus Kondre and Casipora are Lokono communities. Nowadays, the population is more ethnically diverse; 45% of Pierre Kondre Kumbasi inhabitants are mixed Kaliña-Lokono, and in Redi Doti almost half of the population is mixed with non-Indigenous. In the most isolated and traditional community of Casipora, three quarters of inhabitants continue to self-identify as “pure” Lokono.

A loss of traditional knowledge and culture was reported in all five Indigenous villages. The causes include missionary activity, (temporary) migration during the Interior War, improved accessibility and resulting influx from outsiders, labor migration, and the influence of television. As a direct result of improved access, tourists now visit the communities in larger numbers while also making it easier for villagers to buy products in Paramaribo and market their products in the city. Moreover, the presence of Suralco, SEMC NV., and other firms has brought outside laborers to the area. Meanwhile the relatively limited local employment opportunities cause many Indigenous individuals to leave in search for employment. Community inhabitants reported that the increasingly mixed composition of the villages from the influx of other Indigenous and non-Indigenous cultures has contributed to cultural change.

Specific cultural expressions such as traditional dancing and music have deteriorated and are seldom practiced. Crafts such as the Indigenous hammocks are also seldom fabricated. Only elderly people still know the skills of fabricating hammocks from white cotton (*Gossypium Spp.*) or fibers of the Morisi palm (*Mauritia flexuosa*). Folklore costumes for tourism purposes are still made but the production process has changed. In all villages, working together collaboratively (Lok: nekobotang; Kaliña: moshiro) is still practiced and remains culturally significant.

Evidence suggests that Dutch and Sranantongo are increasingly replacing the Indigenous languages. While elders (70+) still speak Kaliña and Lokono fluently, young people primarily speak Sranantongo and Dutch. Children rarely understand and speak the Indigenous languages. The fact that Dutch is the formal school language probably affects this result. Various language programs have been developed or are in development by VIDS that focuses on incorporating Indigenous language as part of the school curriculum. Among others, VIDS is working on the Penard's Kaliña Encyclopedia project that will be introduced in the school of Redi Doti.

In Casipora, Redi Doti and Pierre Kondre Kumbasi, Sranantongo has strongly influenced the use of Indigenous languages so that a hybrid language is formed, such as Lokono with Sranantongo pronunciation and words. The community of Casipora counted the highest proportion of Lokono speakers and the lowest share of people with fluent Dutch skills. In Pierre Kondre Kumbasi and Redi Doti, there were no people who reported the Indigenous language as their most used language. Pierre Kondre Kumbasi counted the largest share of respondents who reported speaking Dutch fluently, with little difference between women and men.

4.12.3.3.2 Religion, Rituals Taboos and Rites of Passage

The Catholic Church has a long history of missionary activity in East Para and has established churches in all target villages. Other church societies, such as the Pentecostal Church and Jehovah's Witnesses, organize their praying sessions at home as they are not allowed to build prayer houses in the community. *Kapiteins* reported that other church societies can divide the community and are hostile towards expressions of traditional Indigenous culture. The Catholic Church is regarded to be more tolerant towards expressions of traditional Indigenous religion. The traditional spiritual leaders of the Lokono and Kaliña are the shamans or piai. Currently only Pierre Kondre Kumbasi and Redi Doti have a piai. Indigenous rituals continue to be performed with important events and may include libation. Libation can be done by either men or women, and does not necessarily need to be done by the Kapitein but does need to be executed in the traditional language.

Taboos are an integral part of the traditional Indigenous belief system. There are taboos around sacred waterbodies (creeks and rivers), animals of importance (boa constrictor) and particularly women's menstruation. Menstrual taboos include prohibitions against entering certain places (e.g., the forest, cemetery) and certain behaviors (e.g., cooking for men). Like the Maroons, Indigenous peoples traditionally adhere to menstrual taboos but these taboos are no longer strictly obeyed in all Indigenous communities of East Para.

Rituals around rites of passage such as pregnancy, child birth and transition to adulthood for both girls and boys are either no longer performed or have been adapted to be aligned with the expectations of younger people. While traditionally, a pregnant woman was not allowed to eat certain foods and their spouse had to obey hunting and fishing restrictions, few young couples follow these rules today. Similarly, transitions to adulthood rituals have been mostly abandoned. One such example of the modernization of rituals is the shortening of the mourning periods for the deceased with traditional festivities involving kasiri consumption, vomiting, and hair cutting only reported in Casipora and Pierre Kondre Kumbasi.

In the traditional religion, certain trees, plants and animals have special spiritual meaning and some of these beliefs are very similar to those in the Maroon Winti religions. However, only a few of the respondents named examples of sacred plants/tree and animals. These included mentions of the Kankantrie, tobacco tree, pepper tree, Takini-tree, a sacred vine, areas of the forest that cannot be removed, and the Boa Constrictor/Suriname Redtailed Boa.

While the practice of rituals may be on the decline, people continue to harvest non-timber forest products, including medicinal plants, construction materials, plants and plant parts to fabricate crafts and utensils, plants for hunting and fishing purposes, and edible fruits and plants (e.g., palm fruits). Medicinal plants are used for a wide variety of illnesses, injuries and conditions. Some individuals who rely on medicinal plants attribute healing powers to these plants by themselves, while other people combine plant use with rituals. As compared to elders, youth are much less knowledgeable about medicinal plants and many do not seem interested in learning this type of traditional knowledge. In Casipora, Powakka and Philipus Kondre there are *dresiman* or traditional healers. Casipora and Powakka also have traditional midwives. Pregnant women can choose to go to the Medical Mission clinic for prenatal care and delivery or to the traditional midwife upon which they must also follow cultural rules.

Representatives from Casipora, Redi Doti and Pierre Kondre Kumbasi reported several places with special spiritual, historic and/or cultural significance around their villages, including forests of importance. Some places are physically recognizable (e.g., *tokai* houses and burial sites) and others are less obvious to outsiders but may be recognized by certain vegetation or landscape features. The use of natural resources is an important part of the culture and livelihoods of these villages.

4.12.3.3.3 Leadership

The authority structure of *Kapiteins* and *Basjas* was implemented in Indigenous communities and modelled after the Maroons. However in contrast to most Maroon tribal groups, the Lokono and Kaliña Indigenous groups do not have a *Granman* or Paramount Chief. Paramount Chiefs existed up to 200 years ago but due to wars and internal conflicts, the Indigenous peoples no longer have central leadership. Village authorities have discussed with VIDS about whether *Granman* should be reinstalled and noted that more discussion is needed before a decision can be made,

The *Kapiteins* are the head of the traditional village governance structure and they and other members of the traditional authorities are appointed through designation. However in recent years, some Indigenous communities have opted for democratic election to select their community authorities. Casipora and Red Doti appoints traditional leaders through designation although villagers can influence the outcome by providing their input on the potential leader. In Powakka and Redi Doti, the current village authorities were elected. In Powakka, the election process was supported by VIDS through the appointment of a commission that defined the profile for suitable candidates. *Kapiteins* once appointed or elected automatically become a member of VIDS. VIDS is not involved in the appointment process but occasionally will intervene such as when a *Kapitein* is asked by the village to step down but refuses to go. They may sit in the meetings as silent observers and give advice, but ultimately it is the village that decides.

4.12.4 Historical Narrative of Traditional Lands around the Project

This summary provides an overview of the traditional land ownership of the Project area and discusses cultural sensitive engagement and decision making processes with rights holders. The report focuses on the Kawina area of occupation, villages and settlements and land uses, and enables conclusions about land claims based on UNDRIP (United Nations Declaration on the Rights of Indigenous Peoples) and ADRIP (American Declaration on the Rights of Indigenous Peoples)[27].The objective was to determine whether the Project area is situated within traditionally owned land but did not undertake determination of tribal boundaries.

4.12.4.1 Methodology

The Historical Narrative study consisted of collecting, analyzing and validating existing information and collection of non-documented information. The methodology was designed in two parts:

1) literature review and validation of historical maps (through participatory mapping validation meetings, semi-structural interviews, storytelling sessions, focus group meetings, a workshop and field mapping excursion, visits and verification meetings) with the Saramaka/Saakiiki, Kawina, Lokono, Kaliña, and Paamaka; and,

2) assessing the Kawina land claim in the Project area and their traditional studies. The study also sought to address the validity of the Kawina land claim to the Commewijne watershed area near the Merian mine and to preclude the possibility that the other tribes could make a claim.

The determination of the criteria for the identification of traditional land rights (“the criteria”) reflect the UNDRIP and ADRIP:

- Evidence of the historical occupation and use of the lands and resources by members of the community;
- Evidence of the development of traditional subsistence;
- Ritual and healing practices therein; and
- Of the names given to the area in the community’s language.

The research approach was designed to verify the validity of potential traditional land rights claims against these criteria.

4.12.4.2 Traditional Territory

Preliminary desktop study and the mapping validation exercises in particular yielded the following outcomes:

- Indigenous peoples of upper Para region, as well as Paamaka and Ndyuka, including Kawina, recognize that Indigenous peoples are the first inhabitants of the territory surrounding the Sabajo Hills;
- Indigenous peoples of upper Para region (Kaliña and the Lokono in the Carolina bridge area) do not claim land in Newmont’s Project Area and their traditional territory does not overlap the project area;
- According to Kawina people, the Peace Treaty of 1760 (1761) is still valid and they recognize the territory upon which the Sabajo Project is located as their traditional territory;
- The watershed of the Commewijne River and the watershed of the upper Suriname River are the natural borders for the Kawina and Saramaka, respectively; and,

[27] Resp.article 24 to 29 (UNDRIP) and section V, article XXV (IADRIP) directly address the rights of Indigenous peoples’ land, territories and resources.

- The Commewijne River is still inhabited and the Tempati and Little Commewijne Creeks are still traditionally used by the Kawina people.

Further data collection found evidence of traditional collective habitation and use of land by the Kawina people within the Commewijne River area including the Tempati, Little Commewijne and Mapane Creeks. The watershed of the Commewijne River belongs to the Kawina according to Kawina and as agreed by the Paamaka. This watershed includes the land upon which the Merian mill and tailings facility sits. Kawina people have been present in the area for at least five generations according to their own oral history while literature demonstrates traditional occupation of the Commewijne watershed territory by the Ndyuka tribe since the first half of the 17th century.

Due to the Interior War in Suriname (1986-1992), the Kawina people were forced to flee their communities. After the war, many were unable to return to their villages due to a lack of resources to rebuild the villages. Some still maintain agriculture plots and practice hunting and fishing in the area as well as logging and other economic activities. People are still buried on the land and other spiritual ceremonies and rituals are regularly practiced in their territory. As the Kawina do speak their own language, places and important cultural activities are named in their mother tongue. During school holidays, Kawina families travel from the city to stay in the villages. The Kawina people continue to consider the land as their collective territory.

According to the criteria and the international rights of Indigenous and tribal peoples, the Kawina land claim is valid[28]. Literature, maps and interviews demonstrate historical occupation and use of the lands and resources (criterion 1); maintenance of agriculture and other economic activities demonstrates development of their traditional subsistence (criterion 2); rituals and healing are practiced (criterion 3); and places and important cultural activities are named in their mother tongue (criterion 4).

Although the research team was not able to travel entirely to Newmont's Project area via the Little Commewijne Creek, the team interacted with a Kawina elder throughout the excursion. The elder named places and shared narratives about traditional use and occupation and demonstrated knowledge of the territory. Very near to the end of the excursion, fewer names were given to places and the creek became very dense. According to the narratives, this spot holds some taboos but the whole Commewijne Creek was in use by Kawina as told by them.

Literature review as well as data from interviews and focus group meetings with Saramaka/Saakiiki community members do not indicate that the Saramaka/Saakiiki people have traditional collective habitation and use of the territory at Sabajo Hills. The Paamaka do not claim the Commewijne River area and acknowledge that the mountain ridge of the Nassau Hill (which also passes through the Merian Mine) is the border between their area and the area of the Kawina people. Tempati Creek is in the watershed of the Commewijne River. The Paamaka recognize that the Merian Mine area is on the border between Kawina and Paamaka territory. The watershed should define the exact border.

[28] Just like any human society, Indigenous peoples –and the communities that compose them- have their own history. They are dynamic human groups, who reconfigure themselves over the course of time on the grounds of the cultural traits that distinguish them. Indeed, Indigenous and tribal peoples' culture is continually adapting to historical changes; Indigenous and tribal peoples develop their cultural identity over time. In this sense, the Inter-American Commission on Human Rights (IACHR) has recognized, for example, that Guatemalean Indigenous peoples, in spite of the ethnic discrimination to which they have historically been subjected, "whether they live in rural or urban areas, they maintain an intense level of activity and social organization, a rich culture, and are continuously adapting to situations imposed by the exigencies of historical change, while protecting and developing their cultural identity" [IACHR, *Fifth Report on the Situation of Human Rights in Guatemala*. Doc. OEA/Ser.L/V/II.111, Doc. 21 rev., April 6, 2001, Chapter XI, par. 4].

4.12.4.3 Traditional Protocols

The Historical Narrative report discusses Ndyuka tradition, ceremonies and experiences as they relate to protocols of engagement and agreement making. Key findings are as follows:

- Ndyuka use a matrilineal sequence method to determine succession of a captain. Preferably the Granman (paramount chief of tribe) and captains are chosen from the same 'lo' (family line) as their predecessor. However, politics sometimes has a large influence on the designation of a captain due to the government's ability to also appoint captains. This is against the tradition and it is breaking up important structures of the Ndyuka society.
- Formal Traditional Authority still exists, but is difficult to practice since most Kawina now live in Paramaribo. For traditional communities, the institution of the village meeting, Krutu, is very important. Depending on the agenda, Kapiteins, Head Kapiteins and the Granman are present and leading the krutu with the conversation being led by a Basja. If necessary, the Kapiteins and other leaders speak directly to their villagers. Kapiteins will organize a krutu in Paramaribo via local radio stations to meet with villagers regarding issues at the village or tribal level.
- Although individual Kapiteins are criticized for not fairly distributing community benefits, the institution of the traditional authority is still very alive, so the strength of this institution is relevant:
    - Kapiteins selected through their matrilineal kinship line and appointed through their traditional structures have a broad support system;
    - One cannot bypass Kapiteins in making an agreement on behalf of a village since the institution of traditional authorities is still respected; agreements with Kawina peoples as a group should be discussed with the Granman of the Ndyuka tribe who will then decide on the process after being informed;
    - In relation to Newmont's project development, the Granman clearly explained that agreement making is part of the engagement and negotiation process of Kawina people themselves; Kawina can make their own decision related to agreements; and
    - Kapiteins are expected to have internal meetings between the traditional authorities and other village Kapiteins.
- Three Community Based Organizations' (CBOs) coordinated efforts to rebuild villages. While the organizations made efforts for a few years, insufficient finances on a community level, lack of support of traditional authorities and donor organizations have resulted in inactivity of the CBOs at the time of this report.
- Agreements, including unwritten agreements, are sacred. Regarding any agreement making efforts between Newmont and communities, the Granman of the Ndyuka proposed establishing a commission consisting of traditional authority, men, women, youth and miners from villages as well as an expert.

4.12.4.4 Recommendations

The Historical Narrative report made a number of recommendations regarding the process of engagement and negotiation with the Kawina people. Communities should be approached through the traditional structures. The Granman is the highest in hierarchy of traditional authorities of Ndyuka and all other Maroon tribes. Respect should be shown for this institution and the Granman should always be informed. Discussions should be first held with the Granman unless the Granman decides otherwise. Contact with the Granman should be conducted through his secretary, Kapitein or Basja as direct contact is not respectful. The structure of consultation and the engagement process should be decided upon collaboratively with the Granman. The krutu is an institution that should be respected and typically forms part of the process of information sharing and decision making. Capacity building will be necessary and should be culturally sensitive and should take into account customs, capabilities and different perspectives.

4.12.5 Historical and Archaeological Resources

4.12.5.1 Introduction and Background

The scope of work for the Sabajo Project tangible heritage baseline study is to identify, describe and determine the significance of tangible cultural heritage, defined as moveable or immovable objects; property; sites; structures; or groups of structures, having archaeological (prehistoric) or historical value, in the proposed Project footprint. This section provides a summary of the objectives, methods and results of the Project tangible heritage baseline study.

The tangible heritage baseline study is consistent with internationally recognized good practice as described in the International Council on Monuments and Sites (ICOMOS 1990) Charter for the Protection and Management of the Archaeological Heritage and the GoS.

4.12.5.2 Methods

This Baseline study consists of three main parts. First, the study attempts to understand the cultural context of the proposed Project footprint and identify locations with the potential to contain tangible heritage resources through a review of readily available information pertaining to the environment, archaeology and history[29]. Second, 'study area communities' were defined as groups of persons that have the potential to be directly affected by, participate in, or benefit from the proposed Sabajo Project. This includes the following groups.

- the Kawina[30] who are a mix of Ndyuka Maroons and Ndyuka Maroons intermarried with Amerindian peoples, and who have historically been located in four villages in the area of Java, more than 30 km northeast of the Project. The majority of this community currently reside in the coastal capital of Paramaribo.
- the Saramaka and Ndyuka Maroons in six communities along the Afobaka Road running parallel to the Suriname River, approximately 15 km west of the Project.
- the ASM camps located in and around the Project footprint with persons from either of these Maroon groups as well as Brazilians and Hindustani.

The purpose of community consultation was to engage Newmont's study area communities about their relationship to what they define as their traditional territory. This process helps to solicit and confirm permission for access and study of said areas and to collect relevant data to help locate and describe tangible heritage sites or areas with archaeological potential in the Project area. In addition, verification meetings were conducted upon completion of the baseline study to allow study area communities to give feedback about the process and to identify errors in data collection and reporting.

Third, field work was undertaken in the Project footprint with adjoining natural creeks in the proposed Project footprint (Map 4.12-1). These areas are considered to have potential for tangible cultural heritage sites. These areas, were subject to pedestrian traverses and surface inspection.

This document is a summary of a more detailed archaeological study (White 2017).

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[29] Primary documents of maps and travellers notes were obtained from the Suriname National Archive. Secondary documents, including archaeological field reports were obtained from the Stitching Surinaams Museum Research Library. In addition the consultant relied on a wide variety of open source information. Landsat maps were made available by ILACO.

[30] See Historical Narrative section of the ESIA (Section 4.12.4).

4.12.5.3 Results

4.12.5.3.1 Literature Review: Cultural Setting

This section provides an overview of the pre-Columbian and colonial landscape relevant to the Project. Herein presented are: the pre-Columbian cultures that traversed the tropical forest region of the Project Area; the study area communities created in the colonial period, the Kawina Maroons historically located at Mapane, Little Commewijne and Tempati Creeks and the Saramaka and Ndyuka Maroon communities currently occupying villages of the Afobaka Road along the Suriname River. This section concludes with a review of 20th century tangible heritage.

Pre-Columbian Tangible Heritage

Suriname's prehistory sits within the broader context of the Guiana Shield, which encompasses Venezuela, Brazil, Suriname, French Guiana and Guyana. The Project footprint is located in the Precambrian Guyana Shield area described as inland, interior uplands or the hill and mountain.

Pre-Columbian sites have been extensively researched and inventoried in the coastal region but not in the inland (Versteeg and Bubberman 1992). As colonialism spurred disintegration and migration of Indigenous peoples throughout the country, many gravitated toward villages used as trading posts fabricated by colonists. During the colonial period, the plantation system developed a tolerant relationship with the Indigenous peoples to end their continued ravaging of planter properties. Indigenous groups were allowed to settle near colonists and trade items such as wood and dyes in exchange for European goods (Ngwenayama 2007:91).

Ethnohistoric records demonstrate that many of the Indigenous groups in the inland maintained short-lived villages, abandoning many of them after only five or six years of occupation. The Carib and Arawak Indians of this region practiced slash-and-burn cultivation, along with hunting, fishing, and the gathering of other natural resources (Koelewijn 1987; Stewart 1963).

Sabajo Project Area Potential Pre-Columbian Archaeological Impact

The pre-Columbian tangible heritage relevant to the Newmont Suriname, LLC (Newmont) study area communities and Sabajo Project are the so called Tropical Forest Cultures of the Precambrian Guyana Shield inland: Koriabo Culture, Brownsberg Culture and Pondocreek Culture.

The Koriabo Culture (AD 1200 to 1500) is believed to have originated in the lower Amazon with a tradition of appropriating settlements of other Indigenous groups. It is characterized by stone axes used to fell trees for slash and burn agriculture and a limited variety of artifacts, including ceramics with thin line incisions along the rim and animal appliques. In addition, there are circular to cylindrical shaped stones to crack nuts and polish stones. Sites from the Koriabo Culture are typically located in high sandy banks of rivers and creeks.

The Brownsberg Culture—as defined in the available literature—dates to AD 1200 to 1500 and is characterized by mined metabasalt from the Brownsberg (a mountain range west of the Afobaka Lake in the district of Brokopondo), fashioned into stone axes in varying degrees of completeness, ceramics with non-intersecting linear incisions at the rim and the appearance of trade goods associated with the Koriabo Culture. Early 19th century archaeological research revealed whetgrooves or grinding grooves (Photo 4.12-1); egg-shaped depressions in groups of five to six at regular intervals where stone axes were sharpened. Grinding grooves are also identified along the river basins near Maroon villages. The most commonly identified artifacts at these sites are stone tools made of quartz and rhyolite (Versteeg 1998, 2003; Versteeg and Bubberman 1992).

The Pondocreek Culture (AD 850 to 1600) has only been identified at the confluence of the Mapane Creek and Commewijne River and is the only site of this kind attributed to this Indigenous culture. The site itself boasts a circular mound that possibly functioned as a Maroon fortified village with a palisade, few moveable objects and no evidence of cultural soils. The identification of this site is the first instance of oral testimonials about Maroon appropriation of an Indigenous settlement.

Photo 4.12-1 Example of rock outcrop in a creek with a series of grinding grooves and an axe.

Registered Archaeological Sites Relevant to the Sabajo Project Area

All registered archaeological sites within 50 km of the Project area are characterized as pre-Columbian (Table 4.12-3). None of these are close to the Project. Suriname's archaeological record is biased toward pre-Columbian sites, with Maroon archaeological sites reported, identified and excavated, but not placed on the national register of heritage sites. The lack of national register status does not mean that Maroon sites do not exist in or near the Project footprint.

Table 4.12-3 Registered Archaeological Sites in Proximity to Newmont Study Area Communities and Sabajo Project Area

National Register Site Code[(a)]	Name	District	Type of Pre-Columbian Culture	Characteristic(s)	Location in Proximity to Sabajo Project	Distance from Sabajo Project in km
Sur-20	Kamp 8-LBB	Suriname (Para)	Koriabo	Settlement	Powakka Corridor	27.44
Sur-36	Phedra	Brokopondo	Koriabo	Settlement	Suriname River	36.13
Sur-38	Rama: Murphyweg	Brokopondo	Koriabo	Settlement	Powakka Corridor	36.36
Sur-93	Jennikreek	Commewijne	n/a	Settlement	Little Commewijne Creek	35.51
Sur-117	Baboenhol	Brokopondo	n/a	Settlement	Suriname River	32.47
Sur-120	Little Simonskreek-3	Brokopondo	n/a	Settlement	East of Suriname River	30.91
Sur-121	Little Simonskreek-2	Brokopondo	n/a	Settlement	East of Suriname River	25.56
Sur-123	Casiporakreek-1	Suriname (Para)	n/a	Settlement	Powakka Corridor	33.31
Sur-124	Casiporakreek-2	Suriname (Para)	n/a	Settlement	Powakka Corridor	29.19
Sur-125	Sarwacreek-1	Commewijne	n/a		? Powakka Corridor	29.59
Sur-126	Sarwacreek-2	Commewijne	n/a	Settlement	? Powakka Corridor	30.58
Sur-127	Berg gen Dal Fernootkreek	Brokopondo	n/a	Settlement	West of Suriname River	28.14
Sur-129	Victoria	Brokopondo	n/a	Settlement	Suriname River/ Afobaka Road	20.04
Sur-130[(b)]	Kaaimankreek	Commewijne	Brownsberg	Settlement with workshop	Northwest of Sabajo Project Footprint	9.07
Sur-131	Pondokreek-1	Commewijne	n/a	Settlement	Little Commewijne Creek	32.75
Sur-132	Pondokreek-2	Commewijne	Pondocreek	Ceremonial Site	Little Commewijne Creek	33.4
Sur-133	Java	Commewijne	n/a	Settlement	Little Commewijne Creek	39.57
Sur-226	Mapane	Commewijne	n/a	Settlement		34.77
Sur-346	Victoria-2	Brokopondo	n/a	Settlement	Suriname River/ Afobaka Road	18.6
Sur-391	Klaaskreek	Brokopondo	n/a	Stone axe with handle	Suriname River	29.94

Source: Versteeg (2003).

Notes:

a) The national register site code nomenclature is, Sur- (an abbreviation of Suriname) followed by a site number.

b) This site is nearest to the Sabajo Project Footprint. The exact location is unknown.

km = kilometer.

Literature Review: Colonial Period Tangible Heritage

The Dutch occupied Suriname in the mid-1600s after failed attempts by the French and English. In a span of 20 years, from the early 1630s to 1640, Suriname had changed hands from the French to the Spanish and Portuguese, who were quickly driven away by Indigenous peoples, and by 1634 to the English who sought to establish settlements in Suriname. However, each of these instances of attempted habitation was short lived and precipitated years of repetitive power struggles leading toward colonization (Ngwenayama 2007:58).

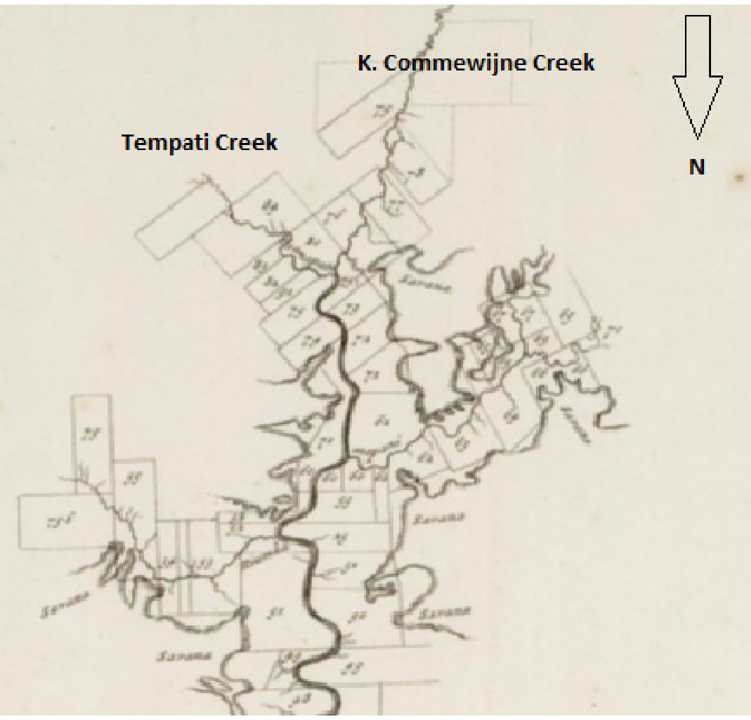
Suriname did not begin to gain colonial consistency until the appearance in 1650 of English Lord Francis Willoughby. The short-lived British settlement soon fell to a garrison sent from the Dutch province of Zeeland. Its English inhabitants were consigned to pledge allegiance to the States of Zeeland. A military post was shortly thereafter erected in Paramaribo at the mouth of the Suriname River and named Fort Zealandia.

The exacerbated costs of protecting the colony against attacks from Indigenous (Amerindian) peoples proved too much to bear, and the colony was soon partitioned to the City of Amsterdam and to M. Corneille d'Aersens Lord of Sommelsdyk, who continued as Governor. The plantation system soon became the mainstay for future Surinamese colonist wealth.

Plantation System of the Little Commewijne and Tempati Watershed

More than 30 kilometers northeast of the Project area are a configuration of 17th to 18th century plantations located at the confluence of the Mapane, Little Commewijne and Tempati Creeks, near the cluster of the four original Kawina villages. In the late 1600s there were over a dozen plantations (Figure 4.12-1) and by the mid to late 1700s that amount tripled (Figure 4.12-2). By the late 1600s, the Commewijne River and its southward extending tributaries boasted an established plantation system with sugar as the primary product.

Figure 4.12-1 1688 Map from Frederic de Wit with Few Plantation Lots at the Confluence of the Mapane, Little Commewijne and Tempati Creeks



Not to scale. (KDV Architects 2004)

Figure 4.12-2 1790 Map by Heneman of Tempati and Little Commewijne Creek Plantations

Not to scale. (KDV Architects 2004)

The plantations were established initially producing sugar. Types of large and fairly immovable tangible heritage found at Commewijne River sugar plantations include foundations, sugar mills and steam machinery. Smaller artifacts of European and Indigenous origin, including ceramic potsherds, green glass bottles, clear white medicine bottles and ceramic storage jars can also be found at plantations (Photo 4.12-2).

Photo 4.12-2 Examples of plantation tangible heritage. Photo on the left is a sugar boiling pot known as Kappa, center photo is a small cast iron sugar press (Photos by KDV Architects 2003). Photo on right is an 18th century green glass bottle.

Aside from what we know from archival maps, there have been no structured field assessments to identify plantation era tangible heritage in the area of Tempati and Little Commewijne Creeks. Therefore there is no archive of moveable and immovable tangible heritage that might still be visible on the ground surface.

By the early to mid-1700s the economic driver shifted from its primary product of sugar, to wood exploitation for timber needed to support a developing colony. This took place mainly along the tributaries of the Tempati and Little Commewijne Creeks. These new economic ventures did not stop long held resentment between colonists and escaped slaves. Throughout the mid to late 1700s on both Little Commewijne and Tempati Creeks there was guerilla warfare between the Maroon and Dutch colonials.

The 1757 uprising of five plantations on the Tempati Creek—La Paix, Bleyenburg, Maagdenburg, l'Hermitage, and Beerenburg—marked the beginning of the end of the sugar plantation system along these creeks (KDV Architects 2004). The uprising culminated at the Oranibo plantation at the Pennenica Creek with the Dutch taking a last stand before withdrawing altogether from the Tempati and Little Commewijne Creeks. These series of events precipitated the signing of the 1760 peace treaties between the colonial Dutch and the Maroon groups. In October 1760, the Aucaneer (Ndyuka) Maroons were the first to sign a peace treaty with Dutch colonial government, and the Saramaka Maroons followed in 1762. General terms of the peace treaties state: Maroons were to maintain several hours travel distance from the nearest post; permission was given to engage in trade of wood, cotton and livestock and collect in groups of no more than 50 at certain river banks.

In the time following the peace treaties, the Little Commewijne and Tempati Creeks were used primarily for wood exploitation. A military post was established at Maagdenburg from which expeditions were launched to monitor and quell attacks by antagonist Maroons. Furthermore, Maagdenburg was established as an infirmary and housed with medical specialists to treat ill Dutch soldiers recruited for the expeditions (Stedman 1791). From the late 1770s onward the Oranibo plantation also functioned as a military post working in tandem with the Maagdenburg post located in the heart of Maroon territory along the Tempati Creek (KDV Architects 2005).

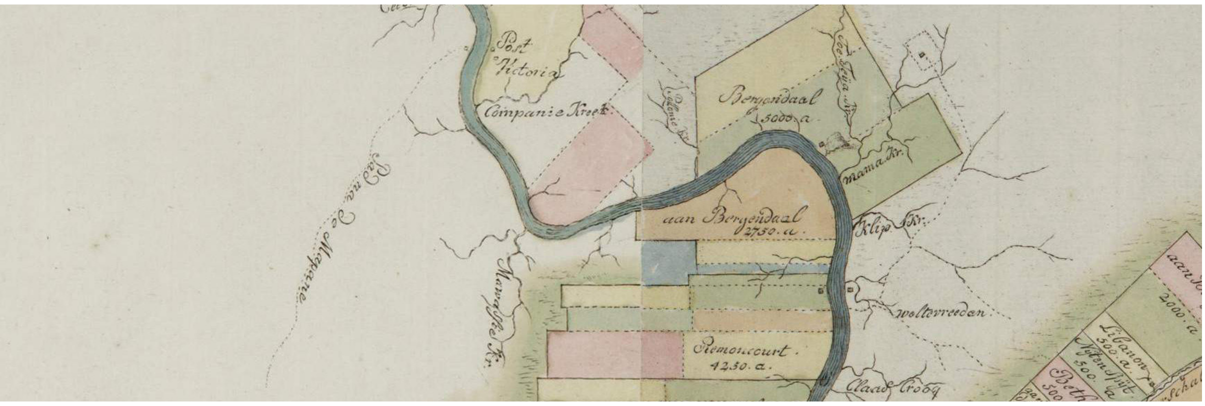
It is unclear whether the uprising of Tempati slaves was instigated by Ndyuka Maroons from the Auca (Ndyuka formal name "Aucaneers") plantation of the Suriname River and whether the Tempati slaves then joined the Ndyuka group. Even though Kawina Maroons refer to themselves as an offshoot of Ndyuka, it is unclear at what point in time they began to refer to themselves as Kawina.

Plantation System of the Suriname River (Afobaka Road Section)

Colonial plantations existed along the Suriname River in the current location of the Afobaka Road transportation corridor and Saramaka and Ndyuka study area community villages. Prominent on the landscape at this time was the Bergendal and Victoria sugar plantations. Both were far removed from the forts of the Cordonpad designed to protect the upper and lower courses of the Commewijne River (Figure 4.12-3).

Due to Victoria's position as the last plantation on the Suriname River at the time, it was the most vulnerable to attacks by Amerindians and Maroons. Moreover, by the mid-18th century the Suriname Mineral Compagnie and Victoria Wood, both with licenses to explore natural resources in the inland, took their position among the planters in this region of the Suriname River.

Figure 4.12-3 1801 Map by Moseburg of Post Victoria along the Suriname River by the Companie Kreek



Source: KDV Architects 2009.

However, poor management and repeated attacks by Maroons soon made the ventures unsupportable. In the late 1770s the military outpost, Post Victoria was erected near the contemporary village of Drepada (study area community of the Afobaka Road) to keep Maroons from gathering to slaughter company workers. Post Victoria was the most southern of the 94 km long Cordonpad military defense line that extended from the northeast Commewijne River.

Literature Review: Contemporary Period Tangible Heritage

Remnants of early 20th century gold mining activities, in the form of graves, railroads and machinery, may be located near the Sabajo Project Area.

At the turn of the 20th century (1880 to 1910) Suriname experienced its first gold rush in the southeastern region of the country (Heilbron and Willemsen 1980). At this time there were numerous gold concessions being worked by Caribbean foreigners.[31] The then Dutch government responded by attempting to build a rail station to facilitate the transfer of gold to the coastal capital of Paramaribo. The rail line venture was short sighted and partially destroyed during the construction of the hydropower dam in the 1960s. Remnants of the rail station can be found at the bottom of the Afobaka Lake. Through the years there were attempts by the GoS to revitalize this effort but with little success.

By 1970, an oil palm company was established on the grounds of Victoria on the Suriname River. The company's intent was to provide employment to the Afobaka Road resettlement villages (Boslanti, Tapoeripa and Compagnie Kreek) caused by the construction of the Afobaka Lake. The processing facilities of Victoria—named after the former military post—were a crude oil processing plant (1974), a refinery (1977), and a kernel extraction plant (1983). Due to the interior war of the mid-1980s and a crop failure of the palms the company all but stopped production; in the 1990s the company resumed activities, but was less productive (KDV Architects 2009).

At the end of the interior war a gold rush began in the eastern parts of the country and for the past twenty years small scale miners have changed the interior landscape[32] (see ASM baseline study).

4.12.5.3.2 Desktop Review Overall Results

This review indicated there are no previously recorded archaeological sites within the proposed Project footprint. Expected heritage sites in the proposed Project footprint include rocks with grinding

[31] In 1901, 5,551 registered gold miners worked in the gold fields of the Suriname interior, mostly from Caribbean countries.

[32] The ASM currently occupying the Sabajo Project Footprint are a product of Suriname's most recent gold rush.

grooves found along rivers and creeks; whole or partial ceramic pots with linear rim incisions; round, wrist sized pounding stones; round pottery disks; stone artifact scatters and stone axes. The proposed Project footprint does not include environmental zones that are typically associated with pre-Columbian agricultural settlements.

4.12.5.3.3 Field Work Results

A total of 61 shovel test pits were excavated to prospect for buried archaeological materials, including artifacts and anthropogenic soils. Shovel tests were excavated 5 to 25 meters (m) from the creek bed within the flat bank, depending on water saturation of the soil, and distance from any back filled dirt created by past ASM or logging activities. Shovel test pits were dug at intervals of 15 to 40 m depending on the length of the area to be tested. Demarcated construction zones with low archaeological potential (extensive ground disturbance, standing water or absence of a natural watercourse) were not surveyed or tested. In all of the pits and tests, no tangible heritage resources were found in the 182 ha area that was subject to archaeological survey.

4.12.5.4 Summary of Results

Based on the results of the desktop research, it was determined that there are no previously recorded archaeological sites in the proposed Project footprint. Community consultation identified one previously unrecorded pre-Columbian archaeological site in the vicinity of the Santa Barbara Pit and an unrecorded slave route in the proposed Sabajo Project Footprint. No tangible heritage resources were found in the 182 ha area that was subject to archaeological survey.

4.12.5.5 Additional Information Needed

Given access constraints and uncertainty around the location of some of the proposed Project components, the field component of the baseline heritage assessment was limited and not all areas have been subject to field investigation. Un-surveyed areas with potential for tangible heritage resources are identified in a map provided with Section 5.9 of this ESIA, and will be assessed to the same standard prior to, or concurrent with proposed future ground disturbance activities by Newmont.

4.12.6 Health

4.12.6.1 National System

The Ministry of Health (MOH) coordinates the national health system in Suriname. Healthcare provision is fragmented but coordinated, and it is organized around three main geographic areas that include Paramaribo, and the urban coastal and interior regions of the country. The primary health service caters to the population in both the interior (through Medical Mission) and the urban coastal area (Regional Health Services (De Regionale Gezondheidsdienst [RGD]; MOH 2011)). Suriname has limited medical facilities and has been experiencing a shortage of imported medication due to limited financial resources.

Non-communicable diseases are the main cause of mortality in Suriname. According to the 2015 data, cerebrovascular disease ranks first and is the most common cause of deaths, followed by heart disease and diabetes (IHME 2017; Research Gate 2017). Among communicable diseases, human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and lower respiratory infections are the most common diseases responsible for mortality in Suriname. According to the 2009 data, the percentage of cardiovascular disease (CVD) mortality in Brokopondo is lower than the other districts in Suriname (IGSR 2014).

There are four hospitals in Paramaribo with different level of capabilities and a district hospital in Nickerie. Medical care provision in the interior areas is limited as there are no hospitals. The Medical Mission (MZ PHC Suriname) is responsible for providing primary health care in the interior, operating

56 rural health centers and clinics in Brokopondo district, while the RGD provides the first level of care to Suriname's coastal areas through 43 health-care facilities.

4.12.6.2 Project Area

Primary healthcare near the Carolina communities and the six Brokopondo communities is provided by the Medical Mission through five health centers. Brokopondo has three health centers: Brokopondo (serving Brokopondo Centrum, Afobaka Centrum, Boslanti, Compagnie Kreek [Compagniekreek], Drepada and Tapoeripa villages), Asigron (serving Asigron and Victoria villages), and Balingsoela (serving Balingsoela village). The Carolina region includes two health centers in Powakka (serving Groot Powakka and Klein Powakka) and Redi Doti (serving Redi Doti, Pierre Kondre and Casipora).

A higher number of cases of vector-borne diseases, respiratory illnesses, soil-related diseases, non-communicable diseases, such as hypertension, and other CVDs were observed in the Brokopondo region as compared to the Carolina region. The number of health clinic visits in 2015 was higher in the Brokopondo region than in the Carolina region; however, numbers were lower in mid-2017.

Diseases Reported in the Project Area

There are many diseases prevalent in Suriname; however, according to the data given by the Medical Mission, only a few are prevalent in the communities and Project area. The occurrence of these diseases is monitored by the Medical Mission through surveys.

Vector-borne diseases:

- *Chikungunya*: In 2014, there was a chikungunya outbreak in Suriname concentrated in the coastal areas. The outbreak spread to the interior of Suriname by mid-2014. The number of chikungunya cases was highest in 2016 in the Medical Mission area (1,792 cases), followed by the Brokopondo (315 cases) and Carolina areas (12 cases in 2012 and no case in 2016).
- *Zika*: Zika outbreak was reported at the end of 2015. The Medical Mission carried out a serological survey in January 2016 and conducted surveillance. A total of 16 cases were reported in the Carolina region and one in Brokopondo in that year. There were no cases of Zika reported in any of the regions in 2017.
- *Leishmaniosis*: Though monthly surveillance is conducted by the health centers, a single case of Cutaneous Leishmaniosis was reported in the interior areas of Suriname. A higher number of cases (110) was seen in the Medical Mission areas in 2014. This number reduced in 2017 (nine cases). A total of three cases were reported over the years in the Brokopondo and one in Carolina areas.
- *Malaria*: The incidence of malaria cases has reduced significantly in all interior regions; a higher number of cases were observed in the Medical Mission area in 2016 than in the Carolina area (no cases) or Brokopondo area (one case).

Respiratory issues:

- *Influenza*: The Medical Mission performs weekly surveillance for monitoring the occurrence of influenza, which is the biggest respiratory problem in the area. Surveillance occurs on a seasonal basis in the Project area.
- *Other respiratory infections*: In the Brokopondo area, the number of cases of lower respiratory infections was 94, 170 and 97 in 2015, 2016 and mid-2017, respectively. In the Carolina area, the number of cases was 74, 45 and 32 during the same time period.

Sexually transmitted infections (STIs):

- *HIV/AIDS*: The estimated prevalence of HIV/AIDS in the Brokopondo region is 0.59% and in the Carolina region is 0.72%. In the event that a pregnant woman tests positive for HIV/AIDs, the Medical Mission provides treatment to prevent transmission from mother to child.
- *Other STIs*: The Medical Mission has a syndromic treatment[33] for other STIs, such as gonorrhea. Monthly surveillance is performed by reporting the number of patients who have visited different health centers. The number of cases reported in Brokopondo was 14, 16 and 10 in 2015, 2016 and mid-2017, respectively. In the Carolina area, the number of cases was 13, 6 and 6 during the same time period.

Soil, water and sanitation-related diseases:

- *Diarrhea:* This is the most common disease in the interior regions and Medical Mission conducts a weekly surveillance on it. Diarrhea cases were high in the Brokopondo area in 2016, but have shown significant reduction in 2017 with fewer cases in a year. It was also reported that health education is imparted in the community for awareness and knowledge. The focus areas of the Medical Mission are hygiene, cooking practices, use of drinking water, and hand washing techniques.

Non-communicable diseases:

- *Hypertension and diabetes:* In the interior, hypertension and diabetes mellitus is found in both the Maroon and the Amerindian populations. The prevalence of hypertension is higher than diabetes mellitus in both the Medical Mission and Brokopondo areas. The prevalence of hypertension in the entire Medical Mission area is 4.33%, while it is 3.91% in the Brokopondo area and 5.79% in the Carolina area. Apart from this, there is no data on cancer, mental health and other major chronic diseases as the data presented is dependent on the health visits due to chronic diseases.

Health Clinic Visits

The number of visits to the health clinics in the Brokopondo region was higher than in the Carolina region in 2015 due to chronic diseases. In the Brokopondo region, the clinics are visited most for hypertension. In the Carolina region, the clinics are visited most due to diabetes and hypertension.

The referral cases in both the regions were reported to be high in mid-2017. Women are referred more frequently than men in all age groups for both Brokopondo. In 2017, 81% of referrals were women. The same is true in the Carolina region where 62% of referrals in 2017 were women. There are different reasons for referral cases, the most common of which include pregnancy, vision problem, burns, mental retardation, scabies and hernia umbilical.

Vaccination Coverage

In the interior, every child is vaccinated against yellow fever at the age of one year. Vaccination against measles, mumps, and rubella is also prevalent. Vaccination coverage was high in both the regions until 2015, but significantly reduced by mid-2017. This could be due to low availability of vaccines and logistical problems in the health clinics.

All pregnant women are vaccinated with diphtheria and tetanus vaccines, depending on the vaccination status on the card. There was no maternal mortality reported from 2015 to mid-2017 in both the Brokopondo and Carolina regions; only one neonatal death was reported in 2016 in Carolina.

[33] The diagnosis is done by the doctors according to the symptoms without relying on a laboratory diagnosis.

Road Traffic Accidents

Road traffic accidents most common on the paved Afobaka Road in the Brokopondo region. From 2015 to mid-2017, a total of 40 road traffic accidents were recorded in the Brokopondo region, while two were recorded in the Carolina area. About 70% of road accidents involved males with an average age of 35 years. Females involved in road accidents have an average age of 29 years. Accidents are mainly due to erratic driving and high speeding.

4.13 Traffic

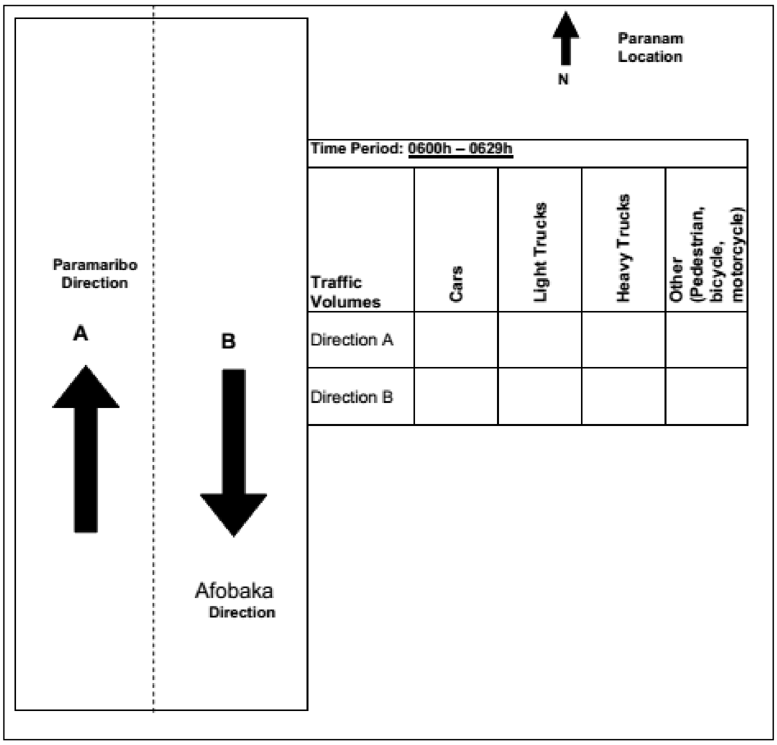
4.13.1 Introduction

A traffic baseline study was carried out to set the stage to determine how much the Sabajo Project (the Project) will affect traffic along publicly accessible access roads to Sabajo. This section summarizes the results of the baseline traffic study (ILACO 2017c).

4.13.2 Method

The traffic baseline was conducted by undertaking field counts of traffic in 11 locations, numbered T-1 to T-11 (Map 4.13-1). At each location, two trained counters with a set of count forms and maps carried out the survey, for each direction of traffic. The survey counters were positioned in a safe position away from the road that also gave a clear view of the road and traffic. As vehicles and road users passed an observation point, the observer recorded each vehicle on a survey form according to vehicle type and time interval. Traffic was recorded continuously between 6:00 am and 6:00 pm with half hourly intervals on a midweek day (Tuesday through Thursday) and on a weekend day (Saturday or Sunday) in the rainy and the dry season. Only daytime measurements have been taken, because the Project will typically have transportation to and from the site on public roads during daylight hours only, with very minimal traffic during the night. The survey was conducted both during business-as-usual days and during the public holidays (peak period) to try to capture the range of variation of traffic present at each location. An example survey form is shown in Figure 4.13-1.

Figure 4.13-1 Example Survey Form



In addition to traffic counts, general road conditions were recorded and residents of communities along the possible access routes were consulted to pass on their knowledge and identify their concerns with respect to present day traffic conditions.

4.13.3 Results

4.13.3.1 Traffic Counts

Traffic counts observed at each study site are provided in the following tables (Map 4.13-1; Tables 4.13-1 to 4.13-11).

Table 4.13-1 Traffic Counts at Junction Afobaka Road and Road to Overbridge

Type of vehicles	T-1[a] Weekday – Rainy Season 4 Jul. 2017	T-1[a] Weekend – Rainy Season 8 Jul. 2017	T-1[a] Weekday – Dry Season 21 Sep. 2017	T-1[a] Weekend – Dry Season 23 Sep. 2017	Overall Average Traffic
Cars	465	901	783	1354	876
Light Trucks	309	431	372	508	405
Busses	314	398	418	616	437
Large Truck	253	155	268	208	221
Logging Truck	29	34	115	105	71
Motorbikes	56	76	64	61	64
Bikes	2	4	2	0	2
Others (ATV, UTVs, etc.)	3	30	1	2	9
Pedestrians	11	30	16	23	20
Total vehicles	1442	2059	2039	2877	2104

Note:
a) T-1 – Traffic count data collection point at Junction Afobaka Road and Road to Overbridge.
ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-2 Traffic Counts at Redi Doti

Type of vehicles	T-2[a] Weekday – Rainy Season 5 Jul. 2017	T-2[a] Weekend – Rainy Season 8 Jul. 2017	T-2[a] Weekday 0 Dry Season 21 Sep. 2017	T-2[a] Weekend – Dry Season 23 Sep. 2017	Overall Average Traffic
Cars	36	63	157	265	130
Light Trucks	48	79	78	185	98
Busses	28	33	57	118	59
Large Truck	11	6	11	4	8
Logging Truck	9	7	16	18	13
Motorbikes	19	26	11	12	17
Bikes	0	0	0	0	0
Others (ATV, UTVs, etc.)	2	0	2	1	1
Pedestrians	0	1	3	0	1
Total vehicles	153	215	335	603	327

Note:
a) T-2 – Traffic count data collection point at Redi Doti.
ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-3 Traffic Counts at Junction Afobaka Road and Road to RGM (Bronsweg)

Type of vehicles	T-3[(a)] Weekday – Rainy Season 6 Jul. 2017	T-3[(a)] Weekend – Rainy Season 9 Jul. 2017	T-3[(a)] Weekday 0 Dry Season 22 Sep. 2017	T-3[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	395	511	573	658	534
Light Trucks	303	262	368	234	292
Busses	414	287	433	432	392
Large Truck	118	43	132	20	78
Logging Truck	8	19	97	27	38
Motorbikes	15	10	14	60	25
Bikes	0	0	0	0	0
Others (ATV, UTVs, etc.)	3	0	1	2	2
Pedestrians	10	19	12	4	11
Total vehicles	1266	1151	1630	1437	1371

Note:

a) T-3 – Traffic count data collection point at Junction Afobaka Road and Road to RGM (Bronsweg).

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-4 Traffic Counts at Junction Afobaka Road and Musa Road

Type of vehicles	T-4[(a)] Weekday – Rainy Season 6 Jul. 2017	T-4[(a)] Weekend – Rainy Season 9 Jul. 2017	T-4[(a)] Weekday – Dry Season 22 Sep. 2017	T-4[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	101	161	136	206	151
Light Trucks	99	87	102	81	92
Busses	120	119	120	116	119
Large Truck	17	6	14	4	10
Logging Truck	12	1	5	2	5
Motorbikes	13	22	22	25	21
Bikes	0	0	0	0	0
Others (ATV, UTVs, etc.)	7	4	12	15	10
Pedestrians	8	6	6	8	7
Total vehicles	377	406	417	457	414

Note:

a) T-4 – Traffic count data collection point at Junction Afobaka Road and Musa Road.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-5 Traffic Counts at Junction of Afobaka Road and Philipus Kondre

Type of vehicles	T-5[(a)] Weekday – Dry Season 21 Sep. 2017	T-5[(a)] Weekend – Dry Season 23 Sep. 2017	Overall Average Traffic
Cars	728	1263	498
Light Trucks	372	489	215
Busses	406	574	245
Large Truck	254	213	117
Logging Truck	127	119	62
Motorbikes	71	69	35
Bikes	2	1	1
Others (ATV, UTVs, etc.)	1	0	0
Pedestrians	9	11	5
Total vehicles	1970	2739	1177

Note:

a) T-5 – Traffic count data collection point at Junction Afobaka Road and Philipus Kondre.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-6 Traffic Counts at Multicultureel Centrum Powaka

Type of vehicles	T-6[(a)] Weekday – Dry Season 21 Sep. 2017	T-6[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	207	697	452
Light Trucks	63	124	94
Busses	38	176	107
Large Truck	5	3	4
Logging Truck	30	3	17
Motorbikes	72	48	60
Bikes	8	2	5
Others (ATV, UTVs, etc.)	0	0	0
Pedestrians	193	152	173
Total vehicles	616	1205	911

Note:

a) T-6 – Traffic count data collection point at Multicultureel Centrum Powaka.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-7 Traffic Counts at Redi Doti, Smaller Road 1

Type of vehicles	T-7[(a)] Weekday – Dry Season 25 Sep. 2017	T-7[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	79	279	179
Light Trucks	52	87	70
Busses	22	65	44
Large Truck	7	2	5
Logging Truck	5	6	6
Motorbikes	8	9	9
Bikes	0	0	0
Others (ATV, UTVs, etc.)	0	0	0
Pedestrians	3	0	2
Total vehicles	176	448	312

Note:

a) T-7 – Traffic count data collection point at Redi Doti, Smaller Road 1.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-8 Traffic Counts at Redi Doti, Pineapple Farm

Type of vehicles	T-8[(a)] Weekday – Dry Season 25 Sep. 2017	T-8[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	69	211	140
Light Trucks	33	84	59
Busses	21	54	38
Large Truck	9	3	6
Logging Truck	2	3	3
Motorbikes	1	4	3
Bikes	0	0	0
Others (ATV, UTVs, etc.)	0	0	0
Pedestrians	3	1	2
Total vehicles	138	360	249

Note:

a) T-8 – Traffic count data collection point at Redi Doti, Pineapple Farm.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-9 Traffic Counts at Junction Road to Sabajo and Kashipurhiweg

Type of vehicles	T-9[(a)] Weekday – Dry Season 21 Sep. 2017	T-9[(a)] Weekend – Dry Season 23 Sep. 2017	Overall Average Traffic
Cars	20	32	26
Light Trucks	28	35	32
Busses	13	8	11
Large Truck	0	1	1
Logging Truck	13	6	10
Motorbikes	2	7	5
Bikes	0	0	0
Others (ATV, UTVs, etc.)	1	0	1
Pedestrians	0	0	0
Total vehicles	77	89	83

Note:

a) T-9 – Traffic count data collection point at Junction Road to Sabajo and Kashipurhiweg.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-10 Traffic Counts at Road to the Carolina Bridge and Recreation Site of Paratjima

Type of vehicles	T-10[(a)] Weekend – Dry Season 23 Sep. 2017	T-10[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	19	42	31
Light Trucks	1	0	1
Busses	0	1	1
Large Truck	0	0	0
Logging Truck	1	0	1
Motorbikes	2	0	1
Bikes	0	0	0
Others (ATV, UTVs, etc.)	0	0	0
Pedestrians	0	0	0
Total vehicles	23	43	33

Note:

a) T-10 – Traffic count data collection point at Road to the Carolina Bridge and Recreation Site of Paratjima.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Table 4.13-11 Traffic Counts at Redi Doti, Smaller Road 2

Type of vehicles	T-11[(a)] Weekday – Dry Season 25 Sep. 2017	T-11[(a)] Weekend – Dry Season 24 Sep. 2017	Overall Average Traffic
Cars	82	275	179
Light Trucks	54	95	75
Busses	23	65	44
Large Truck	7	2	5
Logging Truck	5	6	6
Motorbikes	8	13	11
Bikes	0	0	0
Others (ATV, UTVs, etc.)	0	0	0
Pedestrians	10	6	8
Total vehicles	189	462	326

Note:

a) T-11 – Traffic count data collection point at Redi Doti, Smaller Road 2.

ATV = all-terran vehicle; UTV = utility terrain vehicle.

Some of the key learnings from the data collection with respect to traffic counts included:

- The location with most pedestrians observed was T-6, Multicultureel Centrum Powakka, where a considerable number of children are included in the pedestrian numbers.
- Peak traffic typically occurred between 16:00 (4 pm) and 18:00 (6 pm) in most locations; peak pedestrian times were more varied and occurred in the morning or around 15:30 after school let out.
- On both the Afobaka and Carolina Roads, traffic gradually decreases moving north to south; very little traffic exists toward the southern end of these roads.
- At most locations and most dates, the most common type of vehicle was the car, with light trucks the second most common.
- Weekend traffic is substantially higher than weekday traffic at the majority of the sampling sites.

4.13.3.2 Road Conditions

Road conditions along the Carolina and Afobaka Roads have been mapped in Map 4.13-2. Poor road conditions may include steep hills, rutted roads, on sharp turns; these conditions occur most commonly along the Musa Road, the unpaved road between the Project and Afobaka Centrum, with about 40 instances of poor or unsafe road conditions in about 30 kilometers (km) of road. Along the Carolina Road from the Project to the intersection with the Afobaka Road at Powakka, about 35 instances of poor or unsafe road conditions occur within about 60 km of unpaved road. Along the Afobaka Road, 5 instances of poor or unsafe road conditions occur along about 60 km of paved road. Poor and unsafe road conditions increase the risk of accidents along the road.

4.13.3.3 Sensitive Receptors for Traffic

Sensitive receptors mapped along the Afobaka and Carolina Roads are shown in Map 4.13-3. These include:

- The primary school at Powakka, where most children are bussed from nearby towns; 4 school busses were counted traveling through Powakka and Redi Doti during baseline studies (ILACO 2017c), and pedestrians, mainly children, are active at bus stop locations and at the school itself both in the morning (7:00-7:30) and afternoon (13:00-16:00).
- The town of Powakaa itself and pedestrians in Powakka; for example, on non school days, 40 children were counted passing along the Carolina Road on a weekend and 46 children were counted passing along the Carolina Road on a weekday. The average total pedestrian traffic observed in Powakka was 173 people per day. One popular location along the road is the Paratjima Swim Area (Photo 4.13-1).
- School bus stops along the Carolina and Afobaka Roads: for example, on a single day at baseline study point T-3 on this road, 16 school busses were observed passing between 7:00 and 16:00. Between the Philipus Kondre turnoff and Afobaka Dam, 14 formal bus stops were counted. An example is shown in Photo 4.13-2).
- Other locations where people congregate close to the Afobaka and Carolina Roads include fruit sales stands (Photo 4.13-3), muster points, churches and recreational sites (Map 4.13-3).

Photo 4.13-1 Paratjima Swimming Area – at Powakka (Credit: ILACO 2017c)

Photo 4.13-2 Typical Bus Stop along Afobaka Road

Photo 4.13-3 Typical Fruit Stand along Afobaka Road (about 10 m from the road; credit: ILACO 2017c)

In addition along the Carolina Road there is a Checkpoint stop at Redi Doti that may at times be a location where people and vehicles congregate. And along the Afobaka Road there is a logging company site where large trucks enter and depart from regularly (Map 4.13-3). During busy periods, the presence of these types of locations can also increase the chance for accidents.

4.13.4 Uncertainties

Sufficient traffic data have been collected to understand the major trends in traffic spatially and temporally on the Afobaka and Carolina Road. It is possible that traffic levels will change prior to Project development, and the level of change that may occur is an uncertainty.

4.14 Landscape and Visual Resources

4.14.1 Introduction

The visual appearance of the exploration lease area where the Sabajo Project (the Project) is proposed to be developed is influenced by its geomorphology, vegetative cover, and present level of disturbance. The actual visibility of the site to viewers is influenced by its location, surrounding topography, and proximity to populated locations. Each of these topics will be briefly discussed in this section to provide an indication of the present-day visual aesthetics of the site.

4.14.2 Method

This baseline has been completed using literature and the results of other discipline assessments, and using the results of a field visit to the site. The desktop review included:

- review of baseline studies on the geomorphology of the site;
- review of baseline studies on the vegetative cover at the site; and
- review of social baseline data collected for social, economic and cultural aspects of the site and relevant population centres.

The field visit included acquisition of photographs of both natural/undisturbed and disturbed areas where the Project will be developed.

4.14.3 Results

The landforms of the study area have been mapped as part of the soils and geomorphology baseline (Section 4.4). The location of the proposed Sabajo mine site includes primarily hilly upland with some incised creeks and undulating and rolling lowlands at the periphery of the Project. The elevation of the land varies between 25 meters above sea level (masl) and 75 masl (ILACO 2017a) . The haul road to be developed between Merian and Sabajo passes over some higher and steeper-sloped areas.

The vegetation within the study areas is upland forest on the hilltops, and wetland or riparian (seasonally flooded) forest in the lowlands, overall forming a dense, tall forest canopy over the undisturbed areas throughout the study area. One vegetation type that appears different is a wet savanna forest the grows in areas of bleached sandy soil on the east side of the Sabajo site.

The appearance of the land use is illustrated on the following pages. Photos 4.14-1 and 4.14-2 show relatively undisturbed areas with thick upland tree cover and rolling topography. Such undisturbed areas represent about 75% of the land to be affected by the Project, including most of the length of the proposed haul road between Sabajo and Merian. Photos 4.14-3 and 4.14-4 show the heavily disturbed landscape at Sabajo surrounding the Cassador Pit, which was previously excavated by small scale miners. Photos 4.14-5 and 4.14-6 show disturbed areas at Margo in a landscape that includes a steep ridgeline. Photos 4.14-7 and 4.14-8 show disturbed areas at Santa Barbara, which is a lower-lying area that has been extensively altered through long-term small scale mining.

In the vicinity of the Project, there are no visually-outstanding features such as notable hills, mountains, wide rivers, lakes, or waterfalls. There are no features that have historically attracted tourism to the area, or features identified as culturally important due to their appearance (Social Solutions 2017). The closest notable attractions and the closest areas with long term populations are near the Suriname River to the west and the Afobaka Reservoir to the southwest. The rolling topography and dense vegetation tends to restrict views from the roads in the vicinity of the Project at present.

Photo 4.14-1 Example of Natural Topography in the Project Region

Photo 4.14-2 Example of Natural Topography Adjacent to Watercourse, Ground View

Photo 4.14-3 Example of Disturbed Area, Sabajo and Small Scale Mining Area, Cassador Pit

Photo 4.14-4 Example of Disturbed Area, Sabajo Small Scale Mining Area, Tailings Deposition area South of Cassador Pit

Photo 4.14-5 Example of Disturbed Area, Margo Small Scale Mining Area, Eroded soils in Watercourse

Photo 4.14-6 Example of Disturbed Area, Margo Small Scale Mining Area

Photo 4.14-7 Example of Disturbed Area, Santa Barbara Small Scale Mining Area

Photo 4.14-8 Example of Disturbed Area, Santa Barbara Small Scale Mining Area

Under baseline conditions, there are very few people who view the Project area. Small scale miners and timber cutters are intermittently present on the landscape and are actively involved in shaping its appearance. No known ‘sensitive’ viewers (i.e., viewers who would be negatively affected by seeing visual changes on the landscape) are present in the area, as there are no towns or known visitor destinations within viewing distance.

4.14.4 Uncertainties

The appearance of the landscape under baseline conditions is well understood. The types of people viewing the Project areas under baseline conditions are also understood. Therefore, there are no major uncertainties associated with this baseline.

5 IMPACT ASSESSMENT

5.1 Impact Assessment Methods and Study Areas

5.1.1 Issue Scoping

Issue scoping is a critical first step of the Environmental and Social Impact Assessment (ESIA), as it allows important issues (as defined by stakeholders and specialists familiar with the potential effects of the Sabajo Project [the Project]) to be clarified and given proper emphasis in the course of the assessment.

The ESIA is divided into many disciplines: the physical disciplines (hydrology, water quality, air quality, etc.); the biological disciplines (flora, fauna, fish aquatic habitats, etc.); and the social disciplines (socioeconomics, cultural resources, health, etc.). For each discipline, a bullet list was created to identify the environmental and social changes that could result from the Project. This list was derived from experience with the Merian Gold Mine (Merian mine) and early public consultation input (Section 1.3), Newmont standards and the knowledge of the study team. A draft Terms of Reference (ToR) and scoping document were prepared and presented in a further round of public consultations with potentially impacted stakeholder groups. Potential negative issues relating to impacts and positive effects were identified. Each ESIA Section first presents a summary of the issue scoping process, identifying important issues raised for that discipline within the ToR and engagement process. Issues are summarized in a table similar to Table 5.1-1. Some issues were identified based on professional knowledge and may not have been mentioned in the engagement comments. In this case the engagement column indicates "none".

Table 5.1-1 Potential Impact Issues for Air Quality[(a)]

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Potential Effect on Air Quality from Project mining activities	*-How far does an air particle travel?* – Meeting at Pierre Kondre Kumbasi, 6/22/17 *-A man stated that dust may not come here but may return back with the rain* – Meeting at Pierre Kondre Kumbasi, 6/22/17
2	Potential Effect on Air Quality from Project related offsite traffic	*-What will the company do to mitigate impacts such as noise, dust? These will have great impact on the living conditions of all 5 communities.* – Meeting with Carolina Road Amerindian communities, 5/4/17 *-How far does an air particle travel?* – Meeting at Pierre Kondre Kumbasi, 6/22/17 *-A man stated that dust may not come here but may return back with the rain* – Meeting at Pierre Kondre Kumbasi, 6/22/17 *-A woman stated that the children already get dust on their uniforms from cars driving by* – Meeting at Pierre Kondre Kumbasi, 6/22/17
3	Potential Effect on Climate due to Project GHG emissions	No comments were raised with respect to Climate during engagement.

a) Example only
the Project = the Sabajo Project; GHG = greenhouse gas.

5.1.2 Linkage analysis

The linkage analysis section in each discipline ESIA answers the question: Does the Project affect the key issues raised for this discipline?

The process of determining if potential effects need to be assessed in detail is carried out by defining the possible linkages between project activities and key indicators. The validity of each potential impact linkage is determined through a scoping-level analysis of the way the Project activity will (or will not) result in a change that could be considered an impact on either people or the environment. In cases where changes due to the Project do not affect specific social or environmental characteristics being assessed, this is clearly stated and further analysis is not done.

For example, for water quality, some watersheds of interest to the public will not be affected at all by the Project, and if issues were raised for those watersheds, the linkage analysis will state that the linkage for effects on those watersheds are invalid. Meanwhile, the linkages for water quality effects on the watersheds directly occupied by the Project would be valid.

5.1.3 Key Indicators

Indicators are measurable parameters that can be used to help evaluate effects associated with key issues.

For the purposes of the ESIA, indicators were selected for each discipline. Every issue defined in the key issues section which was determined to present the potential for impacts in the linkage section is required to have indicators identified. The table below outlines an example list of applicable indicators and their context for one discipline, air quality.

Table 5.1-2 Potential Project Indicators for Air Quality[(a)]

Issue Number	Key Issue	ESIA Indicators
1	Potential effect of pollutant emissions from Project mining	Ambient concentration of PM_{10}, $PM_{2.5}$, NO_2, CO, and SO_2, expressed in µg/m³
2	Potential effect of pollutant emissions from offsite Project traffic	Ambient concentration of PM_{10}, $PM_{2.5}$, NO_2, CO, and SO_2, expressed in µg/m³
3	Potential GHG emissions from Project mining	GHG emissions, expressed in t/y CO_2e

a) Example only.

the Project = the Sabajo Project; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less; NO_2 = nitrogen dioxide; CO = carbon monoxide; SO_2 = sulfur dioxide; µg/m³ = micrograms per cubic meter; GHG = greenhouse gas; t/y = tons per year; CO_2e = carbon dioxide equivalent.

5.1.4 Spatial and temporal considerations

5.1.4.1 Spatial Scope

Defining the geographic extent of study areas is a key element of ESIA. For the assessment of local impacts, the area should be large enough to efficiently analyze and mitigate the obvious potential effects from the Project on the receiving environment, but not too large as to dilute or confound the potential Project-related effects with other human-induced and natural influences.

Study areas were selected for each discipline based upon the anticipated areas of influence of the Project. Study areas for the baseline field programs are presented in Section 4. These were based on the best project information available at the time of baseline completion. Once the preferred alternatives were selected for the Project, discipline-specific impact assessment study areas were derived (Maps 5.1-1, 5.1-2, 5.1-3 and 5.1-4).

5.1.4.2 *Temporal Scope*

This ESIA is designed to evaluate a specific project plan that occurs in a specific period of time. By defining a temporal scope, clear boundaries are established for the time period being assessed. The Project is defined as having:

- a construction period of 2 years, from 2024 to 2026;
- an operation period of 10 years, from 2026 through 2037;
- a closure phase (during which active reclamation and decommissioning is completed) of four years, from 2037 to 2041; and
- a post-closure phase (during which monitoring and follow up of reclamation is completed) from 2041 on, until Project-related monitoring and mitigation is satisfactorily complete.

Some ESIA disciplines examine the Project under three temporal conditions: pre-development, full development (i.e., maximum extent of disturbance) and closure. Although there will be sequential reclamation of disturbances on the landscape, this sequential development and reclamation process will not be included in the assessment. Therefore, the assessment will be conservative in its approach as the maximum possible extent of disturbance will be considered. For the terrestrial assessments, post-closure was defined as ten years following reclamation.

5.1.5 Assessment Cases

Three assessment cases, or scenarios, are considered in this document:

- baseline (scenario considering conditions prior to the Project activity);
- Project (scenario considering the changes that the Project alone will cause); and
- cumulative effects (scenario considering the changes that the Project and any other foreseeable projects will have during the defined temporal scope of the assessment).

The first of these scenarios is described in the baseline summary section for the discipline (Section 4), and the second and third are described in the impact assessment section. In the impact assessment for each discipline, the Project Case and the Cumulative Case will contain an impact analysis (in both cases, assessing the impacts with consideration of mitigation) as described in Section 5.1.6.

5.1.5.1 *Project Case*

The Project case is used to assess the impact of the Project itself on the environment. It is meant to describe the effects that the Project, alone, has in causing or increasing environmental and social impacts.

5.1.5.2 *Cumulative Effects Case*

Cumulative effects is the impact on the environment which results from the incremental impact of the Project in addition to other past, present, and reasonably foreseeable future actions regardless of what agency, company or person undertakes such other actions. The cumulative environmental effects of the Project and other existing projects or disturbances will be limited to an evaluation of those effects within the region that are planned or are reasonably foreseeable.

In addition to the Project, the other activities considered in assessing cumulative effects (where their effects overlap in space or time with the Project) are:

- the Merian mine, and transport to and from the mine;
- the Rosebel mine and its potential extension, referred to as Saramacca;
- artisanal and small scale mining (ASM); and
- forestry, and transport of timber on the Carolina Road.

These will all be qualitatively considered in the cumulative assessment. The first part of the assessment evaluates if there are overlapping effects for the Project and any of these other projects that extend into the future. If there are overlapping effects, the second part of the assessment determines the effect of the Project in addition to other projects, using the same impact classification approach as in the Project case.

5.1.6 Impact Analysis

The impact analysis is carried out for each indicator identified in the linkage analysis as having a valid linkage. First, the discipline impact assessment section has a methods section to describe any specific methods used (for example, how a model was applied to assess an effect). Then, the impact analysis is presented in four main steps:

- evaluation of the potential effects through professional judgment, an understanding of baseline conditions, scientific modelling, and stakeholder engagement;
- description of mitigations for potential effects;
- analysis and characterization of residual effects, both with and without mitigation; and
- identification of monitoring to evaluate and track performance.

For the purpose of this ESIA, mitigation applies to the construction, operation and closure design principles to minimize or eliminate potential adverse impacts and, where possible, enhance environmental or social benefit.

Quantitative methods of assessment are used where possible. Predictive modeling is used as a tool in the air, noise, vibration, hydrogeology, hydrology and water quality assessments. Geographic information systems are used to assess impacts on biological resources.

5.1.6.1 Assessment Methods

A separate discussion is provided on methods for each key indicator within each discipline section, if appropriate. Means of field measurement, modeling techniques and other methods are described. Sufficient description of methods is provided to allow duplication by others (i.e., a scientific method). For some disciplines, impacts are addressed for each project phase. For others, phases are combined, or only phases with the greatest potential impact are analyzed.

5.1.6.2 Results

In this section, the results of modeling and data analyses that were conducted in support of the impact assessment are provided. The information is presented so as to be transparent, although if the results are highly detailed, the key results are presented in the text and detailed results in an appendix. Key results include the changes in the specific indicators measured.

5.1.6.3 Mitigation

The mitigation that will be implemented by the Project related to the effects being evaluated is described. All phases (construction, operations, closure) are considered. For each phase mitigations are presented as follows:

- What design techniques were used to avoid the impact? (e.g., avoid siting the facilities in agricultural areas).
- What methods will be used to minimize the impact? (e.g., use dust suppression on roads in dryer months).
- What methods will be used to rehabilitate/repair an impact? (e.g., reclaim an area after disturbance).
- What will be undertaken to compensate for impacts? (e.g., provide alternate access to a site if original access is blocked).
- What will be undertaken to have a positive, lasting long-term effect (e.g., promotion of small businesses).

5.1.6.4 Impact Analysis

This section describes the approach used to assess negative effects. Impacts assessed are evaluated both before mitigation and after all mitigation has been applied. The pre- and post- mitigation impacts are classified using criteria to determine the overall effect, termed the environmental or social consequence. Each impact is first described using the following criteria: direction, magnitude, geographic extent, and duration (which includes reversibility and frequency). These criteria are defined below.

Direction: this may be positive, neutral or negative with respect to the key question (e.g., a habitat gain for a key species would be classed as positive, whereas a habitat loss would be considered negative).

Magnitude: is the degree of change in a measurement or analysis, and is classified as negligible, low, moderate or high. The categorization of the impact magnitude is based on a set of criteria, ecological concepts and/or professional judgment pertinent to each of the discipline areas and indicators analyzed.

Geographic extent: refers to the area affected by the impact and is classified as local, regional or beyond regional. A method of defining impacts within a study area, in terms of the percentage of a certain resource or population affected, is influenced by the size of the study areas. As such, quantitative values of impacts must be tempered with an overall qualitative approach that considers the Project impacts on the overall viability and diversity of social and ecological units.

Duration: refers to the length of time over which an environmental or social impact occurs. Short-term is defined as less than the construction phase (less than 2 years); medium-term as longer than short-term and up to the operational duration of the Project plus up to four years of active closure (2 to 16 years); long-term is greater than medium term (greater than 16 years).

Impact description criteria have been established for all project components (for example, see Table 5.1-3 for an air quality example) based on professional judgment of the ESIA team and the considerations of the issues that were identified as particularly significant to stakeholders. The precise use of the above system is varied as appropriate for certain disciplines. The results of this analysis is presented in each discipline report, for each indicator.

Table 5.1-3 Example of Impact Description Criteria for Air Quality

Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]
Positive: a reduction in air quality concentrations or GHG emissions **Negative:** an increase in air quality concentrations or GHG emissions	**Air Quality** **negligible**: the maximum predicted concentration is below 25% of the applicable WHO AAQG or USEPA NAAQS (standards) or the predicted change in concentration is less than 1% of the applicable standard **low**: the maximum predicted concentration is between 25% and 50% of the applicable standard **moderate**: the maximum predicted concentration is between 50% and 100% of the applicable standard **high**: the predicted change in concentration is greater than 100% of the applicable standard	**local**: effect restricted to the study area **regional**: effect extends beyond the study area **beyond regional**: effect extends more than 50 km from the Project	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.

b) Magnitude: degree of change to analysis endpoint.

c) Geographic Extent: area affected by the impact.

d) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period, a 10-year operations period and a 4-year active closure period.

the Project = the Sabajo Project; WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; USEPA = United States Environmental Protection Agency; NAAQS = National Ambient Air Quality Standards; GHG = greenhouse gas; km = kilometer; >= greater than; <= less than;% = percent.

An overall residual impact is determined in order to make the results of the impact assessment more comparable across disciplines and understandable to stakeholders. The overall residual impact for each effect is termed the environmental or social consequence, and is classified to one of: negligible, low, moderate or high by evaluation of the rankings for magnitude, geographic extent and duration (Table 5.1-4). Taking into account the probability of the effect, the overall significance is then rated (Table 5.1-5). For example, an impact with a moderate magnitude, local extent, and short duration would be classified as having a low overall environmental consequence. If this effect has is certain to occur, it would then be rated as a “medium effect” in overall significance.

Table 5.1-4 Screening System for Environmental or Social Consequences

Magnitude (Severity)	Geographic Extent	Duration	Environmental or Social Consequence
Negligible	all	All	negligible
Low	local	short-term	negligible
Low	local	medium-term	low
Low	local	long-term	low
Low	regional	short-term	low
Low	regional	medium-term	moderate
Low	regional	long-term	moderate
Low	beyond regional	short-term	low
Low	beyond regional	medium-term	moderate
Low	beyond regional	long-term	moderate
Moderate	local	short-term	low
Moderate	local	medium-term	low
Moderate	local	long-term	moderate
Moderate	regional	short-term	moderate
Moderate	regional	medium-term	moderate
Moderate	regional	long-term	high
Moderate	beyond regional	short-term	moderate
Moderate	beyond regional	medium-term	high
Moderate	beyond regional	long-term	high
High	local	short-term	moderate
High	local	medium-term	high
High	local	long-term	high
High	regional	short-term	moderate
High	regional	medium-term	high
High	regional	long-term	high
High	beyond regional	short-term	high
High	beyond regional	medium-term	high
High	beyond regional	long-term	high

Table 5.1-5 Rating Matrix for Overall Significance – Social and Environmental Effects

Likelihood	Consequence			
	1 Negligible	2 Low	3 Moderate	4 High
5 Certain	11 Low	16 Medium	20 High	23 High
4 Likely	7 Negligible	12 Low	17 Medium	21 High
3 Possible	4 Negligible	8 Low	13 Low	18 High
2 Unlikely	2 Negligible	5 Negligible	9 Low	14 Medium
1 Rare	1 Negligible	3 Negligible	6 Negligible	10 Low

For some key indicators, impacts have to be assessed separately by project phase (construction, operation, closure, post-closure) or facility type. A worst-case project phase may be selected in order to carry out an assessment that is conservative overall (i.e., to determine the worst that the effect will be).

Example tables for presenting the results of the Results are presented in the text or in a table such as Table 5.1-6. This table includes the results of the analysis for both Tables 5.1-4 and 5.1-5 above.

Table 5.1-6 Classification of Effects, and Residual Impact Classification

Effect	Effect Classification					Residual Impact		Mitigation Measures
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-mitigation	Post-mitigation	
Effect XX (construction and operation phase	positive	Low	local	long-term	Possible	Low	Low	X,Y,Z
Effect yy (operation phase)	negative	High	regional	medium-term	Likely	Medium	Low	X,Y,Z
Effect zz (construction and operation phase)	negative	Low	regional	medium-term	Certain	High	Medium	X,Y,Z

a) Example only for table content; final significance ratings to be shown in the following table

5.1.7 Methods for Human Rights Impact Assessment

The Human Rights Impact Assessment (HRIA) is an integrated part of the ESIA for the Project. The assessment covers the full range of Project activities that may have human rights impacts. This HRIA will identify and assess the risks to the enjoyment of human rights related to the management of social and environmental impacts as well as other project-based activities such as security. Given the scope of this work, which is focused on a specific project, this HRIA does not assess broader human rights risks from relationships with business partners, country-level risks or the current status of Newmont overall. The ESIA integration of HRIA brings the human rights lens to the identification of impacts and design of avoidance/mitigation measures and constitutes an important part of Newmont's human rights due diligence process for this proposed development.

As a predictive assessment prior to development of the mine, the HRIA takes a risk-based approach with a focus on putting in place risk control measures to avoid or reduce the risks identified in the assessment. Similar to mitigation measures for social and environmental impacts, the risk-based approach seeks to identify the potential negative impacts of the Project on human rights of affected stakeholders in order to avoid or mitigate those impacts. The United Nations Guiding Principles (UNGP) on Business and Human Rights, approved by the United Nations (UN) in 2011, provides the principal reference for this process.

The methodology integrates evaluation criteria developed by the UN and other organizations[1] and is adapted to this ESIA.[2]

The data used to identify and assess the human rights risks come from the Project Description and Social baseline and impact assessments, and supplemented with information from qualitative sources, records of community engagement activities and ESIA workshops. The engagement activities and workshops provided direct input from rights-holders; and key informant interviews of external sources and company personnel further expanded understanding of the issues. The methodology combines quantitative and qualitative data to identify and characterize risks from Project impacts and to establish management priorities within the scope of responsibilities to address potential human rights impacts. A human rights analysis is included in discipline-specific sections where applicable.

5.1.7.1 Process steps for undertaking the HRIA

Step 1: Document review

The first step comprised a review of the documents provided by Newmont Suriname regarding the Sabajo Project as well as review of secondary documents on Suriname and its human rights record, the history of the extractive industries, documents relevant to the Merian mine, and issue-specific documents on a range of human rights related issues.

Step 2: Scoping review

A scoping stage matrix linked Sabajo activities with potential for human rights impacts. This initial risk matrix provided a list of potential risks that were then reviewed in detail during the ESIA process. The teams carrying out social and cultural studies asked specific questions to be included in their data collection, in particular for the socioeconomic baseline, the assessment of ASM sites of Margo and Santa Barbara, and the cultural heritage review of the Amerindian communities along the Carolina Road.

Step 3: Stakeholder Engagement

The Newmont Social Responsibility team carried out stakeholder engagement prior to and throughout the ESIA, logging an extensive number of visits and meetings with stakeholders throughout the area of the Project, to track issues and concerns raised by rights-holders, including potential traditional owners of the area. The human rights consultant was present to observe and participate in targeted meetings with key rights-holder groups during the baseline data validation meetings for the ESIA.

To increase the understanding of key rights-holder groups, and to include their perspectives, the Social Responsibility team included human rights-specific questions in their consultations with communities about potential impacts from the Project; specific feedback and comments on human rights risks were obtained from these rights-holders and incorporated in the final risk prioritization list and the management plan.

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[1] Interpretation and implementation tools that provide the framework for applying the Guiding Principles are being developed by the UN High Commission for Human Rights and several internal working groups.

[2] The evaluation methodology was developed based on the UNGP on Business and Human Rights, IFC Human Rights Impacts Evaluation and Impact Management Guide; Newmont's Corporate policies and international commitments, in particular ICMM's Principles; and Business and Human Rights Impacts: Identifying and Prioritizing Human Rights Risk of Social and Economic Council and Danish Institute for Human Rights.

Meetings with various civil society and government organizations provided more up to date and locally informed knowledge of the level of probability associated with specific prioritized rights or concerns from the fieldwork and ESIA documents.

Step 4: Analysis and Reporting

Data from the site visit and interviews combined with the baseline studies and impact assessments allowed for analysis of potential human rights impacts, as described in the following section. Further impacts were identified based on impacts in the environmental and technical areas, including potential water quality and traffic impacts.

5.1.7.2 Assessment of Human Rights Prioritization

Once a potential impact is identified and characterized, the potential consequences on human rights for impacted stakeholders are assessed, in line with the UNGP. Although there is no hierarchy within or between human rights, it is important to define the potential relative severity of different impacts and implications in order to prioritize company actions.

The impact severity is important for defining the level of effort or magnitude of remedial actions that the company must put in place to show that it is respecting the rights in question. According to Guiding Principle 14 commentary, severity weighting is performed on the following factors: scale, scope and ability to remediate. The scale of impact on one or more associated human rights relates to the severity of the impact and its consequences[3]; the scope addresses the number of people that may be affected; the ability to remediate relates to the amount of energy or resources needed to allow an impacted stakeholder to enjoy their human rights once again. The assessment combines both quantitative measures as well as qualitative judgments to ensure that vulnerable groups and specific situations are also considered.

The final assessment provides a level of prioritization for addressing the risk (Table 5.1-7), and depends not only on the severity, but also the analysis of probability (likelihood). It considers also the nature of the company's involvement (cause, contribute to or linked through a business relationship) because it has direct bearing on the kind of actions that the company should take to address the human rights risk.

Table 5.1-7 Human Rights Priority Rating Matrix

Salience (Severity and Remediability)	High	High Priority	High Priority	High Priority
	Medium	Medium Priority	Medium Priority	High Priority
	Low	Low Priority	Low Priority	Medium Priority
		Possible	**Probable**	**Certain**
		Probability (Likelihood)		

[3] Question 13, The corporate Responsibility to Respect Human Rights: An interpretive Guide (UN 2012).

5.1.8 Methods for Alignment with Free Prior and Informed Consent Commitments

In its Indigenous Peoples Standard, Newmont commits to upholding the principle of FPIC where it has, or plans to have, activities on land over which Indigenous Peoples claim traditional land rights. The Inter-American Court of Human Rights has recognized traditional land rights for Maroon and Amerindians tribes in Suriname in various rulings, the first one occurring in 2007. These rulings are considered binding because the Government of Suriname ratified the Inter-American Convention on Human Rights in 1987 and as a result directly recognizes the Court's jurisdiction (OAS 2011a).

The Project's public consultation and disclosure efforts, as well as baselines studies, have included the broadest range of Indigenous and Tribal groups that could be impacted by the Project. The engagement is striving to fully inform the general public along with possible land rights holders of all aspects of the Project. Approval of the ESIA approach is not the same as consent for land use. Nevertheless, it is considered important that all groups potentially impacted by the Project be given the chance to shape the ESIA process. Where people's rights are likely to be affected, those people were able to provide during public meetings input to the design, the decisions and, ultimately, the ability of the relevant aspects of the Project to proceed as envisioned.

The following represents practical measures inserted in the ESIA design with the objective to fully inform stakeholders and provide opportunities to approve or withhold consent related to the ESIA process and outcomes (Table 5.1-8).

Table 5.1-8 Practical ESIA Design Measures

ESIA Process	Examples
Planning & Design	Prior to the mandatory public hearings, a series of informal public meetings in each community were organized and completed. This was to provide early, less formal opportunities for people to ask questions and familiarize themselves with the information that would be presented during the government-mandated public hearings. Four official public consultation meetings were conducted with four different stakeholder groups, each in their own preferred local language. The Newmont Social Responsibility team visited each community following the public meetings to provide people with the chance to confirm their understanding of what was presented and to answer any questions, or following-up on what was presented or on any other matters of interest. An advertisement was placed in national newspapers to remind the general public about the possibility to comment on the Scoping Report for the ESIA, which is published on the Newmont website.
Implementation	All social baseline studies are conducted by local rather than international experts to ensure the approach is culturally specific and that knowledge gained during the ESIA remains in Suriname. All local experts were presented to the communities before they started their work to outline their proposed approach to each stakeholder group and make adjustments as needed in response to stakeholder feedback. These meetings served as an opportunity to receive an explicit validation of the proposed approach. Survey questions were tested with the communities themselves and consent for the household survey was requested from each household so that stakeholders became part of the survey design process.
Validation & Impact Mitigation	Each local consultant presented the findings of their baseline studies (small-scale mining, socio-economic, cultural resources, etc.) to communities to validate the findings. Key reports such as the Scoping Report and the (Draft) ESIA will have summaries or be fully translated in Dutch. The ESIA report will include a non-technical summary that is written in easily accessible language. A series of public disclosure meetings will provide another formal opportunity for stakeholders to express their opinions when the draft ESIA is presented for comment.

ESIA = Environmental and Social Impact Assessment.

5.1.9 Additional Baseline Needs

The additional baseline studies Newmont is committing to for this discipline, if applicable, will be described in this section.

5.1.10 Monitoring

The monitoring necessary to track the impacts presented, if applicable, will be described in a monitoring section.

5.2 Air Quality and Climate

5.2.1 Air Quality and Climate Discipline Methods

The assessment of effects on air quality is based on quantitative dispersion modelling of air emissions from:

- mining operations at the Sabajo Project (the Project) including traffic on the haul road between the Project and the Merian Gold Mine (Merian mine) (the Sabajo-Merian Haul Road); and
- traffic along offsite roads of the Project Access Route that may be used by the Project (i.e., Carolina Road and Afobaka Road).

Dispersion modelling was performed for:

- mining operations of the Project at the Sabajo site including a segment of the Sabajo-Merian Haul Road; and
- a road segment simulating increased traffic on the Project Access Route.

The effect on air quality was characterized using the predicted ground-level concentrations resulting from the dispersion modelling of several pollutants that will be emitted by the Project.

The approach to assessing potential future emissions from Project operations involves quantifying background air quality concentrations, and adding the predicted ground-level concentrations resulting from dispersion to the background values to produce future estimates of air quality concentrations. Modelling is completed using the maximum predicted emissions rates from the Project.

The air quality assessment methodology and model was based on recommendations and guidance from the United States Environmental Protection Agency (USEPA) for air quality modelling.

Key elements of the model analysis included:

- estimations of air emissions from the Project for the following compounds:
  - fine particulate matter with a mean aerodynamic diameter of 10 micrometers (μm) or less (PM_{10});
  - fine particulate matter with a mean aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$);
  - nitrogen oxides (NO_X) and the resulting nitrogen dioxide (NO_2);
  - carbon monoxide (CO); and
  - sulfur dioxide (SO_2).
- the most recent publicly available version of the AERMOD dispersion model (version 161216r);
- a five-year meteorological data set (2012 to 2016) representative of the Project location (Lakes 2017);
- terrain, land use, and emission source release characteristics;
- a receptor grid extending 20 kilometers (km) from the approximate centre of Project activities at the Project (i.e., a 40 km by 40 km grid) and discrete receptors at the location of communities within 20 km of the Project;
- a receptor transect extending 1 km out from the modelled road segment of the Project Access Route; and

- model analysis of predicted ground-level concentrations resulting from Project emissions and baseline conditions.

More detailed information on the methodology used in the air quality assessment is provided in the Air Quality Technical Memorandum for the Project (Golder 2018).

Suriname has no regulatory standards against which the changes to air quality resulting from the Project can be compared. As such, ground-level concentrations predicted through dispersion modelling were assessed in the context of the World Health Organization (WHO) Ambient Air Quality Guidelines (AAQG; WHO 2005; IFC 2007). As guidelines for CO are not addressed in the AAQG, the USEPA National Ambient Air Quality Standards (NAAQS) were used as a reference for assessing CO concentration predictions (USEPA 2017a).

The AAQG and NAAQS for compounds that are expected to be emitted by the Project are summarized in Table 5.2-1.

Table 5.2-1 WHO and USEPA Ambient Air Quality Standards

Pollutant	Source	Averaging Period	Standard [µg/m³]
PM_{10}	WHO AAQG	24-hour	50
		Annual	20
$PM_{2.5}$	WHO AAQG	24-hour	25
		Annual	10
NO_2	WHO AAQG	1-hour	200
		Annual	40
CO	USEPA NAAQS	1-hour	40,000
		8-hour	10,000
SO_2	WHO AAQG	10-minute	500
		24-hour	20

Sources: WHO 2005; USEPA 2017b

NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less; WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; USEPA = United States Environmental Protection Agency; NAAQS = National Ambient Air Quality Standards; µg/m³ = micrograms per cubic meters.

The assessment of effects on climate is based on quantification of emissions of greenhouse gases (GHGs) from the Project. The effect on climate was characterized using the Project emissions of megatons (Mt) of carbon dioxide (CO_2) equivalent (CO_2e), which are calculated based on the global warming potential for each gas relative to CO_2.

Impact criteria for the assessment of air quality and climate effects are presented in Table 5.2-2.

Table 5.2-2 Impact Description Criteria for Air Quality

Direction	Magnitude	Geographic Extent	Duration[a]
Positive: a reduction in air quality concentrations or GHG emissions **Negative:** an increase in air quality concentrations or GHG emissions	<u>**Air Quality**</u> **negligible**: the maximum predicted concentration is below 25% of the applicable WHO AAQG or USEPA NAAQS (standards) or the predicted change in concentration is less than 1% of the applicable standard **low**: the maximum predicted concentration is between 25% and 50% of the applicable standard **moderate**: the maximum predicted concentration is between 50% and 100% of the applicable standard **high**: the predicted change in concentration is greater than 100% of the applicable standard	**local**: effect restricted to the study area **regional**: effect extends beyond the study area **beyond regional**: effect extends more than 50 km from the Project	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period, a 10 year operations period and a 4 year closure period.

the Project = the Sabajo Project; WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; USEPA = United States Environmental Protection Agency; NAAQS = National Ambient Air Quality Standards; GHG = greenhouse gas; < = less than; > = greater than;% = percent.

Magnitude criteria for the assessed air quality compounds are presented in Table 5.2-3.

Table 5.2-3 Magnitude Classifications for Air Quality

Parameter	Magnitude if Prediction is:			
	Negligible [µg/m³]	**Low [µg/m³]**	**Moderate [µg/m³]**	**High [µg/m³]**
24-hour PM_{10}	<12.5 or change ≤0.5	12.5 ≤ prediction <25	25 ≤ prediction <50	≥50
Annual PM_{10}	<5 or change ≤0.2	5 ≤ prediction <10	10 ≤ prediction <20	≥20
24-hour $PM_{2.5}$	<6.25 or change ≤0.25	6.25 ≤ prediction <12.5	12.5 ≤ prediction <25	≥25
Annual $PM_{2.5}$	<2.5 or change ≤0.1	2.5 ≤ prediction <5	5 ≤ prediction <10	≥10
1-hour NO_2	<50 or change ≤2	50 ≤ prediction <100	100 ≤ prediction <200	≥200
Annual NO_2	<10 or change ≤0.4	10 ≤ prediction <20	20 ≤ prediction <40	≥40
1-hour CO	<10,000 or change ≤400	10,000 ≤ prediction <20,000	20,000 ≤ prediction <40,000	≥40,000
8-hour CO	<2,500 or change ≤100	2,500 ≤ prediction <5,000	5,000 ≤ prediction <10,000	≥10,000
10-minute SO_2	<125 or change ≤5	125 ≤ prediction <250	250 ≤ prediction <500	≥500
24-hour SO_2	<5 or change ≤0.2	5 ≤ prediction <10	10 ≤ prediction <20	≥20

NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; CO = carbon dioxide; SO_2 = sulfur dioxide; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less; µg/m³ = micrograms per cubic meter; ≤ = less than or equal to; ≥ = greater than or equal to; < = less than.

5.2.2 Issue Scoping

Based on experience with similar projects, there are three main ways that changes in air quality can result in effects to people:

- mining operation emissions can increase ground-level concentrations of pollutants at receptors in the vicinity of the Project;
- Project-related traffic emissions along Project Access Route can increase ground-level concentrations of pollutants at receptors in the vicinity of these roads; and

- Project GHG emissions may contribute to climate change.

These three categories of air quality effects to people are addressed in this section. Other kinds of effects in relation to air quality effects on quality of life for people and on biodiversity are addressed in other sections (Sections 5.11 and 5.9, respectively).

In relation to the three categories of air quality effects, several comments were received confirming their importance to local residents (Table 5.2-4). All of these issues are addressed in this assessment. No other issues were raised in the engagement process for the Project that directly relate to air quality.

Table 5.2-4 Potential Impact Issues for Air Quality

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Potential Effect on Air Quality from Project mining activities	-*How far does an air particle travel?* – Meeting at Pierre Kondre Kumbasi, 6/22/17 -*A man stated that dust may not come here but may return back with the rain* – Meeting at Pierre Kondre Kumbasi, 6/22/17
2	Potential Effect on Air Quality from Project related offsite traffic	-*What will the company do to mitigate impacts such as noise, dust? These will have great impact on the living conditions of all 5 communities.* – Meeting with Carolina Road Amerindian communities, 5/4/17 -*How far does an air particle travel?* – Meeting at Pierre Kondre Kumbasi, 6/22/17 -*A man stated that dust may not come here but may return back with the rain* – Meeting at Pierre Kondre Kumbasi, 6/22/17 -*A woman stated that the children already get dust on their uniforms from cars driving by* – Meeting at Pierre Kondre Kumbasi, 6/22/17
3	Potential Effect on Climate due to Project GHG emissions	No comments were raised with respect to Climate during engagement.

the Project = the Sabajo Project; GHG = greenhouse gas.

5.2.3 Linkage Analysis

The Project mining activity emissions will increase ground-level concentrations of pollutants in the vicinity of the Project site including the Sabajo Merian Haul Road. Project-related traffic emissions will increase ground-level concentrations of pollutants in the vicinity of the Project Access Route. Project activities will increase GHG emissions to the atmosphere.

The linkage between project activities and an increase in ground-level concentrations and for increases in GHG emissions is valid for the construction, operation, and closure phases, since Project activities will emit pollutants and GHGs in all three phases. However, Project activities are expected to be most intense during the operations phase (e.g., largest mining fleet, highest traffic volume). The assessment of Project effects on air quality has consequently focused on the mining year with the maximum amount of material mined during the operations phase. It is in this period when the changes to air quality are likely to be greatest. Project effects on air quality and climate during other phases will be smaller than the effect during operations.

5.2.4 Key Indicators

Key indicators to be used to assess effects on each key issue to be included in this assessment as per the issues list and linkage analysis above have been identified in Table 5.2-5.

Table 5.2-5 Project Indicators for Air Quality and Climate

Issue Number	Key Issue	ESIA Indicators
1	Potential effect of pollutant emissions from Project mining	Ambient concentration of PM_{10}, $PM_{2.5}$, NO_2, CO, and SO_2, expressed in µg/m³
2	Potential effect of pollutant emissions from offsite Project traffic	Ambient concentration of PM_{10}, $PM_{2.5}$, NO_2, CO, and SO_2, expressed in µg/m³
3	Potential GHG emissions from Project mining	GHG emissions, expressed in t/y CO_2e

PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less; NO_2 = nitrogen dioxide; CO = carbon monoxide; SO_2 = sulfur dioxide; µg/m³ = micrograms per cubic meter; GHG = greenhouse gas; t/y = tons per year; CO_2e = carbon dioxide equivalent.

5.2.5 Spatial and Temporal Considerations

Section 5.1 presented the time frames for three major Project phases that will be affected: construction, operations, and closure phases. As discussed above, the air quality and climate assessment focuses on the Project operations phase, since this is the phase with the maximum potential changes to ambient air quality and greenhouse gas emissions.

The model domain for the Sabajo Project is defined by a 40 km by 40 km area centered on the Project activities within the Concession Boundary. This area was chosen to capture nearby communities within the model domain, which are located to the west near the edge of the study area. The Project boundary was taken as the Sabajo Concession Boundary. The AAQG were evaluated at and beyond the Project boundary. The study area for the Sabajo site and the Project boundary are shown in Map 5.2-1.

The model domain for the Project Access Route is defined by a 2000 meter (m) corridor centered along a representative section of the access road. A 2 km long segment of unpaved road was modelled in a generic and representative location to simulate the predicted effects of Project traffic along the Project Access Route. The generic model domain for the Project Access Route are shown in Map 5.2-2.

5.2.6 Project Case Impact Assessment

5.2.6.1 Effects Analysis – Air Quality

5.2.6.1.1 Project Access Route Impact Assessment

Monitoring locations SBB1 and SBB2 were used to determine PM_{10} and $PM_{2.5}$ background concentrations for the Project Access Route, as the locations were along an unpaved section of one of the proposed route options, and were used to adjust the model predictions to more reasonably reflect existing conditions . As the background concentrations were recorded during dry season conditions, they represent a conservative estimate of particulate emissions throughout the year. Unpaved road Project Access Route background concentrations are presented in Table 5.2-6.

Table 5.2-6 Project Access Route Background Concentrations

Compound	Averaging Period	Background Concentration [µg/m³]	
		SBB1 (30 m from road)	SBB2 (10 m from road)
PM_{10}	24-hour	11	19
$PM_{2.5}$	24-hour	9	8

m = meter; µg/m³ = micrograms per cubic meter; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less.

As the locations were along an unpaved section of one of the proposed route options, they were used to adjust the model predictions to more reasonably reflect existing conditions. Background concentrations were not added to the assessment predictions of the Project Access Route, as the Project Access Route model was adjusted using the background and is implicitly included. Because the background concentrations were recorded during dry season conditions, they represent a conservative estimate of particulate emissions likely to be observed over the course of a full year.

The projected Project traffic per day along the Project Access Route, as discussed in the Environmental and Social Impact Assessment (ESIA) Traffic Assessment Section 5.10, is a total of 131 car sized and larger vehicles per day. Road use is assumed to be confined mainly to the hours of 07:00 to 22:00. The emissions are applied over this time period, and are assumed to be zero during the remaining hours. Given the low volume of projected traffic along the road during the nighttime hours, vehicle combustion emissions (NO_X, SO_2, and CO) are insignificant and were not assessed. Fugitive dust emissions from Project traffic will be minimal on paved surfaces, so effects along paved segments of the road were not assessed. Traffic along unpaved segments of the road will emit road dust, therefore PM_{10} and $PM_{2.5}$ emissions effects were assessed for unpaved (dirt) segments. As the road is paved in towns and communities, the fugitive dust emissions assessed for the Project Access Route occur only outside of population centres.

A 2 km length of road oriented perpendicular to the prevailing wind is sufficient to provide a modelled estimate of worst-case conditions along the road. To assume worst-case 24-hour emission rates, no control of dust emissions from rain was applied for the 24-hour results. Annual emission rates do include natural control by rain.

The current Baseline Case daily traffic average per day along the Project Access Route (near monitoring stations SBB1 and SBB2), as discussed in the ESIA Traffic Assessment Section 5.10, is 308 car sized and larger vehicles per day. The Total Effects Case considers the cumulative effects of Project Case traffic emissions in combination with the Baseline Case traffic emissions. Table 5.2-7 summarizes the emissions on unpaved portions of the Project Access Route for all three cases.

Table 5.2-7 Project Access Route Emission Rates (Per 2 Kilometer Length)

Time Period	Case	Modelled PM_{10} Emissions		Modelled $PM_{2.5}$ Emissions	
		[g/s][c]	[t/d][d]	[g/s][c]	[t/d][d]
24-hour[a]	Project Case	0.249	0.022	0.126	0.011
	Baseline Case	0.585	0.051	0.295	0.026
	Total Effects Case	0.834	0.072	0.421	0.036
Annual[b]	Project Case	0.070	0.006	0.035	0.003
	Baseline Case	0.164	0.014	0.083	0.007
	Total Effects Case	0.233	0.020	0.118	0.010

a) 24-hour emissions assume no precipitation occurs.

b) Annual emissions assume precipitation occurs.

c) This emission rate is applied during the hours of 07:00 to 22:00. The remaining hours have no emissions.

d) Applied along a 2 km stretch.

g/s = grams per second; t/d = tons per day; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less.

Table 5.2-8 through Table 5.2-11 and Figures 5.2-1 through 5.2-4 present the maximum PM_{10} and $PM_{2.5}$ predictions for unpaved segments of the Project Access Route. Concentrations were predicted for nominal upwind and downwind receptors along the representative unpaved section of the Project

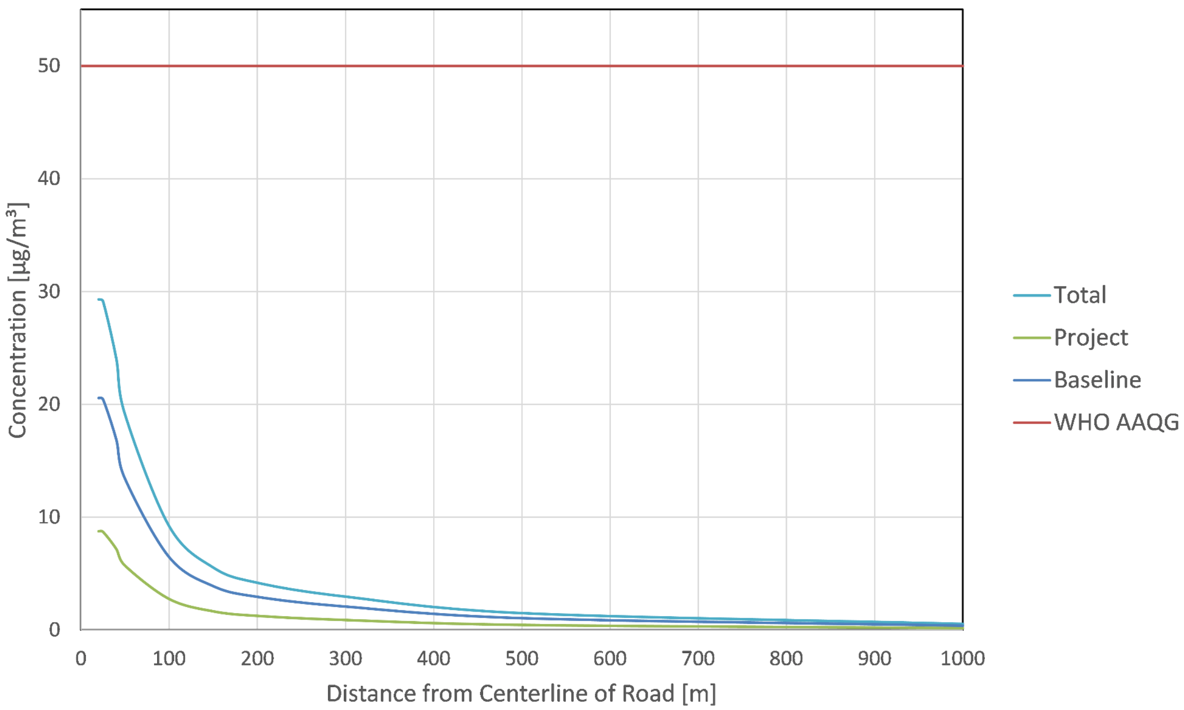
Access Route model. In all cases, the maximum PM_{10} and $PM_{2.5}$ predictions are in compliance with the applicable WHO AAQG at 20 meters (m) from the road center and beyond. At a distance of 1 km, maximum predictions are well below the applicable AAQG.

Table 5.2-8 Predicted 24-hour PM_{10} Concentrations along Unpaved Project Access Route

Receptor Distance from Road Centerline [m]	Maximum 24-hour Concentration [µg/m³]		
	Project Case	Baseline Case	Total Effects Case
20	8.7	20.6	29.3
25	8.7	20.4	29.1
40	7.2	16.9	24.1
50	5.7	13.4	19.1
100	2.7	6.5	9.2
150	1.7	3.9	5.5
200	1.2	2.9	4.2
300	0.9	2.1	3.0
500	0.4	1.0	1.5
1000	0.3	0.7	1.0
WHO AAQG [µg/m³]	**50**		

WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; m = meter; µg/m³ = micrograms per cubic meter; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less.

Figure 5.2-1 Project Access Route Maximum 24-hour PM_{10} Concentrations



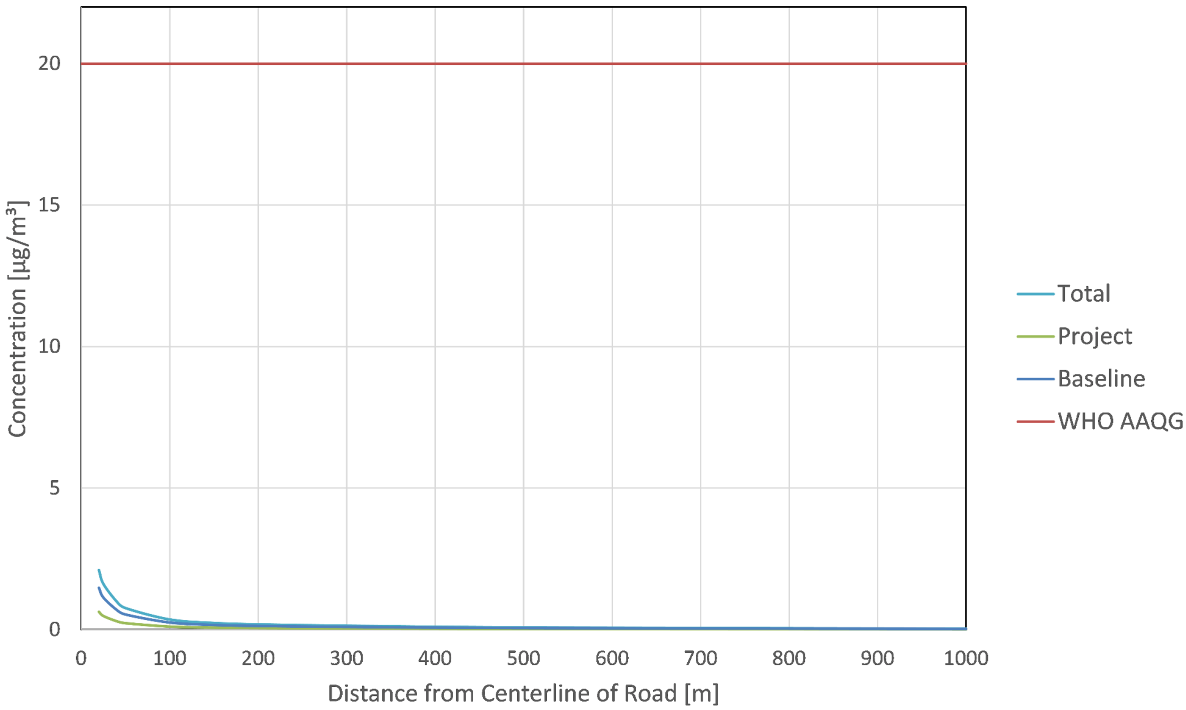
WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; µg/m³ = micrograms per cubic meters; m = meter.

Table 5.2-9 Predicted Annual PM_{10} Concentrations along Unpaved Project Access Route

Receptor Distance from Road Centerline [m]	Maximum Annual Concentration [µg/m³]		
	Project Case	Baseline Case	Total Effects Case
20	0.6	1.5	2.1
25	0.5	1.1	1.6
40	0.3	0.7	1.0
50	0.2	0.5	0.8
100	0.1	0.3	0.4
150	0.1	0.2	0.2
200	0.1	0.1	0.2
300	0.0	0.1	0.1
500	0.0	0.1	0.1
1000	0.0	0.0	0.0
WHO AAQG [µg/m³]	**20**		

WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; m = meter; µg/m³ = micrograms per cubic meters; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less.

Figure 5.2-2 Project Access Route Maximum Annual PM_{10} Concentrations



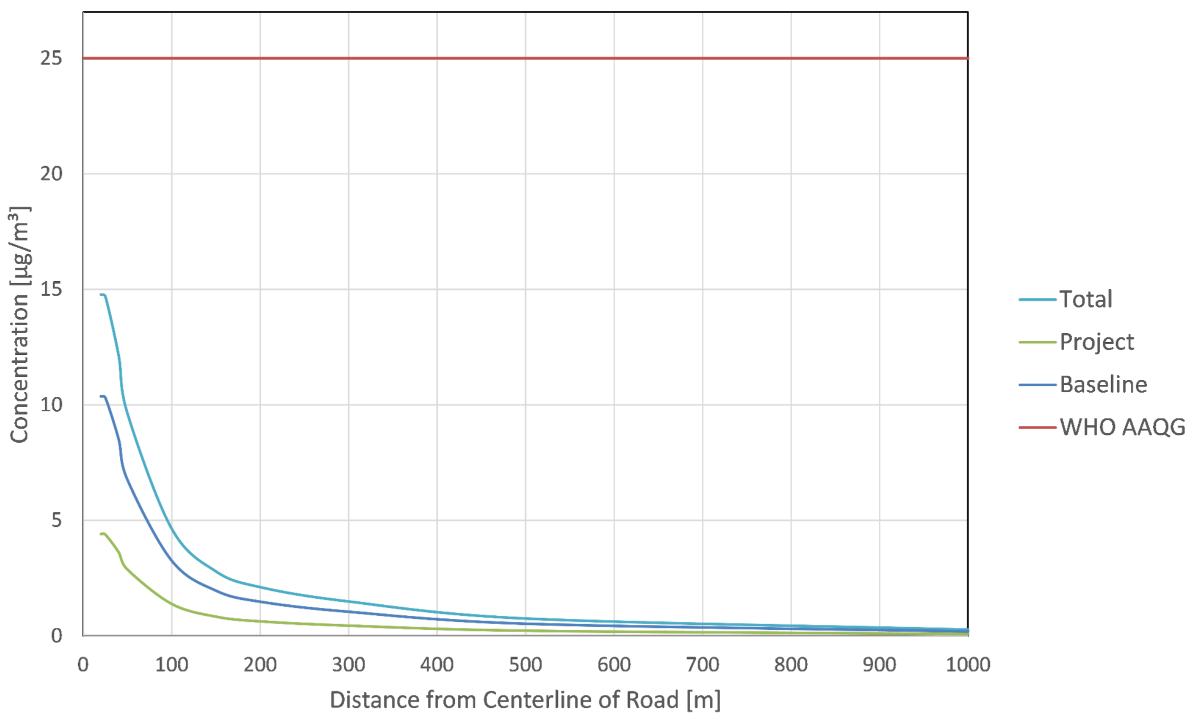
WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; µg/m³ = micrograms per cubic meters; m = meter.

Table 5.2-10 Predicted 24-hour $PM_{2.5}$ Concentrations along Unpaved Project Access Route

Receptor Distance from Road Centerline [m]	Maximum Annual Concentration [µg/m³]		
	Project Case	Baseline Case	Total Effects Case
20	4.4	10.4	14.8
25	4.4	10.3	14.7
40	3.6	8.5	12.1
50	2.9	6.8	9.6
100	1.4	3.3	4.6
150	0.8	2.0	2.8
200	0.6	1.5	2.1
300	0.4	1.0	1.5
500	0.2	0.5	0.8
1000	0.1	0.3	0.5
WHO AAQG [µg/m³]	**25**		

WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; m = meter; µg/m³ = micrograms per cubic meters; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less.

Figure 5.2-3 Project Access Route Maximum 24-hour $PM_{2.5}$ Concentrations



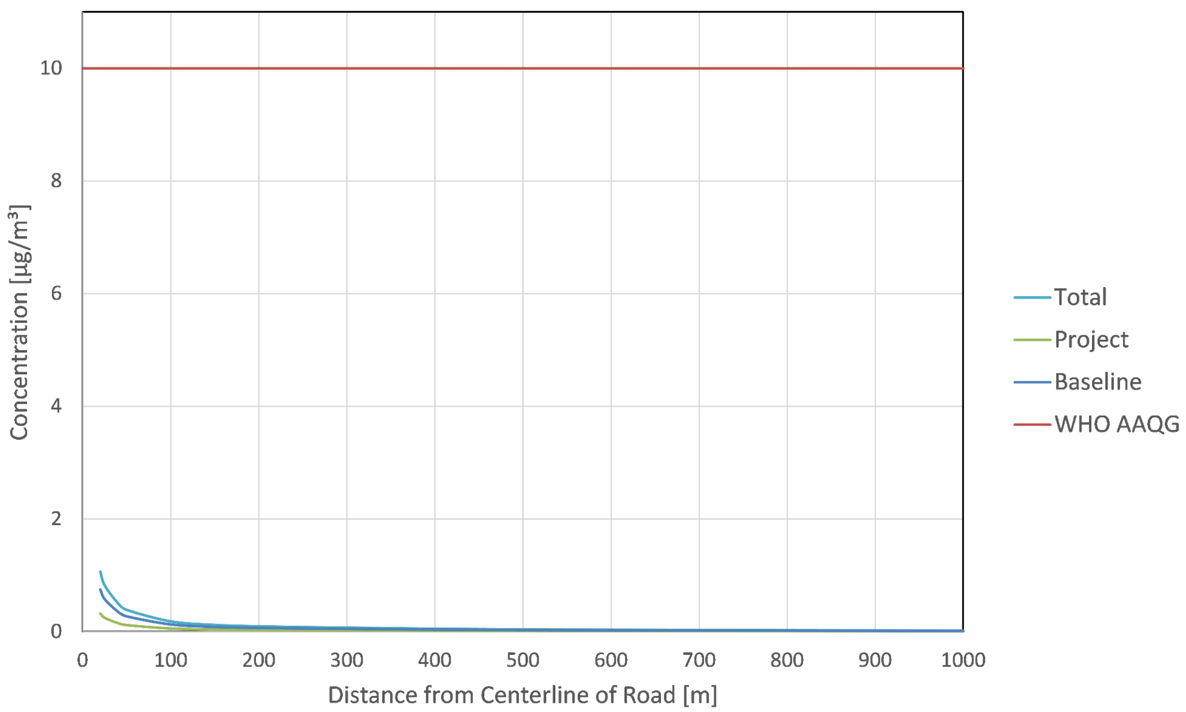
WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; µg/m³ = micrograms per cubic meters; m = meter.

Table 5.2-11 Predicted Annual $PM_{2.5}$ Concentrations along Unpaved Project Access Route

Receptor Distance from Road Centerline [m]	Maximum Annual Concentration [µg/m³]		
	Project Case	Baseline Case	Total Effects Case
20	0.3	0.7	1.1
25	0.2	0.6	0.8
40	0.2	0.4	0.5
50	0.1	0.3	0.4
100	0.1	0.1	0.2
150	0.0	0.1	0.1
200	0.0	0.1	0.1
300	0.0	0.0	0.1
500	0.0	0.0	0.0
1000	0.0	0.0	0.0
WHO AAQG [µg/m³]	**10**		

WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; m = meter; µg/m³ = micrograms per cubic meters; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less.

Figure 5.2-4 Project Access Route Maximum Annual $PM_{2.5}$ Concentrations



WHO = World Health Organization; AAQG = Ambient Air Quality Guidelines; µg/m³ = micrograms per cubic meters; m = meter.

5.2.6.1.2 Sabajo Mine Site and Haul Road Impact Assessment

The impact assessment for the emissions from the mine site and Sabajo-Merian Haul Road considered the following types of Project sources:

- exhaust from stationary combustion sources (power generation);

- diesel engine exhaust from mobile mine fleet equipment (i.e., excavators, loaders, graders, haul trucks and loader); and
- fugitive dust from mining activities (i.e., blasting, drilling, loading/unloading, dozing, and grading), wind-blown dust from rock piles, and road dust from on-site vehicle traffic.

Air emission calculations and source characteristics are discussed in greater detail in the Air Quality Technical Memorandum for the Project (Golder 2018). Emission estimations are based primarily on USEPA AP-42 emission factors (USEPA 2017b).

Three assessment cases were evaluated. The Project Case presents the predicted ground-level concentrations resulting from Project emissions from the Sabajo mine site and Sabajo-Merian Haul Road. The Baseline Case represents the predicted ground-level concentrations resulting from background air quality concentrations. The background concentrations represent contributions from industrial emissions (e.g., Merian Mine emissions outside of the model domain), non-industrial emissions (e.g., traffic emissions and other typical emissions such as cooking fuel and agriculture activities from local populations in the region), natural sources, and unidentified, possibly distant sources contributing to the ambient concentrations in the study area. The Total Effects Case presents the predicted ground-level concentrations resulting from Project emissions in combination with Baseline Case background air quality concentrations.

Emissions from the Merian Mine were not directly included in the assessment, as the Merian Mine is located outside of the study area. Background concentrations included in the Total Effects Case allow for the contribution of emissions from the Merian Mine to be captured in the results assessment. Background concentrations were determined from the baseline monitoring discussed in in the Air Quality Baseline in Section 4.9.

A monitoring location at the future location of the proposed haul road to Margo was used to determine background concentrations for the mine site of the Project and the Sabajo-Merian Haul Road, as this location was remote and uninfluenced by immediate emission sources. Only SO_2, PM_{10} and $PM_{2.5}$ background concentrations were viably recorded. These background concentrations are presented in Table 5.2-12.

Table 5.2-12 Sabajo Project Background Concentrations (Mine Site)

Background Concentration [µg/3³][(a)]	NO_2	CO	SO_2	24-hour PM_{10}	Annual PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$
	—	—	0	11.0	6.3	8.0	4.8

a) Haul Road to Margo monitoring location.

µg/m³= micrograms per cubic meter; NO_2 = nitrogen dioxide; CO = carbon monoxide; SO_2 = sulfur dioxide; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less; — = no available data.

The Project Case and Total Effects Case provide a conservative estimate of the potential effects of emissions on air quality, as they assume that the Project is operating during the maximum annual emissions scenario of the Operation phase of the Project. Construction and Closure phases are not modelled, as emissions during these phases will be lower than during the Operation phase.

The Project Case emissions represent the emissions associated with expected mining activities during the maximum potential year of emissions for the Project. As emission rates from Project sources are primarily dependant on the tonnage mined, the year of maximum tonnage mined represents the worst-case emission scenario. Year 7 of operations was assessed as the worst-case year, with 20,720 kilotons or material mined. Pit 1 and Pit 6 will be in operation during year 7. Project emissions and effects from emissions in other years will be less than those occurring during year 7.

A summary of annual Project emissions based on year 7 of operations is presented in Table 5.2-13. Information in the Air Quality Technical Memorandum for the Sabajo Project (Golder 2018) describes the approach used to estimate the annual emissions.

Table 5.2-13 Summary of Project Emissions (Mine Site)

Annual Emission Rate [t/y]	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$
	450.66	200.61	2.11	647.35	115.52

t/y = tons per year; NO_X = nitrogen oxides; CO = carbon monoxide; SO_2 = sulfur dioxide; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less.

Project SO_2 emissions were estimated based on the use of ultra-low sulfur diesel (ULSD) at the Project. Conservative assumptions include that power generation runs at 100% load continually during the maximum year of operations. Given the maximum estimated annual emission rate of 2.11 t/y, Project SO_2 emissions are considered insignificant, therefore SO_2 concentrations were carried forward to modelling.

Given the low wind speeds at the Project, fugitive dust emissions from storage piles due to wind erosion were estimated to be nil. Fugitive dust emissions from storage piles at the Project were therefore not considered further.

The maximum emissions by source category are presented in Table 5.2-14. Two emissions rates are presented for road dust: rainfall-unmitigated and rainfall-mitigated. The rainfall-unmitigated emission rates assume that no natural mitigation of road dust by rainfall occurs. The rainfall-mitigated emission rates assume that rainfall occurs over the course of the year, and that road dust emission rates are reduced on an annual basis by the number of days on which rain occurs per year. The dispersion model conservatively included the higher, rainfall-unmitigated road dust emission rate for all 24-hour concentration predictions. Annual predictions modelled the rainfall-mitigated rate.

Table 5.2-14 Project Source Category Emission Rates (Mine Site)

Source Category	Emission Rate [t/d]			
	NO_X	CO	PM_{10}	$PM_{2.5}$
Power Generation	0.267	0.053	0.005	0.005
Grading	0.000	0.000	0.119	0.013
Bulldozing	0.000	0.000	0.089	0.045
Blasting and Drilling	0.043	0.198	0.089	0.071
Loading and Unloading	0.000	0.000	0.063	0.005
Mine Fleet Exhaust	0.925	0.299	0.042	0.041
Road Dust (rainfall-unmitigated)	0.000	0.000	4.888	0.489
Road Dust (rainfall-mitigated)	0.000	0.000	1.366	0.137

t/d = tons per day; NO_X = nitrogen oxides; CO = carbon monoxide; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less.

The AERMOD model was used to predict NO_2, CO, PM_{10}, and $PM_{2.5}$ ground-level concentrations. To aid in the interpretation of the dispersion modelling, the results are presented in a tabular format, which allows comparison between the predicted ground-level concentrations and relevant air quality criteria discussed in Section 5.2.1. The AERMOD modelling used five years of meteorological data; therefore, for each pollutant modelled, the maximum 1-hour, 8-hour, 24-hour or annual average concentrations relevant to the specific air quality criteria were predicted for each year, separately. The highest (maximum) value of the five years' predictions is presented.

For the Project mine site modelling, the predicted maximum ground-level concentrations for offsite receptors (i.e., outside of the Concession Boundary), also referred to as the maximum point of impingement (MPOI), are assessed.

Table 5.2-15 presents the maximum ground-level predictions for the Project Case, Baseline Case, and the Total Effects Case at the concession boundary. All predictions except for 24-hour PM_{10} are below the applicable standard at and beyond the concession boundary. The Project Case 24-hour PM_{10} predictions exceed the WHO AAQG at the concession boundary once per year, and the Total Effects Case 24-hour PM_{10} predictions exceed the WHO AAQG at the concession boundary twice per year, but concentrations are well below the AAQG at the communities within the study area. The two days where exceedances were predicted are characterized by relatively low wind speeds (<0.5meters per second) for several consecutive hours, coincident with a transition from a stable to neutral atmosphere in the early morning. Stable conditions are associated primarily with night time cooling, which result in suppressed turbulence levels (poorer dispersion).

Table 5.2-15 Predicted Maximum Concentrations (Mine Site)

Compound	Averaging Period	Standard[(a)(b)] [µg/m³]	Project Case Maximum Concentration [µg/m³]	Background Concentration [µg/m³]	Total Effects Case Maximum Concentration [µg/m³]	Maximum Number of Exceedances per Year
PM_{10}	24-hour	50	71.8	11.0	82.8	2
	Annual	20	2.6	6.3	8.9	0
$PM_{2.5}$	24-hour	25	9.4	8.0	17.4	0
	Annual	10	0.5	4.8	5.3	0
NO_2	1-hour	200	180.5	—	180.5	0
	Annual	40	3.4	—	3.4	0
CO	1-hour	40,000	292.1	—	292.1	0
	8-hour	10,000	87.8	—	87.8	0

a) World Health Organization Ambient Air Quality Guidelines applied for PM_{10}, $PM_{2.5}$ and NO_2.

b) United States Environmental Protection Agency National Air Quality Standards referenced for CO.

µg/m³ = micrograms per cubic meter; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; NO_2 = nitrogen dioxide; CO = carbon monoxide; — = no available data.

Table 5.2-16 presents the maximum Total Effects Case ground-level predictions at the communities within the model domain. All predictions are well below the applicable standard at the communities Maximum predictions for particulate matter are dominated by background concentrations, meaning that the Project has very little effect.

Table 5.2-16 Predicted Total Effects Case Maximum Concentrations at Communities Near Mine Site

Compound	Averaging Period	Standard[(a)(b)] [µg/m³]	Background [µg/m³]	Total Effects Case Maximum Concentration including Background [µg/m³]				
				Balingsoela	Tapoeripa	Asigron	Brokopondo Centrum	Afobaka Centrum
PM_{10}	24-hour	50	11.0	13.0	14.2	13.8	12.9	16.1
	Annual	20	6.3	6.4	6.4	6.3	6.4	6.4
$PM_{2.5}$	24-hour	25	8.0	8.3	8.4	8.4	8.3	8.7
	Annual	10	4.8	4.8	4.8	4.8	4.8	4.8
NO_2	1-hour	200	—	17.2	50.3	53.0	46.0	68.3
	Annual	40	—	0.2	0.2	0.1	0.2	0.3
CO	1-hour	40,000	—	12.1	39.2	40.6	35.1	47.7
	8-hour	10,000	—	2.2	5.1	6.8	4.5	7.3

a) World Health Organization Ambient Air Quality Guidelines applied for PM_{10}, $PM_{2.5}$ and NO_2.

b) United States Environmental Protection Agency National Air Quality Standards referenced for CO.

µg/m³ = micrograms per cubic meters; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; NO_2 = nitrogen dioxide; CO = carbon monoxide; — = no available data.

Contour maps of the Total Effects Case concentration predictions are presented in Maps 5.2-3 to 5.2-10.

5.2.6.2 Effects Analysis – Climate

Project activities will result in GHG emissions. These emissions should be considered in a global context given the potential for GHG emissions to contribute to global climate change. Comprehensive global GHG emission totals are not available on an annual basis; however, organizations such as the World Resources Institute (WRI), and the United Nations Framework Convention on Climate Change (UNFCCC), do provide global summaries from reporting nations for consideration.

Estimates of GHG emissions can be expressed as Mt of CO_2e, which are calculated based on the global warming potential for each gas relative to CO_2. GHGs are presented as CO_2e based on global warming potentials as outlined in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007).

The primary factors influencing GHG emissions are the anthropogenic sources of emissions, including industrial activities, vehicle traffic, urban and industrial development, and related infrastructure.

Global and national GHG emissions are summarized in Table 5.2-17.

Table 5.2-17 Global and National GHG Emissions Summary

GHG Emission Source Location	Total GHG Emissions [Mt CO_2e]
Global (2012)[(a)]	25,764
Suriname (2008)[(b)]	6.366

Global totals are for the most recent year available (UNFCCC 2014).
National totals are for the most recent year available (Republic of Suriname 2016).
Mt CO_2e = megatons carbon dioxide equivalent; GHG = greenhouse gas.

Similar to the air emissions discussed in Section 5.2.6.1.1, the GHG emissions from Project operation were estimated based on the Project year 7 of operations, the year of maximum tonnage mined. For all other years of the Project construction, operation, and decommissioning phases, the GHG emissions will be less than for year 7. The main sources of GHG emissions during the operation of the Project will be mine fleet equipment and power generation. The GHGs emitted by these sources are a by-product of diesel fuel combustion. Carbon emissions from forest clearing due to Project activities in the study area are also included.

The maximum annual GHG emission contribution from the Project is estimated to be 75,757 tons per year of CO2 equivalents, or 0.076 megatons per year (Table 5.2-18). The annual maximum GHG emissions are a conservative estimate. For example, power generation is assumed to run at 100% load continually, and clearing activities are assumed to occur progressively over 10 years through operations.

Table 5.2-18 Project GHG Emissions Summary

GHG Emission Source	Maximum GHG Emissions [t/y]			
	CO_2	CH_4	N_2O	CO_2e[(a)]
Power Generation	8,609	0.5	0.0	8,622
Mine Fleet Diesel Engines	35,101	2.0	0.9	35,394
Forest Clearing Activities	31,741	0.0	0.0	31,741
Total	75,451	2.5	0.9	75,757

a) Based on global warming potentials (The Climate Registry 2017). Forest clearing activities represent a single occurrence (i.e., total volume of loss of 317,409 tons CO_2), divided by 10 to provide a per-year loss estimate over life of project.

t/y = tons per year; CO_2e = carbon dioxide equivalent; GHG = greenhouse gas; CO_2 = carbon dioxide; N_2O = nitrous oxide; CH_4 = methane.

Table 5.2-19 presents total GHG emissions of the Project and the Merian mine, along with Global and national totals for comparison.

Table 5.2-19 GHG Emissions Summary

GHG Emission Source Location	Total GHG Emissions [Mt CO_2e]
Global (2012)[(a)]	25,764
Suriname (2008)[(b)]	6.366
Merian Mine (Maximum Annual)[(c)]	0.368
Sabajo Project (Maximum Annual)[(d)(e)]	0.076

a) Global totals are for the most recent year available, 2012 (UNFCCC 2014).
b) National totals are for the most recent year available, 2008 (Republic of Suriname 2016).
c) Merian ESIA (ERM 2013).
d) Using the Climate Registry reporting protocol (The Climate Registry 2016).
e) Calculated using default emissions factors from the Climate Registry (The Climate Registry 2017).
Mt CO_2e = megatons carbon dioxide equivalent; GHG = greenhouse gas.

After Project closure, GHG emissions in the study area will return to the same levels as prior to Project construction. Revegetation will result in the fixing of atmospheric CO_2 through carbon sequestration during and after closure, and on reclaimed areas of the Project during operations.

5.2.6.3 Classification of Effects

For issue # 1 - Potential Effect on Air Quality from Project mining activities:

- the direction of the effect is classified as negative, since mining activities will increase NO_2, CO, SO_2, PM_{10} and $PM_{2.5}$ concentrations in the vicinity of the Project;
- the magnitude of the effect is classified as:

    - negligible for 10-minute and 24-hour SO_2 concentrations, since Project combustion sources will emit negligible amounts of these compounds.
    - negligible for 1-hour and 8-hour CO concentrations at the Concession Boundary and at communities within the study area, since CO concentration predictions are below 25% of the USEPA NAAQS.
    - moderate for 1-hour and negligible for annual NO_2 concentrations at the Concession Boundary, since 1-hour NO_2 concentrations are between 50% and 100% and annual NO_2 concentration predictions are below 25% of the AAQG; low for 1-hour NO_2 concentrations and negligible for annual NO_2 concentrations at communities within the study area, since 1-hour NO_2 concentrations are between 25% and 50% and annual NO_2 concentration predictions are below 25% of the AAQG.
    - high for 24-hour and low for annual PM_{10} concentrations at the Concession Boundary, since 24-hour PM_{10} concentrations are above 100% and annual PM_{10} concentration predictions are between 25% and 50% of the AAQG; low for 24-hour and annual PM_{10} concentrations at communities within the study area, since 24-hour and annual PM_{10} concentrations are between 25% and 50% of the AAQG.
    - moderate for 24-hour and negligible for annual $PM_{2.5}$ concentrations at the Concession Boundary, since 24-hour $PM_{2.5}$ concentrations are between 50% and 100% and annual $PM_{2.5}$ concentrations are below 25% of the AAQG; low for 24-hour and annual $PM_{2.5}$ concentrations at communities within the study area, since 24-hour and annual $PM_{2.5}$ concentrations are between 25% and 50% of the AAQG.
- the geographic extent of the effect is classified as local, since the predicted concentrations of NO_2 and PM_{10} as a result of Project activities are predicted to have diminished to low levels with no exceedances of the air quality criteria at the edge of the study area;
- the duration of the effect is classified as short-term, since the period when Project effects are predicted to exceed air quality criteria are short duration and infrequent. Project effect will cease and concentrations of assessed pollutants will return to baseline values after completion of the Project closure phase; and
- The likelihood of the effect is classified as likely, since Project effects are predicted to exceed air quality criteria infrequently, and since Project emissions are conservatively assessed.

For issue # 2 - Potential effect of pollutant emissions from offsite Project traffic:

- the direction of the effect is classified as negative, since offsite traffic will increase PM_{10} and $PM_{2.5}$ concentrations in the vicinity of the Project Access Route;
- the magnitude of the effect is classified as:
    - negligible for NO_2, CO and SO_2 concentrations for all sections of the Project Access Route, since Project traffic will emit negligible amounts of these compounds;
    - negligible for PM_{10} and $PM_{2.5}$ concentrations for all paved sections of the Project Access Route, such as through communities, since Project traffic will emit negligible amounts of particulate matter on paved roads;
    - negligible for 24-hour PM_{10} concentrations at 100 m and further from unpaved sections of the road and negligible for annual PM_{10} concentrations along unpaved sections of the road at any distance since PM_{10} concentration predictions are below 25% of the AAQG;
    - negligible for 24-hour $PM_{2.5}$ concentrations at 100 m and further from unpaved sections of the road and negligible for annual $PM_{2.5}$ concentrations along unpaved sections of the road at any distance, since $PM_{2.5}$ concentration predictions are below 25% of the AAQG;

- the geographic extent of the effect is classified as local, since the increase in PM_{10} and $PM_{2.5}$ concentrations as a result of Project traffic along the Project Access Route will diminish to negligible levels within 100 m of unpaved sections of the road, and will be negligible along paved sections of the road;
- Project particulate emissions will only occur when Project vehicles pass along a section of unpaved road, and concentrations will return to baseline values soon after Project vehicles pass by. However, the WHO AAQG are based on 24-hour and annual averages and so duration of the effect is classified as medium-term, since PM_{10} and $PM_{2.5}$ 24-hour and annual average concentrations in the vicinity of unpaved sections of the Project Access Route will increase over the duration of the Project; and
- The likelihood of the effect is classified as likely, since offsite Project traffic will make use of Carolina Road or Afobaka Road along the Project Access Route.

For issue # 3 - Potential Effect on Climate due to Project GHG emissions:

- the direction of the effect is classified as negative, since Project activities will increase GHG emissions;
- As noted in guidance such as provided by the Canadian Environmental Assessment Agency, “unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured” (CEA Agency 2003). The change in ambient global GHG emissions from Project construction, operation, and closure are not likely to be detectable, and the importance of the effects on climate is predicted to be negligible as compared to global GHG emissions. Therefore, the predicted effect of the Project on climate is negligible.
- the geographic extent of the effect is classified as beyond regional, since climate effects are considered on a global scale;
- the duration of the effect is classified as medium term, since GHG emissions will occur over the operation of the Project; and
- The likelihood of the effect is classified as certain, since GHG emissions will occur over the construction, operation, and closure phases of the Project.

The magnitude classifications presented above assume that the mitigation measures described in Section 5.2.6.4 will be implemented. If mitigation measures from Section 5.2.6.4 were not implemented, the magnitude of effects would be greater.

As discussed in Section 5.2.6.1.1, the effects assessment presented in Table 5.2-20 is focused on the maximum year of production during the Project operations phase, since effects during other Project phases and years will be smaller than during the maximum year of production. A number of conservatisms have been built into the assessment, and the magnitude classification of high for air quality from the Project occurs for a maximum of two days per year for 24-hour PM_{10} concentrations at the immediate Concession Boundary. The magnitude of effects at the communities are low. Effects along the Project Access Route are negligible.

Table 5.2-20 Classification of Effects, Consequence and Likelihood

Effect	Effect Classification					Impact Significance Post-Mitigation	Mitigation or benefit enhancement measure
	Direction	Magnitude	Geographic Extent	Duration	Likelihood		
Effect of air quality from Sabajo Project mining activities (operation phase)	Negative	High	local	Short-term	Likely	Medium	• implementing an idle-reduction program; • use of ULSD fuel for Project equipment; • watering of Project roads and ore stockpile as necessary; • limit speed of trucks; • use of best available technology economically achievable (BATEA) for emissions controls; • implementing an quality monitoring program for PM_{10}, $PM_{2.5}$ and NO_2 at the Project site during construction and operation phases; and • reclaim mine ore stockpiles and disturbed areas as they become available.
Effect of air quality from offsite Project traffic on Project Access Route (operation phase)	Negative	Negligible	Local	Short-term	Likely	Negligible	• use of ULSD fuel for Project equipment; and • limit speed of trucks.
Effect of climate from Sabajo Project mining activities (operation phase)	Negative	Negligible	Beyond regional	Medium-term	Certain	Negligible	• implementing an idle-reduction program; and • limit speed of trucks. • quantify and report GHG emissions per IFC guidance; and • reclaim mine ore stockpiles and disturbed areas as they become available.

IFC = International Finance Corporation; GHG = greenhouse gas; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less: ULSD = ultra-low sulfur diesel; NO_2 = nitrogen dioxide.

5.2.6.4 *Effects Analysis – Mitigation*

Mitigation for effects on air quality will include:

- regular maintenance on all mine equipment and Project vehicles in accordance with manufacturer specifications;
- standard emissions controls on vehicles;
- implementing an idle-reduction program;
- use of ULSD fuel for Project equipment;
- watering of Project roads and ore stockpile as necessary;
- limit speed of trucks;
- use of best available technology economically achievable (BATEA) for emissions controls;
- implementing an quality monitoring program for PM_{10}, $PM_{2.5}$ and NO_2 at the Project site during construction and operation phases; and
- progressive reclamation of mine ore stockpiles and disturbed areas.

Mitigation for effects on climate will include:

- regular maintenance on all mine equipment and Project vehicles in accordance with manufacturer specifications;
- implement an idling-reduction program;
- limit speed of trucks;
- quantify and report GHG emissions per IFC guidance (IFC 2017) and Newmont standards; and
- reclaim mine ore stockpiles and disturbed areas as they become available.

5.2.7 Cumulative Effects Case Impact Assessment

The following activities may contribute to cumulative effects on air quality and climate:

- the Merian mine;
- the Saramacca mine;
- the Rosebel mine;
- artisanal and small scale mining;
- forestry; and
- non-Project traffic on the Project Access Route.

All of these activities, other than the proposed Saramacca Mine, were underway at the time of the field program to measure baseline air quality levels Consequently, potential air quality effects from most of these activities were captured in the baseline air quality measurements. The Saramacca Mine would represent a continuation of effects due to the Rosebel Mine, so is not considered to have an additive effect to air emissions. Because the assessment of Project air quality effects presented above considers Project air quality concentrations in the context of the measured baseline, a cumulative effects assessment was effectively completed for air quality. There are no presently foreseeable future activities that will add substantially to air quality concentrations in the study area.

As noted in Section 5.2.6.3, the contribution of an individual project to climate change cannot be measured. Consequently, a cumulative effects assessment for climate is not warranted.

5.2.8 Additional Baseline Needs

No additional baseline data collection is proposed for air quality and climate.

5.2.9 Monitoring

Air quality monitoring for PM_{10}, $PM_{2.5}$ and NO_2 will be conducted at the Sabajo Project and selected Project Access Route locations during construction and operation phases of the Project. Monitoring will be similar to that performed at the Merian Mine.

5.3 Noise and Vibration

5.3.1 Noise and Vibration Discipline Methods

The assessment of effect on noise is based on quantitative modelling of:

- traffic along offsite roads that may be used by the Sabajo Project (the Project; i.e., Carolina Road and Afobaka Road)
- mining operations in each of the Project pits; and
- traffic on the Sabajo-Merian Haul Road between the Project and Merian Gold Mine (Merian mine).

The effect on noise was characterized using the energy equivalent sound level (L_{eq}), expressed in A-weighted decibels (dBA). The L_{eq} parameter represents the average noise level over a particular time period. Common L_{eq} time periods include twenty-four hours ($L_{eq,24}$), one hour ($L_{eq,1hr}$), and one minute ($L_{eq,1min}$). A-weighting is a procedure for scaling noise levels to reflect the frequency sensitivity of the human auditory system. The decibel is a logarithmic unit used to compress the wide range of noise levels that are encountered in the environment into a manageable numeric scale. Examples of typical noise levels are shown in Figure 5.3-1.

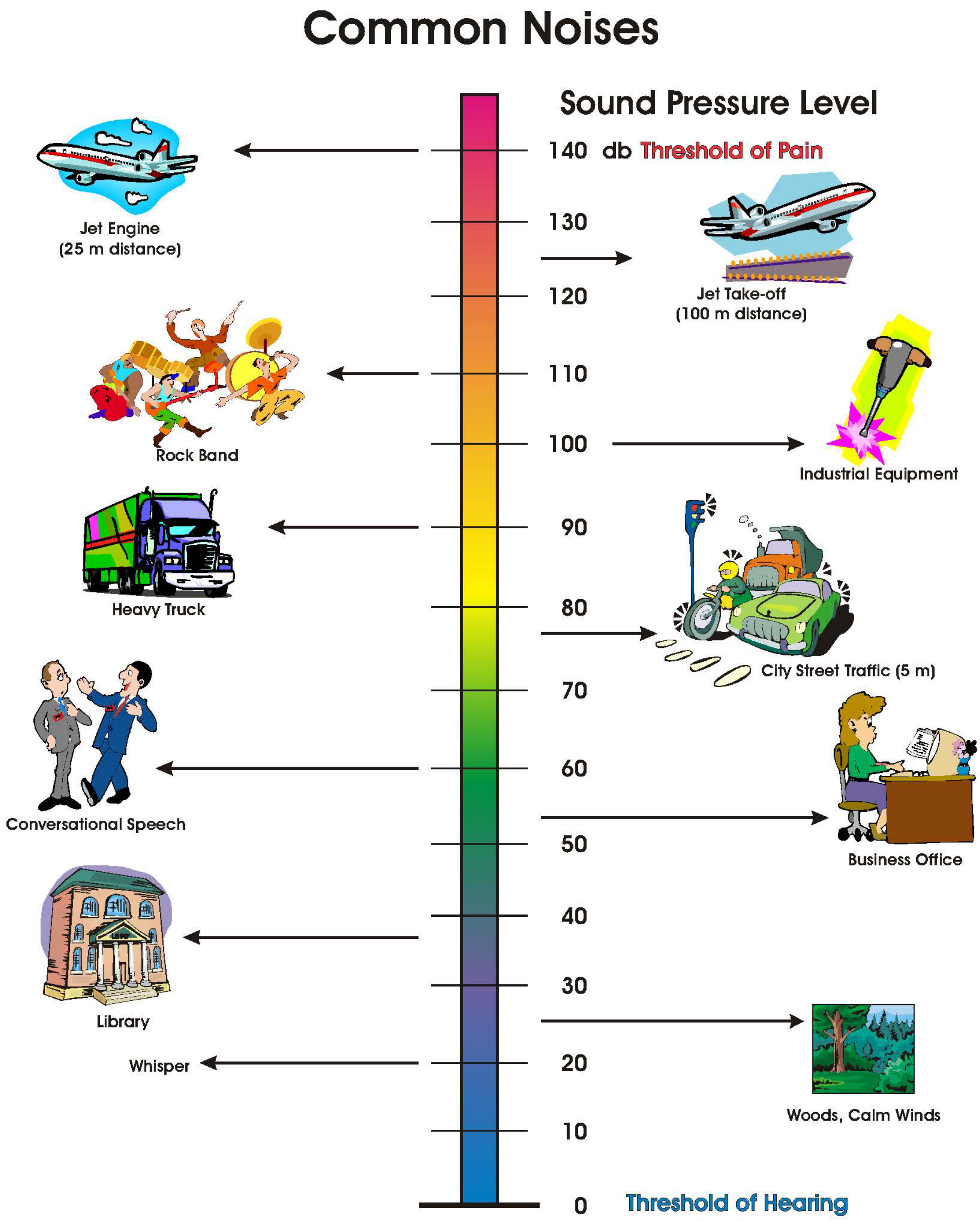
The approach to modelling potential future noise involves understanding the present baseline noise levels as per the baseline presented in Section 4.9, and adding what is considered to be the maximum potential Project noise to the existing noise in order to produce future noise estimates.

Noise from traffic on Carolina Road and Afobaka Road was modelled using the United States Department of Transportation (USDOT) Traffic Noise Model (TNM). Inputs to the TNM model consisted of daily traffic flow rates broken down by vehicle type (e.g., light vehicles, buses, heavy trucks), as well as environmental parameters that are known to influence noise propagation outdoors. Given the length of Carolina Road and Afobaka Road, it was not feasible to model noise levels at each discrete receptor along both roads. Instead, the TMN model was used to predict traffic noise levels at various distances from Carolina Road and Afobaka Road.

Noise from mining operations and the Sabajo-Merian Haul Road traffic was modelled in accordance with an International Organization for Standardization (ISO) technical standard (ISO 1996). Inputs to the ISO model consisted of noise emissions from haul trucks and other mining equipment, as well as environmental parameters (e.g., ground cover, temperature, humidity) that are known to influence noise propagation outdoors. In the absence of discrete noise receptors in the vicinity of the Project mine or the Sabajo-Merian Haul Road, the ISO model was used to predict maximum noise levels at the edge of the Project Concession and at various distances from the haul road.

Suriname has no regulatory standards for noise pollution. As such, noise level predictions from the ISO and TMN models were assessed in the context of the International Finance Corporation (IFC) environmental noise guideline (IFC 2007). Use of the IFC guideline to assess Project noise levels is consistent with the approach taken in noise assessment conducted for the Merian Project Environmental and Social Impact Assessment (ESIA; Surgold 2013). IFC guideline values are specified in dBA using the $L_{eq,1hr}$ parameter. Separate IFC guideline values are specified for the daytime period, defined as 07:00 to 22:00, and for the nighttime period, defined as 22:00 to 07:00 (IFC 2007).

Figure 5.3-1 Examples of Noise Levels



db = decibel; m = meter.

The assessment of effect on vibration is based on quantitative modelling of explosive blasting during mining operations. Blasting was characterized in the context of:

- ground vibration, quantified using the Peak Particle Velocity (PPV) parameter and expressed in millimeters per second (mm/s); and
- airblast overpressure, quantified using the Peak Pressure Level (PPL) parameter and expressed in linear decibels (dBL) – i.e., decibels to which no frequency weighting has been applied.

Ground vibration and airblast overpressure from blasting was modelled using empirical formulae developed by Terrock Consulting Engineers (Terrock) based on statistical analysis of blast measurements from many different sites (Terrock n.d.; Terrock 2009). The empirical formulae used to model Project blasting are the same formulae used in the vibration assessment conducted for the Merian mine ESIA (Surgold 2013). Inputs to the blasting formulae consist of blast parameters (e.g., charge mass, blast hole diameter, burden depth) and parameters that characterize the surrounding environment and the nature of the material being blasted. In the absence of discrete receptors within the study area, the empirical formulae were used to predict ground vibration and airblast overpressure levels at various distances from the blast site.

The formula below was used to predict the distance at which ground vibration PPV would reach particular threshold levels. In the formula below, *D* represents distance in metres, *Q* represents charge mass in kilograms (kg), *v* is PPV ground vibration in mm/s, *k* is the “site constant” that characterizes the material being blasted, and *e* is the “site exponent” that characterizes propagation into the environment.

$$D = \sqrt{Q}\,10^{\left(\frac{-1}{e}\log_{10}\frac{v}{k}\right)}$$

The formula below was used to predict the distance at which airblast overpressure PPL would reach 120 dBL. In the formula below, D_{120} is the distance in metres at which the airblast overpressure reaches 120 dBL, *Q* is the charge mass in kg, *d* is the diameter of the blast hole in millimeters (mm), *B* is the depth of the burden in mm, and k_a is an “environmental constant” that characterizes the blast site. Airblast overpressure levels at other distances from the blast site were calculated using D_{120} as a starting point and assuming a decay rate of 9 dBL per doubling distance, which is the same decay rate used in the Merian Project ESIA (Surgold 2013).

$$D_{120} = \left(\frac{k_a \times d}{B}\right)^{2.5} \times \sqrt[3]{Q}$$

Suriname has no regulatory standards for blasting. As such, ground vibration and airblast overpressure predictions were assessed in the context of the Australia and New Zealand Environmental Conservation Council (ANZECC) blasting guideline (ANZECC 1990). Use of the ANZECC guideline to assess ground vibration and airblast overpressure from Project blasting is consistent with the approach taken in the vibration assessment conducted for the Merian Project ESIA (Surgold 2013). The ANZECC guideline provides both recommended and maximum levels for ground vibration (PPV) and airblast overpressure (PPL).

Impact criteria for assessment of noise and vibration effects are presented in Table 5.3-1.

Table 5.3-1 Impact Description Criteria for Noise and Vibration

Direction[(a)]	Magnitude[(b)]	Geographic Extent[(c)]	Duration[(d)]
Positive: a reduction in noise or vibration levels **Negative:** an increase in noise or vibration levels	**Noise:** **negligible**: effect from Project is not perceptible; noise levels are within the range of existing background conditions **low**: effect from Project is perceptible; noise levels increase up to 3 dBA compared to existing background levels and comply with IFC guideline **moderate**: effect from Project is readily noticeable; noise levels increase up to 10 dBA compared to existing background levels **high**: effect from Project is disturbing; noise levels increase more than 10 dBA compared to existing background levels **Ground Vibration:** **negligible**: effect from Project is not perceptible; PPV levels up to 0.1 mm/s **low**: effect from Project is perceptible; PPV levels comply with ANZECC recommended guideline of 5 mm/s **moderate**: effect from Project is readily noticeable; PPV levels comply with ANZECC maximum guideline value of 10 mm/s **high**: effect from Project is disturbing; PPV levels exceed ANZECC maximum guideline value of 10 mm/s **Airblast Overpressure:** **negligible**: effect from Project is not perceptible; PPL levels up to 60 dBL **low**: effect from Project is perceptible; PPL levels comply with ANZECC recommended guideline of 115 dBL **moderate**: effect from Project is readily noticeable; PPL levels comply with ANZECC maximum guideline value of 120 dBL **high**: effect from Project is disturbing; PPL levels exceed ANZECC maximum guideline value of 120 dBL	**local**: effect restricted to the study area **regional**: effect extends beyond the study area **beyond regional**: effect extends more than 50 km from the Project	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.

b) Magnitude: degree of change to analysis endpoint.

c) Geographic Extent: area affected by the impact.

d) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period and a 16-year operations period.

the Project = the Sabajo Project; ANZECC = Australia and New Zealand Environmental Conservation Council; IFC = International Finance Corporation; PPV = Peak Particle Velocity; PPL = Peak Pressure Level; dBA = A-weighted decibel; dBL = linear decibels; mm/s = millimeters per second; km = kilometer; < = less than; > = greater than.

5.3.2 Issue Scoping

Based on experience with similar projects, changes in noise and vibration can result in four main categories of impacts that affect people:

- Project-related traffic along Carolina Road and Afobaka Road can increase noise levels at receptors in the vicinity of these roads;
- mining operations can increase noise levels at receptors in the vicinity of the Project pits;
- traffic on the Sabajo-Merian Haul Road between the Project and Merian can increase noise levels at receptors in the vicinity of the haul road; and
- explosive blasting can cause ground vibration and airblast overpressure at receptors in the vicinity of the Project pits.

These four categories of noise and vibration effects to people are addressed in this section. Effects in relation to noise and vibration effects on wildlife are addressed in the biodiversity section (Section 5.8) of this assessment.

In relation to the four categories of noise and vibration effects, a number of comments were received confirming their importance to local residents (Table 5.3-2). All of these issues are addressed in this assessment. No other issues in direct relation to noise and vibration were raised in the engagement for the Project.

Table 5.3-2 Potential Impact Issues for Noise and Vibration

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Potential effect of noise from offsite traffic	-*What will the company do to mitigate impacts such as noise, dust? These will have great impact on the living conditions of all 5 communities.* – Meeting with Carolina Road Amerindian communities, 5/4/17 -*Will the now existing (baseline) noise increase?* – Meeting at Pierre Kondre Kumbasi, 6/22/17
2	Potential effect of noise from Project mining	-*The wind from Sabajo is also blowing in the direction of the village, what will the effects be, i.e., noise?* – Meeting at Boslanti, 4/26/17
3	Potential effect of noise from Sabajo-Merian Haul Road	-*Will the now existing (baseline) noise increase?* – Meeting at Pierre Kondre Kumbasi, 6/22/17 -*Is there a certain allowable volume for this area (interior)?* – Meeting at Pierre Kondre Kumbasi, 6/22/17
4	Potential effect of ground vibration and airblast overpressure from explosive blasting	-*Will Newmont be using dynamite? Because they have felt the effect of the dynamite used (in the past) at the Cassador pit.* – Meeting at Boslanti, 5/24/17 -*If Newmont will be doing explosions with dynamite, will we be feeling this?* – Meeting at Casipora, 6/22/17

5.3.3 Linkage Analysis

Project-related traffic will increase noise levels in the vicinity of Carolina Road and Afobaka Road. Project activities will increase noise levels in the vicinity of the Project pits and in the vicinity of the Sabajo-Merian Haul Road. Explosive blasting will cause ground vibration and airblast overpressure in the vicinity of the Project pits.

The linkage for increase in noise levels is valid for the construction, operations, and closure phases, since Project activities will emit noise in all three phases. However, Project activities are expected to be most intense during the operations phase (e.g., largest mining fleet, highest traffic volume). Consequently, the assessment of Project effect on noise has focused on the operations phase, when the effect is likely to be greatest as the assessment analyzes all of the Sabajo and Merian traffic using the public roads as discussed in Section 5.3.6. Project effect on noise during other phases is likely to be smaller than the effect during operations.

The linkage for ground vibration and airblast overpressure is valid for the operations phase but not the construction or closure phases, since explosive blasting will only occur during the operations phase. Consequently, the assessment of Project effect on vibration has focused on the operations phase.

5.3.4 Key Indicators

Key indicators to be used to assess effects on each key issue to be included in this assessment as per the issues list and linkage analysis above have been identified in Table 5.3-3.

Table 5.3-3 Potential Sabajo Project Indicators for Noise and Vibration

Issue Number	Key Issue	ESIA Indicators
1	Potential effect of noise from offsite traffic	$L_{eq,1hr}$ expressed in dBA
2	Potential effect of noise from Project mining	$L_{eq,1hr}$ expressed in dBA
3	Potential effect of noise from Sabajo-Merian Haul Road	$L_{eq,1hr}$ expressed in dBA
4	Potential effect of ground vibration and airblast overpressure from explosive blasting	Ground vibration PPV expressed in mm/s Airblast overpressure PPL expressed in dBL

ESIA = Environmental and Social Impact Assessment; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; dBL = linear decibels; PPV = Peak Particle Velocity; PPL = Peak Pressure Level; mm/s = millimeters per second.

5.3.5 Spatial and Temporal Considerations

Section 5.1 has presented the time frames for three major Project phases that will be affected: construction, operations, and closure phases. As discussed above, the noise assessment has focused on the Project operations phase since this is the phase with maximum potential noise effect. As discussed above, the vibration assessment has focused on the Project operations phase since this is the only phase with a valid linkage for vibration.

The study area for the noise and vibration assessment is shown in Map 5.1-1. The noise and vibration study area was established by combining:

- a 15 kilometer (km) buffer surrounding the Project mine footprint;
- a 1 km buffer surrounding the Sabajo-Merian Haul Road;
- a 50 meter (m) buffer surrounding Carolina Road; and
- a 50 m buffer surrounding Afobaka Road.

5.3.6 Project Case Impact Assessment

5.3.6.1 Effects Analysis – Noise

5.3.6.1.1 Background

Table 5.3-4 presents a summary of offsite transport traffic during the Project operations phase. The traffic data presented in Table 5.3-4 served as inputs to the computer noise models of Carolina Road and Afobaka Road. These are conservative numbers, as actual traffic predictions are lower (e.g., refer to traffic assessment, Section 5.10). The traffic data presented in Table 5.3-4 were also considered (in combination with the ore transport trucks identified in Table 5.3-5) when modelling noise from the Sabajo-Merian Haul Road, to account for the fact that both Sabajo and Merian transport vehicle traffic may make use of this road. All offsite transport traffic was modelled during the IFC-defined daytime period (07:00 to 22:00). In other words, it was assumed that there will be no offsite transport traffic during the IFC-defined nighttime period (22:00 to 07:00). Traffic during this period will be very minimal in practice. The Sabajo-Merian Haul Road is planned to be a 24 hour operation and was modeled as such.

Table 5.3-4 Sabajo Project and Merian Mine Offsite Transport Traffic on Public Roads and Sabajo-Merian Haul Road (Operations Phase)

Vehicle Type	Daily Maximum Offsite Transport Traffic[(a)]		
	Sabajo	Merian	Project Total
light vehicles	6	24	30
buses	4	16	20
heavy trucks	20	80	100

a) Conservative (high) traffic estimates used in this table; these numbers are all higher than actual project estimates in the Sabajo Project Description (Section 2) and in the Traffic Assessment (Section 5.10).

Table 5.3-5 presents a list of Project mining equipment considered in the noise assessment for the area of the pits. Table 5.3-5 identifies equipment quantity (i.e., the number of pieces of equipment that will be present on-site), equipment usage factor (i.e., the percentage of time that a given piece of equipment will be active), equipment operating location, and equipment noise emissions in the form of dBA sound power levels. Noise emissions for each piece of mining equipment were estimated using a combination of vendor data sheets, field measurements of similar equipment, empirical formulae, and professional judgment. Where appropriate, the noise emissions presented in Table 5.3-5 include the contribution from a tonal back-up alarm, which has been penalized in accordance with an ISO technical standard (ISO 2003) to account for the increased perceptual prominence associated with this type of noise.

The noise emissions presented in Table 5.3-5 served as inputs to the computer noise models of mine operations and haul road traffic. All sources listed in Table 5.3-5 were assumed to operate 24 hours per day. The Project will consist of eight separate pits. It is understood that mining in these pits will occur sequentially. However, the Project noise assessment conservatively assumes simultaneous mining in all eight pits. In other words, the noise assessment modelled noise levels resulting from the full Project mine fleet operating in each pit simultaneously.

Table 5.3-5 Sabajo Project Mining Equipment

Equipment	Quantity	Usage Factor [%]	Operating Location	Sound Power Level Per Unit [dBA]
genset – CAT 1360 ekW / 1700 kVA	1	100	surface facilities	129.4
rotary drill - AC DML	4	58	pit	117.8
mine truck - CAT 785D	10	68	pit	116.3
track dozer - CAT D9T	3	58	pit	115.2
front-end loader - CAT 980H	1	66	pit	114.4
front-end loader - CAT992	1	41	pit	114.2
motor grader - CAT 16M	3	54	pit	113.5
wheel dozer - CAT 834H	1	58	pit	113.1
fuel/lube truck - CAT 740B	2	54	pit	112.0
water truck - CAT 740B	2	54	pit and Sabajo-Merian Haul Road	112.0
track dozer - CAT D6	1	58	pit	111.8
excavator - CAT 349D	1	54	pit	111.8
compactor - CS533E	1	54	pit	111.5
hydraulic excavator - EX3600	2	60	pit	110.4
ore transport truck – SmithCo 150t	7	41	Sabajo-Merian Haul Road	110.2
emulsion truck	3	54	pit	108.4

dBA = A-weighted decibels;% = percent.

Table 5.3-6 summarizes environmental and other physical parameters that were used to model Project noise. The environmental and physical parameters used in the Project noise models are generally consistent with parameters used in the noise assessment conducted for the Merian ESIA (Surgold 2013).

Table 5.3-6 Environmental and Physical Parameters Used in Noise Modelling

Parameter	Model Setting
source type	area sources – mine pits and surface facilities line sources – Sabajo-Merian Haul Road, Carolina Road, and Afobaka Road
ground absorption	0.2 – within the Project footprint 0.9 – elsewhere in the study area
temperature	20 °C
relative humidity	80%
wind conditions	1 m/s to 5 m/s blowing from source to receptor
receptor height	1.5 m (to match the height at which human exposure to noise typically occurs)
terrain	ground elevation contours at 5 m intervals

°C = degrees Celsius; m/s = meters per second; m = meter;% = percent.

The IFC guideline indicates that noise should be assessed at discrete receptors, which are defined as *"…any point on the premises occupied by persons where extraneous noise and/or vibration are received…[including] permanent or seasonal residences, hotels/motels, schools and daycares, hospitals and nursing homes, places of worship, and parks and campgrounds"* (IFC 2007). In residential areas, the IFC guideline indicates that $L_{eq,1hr}$ noise levels should not exceed 55 dBA during the daytime or 45 dBA during the nighttime, or should not increase noise levels by more than 3 dBA compared to baseline (IFC 2007). In industrial areas, the IFC guideline indicates that $L_{eq,1hr}$ noise levels should not exceed 70 dBA during the daytime or nighttime, or should not increase noise levels by more than 3 dBA compared to baseline (IFC 2007).

5.3.6.1.2 Access Roads Impact Assessment

There are too many receptors along Carolina Road and Afobaka Road to feasibly model them all. Instead, noise levels from Carolina Road and Afobaka Road were predicted and assessed at various distance from these roads, including at the edge of the study area (i.e., 50 m from the roads).

Table 5.3-7 presents the predicted noise levels at various distances from Carolina Road and Table 5.3-8 presents similar data for Afobaka Road. Table 5.3-7 and Table 5.3-8 present noise levels for the Project in isolation and total noise levels obtained by summing the Project contribution with representative baseline levels as per the baseline presented in Section 4.9. Table 5.3-7 and Table 5.3-8 only present noise levels for the daytime period (07:00 to 22:00), since Project traffic will almost exclusively use the transportation access roads during the daytime period. Map 5.3-1 presents contours representing total noise levels (i.e., Project and baseline) at representative locations along Carolina Road and Afobaka Road.

Table 5.3-7 Carolina Road Noise Level Predictions

Distance from Road [m]	Sabajo Traffic Noise Level Prediction [$L_{eq,1hr}$, dBA]	Merian Traffic Noise Level Prediction [$L_{eq,1hr}$, dBA]	Project Total Noise Level Prediction [$L_{eq,1hr}$, dBA]	Representative Baseline Noise Level [$L_{eq,1hr}$, dBA]	Total Noise Level Prediction (Project + Baseline) [$L_{eq,1hr}$, dBA]	Change in Baseline Noise Levels due to Project [$L_{eq,1hr}$, dBA]
	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]
15	52.0	57.1	58.3	63.9	65.0	1.1
50 (edge of the study area)	45.4	50.5	51.7	56.9	58.0	1.1
100	39.4	44.4	45.6	50.7	51.9	1.2
200	33.1	38.0	39.2	44.1	45.3	1.2
300	29.0	34.0	35.2	39.9	41.2	1.3

Project = Sabajo Project; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter.

Table 5.3-8 Afobaka Road Noise Level Predictions

Distance from Road [m]	Sabajo Traffic Noise Level Prediction [$L_{eq,1hr}$, dBA]	Merian Traffic Noise Level Prediction [$L_{eq,1hr}$, dBA]	Project Total Noise Level Prediction [$L_{eq,1hr}$, dBA]	Representative Baseline Noise Level [$L_{eq,1hr}$, dBA]	Total Noise Level Prediction [$L_{eq,1hr}$, dBA]	Change in Baseline Noise Levels due to Project [$L_{eq,1hr}$, dBA]
	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]	Daytime [07:00 to 22:00]
15	52.0	57.1	58.3	64.8	65.7	0.9
50 (edge of the study area)	45.4	50.5	51.7	57.5	58.5	1.0
100	39.4	44.4	45.6	50.2	51.5	1.3
200	33.1	38.0	39.2	43.6	44.9	1.3
300	29.0	34.0	35.2	40.1	41.3	1.2

Project = Sabajo Project; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter.

Project noise levels are predicted to fall below the applicable IFC guideline for all modeled cases (no increase of greater than 3 dBA from project sources) for both the Carolina Road and Afobaka Road.

5.3.6.1.3 Mine Site and Haul Road Impact Assessment

Based on the IFC definition, there are no discrete human receptors located in the vicinity of the Project mine or Sabajo-Merian Haul Road. In the absence of discrete receptors, maximum noise levels from the Project mine were predicted and assessed at the edge of the Project Concession. To generate contour maps, noise levels from the Project mine were also predicted for a grid of receptors. Noise levels from the Sabajo-Merian Haul Road were predicted and assessed at various distances from the road, including at the edge of the study area (i.e., 1 km from the road).

Map 5.3-2 presents a contour map showing noise levels from the Project mine. Table 5.3-9 presents the maximum predicted noise levels along the edge of the Project concession. Table 5.3-9 presents noise levels for the Project in isolation and total noise levels obtained by summing the Project contribution with representative baseline noise levels as per the baseline presented in Section 4.9. As discussed above, the noise predictions presented in Map 5.3-2 and Table 5.3-9 assume simultaneous mining in all eight pits; this assumption is highly conservative and likely to overestimate the Project effect on noise.

Table 5.3-9 Project Mining Noise Level Predictions

Location	Maximum Project Noise Level Prediction [$L_{eq,1hr}$, dBA]		Representative Baseline Noise Level [$L_{eq,1hr}$, dBA]		Maximum Total Noise Level Prediction [$L_{eq,1hr}$, dBA]	
	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]
edge of Project Concession	40.4	40.4	51.4	48.4	51.7	49.0

Project = Sabajo Project; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels.

Table 5.3-10 presents the predicted noise levels at various distances from the Sabajo-Merian Haul Road. Table 5.3-10 presents noise levels for the Project in isolation and total noise levels obtained by summing the Project contribution with representative baseline levels as per the baseline presented in Section 4.9. The noise predictions presented in Table 5.3-10 assume that ore will hauled between the Project and Merian 24 hours per day but that transport traffic will be confined to the daytime period (07:00 to 22:00).

Table 5.3-10 Sabajo-Merian Haul Road Noise Level Predictions

Distance from Haul Road [m]	Project Noise Level Prediction [$L_{eq,1hr}$, dBA]		Representative Baseline Noise Level [$L_{eq,1hr}$, dBA]		Total Noise Level Prediction [$L_{eq,1hr}$, dBA]	
	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]
15	58.8	49.0	49.9	46.9	59.3	51.1
50	52.2	42.8	49.9	46.9	54.2	48.3
100	46.6	39.9	49.9	46.9	51.6	47.7
200	41.2	36.9	49.9	46.9	50.4	47.3
500	34.1	31.2	49.9	46.9	50.0	47.0
1000[(a)]	27.6	22.4	49.9	46.9	49.9	46.9
2000	23.3	15.9	49.9	46.9	49.9	46.9

a) Edge of the study area.

Project = Sabajo Project; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter.

As discussed previously, the IFC guideline is applicable at discrete human receptors and there are no such receptors in the vicinity of the Project mine pits or the Sabajo-Merian Haul Road. Notwithstanding, it is still instructive to compare noise level predictions from the two previous tables to the IFC guideline values.

The Project mining noise levels in Table 5.3-9 are found to be less than the IFC residential andindustrial guideline for both the daytime and the nighttime.

Table 5.3-11 compares predicted total noise levels (i.e., Project and baseline) to the industrial guideline values at various distances from the Sabajo-Merian Haul Road. During the daytime, total noise levels are predicted to be more than 10 dBA below the IFC industrial guideline 15 m from the haul road. During the nighttime, total noise levels are predicted to be more than 18 dBA below the IFC industrial guideline 15 m from the haul road. The predicted change in nighttime noise levels is predicted to fall below 3 dBA at 50 m from the Sabajo-Merian Haul Road.

Table 5.3-11 IFC Guideline vs. Sabajo-Merian Haul Road Noise Levels (Project + Baseline)

Distance from Haul Road [m]	Representative Baseline Noise Level [$L_{eq,1hr}$, dBA]		Total Noise Level Prediction (Project + Baseline) [$L_{eq,1hr}$, dBA]		IFC Industrial Guideline [$L_{eq,1hr}$, dBA]		Change from Baseline (Total minus Baseline)	
	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]	Daytime [07:00 to 22:00]	Nighttime [22:00 to 07:00]
15	49.9	46.9	59.3	51.1	70	70	9.4	4.2
50	49.9	46.9	54.2	48.3	70	70	4.3	1.4
100	49.9	46.9	51.6	47.7	70	70	1.7	0.8
200	49.9	46.9	50.4	47.3	70	70	0.5	0.4
500	49.9	46.9	50.0	47.0	70	70	0.1	0.1
1000 (edge of the study area)	49.9	46.9	49.9	46.9	70	70	0.0	0.0
2000	49.9	46.9	49.9	46.9	70	70	0.0	0.0

Project = Sabajo Project; IFC = International Finance Corporation; L_{eq} = energy equivalent sound level; dBA = A-weighted decibels; m = meter.

5.3.6.2 Effects Analysis – Vibration

As discussed above, there are no discrete receptors located in the vicinity of the Project mine. In the absence of discrete receptors, ground vibration and airblast overpressure levels from Project blasting were predicted at various distance from the blast site.

The ground vibration formula from Section 5.3.1 was used to predict distances at which ground vibration PPV would reach three different threshold values:

- 0.1 mm/s – the threshold of human perception (Bender 2006);
- 5 mm/s – the ANZECC recommended guideline (ANZECC 1990); and
- 10 mm/s – the ANZECC maximum guideline (ANZECC 1990).

The ground vibration modelling was based on a charge mass of 207.1 kg, which is the maximum charge mass expected to be used during any phase of the Project. The ground vibration modelling assumed a value of 1.6 for the site exponent (*e*), which is consistent with the value used in the Merian Project ESIA (Surgold 2013). To account for the different types of material that may be blasted over the life of the Project, ground vibration modelling was conducted for three different site constant (*k*) values: 500 (free face hard / highly structured rock), 1140 (free face average rock), and 5000 (heavily confined rock). These *k* values are consistent with the ground vibration modelling conducted for the Merian Project ESIA (Surgold 2013).

Modelling predicts that ground vibration PPV will decay below the ANZECC maximum guideline of 10.0 mm/s within 700 m of the blast site, will decay below the ANZECC recommended guideline of 5.0 mm/s within about 1 km of the blast site, and may be perceptible (i.e., exceed the 0.1 mm/s threshold of perception) at distances of 10 km or more from the blast site.

To identify the Project blasting scenario with greatest potential impact in terms of airblast overpressure, the formula from Section 5.3.1 was used to model airblast overpressure for several combinations of charge mass and burden depth. In all cases, the blast hole dimeter was modelled as 171.5 mm (i.e., 6.75 inches), since this blast hole diameter will be used for all phases of the Project, and the k_a constant was set to 250, which is the same value used in the Merian Project ESIA (Surgold 2013).

Modelling predicts that the Project blasting scenario consisting of charge mass 74.3 kg and burden depth 4000 mm has the greatest potential impact in terms of airblast overpressure. As such, the assessment of airblast overpressure was conservatively focused on this Project blasting scenario. Using the distance to a PPL of 120 dBL as a starting point and assuming a decay rate of 9 dBL per doubling distance, which is the same decay rate used in the Merian Project ESIA (Surgold 2013), airblast overpressure was predicted for various distances from the blast site. The modelling predicts that airblast overpressure PPL will decay below the ANZECC maximum guideline of 120 dBL within about 1.6 km of the blast site, will decay below the ANZECC recommended guideline of 115 dBL within about 2.3 km of the blast site, and may be perceptible (i.e., exceed the 60 dBL threshold of perception) at distances of 10 km or more from the blast site.

5.3.6.3 Effects Analysis – Mitigation

Mitigation for effects on noise will include:

- offsite Project traffic on Carolina Road and Afobaka Road will only be planned for the IFC-defined daytime period (07:00 to 22:00).

Mitigation for effects on vibration will include:

- confine blasting to the IFC-defined daytime period (07:00 to 22:00), where practical.

5.3.6.4 Classification of Effects

For issue #1 – potential effect of noise from offsite traffic:

- the direction of the effect is classified as negative, since offsite traffic will increase noise levels in the vicinity of Carolina Road and Afobaka Road;
- the magnitude of the effect is classified as:
  - low for Carolina Road, since noise levels are predicted to increase by less than 3 dBA at receptors located 15 m from this road;
  - low for Afobaka Road, since noise levels are predicted to increase by less than 3 dBA at receptors located 15 m from this road;
- the geographic extent of the effect is classified as regional, since the increase in noise levels as a result of Project traffic on Carolina Road and Afobaka Road will extend beyond the study area;
- the duration of the effect is classified as medium-term, since noise levels in the vicinity of Carolina Road and Afobaka Road will increase for up to 16 years but only increase during periods when vehicles pass by; and
- the likelihood of the effect is classified as likely, since offsite Project traffic will make use of Carolina Road or Afobaka Road, but not both roads simultaneously.

For issue #2 – potential effect of noise from Project mining:

- the direction of the effect is classified as negative, since Project mining will increase noise levels;
- the magnitude of the effect is classified as negligible, since noise levels from Project mining are predicted to be within the range of existing conditions and not perceptible at the edge of the Project Concession;
- the geographic extent of the effect is classified as local, since the increase in noise levels as a result of Project mining will be confined to the study area;
- the duration of the effect is classified as medium-term, since Project mining will not increase noise levels beyond the end of the Project; and
- the likelihood of the effect is classified as certain since it is certain that Project mining will increase noise levels in the vicinity of the mine pits.

For issue #3 – potential effect of noise from Sabajo-Merian Haul Road:

- the direction of the effect is classified as negative, since traffic on the Sabajo-Merian Haul Road will increase noise levels;
- the magnitude of the effect is classified as negligible, since noise levels from the Sabajo-Merian Haul Road are predicted to be within the range of existing conditions and not perceptible starting less than 500 m from the haul road;
- the geographic extent of the effect is classified as local, since the increase in noise levels as a result of the Sabajo-Merian Haul Road will be confined to the study area;
- the duration of the effect is classified as short-term, since noise levels in the vicinity of the Project-Merian Haul Road will only increase during periods when vehicles pass by; and

- the likelihood of the effect is classified as certain since it is certain that noise levels in the vicinity of the Sabajo-Merian Haul Road will increase.

For issue #4 – potential effect of ground vibration and airblast overpressure from explosive blasting:

- the direction of the effect is classified as negative, since explosive blasting will create ground vibration and airblast overpressure;
- the magnitude of the effect is classified as:
  - low for ground vibration, since PPV levels are predicted to be less than the ANZECC recommended guideline of 5.0 mm/s within about 1 km of the blast site;
  - low for airblast overpressure, since PPL levels are predicted to be less than the ANZECC recommended guideline of 115 dBLA within about 2.3 km of the blast site;
- the geographic extent of the effect is classified as:
  - local for ground vibration, since PPV levels from Project blasting will be confined to the study area;
  - regional for airblast overpressure, since PPL levels from Project blasting may extend beyond the study area;
- the duration of the effect is classified as short-term, since ground vibration and airblast overpressure will only occur immediately following an explosive blast, and explosive blasting will be infrequent; and
- the likelihood of the effect is classified as certain, since it is certain that explosive blasting will create ground vibration and airblast overpressure.

The magnitude classifications presented above assume that the mitigation measures described in Section 5.3.6.3 will be implemented. If the mitigation measures from Section 5.3.6.3 were not implemented, the magnitude of effects for issue #1 and issue #4 would be greater, as shown in Table 5.3-12.

As discussed in Section 5.3.6.1, the effects assessment presented in Table 5.3-12 is focused on the Project operations phase since effects during other Project phases will be smaller than during operations.

Table 5.3-12 Residual Impact Classification: Project Case

Effect	Effect Classification					Impact Significance		Mitigation or benefit enhancement measure
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-mitigation	Post-Mitigation	
Noise from offsite traffic on Carolina Road (Operation, Construction, Closure)	Negative	Moderate (low)	Regional	Medium-term	Likely, if this option is selected	Medium	Medium	• limit offsite Project traffic to the daytime period (07:00 to 22:00), where practical.
Noise from offsite traffic on Afobaka Road (Operation, Construction, Closure)	Negative	Moderate (low)	Regional	Medium-term	Likely, if this option is selected	Medium	Medium	• limit offsite Project traffic to the daytime period (07:00 to 22:00), where practical.
Noise from Project Mining (Operation, Construction)	Negative	Negligible	Local	Medium-term	Certain	Low	Low	-
Noise from Sabajo-Merian Haul Road (Operation, Construction)	Negative	Negligible	Local	Medium-term	Certain	Low	Low	-
Ground vibration from explosive blasting (Operation)	Negative	Moderate (low)	Local	Short-term	Certain	Medium	Low	• limit blasting to the daytime period (07:00 to 22:00), where practical.
Airblast overpressure from explosive blasting (Operation)	Negative	Moderate (low)	Regional	Short-term	Certain	High	Medium	• limit blasting to the daytime period (07:00 to 22:00), where practical.

the Project = the Sabajo Project; IFC = International Finance Corporation; - = no mitigation or benefit enhancement measure.

5.3.7 Cumulative Effects Case Impact Assessment

The following activities may contribute to cumulative effects on noise and vibration:

- the Merian mine;
- the Saramacca mine;
- the Rosebel mine;
- artisanal and small scale mining;
- forestry; and
- transport of trees on the access road.

All of these activities, other than the proposed Saramacca Mine, were underway at the time of the field program to measure baseline noise levels Consequently, potential noise effects from most of these activities were captured in the baseline noise measurements. The Saramacca Mine would represent a continuation of effects due to the Rosebel Mine, so is not considered to have an additive effect to traffic and road noise. Because the assessment of Project noise effects presented above considers Project noise levels in the context of the measured baseline, a cumulative effects assessment was effectively completed for noise. There are no presently foreseeable future activities that will add substantially to noise levels in the study area.

Project blasting will occur infrequently and the duration of an individual blast will be very short. In addition the distance from Sabajo to Merian and Saramacca or Rosebel Mines are large. As such, it is unlikely that explosive blasting at the Project will temporally overlap explosive blasting at another mine facility (e.g., Merian or Saramacca); and in the unlikely event it does, the combined additive effect will be small and very likely not noticeable. Consequently, a cumulative effects assessment for ground vibration and airblast overpressure from explosive blasting is not warranted.

5.3.8 Additional Baseline Requirements

No additional baseline data collection is proposed for noise and vibration.

5.3.9 Monitoring

Noise monitoring will be conducted along the roadway at Powakka twice per year during the dry season. The noise monitoring should be conducted in general accordance with IFC guidance (IFC 2007). Vibration monitoring is not anticipated to be required.

5.4 Soil and Geomorphology

5.4.1 Soil and Geomorphology Discipline Methods

The purpose of this section is to evaluate the Sabajo Project (the Project) impacts on geomorphology, terrain and soil resources within the Project Disturbance Footprint, where ground disturbance is expected as a result of Project activities. Mine pits, dump areas, ore stockpile areas, campsite and facility areas as well as the Sabajo-Merian Haul Road could all be subject to disturbance, and together form the Disturbance Footprint.

The potential impacts to geomorphology, terrain and soils are summarized as follows:

- Changes to geomorphological and terrain conditions – This includes the potential for increased incidence of landslides, changes in drainage patterns, and shifts in topographic variation. For example, a complex landscape with slopes varying between zero percent (%) and 30% could be replaced by a simpler landscape with a diminished range of slope values.
- Soil quantity and quality changes resulting from Project activities - This includes potential effects during construction and operations phases, as well as during reclamation and post-reclamation phases. For example, some soil may be replaced (lost) by permanent facilities, lakes, etc.

To assess the effects of the Project on geomorphology, terrain and soil resources, both quantitative and qualitative assessment methods are used. Quantitative methods will be used whenever possible, but due to uncertainty surrounding conditions following closure and reclamation activities, some qualitative measures will be utilized where appropriate.

Impact criteria for assessment of traffic effects are presented in Table 5.4-1.

Table 5.4-1 Impact Description Criteria for Geomorphology, Terrain and Soil

Direction	Magnitude	Geographic Extent	Duration[a]
positive: Improvement in Land Suitability Rating resulting from the Project. by one or more classes. **negative:** Degradation in Land Suitability Rating resulting from the Project. by one or more classes. **neutral:** No change in Land Suitability Rating resulting from the Project.	**negligible**: Project activities do not result in any change to overall Land Suitability Ratings. **low**: Project activities result in a one class change to overall Land Suitability Ratings. **moderate**: Project activities result in a two class change to overall Land Suitability Ratings. **high**: Project activities result in greater than a two class change to overall Land Suitability Ratings.	**local**: effect restricted to the Disturbance Footprint **regional**: effect extends beyond the Disturbance Footprint **beyond regional**: effect extends more than 50 km from the Disturbance Footprint	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period and a 10-year operations period and a 4 year closure period.

the Project = the Sabajo Project; km = kilometer; < = less than; > = greater than.

5.4.2 Issue Scoping

Based on experience with similar projects, changes in geomorphology, terrain and soil can result in three main categories of impacts:

- Project activities can change the overall Land Suitability for the Disturbance Footprint resulting from a change in geomorphology or terrain conditions (e.g., Project results, changes in topography, drainage conditions, increased erosion of soil materials, etc.).
- Project activities can change the overall Land Suitability for the Disturbance Footprint resulting from a change in soil quantity (e.g., a conversion from forest land to pit lake); and

- Project activities can change the overall Land Suitability for the Disturbance Footprint resulting from a change in soil quality (e.g., Project activities result in a loss of soil organic matter).

Although the Project has the potential to affect geomorphology, terrain and soil resources through changes in terrain conditions, soil quantity and/or soil quality, these changes are reflected in the inherent ability of land to support native vegetation in some form. The ability of a landscape to support vegetation is typically measured through a Land Suitability Rating system. In this case, a system developed by the Food and Agricultural Organization (FAO; 1977) and modified for use in Suriname (Melitz 1978; Melitz and Alderlieste 1978) was used.

Land Suitability Rating systems can capture changes to soil quantity and quality, and changes in terrain conditions that may limit (or promote) vegetation success.

In the case of soil quantity, this would include such factors as:

- soil erosion;
- loss of productive land to roads or other facilities; and
- loss of soil volume due to soil handling practices.

For soil quality, this would include changes in fertility due to:

- loss of soil organic materials during removal, handling or storage;
- rutting or compaction either during handling or in situ;
- loss of tilth (the physical condition of soil in relation to its suitability for crop growth) due to soil handling practices; and
- soil contamination due to spills, etc.

Finally, in terms of changes to terrain conditions, it could include:

- changes in average slope conditions leading to difficulty in using machinery to work the land, or in changes to baseline erosion levels; and
- changes in landslide frequency or severity leading to more or less land area being affected by landslides.

No issues in direct relation to geomorphology, terrain and soil were raised during the engagement process with the public for the Project however, National Institute of Environment and Development in Suriname (Nationaal Instituut voor Milieu en Ontwikkeling; NIMOS) has identified soil, in general, as an issue of importance (Table 5.4-2).

Table 5.4-2 Potential Impact Issues for Geomorphology, Terrain and Soil

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Change in soil quantity.	No public comments; NIMOS indicated soil as an issue of importance in Project introductory meetings, early 2017.
2	Change in soil quality.	
3	Change in geomorphology or terrain conditions.	

NIMOS = National Institute of Environment and Development in Suriname.

5.4.3 Linkage Analysis

As the topography and soil materials of the Disturbance Footprint will be disturbed during the construction, operations and reclamation phases of the Project, there is the potential to affect soil quantity and quality, and geomorphology or terrain conditions as a result of Project activities during each of these phases. In addition, there is the possibility that effects from Project activities could persist post-closure. There is a potential linkage between the Project activities and effects to soil and terrain resources at all phases of the Project. For example, if a road were not decommissioned, that land area would shift from a somewhat productive state to a non-productive state. This linkage is considered valid within the Disturbance Footprint (shown in Map 5.1-4), but the buffer areas surrounding pits, included in the Project Physical Impact Area, are not included. These areas have the potential to be disturbed by fly rock, but are unlikely to incur direct soil disturbance at any given location. These are included in the overall Project footprint shown on most maps (e.g., the Project area in Map 5.1-2).

5.4.4 Key Indicators

Key indicators to be used to assess the effects on each key issue as per the issues list and linkage analysis above are identified in Table 5.4-3.

Table 5.4-3 Potential Project Indicators for Geomorphology, Terrain and Soil

Issue Number	Key Issue	ESIA Indicators
1	Change in soil quantity.	Land Suitability.
2	Change in soil quality.	Land Suitability.
3	Change in geomorphology or terrain conditions.	Land Suitability.

ESIA = Environmental and Social Impact Assessment.

In more rugged terrain, one of the key indicators for changes in geomorphology and terrain conditions is a change in landslide frequency. In areas where there are on-going issues with landsliding, detailed mapping would indicate areas of either active landsliding or areas of potentially unstable terrain where landslides could be initiated should the ground be disturbed. Given the relatively subdued nature of the terrain coupled with no detailed mapping of the terrain, the indicator landslide frequency has not been included within this study.

5.4.5 Spatial and Temporal Considerations

Section 5.1 presented the time frames for three major Project phases that will be affected: construction, operations, and closure (reclamation and post-reclamation) phases. Any time period where soils are likely to be disturbed or reclaimed would be considered as having potential effects on geomorphology, terrain and soil resulting from the Project. In the construction phase, the Sabajo-Merian Haul Road and other infrastructure areas will be cleared and graded. The operations phase is the time period when all Project areas will ultimately be disturbed, but if progressive reclamation is employed, not all areas will be disturbed at the same moment in time.

The study area for geomorphology, terrain and soil is defined by the Disturbance Footprint (Map 5.1-4.). This area was chosen as it contains all lands that are likely to be disturbed during some phase of the Project.

5.4.6 Project Case Impact Assessment

Land Suitability Ratings for annual crops, perennial crops and cattle production (pasture) are presented below for the Disturbance Footprint (by area) and Sabajo-Merian Haul Road also by linear distance in Table 5.4-4.

Table 5.4-4 Land Suitability Ratings for Annual Crops, Perennial Crops and Cattle Production for the Disturbance Footprint[a]

Land Use Class	Annual Cropping		Perennial Cropping		Cattle Production (pasture)	
Land Suitability Rating	**ha**	**%**	**ha**	**%**	**ha**	**%**
Moderately Suitable	-	-	-	-	144.2	16.3
Moderately - Marginally Suitable	-	-	111.3	12.6	349.5	39.5
Moderately - Not Suitable	-	-	-	-	325.5	36.8
Marginally Suitable	111.3	12.6	382.4	43.2	-	-
Marginally - Not Suitable	32.9	3.7	325.5	36.8	-	-
Not Suitable	740.9	83.7	65.9	7.4	65.9	7.4
No Data[b]	0.4	<0.1	0.4	<0.1	0.4	<0.1
Grand Total	885.5	100.0	885.5	100.0	885.5	100.0

a) This table is not presented in the baseline. It is a compilation of the data from Tables 4.4-2 and 4.4-3 of the baseline section (Section 4.4).

b) <0.1% of the Disturbance Footprint so not rated.

< = less than; ha = hectare;% = percent; - = not applicable.

Note that for annual and perennial crop production almost the entire area of the Disturbance Footprint, including the length of the Sabajo-Merian Haul Road, has either not suitable or marginally suitable Land Suitable Ratings. This assessment will therefore only assess effects with respect to the ability of land to support cattle production since this land use has highest percentage of moderately (16.3%) or marginally suitable (39%). It is important to note that there is no cattle production in the area currently.

5.4.6.1 Impact Assessment

The key aspects being assessed include those factors that could affect land suitability; these are changes in soil quality, soil quantity and geomorphology or terrain. An effects matrix is applied to each key aspect for each major pre-mitigation phase of the Project (Table 5.4-4); post-mitigation residual effects are then discussed assuming that the planned mitigations are effectively applied (Table 5.4-5). Refer to Table 5.4-1 for definitions of the classes used for direction, magnitude, geographic extent and duration.

Pre-mitigation Effects

Pre-mitigation phases include the construction, operations and closure phases.

Pre-mitigation Effects (Construction)

For the purposes of this assessment, it will be assumed that the construction phase includes construction of the Sabajo-Merian Haul Road and any facilities required prior to the operations phase (camps, processing facilities, etc.). Maximum build-out will be assumed for the operations and closure phases; thus, it is assumed that the entire Disturbance Footprint is affected by the Project.

The effect of the Project on soil quantity and quality during the construction phase can be summarized as local, short-term, negative in direction, moderate in magnitude and certain (Table 5.4-5). These ratings were chosen because:

- Effects are considered local as they are confined to areas directly disturbed by Project activities;
- Effects are deemed short-term because they are only assessed during the construction phase;
- Effects are considered negative in direction because soil will no longer be available for cattle production while disturbed;
- Magnitude is rated as moderate because soil will be taken out of production (disturbed) as a result of Project activities, but because at best the disturbed portions of the Project area are marginally productive for cattle grazing, they can only be reduced by a maximum of two Land Suitability classes; and
- Likelihood is deemed certain because soils are certain to be disturbed during Project activities and will be unavailable as cattle grazing land.

During the construction phase it is estimated that somewhere between 25% and 50% of the soils within the Disturbance Footprint will be disturbed. Building roads and other facilities shifts soil Landscape Suitability ratings for cattle grazing, that originally ranged between moderately- to non-productive, to entirely non-productive during this phase of the Project. The resulting pre-mitigation impact significance rating is deemed medium since it is estimated less than half the Disturbance Footprint will be affected at this time.

The Project effects to geomorphology or terrain conditions during construction are expected to be local, short-term, negative in direction and moderate in magnitude. This effect is considered unlikely to affect soil capability however (Table 5.4-5). The terrain effects matrix values differ from those of the soil quantity and quality values in likelihood because it is unlikely that the primary Project activities in this phase would affect the overall geomorphology or terrain conditions within the Disturbance Footprint. The pre-mitigation impact significance is rated as low since it is estimated that less than half the Disturbance Footprint will be affected and the likelihood of effects is low for geomorphology or terrain resources.

Pre-mitigation Effects (Operations and Closure)

During the operations and closure phases, the primary activities are opening pits, undertaking ore extraction, and depositing waste rock. It is assumed that soils within the entire Disturbance Footprint are disturbed during these phases. Although some progressive reclamation is planned, the extent and locations are unknown at this time, so it is reasonable to assume maximum build-out for the entire duration of these phases.

The effect of the Project on soil quantity and quality during the operations and closure stages can be summarized as local, medium-term, negative in direction and moderate in magnitude; the effect is certain (Table 5.4-5). These values are the same as those assessed for the construction phase with the exception of duration; duration was assessed as medium-term to reflect the length of these phases of the Project. For those ratings that did not change, the justifications are the same as those previously explained. Although the soil Landscape Suitability ratings within the Disturbance Footprint are expected to experience a shift from moderately- to non-productive, to entirely non-productive during these phases of the Project, the entire Disturbance Footprint will be affected. This results in a High rating for pre-mitigation impact significance because of the extent of land affected.

The Project effects to geomorphology or terrain conditions during operations and closure are expected to be local, medium-term, negative in direction and moderate in magnitude with an unlikely, moderate consequence (Table 5.4-5). Duration is the only change from the construction phase and this is the result of the length of time affected lands will be taken out of production. The terrain related ratings differ from soil quantity and quality in likelihood because it is unlikely that there would be effects to geomorphology or terrain conditions within the Disturbance Footprint. Although some localized areas will likely have highly modified topography (e.g., pits), much of the Disturbance Footprint topography is likely to be relatively unaffected as far as function is concerned. For example, surface runoff and flow would be controlled through channelization or contouring to blend in with surroundings and little or no change in Land Suitability for cattle grazing would be expected.

Post-mitigation Effects

The post-mitigation phase is a post-closure snapshot when all reclamation activities are complete. Table 5.4-5 lists the predicted pre- and post-mitigation impacts and itemizes the planned mitigations.

The residual impacts post-mitigation on soil quantity and quality are predicted to be negative (soil will either degrade in the ability to support plant growth or be reduced in the amount of land available to support vegetation), but low. Residual effects are predicted to be low overall because if planned mitigation activities are followed, the soil left within the Disturbance Footprint should support plant growth sufficient to graze cattle at a similar capacity as that prior to the Project (similar Land Suitability for cattle grazing). This prediction is supported for the following reasons:

- The planned mitigations are designed to preserve soil quality and quantity;
- Soils were not particularly productive to start with and nutrients (including organic matter) are a limiting factor in this region whether soils are disturbed or not;
- Moisture is not typically a limiting factor for plant growth in this region so intensive management is not generally required to re-establish plant cover;
- Some land (previous artisanal and small scale mining [ASM] areas) will be improved compared to baseline conditions, as part of the overall offsetting plan described in Section 5.8;
- Some land may improve in terms of drainage and/or accessibility as a result of shifting from a more- to a less-complex landscape (e.g., lower slope values); however final closure elevations are unknown at this time so these effects are not quantifiable; and
- Although some land that with potential productivity for grazing will be permanently taken out of grazing production (i.e., converted to roads or other permanent facilities), the overall proportion of the Disturbance Footprint with long term effects will be relatively minor.

Planned mitigations listed in Table 5.4-5 are summarized from the following documents:

- The Sediment and Erosion Control Plan (see Environmental and Social Monitoring and Management Plan [ESMMP], Volume B of this ESIA);
- The Mine Closure and Rehabilitation Plan (MCRP) (see ESMMP, Volume B of this ESIA); and
- The Spill Prevention, Control and Countermeasures Plan (SPCC) (see ESMMP, Volume B of this ESIA).

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Table 5.4-5 Classification of Project Effects and Mitigation

Effect	Effect Classification					Impact Significance		Mitigation or benefit enhancement measure
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation	Post-Mitigation	
Effect of change in soil quantity during construction phase	Negative	Moderate (Low)	Local	Short-term	Certain	Medium	Low	• Implement a Sediment and Erosion Control Plan to limit erosion. Storm water runoff will be managed to reduce erosion and sedimentation. • Implement progressive reclamation as part of the Mine Closure and Rehabilitation Plan. • Salvage topsoil/subsoil/saprolite layers and store without segregation. This admixed material will be used as a growth media during reclamation.
Effect of change in soil quantity during operations and closure phases	Negative	Moderate (Low)	Local	Medium-term	Certain	Medium		
Effect of change in soil quality during construction phase	Negative	Moderate (Low)	Local	Short-term	Certain	Medium	Low	• Implement a Sediment and Erosion Control Plan to limit erosion. • Manage storm water runoff to reduce erosion and sedimentation. • Manage compaction of soils by limiting off-road access. • Implement a Spill Prevention, Control and Countermeasures Plan (SPCC) to minimize the potential for contamination of soils. • Carry out progressive reclamation as part of the Mine Closure and Rehabilitation Plan. • Rip hard-packed soils resulting from Project activities to encourage revegetation. • Revegetate disturbed areas with native species.
Effect of change in soil quality during operations and closure phases	Negative	Moderate (Low)	Local	Medium-term	Certain	Medium		
Effect of change in geomorphology or terrain conditions during construction phase	Negative	Moderate (Low)	Local	Short-term	Unlikely	Negligible	Negligible	• Implement a Sediment and Erosion Control Plan to limit erosion. • Return disturbed and waste rock disposal areas to a landform that approximates and blends in with the surrounding landforms.
Effect of change in geomorphology or terrain conditions during operations and closure phases	Negative	Moderate (Low)	Local	Medium-term	Unlikely	Negligible		

a) Because the land within the Disturbance Footprint is not particularly productive, even for cattle production, the most Land Suitability Ratings can change is by 2 classes, resulting in a magnitude rating of moderate.

Within the Disturbance Footprint, some land is likely to be left as disturbed (e.g., Sabajo-Merian Haul Road and some facilities); however, the extent and exact locations are not known at this time. This conversion from somewhat- to non-productive land is regarded as a soil quantity reduction and it cannot be mitigated. Soil lost to erosion and sedimentation would also be considered as a reduction in soil quantity, however this can be mitigated through the implementation of an effective Sediment and Erosion Control Plan, and MCRP. Erosion and sedimentation can also affect soil quality by stripping away the upper, or active layer where organic matter is typically concentrated. However, native tropical soils tend to be deep and have low levels of organic material (confirmed by field investigations), so that losses through erosion are unlikely to have much of an effect on overall land suitability within the Disturbance Footprint. Rapid revegetation, progressive reclamation, and direct placement, as described or resulting from measures described in the MCRP, would also limit soil quality degradation.

5.4.7 Cumulative Effects Case Impact Assessment

The following are non-Project activities that have the potential to interact with Project activities and contribute to cumulative effects on geomorphology, terrain and soil resources:

- artisanal and small scale mining (ASM); and
- forestry.

These two activities occurred prior to Project initiation. Forestry is likely to continue in the region during all project phases. ASM will not occur on the concession during construction or operations, but could foreseeably be present again after Project closure.

Forest clearing prior to mine development is a necessary step within the Disturbance Footprint, including along the Sabajo-Merian Haul Road. Activities related to tree harvesting will be conducted using mitigative practices developed by Newmont, and no cumulative effects to terrain or soil resources are anticipated.

Given that ASM is limited or eliminated with the Disturbance Footprint, cumulative effects should be either negligible or non-existent, since Project activities will be negligible by the time ASM could potentially resume on a local basis.

5.4.8 Monitoring

A Soil Erosion and Sedimentation Plan that includes a monitoring program will be implemented. This will ensure the effectiveness of mitigation measures put in place to limit erosion and sedimentation is maintained as best as possible. Early identification of erosion or sedimentation issues will limit the negative effects associated with Project activities. In addition, a program to monitor reclamation success will be carried out, as discussed in the closure and reclamation plan (see ESMMP, Volume B of this ESIA).

5.5 Groundwater

5.5.1 Groundwater Discipline Methods

This section evaluates the Sabajo Project (the Project) impacts on groundwater quantity (i.e., lowering of groundwater levels) from mining activities (e.g., mine dewatering). Potential impacts to streamflow and water quality are provided in Sections 5.6 and 5.7, respectively.

The potential impacts to groundwater quantity are related to the dewatering of the pits during mining, and the time to fill the pit after mine closure. Lowering of the water table will potentially reduce the yield of wells and baseflow to surface water streams within the radius-of-influence of the pit; these potential impacts are discussed in Section 5.6. No groundwater users or sensitive habitat areas that rely on groundwater were identified within the Project area. Our assessment of potential impacts included the changes in groundwater levels from pit dewatering and groundwater inflow to the mine during post-closure which may have impacts to surface water flows. Details are provided below:

- Groundwater levels will be lowered within the radius-of-influence of each pit due to pit dewatering activities (pumping of groundwater [and precipitation] from the pit sump to facilitate mining operations). The dewatering will result in a maximum groundwater drawdown at the mine with the drawdown decreasing exponentially with distance from the mine to reach zero drawdown at the radius-of-influence. The distance to the radius-of-influence (location of zero drawdown surrounding the pit) will primarily depend on the permeability and hydraulic behaviour of the geological units exposed by mining, their nature and extent away from the pit, the depth of water in the pit and other hydrogeologic factors including the amount and distribution of recharge. An analytical spreadsheet model was developed to estimate the groundwater inflows to the main Sabajo pit (Pit 1) and the resulting radius-of-influence from mine dewatering.
- Groundwater levels will gradually recover to pre-mining conditions as the pits are filled from precipitation, surface water runoff, and groundwater inflows. A water balance for Pit 1 was prepared to determine the quantities and timing of inflows until the pit lake reaches a post-closure steady-state equilibrium.

The criteria for the groundwater impact assessment are provided in Table 5.5-1.

Table 5.5-1 Impact Description Criteria for Groundwater

Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]
Positive: Increases in groundwater levels **Negative**: Decreases in groundwater levels leading to a reduction in well yields and a reduction in baseflows to streams.	**negligible**: Impacts are very low to immeasurable below of the concession boundary. **low**: Impacts are measureable but low below the concession boundary **moderate to high**: Impacts are substantial below the concession boundary	**local**: effect restricted to the study area **regional**: effect extends beyond the study area	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.
b) Magnitude: degree of change to analysis endpoint.
c) Geographic Extent: area affected by the impact.
d) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period and a 16-year operations period.
< = less than; > = greater than.

5.5.2 Issue Scoping

No issues relevant to groundwater quantity were raised during the public and regulatory engagement process. Furthermore, there are no local groundwater users or sensitive habitat areas that rely on groundwater that would potentially be impacted by lowered groundwater levels associated with mine dewatering and pit filling post closure. The main issue addressed by this assessment is the lowering of the water table, because this effect can in turn, result in a lowering of surface water flows by reducing baseflows, which could potentially affect downstream users.

5.5.3 Linkage Analysis

Mine dewatering will result in lowering of the water table within the radius-of-influence of the pit. This effect has the potential to impact (decrease) the baseflow in streams which traverse the area within the radius-of-influence of Pit 1 (see Section 5.6). Unless mitigated, the effects of reduced baseflow would extend downgradient in the affected streams.

5.5.4 Key Indicators

Model predictions of the radius-of-influence from mine dewatering were used as the primary key indicator to support the assessment for potential impacts related to the reduction in baseflow to streams (Section 5.6).

5.5.5 Spatial and Temporal Considerations

The spatial extent of the groundwater assessment evaluated Pit 1 and the area potentially influenced by lowering of the water table during mine dewatering. Our assessment included two time periods: (1) end of mining (i.e., Year 11), when Pit 1 will be at its deepest, and thus the potential dewatering impact would be at its maximum; and (2) post-closure to evaluate the time for Pit 1 to fill with water, and thus the time for the groundwater system to re-establish equilibrium conditions locally.

Potential impacts from mining at Santa Barbara and Margo were also considered.

No other time periods were evaluated.

5.5.6 Project Case Impact Assessment

The groundwater quantity impact assessment evaluated the radius-of-influence from mine dewatering at Pit 1 during Year 11, when the pit floor elevation will be -260 meters (m) above mean sea level (amsl). Analysis details are provided in a separate technical memorandum titled: *Sabajo Pit 1 – Estimated Steady-State Groundwater Inflow at End of Mining* (Golder 2017a). Mine dewatering is predicted to result in lowered groundwater elevations within a radius-of-influence ranging from 1,700 to 3,300 m from the center of Pit 1 (which would be up to 1,300 to 2,900 m from the crest [perimeter] of the pit). The predicted range in the radius-of-influence based on average permeability conditions is 1,800 to 2,600 m from the center of Pit 1 (i.e., about 1,550 to 2,400 m from the perimeter), as shown in Map 5.5-1.

A post-closure water balance was prepared using a monthly time-step to estimate the time (in years) for Pit 1 to fill with water to its post-mining equilibrium condition. Analysis details are provided in a separate technical memorandum titled: *Sabajo Pit 1 Post-Closure Filling Analysis* (Golder 2017b). The water balance modeling predicts that it will take approximately 28 years for Pit 1 to fill with water to the post-mining equilibrium condition (a water elevation of 30 m amsl). As the pit fills with water, groundwater levels outside the pit (inside the radius-of-influence) will gradually rise to new post-mining equilibrium conditions. As the pit lake level rises, the radius-of-influence will decrease, thereby reducing the baseflow impacts to streams with time. Baseflow in streams that originate within the radius of influence, but distal from the pit, will be impacted to a lesser extent compared to those that originate near the pit. Likewise, distal streams will return to pre-mining baseflow quicker than streams that originate nearer the pit perimeter The post-mining groundwater elevations are expected to be very similar to those measured pre-mining, and thus there will be no permanent groundwater lowering from mine dewatering.

Groundwater impacts from mining at Santa Barbara and Margo will be additive to the impacts from Sabajo. The potential impacts from all three pits are expected to be only slightly greater than the impacts predicted from Pit 1 at Sabajo because of the small size of the Santa Barbara and Margo pits.

The classification of effects, consequences, and likelihood are addressed in Section 5.6.

5.5.7 Cumulative Effects Case Impact Assessment

Cumulative impacts of decreased baseflow are addressed in Section 5.6. No additional cumulative impact assessments are needed to evaluate groundwater quantity.

5.5.8 Additional Baseline Requirements

Additional hydrogeological and geotechnical engineering studies are planned for the Project, including water level monitoring and water quality sampling from existing and proposed wells as the Project develops. Information collected from these planned additional studies will be evaluated and if necessary will be used to update the groundwater impacts assessment for the Project. Baseline hydrogeological studies will be required for the Margo and Santa Barbara areas to evaluate the potential impacts from mining in those locations.

5.5.9 Monitoring

Groundwater level monitoring will occur in existing and planned monitoring wells in the vicinity of the Sabajo pits during pre-construction and operation of the mine to evaluate the effects of mine dewatering on the local groundwater system and on the dewatering/drainage of the pit slopes . Surface water monitoring to evaluate changes in streamflow (including baseflow) from dewatering are discussed in Section 5.6. Groundwater quality monitoring is discussed in Section 5.7.

5.6 Surface Water

5.6.1 Surface Water Discipline Methods

The purpose of this section is to evaluate the Sabajo Project (the Project) impacts on surface water quantity (i.e., streamflows) in streams within and downstream of the Project concession area. Potential impacts to water quality and groundwater are provided in other sections.

The potential impacts to surface water quantity are related to increased surface water runoff during rainfall events and decreased baseflow (groundwater discharge to streams) as a result of pit dewatering activities. Details are provided below.

- Surface water runoff is expected to increase due to site construction and surface mining activities. Removing vegetation from work areas and the creation of waste rock (and saprolite) stockpiles will lead to increased runoff.
- The pit areas will act to mitigate the increase in runoff as rainfall into the pits and groundwater near the pits will be captured as part of pit dewatering activities. The pit water will be discharged so there will be little net loss overall to the environment. Treatment of pit water is a likely mitigation activity for water quality impacts (discussed in the water quality section).
- The hydrologic impact was assessed by using the proposed Project footprint at full build out with Geographic Information System (GIS) to calculate the extent of affected areas, and by developing a simplified monthly water balance to predict the potential change in streamflow during average, wet and dry precipitation years.
  - The water balance calculates water yields on a monthly basis for average, wet and dry precipitation years. The precipitation data were obtained from the Merian Climate Report (Golder 2012a).
  - Runoff yields were predicted using runoff coefficients that were originally developed for the Merian water balance model (Golder 2012b). For forested jungle areas, runoff coefficients varied by month from 0.1 to 0.366. Roads, stockpiles, and other surface facilities were classified as disturbed areas and given a single runoff coefficient of 0.75. Baseline disturbed areas (roads, and artisanal and small scale mining areas) were also considered disturbed areas and given runoff coefficients of 0.75.
  - The areal extent of the site facilities was determined from the current proposed site layout at its maximum extent (i.e., maximum disturbance). Baseline disturbed areas were mapped and delineated manually from recent aerial photographs.
  - Area-weighted runoff coefficients were developed for each impacted watershed and runoff yields were predicted for each month for average, wet and dry years using the monthly precipitation totals. This calculation was made for both the baseline and operational conditions at five locations (Section 5.6.5).
- Baseflows (groundwater contribution to streamflow) are expected to decrease during Project operations, primarily in response to pit dewatering. Pit dewatering will collect groundwater that would otherwise flow to streams. Rainfall that falls directly into the pits will also be captured and may be treated prior to discharge. All water collected from the pits will be discharged back to the hydrologic environment, most likely via discharge to streams, meaning no overall water balance loss on an annual basis. There could be impacts to some streams/locations depending on the location and timing of the discharges to streams. Baseflow impacts at each of the evaluation points were evaluated assuming a “worst-case” scenario: pit water would be discharged to a point outside of or downstream of the evaluation point (i.e., discharge of water back to the environment not included in baseflow impact assessment).

- Baseflow impacts were assessed using an analytical model to predict the maximum zone of influence (capture zone) created from the dewatering of the main pit at Sabajo. The analytical model, described in more detail in the groundwater assessment (Section 5.5), predicts a an average radius of influence of 2,030 meters (m; based on average conditions) for the main pit at Sabajo. This radius of influence extends to cover the five smaller pits at Sabajo. The smaller pits will be shallower than the main pit at Sabajo and will therefore require less dewatering. Pit dewatering from the five smaller pits at Sabajo is not evaluated in this assessment but will be evaluated in more detail during future phases. The pits at Margo and Santa Barbara were also not evaluated for baseflow impacts during this assessment but will be evaluated during subsequent phases of.
- During baseline conditions, baseflows at each evaluation point were assumed to have baseflows (in terms of flow per unit drainage basin area) similar to those measured at Merian because similar baseflows were measured during baseline monitoring at Sabajo (Section 4.7). The baseflows are proportional to watershed area and vary monthly from 0.0023 to 0.0084 cubic meters per second per square kilometer ($m^3/sec/km^2$), as described in the Merian Baseline Hydrology Report (Golder 2012c).
- During operations, baseflows for each evaluation point were calculated using the same method but the extent of the area of influence from the pit dewatering within each evaluation point watershed was removed (i.e., baseflows from that area would report to the pit and not the evaluation point). Therefore, baseflows were predicted to decrease proportionally according to the amount of watershed area up gradient of each evaluation point within the radius of influence of pit dewatering.

- The monthly runoff and baseflows were added together to produce a predicted monthly water yield for both baseline and operational conditions for average, wet and dry year scenarios.
- Small water losses as a result of consumptive use from mine operations and/or water treatment operations are also possible but are considered to be negligible and were not quantified in this assessment.
- For the hydrology impact assessment, the criteria shown in Table 5.6-1 were used to rate project effects.

Table 5.6-1 Impact Description Criteria for Surface Water

Direction[a]	Magnitude[b]	Geographic Extent©	Duration[d]
Positive. Increases in surface water runoff **Negative.** Decreases in surface water runoff, including decreases in baseflow	**negligible**: impacts are very low to unmeasurable below the concession boundary(See below) **low**: impacts are measureable but low below the concession boundary (See below) **moderate to high**: substantial effects beyond concession boundary	**Local:** all effects are within local study area **regional**: effect extends beyond the study area but magnitude of effects decrease downstream (See below)	**Short-term**: less than 2 years **medium-term**: 2 to 16 years. Impacts will be reduced as part of site reclamation activities or will be eliminated soon after end of mine life. **Long-term:** effects substantial beyond 16 years

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.

b) Magnitude: degree of change to analysis endpoint.

c) Geographic Extent: area affected by the impact.

d) Duration: length of time over which the environmental effect occurs.

5.6.2 Issue Scoping

Through the public and regulatory engagement process, no issues relevant to surface water volume were raised. Therefore the issue identified in Table 5.6-2 is based on professional judgment and past experience with similar projects.

Table 5.6-2 Potential Impact Issues for Surface Water

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Potential Effect on stream flows downstream of the Project	N/A

N/A = not applicable.

5.6.3 Linkage Analysis

The Potential Issue presented in Table 5.6-2 is considered to be valid – that is, there may be effects relating to this issue due to the Project, so it is carried forward for assessment.

5.6.4 Key Indicators

Streamflow measurements and model predictions are the primary indicators of Project-related impacts on surface water quantity (Table 5.6-3). For this assessment, several locations were selected to evaluate Project impacts. These evaluation points include three existing monitoring stations down-gradient of Project facilities and two points further downstream. These points are located at the lower-most portions (i.e., lowest elevation) of the primary streams on the west side and east side of the Project Creek 1 and Creek 2), just above their confluence (Map 4.7-1). These lower points are located immediately downstream of the Project concession boundary and therefore show predicted impacts at the Project concession boundary. The locations are described in Section 5.6.5.

Table 5.6-3 Potential Project Indicators for Surface Water Quantity

Issue Number	Key Issue	ESIA Indicators
1	Potential Effect on streamflows downstream of the project	Predicted change in streamflow at evaluation points down-gradient of project facilities.

ESIA = Environmental and Social Impact Assessment.

5.6.5 Spatial and Temporal Considerations

The overall spatial extent for this evaluation was selected to document potential project impacts at varying distances from the project footprint. The furthest downstream locations were selected to evaluate potential effects at a relevant distance from the project for people living in the region. The site is drained by two primary streams, one on the west side of the Project area (Creek 1) and one on the east side of the Project area (Creek 2). The local area hydrology and evaluation points are shown on Map 4.7-1. The Exploitation Concession Boundary crosses these creeks near their confluence (beyond which the two creeks join together and flow to the village of Java, approximately 30 kilometers [km] downstream). Therefore, the termination (i.e., lower-most portion) of each of these streams (just above their confluence) were selected as downstream evaluation points for this assessment. The evaluation was not extended below these points because the results of the analyses (Section 5.6.6.) indicated negligible to surface water quantity down-gradient of these points. Three other points were selected for evaluation that are located within the Exploitation Concession Boundary because these are the furthest downstream surface water monitoring stations:

- CSW-06 is located on the western creek (Creek 1) and is downstream of all of the Sabajo area but upstream the Santa Barbara area;
- CSW-01 is also located on the western creek (Creek 1) and is downstream of all of the Sabajo area and downstream a portion of the Santa Barbara area; and
- CSW-10 is located on the eastern creek (Creek 2) and is downstream of all of the Sabajo area and downstream a portion of the Margo area.

The assessment was evaluated over two time periods: baseline (current conditions prior to Project construction, Year 0) and the proposed full Project buildout at the end of mining operations (year 11). The full Project build-out (i.e., end of mining, Year 11) was selected because the Project impact on surface water quantity is likely maximized at the time.

No additional periods, such as reclamation or closure, were assessed because, as will be shown in Section 5.6.6, the Project impacts on surface water quantity at the end of operations (maximum impact) are negligible at the down-gradient monitoring locations.

5.6.6 Project Case Impact Assessment

The surface water quantity impact assessment has two components: (1) increased runoff related to clearing vegetation in areas as part of operations, and (2) reduced baseflows to streams from pit dewatering. As noted above, the monthly runoff and baseflows were added together to produce a predicted total monthly water yield for both baseline (Year 0) and end of mining (Year 11) conditions for average, wet and dry year scenarios. The percent change in the total monthly water yield from baseline to operational conditions for each evaluation point is shown on Figures 5.6-1 to 5.6-3 and the results are summarized below:

- Overall, there was very little change in water yields between the baseline and operational scenarios, because of the following factors:
  - The total amount of disturbance from the Project is relatively small and much of the area that will be disturbed is in areas that have already been disturbed by small-scale mining. For example, the baseline disturbance areas currently comprise 6 percent (%) to 9% of the total watershed areas for the 5 evaluation points; during operations the percent disturbance increases only slightly, to 8% to 12% of the total watershed areas (17 to 213 km^2). Therefore the overall net increase in runoff is relatively small.
  - The increased runoff is partially offset by both the decrease in predicted baseflows and the presence of the pits because the pits are temporarily storing rain that falls inside the pit area. Furthermore, most of the pit areas fall within previously disturbed areas with high runoff rates.
- For the average precipitation year, the predicted total water yields (runoff plus baseflow) were 830 to 880 millimeters (mm) for baseline (Year 0) and 810 to 870 mm for operations (Year 11). These yields are similar to the baseline water yields at Merian (Golder 2012c).
- For the average precipitation year, the annual change in water yield varied between 1% and 6% (Figure 5.6-1). The biggest change was observed at CSW-06, which has the smallest watershed area and therefore the largest proportional increase in disturbance area. The largest percentage increases occurred during dry months (i.e., largest proportional change), meaning higher average flows during seasonal dry periods but less change during the wet season.. The monthly increase in water yields at CSW-06 vary by 3% (May and June) to 14% (September). The furthest downstream points (western and eastern stream confluences) show much lower predicted change, the annual water yields at these stations are predicted to increase by just 1% (Figure 5.6-1).

- For the wet precipitation year for the operational scenario, the water yields were slightly higher relative to the average precipitation year and ranged from approximately 1,050 mm to 1,110 mm. The total annual water yields are predicted to increase by 1% to 7% during the wet year operational scenario compared to baseline at the five evaluation points (Figure 5.6-2).
- Less change was predicted to occur during dry years due to the lower amounts of runoff. In this scenario, the average water yields were predicted to increase from <1% to 5%. Very small negative change (decreased flow compared to baseline) is predicted to occur during certain months at CSW-10 because of the decreased baseflows from pit dewatering. The pit dewatering predictions indicate that approximately 1,100 hectares (or about 7%) of the watershed area will fall within the dewatering radius of influence at CSW-10, meaning baseflows alone are predicted to decrease by 7% at this station. The total monthly water yields (runoff plus baseflow) are predicted to decrease by no more than 1% in this scenario (Figure 5.6-3).
- As noted above the baseflow impacts were developed from the predicted radius of influence resulting from pit dewatering. A predicted radius of 2,030 m was used for this assessment, which represents the best estimate of the impact to groundwater (See Section 5.5). There is uncertainty in this estimate because the actual hydrogeologic conditions and response to dewatering will not be known until operations begin. A range of predicted values are given in Section 5.5. A larger radius of influence will increase the impacts to baseflow. For example, the maximum predicted radius of influence from Section 5.5 (3,300 m) would extend into the western drainage and reduce baseflows alone at CSW-06 by as much as 50%, and the total annual water yield (average precipitation year) is predicted to decrease by 3% at this station compared to baseline. Smaller decreases (~1%) are predicted for the other evaluation points in this scenario, which is considered unlikely based on the current hydrogeologic conceptual model.
- During mine closure, dewatering activities will stop and the pit will fill as groundwater levels re-equilibrate. Some surface water runoff will also be diverted into the pit. The streamflow impacts during this period are likely to be similar in magnitude as during the operational period of the mine but no mitigation in the form of treated effluent discharges will occur because the effluent treatment plant will no longer be operational.

Engineering controls will serve to mitigate the small impacts to surface quantity. Specifically:

- Sediment control structures down-gradient of the waste rock and saprolite management areas will collect runoff during storm events and act to detain peak flows (i.e., flatten hydrographs) during storm events; and
- Water collected from the pits and dewatering wells will be discharged to streams. Typically, water will be collected and stored temporarily (and potentially treated) before being discharged back into streams down-gradient of a site. The discharge locations have not been determined, but could be targeted to stream reaches that are either most affected by Project operations or to areas where increased flow would be ecologically beneficial.

Project related impacts on surface water quality are summarized in Table 5.6-4.

Figure 5.6-1 Predicted Change in Water Yield for Average Precipitation Year

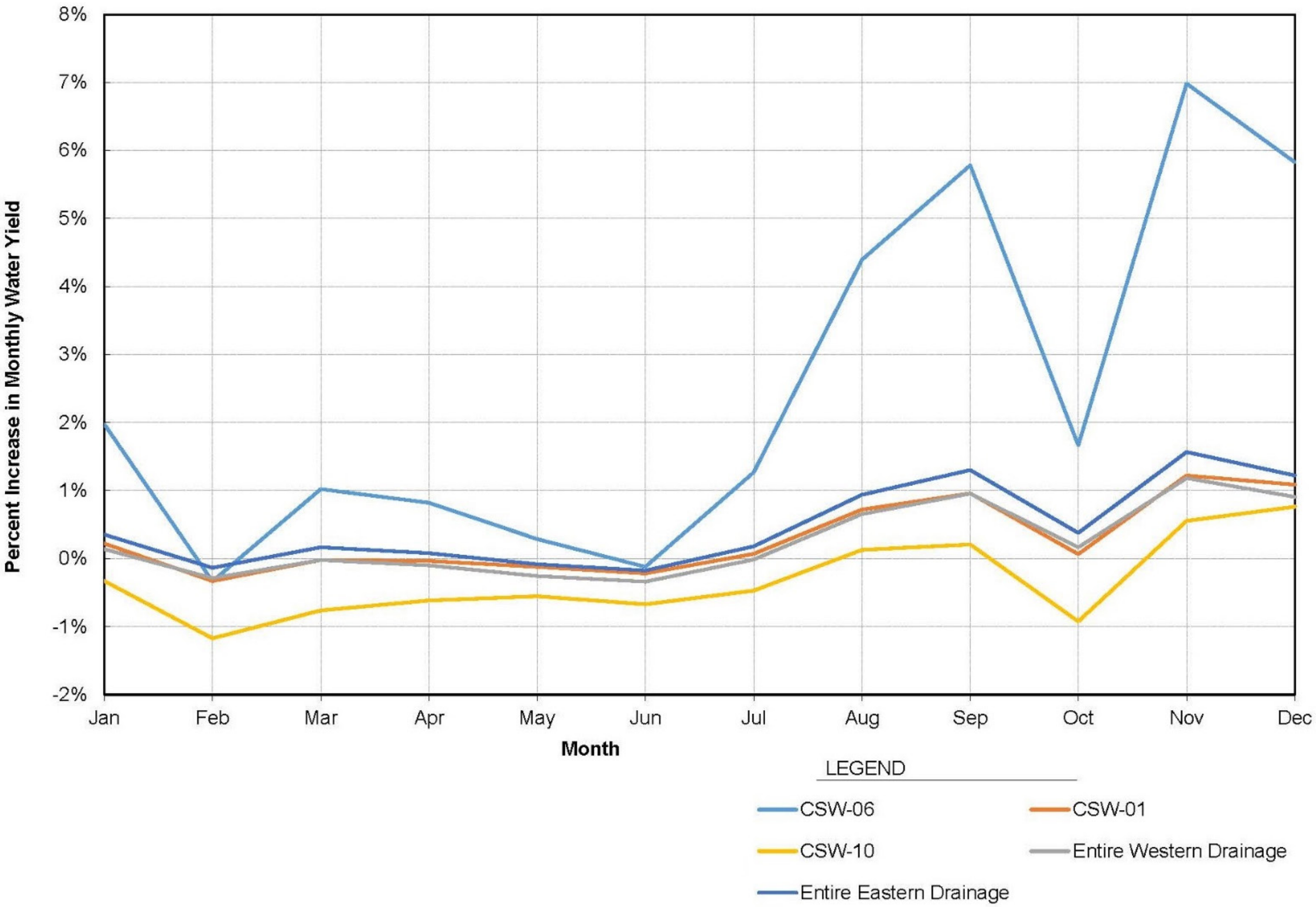


Figure 5.6-2 Predicted Change in Water Yield for Wet Precipitation Year

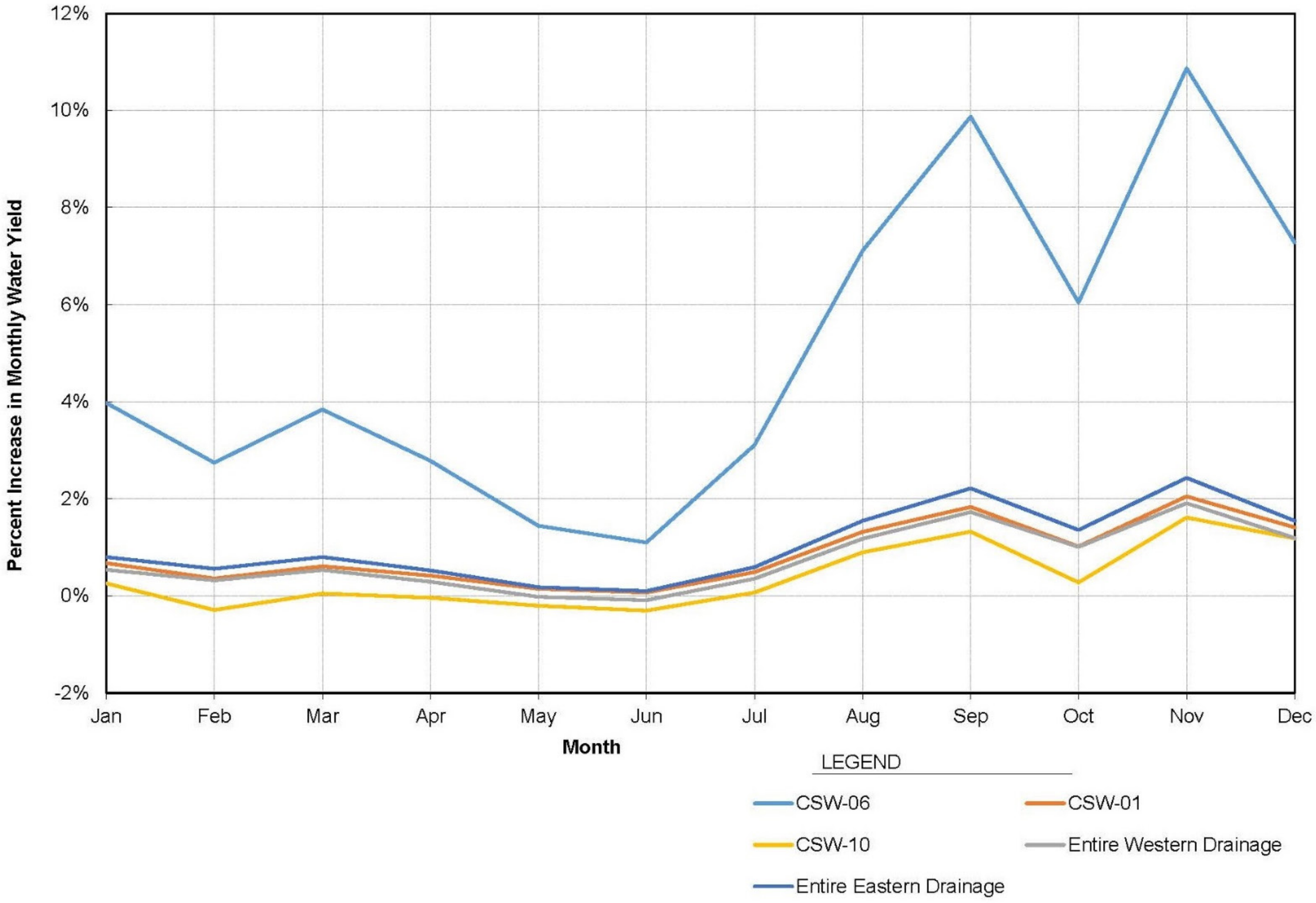


Figure 5.6-3 Predicted Change in Water Yield for Dry Precipitation Year

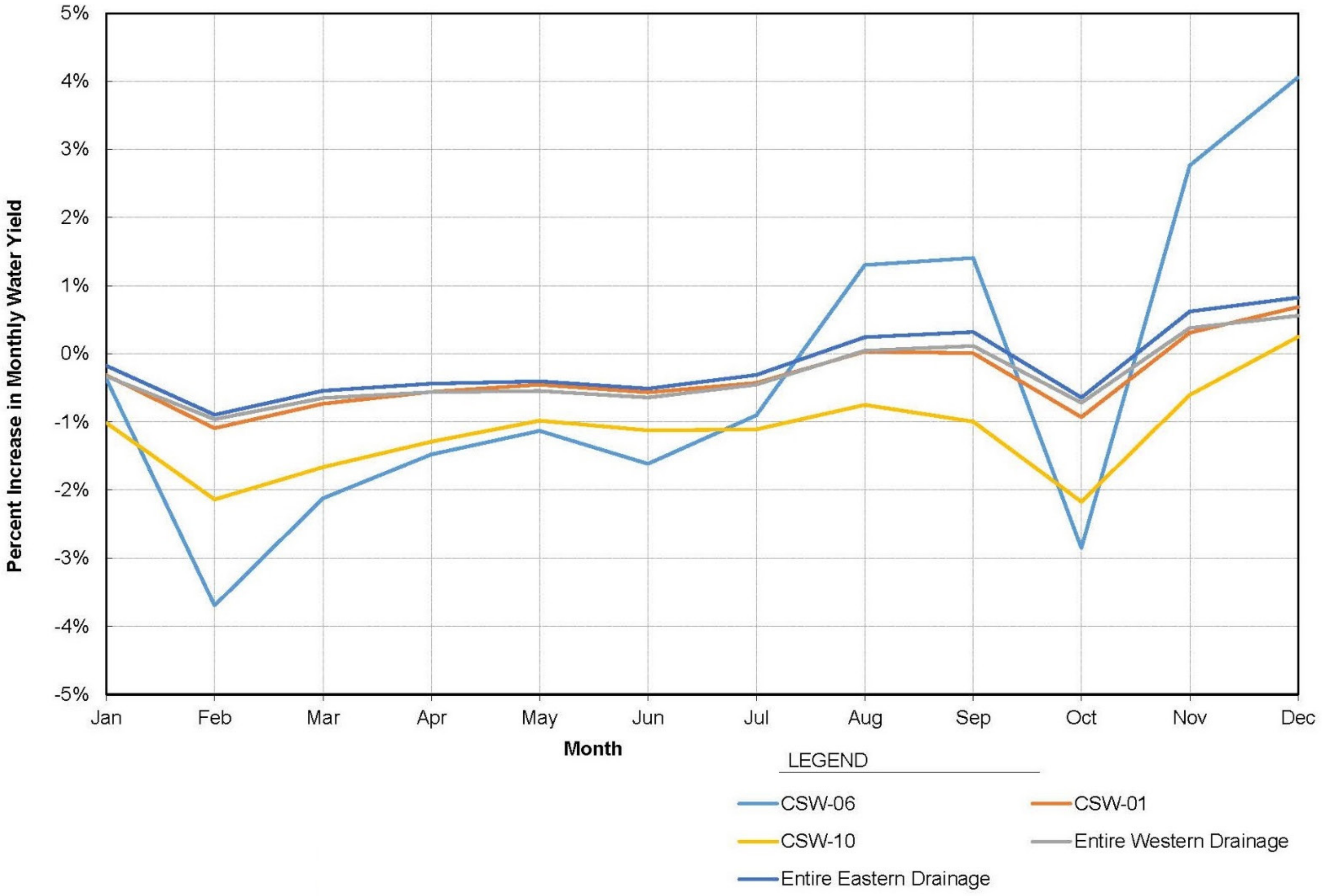


Table 5.6-4 Classification of Effects, Consequence and Likelihood

Effect	Effect Classification					Impact Significance		Mitigation or benefit enhancement measure
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation	Post-Mitigation	
Effect of increased runoff (construction and operation phase; pre mitigation)	Positive	Negligible	Regional	Medium-term	Possible	Negligible Positive	Negligible Positive	-
Effect of decreased baseflows (construction and operation phases)	Negative	Low (negligible)	Regional	Medium-term	Possible	Low	Negligible	• Discharge collected water toward creeks with reduced baseflow.
Effect of decreased baseflows (closure phase)	Negative	Low	Regional	Medium-term	Possible	Low	Low	-

\- = no mitigation or benefit enhancement measure.

5.6.7 Cumulative Effects Case Impact Assessment

The surface water assessment presented above includes the combined, cumulative impact of decreased baseflow and increased runoff. No additional cumulative impact assessments are needed to evaluate surface water quantity alone.

5.6.8 Additional Baseline Requirements

No additional requirements are needed to characterize surface water quantity other than continued surface water monitoring, which may include additional monitoring stations, as described below in Section 5.6.9.

5.6.9 Monitoring

Surface water monitoring should continue at all existing monitoring locations to characterize baseline and operational conditions. The focus of the surface water monitoring program is on water quality (Section 5.7). Currently there is one continuous stream gauge at Sabajo (monitoring station CSW-07). Additional continuous streamflow monitoring stations may be needed to characterize streamflows during operations. Portions of the Margo and Santa Barbara areas are outside of the current monitoring network, and additional surface monitoring stations are needed to characterize water quality, in particular, below these areas as detailed in the Water Quality Assessment (Section 5.7). A monitoring program is set out in more detail in the Environmental Monitoring Plan (see Environmental and Social Monitoring and Management Plan, Volume B of this ESIA).

5.7 Water Quality

5.7.1 Water Quality Discipline Methods

In this section, the potential impacts from the Sabajo Project (the Project) on groundwater and surface quality are evaluated. At full development, the mine will include the following facilities in the Commewijne River watershed (Map 5.1-2):

- **Eight Open Pits**: One primary pit (Cassador Pit) and five smaller pits at the Sabajo deposit, one pit at Santa Barbara and one pit at Margo.
- **Four Waste Rock Facilities (WRFs)**: Two WRFs at Sabajo (North and South) and one WRF each at Santa Barbara and Margo.
- **One Temporary Ore Stockpile**: Ore will be temporarily stored on site prior to transport to the Merian Facility for processing.

Over the life of the Project, the mine will produce approximately 27 million tons of ore and 140 million tons of waste rock. The resource will be developed using open-pit mining as a truck and shovel operation. Blasting will be required for mining of the fresh rock and some of the harder saprolitic material. Blasting, which will begin in year two, will be carried out using a blend consisting of 70 percent (%) emulsion and 30% ammonium nitrate fuel oil (ANFO).

Mining will begin at the Cassador Pit. The North WRF will be established first and will consist primarily of saprolite (Years 1 to 3). The South WRF will be established in the third year of production. The Santa Barbara and Margo WRF facilities will become active in Years 10 and 11, respectively, coincident with the start of mining the Santa Barbara and Margo pits. Waste material will be deposited in approximately 10- to 20-meter (m) benches. The WRFs will be designed to avoid ponding of water on their surface. During operations, WRF slopes will be progressively reclaimed to minimize erosion. Sedimentation structures will be placed downstream of each facility to intercept WRF seepage and runoff.

Geochemical characterization of waste rock and ore has indicated a potential for acid rock drainage (ARD) and metal leaching (Section 4.5). This section describes the approach used to estimate potential impacts to surface water and groundwater from the WRFs, ore stockpile and pits.

The prediction of mine facility water qualities requires an understanding of the geochemical behavior of mine wastes, the mine plan, facility layout, climate conditions and regimes, the site-wide water balance and proposed engineering controls. Development of mine water quality predictions, therefore, requires information from numerous disciplines.

Mine facilities were evaluated individually to develop a range of anticipated source water qualities (i.e., best estimates of upper and lower concentrations). The geochemical characterization results (Section 4.5) and data from analogue sites formed the basis for all mine water quality predictions. It should be noted that the application of laboratory-scale leach test results to predict the magnitude of field-scale leaching is not a straightforward task. Metal leaching at the field scale will likely be variable through time and will be controlled by a number of factors, which may not be captured or accurately represented at the laboratory scale. These factors include the weathering environment (e.g., temperature, nature of the laboratory lixiviant versus meteoric water), the interaction between the solution and solid (e.g., solution to solid ratio and contact/reaction time) and considerations related to physical characteristics of the mine waste, such as particle size and texture.

The objective of the water quality prediction effort was to estimate a likely range of mine water qualities (rather than unique compositions) during operations (WRFs) and at closure (pits) to assess the potential for impacts to groundwater and surface water resources. Laboratory test results were used to bracket the range in expected mine water qualities. Because the geochemical characterization program is ongoing, the water quality prediction effort focused on the identification of constituents of potential concern (COPCs) and areas where engineering controls, including water treatment, may be required to mitigate impacts to water quality. Due to the assumptions and inherent limitations of predictive modeling, results should be considered as order-of-magnitude estimates.

Impacts to water quality were classified as defined in Table 5.7-1.

Table 5.7-1 Impact Description Criteria for Water Quality

Direction[(a)]	Magnitude[(b)]	Geographic Extent[(c)]	Duration[(d)]
Negative: Deterioration in surface water quality relative to baseline conditions **Negative:** Deterioration in groundwater quality relative to baseline conditions	**negligible**: isolated (in reference to the number of parameters and frequency of occurrence) change(s) in water quality – no exceedances of Project water quality standards **low**: consistent (in reference to the number of parameters and frequency of occurrence) measurable change(s) in water quality – no exceedances of Project water quality standards **moderate**: isolated (in reference to the number of parameters and frequency of occurrence) exceedances of Project water quality standards (where project water quality standards were not previously exceeded) **high**: frequent exceedances of Project water quality standards (where project water quality standards were not previously exceeded – beneficial use of water resource compromised)	**local**: effect restricted to immediately downgradient of mine facilities (i.e., within concession boundary) **regional**: effect extends beyond the concession boundary	**short-term**: less than 2 years **medium-term**: 2 to 16 years. Impacts will be reduced as part of site reclamation activities or will be eliminated soon after end of mine life **long-term**: effects beyond life and mine and closure (greater than 16 years)

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.

b) Magnitude: degree of change to analysis endpoint.

c) Geographic Extent: area affected by the impact.

d) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period and a 16-year operations period.

The general approaches for the prediction of WRF and pit water quality are described below.

5.7.1.1 Waste Rock Facility Runoff and Seepage

Static leach test results were used to estimate the expected range of WRF seepage qualities. As described in the baseline geochemistry section (Section 4.5), results are available for two types of leach tests: Synthetic Precipitation Leaching Procedure (SPLP) and Peroxide Acid Generation (PAG). The conditions of the SPLP leach test are considered most representative of the interaction between rainwater and waste rock as this test is designed to assess the environmental stability of a waste material following relatively short-term contact with meteoric water. This test does not, however, provide information on metal leaching following prolonged weathering. The results of the PAG test, a more aggressive test designed to mobilize metals present in association with sulfide mineralization through the use of a hydrogen peroxide solution, are considered a “worst-case” representation of the interaction between waste rock and water that infiltrates the WRFs. As noted in the baseline geochemistry section, kinetic testing of waste rock and ore samples from the Sabajo deposit is ongoing. These data will be compared to the PAG leach test results to ensure that use of PAG leachates as an indication of “worst-case” water quality is indeed appropriate and conservative.

For the impact assessment, a qualitative assessment of WRF runoff was performed. In general, WRF runoff quality is expected to be better than seepage quality due to: 1) shorter contact time between water and rock for runoff compared to seepage; and 2) a higher water to solid ratio for runoff compared to seepage. Because of the climatic conditions in the Project area (i.e., area of high rainfall), the water to rock ratio is expected to be high (i.e., potentially higher than the 20 to 1 ratio of the SPLP test). As noted earlier, the objective of the impact assessment was to provide order-of-magnitude estimates of mine water qualities to identify COPCs and the need for engineering controls. A quantitative prediction of WRF runoff represents a level of refinement that will be more appropriate at a later stage of the testing program when additional geochemical information and more detail related to WRF characteristics are available. In addition, the quality of WRF runoff is affected by its total suspended solids (TSS) concentration. As will be discussed further in Section 5.7.1.3, the focus of the water quality prediction effort is on dissolved phase constituents. The TSS concentration (and associated total metal concentrations) in WRF runoff will be a function of the effectiveness of sediment control structures.

The overall ARD generation potential of the WRFs has not yet been determined. Therefore, for the impact assessment, water quality predictions assumed a range of seepage pH conditions from acidic to alkaline. Metal leaching was evaluated assuming the following pH ranges: acidic (pH <5.5), circum-neutral (pH 5.5 to 8.5), and alkaline (pH >8.5).

The following mass balance mixing model approach was used to estimate WRF seepage quality during operations:

- ***Define WRF tonnage and composition.*** The composition of each of the WRFs (i.e., waste tonnage by regolith – saprolite, saprock and fresh rock) has not been defined. Prediction of WRF seepage, therefore, considered a range of compositions (i.e., proportions of saprolite, saprock and fresh rock). As shown in Table 2-4, during the first few years of mining, primarily saprolite and saprock waste will be generated and the WRFs will consist almost exclusively of this material. Over time, as mining of fresh rock begins, the WRFs will contain a mixture of saprolite, saprock and fresh rock.
- ***Define input water qualities.*** WRF seepage input chemistries were estimated for saprolite/saprock and fresh rock waste. A range of input water qualities was defined for WRF seepage. As presented in Section 4.5, leach testing statistics (i.e., 50th and 95th percentile) were calculated by regolith (i.e., fresh rock and combined saprock and saprolite) for all parameters (i.e., major ions and metals) with project water quality standards. Statistics were calculated over three pH ranges: <5.5 (acidic), 5.5 to 8.5 (circum-neutral), and >8.5 (alkaline) (Table 4.5-9).
- ***Water quality estimate.*** Input water qualities derived for saprolite/saprock and fresh rock were mixed in three ratios to represent a range of WRF compositions:
  - 100% saprolite/saprock (representative of early in the mine life)
  - 50% saprolite/saprock: 50% fresh rock
  - 100% FR (representative of later in the mine life)
- ***Estimation of nitrogen loading***. Prediction of nitrogen concentrations in seepage assumed a source from residual products of blasting agents (i.e., ANFO and emulsion). Emulsion and ANFO will be used as the principal blasting agents. The basic ANFO mixture of 94% ammonium nitrate and six percent fuel oil contains 33% (by weight) nitrogen. Nitrogen is present as ammonium

(NH_4^+) and nitrate (NO_3^-) ions, which are readily soluble in water (Forsyth et al. 1995). The basic emulsion mixture of 63% ammonium nitrate, 18% sodium nitrate and six percent fuel oil contains 25% (by weight) nitrogen. Similar to ANFO, nitrogen from emulsion is present as ammonium and nitrate ions. Although the rate of nitrogen leaching from emulsion has been demonstrated to be slower than ANFO, when given enough exposure to water, emulsion explosives will leach significant nitrogen (Revey 1996). Due to factors such as spillage and undetonated explosives (i.e., misfires), residual explosive concentrations in waste rock are generally estimated to be on the order of up to a few percent. Blasting practices are expected to be consistent with those at the Merian Operation. Therefore, nitrogen concentrations predicted for the Merian gold mine (Merian mine) were assumed to be representative of the levels that may occur for the current Project. Because the use of ANFO at the Merian Operation has just started, site monitoring data are not yet available to verify the Merian Environmental and Social Impact Assessment (ESIA) predictions (Graham 2018).

5.7.1.2 Pit Water Quality at Closure

Estimation of post-closure pit lake water quality requires an integrated assessment of the mine hydrogeology, geochemistry and hydrology. As noted in Section 5.7.1, the mine plan includes multiple pits. Pit water quality at closure was evaluated for the main Sabajo pit (i.e., Cassador Pit), which is the largest and deepest pit and the first pit to be mined.

Figure 5.7-1 illustrates schematically the hydrogeological and geochemical processes that may influence long-term pit water quality. At closure, predicted inflows to the pit include: groundwater, pit wall runoff; WRF runoff, and direct precipitation (i.e., precipitation that falls directly on the pit lake surface and does not contact wall rock). Evaporation is assumed to be the only outflow. The Cassador Pit water balance at closure was analyzed in Golder (2017b). This evaluation assumed a pit depth of 290 m (i.e., pit crest and floor elevations of +30 and -260 meters above mean sea level [m amsl], respectively). Filling of the pit is estimated to occur over a period of 10 years. The relative proportions of inflows in Year 1, Year 5 and Year 10 are shown in Figure 5.7-2. Over the 10-year period, the dominant inflow into the pit is WRF runoff, which accounts for over 60% of the total pit volume. In Year 1, the contributions from pit wall runoff (17%) and groundwater (18%) are similar. Groundwater inflow is dominated by bedrock flow (83% of total groundwater inflow), including the Cassador Fault which is estimated to account for approximately 20% of total groundwater inflow. The groundwater contributions from the saprock and saprolite quartz veins are relatively small (17% of total groundwater inflow). Over time, the contribution of pit wall runoff decreases and direct precipitation increases as the surface area of the pit lake increases and the pit walls are submerged. The distribution of groundwater inflows also changes over time, with the contributions from bedrock and saprock/saprolite quartz veins being similar in Year 10. It should be noted that there is currently a high degree of uncertainty in the inflow estimate for the Cassador fault. Due to the presence of elevated arsenic concentrations in the Cassador Fault wells (as discussed in Section 4.8.4), the amount of inflow from the Cassador Fault is a key factor in the predicted pit lake arsenic concentration.

Figure 5.7-1 Pit Lake Schematic

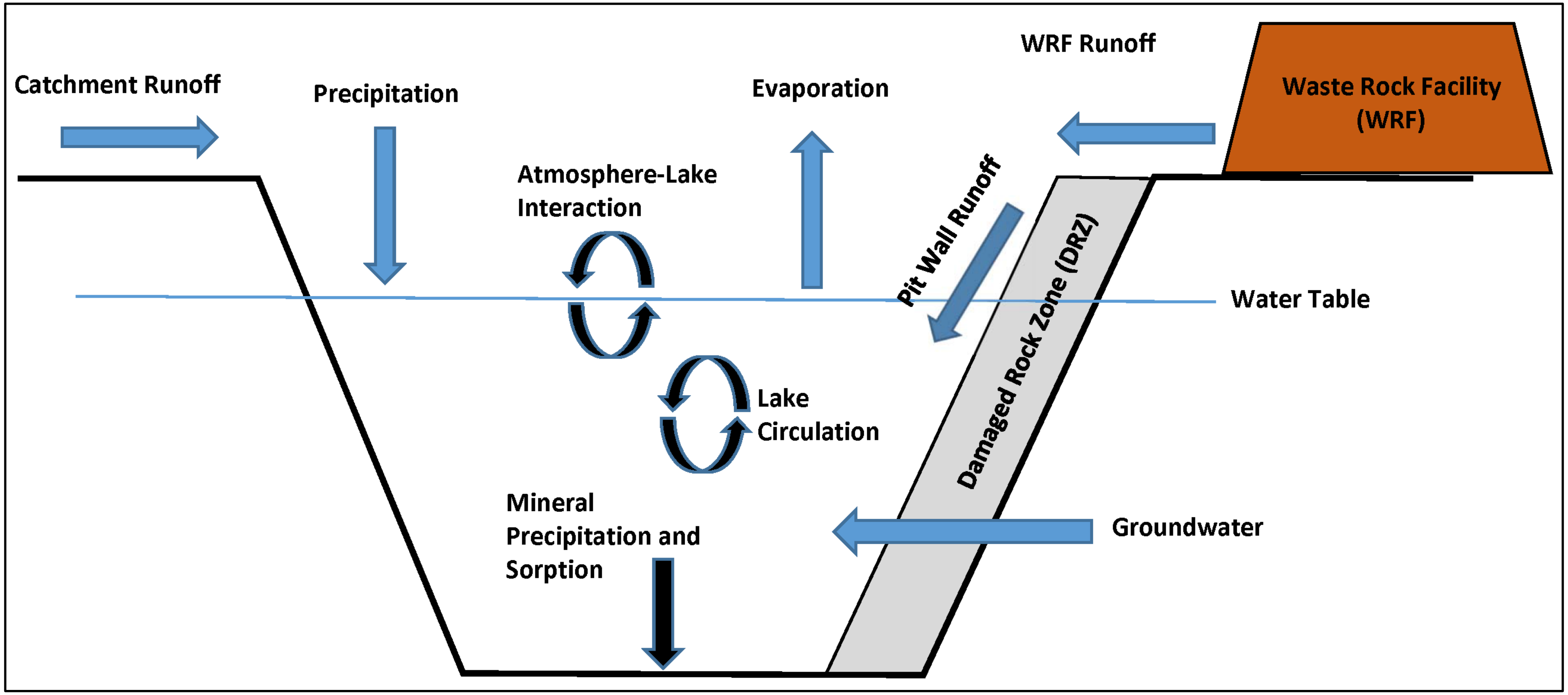
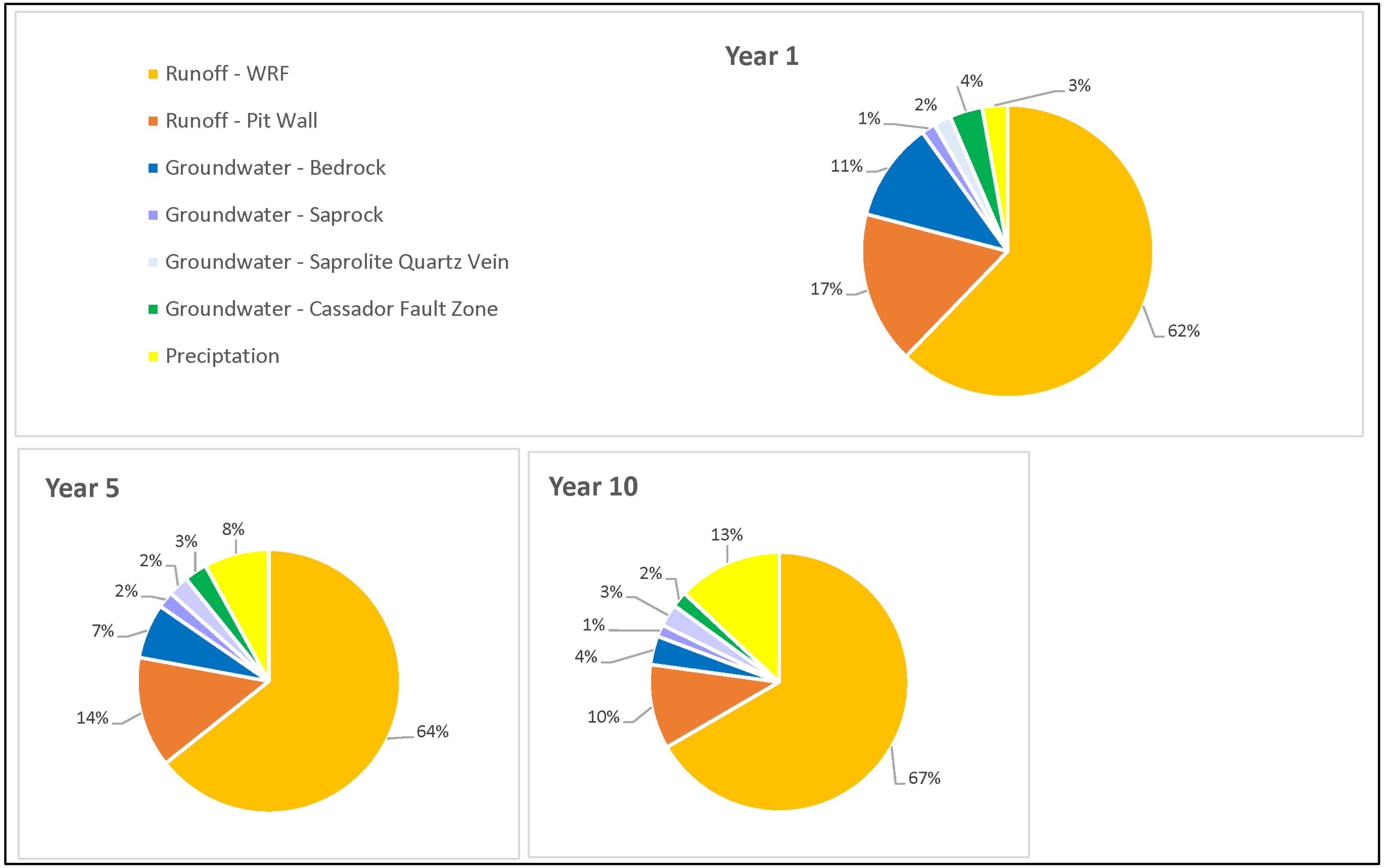


Figure 5.7-2 Distribution of Pit Lake Inflows - Years 1, 5 and 10



WRF = waste rock facility; % = percent.

The following mass balance mixing model approach was used to estimate pit water quality at closure:

- **Calculate mixing ratios**. The pit lake water balance estimates the annual inflow and outflow volumes to the pit over the period of filling. Based on the relative volumes for the various inflows, mixing ratios were calculated on an annual basis over the 10-year period of filling.
- **Define input water qualities.** A water quality was assigned to each of the pit inflows as follows:
  - **Precipitation:** Direct precipitation was assumed to be pure water with no total dissolved solids (TDS). This is a reasonable assumption because the typical TDS of precipitation is a few milligrams per liter (mg/L), which is negligible compared with that of the other inputs to the pit lake. The pH of the direct precipitation was set at 5.67, which is in accordance with the value for pH resulting from interaction between pure water and atmospheric carbon dioxide.
  - **WRF Runoff:** For the pit lake evaluation, WRF seepage quality was assumed to be representative of WRF runoff. This approach is considered conservative (i.e., will result in a bias toward poor water quality) as the quality of WRF runoff is expected to be better than WRF seepage. The approach used to estimate waste rock seepage water quality is described in Section 5.7.1.2. The distribution between saprolite/saprock and fresh rock runoff was assumed to be 41%:59% based on the relative proportion of these materials in waste rock over the life of mine (Figure 4.5-1).
  - **Pit Wall Runoff:** WRF runoff quality (as represented by WRF seepage quality) was assumed to be representative of pit wall runoff. The distribution between saprolite/saprock and fresh rock runoff from the pit wall was roughly estimated based on the predicted rate of water level rise in the pit (Table 5.7-2). This approach assumes a linear relationship between pit wall surface area and depth.
  - **Groundwater:** Baseline groundwater quality monitoring data were used to define groundwater inflow quality. The pit water balance model estimates the groundwater contribution from three geologic units: saprolite quartz vein, saprock and bedrock. The bedrock contribution is further refined to estimate the bedrock contribution from the Cassador Fault and other bedrock groundwater. Groundwater quality for each of these inflows was estimated using monitoring data from wells completed in each of these units. The 95th and 50th groundwater qualities were calculated.
- **Conservative water quality estimate.** Using an annual time step, the various inflows were mixed in the appropriate proportions and the resultant water composition determined. The effect of evaporation on pit water quality (i.e., concentration of the pit lake water quality) was not considered. Because the volume of water that evaporates is small, this mechanism would have a minimal effect on water quality.

To estimate the likely range in pit lake water qualities, for most inputs, a range in water qualities was assumed (i.e., 50th and 95th percentiles). Input water qualities also assumed a range in input pH values. The six mixing model scenarios are listed in Table 5.7-3.

Limnological processes such as lake turn over, density stratification, and wind mixing will also affect the geochemical composition of the lake. In particular, the absence or development of a permanent, reducing hypolimnion at the base of the lake may have significant effects on metals mobility in the pit lake. Biota present in the pit lake (e.g., algae) may also affect the behavior and distribution of pit water constituents. For the current study, limnological and biological processes were not considered.

Table 5.7-2 Pit Lake Walls Exposed Surface Distribution

Year	Pit Level (m amsl)	% Fresh Rock	% Saprolite / Saprock
0	-205		
1	-130	81%	19%
2	-95	72%	28%
3	-65	64%	36%
4	-45	53%	47%
5	-25	40%	60%
6	-10	18%	82%
7	0	0%	100%
8	15	0%	100%
9	25	0%	100%
10	30	0%	100%

Notes:
The interface between bedrock (fresh rock) and saprolite occurs at -15 m amsl.
The interface between saprock and saprolite occurs at -5 m amsl.
m amsl = meters above mean sea level;% = percent.

Table 5.7-3 Pit Lake Mixing Model Scenarios

Model Simulation		WRF Runoff		Pit Wall Runoff		Groundwater
No.	Name	Percentile	pH Range	Percentile	pH Range	Percentile
1	95th, pH <5.5	95th	<5.5	95th	<5.5	95th
2	95th, pH 5.5 to 8.5	95th	5.5 to 8.5	95th	5.5 to 8.5	95th
3	95th, pH >8.5	95th	>8.5	95th	>8.5	95th
4	50th, pH <5.5	50th	<5.5	50th	<5.5	50th
5	50th, pH 5.5 to 8.5	50th	5.5 to 8.5	50th	5.5 to 8.5	50th
6	50th, pH >8.5	50th	>8.5	50th	>8.5	50th

WRF = waste rock facility; No. = number; < = less than; > = greater than.

5.7.1.3 Model Assumptions

The following assumptions were inherent to all predictions:

- All concentrations presented in this chapter are representative of the dissolved phase. The dissolved fraction represents the geochemically-reactive and typically biologically-available component in aqueous environments. Engineering controls (e.g., sediment control structures) are assumed to be effective at preventing significant transport of particulates in the form of TSS.
- In all calculations, non-detect concentrations were assumed equal to the analytical reporting limit. This approach is considered conservative with respect to the prediction of water quality impacts in that it may result in an overestimation of a baseline concentration or constituent loading to groundwater or surface water.
- Geochemical controls (e.g., secondary mineral precipitation, sorption) that may limit the mobility of some constituents were not considered. This approach is considered conservative with respect to the prediction of water quality impacts as these processes may remove metals from the dissolved phase.
- Concentrations that were predicted to be below one microgram per liter (µg/L) are presented as such (i.e., less than 0.001 µg/L) without further quantification.

5.7.1.4 Impact to Surface Water and Groundwater Resources

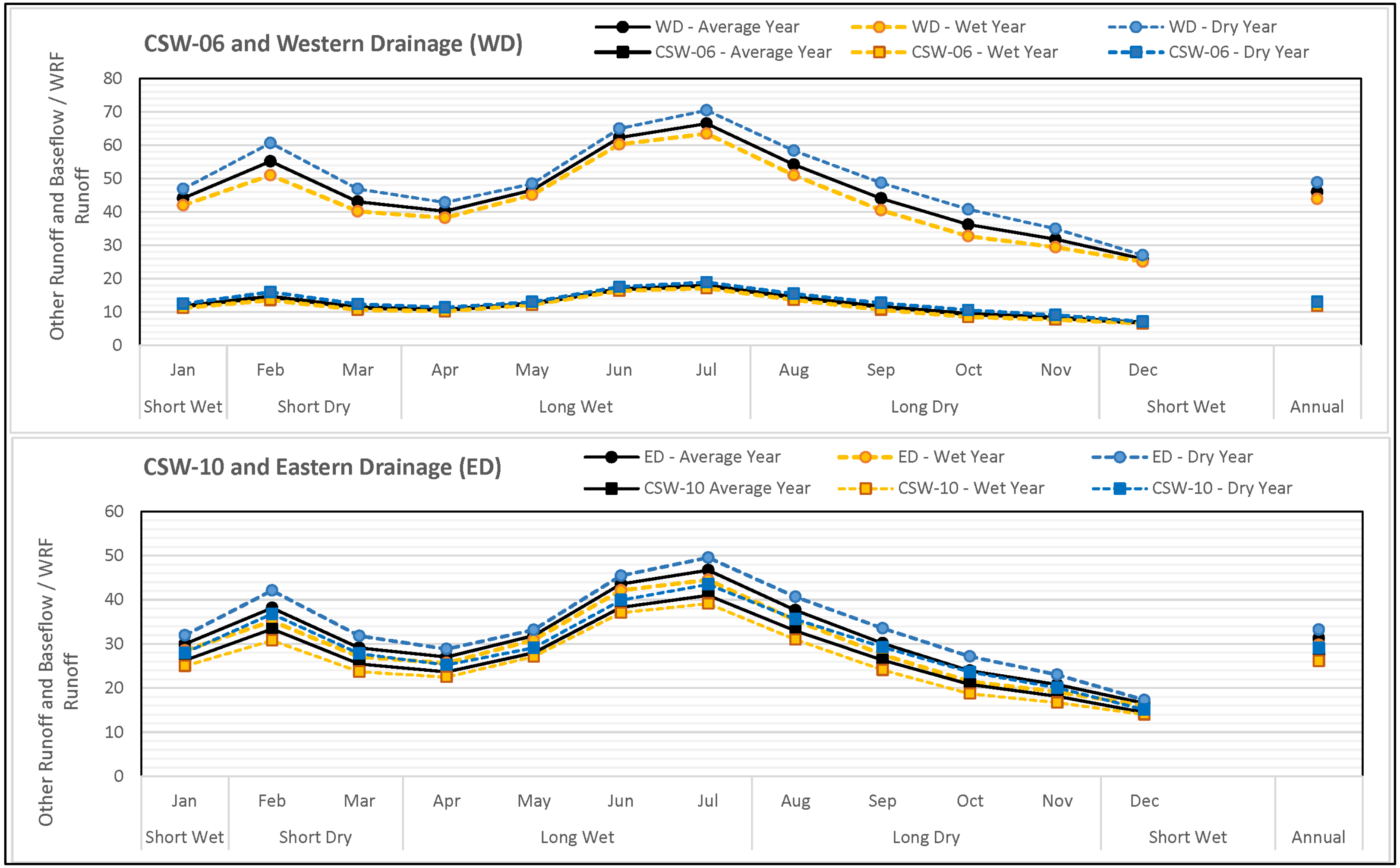
Mine facility water quality predictions were compared to Project water quality standards (Table 4.8-3) to facilitate identification of COPCs. However, to properly evaluate potential impacts to groundwater and surface water resources, a formal fate and transport analysis would be required. A general discussion of the mobility of some COPCs is presented as part of this impact assessment.

The transport of solutes in surface water and groundwater is controlled by both physical (i.e., advection and hydrodynamic dispersion) and (bio)chemical processes (e.g., sorption, mineral precipitation, biodegradation). Advection is the component of solute movement attributed to transport by flowing groundwater or surface water, and dispersion occurs as a result of mechanical mixing (i.e., dilution) and molecular diffusion. “Conservative” transport is the term used to describe a solute whose transport is governed solely by physical processes. Conservative solutes (e.g., chloride) travel at the rate of groundwater or surface water flow. The transport of solutes that participate in chemical or biological reactions is described as “attenuated” or “retarded” relative to the rate of groundwater or surface water flow.

The Project hydrologic impact assessment, that describes potential impacts on surface water quantity (i.e., streamflows) in the vicinity of the Project, is presented in Section 5.6. This assessment evaluates changes in streamflow at the conclusion of mining for a number of locations, including the lower-most portions (i.e., lowest elevation) of the primary streams on the west side and east side of the Project (i.e., Creek 1 and Creek 2), just above their confluence (Map 4.7-1). These locations are immediately downstream of the Project concession boundary. Changes in streamflow were also evaluated at CSW-06 (western drainage) and CSW-10 (eastern drainage), the monitoring locations immediately downstream of the Sabajo deposit and upstream of Santa Barbara, respectively (i.e., the monitoring locations where impacts from mining of only the Sabajo deposit can be evaluated).

At these four locations, average monthly flows were estimated for average, wet and dry precipitation years. The contribution to flow at each location from the following areas was estimated: 1) runoff from disturbed areas (excluding the WRFs), 2) runoff from the WRFs, 3) runoff from undisturbed areas (i.e., jungle runoff), and 4) baseflow (i.e., groundwater discharge to streams). This hydrologic water balance was used to estimate the ratio of “clean” (i.e., jungle runoff and baseflow) and “baseline or existing disturbance” water to WRF runoff to provide an indication of the ratio of unimpacted flow to potentially impacted flow. This ratio, referred to as a “mixing ratio”, is used to estimate when a project water quality exceedance in waste rock runoff may result in a water quality exceedance in streams downstream of Sabajo (i.e., CSW-06 and CSW-10) or at the Project concession boundary. For example, a mixing ratio of 9 would be required for WRF runoff with an arsenic concentration of 0.1 mg/L to be below the drinking water standard of 0.01 mg/L at the Project concession boundary, assuming: 1) no arsenic contribution from the “unimpacted” water sources (i.e., jungle runoff, existing disturbance runoff and baseflow), and 2) conservative transport of arsenic. Estimated mixing ratios at CSW-06, CSW-10 and the bottom of the western and eastern drainages are shown in Figure 5.7-3. The fractions of the watershed that contribute “WRF disturbed area” runoff to the western and eastern drainage assessment locations are 1% and 1.4%, respectively. At CSW-06 and CSW-10 the fractions of the watershed that contribute “WRF disturbed area” runoff are 3.4 and 1.5%, respectively. Mixing ratios exhibit seasonal variability and are predicted to be lowest following the long dry season (i.e., December) and highest at the end of the long wet season (i.e., July). For an average precipitation year, mixing ratios are estimated to range from approximately 26 to 67 (western drainage) and approximately 17 to 47 (eastern drainage). For an average precipitation year, mixing ratios are estimated to range from approximately 7 to 18 at CSW-06 and 15 to 41 at CSW-10.

Figure 5.7-3 Western and Eastern Drainage Mixing Ratios



WRF = waste rock facility.

5.7.2 Issue Scoping

The relevant water quality issues raised through the public and regulatory engagement process are listed in Table 5.7-4.

Table 5.7-4 Potential Impact Issues for Water Quality

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Potential Effect on Water Quality	Potential for mine activities to negatively affect water quality and beneficial use (26 April, 18 May and 24 May 2017 meetings).
2	Measures to Prevent Impacts to Water Quality	Clean water is critical to the livelihood (i.e., fishing and hunting) of the Boslanti. Concern was expressed over the health effects of eating the pakira/wild meat of animals that have consumed surface water (26 April 2017 meeting).
3	Potential Effect on Water Quality – Cyanide Discharges	The Kawina inquired about direct discharge of water to creeks following cyanide use (14 May 2017 meeting).
4	Potential Effect on Water Quality – Cyanide and Mercury Use	The Asigron inquired about use of cyanide and mercury. A potential impact to water quality was implied (4 May 2017 meeting).

5.7.3 Linkage Analysis

Issues 1 and 2 presented in Table 5.7-4 are considered valid and are therefore addressed by the water quality assessment. Issues 3 and 4 are not valid since there will be no cyanide or mercury use by the Project (ore processing will occur at the Merian mine – cyanide use at that operation is addressed in the Merian mine ESIA). Issues 3 and 4 are, therefore, not addressed in this impact statement. Risks associated with the transport of cyanide are addressed in Section 5.12.

5.7.4 Key Indicators

Stakeholders have expressed concerns regarding the potential for mine activities to adversely affect water resources and compromise beneficial use of these resources (comments specifically referenced surface water but due to the interaction between groundwater and surface water, concern over impacts to groundwater is implied). Water quality standards serve as the basis for the assessment of potential project impacts to groundwater and surface water resources. A water quality standard defines the water quality goals of a water body, or a portion thereof, by identifying the water uses and by setting criteria necessary to protect these uses. Project water quality standards were presented in Section 4.8.

It should be noted that direct comparison of predicted mine water quality predictions to applicable standards must consider the expected accuracy of the predictions. The currently-available geochemical data and other information lend themselves to order-of-magnitude estimates. Also, the use of detection limit values in the prediction of mine water qualities (which may result in concentrations that are biased high) must be considered.

Indicators for the key issues assessed in this document are presented in Table 5.7-5.

Table 5.7-5 Project Indicators for Water Quality

Issue Number	Key Issue	ESIA Indicators
1	Potential Effect on Surface Water Quality from WRF and ore stockpile runoff	Qualitative assessment of WRF runoff quality and surface water fate and transport for COPCs.
2	Potential Effect on Groundwater Quality from WRF and ore stockpile seepage	Comparison of predicted WRF seepage quality to Project water quality standards. Qualitative assessment of groundwater fate and transport for COPCs.
3	Pit Lake Water Quality at Closure	Comparison of predicted pit water quality to Project water quality standards.

ESIA = Environmental and Social Impact Assessment; WRF = waste rock facility; COPC = constituent of potential concern.

5.7.5 Spatial and Temporal Considerations

The spatial and temporal assumptions for water quality predictions were as follows:

- **WRF Seepage**: The predicted range of water qualities is assumed to be representative of the range of qualities that will be measured immediately downgradient of the WRFs during operations.
- **Pit Lake Water Quality**: The predicted range of Cassador pit lake water quality is assumed to be representative of the first decade following closure (i.e., period of filling).
- **Surface Water Quality**: A qualitative discussion of the fate and transport of key COPCs is presented to evaluate potential changes in water quality at the concession boundary during operations.
- **Groundwater Quality**: A qualitative discussion of the fate and transport of key COPCs in groundwater immediately downgradient of the WRFs during operations is presented.

5.7.6 Project Case Impact Assessment

Mining activities associated with the Project have the potential for short- and long-term impacts on local surface and groundwater resources. An understanding of these potential impacts is a key component of the ESIA and mine feasibility. Significant findings of the geochemical and water quality evaluations are summarized below.

- Waste Rock Seepage
  - Project design currently assumes that seepage from the WRFs and the ore stockpile will be collected and treated prior to discharge to surface water. This assumption will continue to be evaluated as additional geochemical information becomes available and water quality predictions and/or WRF design are refined.
  - Waste rock seepage water quality predictions are shown in Tables 5.7-6 and 5.7-7 for three materials: saprolite/saprock, fresh rock, and a 50/50 mixture. Results are presented as order-of-magnitude estimates of the range in concentrations expected under acidic (low - L), circum-neutral (middle - M) and alkaline (high - H) pH conditions. These tables present the same results; however, results are compared to different water quality standards. In Table 5.7-6 parameters that may exceed mine effluent water quality standards are identified by grey shading. In Table 5.7-7 parameters that may exceed the lowest surface water or groundwater quality standard (i.e.,lowest of aquatic life and drinking water) are identified by grey shading. WRF seepage quality estimates are compared to surface water and groundwater standards for informational purposes only. Seepage results are compared to surface water standards since WRF seepage may ultimately discharge to surface water (i.e.,

via a groundwater transport pathway). For hardness-dependent aquatic life standards, a hardness value of 10 mg/L as calcium carbonate is assumed.

- Saprolite will be the first material to be mined. The sulfide content, and therefore ARD potential, of this material should be low; however, assay data base results do indicate a potential for some sulfide mineralization to be present. The neutralization potential of the saprolite is low, and therefore at low sulfide concentrations, there is a potential for generation of ARD. Kinetic testing, which is ongoing, will confirm this ARD potential and provide information on expected lag times to ARD, should ARD develop.
- Initially, the pH of saprolite WRF seepage is expected to be circum-neutral to slightly acidic. Under these pH conditions, based on a comparison to mine effluent standards, the following primary COPCs have been identified (Table 5.7-6): copper (Cu) and nickel (Ni). If acidic conditions are established in the saprolite WRFs, increased metal leaching is expected. Under these conditions, the following additional COPCs have been identified: chromium (Cr), iron (Fe) and zinc (Zn).
- Groundwater and surface water quality standards are typically lower than the mine effluent standards. For this reason, estimated seepage water quality was also compared to groundwater and surface water standards. Under circum-neutral to slightly acidic pH conditions, based on a comparison to groundwater and surface water quality standards, the following COPCs have been identified (Table 5.7-7): aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), cobalt (Co), Cu, lead (Pb), manganese (Mn), mercury (Hg), Ni, selenium (Se), silver (Ag), thallium (Tl) and Zn. For many of these parameters (i.e., Al, Ba, Be, Cd, Co, Ni, Ag and Zn), the 50^{th} percentile static leach test concentration exceeded the lowest Project water quality standard (i.e., the aquatic life standard) under circum-neutral pH conditions. For other parameters (i.e., As and Tl), the 95^{th} percentile static leach test concentration exceeded the lowest Project water quality standard under circum-neutral pH conditions. It should be noted that use of the 95^{th} percentile concentrations represents a conservative estimate of the upper range values for seepage water quality.
- If acidic conditions are established in the saprolite WRFs, increased metal leaching is expected. Under these conditions, based on a comparison to surface water and groundwater standards, the following additional COPCs have been identified: Cr and Fe. These parameters were measured in static test leachates above the lowest Project water quality standard under acidic pH conditions.
- Fresh rock will be mined beginning in approximately Year 3. The fresh rock has both a higher sulfide content and higher carbonate content than the saprolite. Static test results indicate an ARD potential for a portion of the fresh rock. Kinetic testing, which is ongoing, will confirm this ARD potential and provide information on expected lag times to ARD, should ARD develop.
- Initially, the pH of fresh rock WRF seepage (or a mixture of fresh rock and saprolite/saprock) is expected to be circum-neutral to slightly acidic. Under these pH conditions, based on a comparison to mine effluent standards, the following primary COPCs have been identified (Table 5.7-6): As, Cu, Ni and Zn. If acidic conditions are established in the fresh rock WRFs, increased metal leaching is expected. Under these conditions, iron has also been identified as a COPC.
- Similar to the saprolite WRFs, comparison of fresh rock WRF seepage quality to surface water and groundwater standards results in identification of a number of parameters with the potential to leach above the lowest Project water quality standard. Under circum-neutral to slightly acidic pH conditions, the following COPCs are identified (Table 5.7-7): Al, Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Se, Ag and Zn. Similar to the saprolite, if

acidic conditions are established, increased metal leaching is expected. Under acidic conditions, the following additional COPCs have been identified: Co and Fe.

- Nitrate and ammonium concentrations in WRF seepage 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. Nitrogen concentrations are predicted to be highest during mine operation and then decrease at closure.

It is important to note that the preliminary estimates of WRF seepage quality may be conservative (i.e., may overestimate the number of COPCs identified as a result of assuming the onset of acid conditions and use of 95th percentile leachate concentrations). Prior to Project development, the water quality assessment will be revised based on additional geochemical testing and further evaluation of the mine plan and the block model with respect to COPCs. Mitigation measures to improve WRF seepage quality may include selective handling and placement of waste rock with elevated sulfide and/or COPC concentrations (e.g., As) to minimize the exposure of sulfidic material to oxygen and water. Concurrent reclamation may also be considered to reduce infiltration, thereby minimizing seepage volume.

As noted earlier, the quality of WRF runoff is expected to be better than that of WRF seepage. During periods of high precipitation, a high water to rock ratio should result in WRF runoff with low TDS concentration. Additional evaluations are required to estimate (i.e., quantify) WRF runoff quality during operations. Prior to operation, additional assessments will be made to ensure that the Project is adequately prepared to protect human health and the environment and to determine if treatment of WRF runoff will be necessary.

Table 5.7-6 Preliminary Estimate of Waste Rock Facility Seepage Quality - Comparison to Mine Effluent Water Quality Standards

Parameter	Effluent Water Quality Standard (mg/L)	Exceedance [a]		Saprolite / Saprock Predicted Concentration Range (mg/L)							50% Saprolite/Saprock and 50% Fresh Rock Predicted Concentration Range (mg/L)							Fresh Rock Predicted Concentration Range (mg/L)						
		SAP/SR	FR	<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000	<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000	<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000
SO_4									M-H	L-M						M-H	L-M						M-H	L-M-H
Al		L-M-H	L-M-H			M	M-H	L-H	L				M	M-H	L	L				M-H	M-H	L	L	
Sb				L-M-H	M-H						L-M-H	M-H						L	L-M-H					
As	0.1	**L-M-H**	L-M-H		L-M-H	L-M-H						L-M-H	L-M-H	L-M					H	L-M-H	L-M			
Ba		L-M-H	L-M-H		M	L-M-H	L-M-H					M	L-M-H	L-M-H					M	L-M-H	L-M-H			
Be		L-M-H	L-M-H	M--H	L-M-H						M-H	L-M-H						M	L-M-H					
B						L-M-H							L-M-H							L-M-H				
Cd	0.05	L-M	L-M-H	L-M-H	L						L-M-H	L						L-M-H	L-H					
Cr	0.1	L-H	L-M-H	M	M-H	L-H	L				M	M-H	L-M-H					M	M-H	L-M-H				
Cl								L-M-H							L-M-H							L-M-H		
Co		L-M	L		M-H	M-H	L-M	L				M-H	M-H	L-M	L				M-H	M-H	L			
Cu	0.3	L-M-H	L-M		M	M-H	L-H	L				M	M-H	L-M	L					M-H	L-M	L		
F						H	L-M-H						H	L-M-H						H	L-M-H			
Fe	2	**L-H**	L			M-H	L-M-H	L-H	L				M-H	M-H	L	L				M-H	M	L	L	
Pb	0.2	**L-M-H**	**L**	M	L-M-H	L-M-H					M	L-M-H	L						L-M-H					
Mn		**L-M**	L-M			M-H	L-M-H	L-M				H	M-H	L-M	L-M				H	M-H	L-M	L		
Hg	0.002			L-M-H							L-M-H							L-M-H						
Mo				L-M	L-M-H						L-M	L-M-H	L					L	L-M-H	L-M				
Ni	0.5	L-M-H	L-M-H		M-H	M-H	L-M	L				M-H	M-H	L-M	L				M-H	M-H	L-M	L		
Se		**L**	**L-M-H**	M	L-M-H						M	L-M-H						M	L-M-H					
Ag		L-M-H	L-M-H	L-M-H	L-M						L-M-H	L						L-M-H						
Tl		**L-M**		L-M-H	L-M						L-M-H	L-M						L-M-H						
Zn	0.5	L-M-H	L-M-H		H	M-H	L	L				H	M-H	L-M	L				H	M-H	L-M			

Notes:

L - low pH leachate (pH <5.5)

M - Medium pH leachate (pH = 5.5 to 8.5)

H - High pH leachate (>8.5)

Grey shading identifies potential for water quality exceedances based on order of magnitude predictions.

a) Exceedance of lowest water quality standard measured in 95th or 50th percentile leachate results. **Red bold** text identifies exceedances that were only measured in 95th percentile.

SAP = saprolite; SR = saprock; FR = fresh rock; SO_4 = sulfate; Al = aluminum; Sb = antimony; As = arsenic; Ba = barium; Be = beryllium; B = boron; Cd = cadmium; Cr = chromium; Cl = chloride; Co = cobalt; Cu = copper; F = fluoride; Fe = iron; Pb = lead; Mn = manganese; Hg = mercury; Mo = molybdenum; Ni = nickel; Se = selenium; Ag = silver; Tl = thallium; Zn = zinc; mg/L = milligrams per liter; < = less than.

Table 5.7-7 Preliminary Estimate of Waste Rock Facility Seepage Quality - Comparison to Surface Water and Groundwater Standards

Parameter	Lowest Water Quality Standard (mg/L)	Lowest Water Quality Standard Type [b]	Exceedance [a]		Saprolite / Saprock Predicted Concentration Range (mg/L)							50% Saprolite/Saprock and 50% Fresh Rock Predicted Concentration Range (mg/L)							Fresh Rock Predicted Concentration Range (mg/L)						
			SAP/SR	FR	<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000	<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000	<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000
SO_4	1,500	DW								M-H	L-M						M-H	L-M						M-H	L-M-H
Al	0.087	A	L-M-H	L-M-H			M	M-H	L-H	L				M	M-H	L	L				M-H	M-H	L	L	
Sb	0.006	DW			L-M-H	M-H						L-M-H	M-H						L	L-M-H					
As	0.01	DW	**L-M-H**	L-M-H		L-M-H	L-M-H						L-M-H	L-M-H	L-M					H	L-M-H	L-M			
Ba	0.04	A (H)	L-M-H	L-M-H		M	L-M-H	L-M-H					M	L-M-H	L-M-H					M	L-M-H	L-M-H			
Be	0.0001	A (H)	L-M-H	L-M-H	M--H	L-M-H						M-H	L-M-H						M	L-M-H					
B	5	A					L-M-H							L-M-H							L-M-H				
Cd	0.0004	A (H)	L-M	L-M-H	L-M-H	L						L-M-H	L						L-M-H	L-H					
Cr	0.01	A (H)	L-H	L-M-H	M	M-H	L-H	L				M	M-H	L-M-H					M	M-H	L-M-H				
Cl	230	A							L-M-H							L-M-H							L-M-H		
Co	0.1	A	L-M	L		M-H	M-H	L-M	L				M-H	M-H	L-M	L				M-H	M-H	L			
Cu	0.0686	A	L-M-H	L-M		M	M-H	L-H	L				M	M-H	L-M	L					M-H	L-M	L		
F	4	DW					H	L-M-H						H	L-M-H						H	L-M-H			
Fe	1	A	**L-H**	L			M-H	L-M-H	L-H	L				M-H	M-H	L	L				M-H	M	L	L	
Pb	0.003	A (H)	**L-M-H**	**L**	M	L-M-H	L-M-H					M	L-M-H	L						L-M-H					
Mn	0.3	A (H)	**L-M**	L-M			M-H	L-M-H	L-M				H	M-H	L-M	L-M				H	M-H	L-M	L		
Hg	0.0008	A			L-M-H							L-M-H							L-M-H						
Mo	0.18	DW			L-M	L-M-H						L-M	L-M-H	L					L	L-M-H	L-M				
Ni	0.007	A (H)	L-M-H	L-M-H		M-H	M-H	L-M	L				M-H	M-H	L-M	L				M-H	M-H	L-M	L		
Se	0.005	A	**L**	**L-M-H**	M	L-M-H						M	L-M-H						M	L-M-H					
Ag	0.0001	A	L-M-H	L-M-H	L-M-H	L-M						L-M-H	L						L-M-H						
Tl	0.002	DW	**L-M**		L-M-H	L-M						L-M-H	L-M						L-M-H						
Zn	0.02	A (H)	L-M-H	L-M-H		H	M-H	L	L				H	M-H	L-M	L				H	M-H	L-M			

Notes:

L - low pH leachate (pH <5.5)

M - Medium pH leachate (pH = 5.5 to 8.5)

H - High pH leachate (>8.5)

Grey shading identifies potential for water quality exceedances based on order of magnitude predictions.

a) Exceedance of lowest water quality standard measured in 95th or 50th percentile leachate results. **Red bold** text identifies exceedances that were only measured in 95th percentile.

b) Water Quality Standard Type: DW = drinking water; A = aquatic life; A (H) = aquatic life, hardness dependent

SAP = saprolite; SR = saprock; FR = fresh rock; SO_4 = sulfate; Al = aluminum; Sb = antimony; As = arsenic; Ba = barium; Be = beryllium; B = boron; Cd = cadmium; Cr = chromium; Cl = chloride; Co = cobalt; Cu = copper; F = fluoride; Fe = iron; Pb = lead; Mn = manganese; Hg = mercury; Mo = molybdenum; Ni = nickel; Se = selenium; Ag = silver; Tl = thallium; Zn = zinc; mg/L = milligrams per liter; <= less than.

- Temporary Ore Stockpile Runoff and Seepage
  - The ESIA baseline geochemical characterization program included only two ore samples. Therefore, for the current assessment, WRF runoff and seepage quality predictions are assumed to be representative of short-term ore stockpile runoff and seepage quality. Although the sulfide content of the ore stockpile will be higher than the WRFs, ore will only be stockpiled for short timeframes and, therefore, the period of exposure of sulfides to atmospheric oxygen and water will be limited.
- Pit Lake Water Quality
  - Cassador pit lake water quality predictions are shown in Tables 5.7-8 and 5.7-9. Results are presented as order-of-magnitude estimates of the range in concentrations expected under acidic (L), circum-neutral (M) or alkaline (H) pH conditions. These tables present the same results; however, results are compared to different water quality standards. In Table 5.7-8, parameters that may exceed the mine effluent water quality standard are identified by grey shading. In Table 5.7-9, parameters that may exceed the lowest surface water or groundwater quality standard are identified by grey shading.
  - Additional evaluation is required to estimate the pH of the final pit lake. As discussed in Section 4.8, water quality samples from the existing Cassador pit were collected in September 2010 and 2016. Pit water pH was measured in a sample collected in September 2010 at 4.4, indicative of acidic conditions. It should be noted that it is likely that this was a surface sample and therefore the results may not be representative of conditions throughout the entire water column. These results do, however, indicate a potential for low-pH conditions. Despite the low-pH conditions observed, measured metal concentrations were low.
  - For the current model scenarios, WRF seepage quality was assumed to be representative of WRF and pit wall runoff quality. This is a conservative assumption and may result in overpredition of pit lake constituent concentrations. The current estimates of pit lake water quality are considered preliminary and will be refined as additional geochemical and hydrogeological information becomes available.
  - Arsenic is identified as one of the principal COPCs in pit lake water. Results for the six model scenarios are shown in Figure 5.7-4. Pit lake arsenic concentrations are predicted to exceed the drinking water standard of 0.01 mg/L under all model scenarios. Under some model scenarios, exceedances of the mine effluent (0.1 mg/L) and aquatic life (0.15 mg/L) water quality standards are also predicted. Groundwater from the Cassador fault, WRF runoff and pit wall runoff are the primary sources of arsenic to the pit. The estimated contribution from the Cassador fault alone results in an exceedance of the drinking water standard. The pit lake model does not consider geochemical controls that may reduce dissolved arsenic concentrations. Under oxidized and circum-neutral pH conditions, precipitation of ferrihydrite is a likely control on dissolved iron concentrations. Co-precipitation or sorption of arsenic may then reduce dissolved arsenic concentrations. Dissolved arsenic concentrations in the September 2010 and 2016 pit samples were <0.002 mg/L and 0.007 mg/L, respectively. It should be noted that the current pit has not yet encountered fresh rock, which is a potential source of arsenic.
  - Under circum-neutral pH conditions, in addition to As, the following parameters may exceed mine effluent water quality criteria in the pit lake (Table 5.7-8): Cu, Fe and Ni. If acidic conditions are established in WRF runoff or pit wall runoff, exceedances of water quality criteria are likely. In an acidic pit lake, Zn is also predicted to exceed the mine effluent water quality criterion.
  - As shown in Table 4.7-9, many parameters are predicted to exceed the lowest groundwater or surface water quality standard in the pit lake under circum-neutral or acidic conditions.

- For some parameters, model simulations indicate a significant range in constituent concentrations. For example, pit lake copper concentrations, shown in Figure 5.7-5, range from tens of micrograms per liter to greater than a milligram per liter, indicating a high level of uncertainty, which is associated with the uncertainty in the pH of the pit lake. Geochemical test work that is ongoing will be used to refine these predictions.

There are many factors that will influence pit lake water quality at closure. The model presented in this ESIA uses available information to provide a preliminary assessment of pit lake water quality. This model will be refined as additional geochemical and hydrogeological information becomes available. The most useful and relevant information to predict pit lake water quality at closure will be the data collected during operations. Water quality and hydrogeological information collected during operations will be used to refine the current predictions and to inform decisions regarding mitigation measures, if deemed necessary.

Table 5.7-8 Preliminary Estimate of Pit Lake Water Quality - Comparison to Mine Effluent Water Quality Standards

		Predicted Concentration Range (mg/L)							
	Effluent Water Quality Standard (mg/L)	**<0.001**	**0.001 to 0.01**	**0.01 to 0.1**	**0.1 to 1**	**1 to 10**	**10 to 100**	**100 to 1,000**	**>1,000**
SO_4							M-H	L-M-H	
Al				M-H	M-H	L	L		
Sb			L-M-H						
As	0.1			L-M-H	L-M-H				
Ba				L-M-H	L-M-H				
Be		L-M-H	L						
B				L-M-H					
Cd	0.05	L-M-H	L-H						
Cr	0.1	M	L-M	L-M-H					
Cl						L-M-H			
Co			M-H	M-H	L-M				
Cu	0.3		M-H	M-H	L-M	L			
F				M-H	L-M-H				
Fe	2				M-H	L-M-H			
Pb	0.2		L-M-H	L					
Mn				M-H	L-M-H	L-M			
Hg	0.002	L-M-H							
Mo			L-M-H	L-M					
Ni	0.5		M-H	M-H	L-M	L			
Se		M	L-M-H						
Ag		L-M-H	L						
Tl		L-M-H	L-M						
Zn	0.5		M-H	M-H	L				

Notes:

L - low pH leachate (pH <5.5)

M - Medium pH leachate (pH = 5.5 to 8.5)

H - High pH leachate (>8.5)

Grey shading identifies potential for water quality exceedances based on order of magnitude predictions.

SO_4 = sulfate; Al = aluminum; Sb = antimony; As = arsenic; Ba = barium; Be = beryllium; B = boron; Cd = cadmium; Cr = chromium; Cl = chloride; Co = cobalt; Cu = copper; F = fluoride; Fe = iron; Pb = lead; Mn = manganese; Hg = mercury; Mo = molybdenum; Ni = nickel; Se = selenium; Ag = silver; Tl = thallium; Zn = zinc; mg/L = milligrams per liter; < = less than.

Table 5.7-9 Preliminary Estimate of Pit Lake Water Quality - Comparison to Surface Water and Groundwater Standards

	Lowest Water Quality Standard (mg/L)	Lowest Water Quality Standard Type	Predicted Concentration Range (mg/L)							
			<0.001	0.001 to 0.01	0.01 to 0.1	0.1 to 1	1 to 10	10 to 100	100 to 1,000	>1,000
SO_4	1,500	DW						M-H	L-M-H	
Al	0.087	A			M-H	M-H	L	L		
Sb	0.006	DW		L-M-H						
As	0.01	DW			L-M-H	L-M-H				
Ba	0.04	A (H)			L-M-H	L-M-H				
Be	0.0001	A (H)	L-M-H	L						
B	5	A			L-M-H					
Cd	0.0004	A (H)	L-M-H	L-H						
Cr	0.01	A (H)	M	L-M	L-M-H					
Cl	230	A					L-M-H			
Co	0.1	A		M-H	M-H	L-M				
Cu	0.0686	A		M-H	M-H	L-M	L			
F	4	DW			M-H	L-M-H				
Fe	1	A				M-H	L-M-H			
Pb	0.003	A (H)		L-M-H	L					
Mn	0.3	A (H)			M-H	L-M-H	L-M			
Hg	0.0008	A	L-M-H							
Mo	0.18	DW		L-M-H	L-M					
Ni	0.007	A (H)		M-H	M-H	L-M	L			
Se	0.005	A	M	L-M-H						
Ag	0.0001	A	L-M-H	L						
Tl	0.002	DW	L-M-H	L-M						
Zn	0.02	A (H)		M-H	M-H	L				

Notes:

L - low pH leachate (pH <5.5)

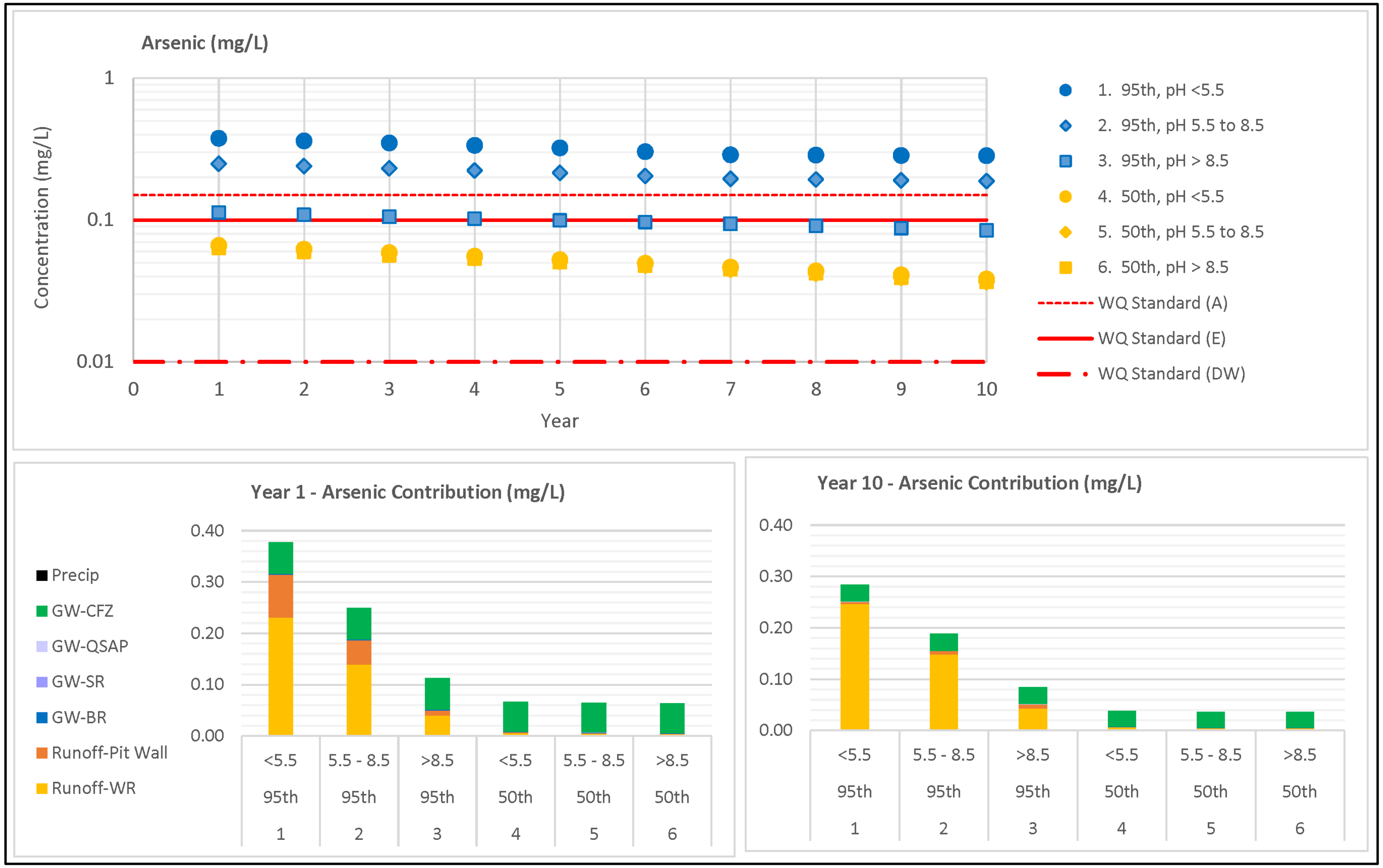
M - Medium pH leachate (pH = 5.5 to 8.5)

H - High pH leachate (>8.5)

Grey shading identifies potential for water quality exceedances based on order of magnitude predictions.

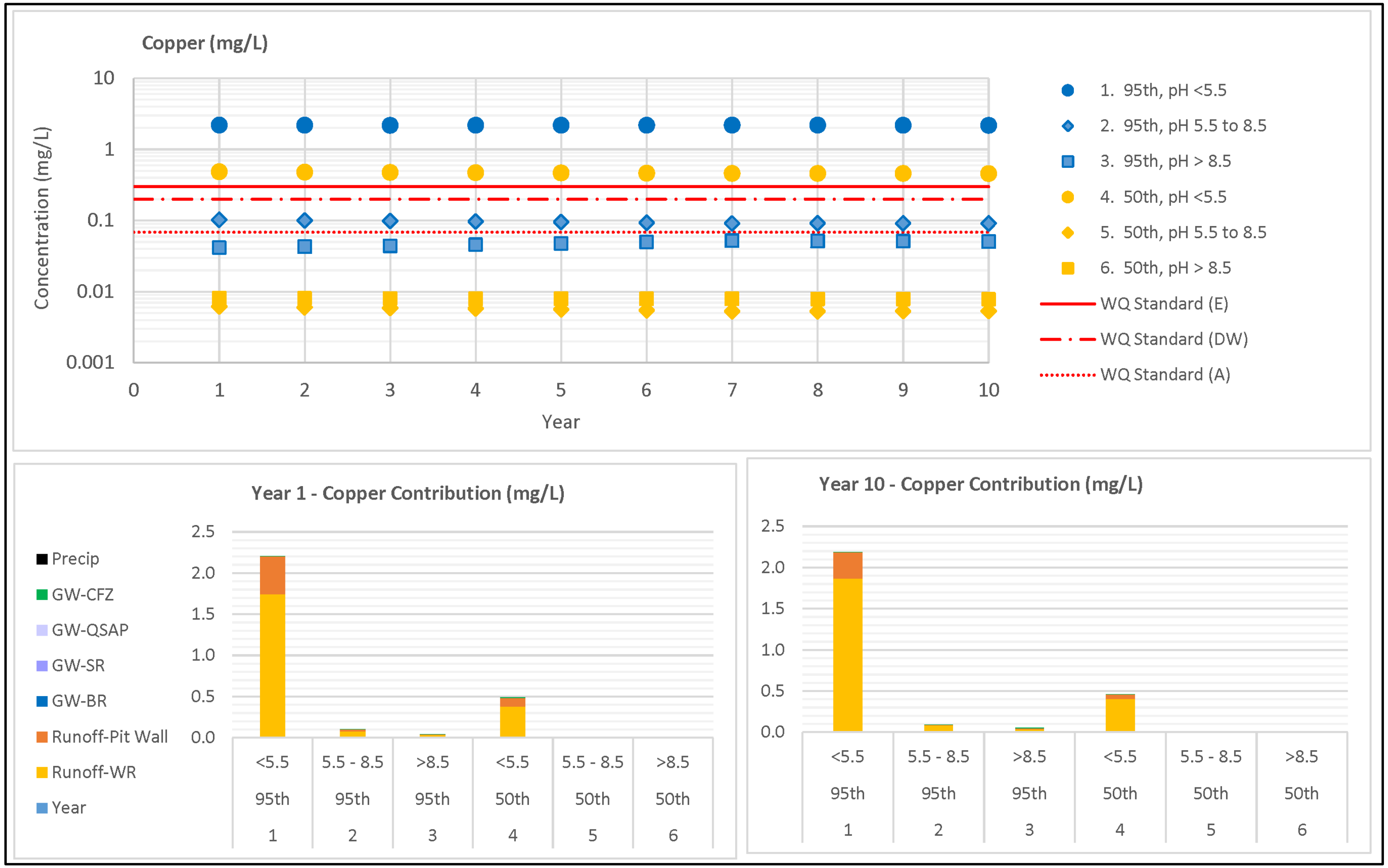
SO_4 = sulfate; Al = aluminum; Sb = antimony; As = arsenic; Ba = barium; Be = beryllium; B = boron; Cd = cadmium; Cr = chromium; Cl = chloride; Co = cobalt; Cu = copper; F = fluoride; Fe = iron; Pb = lead; Mn = manganese; Hg = mercury; Mo = molybdenum; Ni = nickel; Se = selenium; Ag = silver; Tl = thallium; Zn = zinc; mg/L = milligrams per liter; < = less than.

Figure 5.7-4 Pit Lake Water Quality Model Results - Dissolved Arsenic



WQ = water quality; A = aquatic life; E = effluent; DW = drinking water; Precip = precipitation; GW = groundwater; CFZ = Cassador Fault zone; QSAP = saprolite quartz veins; SR = saprock; BR = bedrock; mg/L = milligrams per liter; WR = waste rock;< = less than.

Figure 5.7-5 Pit Lake Water Quality Model Results - Dissolved Copper



WQ = water quality; A = aquatic life; E = effluent; DW = drinking water; Precip = precipitation; GW = groundwater; CFZ = Cassador Fault zone; QSAP = saprolite quartz veins; SR = saprock; BR = bedrock; mg/L = milligrams per liter; WR = waste rock;< = less than.

- Constituent Fate and Transport
  - As presented in Section 5.7.1.4, mixing with background surface water will result in a decrease in WRF runoff (and seepage that discharges to surface water) concentrations in streams at the concession boundary. For an average year, dilution factors are estimated to range from 26 to 67 (western drainage) and 17 to 47 (eastern drainage) (Figure 5.7-3). At times in the year when mixing ratios are at the low end of the range, constituent concentrations in WRF runoff will thus need to be within approximately 20 times the water quality standards to ensure that concentrations in streams at the concession boundary remain below Project water quality standards, assuming conservative constituent transport.
  - The WRFs will be underlain by saprolite. For the Merian Operation, laboratory testing was conducted to evaluate the potential for the attenuation of metals due to sorption onto saprolite (Golder 2012d). Test results indicated a potential for attenuation of some parameters (e.g., As, Cu, molybdenum (Mo), Ni, Sb, Se, and Zn). During transport of seepage from the WRFs, some attention of these metals is, therefore, likely.
  - Arsenic and nitrate are two primary COPCs. Under reducing conditions, arsenic mobility is typically high. Under oxidizing and circum-neutral pH conditions, arsenic may be attenuated due to sorption or co-precipitation with iron (oxy)hydroxide phases; however, under reducing conditions these minerals become unstable and undergo reductive dissolution. In surface water, it is assumed that nitrate transport will be conservative. Because nitrate is not adsorbed significantly and is very unlikely to precipitate as a secondary mineral, it is typically transported conservatively (i.e., is not attenuated) in surface water or through the vadose zone to the groundwater table (Chapelle 2001; Wilhelm et al. 1994). Nitrate is mobile in aerobic (oxidized) groundwater and surface water systems. Under reducing conditions, nitrate attenuation may occur due to denitrification.
- Management and Mitigation
  - To prevent adverse impacts to surface water and groundwater, it is assumed that treatment of WRF seepage will be required. This assumption will be verified during final design. This assessment further assumes treatment of arsenic, and likely other metals, in WRF seepage that can be collected, prior to discharge to the environment. The need for treatment of WRF runoff will be assessed once additional information are available.
  - Geochemical testing has shown that the amount of arsenic leaching is correlated to solid phase arsenic concentration (i.e., leachate concentrations generally increase as solid phase concentrations increase). Management of waste rock may, therefore, include segregation and encapsulation of rock with elevated arsenic concentrations to limit exposure to oxygen and water.
  - Pit lake water quality modeling has indicated a potential for elevated metal and possibly sulfate concentrations. To improve pit lake water quality, rapid filling of the pit by the diversion of surface water into the pit may be considered. Rapid filling is intended to decrease the exposure time of reactive sulfides present in the pit wall faces. Inundation prevents exposure to atmospheric oxygen and is, therefore, an effective way to reduce metal and sulfate loading from sulfide oxidation.

Predicted impacts to water quality in the absence of any mitigation measures are summarized in Table 5.7-10. Residual impacts following effective implementation of mitigation measures, if deemed necessary, are also summarized in Table 5.7-10.

Table 5.7-10 Water Quality Classification of Effects (Pre and Post Mitigation), Consequence and Likelihood

Effect	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation Impact Classification	Post-Mitigation Impact Classification	Mitigation
Operation and Closure								
Effect of WRF runoff on surface water quality (ARD/ML)	Negative	Moderate (Low with mitigation)	Local to Regional	Long-term	Possible to Likely	Medium	Low	• Implement runoff and seepage collection and treatment (if necessary), facility design to minimize ARD/ML (e.g., reactive material segregation and encapsulation, placement of covers).
Effect of WRF seepage on groundwater quality (ARD/ML)	Negative	High [(a)] (Low to Moderate with mitigation)	Local [(b)]	Long-term	Likely	High	Medium	
Operation								
Effect of ore stockpile runoff on surface water quality (ARD/ML)	Negative	High (Low to Moderate with mitigation)	Local	Medium-term	Likely	High	Low	• Install a liner; runoff collection and treatment (if necessary).
Effect of ore stockpile seepage on groundwater quality (ARD/ML)	Negative	High (Low to Moderate with mitigation) [(a)]	Local	Medium-term	Likely	High	Low	
Effect of decreased artisanal and small scale mining (ASM) on surface and groundwater quality	Positive	N/A [(c)]	Local to Regional	Long-Term	Likely	N/A	N/A	-
Effect of erosion on surface water quality (increased TSS)	Negative	Moderate (Low with mitigation)	Local to Regional	Long-Term	Likely (Possible with mitigation)	High	Low	• Install sediment control structures, use of flocculant.
Effect of accidental spills on surface water or groundwater quality	Negative	Moderate	Local to Regional	Medium-term	Likely (Possible with Mitigation)	Medium	Low	• Implement standard spill prevention and control measures.
Closure								
Pit Lake water quality (ARD/ML)	Negative	High (Moderate to Low with mitigation)	Local	Long-term	Likely	High	Medium	• Carry out WRF management (to improve the quality of runoff into the pit), rapid filing, in-situ treatment (if necessary).

Notes:

a) Attenuation of metals by sorption to saprolite expected.

b) A comprehensive fate and transport analysis may be required to evaluate the potential for regional impacts.

c) Reduction in ASM should reduce mercury loading to the environment.

N/A = not applicable; ARD = acid rock drainage; ML = metal leaching; WRF = waste rock facility; TSS = total suspended solids.

5.7.7 Cumulative Effects Case Impact Assessment

Project facilities are located within the Commewijne River watershed. The Merian Operation is also located within this watershed. The cumulative effects from the two operations on water quality were not assessed. The objective of both operations is to have no exceedances of Project water quality standards at the concession boundary. Adaptive management procedures will/are used to achieve this objective. Therefore, a cumulative effects impact assessment was not conducted.

5.7.8 Human Rights Impact Assessment

Three aspects of the Project's potential to impact water rights were assessed for their risk in the context of human rights. These are the danger to rights of localized water users from a spill of hazardous materials, the positive contribution to water quality from limiting current artisanal and small scale mining (ASM) impacts, and the risks associated with potential long-term water contamination. Human rights are inter-dependent, and the right to water has implications on the right to a healthy environment and the right to health; water contamination has implications for the rights to property, to self-determination and to freely dispose of natural wealth and resources.

5.7.8.1 Potential Impact on Human Rights

The human right to water[1] is a condition for the enjoyment of the right to an adequate standard of living. Everyone is entitled to safe, sufficient, acceptable, affordable and physically accessible water for personal and domestic uses.[2] To fulfill this right, the water available has to be of good quality, free from elements that might harm a person's health, and in a minimum quantity per day. Company activities may impact access to water if pollution significantly interferes with people's enjoyment of access to water[3] or through inadequate provision of water in workers' accommodations. The long-term potential for negative water quality impacts – some not fully defined yet – has implications for the right to property. This has implications for the right of the Kawina to freely dispose of their natural wealth and resources as aspects of the right to self-determination.[4]

Accidental spills with impacts to nearby water bodies. The short-term impacts from accidental spills from hazardous material transport along the Project access routes to surface and groundwater quality have the potential to negatively impact water resources, potentially causing harm to the communities that use these water resources; such impacts would be addressed within the mitigation plans and remediated but may have residual impacts. The risks would be to the right to water and the right to health; the right to an adequate standard of living could be impacted in that case.

Restrictions to ASM activities within the Project boundaries would improve water quality of the streams throughout the life of the Project including during closure; the effect would be to the right to water and the right to health. Post closure, the likelihood for ASM activity to resume is small but is present and could affect water quality.

Long-term water quality issues are possible, as the pits and WRFs may potentially generate acid, with the potential to mobilize heavy metals. Post-closure seepage and runoff from the waste rock

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[1] The human rights to water and sanitation are derived from the International Covenant on Economic, Social and Cultural Rights, articles 11 and 12. This interpretation was confirmed by the UN General Assembly in Resolution 64/292, as well as in General Comment 15 on the Right to Water of the Committee on Economic, Social and Cultural Rights, E/C.12/2002/11, 20 January 2003.

[2] For information about dimensions of the human rights to water and sanitation, see UN Global Compact CEO Water Mandate, Shift and Pacific Institute, "Guidance for Companies on Respecting the Human Rights to Water and Sanitation: Bringing a Human Rights Lens to Corporate Water Stewardship," p. 17.

[3] Human Rights Translated: A Business Reference Guide, pp. 118.

[4] These are aspects of Article 1 of the ICCPR, the right to self-determination.

facilities carrying heavy metals will me monitored and treated as necessary to maintain permissible levels at the Project boundaries. The magnitude of the potential risk to the right to water remains uncertain however, and further testing is necessary to fully characterize the geochemistry of the waste rock. The risks would be to the right to water and the right to health.

The Project is located in the Commewijne watershed, and all water quality impacts other than road accidents, are restricted to that watershed. The communities are downstream from the Project, at some distance, but to the extent that any populations live there, they will rely on the same watershed for their water. In the event of a catastrophic incident, the potential contamination of water used by Kawina communities could potentially affect hunting and fishing activities on their traditional lands, could have implications for health, and may limit future options for the use of the land. Potential water effects from acid generation and the capacity to control them represents a risk to the right to property.

The remaining water quality issues identified should be adequately addressed during the life of mine and should pose limited risk to human rights.

5.7.8.2 Qualification of Impacts to the Right to Water

The risk to the right to health from accidental spillage is negative and potentially high severity as the spill could be of a hazardous substance. However, the probability is low when taking into consideration the management and mitigation plans, for an overall human rights prioritization of medium. It will require attention to prevent these impacts.

The possible reduction of current contamination by ASM has the potential to positively impact the right to water and the right to health. At present, there are no communities that would benefit from this improvement directly, though episodic use of the area occurs. Should the Kawina return to their traditional lands during the Project’s active management of the site, the Project’s influence would contribute positively to enjoyment of the right to water. It is a potential impact as it is not yet occurring, with low scale and probable likelihood to occur. Human rights prioritization is low as a positive impact.

The post-closure runoff from the waste rock facility has the potential to transport heavy metals, particularly arsenic. Mitigations described in the ESIA include an effluent water treatment plant and selective handling of potentially acid generating waste rock. At the present level of understanding, the impact is negative, potential and the severity is uncertain. The mitigation measures should reduce the probability to only possible. This leads to the determination that the human rights prioritization is medium. The impact, should it occur would be caused by the Project, which therefore has responsibility to prevent or mitigate these impacts (Table 5.7-11).

Table 5.7-11 Human Rights Identification and Classification of Effects

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity/scale**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Accidental spills of hazardous materials	Negative, Low	Right to water, health, and an adequate standard of living	Powakka residents and communities along the Afobaka Road whose watersheds might be impacted	Negative	Potential	High	Potential	Medium	Cause
Restrict ASM activities within Project boundaries	Positive, Low	Right to water, right to health	Kawina people	Positive	Potential	Low	Probable	Low	Cause
Contamination from waste rock facilities	Negative, Possible	Right to water, right to health	Kawina people	Negative	Potential	Uncertain	Potential	Medium	Cause

ESIA = environmental and social impact assessment; ASM = artisanal and small scale mining; HR = human rights.

5.7.9 Additional Data Requirements to Validate the Impact Assessment

Prior to construction, the following additional monitoring should be performed.

- **Tempati Creek Stations**: A single round of samples was collected at these stations. Additional baseline monitoring should be conducted once access to these sites improves.
- **ESIA Baseline Surface Water Monitoring**: Continued monitoring at existing stations and new stations, once established (see Section 5.7.10).
- **ESIA Baseline Groundwater Monitoring**: Continued monitoring at existing monitoring wells and new wells, once established (see Section 5.7.10).

As described in the baseline geochemistry section, additional geochemical data will be collected to refine predictions of ARD and ML potential. This information should be used to refine predictions of source water qualities (i.e., WRF seepage and runoff; ore stockpile seepage and runoff; pit lake water quality). The surface water and groundwater quality impacts presented in this assessment should be updated following refinement of source water qualities. Prior to operations, additional fate and transport evaluation should be performed. As noted earlier, predictions of pit lake water quality at closure should be refined once operational data are available. These represent the most relevant data for accurate prediction of pit water quality at closure.

5.7.10 Monitoring

Surface and groundwater quality monitoring will continue at existing monitoring locations to determine baseline and operational conditions.

The current surface water monitoring network was established to characterize baseline conditions in the vicinity of the Sabajo deposit, and to a lesser extent the Santa Barbara deposit. Portions of the Margo and Santa Barbara areas are, therefore, outside of the current monitoring network, and additional surface stations are needed to monitor water quality. Specifically, a new station should be established downgradient of Margo on the eastern branch of Creek 2. Compliance surface water monitoring stations should be established on Creek 1 and Creek 2 at the concession boundary.

The groundwater monitoring well network is also focused on the Sabajo area. The Margo and Santa Barbara areas are, therefore, outside of the current monitoring network. Additional wells should be installed in these areas to characterize groundwater conditions.

The water quality monitoring program is set out in more detail in the Environmental and Social Monitoring and Management Plan (ESMMP; Volume B of this ESIA).

5.8 Biodiversity

5.8.1 Biodiversity Discipline Methods

The Newmont Suriname, LLC (Newmont) Biodiversity Management Standard sets core requirements for the management of biodiversity at Newmont owned, operated and/or managed operations and lands with the goal of ensuring a consistent approach to biodiversity conservation and sustainable stewardship of resources. It requires all new projects and major expansions to achieve *no net loss* of key biodiversity values as a result of mine-related activities *or a net gain, when possible*, within 10 years post mine closure.

Biodiversity impact assessment and mitigation planning conform to methods described in:

- *Good Practices for Biodiversity Inclusive Impact Assessment and Management Planning.* 2015. Multilateral Financing Institutions Biodiversity Working Group (https://www.hg-llc.com/publications/); and
- Newmont's Biodiversity Management Standard and its Guidance note.

The impact assessment method for biodiversity is a modification of the general Sabajo Project (the Project) Environmental and Social Impact Assessment (ESIA) method described in Section 5.1. The method still considers severity, geographic extent and duration to help define significant impacts. However, rather than combining criteria ratings to calculate environmental consequence, a significant impact on biodiversity is defined as any impact requiring mitigation in order to achieve no net loss of biodiversity, per Newmont's Biodiversity Standard.

As is typical for neo-tropical settings, scientific information is not complete for this area. Therefore, follow-up data collection and analyses will be necessary to fill remaining knowledge gaps prior to Project construction. Existing knowledge gaps are clearly identified in this chapter and follow-up steps are detailed in Section 5.8.8.

Key Biodiversity Values

For purposes of this study, Key Biodiversity Values (KBVs) are:

- ***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.
- ***Species of conservation priority:*** Species listed as Endangered or Critically Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species or equivalently listed on national, regional, and/or state/provincial lists, restricted-range species, and globally significant concentrations of migratory species and/or congregatory species that utilize the site.

Newmont's Biodiversity Management Standard includes within its definition of KBVs the concept of "critical habitat" as defined by the International Finance Corporation's (IFC) Performance Standard 6 (PS6). *All natural habitats and species of conservation priority are afforded the same level of protection as those required by IFC for critical habitat*, therefore it is not necessary to perform a separate critical habitat assessment for Newmont ESIAs. In other words, to achieve the requirements of Newmont's Biodiversity Management Standard, the Sabajo Project must prevent the net loss, if not improve the conservation, of any of the KBVs (species and habitats) known to occur within its area of influence.

Based on the baseline studies a number of KBVs were identified for impact assessment and consideration for mitigation planning (Table 5.8-1). It is important to note that numerous species inhabit the biologically diverse habitats of the study area and each has intrinsic value. *Where this study does not explicitly mention a specific species, it should be assumed that it is considered as a component of a habitat that serves as a surrogate for impact assessment and management planning.* Species that are identified specifically in this study are those that may require assessment and management planning beyond what can be accomplished using a habitat surrogate.

Several species with uncertain taxonomy will be the subject of follow-up baseline study and analysis, as detailed in Section 5.8.7. If they prove to fit the definition of species of conservation priority, they will become KBVs. In addition, one habitat type, wet savanna forest on sandy soil, will also be the subject of follow-up baseline work and analysis to determine its rarity in the region.

Table 5.8-1 Key Biodiversity Values in Study Area

Natural Habitats		
#	**Habitat Name**	**Conservation Notes**
1	Marsh forest in floodplain – Kleine Commewijne (Little Commewijne)	Widely impacted by artisanal and small scale mining (ASM) in Suriname
2	Marsh forest in floodplain – Tempati	Widely impacted by ASM in Suriname
3	Creek forest	Widely impacted by ASM in Suriname
4	Wet savanna forest on sandy soil (w/ xeric aspect)	A less common habitat type in Suriname -- total extent unknown.
5	Marsh forest on loamy soil	Widely impacted by ASM in Suriname
6	Dry mountain savanna forest on duricrust (xeric to meso-xeric)	None
7	High dryland forest	Subject to logging in Suriname
8	Kleine Commewijne River and smaller streams	Upper tributaries of Commewijne River, impacted by ASM
9	Tempati Creek and smaller streams	Upper tributaries of Commewijne River, impacted by ASM

Species – Plants				
#	**Scientific Name**	**Common Name**	**Habitat Association**	**Conservation Notes**
10	Elaeis aff. oleifera	None	Wet savanna forest on sandy soil	Restricted to forests on white sand and savanna brush, very rare in F. Guiana and Suriname
11	Virola surinamensis	Baboonwood	Multiple forest types	IUCN Red List - Endangered, although common throughout Suriname
12	Vouacapoua americana	Bruinheart	High dryland forest	IUCN Red List - Critically Endangered, although common throughout Suriname

IUCN = International Union for Conservation of Nature; # = number.

5.8.2 Impacts and Linkages to Project

The Project can be linked to the following types of biodiversity impacts:

Habitat loss: the project footprint (886 hectares [ha]) will be cleared of terrestrial natural habitats (716 ha). A portion of the project footprint (170 ha) will be on areas already cleared of natural habitat by artisanal and small scale mining (ASM). In addition, 6 kilometers (km) of streams and drainages will be directly impacted within the footprint, all of which have either been directly intervened previously by ASM or are upstream of ASM impacts and therefore have degraded ecological function from impaired connectivity.

Habitat degradation: removal of terrestrial habitat increases fragmentation at the scale of the landscape, reducing the movements of living organisms across the landscape. Fragmentation can also occur through the loss of sections of stream habitat which hinder aquatic species' movement. Terrestrial habitats not removed in the footprint, but within a buffer of 100 meters (m) of roads and mining operations may experience some degree of edge effects (Laurance et al. 2002) and disturbance from light and noise. Riparian vegetation communities may be impacted by changes to surface water flow or quality. Aquatic habitats also have the risk of being degraded by changes in flow, sedimentation and contamination.

Species mortality and population loss: In addition to habitat loss, fragmentation, and degradation, other impacts may selectively result in flora and fauna mortality. Potential risks of this Project include mortality during site clearing, vehicular collisions with wildlife, introduction and spread of invasive species, introduction and spread of animal or plant disease.

5.8.3 Key Indicators

Natural habitats serve as a surrogate for the diversity and structure of species that reside in them and their ecological functions. This study uses *quality-hectares* (QH) as the measure of habitats and their condition. The common currency for analysis of a given habitat type is calculated as:

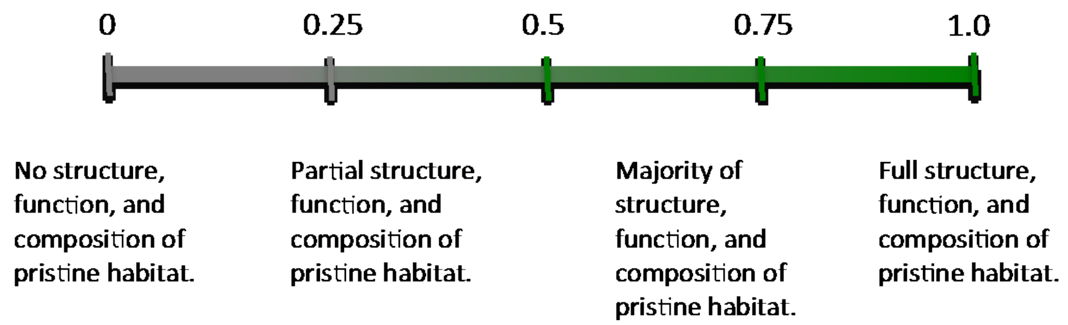
QH = area of habitat (ha) * quality of habitat (Q)

For streams, hectares of habitat can be replaced with linear kilometers (km):

QH = length of stream (km) * quality of habitat (Q)

For purposes of this analysis we use a simplified quality metric (Figure 5.8-1).

Figure 5.8-1 Quality Multipliers for Quality-Hectares



In cases where individual species may be considered particularly vulnerable to project impacts, an additional indicator is used – *viability*. Viability is defined as the ability of the local population of a species to be self-sustaining over the long term, and is evaluated at an ecologically appropriate spatial scale (see Section 5.8.5) for each species. This indicator is qualitative and based on expert opinion, not based on a quantitative population viability model.

Project indicators for biodiversity are presented in Table 5.8-2.

Table 5.8-2 Project Indicators for Biodiversity

Issue Number	Key Issue	Indicators
1-9	Habitat loss Habitat fragmentation and degradation	Change in quality-hectares of natural habitat, by type: Area of habitat (ha) x Quality of natural habitat (Q: 0-1) -or- Length of stream (km) x Quality of natural habitat (Q: 0-1)
10-12	Species mortality and population loss	Reduction or loss of viability of species in the ecologically appropriate area of analysis (see Section 5.8.5)

ha = hectare; km = kilometer.

5.8.4 Spatial and Temporal Considerations

The impact assessment for biodiversity uses three spatial scales for analysis.

- *Project footprint:* the area physically occupied by the mining operation and its infrastructure (Map 5.1-4).
- *Project area of influence*: the geographic area of anticipated project activities and impacts, including the area physically occupied by mining activities, infrastructure and facilities, emissions, effluents, light and noise. No areas of induced/indirect impact are included as the Project does not expect third-party settlement or economic activity in the vicinity of the mine.
- *KBV-specific ecologically appropriate areas of analysis* (EAAA): the local distribution of KBVs in the landscape and the ecological patterns, processes, and functions that are necessary for maintaining them. The EAAA for a given species may vary. For species with large geographic distributions, the ecologically appropriate area may be defined by geographic features such as watersheds that, at a minimum, encompass the area of influence of the Project. For some wide-ranging species, it may not be appropriate to define an ecologically appropriate area based on area of occupancy, but rather areas of aggregation, recruitment, or other habitat features of importance to the species. In all cases, the area should consider the distribution and connectivity of such features in the landscape/seascape and the ecological processes that support them.

The impact assessment assumes that impacts are permanent from the mining pit. Progressive rehabilitation will take place in all other locations. Areas rehabilitated are assumed to recover half of their ecological function within 10 years of mine closure[1], as explained in Section 5.8.6.

5.8.5 Project Case Impact Assessment

5.8.5.1 Pre-Mitigation Impact Assessment

A *significant impact on biodiversity* is defined as any impact requiring mitigation in order to achieve *no net loss* of biodiversity, per Newmont's Biodiversity Standard. In other words, impacts that will result in the permanent loss of habitats or reduce the viability of a species is significant.

A number of significant impacts will occur from the construction and operation of this project, and therefore will require mitigation.

- The project footprint overlay on the habitat maps (Maps 4.11-1 to 4.11-3) provide a basis for calculating the total loss of each terrestrial natural habitat type in the study area, as shown in

[1] Pilot tests are underway at Newmont's Merian mine and projections for the recovery rate of rehabilitated areas will be revised based on that experience.

Table 5.8-3 and Table 5.8-4. It is important to note that these areas are based on the current project footprint and will be revised during final engineering. Accordingly the adjusts may be greater than or lesser than those areas defined in the tables provided. Terrestrial impacts are estimated as the total area of natural habitat multiplied by a quality co-efficient of 1 (i.e., pristine). Baseline studies indicate that much of the area has been impacted by mechanized logging, therefore using a coefficient of 1 is conservative. In all cases, habitat loss *without* mitigation is a long-term impact (>16 years).

- The project footprint overlay also shows where river and stream habitat will be lost and where the Sabajo-Merian Haul Road crosses streams and rivers. In addition to habitat loss, there is potential to increase sedimentation, to impair normal hydrologic function, and reduce connectivity for migrating fish. For aquatic habitat, an estimate of total stream length within the footprint is multiplied by a quality coefficient of 0.5 reflecting the findings of the baseline studies that showed that much of this habitat has been impacted by ASM (Table 4.11-9). Aquatic habitat loss and degradation *without* mitigation is likely a long-term impact (>16 years).
- Impacts to especially vulnerable species are also significant in some cases, as their local viability may decline if *no mitigation* is applied, as shown in Table 5.8-5. By definition, declining viability is a long-term impact (>16 years). In the cases of *Virola surinamensis* and *Vouacapoua americana*, we use the watersheds that encompass the area of influence of the project as the EAAA because both species have wide geographic distributions (see definition of EAAA above).

In some cases, insufficient scientific information is available on individual species to assess impacts at this time. This is a normal occurrence in tropical ecosystems. In compliance with Newmont's Biodiversity Standard, the company will perform follow-up baseline work and analyses *prior* to construction to resolve current scientific knowledge gaps and to ensure that adequate mitigation is designed to ensure there is no net loss of these species, as detailed in Section 5.8.7.

Table 5.8-3 Estimated Pre-Mitigation Terrestrial Natural Habitat Loss

#	Habitat Name	Impact Area (ha)	Pre-Impact Quality (Q:0-1)	Pre-Impact (Q-ha)	Post-Impact Quality (Q:0-1)	Post-Impact (Q-ha)	Net Impact Without Mitigation (Q-ha)
1	Marsh forest in floodplain – Kleine-Commewijne	49	1	49	0	0	-49
2	Marsh forest in floodplain – Tempati	20	1	20	0	0	-20
3	Creek forest	85	1	85	0	0	-85
4	Wet savanna forest on sandy soil (w/ xeric aspect)	69	1	69	0	0	-69
5	Marsh forest on loamy soil	1	1	1	0	0	-1
6	Dry mountain savanna forest on duricrust (xeric to meso-xeric	2	1	2	0	0	-2
7	High dryland forest	474	1	474	0	0	-474
	Habitat not categorized	16	1	16	0	0	-16
	Total	716		716		0	-716

ha = hectare; Q = quality of habitat.

Table 5.8-4 Estimated Pre-Mitigation Aquatic Habitat Loss*

#	Habitat Name	Impact Stream Length (km)	Pre-Impact Quality (Q:0-1)	Pre-Impact (Q-km)	Post-Impact Quality (Q: 0-1)	Post-Impact (Q-km)	Net Impact Without Mitigation (Q-km)
8	Kleine-Commewijne River and streams	6	0.5	3	0	0	-3
9	Tempati Creek and streams	0					0
	Total	6		3		0	-3

Note: Total stream lengths are estimated. They will be measured with more precision, as described in Section 5.8.7
km = kilometer; Q = quality of habitat.

Table 5.8-5 Estimated Pre-Mitigation Key Biodiversity Value Species Impacts

#	Species Name	Conservation Notes	Associated Habitat	EAAA	% EAAA Impacted	Other Project Impacts	Consequence (Significance of Impact)
Plants							
10	Elaeis aff. oleifera	Restricted to forests on white sand and savanna brush, very rare in F. Guiana and Suriname	Wet savanna forest on sandy soil	Unknown	Unknown	None	Not assessed. Will be subject of follow-up study on wet savanna forest habitat.
11	Virola surinamensis	IUCN Red List - Endangered, although common throughout Suriname	Multiple forest types	Klein-Commewijne (65,092 ha) and Tempati watersheds (87,571 ha)	<1%	None	Viability in EAAA may be reduced.
12	Vouacapoua americana	IUCN Red List - Critically Endangered, although common throughout Suriname	High dryland forest	Klein-Commewijne (65,092 ha) and Tempati watersheds (87,571 ha)	<1%	None	Viability in EAAA is reduced.

KBV = Key Biodiversity Value; IUCN = International Union for Conservation of Nature; EAAA = ecologically appropriate areas of analysis; < = less than; % = percent.

5.8.5.2 Mitigation Plan

Mitigation is defined as any actions that correspond to the four components of the mitigation hierarchy: avoid, minimize, rehabilitate, and offset. Following is a description of the strategies to be undertaken for each. Specific actions for each strategy are detailed in the Environmental Management Plan.

Avoid

Design options for the road between Sabajo and Merian (Sabajo-Merian Haul Road) included three alternatives as shown in Map 3-1. Alternatives 2 and 3 were eliminated, in part due to the risk of impacting areas of potentially greater conservation value due to proximity to the foothills of Adelaarstop Mountain, which could include habitat for rare endemic and restricted-range species.

Additional study is scheduled for wet savanna forest on sandy soil, as described in Section 5.8.7. If it is determined that this habitat type and/or species inhabiting it require special protection, additional avoidance actions may be planned. At present, there is insufficient information to guide such a mitigation decision.

Minimize

As discussed elsewhere, construction and operational activities at Sabajo will be subject to environmental controls that minimize the potential impacts to water quality (Section 5.7), air quality (Section 5.2), noise (Section 5.3), light (Section 5.11), and soil contamination (Section 5.4). All have relevance to biodiversity protection as they prevent the degradation of natural habitats in the project area of influence.

The Sabajo-Merian Haul Road involves three minimization actions for biodiversity.

1) Reduced clearing at several locations along the right of way of the Sabajo-Merian Haul Road, where wildlife may be more likely to attempt to traverse the road. Those locations will be determined prior to construction based on landscape factors that will maximize connectivity.
2) Bridges over three river crossings, with spans sufficient to allow for normal hydrologic function of the rivers, ensure connectivity for migrating fish, and to allow the free movement of terrestrial wildlife that use riparian corridors for movement across the landscape. Bridges will span the Klein Commewijne (42 m length), the Tempati (100 m length), and Las Dominicanas (25 m length).
3) Traffic controls to minimize wildlife collisions, including driver awareness through education and signage and requirements for driver adherence to speed limits of 30 to 40 km/hour on the Sabajo-Merian Haul Road.

Ongoing vigilance will be required during road and mine construction and operation to ensure that unnecessary habitat damage is not caused.

During construction and operations, the company will bury organic wastes generated at the site daily and restrict wildlife access to disposal area by routine covering of the organic waste facility.

The company will prohibit hunting and fishing including by its own staff and contractors within the Right of Exploitation.

The company will implement measures to prevent, detect, control and report introductions of invasive exotic species. These include: clean equipment when it arrives at site; prohibit staff from bringing plants and animals to site; minimize unnecessary soil disturbance; maximize the use of native species in reclamation; revegetate as soon as practicable after soil disturbance; seek weed-free seed sources; monitor for occurrences of invasive exotic species at the project site; eradicate invasive exotic species when detected; and monitor the efficacy of control measures.

At present there are no known species at site that require relocation to support a conservation program to maintain their viability. In such case that it is required, relocation of plants and wildlife will be limited to those species where a science-based program is in place.

While “rescue and relocation” is not planned, directional clearing of Project sites to allow wildlife dispersal will be considered on a site to site basis, through discussion between environmental staff and the mine design team. The goal will be when possible to plan clearing in a direction that will prompt mobile faunal species to move ahead of disturbance into un-disturbed areas.

Rehabilitate

The project will implement progressive rehabilitation. Sites disturbed during construction and through the life of mine will be rehabilitated as soon as they are no longer used. The remaining operational areas will be rehabilitated at closure with the exception of the mining pit (126 ha).

The entire waste rock storage area will be rehabilitated as high dryland forest rather than the mosaic of habitat types occurring there prior to construction, including a portion that was impacted prior to mine development (thus resulting in the difference in rehabilitation area of high dryland forest, 587 ha, versus the area impacted, 474 ha).

Rehabilitated terrestrial habitats are expected to achieve a quality of 0.5 (on the quality scale of 0-1 described in Section 5.8.4) within 10 years of mine closure. Rehabilitation of terrestrial habitat will integrate plant species of concern listed in Table 5.8-1, and others of conservation value, to target that more individuals are replaced than lost. These species will be propagated in a nursery at Merian, where germplasm collection and restoration trials will begin soon as part of the progressive restoration plan for that operation.

We assume that rehabilitation of streams impacted within the mine footprint area will not be possible, with the exception of up to 0.5 km, which may achieve 80% of the quality of pristine aquatic habitat (quality = 0.8) – an improvement over the pre-project quality.

Similar restoration approaches have not been conducted before in Suriname and therefore we use conservative estimates for potential restoration outcomes, which are presently being tested with pilot restoration trials at Merian.

Offset

A biodiversity offset will be implemented to compensate for residual impacts not mitigated by avoidance, minimization, and rehabilitation. It is expected that the offset will seek to restore natural habitats *outside of the project footprint*, both aquatic and terrestrial, *impacted by ASM prior* to Sabajo's construction. The goal of the offset will be to restore *up to* 750 ha of impacted terrestrial habitat outside of the project footprint, and directly improve the average quality of *up to* 36 km of streams (as detailed in Table 5.8-8). Stream improvements may also indirectly benefit *up to* 184 km of upstream habitat by improving ecological connectivity. The offset area is scalable depending on actual mine footprint disturbed and dependent on actual quality hectares restored.

Newmont Suriname will conduct restoration actions of two types:

- First, machinery will be used to reshape streambeds that have been impacted by ASM. This work will reconstruct creek morphology to something similar to nearby non-impacted creeks, with the expectation that hydraulic forces will continue to modify and restore natural creek morphology once flow has been restored. Care will be taken not to remobilize significant amounts of residual mercury from ASM.
- Second, revegetation treatments will be implemented, following a system currently being pilot tested at Merian, to optimize the recovery of forests. Riparian vegetation will provide direct benefits to terrestrial plants and animals as well as providing organic inputs to aquatic ecosystems and regulating water temperature.

In addition to active restoration, the company will control (to the extent possible) artisanal mining activity within the area. This will reduce or avoid disturbance to sites that have not previously been damaged by informal mining, as well as avoid the re-disturbance of areas already impacted. It will also help to reduce hunting pressure on wildlife.

The offset will produce two types of benefits. First, by restoring aquatic and terrestrial habitats, Newmont's activities should produce direct benefits for biodiversity within the project's Right of Exploitation. Over the life of mine, Newmont Suriname will attempt to carry out restoration activities that produce benefits of a magnitude that is similar to the residual impacts of the mine. Second, Newmont Suriname seeks to document and share its restoration experience with the broader scientific and conservation communities in the Guianas and more broadly in the tropics. Currently little information is available on restoring sites impacted by artisanal mining – Newmont's experience will contribute significantly to biodiversity conservation in the region.

As with other rehabilitated areas, it is assumed the offset can be expected to restore roughly half of the ecological quality of a pristine terrestrial habitat (quality = 0.5), and improve average stream quality to 80% of pristine aquatic habitat (quality = 0.8). Depending on implementation success, it is possible that actual restoration will result in higher quality hectares and therefore a smaller offset area.

The terrestrial offset will be concentrated in creek forest and marsh forest. The aquatic benefits will accrue primarily to the streams in the Kleine-Commewijne watershed. These habitats are a conservation priority because: a) they are most threatened at a regional scale by informal mining; b) they are more limited than other habitats (e.g. dryland forests) and provide specific habitat for a number of species; c) riparian habitats play important functional roles for wildlife dispersal; d) rivers and riparian areas maintain key ecological processes related to the hydrologic flood regime. Given their priority for conservation, restoration of these riparian habitats is considered "like-for-like or better" compensation for the most impacted habitat at the site, high dryland forest.

5.8.5.3 Post-Mitigation Impact Assessment

The mitigation plan eliminates all significant impacts to KBVs; the tables below show how planned offset measures will increase habitat (Tables 5.8-6 to 5.8-9). Consistent with Newmont's corporate goal to achieve no net loss, if not a gain in biodiversity at all new projects, the mitigation plan results in a net gain in natural habitat (noting that additional analysis will be conducted for wet savanna forest on sandy soil) and no loss in the viability of KBV species (noting that additional analysis will be conducted for *Elaeis aff. Oleifera*), Table 5.8-10. With regard to habitats, the Project's compensation will focus on marsh and creek forests as "like-for-like or better," therefore the net gain in habitat is calculated as the net of all habitat types combined. As previously noted, the tables below represent the biodiversity losses based on the current footprint and will be adjusted based on the final design executed for the Sabajo Project.

Table 5.8-6 Estimated Terrestrial Natural Habitat Loss After Rehabilitation

#	Habitat Name	Impact Without Mitigation (Q-ha)	Rehab Area (ha)	Post Rehab Quality (Q: 0-1)	Post Rehab (Q-ha)	Net Impact (Q-ha)
1	Marsh forest in floodplain – Kleine-Commewijne	-49	40	0.5	20	-29
2	Marsh forest in floodplain – Tempati	-20	20	0.5	10	-10
3	Creek forest	-85	66	0.5	33	-52
4	Wet savanna forest on sandy soil (w/ xeric aspect)	-69	29	0.5	14	-54
5	Marsh forest on loamy soil	-1	0	0.5	0	-1
6	Dry mountain savanna forest on duricrust (xeric to meso-xeric	-2	0	0.5	0	-2
7	High dryland forest	-474	587	0.5	293	-181
	Habitat not categorized	-16	0	0.5	8	-8
	Total	-716	740		378	-321

Note: Rehabilitation area is net of total area impacted, minus areas that cannot be rehabilitated (pit, waste rock facility, haul roads).

Q = quality of habitat; ha = hectare; # = number.

Table 5.8-7 Estimated Aquatic Habitat Loss After Minimization and Rehabilitation

#	Habitat Name	Impact Without Mitigation (Q-km)	Rehab (km)	Post Rehab Quality (Q: 0-1)	Post Rehab (Q-km)	Net Impact (Q-km)
8	Kleine-Commewijne River and streams	-3	0.5	0.8	0.4	-2.6
9	Tempati Creek and streams	0				0
	Total	-3		0.8	0.4	-2.6

Q = quality of habitat; km = kilometer; # = number.

Table 5.8-8 Estimated Terrestrial Habitat Loss With Minimization, Rehabilitation, and Offset

#	Habitat Name	Impact Without Mitigation (Q-ha)	Rehab Area (Q-ha)	Offset Area	Post Rehab Quality (Q:0-1)	Post Rehab + Offset (Q-ha)	Net Impact (Q-ha)
1	Marsh forest in floodplain – Kleine-Commewijne	-49	40	500	0.5	271	222
2	Marsh forest in floodplain – Tempati	-20	20	0	0.5	10	-10
3	Creek forest	-85	66	250	0.5	158	73
4	Wet savanna forest on sandy soil (w/ xeric aspect)	-69	29	0	0.5	14	-54
5	Marsh forest on loamy soil	-1	0	0	0.5	0	-1
6	Dry mountain savanna forest on duricrust (xeric to meso-xeric	-2	0	0	0.5	0	-2
7	High dryland forest	-474	587	0	0.5	293	-181
	Habitat not categorized	-16	0	0	0.5	0	-16
	Total	-716	740	750		745	30

Note: Restoration of creek and marsh forest is intended to compensate for impacts to other habitat types as "like-for-like or better.

Q = quality of habitat; ha = hectare; # = number.

Table 5.8-9 Estimated Aquatic Habitat Loss with Minimization, Rehabilitation, and Offset

#	Habitat Name	Impact Without Mitigation (Q-km)	Rehab (km)	Offset (km)	Post Rehab Quality (Q: 0-1)	Post Rehab + Offset (Q-km)	Net Impact (Q-km)
8	Kleine-Commewijne River and streams	-3	0.5	36	0.8	29	26
9	Tempati Creek and streams	0					0
	Total	-3		36		29	26

Q = quality of habitat; km = kilometer; # = number..

Table 5.8-10 Estimated Species-Level Impacts With Mitigation

Effect	Effect Classification	Impact Significance: Post-Mitigation	Mitigation or benefit enhancement measure
Habitat Effects	Not applicable	None	• Complete habitat offsets for zero net loss.
Impact on *Elaeis aff. Oleifera (*Restricted to forests on white sand and savanna brush, very rare in F. Guiana and Suriname)	Not applicable	Not assessed. Will be subject of follow-up study.	• To be determined after additional study.
Impact on *Virola surinamensis (*IUCN Red List - Endangered, although common throughout Suriname)	Not applicable	Negligible - Viability in EAAA is not reduced.	• Include in rehabilitation program.
Impact on *Vouacapoua americana* (IUCN Red List - Critically Endangered, although common throughout Suriname)	Not applicable	Negligible - Viability in EAAA is not reduced.	• Include in rehabilitation program.

IUCN = International Union for Conservation of Nature; EAAA = ecologically appropriate areas of analysis; < = less than; % = percent.

5.8.6 Cumulative Effects Case Impact Assessment

Cumulative effects refers to the combined impacts of past, current and future human actions on key biodiversity values of interest. In addition to the Sabajo mine, other anthropogenic activities that potentially impact biodiversity and contribute to cumulative effects in the Klein-Commewijne and Tempati watersheds include logging, informal mining, hunting and fishing, and collection of animals for the pet trade. The Sabajo Project is not expected to contribute to cumulative effects because the Project will adopt higher environmental controls than the small scale artisanal mining that it will replace in the Right of Exploitation. These controls include: water quality management; a rehabilitation and offset program to restore forests and creeks on lands disturbed by the mine, as well as outside the project footprint, ensuring a net gain in natural habitats; and, restricting public access in the Right of Exploitation which will reduce pressure on wildlife and fisheries. Cumulative effects in the region are expected to decrease due to the environmental controls adopted by the Sabajo mine.

5.8.7 Additional Study Requirements

The baseline studies to date have allowed for the identification of Key Biodiversity Values and the assessment of residual impacts after application of mitigation actions. However, gaps have been noted in data obtained (see Section 4.11); filling these gaps will further inform biodiversity management planning. Specifically, three types of information are needed to complete the biodiversity baseline studies for the Sabajo project.

- First, there are a number of species collected in 2017 with uncertain taxonomic identifications. These include two species of amphibians (*Scinax* sp. and the *Anomalogossus* sp.), and four species of plants (*Elaeis* aff. *oleifera*, *Anathallis* aff. *ciliolata*, *Lundia* sp. nov, *Oenocarpus* sp. nov.) In addition, it is possible that an undescribed species of fish (*Cetopsis sp*.) occurs in the area of influence. These species are either known species that could not be definitively identified, or are species that are potentially new to science. Additional collections, expert consultation, and deoxyribonucleic acid (DNA) analysis (in the case of amphibians) will help resolve the taxonomic uncertainties.
- Second, due to safety considerations and limited logistical access to the eastern part of the study area in 2017, it was not possible to complete fieldwork in these areas. If the project continues, in 2018 fieldwork will be conducted in the Tempati region for birds, mammals, amphibians and reptiles, and aquatic and terrestrial ecosystems. Baseline studies will then be revised to include the results of this fieldwork and if needed planned mitigation updated.

- Third, a wet season inventory of flora was not possible due to logistical constraints. It will be conducted in 2018, and relevant results will be integrated into the impact assessment.
- Finally, in order to reduce uncertainties concerning the impacts of the Project to potentially vulnerable KBVs, focused fieldwork will be conducted to better understand the regional distribution of species that are possibly new to science, and species associated with wet savanna forest on sandy soils. If any species that are potentially new to science have only been found on the proposed Project footprint, then targeted surveys to find the species elsewhere will be completed prior to construction.

The Biodiversity Management Plan provides more details on the work remaining to complete the baseline studies. When available, the completed baseline studies will be used to review and if necessary update the impact assessment and mitigation planning for the KBVs. Species management plans may be developed for some species, particularly those that are new to science.

5.8.8 Monitoring

The objectives of the biodiversity monitoring programs are to reduce major uncertainties in the impact assessment and to support the adaptive management of mitigation actions. Monitoring will include:

- *Vegetation monitoring* – the Project’s impacts to terrestrial ecosystems will be periodically assessed considering: comparing the actual versus predicted project footprint; understanding the occurrence and extent of any edge effects; and, detecting large-scale forest mortality due to project-induced changes in hydrology. Loss-gain calculations for terrestrial ecosystems will be updated based on the results of the monitoring program.
- *Aquatic biological monitoring* – aquatic biological monitoring will be undertaken at the same location as water quality monitoring, and will include dry season surveys of aquatic invertebrates, fishes, and stream habitat features. Monitoring sites will include control sites above areas of potential impact. The aquatic biological monitoring will *not* seek to attain a particular quality standard as the majority of creeks in the area are heavily impacted by informal mining. Rather, the company will seek to show that aquatic biological parameters are stable or improving over the life of the Project.
- *Wildlife mortality monitoring* – drivers on the Sabajo-Merian transportation corridor will report all wildlife deaths due to vehicular collisions. This information will be used to identify mortality “hot spots” that require additional controls. In addition, some monitoring during site clearances will take place to help evaluate the efficacy of directional clearing in reducing wildlife mortality.
- *Invasive exotic species monitoring* – regular monitoring of the project footprint will help identify the occurrence of invasive exotic species so that appropriate control measures can be implemented. Follow-up monitoring will evaluate the efficacy of control measures.
- *Reclamation monitoring* – the effectiveness of Sabajo’s reclamation program in recreating the plant structure and composition of natural terrestrial habitats will be regularly assessed. For aquatic habitats, measures of reclamation gains will be the similar to those used in baseline studies (stream habitat features, water quality, aquatic invertebrates, and fishes).The loss-gain accounting of natural habitats will be updated to reflect the actual amount and quality of vegetation achieved at reclaimed sites.

A Biodiversity Monitoring Plan will provide details on how each of the monitoring components described above will be implemented.

5.9 Social Impact Assessment

5.9.1 Discipline Methods

This section assesses the Sabajo Project (the Project) impacts on the social environment. This includes an assessment of the following features of the social setting: Socio-Economics; Culture; Artisanal and Small Scale Mining (ASM); Land Use and Tenure; Quality of Life; and Community Health.

Socio-economic impacts are also assessed for their potential risk (or opportunity) in terms of human rights. Human rights aspects are discussed below under each relevant category: Macroeconomic impacts, Employment and business opportunities, Culture and Wellbeing, ASM and Land Use and Tenure. Human rights assessment of Water and Traffic Effects can be found in those sections (Sections 5.7 and 5.10, respectively). Human Rights Impact Assessment methodology is described in section 5.1.7.

It is generally accepted that a project will impact people and communities in different ways, depending on their proximity to the Project, their relationship with the area of the Project and on the degree to which they participate in the Project. While benefits are usually expected (e.g., employment, business development, incomes), they may not be realized by all individuals, families or communities. Further, some people may experience adverse effects from the Project. Mitigation can attempt to address adverse Project effects, and benefit enhancement measures can seek to maximize Project benefits for a wider group of people, however the extent to which mitigations and enhancements are effective is not always apparent or measurable. This is in contrast to adverse biophysical Project effects, which are most often mitigated in reliable and measurable ways through engineering design, good practice and management, and other means.

The approach to social impact assessment (SIA) is thus more qualitative and nuanced than for biophysical assessment. In coming to conclusions, including describing potential and residual effects, there is necessarily a high dependence on engagement results and comparable experiences (in this case, with the existing Merian Mine and other mining projects).

Effects analysis criteria for socio-economics are provided in Table 5.9-1 below. When determining the consequence of socio-economic effects, local and national geographic extents are weighted equally. This is done because the type of social impacts addressed are either focused impacts on a local population, or more broadly relevant but smaller impacts in national capitals or other regions. Further, a key goal of SIA is to identify benefits to communities in a project's Area of Influence (AOI) (i.e., communities that are in local proximity to the Project and/or potentially affected by it).

Table 5.9-1 Socio-Economic Effects Analysis Criteria

Direction	Magnitude	Geographic Extent	Duration
Positive Effect is beneficial **Negative** Effect is adverse **Neutral** Effect is neither positive nor negative	**Negligible** An effect that does not result in a discernible change from baseline conditions **Low** A discernible effect that is not expected to materially alter the socio-economic feature in question **Moderate** A discernible effect that is potentially detrimental but manageable, or potentially beneficial to the socio-economic feature in question **High** A discernible effect that is expected to substantially interfere with or enhance the socio-economic feature in question	**Local** AOI stakeholders: • Carolina communities • Brokopondo communities • Kawina tribe • ASM areas **National** The Republic of Suriname	**Short-term** Effect is reversible at end of construction **Medium-term** Effect is reversible at end of operations **Long-term** Effect is reversible within a defined length of time beyond closure **Permanent** Effect not reversible

AOI = Area of Influence; ASM = artisanal and small scale mining.

5.9.2 Issue Scoping

Issues were identified through engagement with stakeholder groups between January and October of 2017. A summary of stakeholder engagement activities is presented in Section 1.3. Issues identified by stakeholders related to the socio-economic environment are noted in Table 5.9-2. All issues identified through scoping are listed below and addressed in the SIA (Section 5.9).

Table 5.9-2 Stakeholder Inquiries Related to Social Impacts

Topic	Issue	Section
Local Employment, Procurement and Training	All communities have expressed interest in accessing Project employment opportunities	5.9.6.2
	There is concern that the lack of qualification for mining employment amongst working age population in Brokopondo communities would be a barrier in the Brokopondo communities	5.9.6.2
	Some have requested that a fair system be established to ensure no one community will be left out of employment opportunities	5.9.6.2
	The Kawina have inquired if there would be a cooperation agreement with Newmont in place that gives them hiring priority	5.9.6.2
	Brokopondo communities have inquired as to whether they would receive hiring priority given their proximity to the mine.	5.9.6.2
	There is interest in ensuring that there are long-lasting benefits from the Project that extend beyond closure	5.9.6.2
	Some have expressed a desire to receive training from Newmont to improve their access to employment opportunities	5.9.6.2
	Brokopondo communities have experience supplying mines with produce, and are interested in doing so for the Project	5.9.6.2
	Concern has been raised that women may not see the benefits (e.g., employment) of the Project, with employment going only to men	5.9.7
Artisanal and Small Scale Mining	Some have expressed concern over the impact of the removal of small-scale miners in the Project concession area	5.9.8
	There is concern regarding the security of unsanctioned small-scale miners accessing the Project concession	5.9.8
Land Use and Tenure	The Kawina have asserted that, based on traditional territorial boundaries, the Project is within Kawina lands	5.9.9
	Concerns have been raised about the potential impact of haul road construction on community forests	5.9.9
	Some have inquired as to what will happen to timber cleared within the Project's concession area	5.9.9
	There is concern regarding the potential impacts of the Project on scaring away species hunted and fished in the region or allowing more access to others for hunting and fishing	5.9.9
Culture	There has been a request for an archaeological investigation to be carried out in the area of the Project concession	5.9.7
	A comment has been made that youth are currently leaving communities for Paramaribo, and concern that the Project could exacerbate this trend	5.9.7
Quality of Life	There is concern that the Project will generate vibration, dust and noise that will travel into communities	5.9.10
	Some have inquired as to the impact of the Project on water quality in communities, with specific questions around the effects of cyanide and mercury	5.9.10
	There are questions around whether Newmont plans to have security on site and along access roads, and worry that criminals may use these roads for robberies or drug trafficking	5.9.10
	There have been numerous questions regarding the impact of Project traffic on road users and communities, and implications for safety	5.9.10
Infrastructure and Services	Some have inquired as to whether Newmont will be improving transportation infrastructure such as the roads used to access the Project	5.9.6.3
	Kawina people and their Traditional Authorities have asked for support in redeveloping their traditional villages.	5.6.9.3

Project = the Sabajo Project; Newmont = Newmont Suriname, LLC.

5.9.3 Key Indicators

Key indicators by socio-economic topic have been identified based on feedback received during Project-related consultation and engagement activities, and past professional experience. Key socio-economic indicators by topic are:

- Macroeconomics:
  - exports and trade, including the mining industry;
  - government revenues; and
  - employment and incomes.
- Local Economic Effects:
  - direct employment and incomes; and
  - procurement and contracting.
- Transportation Infrastructure;
- Impacts on Land Use:
  - access;
  - forestry; and
  - hunting and fishing.
- Culture and Community Wellbeing:
  - cultural change;
  - social and cultural identity;
  - intergenerational conflict; and
  - gender relations.
- Quality of Life:
  - traffic;
  - nuisance effects (dust, odours, noise); and
  - impacts on water quality.
- Historical and Archaeological Resources:
  - cultural resource integrity; and
  - cultural resource accessibility.
- Community Health:
  - prevalence/probability of various types of potential health and safety issues.

5.9.4 Spatial and Temporal Considerations

The spatial boundaries for the socio-economic assessment are focused to the scale at which effects may be realized. Some socio-economic effects are expected to be national in scale (e.g., government revenues), and so are assessed at the national level. Other effects are expected to be experienced by the specific groups of local communities that have been the focus of consultation and engagement activities. These communities fall within the Project's AOI based on their propensity to experience varying effects from the Project, as described further in Section 5.9.5. Map 5.1-3 shows the study area communities in relation to the Project. For the purpose of this assessment, local communities are grouped as follows:

- Carolina communities: Communities along the Carolina Road who are potentially impacted by Project traffic (as listed in Table 5.9-3).
- Brokopondo communities: Communities along the Afobaka Road between the Asigron turnoff in the north and the Afobaka Dam in the south who are potentially impacted by Project traffic (listed in Table 5.9-3).
- Kawina tribe: The Project sits within the traditional land of the Kawina; the majority of Kawina people now reside in Paramaribo and elsewhere while their historic communities lie within the same watershed as the Project.
- Small scale mining areas: Small scale mining operations at Santa Barbara and Margo, Kilometer 34 and at Polaco (Social Solutions and ILACO 2017a).

5.9.5 Linkage Analysis

Specific groups of communities have been identified according to their geographic location and potential to be impacted by the Project. The Kawina communities as shown on Map 5.1-3 are the traditional communities of the Kawina that were largely abandoned during the Interior War from 1986 to 1992. Self-identifying Kawina now reside largely in Paramaribo. Newmont Suriname, LLC (Newmont) has engaged with Kawina traditional leadership, recognizing that the Project sits within the traditional lands of the Kawina Maroons. As such, in addition to the potential for the Project to create employment opportunities, the Kawina may experience positive Project effects related to land use and wellbeing. The Project is not expected to result in negative impacts to Kawina quality of life,[1] community health or infrastructure and services. Some Kawina people are using their traditional lands and are interested in returning to their communities. These communities are in the same watershed as the Project.

The Brokopondo communities along the Afobaka road to the west of the Sabajo concession may notice increased traffic on the Afobaka road if that option is used to access the site. The Project is not expected to result in adverse impacts related to land use and tenure in Brokopondo communities. Some communities are potentially more affected than others due to their proximity to the road but all communities travel on the Afobaka road.

If the Carolina Road access route is selected, the communities along the road may experience Project effects related to noise, traffic and dust associated with the transportation of workers, goods and equipment between Paramaribo and the Sabajo area. Land use of these communities is not expected to be impacted by the Project. Some communities are potentially more affected than others due to their proximity to the road but all communities travel on the Carolina road.

The final group of potentially affected stakeholders includes the ASM operations of Santa Barbara and Margo, among others. These mining worksites are close to the Project and have the greatest potential to experience socio-economic effects, such as loss of income and economic displacement. Table 5.9-3 provides a brief summary of the Project's potential social impacts.

[1] For the purpose of Environmental and Social Impact Assessment (ESIA), Quality of Life is defined as changes in traffic levels and risk of traffic accidents, dust, noise, and changes in water. Changes in these are assessed together as one category of effect.

Table 5.9-3 Potential Social Impacts by Community

Socio-Economic Topics	Community Cluster																		
	Brokopondo								Kawina				Carolina Road					ASM	
	Afobaka Centrum	Asigron	Balingsoela	Boslanti	Brokopondo Centum	Compagnie Kreek	Drepada	Tapoeripa	Gododrai	Java	Moismoiskondre	Pennenica	Casipora	Phillipus Kondre	Pierre Kondre Kumbasi	Powakka	Redi Doti	Santa Barbara	Margo
Employment, Procurement	○	○	○	○	○	○	○	○	●	●	●	●	○	○	○	○	○	●	●
Land Use and Tenure	○	○	○	○	○	○	○	○	●	●	●	●	○	○	○	○	○	●	●
Culture and Wellbeing [(a)]	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Quality of Life	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Community Health	●	●	●	●	●	●	●	●	○	○	○	○	●	●	●	●	●	●	●
Infrastructure, Services	●	●	●	●	●	●	●	●	○	○	○	○	●	●	●	●	●	●	●

●: Social impact identified; ○: No social impact identified

ASM = artisanal and small scale mining.

5.9.6 Socio-Economic Impact Assessment

5.9.6.1 Macroeconomics

5.9.6.1.1 Effects Analysis

In this section each potential impact is listed as a bullet and then discussed in the text below the bullet.

- The Project will contribute to national exports and the overall economy of Suriname.

Gold is the largest national export of Suriname. In 2016, gold exports accounted for 61 percent (%) of total national exports. The Merian Mine contributed to this figure by a small amount, given that the mine remained in construction and did not start production until the 4th quarter of the year. The Rosebel Mine was the largest contributor to gold exports in 2016, with production of around 300,000 oz. in that year[2] (IAMGOLD 2015, 2017). In 2017, the Merian Mine is expected to more than double annual gold production in Suriname by an average of 350,000-390,000 ounces (oz) per annum (Newmont 2017a), further increasing the importance of gold exportation in the national economy, and positively impacting current trade balance of Suriname.

Assuming that the Project enters operation while the Rosebel and Merian Mines are still producing ore[3], its addition of approximately 61,300 oz. of gold production per annum over 10 years would represent a 9% increase on total annual national production. Should the Project enter operations following the closure of the Rosebel Mine, and assuming constant production volumes at the Merian Mine, the Project's share of total national gold production would grow to around 17%. In either scenario, the Project would represent a significant increase to national gold production and exportation, and an important contributor to the economy of Suriname.

[2] Based on production in 2015 (302,000 oz.), and attributable production in 2017 (295,000 to 305,000.

[3] As of 2015, the Rosebel Mine was predicted to have a 6.6 year lifespan of attributable gold production (IAMGOLD 2017), potentially overlapping with Project operation.

Construction of the Project will require around 40 pieces of equipment over the course of two years, including haul trucks, dozers, graders, loaders, excavators and transport trucks. Much of the equipment required to construct the Project is expected to already exist within the Merian Mine's current fleet, or within Suriname. Similarly, the existing Exploration Camp will be used to house workers during early mine construction activities and while constructing the Operations Camp. It is therefore assumed that limited importation of construction equipment and materials would be required and that national spend on construction activities would be low. The Project's potential impact on the national economy is, therefore, concentrated during the operations phase.

- The Project will contribute fiscal benefits to government in the form of taxes and royalties

During construction, the Project will generate revenue in the form of fixed and consent fees payable to the Government of Suriname equivalent to 2.5% of the value of goods imported to a maximum of $300,000 USD[4]. The Project is not expected to be profitable during construction and no corporate income taxes are anticipated during this phase. Income taxes will also be paid based on personal employment income derived from Project employment, however the value of these is not yet known. During operations, the Project has the potential to generate income tax revenues for the Government of Suriname from employment incomes and profits earned by Newmont. Preliminary estimates of income taxes generated suggest that Newmont`s share of the Project would involve an annual contribution of around $3.5 to 4.0 million if Government of Suriname (GoS) participates over the life of the mine. The exact value of taxes on profits are not known at this time, and are dependent on the realization of profit in any given year of operation.

Once operational, the Project will also pay a royalty to the Government of Suriname equivalent to 6% of the total export value of gold ore produced each year. In the first three quarters of operation, the Merian Mine generated $34 million in resource royalties (Newmont 2017b). It is estimated that total resource royalties for 2017 will amount to $38 million (Newmont 2017a). Assuming annual gold ore production of between 350,000 and 390,000 oz. at the Merian Mine, the Sabajo Project, which is expected to produce around 61,300 oz. of gold per annum, could result in around $4.5 to $5.5 million in annual royalties to the Government of Suriname for approximately 10 years. Relative to the sum of current mining royalties ($26.4 million in 2016; GoS Ministry of Finance 2017) and those projected for the Merian Mine ($34 million in 2017), Sabajo Project royalties could represent a 7.5% to 9.1% increase in total mining royalties paid to the government.

- The Project will generate employment and incomes.

Project construction is expected to require approximately 100 Surinamese workers during ramp up. As construction progresses, the workforce will grow to around 300 Surinamese jobs. Of this peak workforce most employment opportunities will be Surinamese nationals. Some specialized professional and management positions may be filled by expatriates.

Project operations are expected to require 139 to, at peak, 169 direct personnel, in addition to the existing management and planning workforce present at the Merian Mine. Of the total operational workforce, 19 positions (or an average of 12%) will be required to supplement the existing Merian Mine administration, geology and engineering teams. The remainder of the workforce will be comprised of 27 supervisors and surveyors (average of 17%), and 93 to 123 equipment operators (67% to 73%, depending on the year). Demand for equipment operators will peak in years five through seven of Project operations. During operations, Surinamese personnel will work a 14-day-on,

[4] Pursuant to Sections 8.1 and 8.2 of the Mineral Agreement.

7-day-off rotation schedule. Equipment operators, supervisors and surveyors will operate in two 12-hour shifts per day, requiring three operators per piece of equipment. Administrative, engineering and geology personnel will work a single shift per day on rotation.

Project closure activities will require 45 to 48 personnel annually for four years, with a similar workforce distribution relative to operations. Table 5.9-4 provides a preliminary estimated breakdown of workforce requirements by year and position type.

Table 5.9-4 Estimated Workforce Requirements by Operational and Closure Year, and Position Type

Position Type	Year of Operation										Year of Closure			
	-1[(a)]	1	2	3	4	5	6	7	8	9	1	2	3	4
Administration	8	8	8	8	8	8	8	8	8	8	4	4	4	4
Geology	5	5	5	5	5	5	5	5	5	5	3	3	3	3
Engineering	6	6	6	6	6	6	6	6	6	6	3	3	3	3
Supervisor/Surveyor	27	27	27	27	27	27	27	27	27	27	14	14	14	14
Equipment Operator	93	99	108	117	120	123	123	123	105	87	24	24	24	21
Total	**139**	**145**	**154**	**163**	**166**	**169**	**169**	**169**	**151**	**133**	**48**	**48**	**48**	**45**

a) Year “-1” overlaps with the second year of construction, and is a ramp-up year that does not involve production of ore.

Source: GMining Services Inc. 2017.

In the first full year of operations at the existing Merian Mine, Newmont has been able to hire nearly 100% of its equipment operation, supervisor, surveyor and administration needs from within Suriname. Approximately 55% of geological and engineering workforce requirements have also been drawn from the Surinamese labour force (Newmont 2017c). During peak Project operational employment, 169 positions would represent a 14% increase relative to the existing workforce at the Merian Mine (1,178; Newmont 2017d). The majority of the Project’s Surinamese workforce will likely be drawn from Paramaribo given the presence of a labour force skilled in mining.

5.9.6.1.2 Mitigation and Benefit Enhancement

Mitigation measures are not required for impacts to macroeconomic conditions in Suriname, and benefit enhancement measures are limited. The Project’s impact on gold exportation and the overall Surinamese economy is a function of production and exportation, and are not subject to benefit enhancement measures. Similarly, the Project’s impact on government revenues is a function of taxes and royalties – both of which are prescribed and based on agreed upon rates. Given this, the Project Case Impact Classification does not present pre- and post-mitigation residual impacts.

5.9.6.1.3 Project Case Impact Classification

Project Effects are classified in Table 5.9-5. Overall, The Project’s macroeconomic impacts are expected to be positive and of low to moderate magnitude relative to the baseline conditions against which they are measured. While the Project represents substantial benefits in terms of gold exportation and government revenues, its national-level employment impact is more modest. Effects will be most pronounced during operations. Effects will accrue at the national level, will last through the operations phase, and are considered certain to occur based on the assumption that the Project will produce at predicted volumes, pay royalties and taxes to government and require the described workforce.

Table 5.9-5 Classification of Effects, and Likelihood with Mitigation

Effect	Effect Classification					Residual Impact
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	
The Project will contribute to national exports and the overall economy of Suriname	Positive	Moderate	National	Medium-term	Certain	Low Positive
The Project will contribute fiscal benefits to Government of Suriname	Positive	Moderate	National	Medium-term	Certain	Low Positive
The Project will generate employment and incomes	Positive	Low	National	Medium-term	Certain	Medium Positive

the Project = the Sabajo Project.

5.9.6.1.4 Cumulative Effects Case Impact Assessment

The macroeconomic assessment is inherently cumulative in nature, as it measures the Project's effects against a future scenario that includes the operation of the Merian Mine and, potentially depending on schedule, the expansion of the Rosebel Mine. No other new projects that would substantially change macroeconomic conditions in Suriname are foreseeable at this time.

5.9.6.1.5 Potential Impact on Human Rights

A limiting factor to government taking direct action to improve the fulfillment of human rights is often related to the lack of fiscal capacity to invest in social programs. Lack of investment in key areas, like health care and education[5] may be due to issues of prioritization (competing needs, austerity programs or other issues) or inadequate financial resources to meet basic needs.

Qualification of the Human Rights Impacts

Macroeconomic improvement and increased revenue to the government have the capacity to positively impact rights to health care and education and other initiatives. The scale of the impacts are limited due to the relatively limited contribution to overall economic stability and the uncertainty as to whether the additional government revenues will be directed towards shortfalls that address human rights. The positive impact to rights is possible, but low scale, and is a low priority for further management attention. The Project is linked to this potential positive impact by business relationships; the Government of Suriname will determine how the additional revenue is used.

5.9.6.2 Local Economic Effects

5.9.6.2.1 Effects Analysis

- The Project will generate direct employment opportunities and associated incomes

During operations, it is expected that around half[6] of highly skilled positions (i.e., only around six positions) would be filled by expatriates, while the other half would be filled by Surinamese candidates. The Project's management requirements would be met largely by the existing management workforce at the Merian Mine. The majority of Project direct operational employment that would be taken up by the Surinamese labour force would, therefore, be in the areas of equipment

[5] Rights to health and education are protected in the International Covenant on Economic, Social and Cultural Rights (ICESCR).

[6] Based on local hiring performance of professional positions at the Merian mine in 2016 (Newmont 2017c).

operation and mining supervision. Operational employment opportunities are expected to be minimal for low-skilled workers as the workforce must have certain qualifications for operational employment. Newmont would undertake efforts to identify suitable Surinamese candidates for as many positions as possible during both construction and operations with Project operations requiring a more skilled workforce than construction.

A Historical Narrative study (Artist and Rijsdijk 2017) determined that the Project is located within the Kawina traditional territory. Newmont is in contact with the Kawina Traditional Authorities and will continue ongoing engagement with them regarding Project opportunities. Information regarding the labour force characteristics of the Kawina population residing in Paramaribo was not available at the time at which the Environmental and Social Impact Assessment (ESIA) was written, and so no assertion of their eligibility for Project employment, in terms of training and experience, has been made. However, anecdotal evidence suggests that Kawina people have the educational requirements and skills for some positions. Given their experience in mining activities, some small scale miners may also be suited for construction and operations employment positions.

Given the limited number of positions available that would likely be filled by people in the AOI labour force, local employment created by Project operations is expected to be low without benefit enhancement measures (as listed below).

- The Project will generate business opportunities through the procurement of goods and services.

As with employment, procuring goods and services is likely to be modest. Lack of access to credit and capital equipment for producing consumables required by a large mining project, and the lack of businesses with the capacity to supply requisite services are considered major barriers to procurement from many Surinamese vendors. This does not, however, preclude the potential for local procurement in the long-term during Project operations.

In the first three operational quarters of the Merian Mine (2017), Newmont procured nearly $400,000 USD of goods from local vendors near the mine (49 purchase orders were signed with nearby suppliers and vendors). While this amounts to less than 1% of total procurement for the Mine during this period, it is still a substantial sum relative to the local business environment. Most vendors are small, with Merian-associated earnings of under $2,000 USD per month. Nonetheless, vendor revenues of several hundred dollars per month is substantial relative to earnings in non-mining work (typically less than $130 USD per month [IGSR, 2017]). Vendor goods and services varied and have included lumber supply, wooden stake production, boating services, egg and vegetable production.

Newmont’s Local Content Initiative at Merian identifies local vendors and works with them to build capacity for budgeting and bid preparation, operational improvements to meet the demands of a mine, and developing health and safety plans. The Initiative would be adapted to the specific context of the Project.

A list of existing or potential vendors will be prepared for the Project, including goods and services supplied by the vendor, the period of opportunity for them, and proposed actions that Newmont will take to engage the vendor in question. Newmont would then work with identified local vendors to enact the subsequent goals of the Initiative, with an end objective of building local vendor capacity through targeted procurement.

Given the potential for procurement from local vendors, and the impact that this has on their incomes, effects from local procurement by the Project is expected to be low without benefit enhancement measures (as listed below).

5.9.6.2.2 Mitigation and Benefit Enhancement

Benefit enhancement measures to maximise local participation in the Project include:

Ongoing Training

- training of semi-skilled and skilled employees in environmental management and health and safety;
- create career development plans for employees that emphasise on-the-job training and skills development in pursuit of advancement;
- include in the employment responsibility of senior staff the requirement to mentor more junior employees in a manner that encourages skills development and career advancement; and
- provision of training to senior staff aimed at improving their ability to coach and mentor junior staff.

Recruitment

- formal recruitment process that maximises opportunities for employment of key stakeholder[7] groups, where possible, including accessible, timely job postings;
- post positions internally to encourage the advancement of the workforce into other categories of employment, thus creating entry level job openings;
- establish achievable targets for growing the representation of key stakeholder groups in the Project workforce over time; and
- establish achievable targets for growing the representation of women in the Project workforce over time.

Of these measures, on-the-job training has the potential to have spill-over benefits in terms of the workforce's current and future ability to access employment opportunities in the mining industry.

The Project's effect on local economic development through procurement will benefit from the following enhancement measures:

- Implement a process to identify potential suppliers of goods and services and analyse barriers to the ability of key stakeholder groups to supply goods and services relative to Project procurement requirements.
- Give priority to suppliers from key stakeholder groups when sourcing raw materials, finished goods, and services that can be procured in the local market.
- Identify opportunities for 'adhoc' or occasional income generation opportunities (i.e. filling sand bags, collecting seeds for reclamation, etc.).
- Establish achievable targets for local procurement (as a percent of total procurement) from key stakeholder groups that grow over time.
- Provide businesses with timely information on procurement requirements in areas that are mutually considered to be within the capacity of those businesses. Examples include road maintenance, catering, janitorial services, consumables supply, materials handling and expediting, and sewing, repairing uniforms.
- Implement procurement contracting procedures that consider the potential need to break down procurement packages and accommodate financial constraints of small scale enterprises.

[7] Key stakeholder groups will be identified based on final selection of access road options presented in the Project Description.

- Provide explanations to interested businesses that may be denied an opportunity to bid on procurement requests, and to businesses that compete on bids unsuccessfully, as to the reason for their denial or unsuccessful bid.
- Maintain a regularly updated Project database of potential local suppliers of goods and services that identifies:
  - business interest, capacity and the nature of goods and services offered;
  - contact information; and
  - contract performance record.

5.9.6.2.3 Project Case Impact Classification

The Project’s residual impact on local employment, while positive, would be of low magnitude given the small number of suitable jobs that people in the access road communities (Brokopondo and Carolina) may obtain. The Kawina may be better positioned to participate in the Project through employment but new positions are still limited. This impact would exist during construction and operations and would be of medium-term duration. Benefit enhancement measures, while potentially impactful to a small number of employment candidates, will not change the Project’s limited workforce requirements or ability to generate substantial local employment opportunities. Given these factors, the residual impact of Project operations on local employment and incomes is assessed as low and positive.

The Project’s positive residual impact on local business development would be of low magnitude. While it will be some time before capacity building efforts yield results, the potential for the Project to result in local purchase of goods and services, and in turn generate earnings for local vendors, is important to economic activity in communities. While benefit enhancement measures are expected to continue to facilitate local procurement, this impact is not assessed as being of high magnitude given the limited number of vendors that would likely be able to take up Project procurement opportunities during construction and early operations. There is, however, opportunity for small business development and providing goods and services to the Project on an occasional or semi-regular basis (i.e. sewing uniforms, garden crops, baked goods). The impact will be local in extent, and will come to fruition as Project operations advance (i.e., in the medium-term). Given these factors, the Project’s impact on local procurement is assessed as low and positive.

Table 5.9-6 provides a summary of the Project’s effects on local economics before and following mitigation.

Table 5.9-6 Classification of Effects, and Likelihood with Benefit Enhancement Measures

Effect	Effect Classification					Residual Impact	
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Benefit Enhancement	Post-benefit Enhancement
The Project will generate direct employment opportunities and associated incomes	Positive	Low	Local	Medium-term	Possible	Low Positive	Low Positive
The Project will generate business opportunities through the procurement of goods and services	Positive	Low	Local	Medium-term	Likely	Low Positive	Low Positive

the Project = the Sabajo Project.

5.9.6.2.4 Cumulative Effects Case Impact Assessment

The Project and the existing Merian Mine are expected to have different local communities targeted for employment and procurement, and so are not expected to result in enhanced local benefits to the same groups. There is no potential for the Project and the Merian Mine to increase inflation in the event that consumer goods are sourced from and concentrated in the same communities.

The Rosebel Mine is not expected to interact cumulatively with the Project to enhance local economic benefits, or exacerbate adverse local economic effects as the two mines do not overlap in terms of targeted local communities. Though there has been some involvement between the Carolina Road and Brokopondo communities and the Rosebel Mine in the past (e.g., sale of produce, limited employment), baseline studies suggest that this is no longer the case.

5.9.6.2.5 Potential Impact on Human Rights

The assessment of local economic impacts will focus on two main issues; the potential for positive impacts to the right to work, and the right to non-discrimination through local employment and procurement programs. The right to work has implications for right to an adequate standard of living; the right to non-discrimination has implications for women's rights, the right to work and the right to education.

The creation of economic opportunities in areas where these opportunities are extremely limited can contribute to the right to work and the right to an adequate standard of living[8]. The right to work does not guarantee that everyone has a job. Rather, the intention is that governments should assist people to find progressively full and productive employment. Companies creating new jobs, directly through employment or by enhancing national and local procurement, contribute directly to fulfilling this right. Income from work contributes to improved fulfillment of the components of the right to an adequate standard of living, which are food, clothing, housing and improvement in living conditions.

Both the Brokopondo and Kawina populations have expressed hopes that the Project will provide opportunities for employment and economic activities. To the extent that short or long term

[8] These rights are Article 6 and 11 respectively of the ICESCR.

employment or procurement contracts are obtained, there is likely to be a positive impact on these two rights. Individuals and families currently without full and productive employment would improve the fulfillment of their human rights to education and health care as well as overall living conditions through direct employment with the Project or associated contractors or suppliers.

Actual opportunities to employ local unskilled or semi-skilled workers are limited. The ESIA identifies that approximately 300 workers will be required for construction and approximately 150 during operations. The number of individuals and families directly affected will be limited but those who do benefit will have improvements in their enjoyment of rights. People will experience the expected positive impacts to human rights during construction and operations and to a greatly reduced level during closure.

The Project's employment and local supplier programs have the potential to impact the right to non-discrimination.[9] Access to employment or business opportunity is for most people critical for the fulfillment of a range of rights, and that access should be equal for all people without discrimination.

Discrimination can occur in three forms as summarized in Table 5.9-7:

Table 5.9-7 Discrimination Forms

Form	Description	Company-Relevant Example
Direct	Treatment towards one person is different than another in the same situation	Exclusion of pregnancy age-women from applying for employment
Indirect	A law, policy or practice that appears neutral has a disproportionate impact on one group	Lifting requirements that are beyond capacity of most women, instead of accessible storage sites
Structural or systemic	A system of laws, rules or practices that put a people or group in an unequal position relative to roles, decision rights and opportunities[10].	Lack of access to education in rural areas results in local population with low levels of employability

It is important to note that structural forms of discrimination are part of the government's 'duty to protect' human rights, independent of company involvement.

Suriname's education system and infrastructure is widely recognized to suffer from structural inequalities in terms of both access to and quality of education between urban/coastal areas and the country's interior. This has impacts on the fulfillment of human rights for the individual and their families in terms of access to employment, income and adequate/improving standards of living. In this context, which pre-existed and is unrelated to Project impacts, companies should take actions to show they are not reinforcing the status quo. While companies are not responsible for such inequalities, they should pay particular attention to the rights and needs of, and challenges faced by, these vulnerable and marginalized groups in order to ensure that they do not contribute to, or exacerbate, such structural inequality (UN 2012). Guidance on company responsibility to address real or perceived discrimination suggests that companies could take positive actions in order to combat inequalities, including positive steps to address the under-representation of any particular group in the workforce (Castan Centre for Human Rights Law 2016).

[9] Non-discrimination is a fundamental and overarching principal of international human rights and is Article 2(1) in the International Covenant on Civil and Political Rights (ICCPR) and Article 2(2) of the ICESCR.

[10] Structural discrimination, also known as structural inequality, systemic discrimination and institutional racism, is defined by the World Bank as "a condition that arises out of attributing an unequal status to a category of people... that is perpetuated and reinforced by a confluence of unequal relations in roles, functions, decision rights and opportunities" (Dani and de Haan 2008).

The ESIA (Section 5.9.6.2.2) identifies a series of separate measures intended to improve the local economic opportunities provided by the Project in both employment and procurement. While there are limited jobs and procurement opportunities specific to the Project, attention is required to ensure that access is available to under-represented groups in the work force as a whole, and groups with limited employability due to structural discrimination patterns.

Qualification of the Human Rights Impacts

Both the local procurement and local employment program have the potential to contribute positively to the right to work and the right to an adequate standard of living. The potential impacts are evaluated as positive but of limited scale given the limitations to local hiring and procurement identified in the ESIA; the impacts to the right to work are considered certain. Although assessed as a positive impact the prioritization is medium as actual results should be monitored and reported on. The Project's influence is causal.

Local procurement and local employment require that Newmont effectively designs, targets and tracks the proposed 'enhancement' measures in order to assess effectiveness and take corrective action as needed to demonstrate that it is not reinforcing existing inequalities. Development of a Local Procurement and Employment Plan as per the Newmont standard has potential to contribute positively to non-discrimination if implemented effectively and consistent with the stated objectives. Without this level of planning, setting of objectives and internal commitment, the Project is at risk of sustaining patterns of structural discrimination. The risk that the Project does not surmount structural discrimination is negative and potential, with a severity of medium; the likelihood is possible. The human rights prioritization is medium-high and Newmont's influence is causal as the company's employment and procurement programs must attempt to overcome structural discrimination. The prioritization reflects that the actions to avoid this negative impact to human rights should happen in the short to medium term (Table 5.9-8).

Table 5.9-8 Qualification Table for Impact to Human Rights – Local Economic Effects

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity/scale**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
The Project will contribute fiscal benefits to Government of Suriname	Positive, low	Right to health, right to education, others	Surinamese population, school-age children	Positive	Potential	Low	Possible	Low	Linked to
The Project will generate employment and economic opportunity through local procurement	Positive, low	Right to work, right to adequate standard of living	Workers, contractors' labor force, supply chain	Positive	Potential	Low	Certain	Low	Cause
The Project Local Procurement and Employment	Low, Positive	Right to non-discrimination	Interior population	Negative	Potential	Medium	Possible	Medium-high	Cause

ESIA = environmental and social impact assessment; the Project = the Sabajo Project; HR = human rights.

5.9.6.3 Transportation Infrastructure

5.9.6.3.1 Effects Analysis

- The Project will increase use of transportation infrastructure

It is expected that most in-country contracting and procurement would be sourced from Paramaribo as the economic hub of Suriname. Contractors residing in the city travelling to and from the Project construction site would, therefore, represent new traffic on local roads. Locally-sourced goods, materials and heavy equipment would be transported to the construction site via large transport trucks, potentially increasing the presence of large vehicular traffic on connecting roads. It is anticipated that goods and materials sourced internationally would be imported through Paramaribo, increasing use of the port beyond current conditions. This would represent an economic benefit to the port, which already has experience with the importation of equipment associated with mining activities at the Rosebel and Merian mines. The potential for increased traffic during operations is related to the transportation of workers and consumables during shift changes and resupply trips between the Project and Paramaribo. Overall, Project traffic has the potential to place additional wear and tear on road infrastructure between the Sabajo site and Paramaribo. Without mitigation, this wear and tear is expected to represent a low negative effect on road infrastructure

5.9.6.3.2 Mitigation and Benefit Enhancement

The Project-specific Traffic Management Plan outlines safe transportation practices and protocols for road improvements (if needed), along proposed travel routes for the Project (ESIA Volume B). Further description of the Project's impacts on traffic infrastructure and volumes is provided in the Traffic Assessment (Section 5.10).

The Project's potential adverse effect on transportation infrastructure can be mitigated through the development of a Transportation Management Plan, and strategies for improving safety on routes traversed by Project traffic. The Traffic Management Plan includes increased maintenance beyond the current maintenance program that is implemented by Government, and monitoring of Project traffic on the access routes to determine if additional mitigation measures are required.

5.9.6.3.3 Project Case Impact Classification

The Project's residual impact on transportation infrastructure is assessed as positive given the proposed increased maintenance of road infrastructure. While the roads will experience additional wear and tear, repairs and upgrades will be made as needed. The effect is anticipated to be of negligible magnitude (some roads may be upgraded, most would simply be maintained), and would be localized to roads between Paramaribo and the Project. The effect would persist through operations (i.e., medium-term). Given these factors, the Project's effect on road conditions is assessed as low and positive.

A summary of the Projects effects on transportation infrastructure is provided in Table 5.9-9.

Table 5.9-9 Classification of Effects and Likelihood with Mitigation

Effect	Effect Classification					Residual Impact	
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation	Post-Mitigation
The Project will increase use of transportation infrastructure	Positive	Negligible	Local	Medium-term	Certain	Low Negative	Low Positive

the Project = the Sabajo Project.

5.9.6.3.4 *Cumulative Effects Case Impact Assessment*

It is assumed that the Merian mine and the Rosebel mine will both source goods and services from Paramaribo, and so will interact with the Project to have a cumulative impact on transportation infrastructure conditions on shared roads. The extent to which this cumulative effect will occur is not known.

5.9.7 Culture and Wellbeing Impact Assessment

This section discussed potential effects to the cultures and wellbeing of the three sets of communities in the Project's AOI: the Brokopondo communities, the Carolina communities and the Kawina community in Paramaribo and those that are active in their traditional villages. Effects from both the construction and operation phases of the Project are discussed. The main drivers of cultural change from a large-scale mining project are presented in this section and include: the migration of people in and out of the region in search of economic opportunities, ongoing transformation of the economy due to increased wages and incomes, and therefore, changing power relations, and changing values and priorities that are in part due to the modernization of the economy. These drivers are all present to varying degrees in Suriname and in the AOI communities.

5.9.7.1 *Effects Analysis*

- The Project could result in changes in culture associated with both in-migration at a regional scale, and out-migration from AOI communities to Paramaribo.

One of the key ways that cultures change, is through contact with other cultures. When contact occurs between two cultures there is a transfer of ideas, which may lead to a change in the way that people think or act. In the past, this was limited because fewer people were able to travel or communicate with people from faraway places. With advances in travel and information and communication technology cultural change is happening at a more rapid rate. In the Sabajo AOI communities generally, there have been factors that have led to cultural change including the arrival of Christianity, people moving to the villages for marriage or commerce and people travelling for school or work to the City and not returning home. The Kawina have resided in Paramaribo since the Interior war, are broadly dispersed throughout the City and have intermarried with non-Kawina people. Large-scale mining projects can be a driver of cultural change as they may bring people, and new ideas, to the remote regions where mining activities take place.

Migration (or the movement of people) is often associated with the onset of new mining activities or the ramp-up of existing projects in a region. Newcomers, as noted above, will have their own cultures, and therefore be a driver for change of local customs. Even if they are of the same ethnic group moving back to a 'home' community, they may not follow local traditions or cultural practices, which can sometimes lead to tension or conflict.

There is limited potential for the Project to attract migrants to communities in the Project's AOI. Newmont's experience with the Merian mine showed that people living in Paramaribo did not move close to the project in search of employment, even if they were originally from a nearby community and understood that it was targeted to receive employment opportunities. Furthermore, people without an affiliation to one of the Brokopondo or Carolina communities are unlikely to move to one as the traditional authority structure that is present in the communities and the ethnic make-up of communities would be a barrier to entry for migrants who do not have ties to the community. Traditional authorities are responsible for allocating land and accepting new members into their community and it is unlikely that they would grant permission to outsiders.

The construction of the Project haul road has the potential to lead to some limited migration of people who seek to undertake ASM that is made accessible by the new haul road. This may include establishing businesses and small settlements along the road, however as the road will have controlled access by Newmont, induced migration and use of the haul road is likely to occur after Project decommissioning, should the road remain open. The culture of the area, which already has significant ASM activity is unlikely to be affected or changed.

Of greater impact to traditional culture is the potential for *out-migration* of residents in the Brokopondo communities to Paramaribo, should they secure a job with the Project. Experience with the Merian mine has shown that employees who receive regular wages may be drawn to Paramaribo because of better access to schools, health care and other amenities. Young people may be drawn to the cosmopolitan lifestyle of the city, rather than traditional village lifestyles, which is made accessible to them because they have regular wage employment with Newmont.

The out-migration of young people from small communities to cities may exacerbate cultural loss in two ways. The first potential effect is to Brokopondo communities near the Project. As youth move away from their communities, there are fewer people from the new generation to continue traditions and practices that are important for the maintenance of local customs and beliefs. For instance, it has been reported that young people in the Brokopondo communities are less interested in maintaining farming practices. While many younger villagers participate in the ASM sector, many pursue commercial business activities including logging, and some live only seasonally or ‘part time’ in the villages. While the process of urbanisation is underway, the Project may be an additional driver to this trend as Project-related employment gives people the regular income to make it easier to relocate and afford to live in Paramaribo. People in the Carolina communities sometimes commute to Paramaribo for work and there is public transportation, however, there is some evidence of growth due to people that once resided in these communities, moving back to their traditional communities. The pull back to these communities is said to be related to recent access to 24 hour electricity as well as the lower cost of living, while still being able to maintain a job in Paramaribo. The development of mining in the Interior is not regarded as a reason for the growth of or out-migration from the Carolina communities.

The second way that out-migration may interact with traditional culture is that as young adults move to a large multi-cultural city such as Paramaribo, there is an increased potential for them to marry people from other cultures, and they may be less likely to teach children about their cultural traditions including spiritual beliefs or language, for instance. This can, over time, lead to permanent cultural dilution or loss for the entire ethnic group.

With respect to the Project, due to the small number of construction and operation jobs, it is unlikely that there will be high numbers of out-migrants from Brokopondo villages, as was the case at the Merian mine. There is no likelihood of in-migration. With regards to the link between migration and culture, the Saakiiki communities have been able to adapt to changes associated with the construction of the Afobaka Dam with their culture generally being intact. Community consultations indicate that there is an ongoing process of cultural change underway with respect to the practice of taboos, rituals and community decision making processes. While the Project does have the potential to accelerate out-migration, a process that has been linked to cultural dilution (IFC n.d.), the AOI communities and residents of Paramaribo have proven to be resilient and will continue to retain aspects of their cultural traditions and livelihoods that are meaningful and make sense. Newmont recognizes that cultural change through project induced migration is a potential adverse effect of the Project on nearby communities and have identified management strategies and best practices to limit this effect. These include making it clear that people do not have to live in Paramaribo to be employed, having pick up locations near the Project and along the route, as necessary. While people have the choice to relocate if they wish, Newmont's employment policies aim to follow best practice and enable people to remain in their home communities in order to limit cultural change associated with Project activities.

- The Project could influence social and cultural identity.

The communities in the Project's AOI have varying levels of cultural cohesion and community identity. In general, effects to cultural cohesion in a community is linked to the level of external influences in these communities. For example, the diversification of culture has occurred because people and ideas have arrived through intermarriage, in-migration / out-migration and the arrival of Christian missionaries and their religious customs. Changes associated with the mechanisation of natural resource harvesting (i.e. industrial logging, small-scale and large-scale mining operations) have required increased investments in capital, which is also a driver for the erosion of a homogenous cultural identity in remote and rural communities. Social baseline studies identified that within the Brokopondo communities, the villages of Boslanti, Compagnie Kreek and Tapoeripa were more traditional and had placed a higher importance on cultural maintenance than the other five communities. Similarly, within the Carolina communities it was identified that Casipora was the most traditional community. This is likely because it is the most physically isolated community. It is challenging to provide clear answers to why some villages remain more traditional and others are modernizing more quickly. This may be due to the power of the traditional authority, or because there are more living elders to maintain traditions for. What *can* be identified is there is a process of cultural change happening in AOI villages, which is potentially happening at a slower or faster rate, depending on the village. While the Project may be an additional factor towards the process of acculturation that is ongoing, it is not expected to rapidly increase the pace of cultural change or adversely affect cultural identity in the Brokopondo or Carolina communities due to the limited interaction the Project employees, who are expected to mainly reside in Paramaribo.

If the Project does lead to some limited amount of out-migration, these people will likely be integrated into urban culture and give up some of their traditional cultural practices. These traditions are also less likely to be passed onto future generations who are born in the city. In this way, out-migration can lead to cultural dilution for the groups to which out-migrants come from, over-time. In the event that this occurs, given the small scale of the Project and the limited Project employment opportunities that could drive out-migration, no noticeable effect on the social and cultural identity of the AOI communities is anticipated.

On the other hand, the Project may also be a driver of cultural revitalization for the Kawina, who currently have the least homogenous cultural identity among the AOI communities. This is because they do not live in traditional villages, are mainly urbanized, and have a large proportion of multi-cultural families due to intermarriage with other residents of Paramaribo. The Kawina leadership has identified through Project consultation processes that they are motivated to resettle their historic communities[11]. In fact, some community members are already rebuilding homesteads, growing crops on the land that surrounds their traditional villages.

Given this context, it is conceivable that the Project may be a positive force in the strengthening of Kawina culture and identity through its acknowledgements of Kawina land rights in the Project area. The Kawina cultural identity would benefit from acknowledgement of their traditional territory.

[11] The Kawina villages of Pennenica, Java, Moismoiskondre, Gododrai and Awara were destroyed during the interior war in the 1960s.

In addition, if the Kawina are able to receive support for the redevelopment of their villages, and people move back to their communities, this will support the revival of the Kawina culture, and potentially their traditions, customs, rituals and language. In this way, the Project has an opportunity to help strengthen Kawina culture through its acknowledgement of land rights.

- The Project could influence intra-community and inter-community social conflict.

As noted in the discussion above on ‘changes due to increased wage activity and income,’ conflict is a potential adverse effect associated with the declining role of elders (including the traditional authority) as a result of changing values. In fact, Intergenerational conflict due to the increased earning potential and changing values of youth is already occurring in AOI villages. These young earners may be resented by others (e.g., non-income earners, including elders) because through their income they are asserting a status to which they may not be entitled to, but have gained because of the increased value of money and material goods as the economy becomes modernized and commercial. Traditionally, people in AOI communities have gained status because of their political position (e.g., Granman or Kapitein) or because they are from a well-established or founding family who has land or other assets.

Project-related employment could potentially exacerbate conflict in communities because younger people either choose to spend their income in an individualistic manner in their home communities, or leave their home communities for Paramaribo once they are employed. In both cases, youth may be more likely to spend their income on themselves and nuclear families, rather than support elders who live in home communities or use their earnings to contribute to community initiatives.

Another driver of conflict may involve the targeting of particular ethnic groups (i.e. Kawina, Pamaka). The approach may potentially contribute to some inter-community tension between the individuals from groups targeted for employment and people from other ethnic groups living in the region (e.g., Brokopondo communities, Carolina communities and non-Kawina residents of Paramaribo). Individuals who are not targeted for employment may resent the fact that they have to experience potential negative Project effects (i.e., increased traffic, nuisance effects) however may not accrue Project benefits (i.e., employment and procurement opportunities, training and capacity building, community investments).

The Project has a grievance mechanism that can be used to identify if there are Project-related processes that are creating conflict within or between communities.

- The Project could influence gender relations.

Gender relations within the Project’s AOI communities is multi-faceted. Women are generally equal in their ability to be community leaders and make decisions. In Amerindian culture, there is a matrilineal system in place for the selection of traditional authorities, which means that leaders are selected through the mother’s lineage. For instance, if a granman or kapitein was to pass away, the next person to be selected would historically be a brother or nephew from the deceased leaders’ maternal lineage[12]. In addition, women are also able to be kapiteins and basja’s and have the same decision making power as their male counterparts in some communities. Women are active and organised and almost all communities in the AOI report that they have a women’s group, although they have various

[12] Nowadays, it is common for Amerindian community leadership to be selected through election. Amerindian AOI villages select leadership either by matrimonial lineage or election, depending on the community.

levels of functionality. Funding and political rivalry are the main reasons that women report that groups are not working.

While women appear to have equal say when it comes to community decision making, they face challenges with regard to economic and cultural parity with men. For instance, women are disproportionately more reliant on the subsistence economy than men who more often work within the cash/wage economy. The majority of women work in the agricultural sector where much of their produce is consumed by the family. They may trade, barter or sell excess crops at local markets and sometimes earn cash. Men, on the other hand, often work in natural resource harvesting (timber, small-scale gold production), which they earn money for their labour or capital. Men are also more likely to travel to larger urban centres in search of formal jobs, or to work in the informal economy doing small business activities. When men are away, women are responsible for households and children, and the maintenance and wellbeing of their families. As the Brokopondo communities continue to modernize and become more reliant on cash versus subsistence economy, the lack of opportunities for women to participate in the cash economy may reduce their power and decision making authority, if new opportunities are not identified for them to earn an income. The Project should also develop community development strategies that target women's participation to reduce the potential for gender inequalities. For example, the sand bag filling opportunity that was targeted to women from AOI communities during the Project's exploration phase may be a model of how the Project can extend employment and economic development opportunities to local women.

The cultural resources surveys undertaken in the Brokopondo, Carolina and Kawina communities identify that women have a greater number of cultural customs, particularly with regard to taboos around menstruation and rituals surrounding pregnancy and childbirth (see The Cultural Resources baseline; Social Solutions and ILACO 2017b). Women who are menstruating face restrictions on their activities such as preparing food for men. Similarly, they have reduced access to the use of community resources such use of creeks, face greater restriction on how they enter villages (must pass on the side of gates rather than underneath gates) while menstruating. Women may also not be allowed to enter/use their homes or sacred places and participate in rituals during their menstrual period. While there are signs that adherence to these customary rules may be lessening, it is important that the Project considers these customs when interacting with communities.

5.9.7.2 Mitigation and Benefit Enhancement

Mitigation and benefit enhancement measures to minimize Project-related effects to culture and wellbeing are outlined below and include:

Mitigation and Benefit Enhancement Strategies:

- The Project will widely circulate its employment and procurement policy to limit the number of people who come to the region to search for direct and indirect employment opportunities.
- The Project will consult with small-scale mining and logging operations about policies to secure the Project's boundary to prevent encroachment onto the potential mining concession.
- The Project will consistently show respect to traditional authorities and their decisions in order to prevent and manage conflict or aggression.
- The Project will implement cultural sensitivity training programs to help out-of-area Project workforce understand local cultural context; and will complete prior to full time arrival on site.

Increased Wage Activity

- Consider providing Project employees from AOI communities optional money management training, including support for opening up joint bank accounts for employees and their spouses, if requested.
- Project employees should be given the option of suggesting and attending “life skills” presentations on topics of interest. These may include topics such as starting up small businesses, saving and financial tips, effective communication and teamwork.
- The Project should work with cooperatives, women and youth groups, and small businesses early so that current residents can capture some opportunities and Project benefits, even if ad hoc or occasional.
- Project employees receive training on the responsible use of alcohol, and have access to programs for addictions and mental health issues.

Social and Cultural Identity

- The Project will establish workplace conditions that are sensitive to local cultures and values.
- The Social Responsibility Team should continue to engage with communities in the Project’s Area of Influence in a culturally appropriate manner. This includes following their customs about newcomers to the villages, respecting taboos and communicating in their native languages, where possible.
- The Project should consider working with existing community organisations, and in particular women and youth groups that are already organised in order to facilitate any community empowerment, skills development and training, or community development and investment initiatives.
- Kawina miners working in the Sabajo footprint could be targeted for employment or provision of services and will qualify for additional programs designed to create new opportunities for income generation.

Gender

- The Project will provide employment opportunities for both men and women and track hiring of women.
- Project employees should adhere to cultural norms. This may include participating in relevant rituals if there are Project disturbances to land, resources or areas of cultural values. in villages).

With the implementation of the above mitigations and management strategies, residual impacts may not be noticeably different between pre and post mitigation. Cultural change is not easily detected until time has passed and people have the ability to look back on changes. Management strategies are designed to respect cultures and communities.

5.9.7.3 Project Case Impact Classification

The Project has only very limited potential to draw people (in-migrants) to the region in search of economic opportunities. It could indirectly accelerate the process of out-migration of young adults from their home communities if they gain direct on indirect employment with the Projects. The Project will implement mitigation measures identified in Section 5.9.6, which include working with the local and national authorities and leadership to widely circulating the Project’s employment and procurement strategy to deter people from coming to the region. In terms of out-migration, it is more challenging to stop people from leaving their home communities for Paramaribo once they have a regular wage. The out-migration of youth has potential impacts for the maintenance of cultural traditions in the home community. Young adults who leave for the city may also be less likely to carry on their traditions, and therefore this knowledge may not be passed along to future generations. As Project employment levels are small in comparison to the total population of the region, the Projects contribution to cultural loss is expected to be small. After the implementation of mitigation, the effect is expected to be of low magnitude. People may choose to migrate at any phase of the Project, however the largest movement of people is expected during construction when most of the employment opportunities are available. This effect is therefore medium-term in duration. The likelihood of migration is assessed as likely. The residual impact of the Project-related migration is assessed as low.

Project-related direct and indirect employment will be low in Brokopondo and Carolina communities, and therefore there has little potential to increase the wage and cash economy in these communities in a manner impacting culture. There is already a cash economy operating in the Project AOI communities and Paramaribo so Project wages will have minimal effect on the local economy (discussed above in Section 5.9.6). The effect to culture and wellbeing from Project-related wages (direct and indirect) may occur due to changing values of Project employees, including out-migration from home communities to Paramaribo. The magnitude of this effect is expected to be low because of the limited number of Project employment opportunities, and the presence of a cash and wage economy already operating communities. This effect is likely to occur over the medium-term, from construction to the end of operations. The residual impact of this effect is therefore also expected to be low.

The Project is not expected to have a noticeable effect on the social and cultural identity of the Brokopondo and Carolina communities. For the Kawina, however, there is the potential for the Project to support the revitalization of Kawina communities and culture. The Project’s investigation of the Kawina’s position that they have traditional land rights in the area could support the formalization of a land claim, and their decision making authority in any future development activities in the region. The potential effect of the Project on the Kawina’s social and cultural identity is assessed to be a positive effect of high magnitude. This effect will be important at the local level, but also in their ability to negotiate at the national and international levels. This effect is possible to occur, and would be permanent, and not reversible. The residual impact of this effect is assessed as high.

The Project could be a driver of social conflict due to its potential role in changing social status of young people, as they are brought into the wage economy although this process is already occurring. In addition, the Project’s policies to target employment to certain ethnic groups may also be a driver of intra-community conflict if people perceive that the benefits of the Project are not distributed equally. As previously described, the Project is expected to have 300 jobs at peak construction and around 170 during operations, and therefore will not change the economic system, or power relations in any AOI community. As identified in the impact classification of ‘changes due to increased wage activity and income’ this effect is expected to be low. The effect has the potential to occur over the medium-term, defined as from exploration to the end of operations. The residual impact of this effect is assessed to be low.

The Project is not expected to negatively affect gender relations and may even potentially be a driver for equality because of its commitment to offer jobs to both men and women, and to implement outreach and community development initiatives that target women, youth and other marginalized groups. The Project may therefore have a positive effect of low magnitude that would last for the duration of the operations phase (medium-term). This likelihood of this effect is possible. The residual impact of this effect is assessed to be low.

A summary of Project effects on culture is provided in Table 5.9-10.

Table 5.9-10 Classification of Effects and Likelihood with Mitigation

Effect	Effect Classification					Residual Impact	
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-mitigation	Post-mitigation
The Project could result in changes in culture associated with in- or out-migration	Negative	Low	Local	Medium-term	Likely	Low Negative	Low Negative
The Project could influence the social and cultural identity of the Kawina	Positive	High	Local to National	Permanent	Possible	High Positive	High Positive
The Project could influence social conflict	Negative	Low	Local	Medium-term	Possible	Low Negative	Low Negative
The Project could influence gender relations	Positive	Low	Local	Medium-term	Possible	Low Positive	Low Positive

the Project = the Sabajo Project.

5.9.7.4 *Cumulative Effects Case Impact Assessment*

The Project, the Rosebel mine, and the existing Merian mine are expected to have different local AOI communities and so are not expected to interact cumulatively with regard to community level impacts. That being said, cultural change is the result of cumulative pressures on local culture from outside forces. Therefore all development activities in the region interact with the local culture and the more development that there is, the greater the pace of cultural change.

As the Merian mine and Project are both operated by Newmont, the company through its existing operations at Merian has gained capacity about how to work with communities in a culturally appropriate way. It is expected that this experiential knowledge will be transferred to the Project from the outset with respect to it engagement with AOI communities.

5.9.7.5 *Human Rights Assessment of Impacts to Culture and Wellbeing*

This section assesses the link between Project impacts to culture and wellbeing and the human rights of the Indigenous and Tribal communities in the Area of Influence (AOI). Various pressures that could lead to cultural change, tensions or loss of cultural identity are addressed together; a separate assessment will look at potential impacts to cultural rights for the Kawina tribe.

The right to culture for indigenous and tribal people has implications for the right to self-determination and the right to participate in public life, amongst others.

5.9.7.5.1 Potential Impacts to Rights

The rights associated with culture[13] protect an individual and community's ability to pass on their values, customs, religion and cultural 'references' as part of keeping the culture alive and dynamic. There is a fundamental right of people to preserve their customs and cultural diversity,[14] which is of particular relevance for minority cultures.[15] For indigenous and tribal people, cultural rights are also collective rights that sustain and revitalize traditions and practices and protect against forced cultural assimilation. Impacts to the right to culture, negative or positive, may influence traditional authority and self-governance systems, affecting the right to self-determination.

The holders of that culture ideally determine the potential for and significance of cultural impacts; the role of consultation is to ensure that the assessment considers how the rights-holders view and value the impacts. Companies must avoid causing or contributing to a form of forced assimilation caused by the unwelcome influx of people of a different culture (indigenous or tribal) impacting the culture, which was traditionally present in the project area (UN 2013). The ESIA process included consultation with the Amerindian communities along the Carolina Road and the Brokopondo communities along the Afobaka Road, studies to establish tangible and intangible cultural heritage, and meetings with relevant stakeholders to validate the baseline study findings.

5.9.7.5.2 Cultural Loss Due to Project-Induced Changes

Project construction and operation, especially in remote areas, can induce a number of direct and indirect changes to the culture and practices of local communities. The ESIA identified a number of potential impacts to the cultural rights of the Amerindian and Maroon communities in the AOI.

The consultation and baseline studies provided detailed information about the cultural practices and their ongoing importance to community members and leaders. The ESIA baseline studies confirmed this likelihood is low. However, any out-migration from cultural minority communities attributable to a company could negatively impact these rights. Engagement has indicated that specific cultural practices associated with taboos and specific area restrictions need to be respected.

Other social changes that result from the company's activities, as per the ESIA, include tensions over distribution of opportunities and changed gender dynamics within communities, these can cumulatively result in increased culture loss. While these pressures already exist, the cumulative nature of the issues may require the company to monitor how current coping mechanisms are absorbing changing lifestyles.

5.9.7.5.3 Impacts to Culture of Kawina Communities

From a rights perspective, the Kawina have undergone a process of assimilation due to the need to flee their villages during the Interior War and the absence of any post-conflict reconstruction that would have allowed them to return. Studies confirm high levels of multi-cultural marriages, loss of language and traditions in the younger generations and a general concern from the tribal authorities about decline in cultural practices. These changes are unrelated to Newmont's presence.

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[13] Article 15 (ICESCR) is the Right to take part in cultural life and to benefit from scientific progress; the Right to Freedom of Religion (Article 18 of the ICCPR) also supports cultural practice as it protects a person's right to choose as well as to teach and observe religious rituals.

[14] Universal Declaration of Human Rights (UDHR), Article 27.

[15] Article 27 of the ICCPR

Experience from international contexts suggests that acknowledgement of traditional land rights by international companies can positively affect local conditions. There is a potential for the Project to contribute to the Kawina people's enjoyment of the rights to culture by acknowledging their ancestral lands and through potential agreements as to how the Project will share benefits with them.

5.9.7.5.4 Qualification of Human Rights Risk

Prior to Newmont's presence, processes of cultural loss were underway in the interior and the ESIA identifies a number of additional pressures that might stem from the Project. While the extent or severity of any given social change may be low, the cumulative effect might be higher over time, although the specificity of impact is unknown. Given that these are Indigenous and tribal communities, cultural loss is of concern. The direction of impact is negative, of low severity and potential. The Project contributes to this risk to the right to culture and should be taking steps to reduce its contributions.

For the Kawina, there is a potential positive impact to the right to culture and self-determination from Newmont's actions. The scale is high, and likelihood is probable given the public commitments made by Newmont to recognize the Kawina as traditional land owners. The human rights prioritization is low because as a positive impact to rights it does not require prioritized attention from Newmont (Table 4.9-11).

Table 4.9-11 Qualification Table for Impact to Human Rights - Culture and Wellbeing

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Project influence on cultural loss	Negative, Low	Right to Take Part in Cultural Life, Right to Freedom of Religion	Brokopondo and Carolina road communities	Negative	Potential	Low	Possible	Low	Contribute to
Project influence on Kawina social and cultural identity	Positive, High	Right to Take Part in Cultural Life/Religious Freedom, Right to Self-Determination	Kawina communities	Positive	Potential	High	Probable	Low	Cause

ESIA = environmental and social impact assessment; the Project = the Sabajo Project; HR = human rights.

5.9.8 Artisanal and Small Scale Mining Impact Assessment

5.9.8.1 Effects Analysis

- The Project will displace some small scale mining operations

Project development will eventually bring about the displacement of ASM activities around Santa Barbara and Margo as these portions of the mining concession are developed. Unmitigated, this represents the displacement of and removal of livelihoods for those currently engaged in ASM in these areas of the mining concession. As of May 2017, 11 ASM operations were identified in the north Sabajo area with a combined workforce of at least 174. ASM operations in the north Sabajo zone range from eight individuals to over 30. There is also a cabaret of four workers, and a store with five staff supporting ASM activities. Some of the ASM activity in the north Sabajo zone is relatively recent, with most operations only being several months to a year old. Five of the operations claim to have been in existence for more than a year.

While some of those engaged in ASM activity in the north Sabajo zone may possess skills applicable to Project construction and operations, the uptake of project employment positions by ASM workers cannot be guaranteed. It is unlikely that their current experience would meet the operational standards of a large mining project such as Sabajo. Newmont can, through early engagement and targeted training efforts, attempt to build capacity in the existing ASM labour force; however, opportunities at Sabajo are limited due to the small number of jobs. Unmitigated displacement of ASM workers by the Project during construction and operations would result in the loss of their livelihoods. While many of the actual miners would likely move on to other opportunities, the equipment owners would be particularly vulnerable as they would require another site and ASM is often not carried out legally. Without mitigation, the Project's impact of displacement of those participating in ASM is high.

5.9.8.2 Mitigation

The mitigation for the economic displacement of small scale miners is the implementation of an ASM Management Plan. The Strategy is expected to guide engagement with affected miners and will aim to prevent and offset impacts associated with economic displacement to the extent possible.

Newmont plans to engage with ASM operators, equipment owners and landbosses that are present within the proposed Sabajo Right of Exploitation. Engagements will focus on mutual understanding of each parties mining operations and will establish rules for co-existence that identify responsible mining requirements such as environmental management, health and safety, and labor considerations. Before Newmont begins construction in areas with active ASM, advance notice will be given to ASM stakeholders and assistance will be provided to transport equipment out of the area. Options will be provided for livelihood enhancement that include skills training to increase employability in the formal sector and capacity building to develop small businesses.

The Free, Prior and Informed Consent (FPIC) process will include negotiations with the Kawina tribe as traditional landowners to compensate for land use; individual compensation for land use would not be included.

5.9.8.3 Project Case Impact Classification

The Project's residual impact of economic displacement of small scale miners will be largely mitigated through the implementation of Newmont's ASM Strategy for Suriname, reducing what would otherwise be a high magnitude effect to being of moderate magnitude. In addition to the investment into the national economy, Newmont will implement a strategy that aims to benefit affected stakeholders in the long term. Newmont will provide adequate notice to miners, assistance with moving equipment out of the area, and awareness of environmental and safety considerations. Newmont has supported injured or sick miners that come to the camp for help and Newmont has implemented a 'no guns' policy for security providers on its concession. Assuming effective mitigation, this impact is assessed as moderate magnitude given that some small scale miners may be inconvenienced by, and resistant to the process. The effect will be localized to those operators displaced by the Project and would extend beyond Project operations into closure (i.e., long-term). Given these factors, the Project's impact of economic displacement of small scale miners is assessed as moderate.

Table 5.9-12 provides a summary of the Project's effects on ASM.

Table 5.9-12 Classification of Effects and Likelihood with Mitigation

Effect	Effects Classification					Residual Impact	
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-mitigation	Post-mitigation
The Project will displace some small scale mining operations	Negative	High	Local	Long-term	Certain	High Negative	Medium Negative

the Project = the Sabajo Project.

5.9.8.4 Cumulative Effects Case Impact Assessment

The Project is not expected to interact cumulatively with the Merian or Rosebel mines to impact ASM activities at Santa Barbara and Margo, as these projects are not in the vicinity of these communities or requiring their displacement. However, small-scale miners displaced by the Project may relocate to areas near the Merian and Rosebel mines, in turn contributing to ASM activity near these developments.

5.9.8.5 Human Rights Risks from Impacts to Artisanal and Small Scale Mining

This issue is divided into two sections; the first section addresses the removal of ASM operators from sites within the Project footprint and subsequent impacts to livelihoods, specifically those of Kawina operators. The second section assesses the potential for security incidents and potential use of force related to the ASM presence.

5.9.8.5.1 Potential Impacts to Rights

ASM Removal and Impacts on Livelihoods.

Baseline studies observed an existing relationship between Newmont and ASM that could be categorized as co-existence. If the Sabajo Project progresses through to operations, Newmont will ask ASM operators to leave the locations that are directly involved in the construction and operation of the Project. The company will work together with miners to discuss the timeline and provide several months notice for ASM to relocate. In the case that miners refuse to leave, forced removal is a possibility. Forced eviction could potentially affect a range of human rights and must be in full accordance with relevant international human rights standards.[16] The risks often exist because the people in question do not have legal tenure.

ASM is the main economic activity in the interior of the country and is present in many locations, all of it illegally. In spite of the illegality, the sector is relatively organized, with well-established work relationships and payment regimes. While ASM gold mining is unpredictable, the ASM baseline study suggests it has consistently allowed land bosses, workers and mine equipment owners to earn a living.[17]

Miners and other workers are assessed in the baseline study as mobile, with transferable ‘skills’ and capable of redeployment to other small-scale mining operations. In contrast to the mobility of the workers, ASM equipment owners were found to be often more economically at risk as they may have

[16] http://www.ohchr.org/EN/Issues/Housing/Pages/ForcedEvictions.aspx

[17] Data from ASM baseline study and discussions from validation meetings at ASM camps, Santa Barbara (November 2017)

taken on debt in order to finance their equipment. According to ASM experts, this group is less mobile as the activity is illegal and finding equivalent deposits is not guaranteed. Experience internationally has demonstrated that restoration of livelihoods is difficult. Interviews with equipment owners for the ASM baseline study indicated that there could be difficulties in finding other profitable locations.

Kawina ASM operators may experience more of an impact to their livelihoods if they are unable to relocate within Kawina traditional lands as their operating cost would increase with the additional rent payments for mining on another tribes' land. For affected individuals, Newmont is exploring the option of supporting livelihood alternatives and of co-existing with ASM under certain strict conditions of labor, safety and environmental performance.

The ESIA identifies that an ASM Management Plan would address the impacts to miners and equipment owners as part of the Project's management plans. To ensure respect for the rights at risk, a company would need to demonstrate that affected people were in fact able to re-establish their livelihoods elsewhere. The mobile nature of the workforce, lack of a clear baseline on current income and the unpredictability of future earnings will be challenging considerations when designing measurement and monitoring programs.

Qualification of human rights risk

By displacing ASM from the Project footprint, the Project is at risk of causing a negative impact to the right to an adequate standard of living for those displaced. The impact is potential (future), negative, the severity is medium, and the risk is possible. This has a high human right prioritization and the Project's influence is causal.

5.9.8.5.2 Security and Potential Use of Force

Human rights issues associated with mine security, independent of whether the security forces are from the public or private sector, involve risks to the right to security of the person, to health (not being injured) and to the right to life (in case of fatalities). The risk relates to the use of excessive force or harassment against ASM miners or others involved in social unrest.

Several issues raise the level of risk at the Project:

- Some security guards hired by the private security firm are ex-military or police;
- Other international mining projects have experienced invasions by ASM with some violence occurring when public security forces intervened;
- There have been incidents of social protest at Merian; and
- People living or working in the jungle interior of Suriname are frequently armed with common hunting rifles or handguns.

Newmont has an internal security department who contracts mine security to Mozart Security Services, based out of Paramaribo. The Mozart security group are unarmed; no arms are allowed onsite. Their primary role is perimeter control for camp and operations areas and much of the site is unfenced. A similar security situation is expected at the Sabajo mine site. Armed military forces are present at Merian to guard the explosives magazines, and armed Suriname police are present for gold shipments, which will only originate from Merian.

The Ordening Goud Sector (OGS) is the government agency that oversees the ASM sector and is actively engaged in addressing ASM conflicts. The agency's mandate is to control ASM activities and support the legalization of ASM. The OGS has a set of procedures that are aimed to non-violently engage with and remove ASM operations at the request of concession holders.

The Newmont internal security team is responsible for interacting with ASM operations and regularly map ASM presence at Merian and Sabajo using GPS. They rely on OGS when direct intervention with ASM operators is necessary.

Potential Impacts to Rights

Utilization of private or public security forces present risks to the right to security of person,[18] as well as the rights to health and to life. The right to security of person includes not being subject to excessive use of force by public security forces or to abuses by private security forces. Companies have a responsibility to ensure that these rights are respected through the way it contracts for or engages with security forces. Newmont has stated that use of force would be only the last measure to remove ASM operators who need to be removed after all other options have been exhausted.

In the context of the Project, the company is responsible for the behaviour of its security department, its private contractor group Mozart, and by OGS or the police or military to the extent they are on site to support the Newmont's operations. Newmont is responsible for the safety and security of its personnel and operations; local incidents of armed robberies as well as petty theft and general site security standards justify the presence of trained security personnel. The Project's activities put it in competition with the pre-existing activities of the ASM sector, and at times, that competition can create conflict.

Both Newmont and the ASM sector report that current relations are positive and without friction. Mozart remains as the security contractor and instituted many changes internally. Mozart reportedly brought in a new manager well versed with the Voluntary Principles on Security and Human Rights (VPs), developed a management system to enforce their code of conduct, and increased training in the VPs including conflict de-escalation and mediation. All employees must have annual renewal of their VP training and Mozart reported that they are developing case studies and practical applications in conflict management. Mozart has also put in place a 3-tiered screening of new personnel to improve control that no one with human rights allegations is hired. A Mozart employee interviewed onsite was conversant with key points of the VPs and emphasized their preparation in conflict mediation and de-escalation.

Newmont's ability to implement the VP requirements relative to the public security forces has been less successful; while they have signed an MOU with the police, they have not been able to do so with the military or OGS. Police recruits are screened for past human rights violations at a regional level, but the process is not considered effective due to limitations in the process, and because impunity for past human rights violations is common in Suriname.

Newmont management and external specialists in ASM indicate that OGS has not been found to use excessive force and has established procedures for engaging with and when necessary removing ASM. Multiple stakeholders in community meetings confirm that OGS does not use force or violence against community members or ASM. Armed Special Forces are available to support the OGS if required.

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[18] The right to security of the person is Article 9 of the ICCPR

Qualification of Impact

The use of excessive force or harassment during encounters with the population, or use of force during the removal of ASM from the property boundaries could result in injuries or fatalities depending upon the circumstances and the security forces involved. The potential for serious injury or a fatality is greatly reduced by the prohibition on arms. Implementation of the VPSHR and a pro-active and ongoing engagement strategy with ASM have reduced the likelihood of a conflict. The risk of excessive use of force in managing ASM issues is negative and potential (not occurring now); it is of high severity with a low likelihood. Due to the potentially irremediable nature of the human rights risks the prioritization remains at high, recognizing the considerable efforts to control the risks and that ongoing attention is required. The principle risk is with public security forces, and due to the company's efforts to reduce the likelihood of excessive use of force, Newmont would be contributing to rather than causing any human rights violations attributed to public security forces, should they occur on the company's concession (Table 5.9-13).

Table 5.9-13 Qualification Table for Impact to Human Rights - Artisanal and Small Scale Mining

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Removal of ASM from Project footprint	Negative, Moderate	Right to an adequate standard of living	ASM sector, all affected participants	Negative	Potential	High	Possible	High	Cause
Use of excessive force to manage ASM	N/A	Right to security of the person, to health, right to life	ASM miners and equipment owners	Negative	Potential	Medium	Possible	Medium	Contributing to
Use of excessive force in response to social conflict	N/A	Right to security of the person, to health	Community members, other rights-holders	Negative	Potential	Medium	Possible	Medium	Contributing to

ESIA = environmental and social impact assessment; ASM = artisanal and small scale mining; the Project = the Sabajo Project; N/A = not applicable.

5.9.9 Land Use and Tenure Impact Assessment

5.9.9.1 Effects Analysis

- The Project could affirm the customary land tenure of the Kawina

The Project is within the traditional lands of the Kawina. In recognizing this, the Project can affirm the collective rights and customary land tenure of the Kawina in the area of Sabajo.

Artist and Rijsdijk (2017) undertook a Historical Narrative of the Traditional Lands around the Newmont Project that used a threefold approach to evaluate the Kawina claim. The study reviewed secondary literature and several maps from different tribes and organizations. Their work found that people of Ndyuka descent living in the Commewijne River watershed called themselves Kawina, and that these people corresponded to the Kawina community that currently resides in Paramaribo. In addition, the research involved identifying traditional land uses of the area through in-depth consultations with the Kawina. The Kawina's claim was validated through meetings with other tribal and indigenous groups from the region, who confirmed that the area surrounding the Project was the traditional territory of the Kawina (Artist and Rijsdijk 2017).

Newmont recognizes that the Project is located within the Kawina's traditional territory. The Kawina may potentially benefit from this acknowledgement in several ways. First, the relationship between the Kawina and Newmont may provide opportunities for the Kawina to redevelop their historic villages[19]. As noted in Section 5.9.7.1 on Culture and Wellbeing, the acknowledgment of Kawina traditional territory may be a driver for their cultural revival, including the sustained use of land around historic villages for traditional activities. A final pathway by which the Kawina may benefit from the Project's acknowledgment of their land rights is that this affirmation, which was attained through methodologically sound research, can potentially be used to support any future negotiations or claims in which the Kawina may partake. Given these factors, the Project's potential effect on the customary land tenure of the Kawina is considered positive and high.

- The Project could impact recreation and tourism activities in the vicinity of resorts and recreational areas along the selected access route.

The Project will introduce additional large truck traffic on roads between Paramaribo and the mine concession associated with the resupply of goods and the transportation of workers. This traffic will generate nuisance disturbances along the selected access road. The *Blaka Watra* resort near Casipora and the *Jodensavanne* historical site and medicinal healing well in Redi Doti are both over 1 km from the road, and are not expected to be impacted by Project traffic. There are recreational spots at Powakka. One is a picnic area with swimming and access to it is close to the road. Tourism activities near Afobaka Lake occur far from the road, and will not be impacted by nuisance disturbances. The Project's potential impact on tourism activities is expected to be limited to the generation of nuisance disturbances at the Carolina Bridge. Similar nuisance disturbances are already present at this site as a result of logging and other road traffic. While the Project would add to these existing disturbances, it is not expected to substantially change visitors' experiences of the sites relative to baseline conditions. The Project's effects on tourism and recreation as land uses in the region is thus considered to be minimal. Given these factors, the Project's potential effect on local recreational areas and tourism prior to mitigation is expected to be negligible.

- The Project could impact community and commercial forestry activities through direct land take and increased access.

The total area disturbed by the Project is expected to be around 1,550 ha, most of which is forested. The road to the Merian mine will traverse both commercial and community forests over its approximately 30 km span (Map 5.9-1). Where the Project will require clearing within the concession and along proposed roads to the Merian Mine, plans will be made with commercial forestry licence holders and the Traditional Authorities in relevant communities that address impacts of lost forest resources. Such plans involve identifying merchantable trees, and implementing timber salvage efforts that would make cut timber available to communities through their Traditional Authority. The development of access roads associated with the Project will increase access for other users. This could result in increased illegal harvesting of wood in commercial forest harvesting areas and also access to the area for other users (i.e., ASM). Newmont will engage land users to agree on locations of crossings and will not allow any facilities, shops or settlements along the haul road. Given the

[19] The villages of Pennenica, Java, Moismoiskondre, Gododrai, and Awara are historical Kawina villages that were destroyed during the interior war. These villages are not within the traditional territory of the Kawina that has been validated through the 'Historical Narrative of the Traditional Lands of the Newmont Sabajo Project' (Artist and Rijsdijk 2017)

remote location and the fact that they will begin and end at the Project and the Merian Mine (i.e., controlled access sites), illegal wood harvesting is expected to be minimal. Given these factors, the Project's potential effect on commercial forestry prior to mitigation is considered low.

- The Project could impact hunting and fishing activities through direct land take or change in the availability or quality of resource species.

For the limited number of individuals who hunt and fish, activities are carried out near their home community. The Project will not require land take near the Brokopondo, Carolina or Traditional Kawina communities. With the implementation of mitigation, the Project is not anticipated to have an adverse effect on the aquatic (i.e., the Commewijne River watershed) or terrestrial environments around communities that would impact the ability of local people to hunt or fish, or alter the safety of game and fish species for human consumption. Some in the ASM communities of Santa Barbara and Margo practice hunting and fishing for personal consumption. The Project will displace these individuals and thus disrupt their hunting and fishing activities; however, the fact that miners are not dependent on hunting and fishing for food, the impact of this on small-scale miners is expected to be negligible prior to mitigation.

5.9.9.2 Mitigation and Benefit Enhancement

The Project's ability to effect land use activities of local communities is limited by the amount of new disturbance required for the Project and its distance from communities. Potential land use effects related to changes in the quality or availability of resources are avoided through the implementation of mitigation measures in place for air quality (Section 5.2), soils (Section 5.4), water quality (Section 5.7), vegetation (Section 5.8), and biodiversity (Section 5.8). Consultation will be undertaken with those holding rights to practice commercial forestry in areas impacted by the mine concession and access road to the Merian Mine.

5.9.9.3 Project Case Impact Classification

In recognizing the collective rights and traditional lands of the Kawina in the area of Sabajo, the Project has the potential to represent a high magnitude, positive residual impact on Kawina land tenure. The effect will be regional to the area of Kawina traditional lands, and would persist indefinitely into the future (i.e., long-term). Given the importance of the acknowledgement of their traditional lands, the Project's effect on Kawina land tenure is assessed as high.

The Project's residual impact of disrupting recreation and tourism in the region is of negligible magnitude relative to baseline conditions, and is highly localized as a result of Project traffic on the Carolina Road. The effect will persist through operations, and so is medium-term. Mitigation is not required for this impact. Given the limited impact of the Project on recreation and tourism sites in the region, the Project's effect on tourism is assessed as negligible.

The Project's residual impact on forestry will be largely mitigated through stakeholder engagement and then implementation of agreed plans with those holding rights to forest areas disturbed by Project activities, and the limited area of disturbance relative to the overall land availability for the timber concessions. The effect will thus be of low magnitude. The effect will be localized and will persist beyond operations and closure as commercial timber stands regrow (i.e., long-term in duration). Assuming effective mitigation, the Project's effect on commercial forestry activities is assessed as negligible.

The Project's potential effect on hunting and fishing activities is, as with agriculture, limited to the small-scale miners near the Project who practice these activities sporadically. The magnitude of this effect will be negligible and does not require mitigation. The effect will be localized to the ASM communities of Santa Barbara and Margo, and will persist through Project operations (i.e., medium-term in duration). Given these factors, the Project's effect on hunting and fishing is assessed as negligible.

Table 5.9-14 provides a summary of the Project's effects on land use following mitigation.

Table 5.9-14 Classification of Effects and Likelihood with Mitigation

Effect	Effects Classification					Residual Impact	
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation	Post-Mitigation
The Project could affirm the customary land tenure of the Kawina	Positive	High	Regional	Long-term	Likely	High Positive	High Positive
The Project could impact recreation and tourism activities in the vicinity of local communities	Negative	Negligible	Local	Medium-term	Unlikely	Negligible Negative	Negligible Negative
The Project could impact community and commercial forestry activities through direct land take and increased access	Negative	Low	Local	Long-term	Likely	Low Negative	Negligible Negative
The Project could impact hunting and fishing activities of displaced small-scale miners	Negative	Negligible	Local	Medium-term	Certain	Negligible Negative	Negligible Negative

the Project = the Sabajo Project.

5.9.9.4 Cumulative Effects Case Impact Assessment

Given the highly localized nature of the Project's impacts on land use, and the fact that the Rosebel and Merian mines do not physically overlap the Project concession, no cumulative impacts on land use as a result of the Project and other developments are anticipated.

5.9.9.5 Human Rights Assessment of Land Use and Tenure Impacts

The following section addresses the human rights concerns associated with the Project's land and resource use. The discussion focuses on rights associated with changes to land and natural resource use, and the role of FPIC in that process. Potential risks from changes to land use in community forestry concessions are also addressed.

5.9.9.5.1 Potential impacts to rights

Significant mining industry attention has been focused on respecting the right to FPIC. This is a central tenant of the UNDRIP and ILO 169 and has raised challenges for States (associated with sovereignty) and for companies operating in States with no recognition of indigenous land and other rights. FPIC implies that Indigenous People have the right to approve, agree to a modified version of, or withhold consent to a project proposed on their lands. FPIC is an obligation of the State to carry out when actions or decisions will affect indigenous peoples' lands, territories or other resources that they traditionally own, use or occupy, especially in relation to use or exploitation of mineral, water or other resources.[20] Whether or not States fulfill that obligation, companies remain independently responsible to respect the indigenous/tribal rights, should engage in a good faith consultation and should refrain from developing a resource on lands if the traditional owners withhold consent.

FPIC is a mechanism for respecting the individual and collective rights of indigenous and tribal peoples' substantive rights, in particular the right to enjoy and dispose of the wealth and natural resources from their property and the right to self-determination.

5.9.9.5.2 Land Use and Tenure impacts on the rights of the Kawina

Approximately 95% of the country's land is owned by the state; Surinamese indigenous and tribal people lack constitutional and legal recognition of their rights to property. Some Maroon and Amerindians hold individual land titles under the 1982 L-Decrees, which acknowledge limited customary rights, but do not provide effective protection of their full property rights. The Suriname government has issued mineral and forestry concessions and created protected areas on traditional territories without consent or participation in the benefits generated by the activities.

Only the Government of Suriname can legally provide Tribal rights to property and hence ensure protection of other associated rights, and Newmont should respect those rights. For the Sabajo Project, Newmont conducted detailed studies and consultations to determine whether a traditional land claim would be present for the land where Sabajo sits. Newmont acknowledges the Kawina as traditional landowners and intends to achieve FPIC with the tribe.

5.9.9.5.3 Agreement making to respect substantive rights

Concerns about power imbalances and organizational capacity must be considered, as the right to benefit from development of resources is at risk if the agreement making process is not fair (UN 2013). Studies found mixed levels of capacity to negotiate between Kawina communities, a lack of clarity about some aspects of land rights, and recommended provision of legal and other experts.[21]

It is important that the traditional authority structures be respected and followed, and that the process and outcomes are legitimatized by community members. Newmont's responsibility extends to ensuring that the Kawina leadership has the capacity to negotiate and make agreements that are fair and appropriate to the benefit of the entire community. Newmont has participated in an independent review of the FPIC process at Merian to learn how to more effectively achieve FPIC in a rights-compatible way in Suriname, demonstrating ongoing due diligence to improve this process (Resolve 2017).

5.9.9.5.4 Haul road and rights of holders of community forestry concessions

The haul road between the Sabajo Project and Merian will cross four logging concessions; two commercial concessions and two community forest concessions. This road involves a limited amount of land take, but could create opportunities for income and use of resources by forestry concession holders. The Project has committed in the ESIA to address the potential effects of lost forest resources by agreeing with concession holders how to best proceed with construction. In line with the need to respect indigenous and tribal peoples' property rights in Suriname, it is important for the

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[20] Articles 25-29 and 32 of UNDRIP (UN 2008)

[21] Historical Narrative, pg. 57-58 and Recommendations (Artist and Rijsdijk 2017).

company to consult relevant concession holders with respect to their rights over the resources. Initial consultation has taken place between the company and the representatives of community forests, as well as, commercial concession owners to establish a process for managing the impacts and reducing any negative impacts to the concession holders. .

5.9.9.5.5 Qualification of human rights risk

The assessment identifies an enhancement to Kawina property rights and self-determination from Newmont sharing the research with the Kawina that led to the company's acknowledgement of their traditional land rights. This is a positive impact on the enjoyment of these rights, the status is actual and the scale of the impact is high given the contribution it makes to the knowledge base for Kawina land rights. As it is already occurring, the likelihood is certain; further attention by the Project is not required so the prioritization is low.

Three separate risks stem from Project impacts to land use and tenure and are qualified below:

1) The risk that FPIC is not achieved. This would be the case in the event that the company would not be able to obtain consent from traditional landowners or if the process were not consistent with a rights-based approach. Although the formal FPIC process is at an early stage, neither the ESIA nor the consultation process to date identify any significant obstacles that would impede the company's ability to demonstrate its responsibility to respect the right to self-determination. The risk that the company is not able to discharge its responsibility to respect FPIC is negative, potential as FPIC is at an early stage; the severity would be high but the likelihood is low. The human rights prioritization is medium - high because of the national context; actions are underway and ongoing care is required.

2) The risk that the FPIC process will succeed but that the agreement process will not provide an adequate rights-compatible outcome. Kawina participation in the benefits of the project's development should reflect their rights as owners of the land, with the capacity to agree or not to the development through adequate technical and legal support. The impact to rights would be negative and potential. The risk would have a medium-high severity and is considered a possible risk. The human rights prioritization remains medium to focus further effort on reducing the risk.

3) The risk that the right to property is not respected in the land take for the haul road. The right to property should be respected in a land take. Prior consultation is required with the concession holders to determine the significance of the land take and impact it may have on them as owners of those resources, and to involve them in assessment of how to avoid or minimize those impacts, if important to them. This approach is planned by the Project but the risk to these rights remains. The risk is of a potential negative impact, of low severity with likelihood assessed as possible. The human right prioritization is medium because the process is important in recognition of the rights of traditional owners and because the company's actions would cause the negative impact (Table 5.9-15).

Table 5.9-15 Qualification Table for Impact to Human Rights - Land Use and Tenure

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity (scale)**	**HR Risk Likelihood**	**HR Priority**	**Influence**
Project affirmation of Kawina customary land rights	High, positive	Right to property, right to self-determination	Kawina Tribe	Positive	Actual	High	Certain	Low	Cause
FPIC process not achieved for Project	Not in ESIA	Rights to Self-determination	Kawina Tribe	Negative	Potential	High	Possible	High	Cause
Agreement-making not fair or legitimate	Not in ESIA	Right to benefit from development of land and resources	Kawina Tribe	Negative	Potential	Medium-high	Possible	Medium-high	Cause
Land take from community forestry concessions	Negative, negligible	Right to property, to benefit from use of natural resources	Community forestry concession holders	Negative	Potential	Low	Possible	Low-medium	Cause

ESIA = environmental and social impact assessment; FPIC = Free, Prior Informed Consent; the Project = the Sabajo Project; HR = human rights.

5.9.10 Quality of Life Impact Assessment

5.9.10.1 Effects Analysis

For the purpose of ESIA, ‘quality of life’ involves the assessment of a community’s potential to experience nuisance effects such as increased traffic, noise, changes in air quality (dust, odours) and changes in water quality and quantity.

- The Project could impact the quality or quantity of water at the Kawina traditional villages.

The Kawina communities are in the same watershed (i.e., the Commewijne River watershed) as the Project, and so have been included in the assessment of potential impacts on quality of life. As discussed in greater detail above (Sections 5.9.6.3 and 5.9.6.4), some Kawina residing in Paramaribo return to the location of their historical communities to tend to small agricultural plots on weekends; few reside in these communities at present. From discussion with Kawina women and traditional authorities, there is desire and plans to return to these communities. The Kawina communities are geographically located between 29 kilometers (km; Moismoiskondre) and 40 km (Pennenica) from the Project. By river, the communities are between 35 km (Moismoiskondre) and 50 km downstream from the Project. Those that are staying in these communities now, or that return to garden on weekends would not be impacted by nuisance effects such as traffic, noise, or changes in air quality (dust, odor), as potential for these impacted to be realised is localised to within 50 meters (m) of Project activities and transportation routes.

In an average precipitation year, the predicted total water yields (runoff plus baseflow) generated by the Project will add approximately 10 millimeters (mm; 1%) to baseline water yields (830 to 880 mm). Water discharged by the Project into the environment will be treated prior to release, and is not expected to result in a residual effect on surface water quality. The Project’s discharge of water is also not expected to impact the flow rate of the Commewijne River downstream at locations where historical Kawina communities might draw water. Therefore, while these communities are within the same watershed as the Project, construction and operations activities are not expected to have a residual effect on surface or groundwater quality or quantity that would that would change Kawina access to water for agricultural and consumptive purposes. Given the above, the Project is not expected to materially impact the quality of life of the Kawina. This potential effect has, thus, not been carried forward for further assessment.

- The Project could impact the quality of life of those residing in Brokopondo communities.

The Brokopondo communities are far enough from the Sabajo concession that Project construction and operations activities are not expected to generate dust, odours, or noise impacting the quality of life in these communities. Similarly, they are not within the same watershed as the Project, and so are not expected to experience changes in water quality or quantity.

Project traffic could impact the Brokopondo communities should the Afobaka Road be used to transport goods, equipment and personnel to site during construction and operations. This is particularly true for Compagnie Kreek, Drepada, Balingsoela and Afobaka Centrum, the communities closest to the Afobaka Road. No Brokopondo communities are located within 50 m of the road (Table 5.9-16; Map 5.1-3).

Table 5.9-16 Proximity of the Brokopondo Communities to the Afobaka Road

Community	Distance From the Afobaka Road (m)
Afobaka Centrum	340
Asigron	7,240
Balingsoela	646
Boslanti	6,819
Brokopondo Centrum	3,882
Compagnie Kreek	243
Drepada	6,208
Tapoeripa	5,330

m = meter.

The effect of the Project is not projected to exceed International Finance Corporation (IFC) guideline values (i.e., an increase of 3 A-weighted decibels [dBA] from baseline noise levels). Project traffic will not be heard at all from most village locations. Similarly, the combination of baseline and project traffic is not expected to result in dust (particulate matter with mean aerodynamic diameter nominally smaller than 10 microns [PM_{10}] and particulate matter with mean aerodynamic diameter nominally smaller than 2.5 microns [$PM_{2.5}$]) concentrations exceeding World Health Organization (WHO) guidelines at 20 m from the road. The Brokopondo communities are, therefore, far enough from the road that they are not expected to experience dust, odour or noise generated by Project traffic The Project's potential to effect the quality of life of residents of the Brokopondo communities is thus limited to the interaction between Project traffic and local foot and vehicle traffic on the Afobaka Road.

Should the Afobaka Road be used as an access route, the Project will increase heavy vehicle traffic associated with the transportation of goods, equipment and workers. Heavy vehicle traffic is expected to involve five trips per day during construction, increasing to around 34 trips per day during operations, representing a 29% increase over baseline heavy vehicle traffic conditions on the Afobaka Road. The Project's relatively low daily requirement for 20 light vehicles and three buses during construction will increase during operations to 30 light vehicles and 25 buses, Overall, the Project will increase traffic on the Afobaka road by 2% during construction, and by 7% during operations. During both phases, Project and existing heavy truck and logging traffic would interact with other traffic on the road, including nearly 400 buses, 850 light vehicles (cars, light trucks, bicycles and motorcycles), and a small number of pedestrians and cyclists. There are several stands along the road selling consumer goods, and a market at the junction of the Afobaka Road and the Phedra Road.

While the absolute number of large trucks required to supply the Project is small relative to existing traffic volumes on the Afobaka Road, it is the associated change in traffic composition that has the greatest potential to impact the quality of life of those sharing the road. Large truck traffic takes up more space, and, in the event of a collision, presents a higher-risk to public traffic, particularly pedestrians, cyclists, and motorcyclists. In addition to other pedestrians, children have been observed along the road, both as pedestrians, and while waiting for school busses. Public traffic (e.g., cars, trucks, motorcycles, pedestrians) currently has experience with larger vehicle traffic on the Afobaka Road based on the volume of heavy truck and logging traffic on the road. The Project would have a small additive effect, introducing more heavy truck traffic.

Given that the Project is not expected to result in changes to air quality, noise, or access to and quality of water, and that its potential effect on traffic is small, the resultant effect on quality of life is considered low to moderate prior to mitigation.

- The Project could impact the quality of life of those residing in the Carolina communities.

With the exception of Powakka, none of the Carolina communities are closer than 50 m away from the road (i.e., within the area of potential impacts on quality of life related to air quality and noise; Table 5.9-17; Map 5.1-3). While Philipus Kondre is close to the Afobaka Road, it is not immediately beside the road (dwellings are more than 50 m away).

Table 5.9-17 Proximity of the Carolina Communities to the Carolina Road

Community	Distance From the Afobaka Road (m)
Casipora	1,585
Philipus Kondre	50[a]
Pierre Kondre Kumbasi	3,005
Powakka	On the Road
Redi Doti	137

a) Also within about 50 m of Afobaka Road

Should the Carolina access route option be selected, the effect of the Project is not projected to exceed IFC guideline values (i.e., will not increase existing noise by more than 3 dBA). Given its proximity to the road, residences in Philipus Kondre may experience limited and intermittent noise impacts due to daytime Project traffic. Similarly, the combination of baseline and Project traffic is not expected to result in PM_{10} and $PM_{2.5}$ concentrations exceeding WHO guidelines at 20 m from the road. The off-road Carolina communities are, therefore, far enough from the Sabajo concession that Project construction and operations activities are not expected to generate dust, odours, noise or visual disturbances impacting the quality of life in these communities. Similarly, they are not within the same watershed as the Project, and so are not expected to experience changes in water quality or quantity. The potential for residents of these communities to experience Project-related impacts to their quality of life is, therefore, limited to their potential to interact with the Project’s heavy truck traffic when travelling along the road.

The Project will introduce heavy vehicle traffic associated with the transportation of goods, equipment and workers. Heavy vehicle traffic is expected to involve five trips per day during construction, increasing to around 34 trips per day during operations, representing a 162% increase over baseline heavy vehicle traffic conditions on the Carolina Road. The Project's relatively low daily requirement for twenty light vehicles and three buses during construction will increase during operations to 30 light vehicles and 25 buses, Overall, the Project will increase traffic on the Carolina road by 4% during construction, and by 12% during operations. During both phases, Project and existing heavy truck and logging traffic would interact with other traffic on the road, including just over 100 buses, 600 light vehicles (cars, light trucks, bicycles and motorcycles), and a small number of pedestrians and cyclists[22].There are several stands along the road selling consumer goods.

Given existing traffic characteristics on the Carolina Road, the Project will have a considerable impact on traffic composition, representing more than a doubling of heavy traffic on the road. While other road users are familiar with heavy traffic, this could create both a nuisance (sharing the road with large trucks that take up much space, dust, noise and odour) and a safety risk. Unmitigated, the Project's potential impact on the quality of life of road users on the Carolina Road could be substantial.

With the recent provision of reliable electricity in inland communities, including those along the Carolina Road, and the growing cost of living in Paramaribo, some who left their home communities for the city have begun to return. Should this trend continue and grow, more traffic could be expected on the Carolina Road. The Project would, therefore, be adding to even busier baseline conditions than those referenced above.

While the Project is not expected to result in changes to air quality, noise, or access to and quality of water, its potential effect on traffic is substantial. If the Carolina road option is selected, the resultant effect on quality of life is considered moderate prior to mitigation.

- The Project could impact the quality of life of those residing in Powakka.

Powakka is far enough from the Sabajo concession that Project construction and operations activities are not expected to generate dust, odours, noise or visual disturbances impacting the quality of life or residents. Similarly, the community is not within the same watershed as the Project, and so is not expected to experience changes in water quality or quantity.

Should the Carolina road option be selected, it travels directly through Powakka. As a result, residents of this community have the greatest potential to experience impacts to their quality of life associated with Project traffic. During operations, the Project would add three trucks per hour (34 trips per day) to the existing vehicular traffic on the Carolina Road through Powakka, representing a substantial increase in heavy truck traffic of 162%. Dust, odours and noise generated by Project traffic are expected to exacerbate existing issues with these nuisances, though dust may be of lesser concern given that the road is paved through Powakka. Most Project traffic would be concentrated during daytime hours. At no location is the noise from this traffic expected to change the baseline noise by more than 3 dBA, so the Project's effects are within the standards set by the IFC. Baseline noise levels are already in exceedance of guideline values of 55 dBA, but this level of noise is common along roads and neither the baseline nor the impacted noise value is harmful to health.

[22] Outside of the portion of the road that goes through Powakka.

Perhaps the most pronounced impact to the quality of life of residents of Powakka would be the safety risk that Project traffic would pose. Residents of Powakka have noted that the road is used frequently by pedestrians, including young children travelling to and from primary school. This is supported by baseline data that suggests pedestrian traffic on the portion of the road in Powakka is nearly 200 a day. There is a school on the road, and schoolchild foot traffic is greatest between 8:00 and 10:00, and between 12:00 and 14:00[23], overlapping with daily peak Project traffic (i.e., during daylight hours). There is also a road-side market in the community. Residents also expressed concerns over the safety risks of Project-related heavy truck traffic sharing the road with these users. This portion of the Carolina Road currently experiences high volumes of traffic, including heavy truck traffic. Unmitigated, the additive effect of Project traffic in terms of safety risks to pedestrians (in particular children) could be substantial.

With the recent provision of reliable electricity in inland communities, including Powakka, and the growing cost of living in Paramaribo, some who left their home communities for the city have begun to return. Should this trend continue and grow, the more traffic could be expected on the Carolina Road. The Project would, therefore, be adding to even busier baseline conditions than those referenced above.

While the Project is not expected to result in changes to air quality, noise, or access to and quality of water, its potential effect on traffic in Powakka is high. The resultant effect on quality of life is considered High prior to mitigation.

5.9.10.2 Mitigation

Traffic Safety Impacts:

- A traffic and transportation safety management plan has been developed (adopted from the plan in place at Merian) to improve overall traffic safety and reduce risks within the transportation corridor. This will include:
  - Increased maintenance of project access routes beyond the current maintenance program that is implemented by Government, and monitoring for increases in Project traffic to determine if additional mitigation measures are required;
  - adopting limits for trip duration and arranging driver rosters to avoid fatigue;
  - nearly all road use will be in daylight hours, given that the risks of some types of incidents would be higher for vehicles travelling at night;
  - contractors and subcontractors will be required to adhere to Newmont driving standards;
  - use of a reporting system so that local communities can report any issues relating to road use, safety, or other concerns, and Newmont can take action to improve measures for safety where needed; and
  - additional signage, speed bumps or education program near Powakka may be necessary and will be determined through engaging with the Carolina communities should that access route option be chosen.

Noise Mitigation:

- regular maintenance on Project vehicles in accordance with manufacturer specifications; and,

[23] This observation was made on a holiday, and so may not be reflective of the same pattern that would be observed when school is in session.

- limit offsite Project traffic to the daytime period (07:00 to 22:00), where practical.

Air Quality Mitigation

- regular maintenance on all mine equipment and Project vehicles in accordance with manufacturer specifications;
- standard emissions controls on vehicles;
- implementing an idle-reduction program;
- use of ULSD fuel for Project equipment;
- watering of Project roads and ore stockpile as necessary;
- use of best available technology economically achievable (BATEA) for emissions controls;
- implementing an quality monitoring program for PM_{10}, $PM_{2.5}$ and nitrogen dioxide (NO_2) at the Project site during construction and operation phases; and
- reclaim mine stockpiles and disturbed areas as they become available.

Water Quality Mitigation:

- treat water prior to discharge into the environment; and
- discharge into watercourses most impacted by reduced run-off effects of the Project.

5.9.10.3 Project Case Impact Classification

While the overall traffic volume increase is small, changes in traffic composition and flow has been identified as an area of concern for the Brokopondo communities. Even a relatively small contribution such as that brought about by the Project can have an adverse effect where baseline conditions have high volumes of traffic, including large trucks and logging vehicles. This is the case on the Afobaka Road near the Brokopondo communities. This effect is, however, expected to be manageable with mitigation. Therefore, the Project’s impact on quality of life in Brokopondo communities, as related to changes in traffic, is expected to be of low to moderate magnitude, depending on the location. The effect is local to the portion of the Afobaka Road near the Brokopondo communities, and would persist into operations (i.e., medium-term). Given these factors, the Project’s adverse residual impact on quality of life for residents of the Brokopondo communities is assessed as low.

The Project represents a substantial addition of heavy truck traffic on the Carolina Road during operations. It is expected that this effect could be managed through the implementation of mitigation as noted above. The effect of this increase in heavy traffic is, therefore, expected to be of low to moderate magnitude in terms of the quality of life of other road users, depending on location. The effect is local to the portion of the Carolina Road near the associated communities, and would persist into operations (i.e., medium-term). Given these factors, the Project’s adverse residual impact on the quality of life of residents of the off-road Carolina communities is assessed as low to moderate.

The Project’s heavy truck traffic will interact with high volumes of local traffic on the portion of the Carolina road that runs through Powakka, including numerous pedestrians, some of which are young children. The effect of this interaction is expected to be of moderate magnitude in terms of residents’ quality of life, assuming effective implementation of mitigation and depending on location. The effect is local to the portion of the Carolina Road running through Powakka, and would persist into operations (i.e., medium-term). Given these factors, the consequence of the Project’s adverse residual impact on the quality of life of residents of Powakka is assessed as moderate.

Table 5.9-18 provides a summary of residual Project effects on quality of life.

Table 5.9-18 Classification of Effects and Likelihood with Mitigation

Effect	Effects Classification					Residual Impact	
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation	Post-Mitigation
Project traffic will impact the quality of life of those residing in Brokopondo communities	Negative	Low to Moderate	Local	Medium-term	Likely	Low to Medium	Low
Project traffic will impact the quality of life of those residing in the off-road Carolina communities	Negative	Low to Moderate	Local	Medium-term	Likely	Medium	Low to Medium
Project traffic will impact the quality of life of those residing in Powakka	Negative	Moderate	Local	Medium-term	Likely	High	Medium

Project = the Sabajo Project.

5.9.10.4 Cumulative Effects Case Impact Assessment

The Project's adverse impacts on the quality of life of road users and residents of Powakka has been assessed against baseline conditions that include existing traffic associated with the Merian Mine, and so is inherently cumulative. No other developments are known or expected to interact with the Project to impact the quality of life in the Brokopondo and Carolina communities.

5.9.11 Historical and Archaeological Resources Assessment

5.9.11.1 Discipline Methods

The assessment of effects on tangible cultural heritage is based on:

- review of literature to document available information on tangible heritage in the Project (the Project) footprint;
- community engagement to understand and describe community knowledge that exists on tangible cultural heritage resources in the Project area and the wider region; and
- field work in the Project study area to evaluate the potential presence of tangible heritage resources in currently accessible parts of the Project footprint.

The effects assessment is consistent with internationally recognized good practice as described in the International Council on Monuments and Sites (ICOMOS 1990) Charter for the Protection and Management of the Archaeological Heritage, the Government of Suriname Monument Law of 2002 for immoveable archaeological resources and Stichting Bosbeheer's en Bostoezicht 2011 Code of Practice that includes a zoning standard for places of cultural importance and archaeological sites.

Given access constraints and uncertainty around the location of some of the proposed Project components, the field component of the baseline heritage assessment focussed on accessible areas considered to have the highest potential for tangible cultural resources to be found. There are some areas that were not surveyed. The parts of the mine site to be developed in future that have not yet had any surveys in the vicinity and the Sabajo-Merian Haul Road) will be assessed to the same standard prior to, or concurrent with proposed future ground disturbance activities by Newmont.

Impact criteria for assessment of cultural heritage effects are presented in Table 5.9-19

Table 5.9-19 Impact Description Criteria for Cultural Heritage

Direction[(a)]	Magnitude[(b)]	Geographic Extent[(c)]	Duration[(d)]
Positive: increase in knowledge through investigation of cultural heritage **Neutral:** condition of the cultural heritage resource is unchanged in comparison to baseline conditions and trends **Negative**: loss of cultural heritage resources or contextual information	**negligible**: no physical effects occur or no cultural heritage sites are expected to be present **low**: minimal effects to cultural heritage resources of low, moderate or high heritage value **moderate**: moderate to high effects to cultural heritage resources of low or moderate heritage value **high**: moderate to high effects to cultural heritage resources of high heritage value	**site-specific**: the expected measurable effects are within the specific heritage resource boundary **local**: effect restricted to the study area	**short-term**: effect lasts through construction phase **medium-term**: effect does not extend beyond the life of the Project **permanent**: effect results in permanent change

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.
b) Magnitude: degree of change to analysis endpoint.
c) Geographic Extent: area affected by the impact.
d) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period and a 10-year operations period and a 4 year closure period.

5.9.11.2 *Issue Scoping*

Based on experience with similar projects, there are two potential impact issues that relate to cultural heritage (Table 5.9-20).

Table 5.9-20 Potential Impact Issues for Cultural Heritage

Issue Number	Key Issue – Potential Impact	Summary
1	Changes to Cultural Heritage resource integrity	Damage or destruction of heritage resources due to: - Surface disturbance - Subsurface disturbance - Compaction - Erosion
2	Changes to Cultural Heritage resource accessibility	Changes in the amount of access to heritage resources due to: - Increased access (by general public) in the long term, due to access route development by the Project- Unauthorized artifact collection - Lack of access (to sites of interest for community members and others, due to access restrictions around the Project)

the Project = the Sabajo Project.

5.9.11.3 *Linkage Analysis*

Based on the results of the desktop research, it was determined that there are no previously recorded archaeological sites in the proposed Project footprint. Community consultation for the Project and anecdotal conversations directly relating to the tangible culture of the area identified one unrecorded pre-Columbian archaeological site comprised of earthenware ceramics and stone implements in the vicinity of the Santa Barbara Pit (in an area that has now been altered by ASM and an unrecorded slave route in the proposed Project Footprint. However, the areas affected by ASM have been substantially disturbed and have very low potential of containing other tangible cultural resources. The location of the unrecorded slave route is unknown and the provisions outlined in the Cultural Resources Management Plan of this ESIA (see Volume B) will adequately address the potential discovery of tangible cultural heritage associated with this feature. No tangible heritage resources were found in the 182 ha area that was subject to archaeological survey. Given that baseline work completed to date has not identified cultural heritage resources which may be subject to potential Project effects, there are no measurable impacts to assess and cultural heritage is not carried through to the effects assessment.

5.9.11.4 Additional Baseline Studies

Given access constraints and uncertainty around the location of some of the proposed Project components, the field component of the baseline heritage assessment to date has focussed on accessible areas considered to have the highest potential for tangible cultural resources to be found. Prior to site clearing or construction, Newmont will engage a qualified archaeologist to complete additional baseline surveys at: (1) the Sabajo North Waste Rock Facility (WRF); (2) Sabajo Pits 4 and 6; (3) the area to be disturbed by the Margo pit and WRF; and (4) all medium or high potential areas for cultural resources along the Sabajo-Merian Haul Road (Map 5.9-2).

5.9.11.5 Management

A chance find procedure will be part of the overall Environmental and Social Management and Monitoring Plan which is further discussed in the Cultural Resources Management Plan section of this ESIA (Volume B).

5.9.12 Community Health Assessment

5.9.12.1 Discipline Methods

A Rapid Health Impact Assessment (HIA) was conducted by International SOS (ISOS) in November 2017. It draws on desktop research of secondary data from various government and non-government sources, review of environmental and social data, community profiling and key informant interviews.

A visit to Suriname was conducted in 2017 that included communities within the AOI, but the proposed Project area was not visited and no specific consultation was completed regarding health issues. All health data included in the baseline report and used for HIA is secondary data obtained by the Medical Mission or other Surinamese authorities.

The overall approach for health impact criteria ratings are the same as for other disciplines.

5.9.12.2 Issues Identification

The following health issues were considered in the context of potential Project effects. Each was studied, screened and given a priority ranking based on the level of community concern, baseline conditions (Section 4.12) and the potential effects of the Project.

- Issue 1: Vector-Related diseases. Ranking: Moderate.
- Issue 2: Zoonotic diseases. Ranking: Moderate.
- Issue 3: Housing and Respirator Issues. Ranking: Low.
- Issue 4: Sexually transmitted infections. Ranking: High.
- Issue 5: Diseases related to soil, water, sanitation and waste. Ranking: Low.
- Issue 6: Consumption and nutrition related issues. Ranking: Negligible.

- Issue 7: Accidents and Injuries. Ranking: High.
- Issue 8: Exposure to potentially hazardous material. Ranking: Low.
- Issue 9: Social determinants of health. Ranking: Low.
- Issue 10: Cultural health practices. Ranking: Low.
- Issue 11: Health Service infrastructure and capacity. Ranking: Low.
- Issue 12: Non-communicable diseases. Ranking: High.

All issues with priority rankings of moderate and high (1,2,4,7,12) have been carried forward to the impact assessment. These are described below. Issues with priority rankings of low or negligible have not been assessed in the ESIA.

5.9.12.3 Health Issue #1: Vector-Related Diseases

Impact Analysis

- Vector-borne diseases are human illnesses caused by parasites, viruses and bacteria that are transmitted by mosquitoes, sandflies, blackflies, ticks, tsetse flies, mites, snails and lice. The distribution of vector-borne diseases is determined by complex demographic, environmental and social factors (WHO 2017).
- The vectors associated with the transmissions of several vector diseases, such as malaria, Zika and leishmaniasis, are present in the area where Sabajo is located.
- Several vector diseases are present in the area and some have just recently emerged (i.e. Zika); therefore, these diseases are a problem and a burden for the local population and the health system.
  - Although the prevalence of <u>malaria</u> is very low, the presence of ASM in the area causes ongoing transmission as mentioned by the Malaria Program Suriname (ISOS 2017). Similarly, <u>leishmaniasis</u> is present and has been reported as a problem by both ASM and communities.
  - A <u>yellow fever</u> case was registered in Suriname in early 2017, another case was registered in French Guiana in the summer of 2017 and there is an ongoing outbreak in Brazil. Although yellow fever vaccination is now currently included in the national vaccination program, the coverage is not 100% as pockets of the population remain non-vaccinated. According to the Medical Mission, yellow fever vaccination in 2016 was 65%. In addition, ASM vaccination coverage is unclear.
  - <u>Zika</u> infections have been recorded in Suriname over the last few years (ISOS 2017), and these are now included in the surveillance system. Interestingly, during ESIA consultations, 3 people mentioned having suffered from Zika in 2017 among the Amerindian communities, while the Medical Mission has not reported any case during the same time. This means that there is some level of awareness about vector-transmitted infection, but there is no accurate knowledge and/or surveillance.
- An increase in vector-related diseases within the Project footprint is likely**.** Project activities could alter the environment by increasing breeding sites for the vectors and their relative mobility (Walsh 1993).
- The health consequence would be moderate because of the following reasons:
  - <u>Magnitude</u>: Low, as most diseases can be treated locally and the local communities are vaccinated against yellow fever.

- Geographical extent: Limited to Project footprint and communities where employees live.
- Duration: Medium term, as the mitigations for increased breeding sites are not immediately effective.

The significance is therefore Medium (Table 5.9-21).

Project Impact Mitigation

- Ensure project designs reduce the potential for sources of vector breeding. This could include a review of some engineering drawings to assess the design of Project components such as environmental containment dams to minimize mosquito breeding and mosquito–human contact. In addition, the positioning of potential mine accommodation should be assessed in terms of its proximity to breeding sites.
- Consider the inclusion of vector control activities in the current environmental management system. For instance, control interventions may include ensuring proper diagnosis and treatment, screening buildings, sleeping under bed nets, improving drainage and applying insecticides and larvicides.
- Ensure that the site Implements the Newmont Global Health Management Guideline for Pandemic Events and a Health Incident Response Plan (HIRP).

Occupational Health and Safety (OHS)

1) Ensure Newmont-utilized medical facilities can test for and treat malaria, leishmaniasis and other vector-borne diseases.

2) Provide health information on vector-borne disease to workers through posters and awareness sessions.

Residual Impact after Mitigation

The recommendations mentioned above could generate a positive impact as these could contribute to the country goal of malaria elimination and could reduce the disease burden in the local communities.

5.9.12.4 Health Issue #4: Sexually Transmitted Infections

Impact Analysis

- More than 30 different bacteria, viruses and parasites are known to be transmitted through sexual contact. A total of 8 of these pathogens are linked to the greatest incidence of sexually transmitted disease. Of these 8 infections, 4 are currently curable (syphilis, gonorrhoea, chlamydia and trichomoniasis). The other 4 infections (hepatitis B, herpes simplex virus (HSV or herpes), human immunodeficiency virus (HIV) and human papillomavirus (HPV)) are incurable viral infections, however the symptoms of these diseases can be reduced or modified through treatment (WHO 2016).
- The estimated HIV prevalence for the adult population in Suriname (those between the ages of 15 and 49 years) is 0.9%. However, the prevalence among the groups at risk is higher than the general population and was estimated to be 6.7% for men who have sex with men in 2005 and 5.8% for commercial sex workers (CSWs) in 2012. In addition, awareness and knowledge of HIV prevention among the population is minimal and the availability of condoms in the interior is very low (ISOS 2017).
- The prevalence of chlamydia in Suriname is very high, with 10% in a low-risk population and up to 23% in a high-risk population (ISOS 2017). This has also been confirmed in surveys done on

Surinamese residing in the Netherlands, where prevalence of chlamydia >20% was found in adolescent girls between 15 and 19 years of age (M.G. van Veen 2010).

- Although the general population is considered at risk for this impact, there is some high-level concern for the youth as 15 years is the average age of the first sexual intercourse. Younger people are more vulnerable to sexually transmitted diseases (STIs) and HIV. Finally, girls who dropout from school due to pregnancy have limited opportunities for education and further socio-economic development.
- There is the presence of some brothels called "cabarets" in the Project area that service the ASM population. Some sex workers in Santa Barbara are citizens of the Dominican Republic and do not speak local languages and therefore, information or educational material on STI do not reach them.
- At present, there does not appear to be a condom distribution program or educational awareness about STIs among the Newmont workforce.
- The Medical Mission provides access to testing and treatment of STIs to communities, but not to small scale miners and sex workers and therefore, they need to travel to Paramaribo to get tested. In addition, testing in the area might be low due to stigma and any follow up requires the transfer to Paramaribo.

There is a possible likelihood of an increase of STIs as a result of the Project because this is a known problem for the industry and it has been encountered at several mining sites on all continents. For this reason, the International Council on Mining and Metals (ICMM) has developed a "Good Practice Guidance on HIV/AIDS, TB and Malaria", which details steps and mitigations required to address this risk.

- The health consequence would be high because of the following reasons:
  - Magnitude would be high as HIV cannot be treated but it becomes a lifelong condition. While STIs can be treated, often stigma or lack of knowledge or access to a medical provider can be a barrier for diagnosis and treatment.
  - Geographical extent: Beyond regional, as the Newmont staff living in Paramaribo when off duty can be a linking group.
  - Duration: Long term, as any form of behavioural change requires a long process.

The **significance** is therefore High (Table 5.9-21).

Project Impact Mitigation

- An STI and HIV policy for Newmont should be implemented. This should include issues stemming from accommodation camps and extended time away from families, voluntary testing, counselling and access to treatment.
- Health education on STI and HIV should be included during inductions.

Occupational Health and Safety (OHS)

- Improve access to confidential STIs diagnosis and treatment for the workforce.
- Supply free condoms for all employees, contractors and subcontractors.

Residual Impact after Mitigation

The residual impact after the implementation of the recommendations would be low (-). Construction and mining activities are strongly associated in the literature with increase of STIs. Therefore, the mitigations measures will reduce the risk but cannot eliminate it completely.

5.9.12.5 Health Issue #7: Accidents and Injuries

Impact Analysis

- The main types of injuries causing death among the general population in Suriname are self-inflicted injuries, road traffic accidents and other unintentional injuries (falls, struck by/against an object).
- Road traffic accidents are the 8th leading cause of death in Suriname and account for approximately 3.9% of all deaths in Suriname. The highest occurrence of traffic accidents is among young adults aged 20 to 24 years, followed by those 15 to 19 and 25 to 29 years old. 2 or 3-wheel vehicles are frequently involved in traffic accidents.
- The majority of road traffic accidents occurred on the paved Afobaka road in the Brokopondo region.[24] From 2015 to mid-2017, a total of 40 road traffic accident cases were recorded in the Brokopondo region and 2 road traffic accidents were recorded in the Carolina area. About 70% of people involved in road accidents are male and with an average age of 35 years. Females involved in road accidents have an average age of 29 years.
- The most at-risk groups for accidents and injuries at this point consists of:
  - children in school age who take the bus to school; and
  - drivers of 2 and 3-wheel vehicles.
- Only a few studies have specifically examined the risk to children involved in heavy vehicle crashes. Unsafe buses in low-income and middle-income countries are frequently involved in major crashes involving children.
- There is a likely likelihood of an increase in accidents and injuries as a result of the Project due to the increase of vehicle traffic.
- The health consequence would be high because of the following reasons:
  - Magnitude: High, as injuries and accidents can result in death or permanent disability.
  - Geographical extent: Local, as it is associated to the access road to the Project.
  - Duration: Long term, as it will not only be throughout the construction, but also during the operational phase of the mine as material needed for the Project will come by road.

The significance is therefore High (Table 5.9-21).

Project Impact Mitigation

- A traffic and transportation safety management plan should be developed (adopted from the plan in place at Merian) to improve overall traffic safety and reduce risks within the transportation corridor. The plan should include contractors and subcontractors.
- Support an educational program in schools along Project access routes regarding road safety among children and teenagers, as well as for the school bus drivers.

Residual Impact after Mitigation

The residual impact after mitigations will remain medium negative; however, this could change over time. Educational activities that influence the knowledge, attitude and practice of children toward road safety will take time to deliver results. However, their understanding of the risks will improve and this

[24] Minor road accidents that did not involve the emergency room have not been taken into account as no data is available.

will improve their practice. Newmont should implement a mechanism for local communities to report any issues relating to road use and safety.

5.9.12.6 Health Issue #12: Non-Communicable Diseases (NCDs)

Impact Analysis

- Non-communicable diseases (NCDs), also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioral factors. The main types of NCDs are cardiovascular diseases (such as heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma) and diabetes.
- NCDs are the biggest disease burden in the country and in the Project area. According to 2015 data, cerebrovascular disease ranks first and is the most common cause of deaths, followed by ischemic heart disease and diabetes.
- Lifestyle and behavioral risk factors contribute to the NCDs epidemic. An unhealthy diet, physical inactivity, tobacco and alcohol abuse are the major concerns in Suriname.
- These chronic diseases dominate the healthcare needs of the population and therefore, place the highest burden on the Suriname health-care system.
- Hypertension and diabetes mellitus are found in both the Maroon and the Amerindian populations. The prevalence of hypertension in the entire Medical Mission area is 4.33%, while it is 3.91% in the Brokopondo area and 5.79% in the Carolina area.
- There is no local data available on cancer, mental health and other major chronic diseases as these are not recorded and management is done through referral to Paramaribo hospitals.
- There is a low likelihood of an increase in NCDs as a result of the Project in the general population. Changes in lifestyle and economic development are associated with an increase of risk factors for NCDs; however, the change generated by Sabajo in the local area is only one of the components influencing lifestyle. However, the likelihood of an increase in NCDs for the workers is likely as this has been observed at other mining projects (Rodriguez-Fernandez and Rahajeng 2015).
- The health consequence would be moderate because of the following reasons:
  - The magnitude is moderate as some conditions are permanent and might require ongoing management..
  - Geographical extent: Beyond regional, as some conditions are lifelong diseases that require ongoing medical management and the facilities are not always available in the area, plus the cost will be shared by the country at large.
  - Duration: Long term, as these are difficult/impossible to reverse the conditions.

The significance is therefore Moderate (Table 5.9-21).

Project Impact Mitigation: Occupational Health and Safety (OHS)

- Initiate screening programs for the early recognition of chronic diseases and appropriate treatment practices. This is to ensure a healthy productive workforce and also to reduce the risk of occupational illness and injury.
- Ensure medical facilities utilized by Newmont can manage these conditions.
- Ensure the living areas are equipped with facilities for physical activities.

- Consider a system that controls the consumption of alcohol on-site.
- Consider utilizing a rating system on canteen food choices and encourage healthy eating.

Residual Impact after Mitigation

The implementation of the recommendations mentioned above, targeting both workers and communities, could generate a positive impact. NCD is the main disease burden in the country and one of the key priorities for the MOH; therefore, any action aiming at reducing the risk factors associated with NCD could contribute to the achievement of the country plans. In addition, the recommendations could contribute to reduction of absentee rate, and lost day or time rate.

5.9.12.7 Impact Classification

The impact classification for health is presented in Table 5.9-21.

Table 5.9-21 Classification of Effects, Consequence and Likelihood

Most Affected Group	Direction	Magnitude	Geographical Extent	Duration	Health Consequence	Likelihood	Impact Rating	
							Pre-Mitigation	Post-Mitigation
Health Issue #1: Vector-Related Diseases – Priority Ranking: Moderate								
Employees, their families and neighbors	Negative	Low	Beyond regional	Medium term	Moderate	Likely	Medium	Positive
Health Issue #4: Sexually Transmitted Infections – Priority Ranking: High								
General population – all communities but especially the youth	Negative	High	Beyond regional	Long term	High	Possible	High	Low
Health Issue #7: Accidents and Injuries – Priority Ranking: High								
Children in school age Drivers of 2/3 wheel vehicles	Negative	High	Local	Long term	High	Likely	High	Medium
Health Issue #12: Non-Communicable Diseases (NCDs) – Priority Ranking: Moderate								
Workers	Negative	Moderate	Beyond regional	Long term	High	Likely	Medium	Positive

5.9.13 Monitoring

Socio-economic monitoring involves ongoing engagement with impacted stakeholders to identify if predicted impacts are manifesting, and whether or not proposed mitigations are being implemented in an effective manner. Monitoring also involves tracking the success of benefit enhancement measures, and Newmont's performance in meeting local content goals and community development objectives. Socio-economic monitoring is described in detail in the in the Social Management Plan (SMP; Volume B).

5.10 Traffic

5.10.1 Traffic Discipline Methods

The assessment of effect on traffic is based on:

- quantitative calculation of traffic volume changes along the two possible roads to be used by the Sabajo Project (the Project): the Carolina Road and Afobaka Road; and
- qualitative evaluation of potential effects of the Project on traffic congestion, safety and road infrastructure, given the best evidence available.

The approach to modelling potential future traffic involves understanding the present baseline traffic levels as per baseline presented in Section 4.13, and adding what is considered to be the maximum potential Project traffic to the existing traffic in order to produce future traffic estimates.

Impact criteria for assessment of traffic effects are presented in Table 5.10-1.

Table 5.10-1 Impact Description Criteria for Traffic

Direction[a]	Magnitude[b]	Geographic Extent[c]	Duration[d]
Positive: a reduction in traffic volume, improvement in safety, or improvement in infrastructure **Negative**: an increase in traffic volume, adverse effect on safety, or damage to infrastructure	**negligible**: minimal effect on congestion, within the range of variation of current traffic; no perceptible change in safety or infrastructure **low**: small change in traffic congestion with congestion in very limited locations, a change in safety or infrastructure that does not affect residents substantially **moderate**: increased congestion expected, and a change in infrastructure or safety that begins to affect the use of the infrastructure for local people **high**: serious increase in congestion, and any substantial change to safety of the roadway or usability or the road infrastructure	**local**: effect restricted to the study area **regional**: effect extends beyond the study area **beyond regional**: effect extends more than 50 km from the Project	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Direction: positive or negative effect for measurement endpoints, as defined for the specific component.

b) Magnitude: degree of change to analysis endpoint.

c) Geographic Extent: area affected by the impact.

d) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period, a 10-year operations period, and a 4 year closure period.

the Project = the Sabajo Project; km = kilometer; > = greater than; < = less than.

5.10.2 Issue Scoping

Based on experience with similar projects, changes in traffic can result in six main categories of impacts that affect people:

- changes in traffic volume which cause a detriment to road users due to road congestion;
- changes in traffic volume or type which in turn represents an increased hazard for accidents, including harm to people or property;
- changes to traffic, or the use of mitigation, that can harm or improve road infrastructure;
- increases to air emissions along the road;

- increases to dust along the road; or
- increases to vibration that affect people or property near to the road.

Of these categories of effects, the first three are addressed in this section, and the last 3 are addressed in the air impact assessment (Section 5.2) and the noise and vibration impact assessment (Section 5.3) of this assessment. Effects in relation to effects on wildlife and plants are addressed in the ecosystems (Section 5.8) and species (Section 5.8) sections of this assessment.

In relation to the first three categories of effects, a number of comments were received confirming their importance for local residents (Table 5.10-2). All of these issues are addressed in this assessment. No other issues in direct relation to traffic were raised in the engagement for the Project.

Table 5.10-2 Potential Impact Issues for Traffic

Issue Number	Key Issue – Potential Impact	Summary of Engagement Comments
1	Potential Effect on Traffic Congestion	*-What increase traffic can we expect on the Carolina Road?* – Meeting with Amerindian communities, 5/4/17 *-What is the timing of the use of the road? will it be 24/7?* – Meeting with Amerindian communities, 5/4/17 *-Who exactly will be using the road? The company? Also its contractors (and which?)* – Meeting with Amerindian communities, 5/4/17
2	Potential Effect on Safety	*-We are concerned about safety, what safety measures will be taken so community members, especially kids can use the road?* – Meeting with Amerindian communities, 5/4/17 *-Mutual safety concern: as you have notice other heavy traffic is making use of the road as well, especially the wood loggers, they speed, etc. How will Newmont guarantee or make an effort to use the road safely with these other stakeholders?* – Meeting with Amerindian communities, 5/4/17 *-The road has no Footpaths: will Newmont construct those? Specially for the school kids of Powakka that walk to and from school.* – Meeting with Amerindian communities, 5/4/17 *-Will the driving of Newmont be monitored?* – Meeting with Amerindian communities, 5/4/17
3	Potential Effect on Traffic Infrastructure (roads, bridges)	*-Who will maintain the road, especially the unpaved part? Is it Newmont? Is it the government?* – Meeting with Amerindian communities, 5/4/17 *-Newmont should maintain the road if they decide to use it, this will be a good compensation of the impacts to the communities* – Meeting with Amerindian communities, 5/4/17 *-Will Newmont investigate the integrity of the Caroline bridge before they use it?* – Meeting with Amerindian communities, 5/4/17 *-Will Newmont investigate the Caroline Bridge? Because if something bad happens with this bridge we might be isolated again, we don't want that.* – Meeting at Pierre Kondre / Kombassi, 6/22/17

5.10.3 Linkage Analysis

Project traffic will increase use of one or both of the Afobaka and Carolina roads and, once built, traffic will be present on the Sabajo-Merian Haul Road. For the Afobaka and Carolina roads, the linkage for increases in traffic volume, effects on safety, and effect on infrastructure is valid for the construction, operations and closure phases. For the Sabajo-Merian Haul Road, this road does not currently exist. The impact assessment for traffic therefore includes the Afobaka and Carolina roads, but not the Sabajo-Merian Haul Road.

5.10.4 Key Indicators

Key indicators to be used to assess effects on each key issue to be included in this assessment as per the issues list and linkage analysis above have been identified in Table 5.10-3.

Table 5.10-3 Project Indicators for Traffic

Issue Number	Key Issue	ESIA Indicators
1	Potential Effect on Traffic Congestion	Total number of vehicles per day Total number of large trucks per day
2	Potential Effect on Safety	Total number of vehicles per day Qualitative review of Project mitigation
3	Potential Effect on Traffic Infrastructure (roads, bridges)	Total number of vehicles per day Qualitative review of Project mitigation

Project = the Sabajo Project; ESIA = Environmental and Social Impact Assessment.

5.10.5 Spatial and Temporal Considerations

Section 5.1 has presented the time frames for three major Project phases that will be affected: construction, operations and closure phases. In the case of traffic specifically, the operations phase is considered to include the full operations phase of the Merian Gold Mine (Merian mine), because we will conservatively assume that Merian mine traffic also uses the access roads to the Sabajo Project. However, given the start date of the Project, the operations period for Merian mine is presently not forecast to extend longer than that for Sabajo.

The study area for the traffic discipline includes two routes from the Project to Paramaribo (Map 5.1-1), the Carolina Road and Afobaka Road, up to their point of intersection; and also includes the Sabajo-Merian Haul Road.

5.10.6 Project Case Impact Assessment

5.10.6.1 Effects Analysis – Prior to Mitigation

Traffic counts observed at six of the key study sites from the traffic baseline (Section 4.13 and Map 4.13-1) are presented in Table 5.10-4.

Table 5.10-4 Average Traffic Counts at Representative Traffic Baseline Locations

	Locations on Afobaka Road			Locations on Carolina Road		
Type of vehicles	Afobaka Road and Road to Overbridge (T-1)	Afobaka Road and Intersection to Bronsweg (T-3)	Afobaka Road and Musa Road Intersection (T-4)	Multicultureel Centrum Powakka (T-6)	Redi Doti (T-2)	Road to Sabajo and Kashipurhiweg (T-9)
Cars	876	534	151	452	130	26
Light Trucks	405	292	92	94	98	32
Busses	437	392	119	107	59	11
Large Truck	221	78	10	4	8	1
Logging Truck	71	38	5	17	13	10
Motorbikes	64	25	21	60	17	5
Bikes	2	0	0	5	0	0
Others (ATV, UTVs, etc.)[a]	9	2	10	0	1	1
Pedestrians	20	11	7	173	1	0
Total vehicles[b]	2084	1360	407	738	326	83
Total movements	2104	1371	414	911	327	83

a) ATV = all-terrain vehicle; UTV = utility terrain vehicle.

b) 'Total vehicles' excludes pedestrians.

Direct Project effects on traffic volume are summarized for each road affected by the Project in Table 5.10-5 for the construction phase, 5.10-6 for the operations phase and 5.10-7 for the closure phase of the Project. All estimates have conservative assumptions that from the operations phase onward, both Sabajo Project and Merian mine traffic use the access roads. Road usage for both the Afobaka and Carolina routes are currently still being evaluated and there remains the possibility that only Sabajo construction traffic will use either of these alternatives. In addition, in order to assess maximum effect on each road (Afobaka and Carolina), the impact assessment assumes that all the Project traffic uses either the Carolina Road or the Afobaka Road (i.e., a conservative assumption). Depending on the location selected (for example, of those shown in Table 5.10-4), the Project traffic will have different proportional effects on total traffic. For the purposes of the assessment, the key locations used to perform the assessment are the Afobaka Road at the intersection to Bronsweg, and the Carolina Road at Powakka.

Table 5.10-5 Traffic Effects in the Construction Phase

Road Route	Current daily traffic average at location of maximum traffic			Project daily traffic contribution (maximum potential per location – not additive)			Percentage increase in daily traffic			
	Light Vehicles[(a)]	Buses	Heavy Trucks[(b)]	Light Vehicles	Buses	Heavy Trucks	Light Vehicles	Buses	Heavy Trucks	Total
Afobaka Road (Intersection for Bronsweg)	853	392	116	20	3	5	2%	1%	4%	2%
Carolina Road (Powakka)	611	107	21	20	3	5	3%	3%	24%	4%

a) Includes cars, light trucks, bikes, motorbikes and other vehicles. All shown in number of one way vehicle passes.

b) Includes heavy trucks and logging trucks. All shown in number of one way vehicle passes.

Project = the Sabajo Project;% = percent.

Table 5.10-6 Traffic Effects in the Operations Phase

Road Route	Current daily traffic average at location of maximum traffic			Project daily traffic contribution (maximum potential per location – not additive)			Percentage increase in daily traffic			
	Light Vehicles[(a)]	Buses	Heavy Trucks[(b)]	Light Vehicles	Buses	Heavy Trucks	Light Vehicles	Buses	Heavy Trucks	Total
Afobaka Road (Intersection for Bronsweg)	853	392	116	30	25	34	4%	6%	29%	7%
Carolina Road (Powakka)	611	107	21	30	25	34	5%	23%	162%	12%

a) Includes cars, light trucks, bikes, motorbikes and other vehicles. All shown in number of one way vehicle passes.

b) Includes heavy trucks and logging trucks. All shown in number of one way vehicle passes.

Project = the Sabajo Project;% = percent.

Table 5.10-7 Traffic Effects in the Post-Closure Phase

Road Route	Current daily traffic average at location of maximum traffic			Project daily traffic contribution (maximum potential per location – not additive)			Percentage increase in daily traffic			
	Light Vehicles[a]	Buses	Heavy Trucks[b]	Light Vehicles	Buses	Heavy Trucks	Light Vehicles	Buses	Heavy Trucks	Total
Afobaka Road (Intersection for Bronsweg)	853	392	116	2	2	2	<1%	<1%	2%	<1%
Carolina Road (Powakka)	611	107	21	2	2	2	<1%	2%	10%	<1%

a) Includes cars, light trucks, bikes, motorbikes and other vehicles. All shown in number of one way vehicle passes.

b) includes heavy trucks and logging trucks. All shown in number of one way vehicle passes.

Project = the Sabajo Project;% = percent; < = less than.

During the two years of construction, the effects of the Project on traffic volume will be small, with increases of (at maximum) between two and four percent (%) of total traffic. The most noticeable change during this period will be a potential increase of 24% of heavy trucks along the Carolina Road at Powakka, compared to existing levels. Numerically, however, this is an increase of only 5 heavy trucks per day or about one heavy truck every two hours during the day.

During the operations phase, effects of Project traffic on total traffic levels will be a maximum of 7% on the Afobaka Road or 12% on the Carolina Road in the event that this route is used to carry both the Sabajo and the Merian mine traffic. These increases will be noticeable to current road users. In particular, the increase in heavy trucks would be noticed by users of both Afobaka and Carolina roads: the maximum increase in heavy trucks is projected at 29% for the Afobaka Road and 162% for the Carolina Road. These changes equate to an additional maximum of 34 heavy trucks per day for the operations period, or about 3 heavy trucks per hour during the daylight hours.

During the active closure phase of the Project, traffic will decline to about one third of operations traffic. At “post-closure” (including closure of Merian mine as well as Sabajo), traffic will drop to close to zero from the Project.

The effects on traffic congestion are moderated by the small amount of traffic currently using either route. Road capacity appears to be well above present use, and present traffic has not been observed to be congested in any location within the study area. The additional vehicles are not expected to result in any measurable effect of congestion on the roadways used. Outside the study area, toward Paramaribo, the traffic will enter congested areas, but the traffic will also progressively represent a smaller proportion of the total traffic on the road, so will have less proportional impact. In summary, the effects on road congestion will be small due to the Project, but are likely to be highest in populated areas along the Carolina Road, in particular at Powakka, where the road is narrower than the Afobaka Road and existing traffic is highest for any point along the Carolina Road route.

The effects of the Project on traffic safety will be an increased risk of vehicle crashes and injuries due to increased traffic volume, potentially unsafe road conditions including dust and lack of pedestrian facilities. Non-project related traffic accidents already occur on the Carolina and Afobaka roads (Section 4.13). Locations of unsafe conditions and sensitive receptors along the Afobaka and Carolina roads are mapped in Maps 4.13-2 and 4.13-3, respectively. This risk for pedestrian accidents is expected to be largest along the Carolina Road in proximity to Powakka, where existing pedestrian traffic is greatest. The risk of vehicle-on-vehicle accidents is likely to be greatest along the Afobaka

Road north of the Bronsweg intersection where existing vehicle traffic is greatest. Notable sensitive receptors where people, and especially children, may be on or beside the road include:

- The primary school at Powakka, which is attended by children, many of whom are bussed from nearby towns; 4 school busses were counted traveling through Powakka and Redi Doti during baseline studies (ILACO 2017), and pedestrians, mainly children, are active at bus stop locations and at the school itself both in the morning (7:00-7:30) and afternoon (13:00-16:00).
- Other pedestrians in Powakka; for example, on non school days, 40 children were counted passing along the Carolina Road on a weekend and 46 children were counted passing along the Carolina Road on a weekday. The average total pedestrian traffic observed in Powakka was 173 people per day.
- School bus stops along the Afobaka Road: for example, on a single day at baseline study point T-3 on this road, 16 school busses were observed passing between 7:00 and 16:00. Between the Carolina Road turnoff and Afobaka Dam, 8 formal bus stops were counted
- Other locations where people congregate close to the Afobaka and Carolina roads include fruit stands, churches, sports fields (Map 4.13-1)

Given the presence of pedestrian traffic at numerous locations along both roads, and the level of existing other traffic note in Table 5.10-4 , collisions with pedestrians or other vehicles represent a serious risk, and the risk is elevated with the concentration of pedestrian and child traffic at Powakka. However, these effects will be mitigated as described below.

Effects on safety and on the environment could also occur due to the transportation of hazardous materials (including cyanide and other reagents) and fuel along the roadway. A spill or leak could release such materials into the environment. Such effects are improbable, but need to be planned for. This is further discussed in the risk assessment in Section 5.12).

The effects of the Project on infrastructure will be a gradual and cumulative wear on the roadways due to traffic use, and in particular heavy traffic use, which will extend to all seasons of the year. However, the infrastructure, including public bridges, that the Project will use, is considered appropriate for Project traffic, and Newmont Suriname, LLC (Newmont) will work to maintain roads at least at their current condition as discussed below in Section 5.10.6.2. An engineering design review of the Carolina Bridge will be conducted prior to selection of this alternative, however given that this is a relatively new structure based on sound engineering design, it is currently expected that no major design issues will be identified during this review.

5.10.6.2 Mitigation

Mitigation for effects on road safety will include:

- A traffic and transportation safety management plan will be developed (adopted from the plan in place at Merian mine) to improve overall traffic safety and reduce risks within the transportation corridor. This will include:
  - Adopting limits for trip duration and arranging driver rosters to avoid fatigue.
  - Nearly all road use will be in daylight hours, given that the risks of an incident would be higher for vehicles travelling at night.
  - Contractors and subcontractors will be required to adhere to Newmont Suriname driving standards.

  - Use of a reporting system so that local communities can report any issues relating to road use, safety, or other concerns, and Newmont can take action to improve measures for safety where needed.
  - Drivers will be required to follow speed limits, and their speeds will be monitored. Speeds through villages (near Redi Doti and Powakka) will be limited to 30 km/hour.
  - Depending on which access road will be used primarily for the project, further engagement will occur to determine if other means of mitigation are appropriate for Powakka.
- The unpaved roads being used by the Project will be maintained by Newmont.

5.10.6.3 Classification of Effects

Project effects are classified in Table 5.10-8. Construction and operation,and closure phase traffic assumes the worst case traffic for both periods combined, and this is summarized as one effect. Effects at post-closure are negligible. Effects have been split between Carolina and Afobaka Roads, as the level of effect will differ between these.

Prior to mitigation, traffic safety is the most important project issue, with a high impact classification (Table 5.10-8). The Project will be adding traffic, in particular a high proportion of large trucks, to the roadway in a place where existing traffic can be unsafe and already presents a risk. The planned mitigation measures reduce this effect to a medium residual impact, but cannot remove traffic risks altogether.

5.10.7 Cumulative Effects Case Impact Assessment

Through consideration of the addition of both Merian and Sabajo traffic to the existing traffic in Section 5.10.6, a cumulative effects assessment was effectively completed. No other new projects adding substantially to traffic on the assessed roads are presently foreseeable.

Table 5.10-8 Classification of Effects, Consequence and Likelihood

Description of Effect	Impact Criteria					Impact Significance		Mitigation or benefit enhancement measure
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre Mitigation	Post Mitigation	
Effect on traffic congestion (Afobaka Road; construction, operation and closure phases)	Negative	Low	Local	Medium-term	Certain	Negligible	Negligible	-
Effect on traffic congestion (Carolina Road; construction, operation and closure phases)	Negative	Moderate	Local	Medium-term	Certain	Low	Low	-
Effect on Safety (Afobaka Road; construction, operation and closure phases)	Negative	Moderate	Local	Medium-term	Likely	Medium	Medium	• Implement Traffic and Transportation Safety Management Plan.
Effect on Safety (Carolina Road; construction, operation and closure phases)	Negative	High (Moderate)	Local	Medium-term	Likely	High	Medium	• Engage community on Potential Safety Mitigation at Powakka. • Implement Traffic and Transportation Safety Management Plan.
Effect on infrastructure (Afobaka Road; construction, operation and closure phases)	Negative	Low	Local	Medium-term	Likely	Low	Low	• Implement Traffic and Transportation Safety Management Plan.
Effect on infrastructure (Carolina Road; construction, operation and closure phases)	Negative	Moderate (Low)	Local	Medium-term	Likely	Medium	Low	• Upgrading (where needed) and Maintenance of unpaved access roads; and • Implement Traffic and Transportation Safety Management Plan.

- = no mitigation or benefit enhancement measure.

5.10.8 Human Rights Impact Assessment

In this section, issues are discussed specifically related to human rights in addition to assessing impacts from a social and environmental perspective. Specific concerns voiced during scoping consultations and baseline validation meetings with respect to traffic moving along the potential project access routes included pedestrians and local traffic safety, dust and vibration from the heavy trucks and contamination from diesel particulate matter. Powakka residents specifically identified high risk locations such as the Paratjima Recreational site and the location of food stores along a 500 meter (m) stretch of road through the Powakka community. Mitgation for traffic effects is discussed in the main traffic section (above) and in the Hazards section (for spills).

Afobaka Road

ESIA baseline studies determined that this road has the highest number of road accidents and there are no residential populations along the paved road. The potential risk to vulnerable populations is related to the movement of school buses and school bus stops along the road. The combination of school buses and school bus stops with increased traffic volume linked to the Project would increase the risk of accidents that potentially impact school children. The school bus schedules are periodic and relatively predictable.

Carolina Road

The Carolina road is narrower and, while less busy than the Afobaka road, is frequently transited within the Powakka village area where safety concerns are highest. Community infrastructure fronting the road includes a primary school, sports fields and local food stalls (see Map 4.13-1). The road serves as a local transit route for pedestrians, motorcyclists and small vehicles.

The Powakka baseline study identified a population of 462 children under 18. The children attending the Powakka primary school walk between their homes and school twice daily and the older children walk along the road to the bus stop for secondary school. Students from surrounding communities are bussed to the primary school from points along the road, gathering along the highway without any supporting infrastructure. Community concerns expressed during the consultation process also raised the issue of safety related to motorcycles used by local residents.

5.10.8.1 Potential Impacts to Rights

Companies are expected to ensure that their operations and products do not impact the right to health of people, such as workers, consumers and local communities.[1] Special consideration should be made in relation to vulnerable groups. Companies may face close scrutiny over the policies and systems they have in place to ensure, for example that pollution does not negatively impact the right to health of members of surrounding communities (Castan Centre for Human Rights Law 2016).

The following impacts identified in the traffic assessment present risks of negatively impacting the enjoyment of human rights:

- road safety for community members and their animals due to traffic of company or contractor vehicles;
- air quality from dust exposure and exhaust fumes for community members; and

[1] The Right to Health is derived from Article 12 of the International Covenant on Economic, Social and Cultural Rights

- potential spills of hazardous materials and fuel along the roadway.

The increase in traffic volume, in particular of heavy traffic creates risks to the right to health (from injuries) and the right to life. Due to the fact that some of the material being transported is hazardous, there is also a risk to the right to health (contamination) from spills during accidents and the potential fear and uncertainty that community members may experience.

Within the Project area of influence, individuals and groups considered vulnerable include the elderly as well as children and adolescents. While children have the same fundamental human rights as adults, it is also recognized that they have particular needs and vulnerabilities, and these are protected both in international human rights law as well as in the Constitution of Suriname.[2]. The traffic study identified that in Powakka, over 25% of pedestrian traffic on non-school days were children.

When standing adjacent to or on the road, local populations will be exposed to dust and increased emissions caused by the additional volume of trucks (mostly during the construction phase) and busses transporting personnel and equipment. The population considered at risk are people standing alongside the principal road in Powakka as well as those regularly using the road as pedestrians. Children using the roads to and from school will also be exposed to this impact. Outside of these areas, air quality impacts do not present risks to human rights.

Spills of hazardous materials may impact the right to health in certain circumstances. The risk of health impacts from spills exists for both road options. The Carolina Road is narrow and without shoulders. Businesses and homes are located within 50 m of the road portion that passes through Powakka. The Afobaka Road is wider and businesses and homes are further than 50 m from the road.

5.10.8.2 Qualification of Impact

Safety: The risk to human rights from traffic is present throughout the Project life and is present for both roads. Due to the potential to affect the right to life, the impact is negative, severity is high, and probability is possible and has the highest level of prioritization for attention by Newmont. More probable are the risks to the right to health (injury from vehicle-pedestrian interaction), which has a severity of medium and is considered potential, and is also given the highest prioritization. While both road options receive the same level of prioritization, the level of exposure of children is higher on the Carolina Road option.

Dust and Air Quality in Powakka: This impact to the human right to health is negative, of medium scale to specific individuals and of low scope, in that only those individuals within 15 m of the main road in Powakka are exposed. The health assessment did not identify respiratory health as a health risk. The impact is partly remediable and the probability is low.

Potential spills of hazardous materials: The extent of the impact is direct, as it relates to the communities. This impact to the human right to health is rated as high intensity to specific individuals within 15 m of the roads. The impact is remediable and the probability is low.

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[2] The ICESCR also affects the duty of States to "adopt special measures of protection and assistance on behalf of all children and adolescents, without discrimination on grounds of descent or any other status". For its part, the Suriname Constitution states its article 59 that "I. every girl, child and adolescent has the right to their integral development. II. every girl, child and adolescent has the right to live."

Table 5.10-9 Carolina Road Assessment

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity (scale)**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Road safety for community members due to traffic	Low	Right to health	Powakka residents including children, Carolina road communities, all road users	Negative	Potential	Medium	Probable	High	Cause
	Low	Right to life		Negative	Potential	High	Possible	High	Cause
Air quality impacts	Low	Right to health	Powakka residents and business operators/patrons near road	Negative	Potential	Medium	Possible	Low	Cause
Potential spills of hazardous materials and fuel along roadway	Low	Right to health	Powakka residents, children and business operators/patrons near road	Negative	Potential	Medium	Possible	Low	Cause

ESIA = environmental and social impact assessment; HR = human rights.

Table 5.10-10 Afobaka Road Assessment

ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity/scale**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Road safety for community members due to traffic	Low	Right to health	Afobaka road users including school children bussing, all road users	Negative	Potential	Medium	Possible	High	Cause
	Low	Right to life		Negative	Potential	High	Possible	High	Cause
Potential spills of hazardous materials and fuel along roadway	Low	Right to health	Afobaka road users including school children accessing school buses	Negative	Potential	Low	Possible	Low	Cause

ESIA = environmental and social impact assessment; HR = human rights.

5.10.9 Additional Baseline Needs

If more than one year passes prior to the development of the Project, then traffic levels may begin to change and a confirmatory study of traffic at the Powakka location (given it is the most sensitive location along the road for pedestrians) would be undertaken prior to project development to ensure the correct level of mitigation is applied to reduce potential negative effects of traffic travelling through this area.

5.10.10 Monitoring

A monitoring plan will be part of the overall Traffic and Transportation Safety Management Plan. Key performance indicators to be monitored will include:

- speed monitoring of vehicles, with spot-checks and Global Positioning System (GPS) monitoring devices;
- annual number of accidents of different levels of seriousness;
- annual number of complaints or grievances filed; and
- total number of vehicle trips daily/monthly/annually, including all types of vehicles.

5.11 Visual Aesthetics

5.11.1 Visual Aesthetics Discipline Methods

Effects for visual aesthetics are evaluated based on what changes in the visual landscape the Sabajo Project (the Project) will cause, and what viewers could see these changes to the extent they would be affected by them. The impact criteria are presented in Table 5.11-1. The types of visual changes considered include the visibility of project landforms (waste rock facilities [WRF]); effects of clearing the forest; visibility of air emissions including dust; and the visual effects of light emissions at night. All of these analyses are conducted qualitatively, apart from a Geographic Information System (GIS) modelling analysis of the Project viewshed conducted to indicate how visible the WRF could be from the surrounding landscape.

Table 5.11-1 Impact Description Criteria for Visual Aesthetics

Direction	Magnitude	Geographic Extent	Duration(a)
Positive: the landscape becomes more visually attractive **Negative:** the landscape becomes less visually attractive **Neutral:** no change to the landscape's overall visual impression	**negligible**: effects that are not perceptible to viewers, or that no viewers are expected to see **low**: effects that viewers can adapt to easily, or that very few viewers will see **moderate**: effects substantial enough to have an impact on the viewer **high**: effects that will have a major impact on the viewer	**local**: effect restricted to within 5 km of the mine site, or in the immediate vicinity of roads **regional**: effect extends beyond 5 km but within 10 km of the mine site **beyond regional**: effect extends more than 10 km from the mine site	**short-term**: <2 years **medium-term**: 2 to 16 years **long-term**: >16 years

a) Duration: length of time over which the environmental effect occurs. Considers a 2-year construction period and a 16-year operations period.

km = kilometer; <= less than; >= greater than.

5.11.2 Issue Scoping and Key Indicators

Through the public engagement that has been completed to date, no specific concerns with respect to visual aesthetics have been raised. Initial questions about the location of the Project were answered, showing that the Sabajo mine site is at least 15 kilometers (km) from any village.

This assessment will review potential project effects in relation to the issues identified in Table 5.11-2. The indicators used to assess project effects are also listed in Table 5.11-2.

Table 5.11-2 Potential Impact Issues for Traffic

Issue Number	Key Issue – Potential Impact	Indicators
1	Physical Impacts: Project landforms and loss of forest	Distance of visibility and area of visible landscape, compared to proximity of potential viewers
2	Visibility along roadways: dust and emissions	Qualitative effect of visible airborne dust and emissions
3	Impacts of light	Qualitative effect of lighting

5.11.3 Spatial and Temporal Considerations

Section 5.1 presents the temporal timeframes of interest for this assessment: construction, operation and closure. The study area used for this assessment is effectively the air and noise study area for the Project (Map 5.1-2). For the purposes of the viewshed analysis, due to the way the rolling topography limits viewing distances, a viewshed analysis was conducted for the area within 10 km of the most visible Project features, the WRF.

5.11.4 Linkage Analysis

The following linkages are considered valid for this assessment:

- In the area of the mine at Sabajo, the Project will clear lands, build new landforms, and emit light, all of which are visible effects that might be seen by some viewers. Therefore these effects linkages are considered valid and are assessed below.
- In the area of the mine and along the access roads to Sabajo, Project vehicles may release dust that is visible. Other air emissions are not expected to be visible.

5.11.5 Project Case Impact Assessment

5.11.5.1 Physical changes

The physical changes caused by the Project will include excavation of pits, development of waste rock facilities, and clearing of other lands for roads, camps and other infrastructure. As described in Section 4.14, this will occur in an area that is predominantly forested, but with many of the lowlands disturbed by existing artisanal and small scale mining. From close-up, all of these types of disturbances are visible. From a larger distance, the only highly visible disturbances are the built-up WRF, due to their height. Map 5.11-1 shows a viewshed for the WRF, within 10 km of the Project, and assuming that the WRF are at their full design height. Locations in gray are locations from which the facilities could be visible. However, the effects of trees obstructing views is not included in this analysis; because the area is heavily forested, this will in fact reduce the visibility of the facilities from most of the areas shown. Overall, the analysis shows that for viewers standing in clear areas without obstruction, within about 4 km the Project will be visible. Outside of 4 km the Project is visible from some areas, and at 10 km, the vewshed map shows gray dots becoming rare and fragmented. At this distance, visibility of the Project is nearly nil due to a combination of topography, vegetation cover, and distance.

Under baseline conditions, there are very few people who view the Project sites. Artisanal and small scale miners and timber cutters are intermittently present on the landscape, and are actively involved in shaping its appearance. No known ‘sensitive’ viewers (i.e., viewers who would be negatively affected by seeing visual changes on the landscape) are present in the area, as there are no towns or known visitor destinations within viewing distance. However, there remains the possibility that tourists or residents could transiently pass by the Project area at some point in the future. Ecotourism is actively promoted by Suriname and destinations such as Berg en Daal and the Brokopondo Reservoir are within an hour’s drive.

In summary, the Project will be visible to very few viewers – those who come relatively close to the Project. Most of these viewers will not be adversely affected by the Project because they are attuned to seeing disturbance on the landscape. A few viewers, potentially tourists involved in ecotourism travel, could be affected over the long term. No specific mitigation is proposed for this effect.

5.11.5.2 Dust

Unlike the case at the Sabajo Mine Site, people are commonly present along the Carolina Road (although there are no communities directly adjacent to the unpaved portion of the road). From the perspective of aesthetics, therefore, dust along unpaved roads such as the Carolina Road is an issue people are likely to see, and an issue requiring assessment. However, it is already present under baseline conditions and has not been raised as a particular area of concern by those participating in the Projects’ engagement program. Results in the air quality assessment (Section 5.2) indicated that dust caused by traffic and mining activity, in the form of particulate matter with a mean diameter of 10 microns (µm) or smaller (PM_{10}) and particulate matter with a mean diameter of 2.5 µm or smaller

($PM_{2.5}$), will be well within accepted guideline levels from the perspective of air quality. The effect of the Project traffic itself will not substantially increase or change the amount of dust. Therefore, although the Project will contribute incrementally to existing dust levels, this is considered a ‘low’ magnitude esthetic effect (an effect viewers will adapt to easily) .

Decreased visibility along the road during times of heavier traffic could affect drivers using the road. Issues in relation to traffic safety in general are discussed in the traffic section (Section 5.10).

5.11.5.3 Light

Light pollution has not specifically been raised as an issue by the communities and stakeholders engaged with for the Project. Substantial light effects are expected to be limited to the mine site, which will be active (at least in part) and lit at night, and the Sabajo-Merian Haul Road, which will also be used at night. The use of public roads by the Project will be minimal at night. As discussed above, the Sabajo mine site is likely to have few viewers, and the same is the case for the Sabajo-Merian Haul Road, which will not be open to the public. Therefore, although the light levels will be substantially changed in the area of the mine as compared to baseline, the visual aesthetic effect is predicted to be small. No specific mitigation is proposed for this effect.

5.11.5.4 Effects Classification

The classification of effects of physical landscape changes, dust, and light based on the analyses above is presented in Table 5.11-3.

Table 5.11-3 Classification of Project Effects and Mitigation

Description of Effect	Effects Classification					Impact Significance		Mitigation
	Direction	Magnitude	Geographic Extent	Duration	Likelihood	Pre-Mitigation	Post-Mitigation	
Clearing of Forest and Development of Landforms	Negative	Low	Local	Medium-term	possible	Low	Low	-
Dust along roads	Negative	Low	Regional	Medium-term	likely	Medium	Medium	• Described in air section (Section 5.2)

N/A = not applicable; - = no mitigation or benefit enhancement measure.

5.11.6 Cumulative Effects Case Impact Assessment

No additional cumulative effects will occur in the immediate area of the Sabajo mine, because other activity will not occur in the immediate area of the Project.

Dust from vehicle traffic travelling along the Carolina Road has the potential to have an effect additive with all other traffic using the road. Forestry activity and quarry activity contribute to the traffic on this road. As discussed in the air assessment, all of these activities were underway at the time of the field program to measure baseline air quality levels Consequently, potential air quality effects (including dust) from most of these activities were captured in the baseline air quality measurements. Because the assessment of Project air quality effects presented above considers Project air quality concentrations in the context of the measured baseline, a cumulative effects assessment was effectively completed for air quality. There are no presently foreseeable future activities that will add substantially to air quality concentrations in the study area.

5.11.7 Monitoring

No specific monitoring is required for the visual effects of the Project

5.12 Environmental Risks and Accidents

5.12.1 Environmental Risks and Accidents Discipline Methods

The focus of this section is to address project risks that could affect the operation of the Sabajo Project (the Project), or have social or environmental effects beyond those addressed in the preceding discipline impact assessment sections. The risks addressed in this section are for events that are not predicted to occur as a part of typical day to day Project activities, but could occur in rare cases.

The approach for the assessment of potential Environmental Risks and Accidents is to determine the potential likelihood and the potential consequence of each risk, where those are defined as follows in Table 5.12-1 and Table 5.12-2, respectively:

Table 5.12-1 Likelihood Definitions

Level	Category	Criteria[a]
5	**Certain**	The event will occur
		The event occurs daily
4	**Likely**	The event is expected to occur
		The event occurs weekly/monthly
3	**Possible**	The event will occur under some circumstances
		The event occurs annually
2	**Unlikely**	The event has happened elsewhere
		The event occurs every 10 years
1	**Rare**	The event may occur in exceptional circumstances
		The event has rarely occurred in the industry

a) Criteria to be read as ‘Either/Or’.

Table 5.12-2 Consequence Definitions

Level	Health & Safety	Environmental	Community	Operational
1	First Aid Injury Nuisance Value	No or very low environmental impact. Impact confined to small area.	Isolated complaint. No media inquiry.	Loss equivalent to 1 hour of production interruption. Routine wear and tear of screen panels at crusher requires change out.
2	Medical Treatment Injury Restricted Work Injury	Low environmental impact. Rapid cleanup by site staff and/or contractors. Impact contained to area currently impacted by operations.	Small numbers of sporadic complaints. Local media enquiries.	Loss equivalent to 6 hours of production interruption. Metal tooth on loader bucket comes loose while feeding crusher. Crusher plugged and tooth has to be cut out of crusher.
3	Single Lost Time Injury	Moderate environmental impact. Cleanup by site staff and/or contractors. Impact confined within lease boundary.	Serious rate of complaints, repeated complaints from the same area (clustering). Increased local media interest.	Loss equivalent to 12 hours of production interruption. The pressure of oxidation vessel develops a small leak in the brick liner.
4	Multiple Lost Time Injuries. Admission to intensive care unit or equivalent. Serious, chronic, long term effects.	Major environmental impact. Considerable cleanup effort required using site and external resources. Impact may extend beyond the lease boundary.	Increasing rate of complaints, repeated complaints from the same area (clustering). Increased local/national media interest.	Loss equivalent to 3-7 days of production interruption. A critical piece of environmental control equipment for gas cleaning at the roaster facility fails and requires replacement. Ground fall at the open pit closes of access road and buries equipment.
5	Fatality(s) or permanent disability.	Severe environmental impact. Local species destruction and likely long recovery period. Extensive cleanup involving external resources. Impact on a regional scale.	High level of concern or interest from local community. National and/or international media interest.	Loss equivalent to more than a week of production interruption. Pressure oxidation vessel fails and depressurizes. Ground fall at an underground heading causes loss of entire heading.

Using both the likelihood and consequence ratings, the risk is placed into an overall risk rating table as presented below (Table 5.12-3). If necessary, mitigation is then sought to reduce the risk level to an acceptable level. Last, a final risk rating with added mitigation is determined.

Table 5.12-3 Risk Rating Table

		Consequence				
		1- Insignificant	**2 - Minor**	**3 - Moderate**	**4 - Major**	**5 - Catastrophic**
Likelihood	**5 - Certain**	11 - High	16 - High	20 - Extreme	23 - Extreme	25 - Extreme
	4 - Likely	7 - Moderate	12 - High	17 - High	21 - Extreme	24 - Extreme
	3 - Possible	4 - Low	8 - Moderate	13 - High	18 - Extreme	22 - Extreme
	2 - Unlikely	2 - Low	5 - Low	9 - Moderate	14 – High	19 - Extreme
	1 - Rare	1 - Low	3 - Low	6 - Moderate	10 - Moderate	15 - High

5.12.2 Issue Scoping

Table 5.12-4 provides a summary of Environmental Risks and Accidents that have been identified by either the public through the public engagement process, by the Environmental Assessment team, or by Newmont Suriname, LLC (Newmont) itself.

Table 5.12-4 Potential Environmental Risks and Accidents

Issue Number	Key Issue – Potential Risk or Accident	Summary of Engagement Comments
1	Potential high rain event / flooding hazard affecting the Project	N/A
2	Potential high wind event / hurricane affecting the Project	N/A
3	Potential seismic event affecting the Project	N/A
4	Potential geotechnical hazards / slope failures affecting the Project	N/A
5	Spill of cyanide along access road to Project	*Will Newmont Use toxic chemicals?* – Comment from ongoing engagements, July 2017
6	Spill of oil along access road to Project	*Will Newmont Use toxic chemicals?* – Comment from ongoing engagements, July 2017
7	Spill of other / non hazardous material along access road to Project	N/A
8	Spill of cyanide within mine site	*Will Newmont Use toxic chemicals?* – Comment from ongoing engagements, July 2017
9	Spill of oil within mine site	*Will Newmont Use toxic chemicals?* – Comment from ongoing engagements, July 2017
10	Spill of other / non hazardous material within mine site	N/A
11	Accident with damage to vehicles	We are concerned about safety, what safety measures will be taken so community members, especially kids, can use the road? – Amerindian communities meeting, April 2017
12	Accident with impact to people	We are concerned about safety, what safety measures will be taken so community members, especially kids, can use the road? – Amerindian communities meeting, April 2017

N/A = not applicable; the Project = the Sabajo Project; Newmont = Newmont Suriname, LLC.

5.12.3 Linkage Analysis

All of the potential risks and accidents described in Table 5.12-4 are relevant and have a potential to occur, so are carried forward into the assessment. However, the issues (11 and 12) in relation to potential accidents or collisions are addressed in the traffic section and further carried forward within the health assessment section, so these two are not addressed in this section.

5.12.4 Spatial and Temporal Considerations

The study area used for the risks and accidents assessment includes the full study area used for the biodiversity studies in the area of the mine (Map 5.1-2), and the access roads included in the traffic study area extending to where the Carolina Road and Afobaka Road come together west of the Carolina Bridge (Map 5.1-1).

This Environmental and Social Impact Assessment is designed to evaluate a specific project plan that occurs in a specific period of time. By defining a temporal scope, clear boundaries are established for the time period being assessed. The Project is defined as having:

(a) a construction period of 2 years, from 2024 to 2026;

(b) an operation period of 10 years, from 2026 through 2036;

(c) a closure phase (during which active reclamation and decommissioning is completed) of four years, from 2036 to 2040; and

(d) a post-closure phase (during which monitoring and follow up of reclamation is completed) from 2040 on, until Project-related monitoring and mitigation is satisfactorily complete, as discussed in Section 2.

5.12.5 Risk Assessment for Environmental Hazards

A number of environmental hazards have been identified in the risk assessment process, including flooding, hurricane/high winds, seismic, geotechnical hazards/slope failure and spills; each is discussed below.

5.12.5.1 Flooding Hazard

High rainfall events can occur in the Sabajo area. At the Merian site only 30 kilometers to the east of the Project, the estimated precipitation levels for extreme events are:

- 185 millimeters (mm) of rainfall for a one in a 25 year event to occur in a 24 hour period;
- 215 mm of rainfall for a one in a 50 year event to occur in a 24 hour period; and
- 257 mm of rainfall for a one in a 100 year event to occur in a 24 hour period.

Given the possibility for these types of extreme events (and even in the case of less extreme annual events during the short and long wet seasons), low-lying areas and valleys can be inundated with water as a result of these extreme rainfall events. The Project includes development areas that might be susceptible to such flooding, in particular Santa Barbara, which is located in a wide valley, and the Merian-Sabajo Haul Road which crosses Tempati Creek. With extreme storm events, these are areas that could flood.

Secondary effects of flooding / inundation may include:

- failure of slopes along valley walls and at waste rock facilities (the latter is addressed below under geotechnical risks);

- increased incidence of gullying on valley walls;
- non-routine releases of sediment into steam courses; and
- disruption to mining activities, including a halt to transport of materials between Merian and Sabajo.

Given the frequency of high-rainfall events each year and the low-lying areas that are part of the Project, minor flooding events are likely to occur every year, and even substantial flooding events are likely on occasion. Overall the likelihood of flooding is considered ‘possible’ and the consequences, including failure of valley slopes, increased incidence of gullying and non-routine releases of sediment into stream courses as well as delays/halt to mining or delays/ halt to ore transport, are considered potentially ‘moderate’.

5.12.5.2 Hurricane and High Wind Hazards

Based on a review of National Hurricane Center (NHC) Data, Hurricane Tracks in the Atlantic Ocean since 1951 show hurricanes passing throughout the Caribbean, but not inland through Suriname (NHC 2017). Overall, Suriname is considered a low hazard area in terms of hurricanes. High wind events may occur, but are considered manageable for the Project; buildings constructed for Project use should have an appropriate level of engineering for moderate wind events. Given this, serious failures due to wind are considered ‘unlikely’. And consequences of high wind events will be ‘minor’.

5.12.5.3 Seismic Hazards

Suriname is a low hazard area in terms of seismic events (OAS 2011b). The Project occurs in the crystalline basement of the Guiana Shield, an area within the South American Plate consisting of principally igneous and metamorphic rocks. Overall, seismic events are not expected to affect the Project; the likelihood of a seismic event that could affect the Project is ‘rare’. The consequence of such an event would be ‘minor’, should it occur, because smaller earthquake with minor impacts to the mines and mine infrastructure is most likely.

5.12.5.4 Geotechnical Hazards and Slope Failure

Given that the Project is in an area subject to high rainfall, there may be a risk of geotechnical issues where slopes of (Project-built or natural) hillsides fail. The Project will develop waste rock facilities and pit walls, and will cut side-slopes along haul roads. Design of these project facilities and cut slopes along roads will take into account the type of soil materials, presence /absence of groundwater seepage, percent slope and slope length to develop appropriate design measures to reduce any likelihood of instability in these areas (Section 2). Slopes with exposed soils will be revegetated or allowed to revegetate with fast-growing species to mitigate erosion. These measures will all reduce the possibility of slope failures, but such failures remain ‘possible’ and when they occur could have a ‘moderate’ consequence.

5.12.6 Spills

Project storage tanks and Project vehicles will contain materials including:

- oil for vehicle fuel and for the Sabajo power generation facility;
- oil for vehicle fuel for transport of materials from Sabajo to Merian;
- other reagents for the Merian facilities; and
- cyanide, for the Merian facilities vehicle transport only.

The most important hazards from these are from oil and cyanide. The largest potential impacts from these would be a spill in a populated area along the access road to the Project, such as Powakka. In such an area, the risk of a spill could include cyanide, oil or another substance leaking into drinking water, or into soil, and presenting an immediate risk to both human health and the health of the ecosystem and wildlife. A lower class of risk is posed by a similar spill occurring near the mine site, where more day-to-day activity occurs, but where there are no villages and therefore a lower risk of effects on health.

Trucks carrying hazardous materials, including fuel and cyanide but especially cyanide, are subject to special mitigation measures to minimize the chance of any release to the environment (Cyanide Code 2018). In case of an accident, a response plan is in place to mitigate environmental or health related effects (Spill Response Procedure; see Environmental and Social Monitoring and Management Plan [ESMMP], in Volume B of this assessment). Because of the special precautions taken, the likelihood of failure for a cyanide leakage is considered 'unlikely'; the risk of leakage from an oil truck or tank is considered 'possible' (a higher likelihood than for cyanide, since there are many more fuel trucks than cyanide trucks), and the risk for other types of spills is considered 'possible'. The consequence of a significant spill event for cyanide would be 'major', however given the implementation of an emergency response plan and clean-up by Newmont on an immediate basis this poses less of a risk to operations and human health and the environment. All cyanide spills are required to be cleaned up immediately and the affected area remediated within 72 hours. The consequence of a significant spill event for fuel would be moderate' in any area. The consequence of another spill event (non-hazardous materials spill) would be insignificant.

5.12.7 Risk Assessment for Accidents

Vehicle accidents that involve risks for people, for other vehicles, or for property damage are discussed in Section 5.10, Traffic.

5.12.8 Risk Matrix

An overall risk matrix for the risks discussed above is presented below in Table 5.12-5. The highest total risk scores (at 14 and 13, high) are for cyanide spills, flooding events and slope failures. Cyanide spills are considered 'unlikely', but carry a risk of a 'major' consequence. Floods and slope failures are both considered possible and may both have moderate consequences, even after the mitigation described above. In the unlikely event of a cyanide spill, it could affect some people, but would be subject to an immediate spill response plan to protect human health and mitigate environmental effects. The flooding and slope failures are most likely to affect the Project but not any other people, because they would occur at the mine site or along the Sabajo-Merian Haul Road, far from populated locations. The other risk scores that are higher than 'low' are for a significant spill of fuel at the mine or along a public road. These kinds of events present lower overall risks (rated at medium) than the high-risk events describe above, due to their lower consequences, but still must be managed carefully.

Table 5.12-5 Risk Matrix Results

Risk ID #	Risk Type	Risk Description	Impact Category	Potential Cause	Construction[a]	Operation[a]	Closure[a]	Potential Consequence	Current Controls	Failure Likelihood	Consequence	Risk Score	Risk Level
1	Flooding	Flooding of mine areas or infrastructure including roads	Flooding	High rainfall event	X	X	X	Washout of areas; inaccessibility of areas; slower work due to soft soils	To extent possible engineer for high rain events; allow for possibility of disruption of ore transport from Sabajo to Merian in wet seasons	Possible = 3	Moderate = 3	13	High
2	Wind	Potential high wind event / hurricane affecting the Project	Wind	Hurricane or other high wind event during a storm	X	X	X	Destruction of infrastructure via storm events	Construction of buildings with appropriate level of protection from storms	Unlikely = 2	Minor = 2	5	Low
3	Earthquake	Potential seismic event affecting the Project	Seismic	Earthquake	X	X	X	Destruction of infrastructure via earthquake	none required	Rare = 1	Minor = 2	3	Low
4	Slope Failure	Potential geotechnical hazards / slope failures affecting the Project	Geotechnical	Failure of waste rock facility or failure of cut side slope along road	X	X	X	Input of sediment into water bodies, impacts to infrastructure, impacts to access	Engineering design with gradual side slopes; revegetation where possible to reduce erosion; plan to manage slope failures if they occur	Possible = 3	Moderate = 3	13	High
5	Spill	Spill of cyanide along access road to Project	Chemical	Accident/release with Cyanide spilled		X		Health risk for people (public), risk to aquatic ecosystems	Extensive controls associated with prevention of Cyanide spills; vehicle safety; emergency / spill control planning	Unlikely = 2	Major = 4	14	High
6	Spill	Spill of oil along access road to Project	Chemical	Accident/release with oil spilled	X	X	X	Health risk for people (public), risk to aquatic ecosystems	Controls for oil spills; vehicle safety; spill control planning	Possible = 3	Minor = 2	8	Moderate
7	Spill	Spill of other / non hazardous material along access road to Project	Chemical	Accident/release with non-hazardous material spilled	X	X	X	Concern over potential effect by the public; possible minor local effects	Vehicle safety; spill control planning	Possible = 3	Insignificant = 1	4	Low
8	Spill	Spill of cyanide within mine site	Chemical	Leak or accident		X		Health risk for people (employees), risk to aquatic ecosystems	Extensive controls associated with prevention of Cyanide spills; vehicle safety; emergency / spill control planning	Unlikely = 2	Major = 4	14	High
9	Spill	Spill of oil within mine site	Chemical	Leak or accident	X	X	X	Health risk for people (employees), risk to aquatic ecosystems	Controls for oil spills; vehicle safety; spill control planning	Possible = 3	Minor = 2	8	Moderate
10	Spill	Spill of other / non hazardous material within mine site	Chemical	Leak or accident	X	X	X	Concern over potential effect; possible minor local effects	Vehicle safety; spill control planning	Possible = 3	Insignificant = 1	4	Low
11	Traffic Accident	Accident with damage to vehicles	Physical	Accident between Project vehicle and external vehicle or other external property	X	X	X	Property damage	Vehicle safety / driver safety management program; tracking system for issues/incidents; see traffic section	Impact addressed in traffic section			
12	Traffic Accident	Accident with impact to people	Physical	This risk discussed in traffic section and health section	X	X	X	Health and Safety effects	Vehicle safety / driver safety management program; tracking system for issues/incidents; see traffic section	Impact addressed in traffic section and health section			

a) An X indicates the risk is valid in that Project phase.
ID = identification; # = number; the Project = the Sabajo Project.

6 SUMMARY OF COMMITMENTS AND MITIGATION MEASURES

This section summarizes the commitments made by Newmont to carry out follow-up baseline studies, mitigation, and monitoring for the Sabajo Project, should it be determined that the project will go ahead.

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	Commitment	Section Reference
Air and Climate	Mitigation: • Use ultra-low sulfur diesel fuel. • Water roads at the mine site for dust control; water stockpiles if necessary to limit dust in dry / high wind conditions. • Train drivers to minimize vehicle idling. • Establish speed limits for vehicles on the mine site and enforce speed limits for all Newmont employees and contractors/subcontractors. • Use best available technology economically achievable (BATEA) at the time of project construction for emissions controls. • Reclaim mine stockpiles and disturbed areas as they become available.	5.2
	Monitoring: • Monitor for PM_{10}, $PM_{2.5}$ and NO_2 at the Project site (fenceline) during construction and operation phases. • Monitor twice per year for PM_{10}, $PM_{2.5}$ and NO_2 at Powakka, if the project is using the Carolina Road, during construction and operation phases. • Quantify and report greenhouse gas emissions as per IFC guidance and Newmont Standard.	5.2
Noise and Vibration	Mitigation: • Limit offsite Project traffic to the daytime period (07:00 to 22:00), where practical. • Limit blasting to the daytime period (07:00 to 22:00).	5.3
	Monitoring: • If the project uses the Carolina Road, then conduct noise monitoring along the roadway at Powakka twice per year during the dry season, in accordance with IFC noise monitoring guidance.	5.3
Soil and Geomorphology	Additional Baseline: • Conduct a follow up field program before construction to improve the certainty of field mapping in areas not previously visited and to take soils samples for chemical tasting to confirm the soils chemistry identified in the soils baseline.	5.4
	Mitigation: • Implement a Sediment and Erosion Control Plan to limit erosion. • Manage storm water runoff to reduce erosion and sedimentation. • Limit off-road access to reduce compaction of soils. • Implement a Spill Prevention, Control and Countermeasures Plan to minimize the potential for contamination of soils. • Salvage and store topsoil/subsoil/saprolite with segregation, as practical. This material will be used as a growth media during reclamation. • Reclaim land progressively as part of the Mine Closure and Rehabilitation Plan. • Rip hard-packed soils resulting from Project activities to encourage revegetation. • Revegetate disturbed areas with native or local species. • return disturbed and waste rock disposal areas to a landform that approximates and blends in with the surrounding landforms.	5.4
	Monitoring: • Implement a Sediment and Erosion Control Plan that includes a monitoring program. • Carry out a program to monitor reclamation success, as discussed in the closure and reclamation plan.	5.4

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	Commitment	Section Reference
Groundwater	Additional Baseline: • Complete additional hydrogeological and geotechnical engineering studies, including water level monitoring and water quality sampling from existing and proposed wells as the Project develops. Information collected from these planned additional studies will be evaluated and if necessary will be used to update the groundwater impacts assessment for the Project. Baseline hydrogeological studies will be required for the Margo and Santa Barbara areas to verify the potential impacts from mining in those locations.	5.5
	Monitoring: • Carry out groundwater level monitoring in existing and planned monitoring wells in the vicinity of the Sabajo pits during pre-construction (quarterly) and operation (monthly) of the mine to evaluate the effects of mine dewatering on the local groundwater system and on the dewatering/drainage of the pit slopes.	5.5
Surface Water Hydrology	Mitigation: • Collect runoff in sediment control structures down-gradient of the waste rock and saprolite management areas during storm events to detain peak flows (i.e., flatten hydrographs) during storm events. • Discharge water collected from the pits and dewatering wells to streams. Water will be collected and potentially treated before being discharged back into streams down-gradient of a site. The discharge locations have not been determined, but could be targeted to stream reaches that are either most affected by Project operations or to areas where increased flow would be ecologically beneficial.	5.6
	Monitoring: • Continue surface water monitoring at all existing monitoring locations before and during construction (quarterly) and operations (monthly) to characterize baseline and operational conditions. Currently there is one continuous stream gauge at Sabajo (monitoring station CSW-07). Additional continuous streamflow monitoring stations may be needed to characterize streamflows during operations.	5.6
Water Quality and Geochemistry	Additional Baseline: • Conduct quarterly baseline monitoring at Tempati Station(s) once access to this site improves. • Conduct quarterly surface water monitoring at other existing stations and new stations, once established. • Conduct quarterly groundwater monitoring at existing monitoring wells and new wells, once established. • collect additional geochemical data to refine predictions of ARD and ML potential. Use this information to refine predictions of source water qualities (i.e., WRF seepage and runoff; ore stockpile seepage and runoff; pit lake water quality). The surface water and groundwater quality impacts presented in this assessment will be updated following refinement of source water qualities and completion of a fate and transport analysis.	5.7
	Mitigation: • Treat waste rock facility runoff to prevent adverse impacts to surface water and groundwater, if required to meet targets, beyond closure. This assessment assumes treatment of arsenic, and possibly other metals, in waste rock facility runoff and seepage that can be collected, prior to discharge to the environment. • Segregate and encapsulate of rock with elevated arsenic concentrations to limit exposure to oxygen and water. • Consider rapid filling of the pit by the diversion of surface water into the pit, to improve pit lake water quality. Pit lake water quality modeling has indicated a potential for elevated metal and sulfate concentrations. Rapid filling is intended to decrease the exposure time of reactive sulfides present in the pit wall faces. Inundation prevents exposure to atmospheric oxygen and is, therefore, an effective way to reduce metal and sulfate loading from sulfide oxidation.	5.7

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	Commitment	Section Reference
Water Quality and Geochemistry	Monitoring: • Continue surface and groundwater quality monitoring at all existing monitoring locations to determine baseline and operational conditions. • If Margo is confirmed for development, establish a monitoring station downgradient of Margo on the eastern branch of Creek 2. • Prior to construction of the Sabajo Project, establish compliance surface water monitoring stations on Creek 1 and Creek 2 at the concession boundary. • Additional wells will be established for water level monitoring, and these will also be monitored for water quality. • Pre-construction monitoring will be quarterly and operations monitoring will be monthly.	5.7
Biodiversity	Additional Baseline: • Document baseline conditions for ecosystems, flora and fauna in the area of the Sabajo-Merian Haul Road prior to construction.	5.8
	Mitigation: • Minimize the size of the project footprint and explore options to reduce effects to sensitive habitats. • Along the Sabajo-Merian Haul Road, build bridges over major crossings rather than culverts, allowing wildlife movement along riparian corridors beneath the bridges. • Along the Sabajo-Merian Haul Road, at strategic locations establish arboreal connectivity through crossing structures or maintaining continuous canopy across the road. • Implement an exotic species management plan. • Conduct biodiversity awareness training for on-site employees. • Design and implement a biodiversity offset to restore areas impacted according to Newmont's Biodiversity Standard. • Control access to the Right of Exploitation and Sabajo-Merian Haul Road during Operations and prohibit employees from hunting and fishing in the area. • Progressively reclaim sites disturbed during construction and through the life of mine that will no longer be used by the operation. This includes both terrestrial and aquatic ecosystems. • Relocate priority plant species where appropriate. • Integrate priority plant species into reclamation program. • Monitor and record actual clearing and disturbance areas.	5.8
	Monitoring: • Carry out annual aquatic ecosystem monitoring in reference streams and restored areas. • Carry out annual monitoring of terrestrial ecosystems, including comparison of actual footprint to assessed footprint, investigation of potential edge effects, and any forest mortality due to hydrologic changes. • Update loss-gain calculations annually based on the results of the monitoring program. • Conduct reporting of wildlife collisions to identify hotspots where additional control measures are required.	5.8
Social: Culture (Tangible)	Additional Baseline: • Prior to site clearing or construction, Newmont will engage a qualified archaeologist to complete additional baseline surveys at: (1) the Sabajo North Waste Rock facility (WRF); (2) Sabajo Pits 4 and 6; (3) the area to be disturbed by the Margo pit and WRF; and (4) all medium or high potential areas for cultural resources along the Sabajo-Merian Haul Road	5.9
	Monitoring and Mitigation: • Implement a chance find management plan to protect any cultural resources that are found during construction or operations.	5.9

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	Commitment	Section Reference
Social: Culture (Intangible)	Mitigation: • Implement the grievance (complaint) procedure that can be used to identify if there are Project-related processes that are creating conflict within or between communities. • Implement Newmont's employment policies, which aim to follow best practice and enable people to remain in their home communities in order to limit cultural change associated with Project activities. • Consult with small-scale mining and logging operations about policies to secure the Project's boundary to prevent encroachment onto the potential mining concession. • Consistently show respect to traditional authorities and their decisions in order to prevent and manage conflict or aggression. • Implement cultural sensitivity training programs to help out-of-area Project workforce understand local cultural context. • Establish workplace conditions that are sensitive to local cultures and values. • The Social Responsibility Team will continue to engage with communities in the Project's Area of Influence in a culturally appropriate manner. This includes following their customs about newcomers to the villages, respecting taboos and communicating in their native languages, where possible.	5.9.7

Social: Economic development and Recruitment and Income opportunities	Mitigation:
	• Undertake efforts to identify suitable Surinamese candidates for as many positions as possible during both the construction and operations with Project operations requiring a more skilled workforce than construction.
	• Stay in contact with the Kawina Traditional Authorities and continue ongoing engagement with them regarding Project opportunities.
	• Undertake a formal recruitment process that maximises opportunities for employment of key stakeholder groups, where possible, including accessible and timely job postings.
	• Post positions internally to encourage the advancement of the workforce into other categories of employment, thus creating entry level job openings.
	• Establish achievable targets for growing the representation of key stakeholder groups in the Project workforce over time.
	• Establish achievable targets for growing the representation of women in the Project workforce over time.
	• Implement a process to identify potential suppliers of goods and services and analyse barriers to the ability of key stakeholder groups to supply goods and services relative to Project procurement requirements.
	• Give priority to suppliers from key stakeholder groups when sourcing raw materials, finished goods, and services that can be procured in the local market.
	• Identify opportunities for 'adhoc' or occasional income generation opportunities (filling sand bags, collecting seeds for reclamation, etc).
	• Establish achievable targets for local procurement (as a percent of total procurement) from key stakeholder groups that grow over time.
	• Provide businesses with timely information on procurement.
	• Implement procurement contracting procedures that consider the potential need to break down procurement packages and accommodate financial constraints of small scale enterprises.
	• Provide explanations to interested businesses that may be denied an opportunity to bid on procurement requests, and to businesses that compete on bids unsuccessfully, as to the reason for their denial or unsuccessful bid.
	• Maintain a regularly updated Project database of potential local suppliers of goods and services that identifies:
	  ○ business interest, capacity and the nature of goods and services offered;
	  ○ contact information; and
	  ○ contract performance record.
	• Formalize mitigation measures in a Local Employment Plan as per the Local Procurement and Employment Standard including promoting local employability and skills development and setting objectives and KPIs relative to diversity, equity, and gender in a rights-compatible manner and report as a human rights measure.
		5.9.6.2

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	**Commitment**	**Section Reference**
Social: Gender	• Provide employment opportunities for both men and women and track hiring of women. • Adhere to cultural norms. This may include participating in relevant rituals if there are Project disturbances to land, resources or areas of cultural values	5.9.7
Social: In-migration	Mitigation: • Widely circulate the Project's employment and procurement policy to limit the number of people who come to the region to search for direct and indirect employment opportunities.	5.9.7
Social: Land Use and Tenure	Mitigation: • Where the Project will require clearing within the concession and along proposed roads to the Merian mine, make plans with commercial loggers and the Traditional Authorities in relevant communities that address impacts of lost forest resources. Such plans involve identifying merchantable trees and implementing timber salvage efforts. • Engage with land users to agree on approved locations of crossings and do not allow construction of facilities, shops or settlements along the haul road. • Consult with small-scale mining and logging operations about policies to secure the Project's boundary to prevent encroachment onto the potential mining concession. • Provide technical and legal support and resources to Kawina to assess impacts from Project and participate in negotiation process • Provide full disclosure of impacts, especially water quality in appropriate language and detail to ensure comprehension and ensure Kawina are fully informed of potential impacts. • Develop rights-compatible plan for the haul road and document its implementation for prior consultation with and agreements on land take and impacts to forestry concessions. • Engage with Kawina to evaluate potential post closure options and involve them in closure planning. • Evaluate options for participatory environmental monitoring programs with Kawina for potential impacts to their traditional lands.	5.9.9; 5.9.7

Social: Artisanal and Small Scale Mining	Mitigation:
	• Consult with small-scale mining and logging operations about policies to secure the Project's boundary to prevent encroachment onto the potential mining concession and haul road.
	• Socialize and implement a human rights-compatible ASM Management Plan
	• Engage with ASM in Sabajo Right of Exploitation to:
	• Communicate rules for co-existence (e.g. environmental management , health and safety and labor considerations):
	  ○ Prior to construction of the Sabajo Project, provide sufficient advance notice to ASM operators such that they are able to avoid and minimize financial losses from equipment and other related investments.
	  ○ Provide assistance to transport equipment out of the area.
	• Provide options for livelihood enhancement that could include skills training to increase employability in the formal sector and capacity building to develop small businesses.
	• Continue to implement a 'no guns' policy on the concession
	• Conduct a Voluntary Principles external audit, including input from local stakeholders.
	• Continue work to sign MOUs with military and OGS; take additional actions as necessary and document.
	• Implement stronger actions to address risks with public security and report on them publicly, both locally and externally.
	• Develop and carry out training program in human rights, the VPs and the UNGPs with all Newmont Suriname management.
	• Work with private security contractors to screen private security guards for past human rights abuses.
		5.9.8

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	Commitment	Section Reference
Social: Ongoing Training	Mitigation: • Provide training to employees in semi-skilled and skilled positions prior to the commencement of employment and during operations on environmental management and health and safety. • Create career development plans for employees that emphasise on-the-job training and skills development in pursuit of advancement. • Include in the employment responsibility of senior staff the requirement to mentor more junior employees in a manner that encourages skills development and career advancement. • Provide training to senior staff aimed at improving their ability to coach and mentor junior staff. • Consider providing optional money management training for Surinamese employees and their families, including support for opening up bank accounts. • Provide the opportunity for Project employees to suggest and attend "life skills" presentations on topics of interest. These may include topics such as effective communication, time management, hygiene and teamwork. • Track training against objectives of diversity, adapt as required to meet objectives and report as a human rights outcome.	5.9.6.2
Social: Monitoring	• Monitor predicted impacts and mitigations for effectiveness.	5.9.13
Health	Mitigation: • Ensure project designs reduce the potential for sources of vector breeding (i.e. minimize standing water). In addition, assess the positioning of potential mine accommodation in terms of its proximity to breeding sites. • Implement the Newmont Global Health Management Guideline for Pandemic Events and a Health Incident Response Plan. • Ensure Newmont-utilized medical facilities can test for and treat malaria, leishmaniasis and other vector-borne diseases. • Provide health information on vector-borne disease to workers through posters and awareness sessions. • Implement a Sexually Transmitted Infection (STI) and Human Immunodeficiency Virus (HIV) policy for Newmont Suriname. This will include issues stemming from accommodation camps and extended time away from families, voluntary testing, counseling and access to treatment. • Include health education on STI and HIV during inductions. • Improve access to confidential STIs diagnosis and treatment for the workforce. • Supply free condoms for all employees, contractors and subcontractors. • Adapt and apply a traffic and transportation safety management plan (adopted from the plan in place at Merian) to improve overall traffic safety and reduce risks within the transportation corridor. The plan will include contractors and subcontractors. • Support an educational program in schools along the Project access routes regarding road safety among children and teenagers, as well as for the school bus drivers. • Initiate screening programs for the early recognition of chronic diseases and appropriate treatment practices. This is to ensure a healthy productive workforce and also to reduce the risk of occupational illness and injury. • Ensure the living areas are equipped with facilities for physical activities. • Implement a system that controls the consumption of alcohol on-site. • Utilize a rating system on canteen food choices and encourage healthy eating. • Implement a mechanism for local communities to report any issues relating to road use and safety. • Provide employees training on the responsible use of alcohol, and facilitate access to programs for addictions and mental health issues.	5.9.12
	Monitoring: • track incidence of each type of illness and injury on site.	5.9

Table 6-1 Summary of Mitigations and Commitments

Discipline/ Topic	Commitment	Section Reference

Traffic	Mitigation:
	• Adapt and implement a traffic and transportation safety management plan (adopted from the plan in place at Merian) to improve overall traffic safety and reduce risks within the transportation corridor. This will include:
	    o adopting limits for trip duration and arranging driver rosters to avoid fatigue;
	    o nearly all road use will be in daylight hours, given that the risks of some types of incidents would be higher for vehicles travelling at night;
	    o contractors and subcontractors will be required to adhere to Newmont driving standards;
	    o use of a reporting system so that local communities can report any issues relating to road use, safety, or other concerns, and Newmont can take action to improve measures for safety where needed.
	• The traffic and transportation safety management plan will include increased maintenance of project access routes beyond the current maintenance program that is implemented by Government, and monitoring of increased Project traffic on the access route to determine if additional mitigation measures are required.
	• depending on which access route to the Project is selected, further engagement will occur to determine if other means of mitigation are most appropriate for Powakka.
	• Support an educational program in schools along Project access routes regarding road safety among children and teenagers, as well as for the school bus drivers.
		5.10

	Monitoring: • The complaint mechanism will be used for local communities to report issues relating to road use and road safety; these will be tracked and responded to. • Track the total number of vehicle trips in and out at the gate at Sabajo. • Investigate and report any accidents. • Monitor speed of vehicles with spot checks and/or GPS monitoring devices at certain locations along Newmont maintained portions of the access road.	5.10
Visual Aesthetics	Mitigation: • Minimize vehicle traffic (and resulting light) along roads at night, as described in traffic section, above.	5.11
Environmental Risks and Accidents	Mitigation: • To the extent possible, engineer for high rain events and allow for the possibility of disruption of ore transport from Sabajo to Merian in wet seasons. • Construct buildings that can withstand rain storms and occasional high winds. • Design rock storage facilities or dumps with gradual side slopes to increase stability; revegetation where possible to reduce erosion; plan to manage slope failures if they occur. • Implement emergency/spill control planning within the ESMMP; special controls in accordance with the Cyanide Code for prevention of cyanide spills.	5.12
	Monitoring: • monitoring to measure contamination after any substantial release or spill.	5.12

Newmont = Newmont Suriname, LLC; the Project = the Sabajo Project; UNGP = United Nations Guiding Principles; OGS = Ordening Goudsector; KPI = Key Performance Indicator; ARD = acid rock drainage; WRF = waste rock facility; ML = metal leaching; IFC = International Finance Corporation; PM_{10} = particulate matter with mean aerodynamic diameter nominally smaller than 10 microns; $PM_{2.5}$ = particulate matter with mean aerodynamic diameter nominally smaller than 2.5 microns; NO_2 = nitrogen dioxide; GPS = Global Positioning System; ESMMP = Environmental and Social Monitoring and Management Plan.

7 CONCLUSIONS

Impact Assessment

The Sabajo Project (the Project) will result in a number of positive and negative effects on air, noise, water, soil, biodiversity, social, cultural, health, traffic, and visual receptors. After mitigation, no high negative impacts are predicted. Eleven medium negative impacts are predicted; two high positive impacts and one medium positive impact are also predicted. These impacts are:

- High negative: None.
- Medium negative: 11 negative effects falling into 8 categories:
  - the effects on air quality at the mine site and extending beyond the right of exploration boundary;
  - the effects of noise along the Afobaka and Carolina Roads;
  - air vibration from blasting at the mine (will not extend as far as villages);
  - effect of runoff from Waste Rock Facilities on water quality;
  - displacement of artisanal and small scale miners from the Project areas;
  - overall effect of air, noise and traffic on quality of life at Powakka and potentially other Carolina Road communities;
  - effect of traffic on safety and potential accidents and injuries on the Carolina and Afobaka Roads; and
  - visual effect of dust along unpaved access roads to the Project.
- High positive:
  - the Project will positively impact Kawina cultural identity; and
  - the Project will positively affirm Kawina land tenure.
- Medium positive:
  - the Project will generate employment and incomes.

The remainder of effects have an impact classification of low or negligible. All effects are presented below in Table 7-1. This table presents the impacts identified in the same order as they are presented in the impact assessment. For most disciplines, the classification of input into categories is then provided, as described in the Methods Section (5.1). In these columns, if the impact classification is changed by mitigation, the new impact classification is shown after mitigation are in brackets. Next, the pre-and post-mitigation effects ratings are shown.

Last, a summary of the mitigation or enhancement measures is provided. Mitigation may include measures to reduce negative effects, or measures to promote positive effects such that the overall positive effect is increased. The mitigation measures are summarized in Table 7-1 but both mitigation and monitoring have been provided in more detail in Section 6, and the details for implementation for these measures are provided in the Environmental and Social Monitoring and Management Plans (ESMMP; Volume B of this document).

Risk Assessment

The Project will result in 4 high-consequence risks:

- risk of flooding affecting the Project;
- risk of geotechnical slope failures affecting the Project;
- risk of spills of cyanide along access roads; and
- risk of Cyanide spills at the mine site.

The Project will also result in six other medium or low risks as identified in Table 7-2 below.

All risks are considered manageable and mitigation plans have been developed for them.

Human Rights Assessment

Based on the Human Rights Assessment, there are 4 areas of potential high risk where the project could contribute to causing an issue in relation to human rights:

- Risk of removing livelihoods from ASM miners, which would affect the right to an adequate standard of living
- Risk of the project not achieving Free, Prior and Informed Consent, which would affect right to self-determination of the land rights holders;
- Risk of project traffic impacting local people through accidents on the Carolina Road, which could affect right to health or right to life; and
- Risk of project traffic impacting local people through accidents on the Afobaka Road, which could affect right to health or right to life.

The results of the human rights assessment are summarized below in Table 7-3.

Table 7-1 Classification of Effects and Residual Impact Classification

Air Quality and Climate (Section 5.2)							
Effect	**Effect Classification**					**Impact Significance Post-Mitigation**	**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**		
Effect of air quality from Sabajo Project mining activities (operation phase)	Negative	High	local	Short-term	Likely	Medium	• implementing an idle-reduction program; • use of ULSD fuel for Project equipment; • watering of Project roads and ore stockpile as necessary; • limit speed of trucks; • use of best available technology economically achievable (BATEA) for emissions controls; • implementing an quality monitoring program for PM_{10}, $PM_{2.5}$ and NO_2 at the Project site during construction and operation phases; and • reclaim mine ore stockpiles and disturbed areas as they become available.
Effect of air quality from offsite Project traffic on Project Access Route (operation phase)	Negative	Negligible	Local	Short-term	Likely	Negligible	• use of ULSD fuel for Project equipment; and • limit speed of trucks.
Effect of climate from Sabajo Project mining activities (operation phase)	Negative	Negligible	Beyond regional	Medium-term	Certain	Negligible	• implementing an idle-reduction program; and • limit speed of trucks. • quantify and report GHG emissions per IFC guidance; and • reclaim mine ore stockpiles and disturbed areas as they become available.

Table 7-1 Classification of Effects and Residual Impact Classification

Noise and Vibration (Section 5.3)								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-Mitigation**	
Noise from offsite traffic on Carolina Road (Operation, Construction, Closure)	Negative	Moderate (low)	Regional	Medium-term	Likely, if this option is selected	Medium	Medium	• Limit offsite Project traffic to the daytime period (07:00 to 22:00), where practical.
Noise from offsite traffic on Afobaka Road (Operation, Construction, Closure)	Negative	Moderate (low)	Regional	Medium-term	Likely, if this option is selected	Medium	Medium	• Limit offsite Project traffic to the daytime period (07:00 to 22:00), where practical.
Noise from Project Mining (Operation, Construction)	Negative	Negligible	Local	Medium-term	Certain	Low	Low	-
Noise from Sabajo-Merian haul road (Operation, Construction)	Negative	Negligible	Local	Medium-term	Certain	Low	Low	-
Ground vibration from explosive blasting (Operation)	Negative	Moderate (low)	Local	Short-term	Certain	Medium	Low	• Limit blasting to the daytime period (07:00 to 22:00), where practical.
Airblast overpressure from explosive blasting (Operation)	Negative	Moderate (low)	Regional	Short-term	Certain	High	Medium	• Limit blasting to the daytime period (07:00 to 22:00), where practical.

Soil and Geomorphology (Section 5.4)								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Effect of change in soil quantity during construction phase	Negative	Moderate (Low)	Local	Short-term	Certain	Medium	Low	• Implement a Sediment and Erosion Control Plan to limit erosion. Storm water

Table 7-1 Classification of Effects and Residual Impact Classification

Soil and Geomorphology (Section 5.4)								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Effect of change in soil quantity during operations and closure phases	Negative	Moderate (Low)	Local	Medium-term	Certain	Medium		runoff will be managed to reduce erosion and sedimentation. • Implement progressive reclamation as part of the Mine Closure and Rehabilitation Plan. • Salvage topsoil/subsoil/saprolite layers and store without segregation. This admixed material will be used as a growth media during reclamation.
Effect of change in soil quality during construction phase	Negative	Moderate (Low)	Local	Short-term	Certain	Medium	Low	• Implement a Sediment and Erosion Control Plan to limit erosion. • Manage storm water runoff to reduce erosion and sedimentation. • Manage compaction of soils by limiting off-road access. • Implement a Spill Prevention, Control and Countermeasures Plan (SPCC) to minimize the potential for contamination of soils. • Carry out progressive reclamation as part of the Mine Closure and Rehabilitation Plan. • Rip hard-packed soils resulting from Project activities to encourage revegetation. • Revegetate disturbed areas with native species.
Effect of change in soil quality during operations and closure phases	Negative	Moderate (Low)	Local	Medium-term	Certain	Medium		
Effect of change in geomorphology or terrain conditions during construction phase	Negative	Moderate (Low)	Local	Short-term	Unlikely	Negligible	Negligible	• Implement a Sediment and Erosion Control Plan to limit erosion.

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Table 7-1 Classification of Effects and Residual Impact Classification

Soil and Geomorphology (Section 5.4)								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Effect of change in geomorphology or terrain conditions during operations and closure phases	Negative	Moderate (Low)	Local	Medium-term	Unlikely	Negligible		• Return disturbed and waste rock disposal areas to a landform that approximates and blends in with the surrounding landforms.

Groundwater (Section 5.5) and Surface Water (Section 5.6)								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Effect of increased runoff (construction and operation phase; pre mitigation)	Positive	Negligible	Regional	Medium-term	Possible	Negligible Positive	Negligible Positive	-
Effect of decreased baseflows (construction and operation phases)	Negative	Low (negligible)	Regional	Medium-term	Possible	Low	Negligible	• Discharge collected water toward creeks with reduced baseflow.
Effect of decreased baseflows (closure phase)	Negative	Low	Regional	Medium-term	Possible	Low	Low	-

Water Quality (Section 5.7):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Operation and Closure								
Effect of WRF runoff on surface water quality (ARD/ML)	Negative	High (Low to Moderate with mitigation)	Local to Regional	Long-term	Likely	High	Medium	• Implement runoff and seepage collection and treatment (if necessary), facility design to minimize ARD/ML (e.g.,

Table 7-1 Classification of Effects and Residual Impact Classification

Water Quality (Section 5.7):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Effect of WRF seepage on groundwater quality (ARD/ML)	Negative	Moderate [(a)] (Low with mitigation)	Local [(b)]	Long-term	Likely	Medium	Low	reactive material segregation and encapsulation, placement of covers).
Operation								
Effect of ore stockpile runoff on surface water quality (ARD/ML)	Negative	High (Low to Moderate with mitigation)	Local	Medium-term	Likely	High	Low	• Install a liner; runoff collection and treatment (if necessary).
Effect of ore stockpile seepage on groundwater quality (ARD/ML)	Negative	High (Low to Moderate with mitigation) [(a)]	Local	Medium-term	Likely	High	Low	
Effect of decreased artisanal and small scale mining (ASM) on surface and groundwater quality	Positive	Not determined	Local to Regional	Long-Term	Likely	N/A	N/A	-
Effect of erosion on surface water quality (increased TSS)	Negative	Moderate (Low with mitigation)	Local to Regional	Long-Term	Likely (Possible with mitigation)	High	Low	• Install sediment control structures, use of flocculant.
Effect of accidental spills on surface water or groundwater quality	Negative	Moderate	Local to Regional	Medium-term	Likely (Possible with Mitigation)	Medium	Low	• Implement standard spill prevention and control measures.
Closure								
Pit Lake water quality (ARD/ML)	Negative	High (Low to Moderate with mitigation)	Local	Medium-term	Likely	High	Low	• Carry out WRF management (to improve the quality of runoff into the pit), rapid filing, in-situ treatment (if necessary).

Table 7-1 Classification of Effects and Residual Impact Classification

Biodiversity (Section 5.8):			
Effect	**Effect Classification**	**Impact Significance: Post-Mitigation**	**Mitigation or benefit enhancement measure**
Habitat Effects	Not applicable	None	• Complete habitat offsets for zero net loss.
Impact on *Elaeis aff. Oleifera (*Restricted to forests on white sand and savanna brush, very rare in F. Guiana and Suriname)	Not applicable	Not assessed. Will be subject of follow-up study.	• To be determined after additional study.
Impct on *Virola surinamensis (*IUCN Red List - Endangered, although common throughout Suriname)	Not applicable	Negligible - Viability in EAAA is not reduced.	• Include in rehabilitation program.
Impact on *Vouacapoua americana* (IUCN Red List - Critically Endangered, although common throughout Suriname)	Not applicable	Negligible - Viability in EAAA is not reduced.	• Include in rehabilitation program.

Social (Section 5.9):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-mitigation**	
Socio-Economics: Macroeconomics								
The Project will contribute to national exports and the overall economy of Suriname	Positive	Moderate	National	Medium-term	Certain	Low Positive		-
The Project will contribute fiscal benefits to Government of Suriname	Positive	Moderate	National	Medium-term	Certain	Low Positive		-
The Project will generate employment and incomes	Positive	Low	National	Medium-term	Certain	Medium Positive		-

Table 7-1 Classification of Effects and Residual Impact Classification

Social (Section 5.9):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-mitigation**	
Socio-Economics: Local Economic Effects								
The Project will generate direct employment opportunities and associated incomes	Positive	Low	Local	Medium-term	Possible	Low Positive	Low Positive	• Identify Surinamese candidates for as many positions as possible. • Undertake a recruitment process that maximizes employment of key stakeholder groups.
The Project will generate business opportunities through the procurement of goods and services	Positive	Low	Local	Medium-term	Likely	Low Positive	Low Positive	• Implement a process to identify potential suppliers of goods and analyse barriers for key stakeholder groups to be suppliers of the goods. • Give priority to suppliers from key stakeholder groups. • Identify opportunities for occasional income opportunities for stakeholder groups. • Implement procurement processes that consider the financial constraints of small scale enterprises.
Socio-Economics: Transportation Infrastructure								
The Project will increase use of transportation infrastructure	Positive	Negligible	Local	Medium-term	Certain	Low Negative	Low Positive	• Upgrade (as needed) and maintain unpaved road routes being used.

Table 7-1 Classification of Effects and Residual Impact Classification

Social (Section 5.9):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-mitigation**	
Culture and Wellbeing								
The Project could result in changes in culture associated with in- or out-migration	Negative	Low	Local	Medium-term	Likely	Low Negative	Low Negative	• Widely circulate the project's employment and procurement policy to limit the number of people who come into the region searching for direct employment opportunities.
The Project could influence the social and cultural identity of the Kawina	Positive	High	Local to National	Permanent	Possible	High Positive	High Positive	-
The Project could influence social conflict	Negative	Low	Local	Medium-term	Possible	Low Negative	Low Negative	• Consistently show respect to traditional authorities and their decisions in order to prevent and manage social conflict. • Implement training to help out of area employees understand local cultural context. • Establish workplace conditions that are sensitive to local culture and values.
The Project could influence gender relations	Positive	Low	Local	Medium-term	Possible	Low Positive	Low Positive	• Establish achievable targets to grow the representation of women in the workforce over time.
Artisanal and Small Scale Mining								
The Project will displace some small scale mining operations	Negative	High	Local	Long-term	Certain	High Negative	Medium Negative	• Provide adequate notice to ASM miners, provide assistance with moving equipment out of the area, and raise awareness of labor, environmental and safety considerations in mining practice.

Table 7-1 Classification of Effects and Residual Impact Classification

Social (Section 5.9):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-mitigation**	
Land Use and Tenure								
The Project could affirm the customary land tenure of the Kawina	Positive	High	Regional	Long-term	Likely	High Positive	High Positive	-
The Project could impact recreation and tourism activities in the vicinity of local communities	Negative	Negligible	Local	Medium-term	Unlikely	Negligible Negative	Negligible Negative	-
The Project could impact community and commercial forestry activities through direct land take and increased access	Negative	Low	Local	Long-term	Likely	Low Negative	Negligible Negative	• Where the Project will require clearing within the concession and along proposed roads to the Merian mine, plans will be made with commercial forestry and community forest licence holders that address the impacts of lost resources.
The Project could impact hunting and fishing activities of displaced small-scale miners	Negative	Negligible	Local	Medium-term	Certain	Negligible Negative	Negligible Negative	-

Table 7-1 Classification of Effects and Residual Impact Classification

Social (Section 5.9):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-mitigation**	
Quality of Life								
Project traffic will impact the quality of life of those residing in Brokopondo communities	Negative	Low to Moderate	Local	Medium-term	Likely	Low to Medium	Low	• Refer to mitigation for traffic, air, and noise.
Project traffic will impact the quality of life of those residing in the off-road Carolina communities	Negative	Low to Moderate	Local	Medium-term	Likely	Medium	Low to Medium	• Refer to mitigation for traffic, air, and noise.
Project traffic will impact the quality of life of those residing in Powakka	Negative	Moderate	Local	Medium-term	Likely	High	Medium	• Refer to mitigation for traffic, air, and noise.

Table 7-1 Classification of Effects and Residual Impact Classification

Social (Section 5.9):								
Effect	**Effect Classification**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-mitigation**	**Post-mitigation**	
Community Health								
Effect of Vector Related Diseases (mainly for Employees, their families and neighbors)	Negative (Positive)	Low	Beyond regional	Medium term	Likely	Medium	Positive	• Ensure Project designs minimize areas for vector breeding (standing water) and assess mine accommodation for proximity to breeding sites. • Ensure Newmont medical facilities can diagnose and treat vector-borne diseases. • Provide information on vector borne diseases to workers.
Effect of Sexually Transmitted Infections (general population)	Negative	High	Beyond regional	Long term	Possible	High	Low	• Implement a sexually transmitted Infection (STI) and HIV policy. • Include health education for STIs and HIV during inductions. • Improve access to confidential STI diagnosis and treatment. • Supply free condoms for workers, contractors and subcontractors.
Accidents and Injuries (Children in school age Drivers of 2/3 wheel vehicles)	Negative	High	Local	Long term	Likely	High	Medium	• Implement a Traffic and Transportation Safety Management Plan. • Support education in schools on road safety among children and teenagers.
Non Communicable diseases (mainly for Workers)	Negative	Moderate	Beyond regional	Long term	Likely	Medium	Positive	• Carry out screening programs for recognition of chronic diseases;. • Ensure living areas are equipped with facilities for physical activities. • Implement a system for control of on-site alcohol consumption. • Maintain a rating system on canteen food choices and encourage healthy eating.

Table 7-1 Classification of Effects and Residual Impact Classification

Traffic (Section 5.10)								
Description of Effect	**Impact Criteria**					**Impact Significance**		**Mitigation or benefit enhancement measure**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre Mitigation**	**Post Mitigation**	
Effect on traffic congestion (Afobaka Road; construction, operation and closure phases)	Negative	Low	Local	Medium-term	Certain	Negligible	Negligible	-
Effect on traffic congestion (Carolina Road; construction, operation and closure phases)	Negative	Moderate	Local	Medium-term	Certain	Low	Low	-
Effect on Safety (Afobaka Road; construction, operation and closure phases)	Negative	Moderate	Local	Medium-term	Likely	Medium	Medium	• Implement Traffic and Transportation Safety Management Plan.
Effect on Safety (Carolina Road; construction, operation and closure phases)	Negative	High (Moderate)	Local	Medium-term	Likely	High	Medium	• Engage community on Potential Safety Mitigation at Powakka. • Implement Traffic and Transportation Safety Management Plan.
Effect on infrastructure (Afobaka Road; construction, operation and closure phases)	Negative	Low	Local	Medium-term	Likely	Low	Low	• Implement Traffic and Transportation Safety Management Plan.
Effect on infrastructure (Carolina Road; construction, operation and closure phases)	Negative	Moderate (Low)	Local	Medium-term	Likely	Medium	Low	• Upgrading (where needed) and Maintenance of unpaved access roads; and • Implement Traffic and Transportation Safety Management Plan.

Table 7-1 Classification of Effects and Residual Impact Classification

Visual Aesthetics (Section 5.11)								
Description of Effect	**Effects Classification**					**Impact Significance**		**Mitigation**
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Likelihood**	**Pre-Mitigation**	**Post-Mitigation**	
Clearing of Forest and Development of Landforms	Negative	Low	Local	Medium-term	possible	Low	Low	-
Dust along roads	Negative	Low	Regional	Medium-term	likely	Medium	Medium	• Described in air section (Section 5.2)

a) Because the land within the Disturbance Footprint is not particularly productive, even for cattle production, the most Land Suitability Ratings can change is by 2 classes, resulting in a magnitude rating of moderate.

the Project = the Sabajo Project; IFC = International Finance Corporation; GHG = greenhouse gas; PM_{10} = fine particulate matter with a mean aerodynamic diameter of 10 microns or less; $PM_{2.5}$ = fine particulate matter with a mean aerodynamic diameter of 2.5 microns or less: ULSD = ultra-low sulfur diesel; NO_2 = nitrogen dioxide; IUCN = Intonational Union for Conservation of Nature; EAAA = ecologically appropriate areas of analysis; < = less than; % = percent.; N/A = not applicable; - = no mitigation or benefit enhancement measure.

Table 7-2 Environmental Risk Matrix Results

Risk ID #	Risk Type	Risk Description	Impact Category	Potential Cause	Construction(a)	Operation(a)	Closure(a)	Potential Consequence	Current Controls	Failure Likelihood	Consequence	Risk Score	Risk Level
1	Flooding	Flooding of mine areas or infrastructure including roads	Flooding	High rainfall event	X	X	X	Washout of areas; inaccessibility of areas; slower work due to soft soils	To extent possible engineer for high rain events; allow for possibility of disruption of ore transport from Sabajo to Merian in wet seasons	Possible = 3	Moderate = 3	13	High
2	Wind	Potential high wind event / hurricane affecting the Project	Wind	Hurricane or other high wind event during a storm	X	X	X	Destruction of infrastructure via storm events	Construction of buildings with appropriate level of protection from storms	Unlikely = 2	Minor = 2	5	Low
3	Earthquake	Potential seismic event affecting the project	Seismic	Earthquake	X	X	X	Destruction of infrastructure via earthquake	none required	Rare = 1	Minor = 2	3	Low
4	Slope Failure	Potential geotechnical hazards / slope failures affecting the project	Geotechnical	Failure of waste rock facility or failure of cut side slope along road	X	X	X	Input of sediment into water bodies, impacts to infrastructure, impacts to access	Engineering design with gradual side slopes; revegetation where possible to reduce erosion; plan to manage slope failures if they occur	Possible = 3	Moderate = 3	13	High
5	Spill	Spill of cyanide along access road to project	Chemical	Accident/release with Cyanide spilled		X		Health risk for people (public), risk to aquatic ecosystems	Extensive controls associated with prevention of Cyanide spills; vehicle safety; emergency / spill control planning	Unlikely = 2	Major = 4	14	High
6	Spill	Spill of oil along access road to project	Chemical	Accident/release with oil spilled	X	X	X	Health risk for people (public), risk to aquatic ecosystems	Controls for oil spills; vehicle safety; spill control planning	Possible = 3	Minor = 2	8	Moderate
7	Spill	Spill of other / non hazardous material along access road to project	Chemical	Accident/release with non-hazardous material spilled	X	X	X	Concern over potential effect by the public; possible minor local effects	Vehicle safety; spill control planning	Possible = 3	Insignificant = 1	4	Low
8	Spill	Spill of cyanide within mine site	Chemical	Leak or accident		X		Health risk for people (employees), risk to aquatic ecosystems	Extensive controls associated with prevention of Cyanide spills; vehicle safety; emergency / spill control planning	Unlikely = 2	Major = 4	14	High
9	Spill	Spill of oil within mine site	Chemical	Leak or accident	X	X	X	Health risk for people (employees), risk to aquatic ecosystems	Controls for oil spills; vehicle safety; spill control planning	Possible = 3	Minor = 2	8	Moderate
10	Spill	Spill of other / non hazardous material within mine site	Chemical	Leak or accident	X	X	X	Concern over potential effect; possible minor local effects	Vehicle safety; spill control planning	Possible = 3	Insignificant = 1	4	Low
11	Traffic Accident	Accident with damage to vehicles	Physical	Accident between Project vehicle and external vehicle or other external property	X	X	X	Property damage	Vehicle safety / driver safety management program; tracking system for issues/incidents; see traffic section	Impact addressed in traffic section			
12	Traffic Accident	Accident with impact to people	Physical	This risk discussed in traffic section and health section	X	X	X	Health and Safety effects	Vehicle safety / driver safety management program; tracking system for issues/incidents; see traffic section	Impact addressed in traffic section and health section			

a) An X indicates the risk is valid in that project phase.
ID = identification; # = number.

Table 7-3 Human Rights Identification and Classification of Effects

Water Quality (Section 5.7)									
ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	Impact Rating	Human Rights	Rights-holders	Direction	State	Severity/scale	HR Risk Likelihood	HR Prioritization	Influence
Accidental spills of hazardous materials	Negative, Low	Right to water, health, and an adequate standard of living	Powakka residents and communities along the Afobaka Road whose watersheds might be impacted	Negative	Potential	High	Potential	Medium	Cause
Restrict ASM activities within Project boundaries	Positive, Low	Right to water, right to health	Kawina people	Positive	Potential	Low	Probable	Low	Cause
Contamination from waste rock facilities	Negative, Possible	Right to water, right to health	Kawina people	Negative	Potential	Uncertain	Potential	Medium	Cause

Social (Section 5.9)									
Socio-Economics: Local Economic Effects									
ESIA Effect Classification		Identification		Category		Severity		Assessment	
Effect	Impact Rating	Human Rights	Rights-holders	Direction	State	Severity/scale	HR Risk Likelihood	HR Prioritization	Influence
The Project will contribute fiscal benefits to Government of Suriname	Positive, low	Right to health, right to education, others	Surinamese population, school-age children	Positive	Potential	Low	Possible	Low	Linked to
The Project will generate employment and economic opportunity through local procurement	Positive, low	Right to work, right to adequate standard of living	Workers, contractors' labor force, supply chain	Positive	Potential	Low	Certain	Low	Cause
The Project Local Procurement and Employment	Low, Positive	Right to non-discrimination	Interior population	Negative	Potential	Medium	Possible	Medium-high	Cause
Culture and Wellbeing									
Project influence on cultural loss	Negative, Low	Right to Take Part in Cultural Life, Right to Freedom of Religion	Brokopondo and Carolina road communities	Negative	Potential	Low	Possible	Low	Contribute to
Project influence on Kawina social and cultural identity	Positive, High	Right to Take Part in Cultural Life/Religious Freedom, Right to Self-Determination	Kawina communities	Positive	Potential	High	Probable	Low	Cause

Table 7-3 Human Rights Identification and Classification of Effects

Social (Section 5.9)									
Socio-Economics: Local Economic Effects									
ESIA Effect Classification		**Identification**		**Category**		**Severity**		**Assessment**	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity/scale**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Artisanal and Small Scale Mining									
Removal of ASM from Project footprint	Negative, Moderate	Right to an adequate standard of living	ASM sector, all affected participants	Negative	Potential	High	Possible	High	Cause
Use of excessive force to manage ASM	N/A	Right to security of the person, to health, right to life	ASM miners and equipment owners	Negative	Potential	Medium	Possible	Medium	Contributing to
Use of excessive force in response to social conflict	N/A	Right to security of the person, to health	Community members, other rights-holders	Negative	Potential	Medium	Possible	Medium	Contributing to
Land Use and Tenure									
Project affirmation of Kawina customary land rights	High, positive	Right to property, right to self-determination	Kawina Tribe	Positive	Actual	High	Certain	Low	Cause
FPIC process not achieved for Project	Not in ESIA	Rights to Self-determination	Kawina Tribe	Negative	Potential	High	Possible	High	Cause
Agreement-making not fair or legitimate	Not in ESIA	Right to benefit from development of land and resources	Kawina Tribe	Negative	Potential	Medium-high	Possible	Medium- high	Cause
Land take from community forestry concessions	Negative, negligible	Right to property, to benefit from use of natural resources	Community forestry concession holders	Negative	Potential	Low	Possible	Low-medium	Cause

Traffic (Section 5.10)									
ESIA Effect Classification		**Identification**		**Category**		**Severity**		**Assessment**	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity (scale)**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Carolina Road Assessment									
Road safety for community members due to traffic	Low	Right to health	Powakka residents including children, Carolina road communities, all road users	Negative	Potential	Medium	Probable	High	Cause
	Low	Right to life		Negative	Potential	High	Possible	High	Cause
Air quality impacts	Low	Right to health	Powakka residents and business operators/patrons near road	Negative	Potential	Medium	Possible	Low	Cause
Potential spills of hazardous materials and fuel along roadway	Low	Right to health	Powakka residents, children and business operators/patrons near road	Negative	Potential	Medium	Possible	Low	Cause

Table 7-3 Human Rights Identification and Classification of Effects

Traffic (Section 5.10)									
ESIA Effect Classification		**Identification**		**Category**		**Severity**		**Assessment**	
Effect	**Impact Rating**	**Human Rights**	**Rights-holders**	**Direction**	**State**	**Severity (scale)**	**HR Risk Likelihood**	**HR Prioritization**	**Influence**
Afobaka Road Assessment									
Road safety for community members due to traffic	Low	Right to health	Afobaka road users including school children bussing, all road users	Negative	Potential	Medium	Possible	High	Cause
	Low	Right to life		Negative	Potential	High	Possible	High	Cause
Potential spills of hazardous materials and fuel along roadway	Low	Right to health	Afobaka road users including school children accessing school buses	Negative	Potential	Low	Possible	Low	Cause

ESIA = environmental and social impact assessment; ASM = artisanal and small scale mining; the Project = the Sabajo Project; HR = human rights.