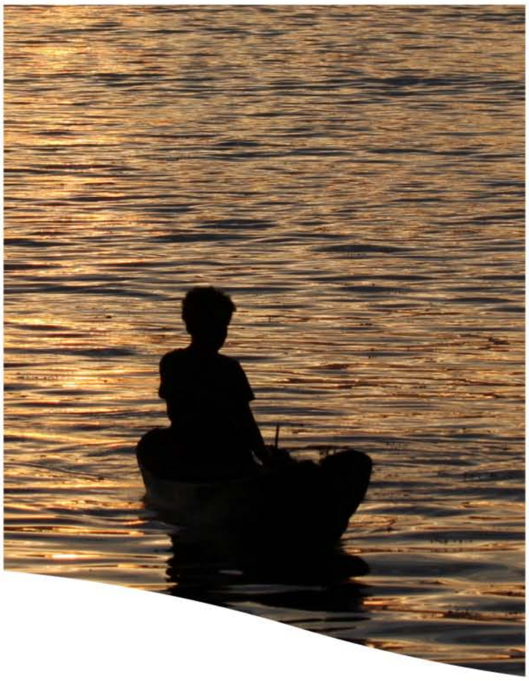
Chapter 4

Environmental Values and Management of Impacts


SMM SOLOMON LIMITED

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4. Environmental Values and Management of Impacts

4.1 Introduction

SMM Solomon Limited (SMM Solomon) is required to identify, assess and mitigate any adverse environmental and social risks associated with the construction, operation and decommissioning of the Solomon Islands Nickel Project on Santa Isabel Island. The identification and management of potential impacts has been undertaken through a risk assessment. Risk assessment is a process that evaluates the probability (likelihood) and consequences (extent, duration and intensity) of positive and negative environmental and social effects occurring as a result of exposure to one or more hazards.

The methodology employed in assessing the significance of the possible impacts associated with the Project is described in Chapter 1. There is no universally applicable methodology for assessing impacts within an Environmental Impact Assessment (EIA) process. However, the assessment has been conducted in accordance with recognised international standards and industry guidelines. A risk matrix approach has been tailored for application to this Project on the basis of systems, processes and methodologies developed by Hatch (Australia). The risk assessment methodology complements the sustainability framework (outlined in Chapter 1) to which SMM Solomon is committed. To ensure consistency in the assessment of impacts, all Impact Assessment Reports used the impact assessment methodology described in Chapter 1.

4.1.1 Objectives

This introduction to Chapter 4:

- identifies the relevant legislative framework associated with the impact assessment including standards and guidelines
- describes the risk-based approach that has been implemented to identify and manage the impacts associated with the Project including mitigation measures
- discusses the process used for determining potential adverse cumulative impacts associated with the Project
- provides an overview of the format of the chapter.

The following terminology has been used throughout Chapter 4:

- Project – Activities occurring on Santa Isabel Island as part of the Solomon Islands Nickel Project.
- Tenement - SMM Solomon Prospecting License (either Isabel Tenement D or Isabel Tenement E).
- Project area - Proposed Mining Lease Area incorporating the existing Isabel Tenement D and Isabel Tenement E areas.
- Survey area - The area surveyed by specialist field teams during baseline surveys, including the Project area and other areas that may be indirectly impacted by the Project (e.g. downstream areas and marine areas adjacent to the Project area).

4.1.2 Project Description

The Isabel Tenement D and Isabel Tenement E are located in the southwestern portion of Santa Isabel Island and are collectively referred to as the Project area for the purposes of this EIS. The Project area is identified in Figure 4-1.

The Project proposes to mine nickel laterite occurring in the ground as two distinct types, namely higher quality saprolite ore and lower quality limonite ore, which has formed above the saprolite ore zone.

Key Project facilities and infrastructure to support the mining operation will include the Mine Industrial Area (MIA), Port-I1, Port-I2, accommodation camp, Water Storage Facility (WSF), borrow pit (if required) and road (haul, mine access, facilities, services) infrastructure.

The construction phase of the Project will require both early works and pre-production development activities. Construction activities are anticipated to commence approximately 24 months prior to the commencement of operations. The operations phase is planned based on a proposed mine life of 23 years. Following mine closure it is anticipated that a small team will remain on site for several years to monitor the rehabilitation works.

A full Project description has been provided in Chapter 3.

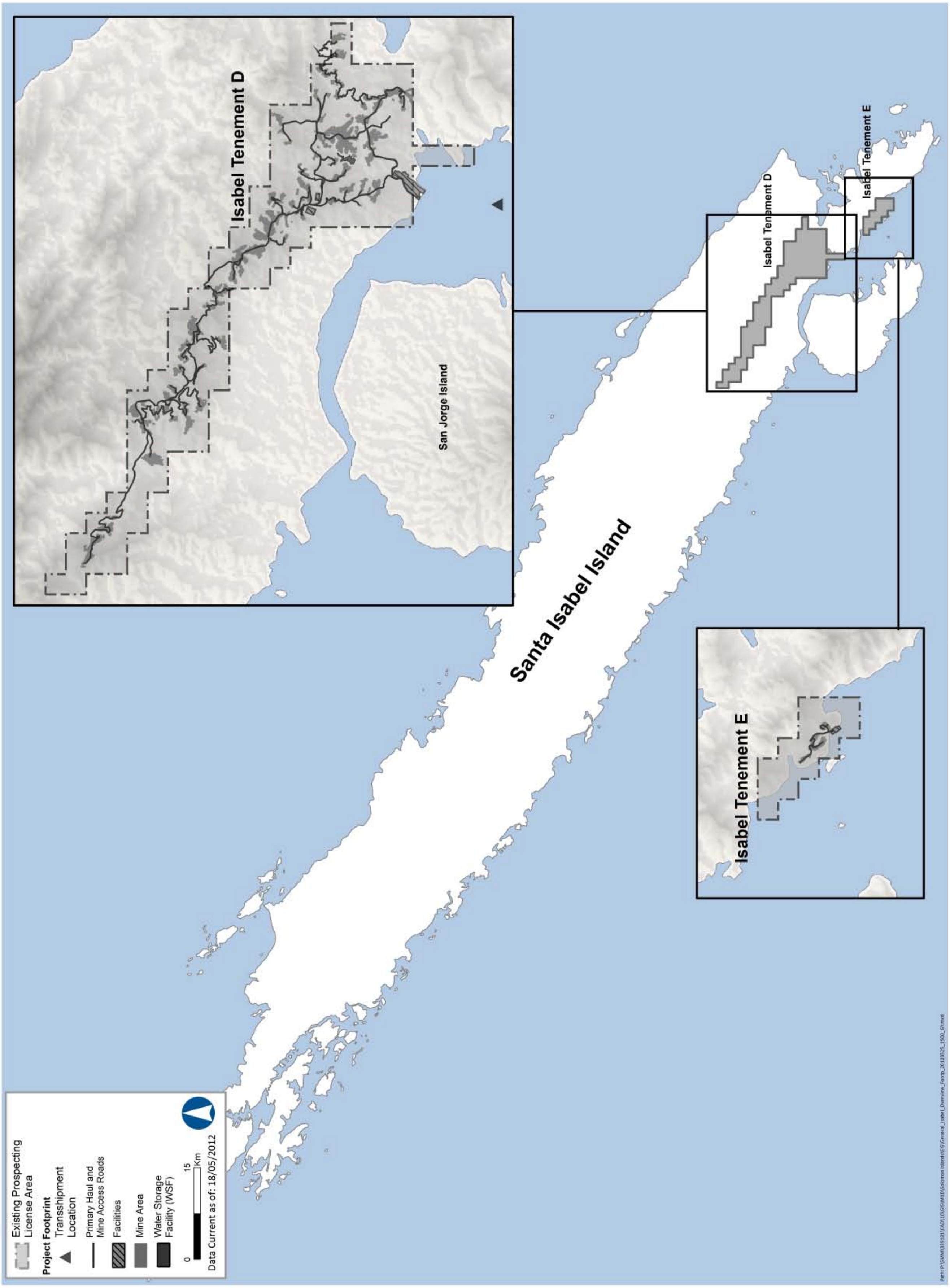

Figure 4-1 Location of Project Area on Santa Isabel Island

4.1.3 Legislative Overview

The following is an overview of current legislation that have been applied to the Project. In the absence of comprehensive national regulations, good international industry practices have been selected.

4.1.3.1 The Constitution of 1978

The Constitution is the supreme law in the Solomon Islands. It lays down the framework defining fundamental political principles, establishes the structure, procedures, powers and duties of the government and spells out the fundamental rights, directive principles and duties of citizens. It declares that the natural resources of Solomon Islands are vested in the people and in the State and recognises customary land ownership and right for compensation. It provides for the protection from deprivation of property but also allows for specific situations where property may be acquired against compensation.

4.1.3.2 Mines and Minerals Act 1996 and Mines and Minerals Regulations 1998, 2008, 2011

The Mines and Minerals Act 1996 (MMA) provides that the State has the exclusive right to deal with and develop mineral resources. It refers to the legal, regulatory and contractual elements governing the processes of mining which include reconnaissance, prospecting, mining and closure. This Act discusses the underlying tenure considerations, some taxation requirements and environmental factors. It outlines that an environmental assessment must include details of the anticipated infrastructure and description of the area or areas as necessary.

Mining operations under this Act are conditional on the applicant demonstrating it will provide adequate environmental protection within the mining permit area. MMA (Part VI, Regulation 18) requires the title holder to carry out operations with due diligence, efficiency and economy and in accordance with good technical engineering practice, in order to avoid waste of minerals and to prevent ecological damage, and any action that could endanger the health and safety of people and harm to water, marine and animal life.

Other environment related requirements for obtaining a mining permit include the submission of an EIS approved by the Director of the Environment and Conservation Division, a program for tailings and waste disposal, a rehabilitation plan and the monitoring and management of impacts of mining on air, land and water.

The MMA imposes a compliance obligation on the operator, the provision of a discretionary "compliance bond" to prevent inadequate rehabilitation, and enables the Director of Mines to suspend the mineral rights or retain the bond if the operator fails its obligations or reporting requirements.

Special Sites rights related to water rights and earth disposals are governed by the MMA, which also provides for the rehabilitation of the land disturbed.

The MMA includes provisions related to the payment of royalties to the landowners and the central and provincial governments, which are prorated on a case-by-case basis. In addition, *the Mines and Minerals Regulations 1996* contain extensive land-related provisions and address the relationship between the Mining Lease holder and landowners as well as fees and compensation.

4.1.3.3 Environment Act 1998 and Environment Regulations 2008

The *Environment Act 1998* is the Solomon Islands' governing piece of environmental legislation. Mining operations under the Act are conditional on the issue of a Development Consent from the Director of the Environment and Conservation Division, after public consultation.

The Act itself provides for an integrated system of development control, environmental assessment and pollution control including compliance with regional and international conventions and obligations regarding the environment.

The *Environment Regulations 2008* establish the procedures for undertaking the independent environmental assessment of any projects categorised as "Prescribed Activities", which includes mining. The Director of the Environment and Conservation Division requires an EIS if further assessment is necessary based on the Development Application submitted by the operator.

For major projects like mines, the EIS requires technical, economic, environmental and social investigation and public consultation and the Minister will grant a Development Consent if:

- The EIS recommendation supports the proposed development.
- The Project will be carried out in compliance with environmental policies and regulations.
- All reasonable steps will be taken to minimise any risk to the environment.

Developments must comply with all environmental obligations under any international treaty convention or instrument to which the Solomon Islands is a party, including UN Agenda 21 Action Plan for Sustainable Development.

Following approval by the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM), the competent Minister will issue a Declaration of Consent, which is a condition for granting the Mining Lease and is included in the Mining Lease application package.

The Environment Act (articles 35 to 49) also empowers its Director to issue an abatement notice or a stop notice to prevent a breach of an approved policy or a prescribed standard. However, policies or standards in some areas like waste management are not yet included nor defined in the Act or Regulations.

Environmental standards are not provided in the Regulations, and the MECDM request World Health Organization (WHO) standards for the EIS. Although the Regulations provide for licenses to discharge waste or emissions, their enforcement would appear to be difficult without defined standards.

4.1.3.4 The Provincial Government Act 1997

The *Provincial Government Act 1997* gives substantial power to the provinces to pass their own legislation, including matters pertaining to the environment and conservation. Their areas of jurisdiction extend three nautical miles (Nm) from the water line and the assemblies can pass regulations that will affect the Project regarding:

- Transport, coastal and lagoon shipping, construction, maintenance and improvement of harbours, roads and bridges.
- Cultural and environment – protection of wildlife, historical remains, local crafts.
- Agriculture and fishing – protection, improvement and maintenance of freshwater and reef fisheries.
- Land and land use – codification and amendment of existing customary laws about land. Registration of customary rights in respect of land including customary fishing rights.
- Business licenses – while the central government abandoned the foreign investment authorisation process, provinces are permitted to issue authorisation to trade and conduct business, giving the province effective control over foreign investment and activity in their jurisdiction.
- Physical planning except within a local planning area (developed under the *Town and Country Planning Act 1982*).
- Local matters like fire services, waste disposal, parks building standards, use of water, pollution, water supply.

The *Provincial Government Act 1997* also delegates legislative authority to complement national legislation governing road and traffic, compulsory land acquisition, forestry activities, rivers and water regulations. Those powers are exercised by the provincial governments under separate Provincial Ordinances. Provincial Ordinances relevant to the Project activities are described briefly below.

4.1.3.5 Santa Isabel Preservation of Culture Ordinance 1994

The Preservation of Culture Ordinance 1994 requires the survey of cultural heritage sites under the authority of the Provincial Executive before any mining activity. It grants customary owner groups the power to pass their own policies and plans for the development of resources within their customary lands.

4.1.3.6 Isabel Province Conservation Area Ordinance 1993

The Conservation Area Ordinance 1993 reinforces customary landowners rights over their land by enabling the Provincial Executive to declare a Conservation Area, where mining earthworks, cultivation and logging are prohibited.

4.1.3.7 Isabel Province Resource Management Environmental Protection Ordinance 2006

The Resource Management and Environmental Protection Ordinance 2006 consolidates previous provincial regulations and covers management of natural resources, protection of biodiversity and resources management.

This Ordinance addresses issues around the protection of flora and fauna, depletion and pollution, prevents anchorage within 500 yards from a reef, and restricts logging and harvesting.

It also reinforces the right for customary groups to make their policies regarding the use of resources within their land and to seek Isabel Provincial government protection of wildlife, natural resources or of "areas with spiritual or custom purposes" by the issue of Provincial Resource Management Orders, which regulate mining and earthworks activities.

The Ordinance also provides for the declaration of protected wildlife sanctuaries restricting general access.

4.1.3.8 Land and Titles Act 1978

The *Land and Titles Act 1978* defines "customary land" and regulates the purchase or lease of customary land, and its compulsory acquisition by the State. It covers the organisation and administration of land registries and land ownership. The Act also implements a Registrar of Titles and the mechanism for the resolution of disputes between customary owners.

4.1.3.9 Customary Land Records Act 1994

The *Customary Land Records Act 1994* sets the registration process and dispute resolution mechanism of customary boundaries. This Act empowers land holding groups to appoint representatives to deal with land holdings issues. It provides for the appointment of a magistrate by the judiciary to record customary land holdings, for the establishment of an office of national recorder of customary land and recording offices in the provinces and for other connected matters. The Recorder also facilitates boundaries dispute resolutions and refers unresolved disputes to the traditional chiefs. The Act also empowers the Recorder to register High Court or Court of Appeal decisions regarding land boundaries.

4.1.3.10 Wildlife Protection and Management Act 1998

The *Wildlife Protection and Management Act 1998* provides for the protection, conservation and management of wildlife in the Solomon Islands by regulating the export and import of certain flora and fauna and the management of flora and fauna to ensure sustainable uses of these resources.

4.1.3.11 Explosive Acts 1968

The *Explosive Act 1968* specifies the requirements for importing, storing, transporting and using explosives. It sets out the licensing requirements associated with explosives, including safety measures.

4.1.3.12 Ports Act 1956 (1998 revision)

The *Ports Act 1998* requires the ports to be established by the Project to be registered, operated and maintained in accordance with the Act. The Solomon Islands Ports Authority must be consulted regarding the establishment of any new port.

4.1.3.13 Shipping Act 1998

The *Shipping Act 1998* implements safety regulations under international marine conventions ratified by the Solomon Islands, such as the International Convention for the Prevention of Pollution from Ships 1973 (MARPOL). It also covers the transport of hazardous and dangerous goods and creates a 'registrar of vessels'.

4.1.3.14 Maritime Safety Administration Act 2009

The *Marine Safety Administration Act 2009* describes the establishment, functions and powers of the Solomon Islands Maritime Safety Administration, whose functions include maritime pollution prevention and response and related matters.

4.1.3.15 Environmental Health Act 1980 and Regulations (consolidated in 2006)

The *Environmental Health Act 1980* provides for the management and control of public health in the Solomon Islands. It prescribes various measures to prevent and contain disease and to maintain public health by empowering local authorities to manage sewers, drainage, and sanitation of vessels and buildings.

4.1.3.16 Quarantine Act 1978

The *Quarantine Act 1978* provides for the inspection, exclusion, detention, observation, segregation, isolation, protection, treatment, sanitary regulation and disinfection of vessels, persons, goods and things, and the prevention of the introduction or spread of diseases or pests affecting man. The operation of Project airports and ports receiving international passengers and goods will have to comply with the requirements of this Act.

4.1.3.17 Agriculture Quarantine Act 1996

The Agriculture Quarantine Act 1996 provides for the prevention of diseases introduced into the Solomon islands through the importation or landing of fauna or flora, and the prevention or restriction on introduction of pests and undesirables. Vessels and aircrafts are required to notify their arrival in advance to enable preventive controls.

4.1.3.18 National Park Act 1978

The *National Park Act 1978* grants discretionary power to the MECDM to declare national parks. The Minister may purchase or acquire any land for the purpose of a national park. The administration of the Act is the responsibility of the Minister and Park Rangers.

4.1.3.19 Protected Areas Act (Draft) 2010

The draft *Protected Areas Act 2010* provides for the declaration and management of protected areas or areas where special measures need to be taken to conserve biological diversity, and the regulation of biological diversity and prospecting research. It lists the protected areas in the Solomon Islands.

4.1.3.20 Labour Act 1981

The *Labour Act 1981* deals with employment of workers and establishes the requirements for employers to provide workers with acceptable working conditions, health and accommodation, rations, etc. It addresses issues such as protection from malaria, provision of water, sanitation, housing and medical care. It also imposes an injury reporting requirement.

4.1.3.21 Employment Act 1981

The *Employment Act 1981* provides for redundancy payments and pension benefits for long service, requires employers to provide written particulars of terms of employment and to prevent and ensure against liability for injury or disease suffered by their employees.

4.1.3.22 Safety at Work Act 1996 and Safety at Work (Pesticide Regulations) 1983

The *Safety at Work Act 1996* imposes minimum safety standards without describing them and the employer's general duty of care towards employees and any persons who are not employed but are exposed to the operations. The *Safety at Work (Pesticide Regulations) 1983* is an extension of this Act and deals with the registration and use of pesticides and protection against possible contamination.

4.1.3.23 Workmen Compensation Act 1952

The *Workmen Compensation Act 1952* covers injuries, reporting procedures, compensation triggers and mechanisms in case of workplace injury or occupational disease.

4.1.3.24 Immigration Act 1987

The *Immigration Act 1987* states that visitors' permits are issued for a maximum of three months within twelve consecutive months. These are extendable for another three months by exception. This Act also describes business visitor visas which can convert into work permits, valid for a maximum two years renewable.

4.1.3.25 Customs and Excise Act 1960

The *Customs and Excise Act 1960* provides for the imposition, collection and management of customs and excise duties, the licensing and control of warehouses and of premises for the manufacture of certain goods and the regulation, control and prohibition of imports and exports.

4.1.3.26 Civil Aviation Act 1986

The *Civil Aviation Act 1986* specifies that aircraft and aerodromes are subject to certification, registration and permit requirements, and the Ministry of Communication and Aviation must be consulted regarding the establishment of new air services and aerodromes/airstrips.

4.1.3.27 Petroleum Act 1987

The Petroleum Act 1987 includes regulations governing the carriage and storage of petroleum.

4.1.3.28 Pharmacy and Poisons Act 1988

The Pharmacy and Poisons Act 1988 regulates the storage, purchase, transport of some chemicals required for the construction and operation of the Project (e.g. acids).

4.1.3.29 Electricity Act 1988

The Electricity Act 1988 regulates electricity supply and monitors safety. It also describes the licensing process and conditions enabling an entity to supply power to third parties.

4.1.3.30 Fisheries Act 1998 and subsequent Fisheries [Amendment] Act 2009

These Acts provide for the long-term conservation and sustainable utilisation of the fishery resources of the Solomon Islands for the benefit of the people of the Solomon Islands.

4.1.3.31 River Waters Act 1964

The *River Waters Act 1964* provides for the protection of designated rivers. The Act contains provisions for the regulation of various activities and rights in respect of rivers. 'River' includes any watercourse whether natural or artificial, and any dam, lake, pond, swamp, marsh or other body of water forming part of that watercourse. None of the rivers listed in this Act are found on Santa Isabel Island.

4.1.3.32 Water Resources Act (Draft) 2008

The draft *Water Resources Act 2008* provides for the management of all water resources in the Solomon Islands and integrates the impacts of climate change in drafting water resources policies.

4.1.3.33 Water Authority Act 1993

The *Solomon Islands Water Authority Act 1993* focuses on urban water and its supply, ensuring that it is properly managed, distributed, and used in ways which are consistent with good water management practices. The Act provides for the establishment of the Solomon Islands Water Authority (SIWA). The provision outlines prohibited activities in catchment areas, provisions to control or regulate polluting activities and describes permitting requirements to abstract water within the catchment areas in the schedule.

4.1.3.34 Forest Act 1999

The objective of this Act is to improve the management of forest resources, to develop a sustainable timber industry and to protect forest resources and ecosystems. Although this Act was passed in parliament on 2 June 1999, there is no gazetted record available.

4.1.3.35 Forest Resources and Timber Utilisation Act 1970

The *Forest Resources and Timber Utilisation Act 1970* aims to regulate the timber industry in the Solomon Islands. It describes a licensing mechanism empowering the government to regulate and control the industry and issue timber licenses authorising the felling and removal of trees for milling or exports, through a process which involves the consent from the Provincial Government Executive and customary owners. Other regulations relevant or complementary are the *Timber (levy and milling) Regulations*, the *Forest Resources and Timber Utilisation Regulations*, which deal with appeal to logging licenses in front to the customary courts, protected species and standard logging agreement template.

4.1.3.36 The Proposed Forestry Bill 2004

The proposed *Forestry Bill 2004* addresses the conservation of forests and forest management. If implemented, it will supersede the *Forest Resources and Timber Utilisation Act 1970* and will govern the license process authorising the clearing of trees, along a process similar to Site Access Right's for mining and the issue of licenses on State forests.

4.1.3.37 Protection of Wrecks and War Relics Act 1973

The Protection of Wrecks and War Relics Act 1973 contains provisions for the protection of World War II war relic sites, including licensing requirements for interference with wrecks and war relics.

4.1.3.38 Local Government Act 1971

The *Local Government Act 1971* regulates local councils and empowers them to regulate on health, welfare, to maintain order and appoint local enforcement agents.

4.1.3.39 Town and Country Planning Act 1982

The *Town and Country Planning Act 1982* does not apply to customary land but generally affects urban areas of the Solomon Islands. The Act provides for land in the Solomon Islands to be developed and used in accordance with properly considered policies based on adequate information.

The Act is relevant to any planning development used for building and mining under a local development scheme. It aims to protect the health, amenity, convenience and general welfare of communities. It enables local, provincial and national governments to implement planning and land development schemes, including site and access of proposed roads, airfields and to regulate land development.

4.1.3.40 *Foreign Investment Act 2005*

The *Foreign Investment Act 2005* cancels prior authorisation requirements to open a business but maintains constraints and controls. The foreign investment office sees itself as a facilitator. Government approval is required for the importation of capital; repatriation of capital; transfer of profits, dividends, interest and royalties; borrowing of overseas funds; settlement of intercompany accounts; transfers overseas of the proceeds from sales of Solomon Islands' assets; and direct investment overseas.

4.1.3.41 *Income Tax Act 1965*

The *Income Tax 1965 (1996 revision)* covers corporate tax, personal income tax, withholding tax, profit tax and dividend tax for residents, non-residents and foreign companies. This Act also provides information regarding depreciation, tax credit mechanisms and foreign investment.

4.1.3.42 *Goods Tax Act 1992*

The *Goods Tax Act 1992* regulates taxes on domestic and foreign products.

4.1.3.43 *Sales Tax Act 1996*

The *Sales Tax Act 1996* regulates tax on services and goods purchased in the Solomon Islands.

4.1.3.44 *Stamp Duties Act 1996*

The *Stamp Duties Act 1996* indicates the variable nominal fees to be levied on registered agreements and titles.

4.1.4 *Other Potentially Applicable National Plans or Policies*

This section is a summary of the other national plans or policies of the Solomon Islands that may be applicable to the Project.

4.1.4.1 *Solomon Islands' National Health Strategic Plan (2011-2015)*

The Solomon Islands' National Health Strategic Plan (2011-2015) (NHSP) aims to improve the health status of the Solomon Islands by focusing on primary health, health promotion and public health strategies. The programme's approach centres on community empowerment and development through partnerships with relevant sectors such as education and transportation.

4.1.4.2 *The National Watsan Policy*

The National Watsan Policy supports the National Water Supply and Sanitation Unit of the Environmental Health Division of the Ministry of Health and Medical Services. The Policy aims to assist rural communities in obtaining basic safe water supply and sanitation facilities. The community has the main responsibility of the facilities and the policy aims to choose communities which are equipped to maintain the facilities.

4.1.4.3 *Proposed Tax Policy Applicable to the Mining Industry*

The Economic Reform Unit is currently reviewing the fiscal system applicable to the mining sector. The proposal is partly inspired by the Goldridge fiscal regime, and is currently opened for comments before finalisation and presentation to parliament for ratification. Its propositions have been taken into consideration in the Impact Assessment Report – Economics undertaken for this EIS.

4.1.5 *Project Standards and Guidelines*

This section is a summary of the overall standards and guidelines applicable to the Project.

The EIS will be generally consistent with the Equator Principles, International Finance Corporation (IFC) Performance Standards on Social and Environmental Sustainability, IFC Environmental, Health and Safety Guidelines (EHS), International Council on Mining and Metals (ICMM) Sustainable Development Principles, World Bank Operational Policies and Safeguard Policies, and Japan Bank for International Cooperation (JBIC) requirements.

In addition, the EIS is required to conform to the requirements of all Solomon Island guidelines, including the Solomon Islands Environmental Impact Assessment Guidelines (2010), and the EIS reporting requirements outlined within *The Environment Act of 1998* and *The Environment Regulation 2008*.

The key overall standards, guidelines, principles and initiatives referred to throughout this chapter are discussed in the following sections.

4.1.5.1 Business and Biodiversity Offsets Program (BBOP)

BBOP is a collaboration of approximately 50 companies, financial institutions, governments, and civil society organisations, including the IFC and the International Union for Conservation of Nature (IUCN). The key aim of BBOP is to provide leadership in the establishment of biodiversity offsets as a widely recognized and applied tool. BBOP has published a set of 10 principles in order to provide a framework for designing and implementing biodiversity offsets and verifying their success.

1. No net loss: A biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.
2. Additional conservation outcomes: A biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. Offset design and implementation should avoid displacing activities harmful to biodiversity in other locations.
3. Adherence to the mitigation hierarchy: A biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimisation and on-site rehabilitation measures have been taken according to the mitigation hierarchy.
4. Limits to what can be offset: There are situations where residual impacts cannot be fully compensated for by a biodiversity offset because of the irreplaceability or vulnerability of the biodiversity affected.
5. Landscape context: A biodiversity offset should be designed and implemented in a landscape context to achieve the expected measurable conservation outcomes taking into account available information on the full range of biological, social and cultural values of biodiversity and supporting an ecosystem approach.
6. Stakeholder participation: In areas affected by the project and by the biodiversity offset, the effective participation of stakeholders should be ensured in decision-making about biodiversity offsets, including their evaluation, selection, design, implementation and monitoring.
7. Equity: A biodiversity offset should be designed and implemented in an equitable manner, which means the sharing among stakeholders of the rights and responsibilities, risks and rewards associated with a project and offset in a fair and balanced way, respecting legal and customary arrangements. Special consideration should be given to respecting both internationally and nationally recognised rights of indigenous peoples and local communities.
8. Long-term outcomes: The design and implementation of a biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at least as long as the project's impacts and preferably in perpetuity.
9. Transparency: The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner.

10. Science and traditional knowledge: The design and implementation of a biodiversity offset should be a documented process informed by sound science, including an appropriate consideration of traditional knowledge.

4.1.5.2 *Convention on Biological Diversity (CBD)*

The main goal of the CBD is to conserve and sustainably manage the biodiversity of the country. It also identifies some of the key threats and barriers to conserving biodiversity and focuses on actions to mitigate potential risks.

4.1.5.3 *The Equator Principles*

The Equator Principles (2006) are a voluntary set of standards developed by a number of private sector banks for the assessment and management of social and environmental risk in project financing. The Equator Principles Financial Institutions (EPFIs) commit to ensure socially responsible and sustainable environmental management practices from the lender and all other parties involved in the project financing activities.

The internationally accepted approach stipulates the environmental policies, procedures and standards as stated in ten principles. They are based on IFC Performance standards and the World Bank Group EHS Guidelines. The ten principles are:

1. Review and Categorisation.
2. Social and Environmental Assessment.
3. Applicable Social and Environmental Standards.
4. Action Plan and Management System.
5. Consultation and Disclosure.
6. Grievance Mechanism.
7. Independent Review.
8. Covenants.
9. Independent Monitoring and Reporting.
10. EPFI Reporting.

The most applicable principle to this chapter is Principle 4 – Proponent Action Plan. This principle describes the actions required to implement mitigation measures, corrective actions and monitoring measures necessary to manage the impacts identified in the assessment.

4.1.5.4 *Global Reporting Initiative (GRI) Sustainability Reporting Guidelines (version 3.1)*

GRI is a sustainability reporting framework that promotes ecologically sustainable development. It sets out the principles and indicators that organisations can use to measure and report their economic, environmental, and social performance.

The core GRI performance indicators for G3.1 summarised by category are:

- Economic
  - economic performance
  - market presence
  - indirect economic impacts.
- Environmental
  - materials

- energy
- water
- biodiversity
- emissions, effluents, and waste
- products and services – environmental impacts
- compliance costs
- transport
- overall environmental protection expenditures and investments.

- Labour Practices and Decent Work
  - employment
  - labour/management relations
  - occupational health and safety
  - training and education
  - diversity and equal opportunity
  - equal remuneration for women and men.
- Human Rights
  - investment and procurement practices
  - non-discrimination
  - freedom of association and collective bargaining
  - child labour
  - forced and compulsory labour
  - security practices
  - indigenous rights
  - assessment of operations
  - grievances and remediation.
- Society
  - local community
  - corruption
  - public policy
  - compliance costs.

GRI also offers guidance on data compilation of performance indicators that includes reporting on trends, the use of relevant protocols, and the presentation and level of aggregation of information.

4.1.5.5 *GRI Sustainability Reporting Guidelines - Mining and Metals Sector Supplement*

The GRI mining and metals sector supplement (2011) is a tailored version of the sustainability reporting guidelines currently based on version 3 (G3). The supplement has additional commentaries and performance indicators relevant for the sector. The sector specific issues include:

- biodiversity management and ecosystem services
- community consultation
- indigenous people's rights in exploration phase
- number and handling of disputes related to land
- resettlement of local communities
- closure plans of mines
- programs and progress relating to materials stewardship.

4.1.5.6 *International Council on Mining and Metals Sustainable Development Framework*

ICMM sustainable development framework (2008) is a benchmark system for corporate members to measure their sustainable development performance against a set of ten Principles.

SMM Solomon as a signatory of ICMM has committed to ten Principles of the Sustainable Development Framework:

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

4.1.5.7 *International Finance Corporation Performance Standards on Social and Environmental Sustainability*

The IFC Performance Standards (2012) refer to a system for addressing the management of social and environmental risks and impacts. IFC is committed to environmental and social sustainability through eight performance standards. The standards serve as guidelines for impact mitigation and risk management of investment projects to ensure sustainable development.

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts.
- Performance Standard 2: Labour and Working Conditions.
- Performance Standard 3: Resource Efficiency and Pollution Prevention.

- Performance Standard 4: Community Health, Safety and Security.
- Performance Standard 5: Land Acquisition and Involuntary Resettlement.
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.
- Performance Standard 7: Indigenous Peoples.
- Performance Standard 8: Cultural Heritage.

Performance Standard 1 establishes the importance of: (i) integrated assessment to identify the social and environmental impacts, risks, and opportunities of projects; (ii) effective community engagement through disclosure of project-related information and consultation with local communities on matters that directly affect them; and (iii) the proponent's management of social and environmental performance throughout the life of the project.

Performance Standards 2 through 8 establish requirements to avoid, reduce, mitigate or compensate for impacts on people and the environment, and to improve conditions where appropriate.

4.1.5.8 IFC Environmental, Health and Safety Guidelines

The IFC Environmental, Health and Safety Guidelines (2007) are technical reference documents with general and industry-specific examples of "Good International Industry Practice" and contain the expected performance levels and measures normally acceptable to the IFC. Both General and Industry Sector guidelines are applicable to the Project:

The IFC General EHS Guidelines address environmental, health and safety issues under the following organisational structure:

1. Environmental

- Section 1.1 – Air Emissions and Ambient Air Quality
- Section 1.2 – Energy Conservation
- Section 1.3 – Wastewater and Ambient Water Quality
- Section 1.4 – Water Conservation
- Section 1.5 – Hazardous Materials Management
- Section 1.6 – Waste Management
- Section 1.7 – Noise
- Section 1.8 – Contaminated Land

2. Occupational Health and Safety

- Section 2.1 – General Facility Design and Operation
- Section 2.2 – Communication and Training
- Section 2.3 – Physical Hazards
- Section 2.4 – Chemical Hazards
- Section 2.5 – Biological Hazards
- Section 2.6 – Radiological Hazards
- Section 2.7 – Personal Protective Equipment
- Section 2.8 – Special Hazard Environments

- Section 2.9 – Monitoring

3. Community Health and Safety

- Section 3.1 – Water Quality and Availability
- Section 3.2 – Structural Safety of Project Infrastructure
- Section 3.3 – Life and Fire Safety
- Section 3.4 – Traffic Safety
- Section 3.5 – Transport of Hazardous Materials
- Section 3.6 – Disease Prevention
- Section 3.7 – Emergency Preparedness and Response

4. Construction and Decommissioning

- Section 4.1 – Environmental
- Section 4.2 – Occupational Health and Safety
- Section 4.3 – Community Health and Safety

Industry Sector EHS Guidelines referenced by the Impact Assessment Reports include:

- IFC EHS Guidelines for Mining (2007)
- IFC EHS Guidelines for Ports, Harbours and Terminals (2007)
- IFC EHS Guidelines for Waste Management Facilities (2007)
- IFC EHS Guidelines for Water and Sanitation (2007)
- International Organization for Standardisation (ISO).

ISO is the largest developer and publisher of international standards. ISO standards applicable to individual Impact Assessment Reports are listed in the relevant sub-sections of this chapter.

4.1.5.9 Japan Bank for International Cooperation (JBIC) Guidelines for Confirmation of Environmental and Social Considerations

The JBIC Environmental and Social Guidelines (2009) set out policies and procedures confirming that the borrowers or project proponents have taken appropriate steps for environmental and social considerations. This is to prevent or minimise the impacts on the environment and local communities that may be caused by the projects.

4.1.5.10 Environmental Impact Assessment for Developing Countries in Asia

Environmental Impact Assessment for Developing Countries in Asia by Lohani *et al*. (Volume 1 – Overview (1997)) is an Asian Development Bank (ADB) publication that supports ADB environmental and social safeguard policies as the basis for its support of inclusive and sustainable growth of the economy and environment. The Volume includes safeguard policies on the environment aimed at addressing environmental and social impacts and risks. It is also a key reference utilised in the Solomon Islands Environmental Impact Assessment Guidelines.

4.1.5.11 United Nations (UN), UN Global Compact

The UN Global Compact (2004) is a framework "for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labour, the environment and anti-corruption".

Initially launched in 2000, with nine principles, a tenth principle was added in 2004 as follows:

- **Human rights**
  - Principle 1: Businesses should support and respect the protection of internationally proclaimed human rights.
  - Principle 2: Make sure that they are not complicit in human rights abuses.
- **Labour**
  - Principle 3: Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining.
  - Principle 4: The elimination of all forms of forced and compulsory labour.
  - Principle 5: The effective abolition of child labour.
  - Principe 6: The elimination of discrimination in respect of employment and occupation.
- **Environment**
  - Principle 7: Businesses should support a precautionary approach to environmental challenges.
  - Principle 8: Undertake initiatives to promote greater environmental responsibility.
  - Principle 9: Encourage the development and diffusion of environmentally friendly technologies.
- **Anti-corruption**
  - Principle 10: Businesses should work against corruption in all its forms, including extortion and bribery.

Additional standards and guidelines used to inform the survey design, methodology and data analysis of each Impact Assessment category are summarised in the relevant sub-sections of this chapter or are found in more detail in the Impact Assessment Reports.

For cases where a legal or other environmental requirement has not been specified within the Solomon Islands for a particular parameter in an Impact Assessment Report, the following order has been applied in selecting appropriate limits.

1. An international standard or guideline developed by a reputable organisation, such as WHO, ISO or ASTM.
2. Australian, Japanese or New Zealand standards and guidelines where an international standard is not available.
3. The most stringent standards are utilised, wherever practical.
4. Good international industry practice, including the use of best available technology.

4.1.6 Impact Assessment Methodology

The objective of the assessment of impacts is to identify and assess the significance of impacts that may arise as a result of the proposed Project. The process of assessing the impacts of the Project encompassed the following four activities:

- identification of potential impacts
- prediction of the nature, magnitude, extent, duration and likelihood of potentially significant impacts occurring

- assessment of impacts to determine a consequence rating
- evaluation of the significance of the impact by combining consequence and probability.

These four steps are detailed in Chapter 1.

The potential impacts associated with each facility of the Project were identified by the technical specialists within the EIS Project Team. To ensure that risks associated with the construction and operation phases were comprehensively identified, the process of risk identification included:

- baseline field surveys to identify the existing environmental, community, social and cultural heritage values within the Project area
- desktop research
- facilitated workshops with technical specialists
- application of relevant industry and Solomon Islands legislation, standards and guidelines.

Where an activity was identified as posing a potential risk, an assessment was undertaken to determine what aspects of that activity could result in an impact to environmental, community, social and/or cultural heritage values. The significance of the impact was re-evaluated after consideration of the proposed mitigation measures.

Ongoing monitoring and review will be undertaken to ensure the risk assessments that have been conducted remain relevant. The risk assessment process, including identification of risks, impact prediction and identification and implementation of mitigation measures, will continue to be reviewed and refined throughout all phases of the Project as additional information becomes available.

Monitoring of the effectiveness of mitigation measures will also be undertaken throughout all phases of the Project. This monitoring will be undertaken through a combination of continuous monitoring (e.g. measuring parameters) and internal audits. Chapter 5, presents the preliminary Environmental Management Plan (EMP), which will guide the frequency and type of monitoring to be undertaken.

4.1.7 Cumulative Impact Assessment Methodology

The objective of the assessment of cumulative impacts is to identify and assess the significance of impacts that may arise as a result of the Project in combination with any similar impacts from past, existing or planned projects. The cumulative impact assessment methodology involved:

- desktop research to identify other developments planned for Santa Isabel Island and internet searches to access reports
- identification of potential key direct and indirect impacts associated with the Project, as presented in each of the Impact Assessment Reports, and the nature (positive or negative) of these impacts
- identification of appropriate spatial boundaries for analysis of cumulative impacts

  The spatial boundary for the analysis of cumulative impacts was that of the Project area. However, it was recognised that the pre-mitigation impacts of the current combined developments may be considered collectively to represent regional-scale impacts rather than representing clear localised impacts. This broad scale nature of the impacts reduces the risk of the impacts within the Project area itself
- identification of appropriate temporal boundaries for analysis of cumulative impacts, considering short term, medium term and long term impacts

- consideration of the relationship of the impacts of existing, approved or proposed projects to each other
- development of mitigation measures that could be implemented to reduce the severity or significance of the impacts of the Project.

The assessment of cumulative impacts was based on five categories of projects which have been identified within Santa Isabel Island including agriculture, forestry, tourism, mining and fishing.

Cumulative impacts on environmental, social, cultural and economic values have been assessed to the extent that the information regarding potential impacts for other projects and developments has been made available at the time of the study. The area of assessment has been limited to Isabel Tenements D and E for most impacts. However, some impacts were considered to be of regional significance, i.e., marine and aquatic ecology where flow-on effects may accumulate due to a number of developments. Cumulative social, socio-economic, workforce influx and health impacts were also considered from a regional perspective as they cannot be contained within the Project areas.

Cumulative impacts were assigned a risk rating based on the spatial and temporal scale of impacts and complexity of interactions. For many of the environmental values (e.g. land and geology, terrestrial ecology, marine ecology, air quality, noise and water quality), the impacts arising from the various projects are localised and mitigation strategies are required at the local level, following well established practices and complying with regulatory requirements. Therefore the cumulative level of risk would not be significantly compounded by the effects of other projects and a ‘low’ rating is appropriate.

A ‘medium’ rating would be appropriate for other values (e.g. surface water quality, soil, freshwater ecology, social and health) because the pre-mitigation impacts may collectively be considered to represent regional-scale impacts rather than representing clear localised impacts. Despite the broader scale of the impact, these impacts may be mitigated by well established procedures and/or regulated approaches.

A ‘high’ rating is considered appropriate for values (e.g. visual amenity, land use and tenure, social) for which one or more of the following factors is relevant:

- a relatively high degree of complexity relating to characteristics of the value
- a relatively high degree of complexity relating to cumulative impact mechanisms
- available mitigation approaches are not standardised and require the ongoing cooperation of multiple parties.

4.1.8 Chapter Overview

Sections 4.2 to 4.23 of this Report are summaries of the Impact Assessment Reports appended to this document. This section has the following structure:

- Section 4.2 – Weather and Climate
- Section 4.3 – Geology, Geohazards and Soils
- Section 4.4 – Surface Water Quality and Flows
- Section 4.5 – Groundwater
- Section 4.6 – Community Water Supply
- Section 4.7 – Freshwater Surface Water Ecology
- Section 4.8 – Marine Ecology

- Section 4.9 – Terrestrial Ecology
- Section 4.10 – Air Quality
- Section 4.11 – Noise
- Section 4.12 – Visual Amenity
- Section 4.13 – Waste Management
- Section 4.14 – Transport
- Section 4.15 – Society and Community
- Section 4.16 – Cultural Heritage
- Section 4.17 – Land Use and Tenure
- Section 4.18 – Socio-Economics
- Section 4.19 – Public Heath
- Section 4.20 – Workforce Influx
- Section 4.21 – Economics
- Section 4.22 – Cumulative Impact Assessment
- Section 4.23 – Conservation Strategy

Further details on the methodology, existing environmental and social values, and potential impacts presented in the sections identified above are presented in the individual Impact Assessment Reports.

Relevant information is summarised in each section of this chapter using the following format:

- Methodology – describes the methods used to undertake the risk assessment. This includes for example, background research, field surveys and community consultations.
- Existing Values – describes the existing environmental and social setting within the Project area. This includes for example, ecological, health and community resources.
- Potential Impacts – describes the potential impacts of the Project on the existing environmental and social setting during the life of the Project.
- Risk Assessment – summarises in tabular form, the significance of identified impacts, the associated confidence level after consideration of the consequence and likelihood of occurrence and the significance of the impact with mitigation measures in place.
- Mitigation Measures – identifies measures to mitigate or minimise negative impacts and to maximise the benefits of positive impacts.

4.2 Weather and Climate

This section describes:

- historical and current weather and climate conditions for both the Solomon Islands and for Santa Isabel Island and the Project tenements, Isabel Tenement D and E
- meteorological data from government weather stations and from weather stations installed by SMM Solomon on Santa Isabel Island
- climatic extremes in the Solomon Islands such as thunderstorms, tropical cyclones and low pressure systems, floods and droughts
- the magnitude and frequency of these climatic extremes.

Further details are provided in the Report – Weather and Climate. See also Report - Climate Change and GHG Emissions, for discussion of climatic extremes and predicted future climate change trends in the Solomon Islands.

4.2.1 Methodology

Weather and climatic conditions for Santa Isabel Island were evaluated using data from three government weather stations, located at Auki, Henderson Airport and Honiara, and three SMM Solomon-operated weather stations on Santa Isabel Island (IWS01, 1WS02 and 1WS03). The locations of these weather stations are shown in Figure 4-2 and Figure 4-3**.**

Weather data for Auki, Henderson Airport and Honiara was obtained from the Australian Bureau of Meteorology (BOM), the Solomon Meteo-statistic database and the MECDM.

Raw weather data from the SMM Solomon weather stations was checked against the evaluation procedures of the World Meteorological Organisation for any potential inconsistencies or errors.

Average and maximum monthly values were obtained for the following weather components:

- temperature
- relative humidity
- rainfall
- wind speed
- solar radiation.

Total monthly rainfall data was calculated by taking the sum of the daily rainfall readings for the month.

Wind was analysed using Windrose PRO3® .

Extreme climate conditions were identified through publicly available information from databases and reports on natural hazards. Records were obtained from:

- Australian Bureau of Meteorology (BOM).
- Centre for Research on the Epidemiology of Disasters (CRED), Solomon Islands.
- Climate Centre, Solomon Islands.
- Fiji Meteorological Service.
- Joint Typhoon Warning Centre.
- Meteorological Service Division (MECDM), Solomon Islands Government.
- National Climatic Data Centre.

- National Institute of Water and Atmospheric Research (NIWA), New Zealand.
- National Oceanic and Atmospheric Center, United States of America.
- National Weather Service.
- Office of the United States Foreign Disaster Assistance (OFDA).
- Pacific Climate Change Science Program (PCCSP) Data Portal.
- Solomon Islands National Disaster Council.
- World Meteorological Organisation (WMO).

The information acquired only included readily available, published or online reports from agencies or organisations. Natural disasters data was very limited and only documented events were included.

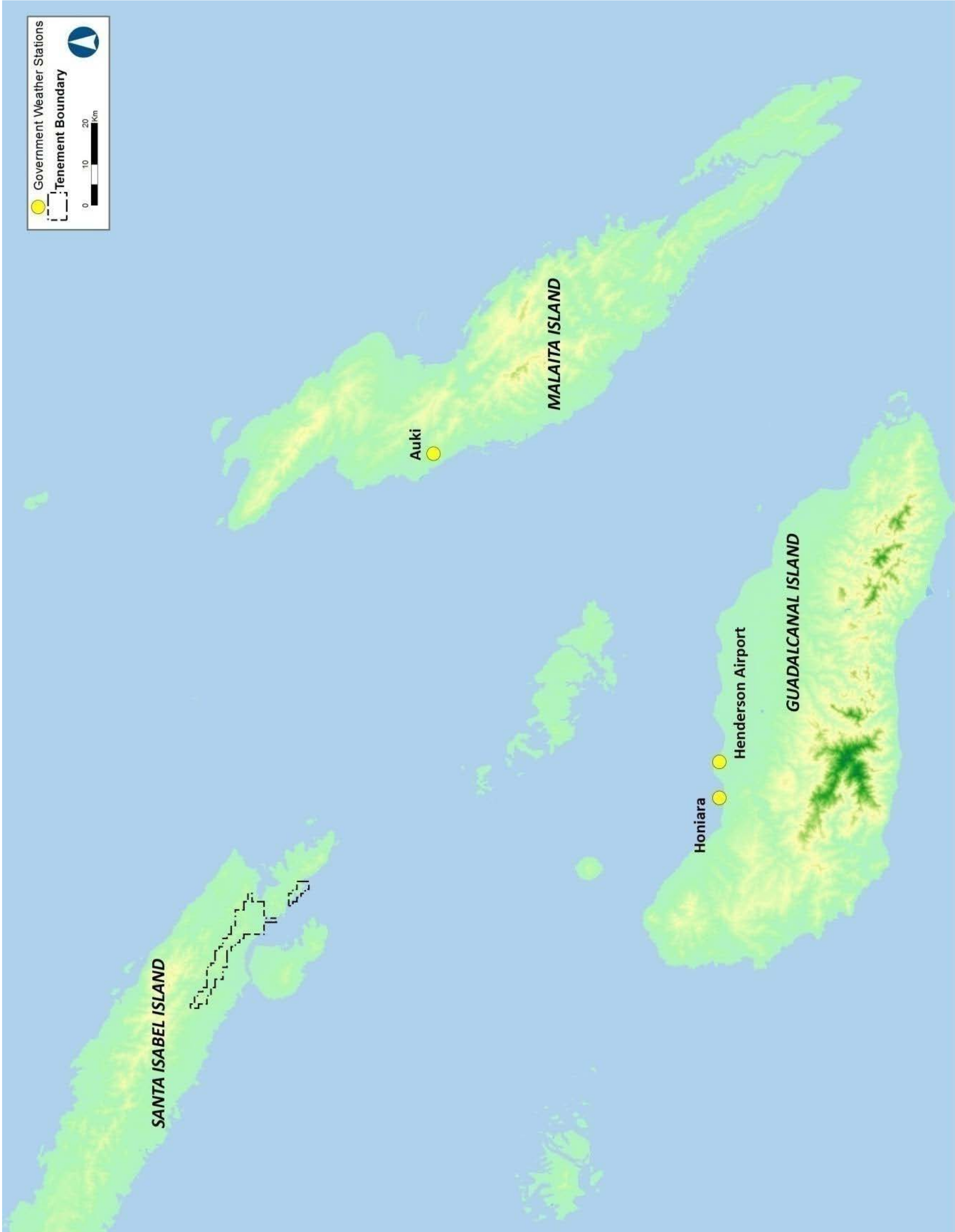

Figure 4-2 Government Weather Stations near Santa Isabel Island

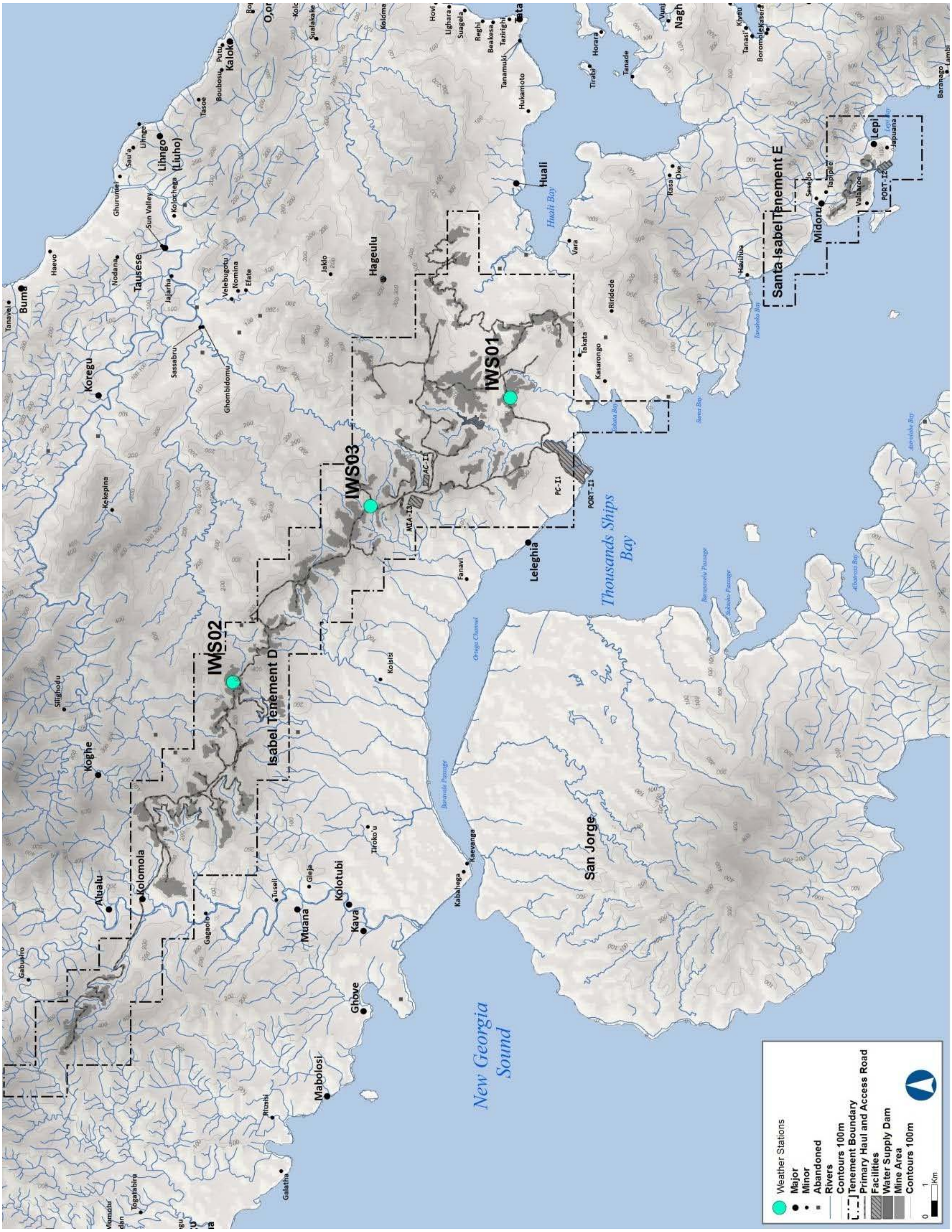

Figure 4-3 SMM Solomon Weather Stations on Santa Isabel Island

4.2.2 Existing Environment

The Solomon Islands is located within a tropical region, with high and fairly uniform temperature and humidity and abundant rainfall in most areas throughout the year.

4.2.2.1 Temperature

The average daily temperature in the Solomon Islands generally ranges from 23°C to 30°C. The average temperature values measured at the Auki, Henderson Airport and Honiara weather stations were relatively similar (see Figure 4-4). Temperature readings for Auki from 1981 to 2010 ranged from 22.7°C to 31.3°C, while temperatures for Honiara ranged from 21.6°C to 31.7°C. Monthly mean temperature trends show increasing temperatures at Henderson Airport and Honiara weather stations of 0.34°C per decade and 0.18°C per decade, respectively.

The IWS01 weather station recorded minimum temperatures between 20.4°C and 23.4°C and maximum temperatures between 31.5°C and 35.9°C. The monthly average temperature ranged between 25.5°C and 26.9°C. The monthly minimum, average and maximum temperatures are uniform throughout the year (Figure 4-5).

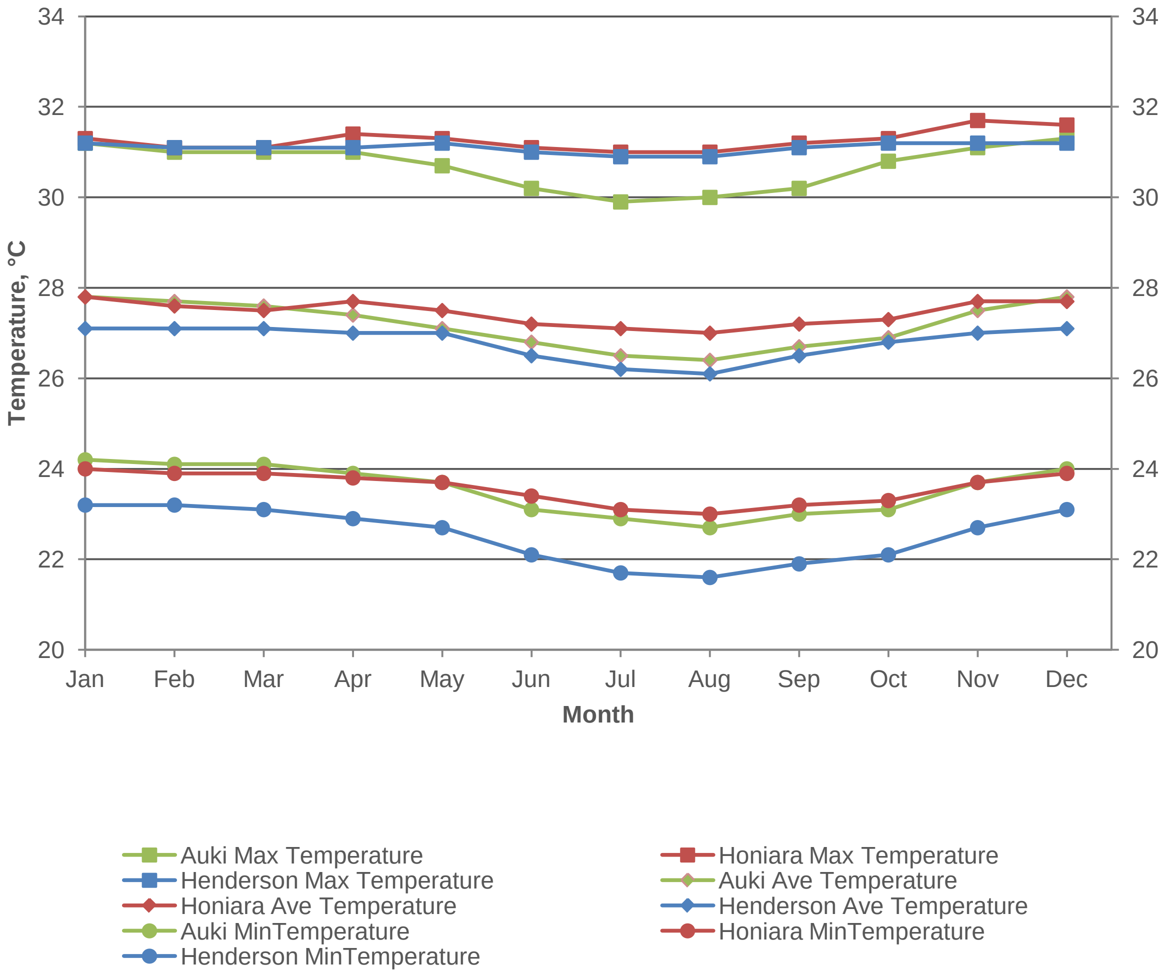

Figure 4-4 Monthly Minimum, Average, and Maximum Mean Annual Cycle of Temperature for Auki, Henderson Airport and Honiara Weather Stations (1981 to 2010)

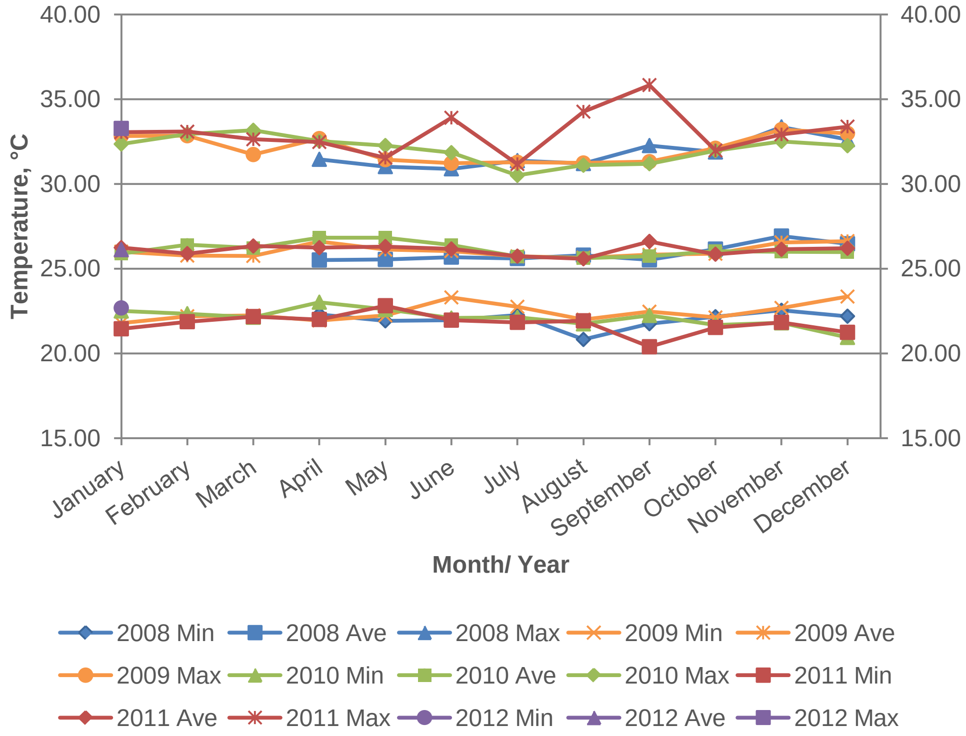

Figure 4-5 Monthly Minimum, Average and Maximum Temperature for IWS01 Weather Station (2008 to 2012)

4.2.2.2 *Humidity*

Relative humidity in the Solomon Islands has diurnal variation and low seasonal variation. The recorded range is between 64% and 99% for Henderson Airport Weather Station (See Figure 4-6).

Data from the IWS01 weather station showed a wider variation in relative humidity with a minimum of 39.5% to 64.0% and maximum of 94.6% to 96.8% (see Figure 4-7). These wider differences have been attributed to diurnal variations occurring from day-to-day. However, relative humidity data from the IWS01 weather station exhibited a uniform trend throughout the year.

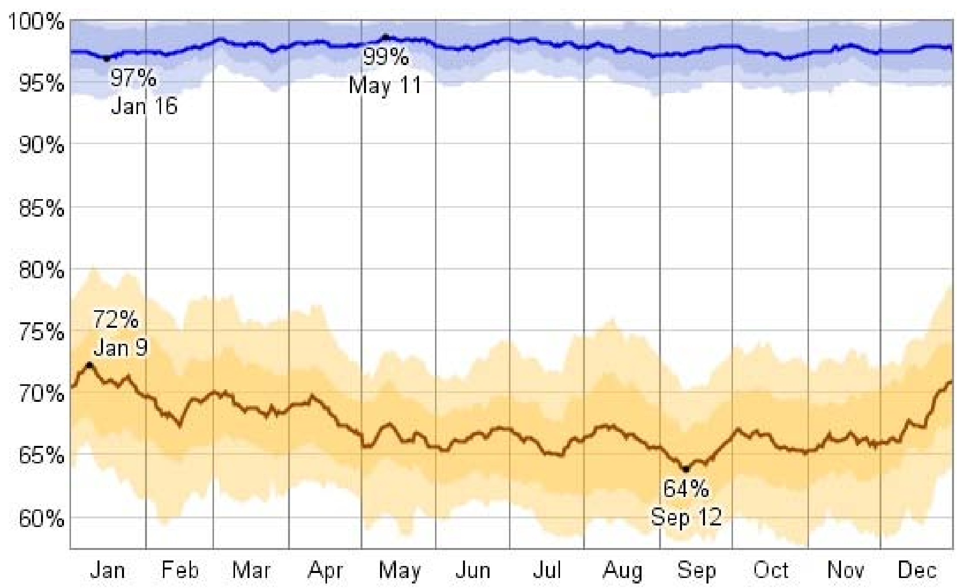

Figure 4-6 Average Monthly Relative Humidity for Henderson Airport Weather Station (1974 to 2011)

Figure 4-7 Monthly Minimum, Average, and Maximum Relative Humidity for IWS01 Weather Station (2008 to 2012)

4.2.2.3 *Rainfall*

In the Solomon Islands, annual rainfall is typically 3,000 mm to 5,000 mm, with monthly rainfall typically exceeding 200 mm. Significant variations in rainfall can occur between locations due to factors such as prevailing winds and topography. Rainfall can be expected to increase with elevation, with the maximum rainfall occurring at approximately 660 to 1,000 m elevation on windward slopes. Although the maximum average rainfall is associated with the northwest monsoon season from December to April, very heavy daily rainfalls can occur during the south-easterly season at places exposed to prevailing winds.

See Table 4-1 for extreme rainfall summary for Auki, Henderson Airport and Honiara weather stations over the last 30 years.

Table 4-1 Highest, Lowest and Average Annual Rainfall Distribution for Auki, Henderson Airport and Honiara (1980 to 2010) and Year of Occurrence (as shown in the parentheses)

Weather Station	Highest Rainfall (mm)	Lowest Rainfall (mm)	Average Rainfall (mm)
Auki	3,851 (1998)	2,239 (1987)	3,015
Henderson Airport	2,639 (1988)	1,174 (1992)	1,845
Honiara	2,725 (2008)	1,264 (1993)	1,940

For the Santa Isabel IWS01 weather station, the minimum monthly rainfall occurred in April 2010 (106.0 mm) while the maximum monthly rainfall occurred in January 2010 (643.5 mm). Overall, the monthly recorded rainfall data is sporadic with no defined wet and dry seasonal pattern (see Figure 4-8).

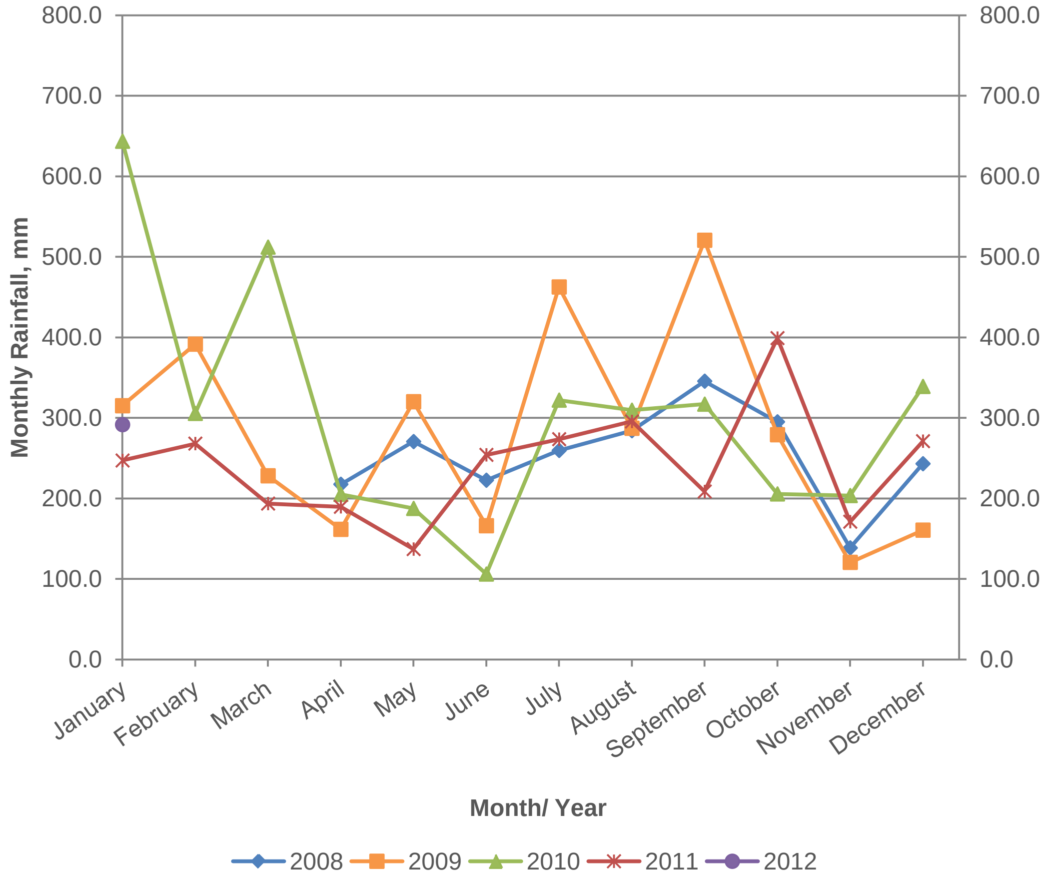

Figure 4-8 Total Monthly Rainfall for IWS01 Weather Station (2008 to 2012)

4.2.2.4 Wind

In the Solomon Islands, east to southeast winds predominately occur from May to October. Wind speeds are 30 to 40 km/hr. The wind direction tends to shift west to northwest from November to April. Wind speeds during this time are usually lower (compared to May to October). Wind speed over the land areas increases during the morning, reaches a peak during the afternoon when temperature is at its daily maximum, then decreases at night.

The IWS01 weather station data shows that the wind direction is variable. West-southwest winds predominantly occur during January and shift to the northwest in February and March. The wind direction then shifts again from northwest to northeast in June and vice versa in October. Winds were recorded throughout the year with an average speed of about 1.33 km/h to 2.41 km/h and a maximum speed of 4.14 km/h to 8.93 km/h.

4.2.2.5 Solar radiation

Solar radiation is the amount of energy emitted from the sun and when measured on the ground may serve as a measure of cloud cover in a specific area. Solar radiation tends to peak in the middle of the day. For IWS01 the minimum value recorded during sunrise and sunset was 0.002 Watts/m^2 to 0.012 Watts/m^2. The maximum value recorded during the day was 1354.566 Watts/m^2. There are no seasonal patterns for solar radiation. Monthly solar radiation levels for the IWS01 weather station are shown in Figure 4-9.

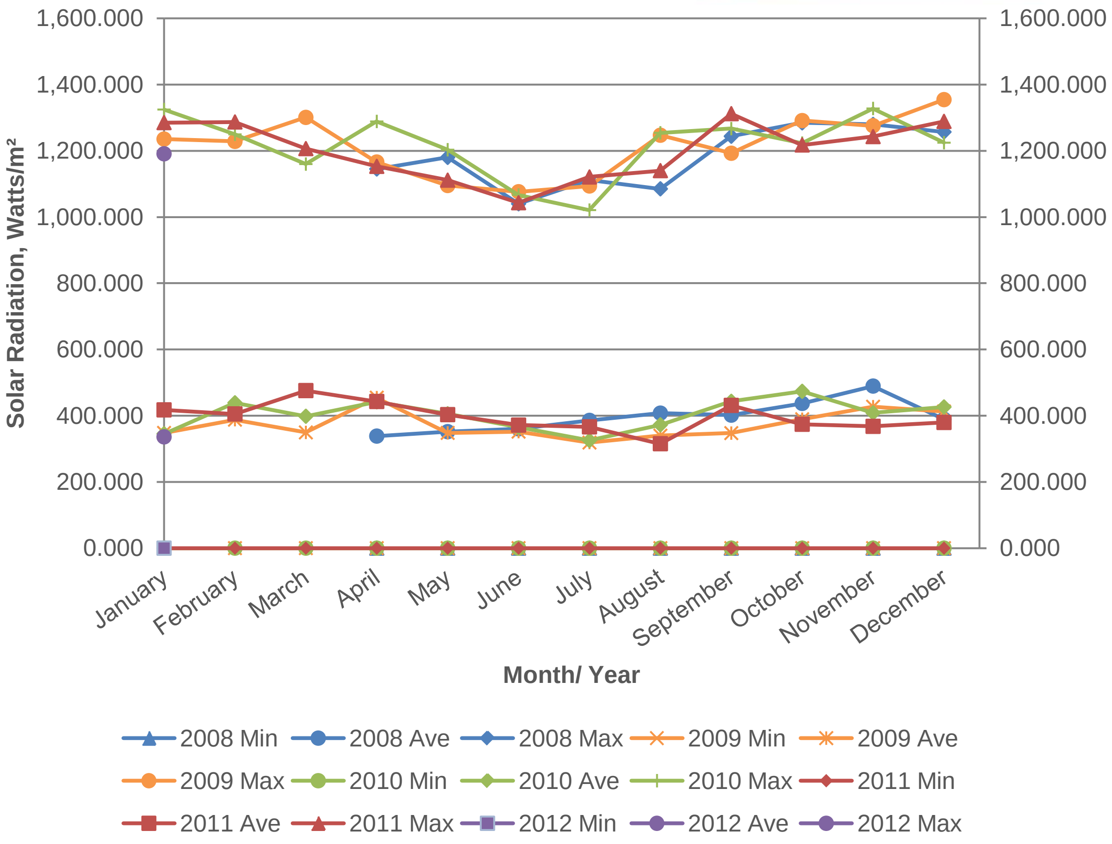

Figure 4-9 Monthly Minimum, Average, and Maximum Solar Radiations for IWS01 Weather Station (2008 to 2012)

4.2.2.6 *Natural Hazards*

Countries in the Pacific region are frequently subject to climatic extremes. The most common natural disasters are thunderstorms, tropical cyclones and low pressure systems, floods and droughts. Table 4-2 lists the five worst natural disasters in the Solomon Islands (in terms of people affected) between 1900 and 2012.

Table 4-2 Worst Natural Disasters in Solomon Islands between 1900 and 2012

Sorted by Number of Fatalities				Sorted by Number of Total Affected Persons			
	Natural Disasters	**Date**	**Fatalities**	**Natural Disasters**	**Disaster**	**Date**	**Total Affected Persons**
1	Storm	1956	200	1	Storm	19 May, 1986	150,000
2	Earthquake (seismic activity)	21 July, 1975	200	2	Storm	04 January 1993	88,500
3	Storm	19 May, 1986	101	3	Storm	April 1982	30,000
4	Earthquake (seismic activity)	02 April, 2007	52	4	Flood	21 January, 2010	16,017
5	Earthquake (seismic activity)	03 October, 1931	50	5	Flood	29 January, 2009	7,000

Thunderstorms frequently occur over mountainous islands like Santa Isabel Island and tend to occur from December to March. Damage from thunderstorms usually results from strong downburst winds and flash flooding associated with heavy rainfall.

Tropical low pressure areas frequently occur over the Solomon Islands but very few develop into tropical cyclones. Tropical cyclones occur from November to April, generally once or twice per year. Severe tropical cyclones have high wind speeds and can cause great damage to land and people.

Flooding is one of the effects of a tropical cyclone. Coastal flooding is a major problem for the small atoll islands and coastal areas of large islands in the Solomon Islands.

Drought, which is influenced by the El Niño and La Niña phenomenon, often occurs in the Solomon Islands. During the 1998 to 2001 La Niña event, thousands of people experienced food and water shortages. An increase in cases of diarrhoea, skin complaints, eye infections and influenza occurred during the drought period.

4.3 Geology, Geohazards and Soils

This section describes:

- regional and local geology of the Project area
- key geologic and pedologic characteristics of the Project area that are of significance to the Project
- Project phases or processes that may impact the natural geology, geomorphology and pedology of the Project area
- potential impacts of existing geological conditions and inherent geohazards to the Project
- appropriate mitigation or control measures to address the identified potential impacts.

4.3.1 Standards and Reference Values Applied

The following international standards or reference values were used to determine the baseline geochemistry of the soils, where applicable.

- The United States Department of Agriculture (USDA) Soil Taxonomy Classification is the basic reference used worldwide for soil classification and for undertaking and interpreting soil surveys.
- The Food and Agriculture Organization (FAO) New Global Soils Database helps identify the land and water limitations of the soils and assess risks in relation to soil degradation. The FAO database was used in this study to supplement purely descriptive soil guides such as the USDA taxonomic classification.
- The International Soil Reference Information Centre (ISRIC) is an independent knowledge centre established in 1966 that aims to provide world soil information. ISRIC was used for this study primarily to supplement existing references and validate soil analysis through metadata services for mapping. ArcGIS software was used for mapping. It consists of a suite of Geographic Information System (GIS) data used to compile information and generate these as images or maps.
- In the absence of site-specific standards for metal concentrations in soils and sediments in Solomon Islands, Average Shale Values (ASV) were used as a reference in determining the relative enrichment of known heavy metal concentrations (which may impact on the health of mine workers and environmental values).

4.3.2 Methodology

The geology, geohazards and soils of the Project area were described based on:

- a desktop review of data from baseline studies conducted by Hatch Associates Pty Limited, Australia (Hatch) for geology, geochemistry and soils in 2010; and related literature published in internationally refereed journals
- geologic assessments based on field surveys carried out in October 2011
- soils assessments.

Geologic and soils assessments are detailed in the following sections.

4.3.2.1 Geologic Assessment

Geologic field surveys were conducted from 17 to 22 October, 2011 and consisted of:

- trail and access road traverses
- helicopter and vantage point observations

- coastal surveys wherein rock types, mineralization and geologic structures were identified to confirm borehole and secondary data.

The coastal surveys were the most thorough since the coast provides the most rock exposures and outcrops out of all areas visited. Outcrops were documented through photographs and logging of GPS coordinates. Petrologic megascopic identification (rock identification) was done in the field.

Geological data were integrated into base topographic and mine development maps using ArcGIS. In addition to the provision of basic geological and geomorphic information, interpretative maps generated from GIS post-processing were utilised in the evaluation of existing natural geological hazards in the Project area.

Computations and comparisons were made for determination of Potential Ground Acceleration (PGA) and spatial analyses of generated maps was undertaken to determine areas that are susceptible to the identified geological hazards. The types of geohazards presented pertain only to surficial processes and excludes hazards in relation to seismicity and volcanism. Petrographic analysis of rocks and confirmation of rock identifications were completed in the University of the Philippines National Institute of Geologic Sciences.

4.3.2.2 Soils Assessments

Bulk samples of soils were collected from the ports in Tenements D and E, Mine Areas, and the Water Storage Facility. Soils were only excavated to a depth of 20 cm since soil cover in the resource areas is generally thin. Soil samples were taken from depths of 15 cm to 20 cm. The upper 5 cm of the soil which contains plant roots, organic matter, and rubble were removed before an undisturbed bulk sample was removed and sealed for laboratory analyses. The pH for soils was measured in situ using a portable and waterproof pH meter. Once pH values and textures were logged, approximately 3 kg of sample were collected per site using a standard grade non-reactive plastic trowel. The samples were placed in a 4 mm polyethylene container and sealed airtight using tape and microfilm. The samples were properly stacked in boxes and stored in a cool, dark room prior to transport to the laboratory. Sampling methodology was derived from the USDA soil taxonomic classification manual. Vegetation (woodland and garden crops via common name identification) was also noted for the sampling site. Soil sampling sites are shown in Figure 4-10.

As local soil standards were lacking, the Average Shale Value (ASV) and computation of Geo-accumulation indices were used to determine the relative enrichment of the heavy metals. ASVs are particularly useful in areas such as Santa Isabel where the baseline concentrations of major elements such as iron, aluminium, chromium, nickel and cobalt are expected to be higher. Other physico-chemical parameters were also assessed in comparison with references from the USDA and FAO to determine soil classes and land capability.

Methods for the assessment of land, soils and geology, including the limitations of the baseline survey, are further described in the Impact Assessment Report – Geology, Geohazards and Soils.

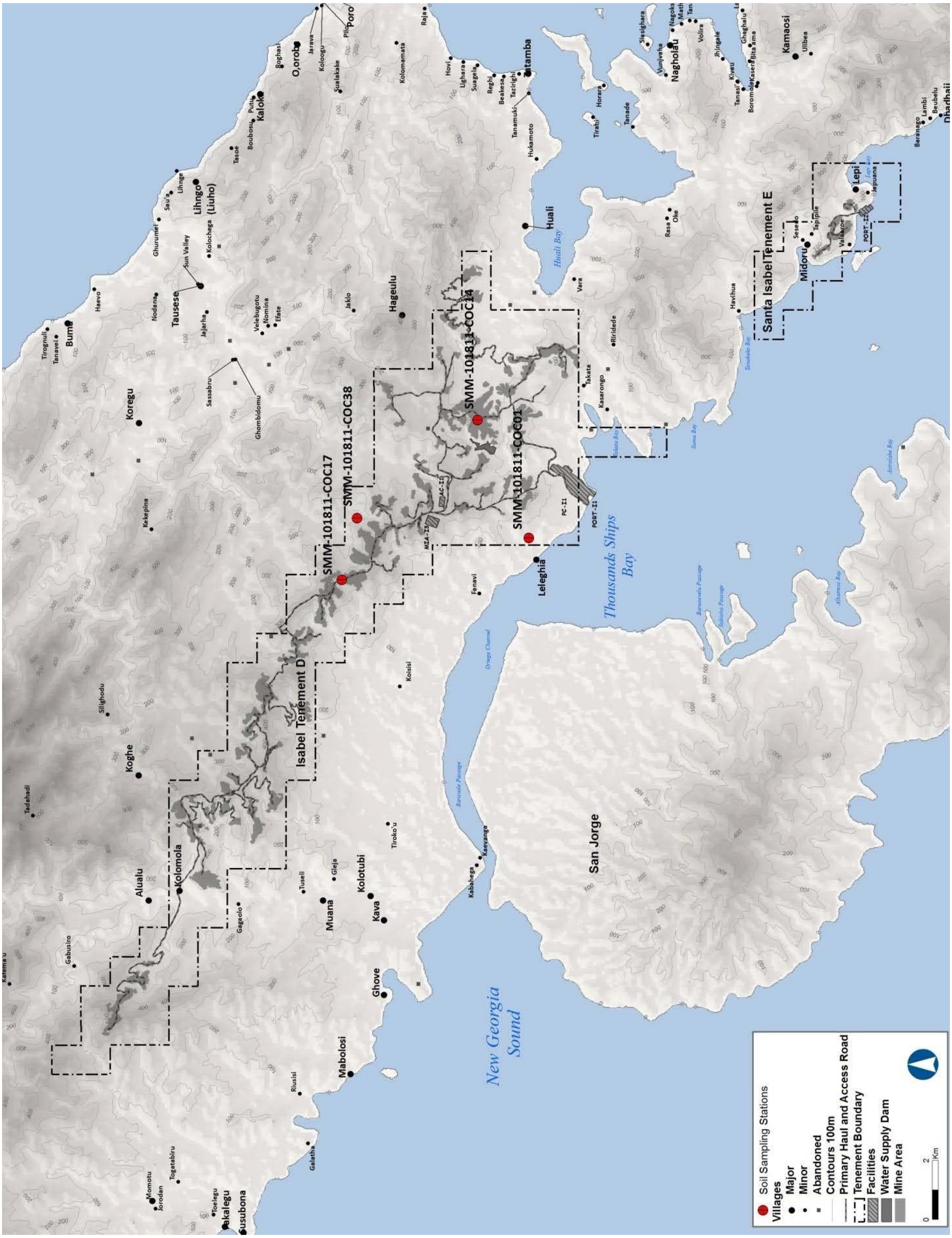

Figure 4-10 Soil Sampling Sites

4.3.3 Existing Values

4.3.3.1 Regional and Local Geology

The Solomon Islands is an archipelago composed of six major islands forming a northwest-south-east trending double chain of islands. The islands are composed of distinct crustal units called terrains, which have their corresponding rock types and geologic structures. Most of the islands and their corresponding geology are derived from volcanic activities and crustal uplift due to the presence of active subduction and collision zones between the Indo-Australian and Pacific Tectonic Plates.

Santa Isabel Island is underlain by Late Cretaceous Ultramafics composed predominantly of harzburgite (shown in Figure 4-11). The harzburgite is composed mainly of olivine and pyroxene and is chloritized in large outcrops along the coast. The harzburgite is overlain by massive to pillow Ontong Java Plateau (OJP) basalts and its plutonic equivalent, gabbro. The contact between the harzburgite and the basalts are mainly erosional. The ultramafic sequence is, in turn, overlain by volcaniclastic sediments of OJP composition and its weathering product, limonite. Small (<1 ha) areas of minor arc volcanism composed predominantly of basalt are also found within the island. Recent subtidal carbonate platforms and fringing reefs are found around the island.

The most significant geologic structure within the island is the Kia–Korigole-Kaipito Fault Zone (KKKFZ) previously interpreted as a left-lateral strike-slip fault. This fault zone separates the Tertiary volcanic and sedimentary rocks northeast of the island along the central trace of the fault from the ultramafic rocks towards the west where the resources are located.

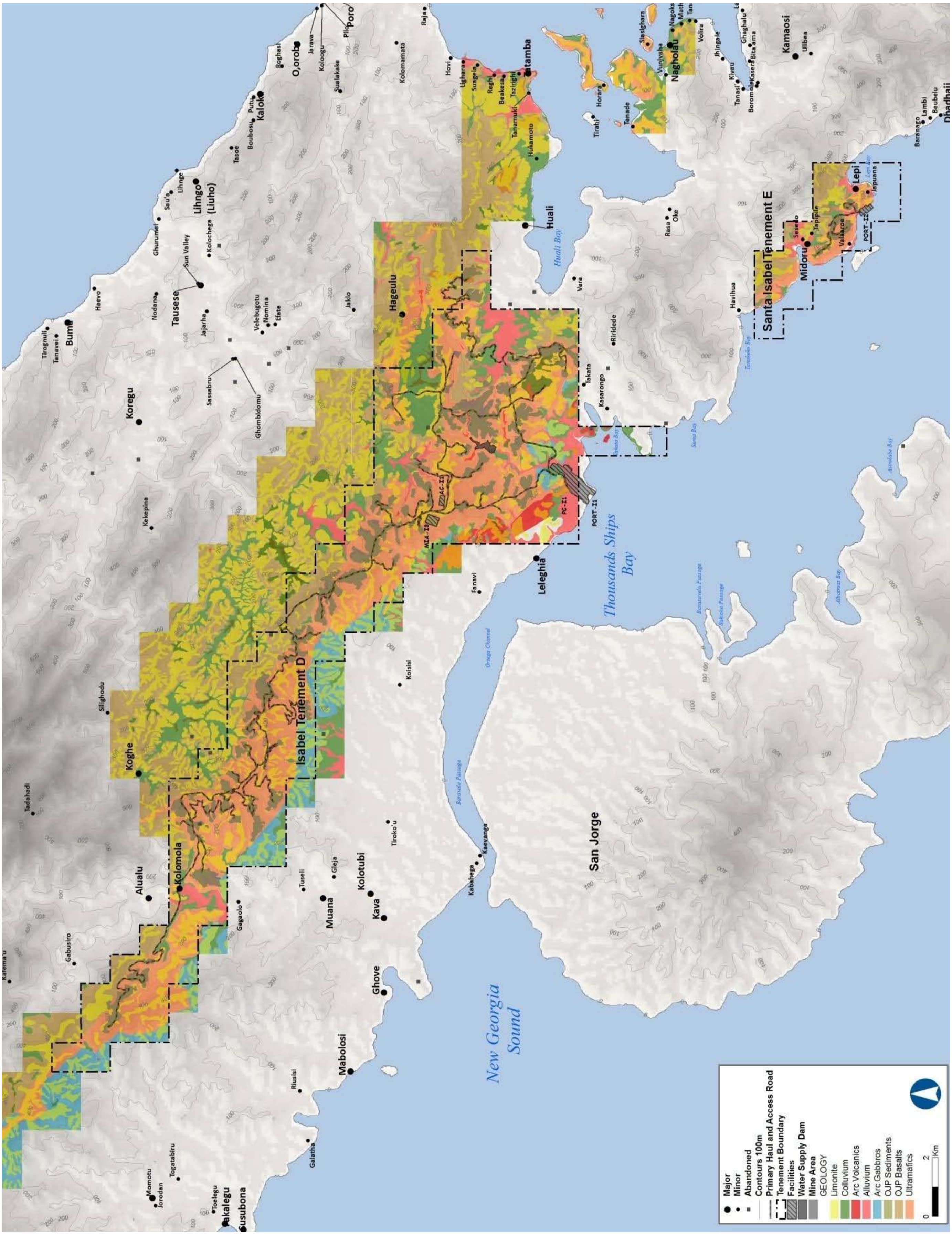

Figure 4-11 Geologic Map of the Project Area

4.3.3.2 Geomorphology

Santa Isabel Island is characterized by moderately steep to steep narrow ridges with average elevations of 250 m to 400 m. The ridges are generally aligned parallel to the orientation of Santa Isabel Island. The ridges are surficial expressions of the resource and the underlying folded ultramafic sequence and the relation of these deposits with the thrust fault system of the island. The ridges are incised by narrow river channels with nearly absent river terraces due to thick vegetation cover. The rivers also lack distinct flood plains. The ridges abruptly terminate to the coastal flat areas but the boundaries are indistinct due to the vegetation cover.

The proposed Water Storage Facility will be located on the junction of three river channels at elevations of 200 m to 250 m. The rivers drain along the Leleghia NAP and ultimately to Takata Bay.

4.3.3.3 Soil Types, Geochemistry and Land Capability

Geo-accumulation indices were computed for the soil samples to determine the background enrichment concentrations of major metals within the tenement. The following metals had reported results from the soil physciochemical laboratory analysis: pH, moisture content, exchangeable sodium percentage (ESP), ESP classification, sodium absorption ratio, exchange sodium, exchange potassium, exchange calcium, exchange magnesium, cation exchange capacity, bicarbonate alkalinity, sulphate, soluble major cations (calcium, magnesium, potassium), total major cation (magnesium), total metals (aluminium, cobalt, iron, manganese, molybdenum, selenium, arsenic, cadmium, chromium, copper, lead, nickel, zinc), total recoverable mercury, fluoride extractable phosphorous and organic matter.

Concentrations of cadmium, chromium, copper, and iron exceed the Average Shale Values. The rest of the metals including arsenic, nickel, and aluminium are within their respective normal crustal values. Consequently, the geo-accumulation indices of the metals include moderately polluted to extremely polluted categories, which indicates high crustal enrichment of the metals. Refer to Section 4.4.1 for standards applied in this assessment.

The soil profile of Santa Isabel Island is subdivided into three divisions, namely the laterite or limonitic zone, saprolitic zone, and basement rocks. The limonitic zone is further subdivided into three limonite types classified according to colour, texture, and grainsize. The limonitic zone is followed by the saprolitic zone with depths typically varying from 7 mbgs to 8 mbgs up to 11 mbgs to 12 mbgs. The basement rock, subdivided into the weathered zone and base rocks, underlies the saprolitic zone. Detailed descriptions of the horizons of the soil profile are shown in Table 4-3.

Table 4-3 Soil Profile and Leaching Effects (modified from Hatch, 2010 and Sagapoa et al., 2011)

Division	Subdivision	Average depths where horizon is encountered (mbgs)	Description	Leaching Effects
Pedolith (Laterite)	Topsoil	0 to 0.1	Soil composed of plant roots, plant litter and organic materials	
	Red Limonite Zone (Limonite 1)	0.1 to 4	Reddish brown to dark brown silty to clayey heterogeneous limonitic laterite	Mg and Si leached; Fe, Cr and Al residually enriched
	Limonite 2	1 to 5	Brown, silty limonitic laterite	
	Limonite 3	2 to 8	Yellow to yellowish brown heterogeneous silty limonitic laterite, sometimes with observable soil bandings (yellow, brown, dark)	Mg and Si leached; Ni, Co and Mn residually enriched
Regolith (Saprolitic Zone)	Transition Zone	7 to 8	Yellowish brown, sandy or clayey soil with highly weathered serpentinite fragments and intense garnierite stains	Ni enriched
	Decomposed Serpentine	7 to 12	Sandy or clayey soils with serpentinite fragments to fragmented ultramafics and	

Division	Subdivision	Average depths where horizon is encountered (mbgs)	Description	Leaching Effects
			intensively decomposed serpentinite	
Basement	Highly weathered zone	2 to 16	Highly weathered gabbro, ultramafics or serpentinite; May have cross-cut veining and garnierite-filled voids	Minimal to none
	Base rock	3 to 27	Fresh basement rock (gabbro, ultramafics, serpentinite)	

Santa Isabel Island has 13 soil associations with eight of these found in the tenement (shown in Figure 4-12). The soil associations are associated with the geology since the underlying rock types dictate the composition and characteristics of the soil. In terms of the USDA soil order, the majority of the soils within the tenement fall within the Inceptisols and Oxisols group to the JIX and IJ soil associations. Soil association EBF which consists of the great groups Sulfihemists, Endoaquepts, and Sulfaquepts are considered potentially acid sulfate soils and are found in the coastal areas of Takata Bay.

In terms of land capability, the majority of the soil cover in the Santa Isabel tenement is unsuitable for agriculture and is restricted to forest land in terms of suitable usage. These soils are categorized under Class VI of the USDA Land Capability Classification scheme. Other soil associations found within the tenement have severe limitations that restrict the vegetation that can be supported or require special conservation practices.

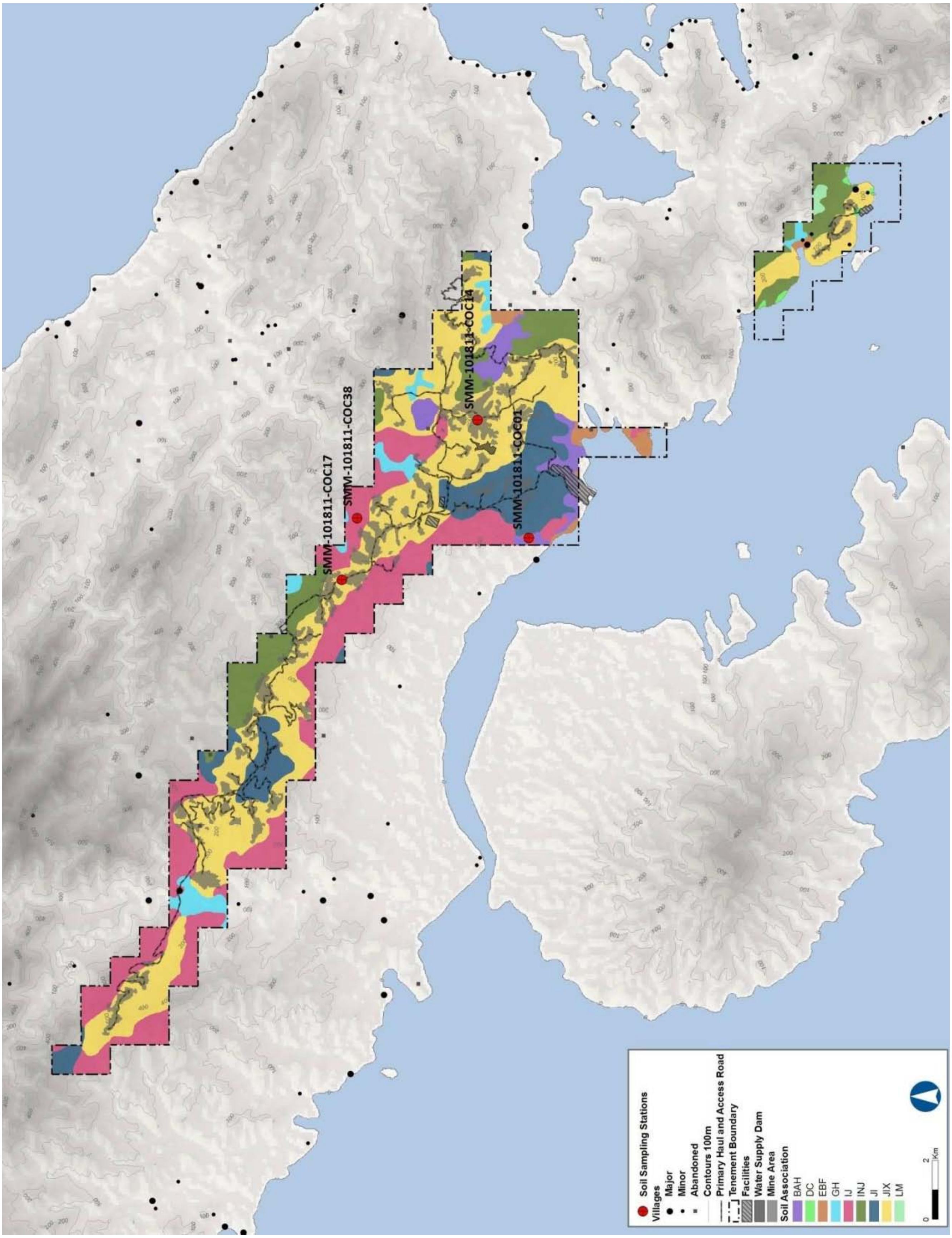

Figure 4-12 Soil Associations of Santa Isabel Island

4.3.3.4 Geohazards

The inherent geohazards identified for the Project on Santa Isabel Island, in order of decreasing probability, are:

- topsoil loss
- land use or geomorphologic change
- slope failure
- earthquake hazards
- tsunami
- volcanism.

Topsoil loss and change in landforms will occur due to the proposed mining activities and the construction of the mine infrastructure. Since the majority of the island's slopes fall are moderately steep, the occurrence of slope failure such as landslides is possible, particularly during periods of heavy rainfall. Since the island and the region are located in a tectonically active area, hazards associated with the occurrence of earthquakes and volcanism are also possible within the duration of the Project life. The Solomon Island arc experiences numerous seismic activities generally within the magnitude 4 to 7 and originating from depths of 35 km to 300 km. Historic earthquake occurrences and moment tensors around the Solomon Islands are mapped in Figure 4-13.

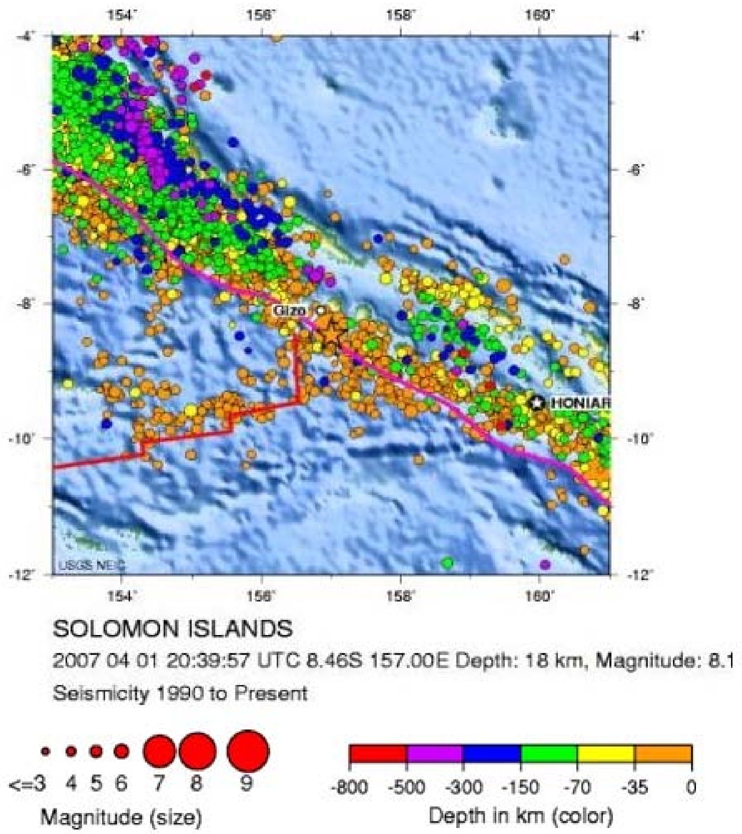

Figure 4-13 Historic Earthquake Occurrences and Magnitudes (NEIC, 2010)

The Solomon Islands subduction zone is noted for producing earthquake patterns called doublets. Doublets are two earthquakes of similar magnitude that occur close to each other spatially and temporally.

Doublets have occurred 200 km southeast of Santa Isabel Island from the Woodlark Plate and Australian Plate subduction slabs as documented by Lay and Kanamori (1980) in 1931 and 1939. A rare seismic event called a triplet (three consecutive earthquakes each having its own aftershock) was recorded in 1977. The doublets and triplet earthquakes were within the range of magnitude 7 to 8.

The occurrence of doublets is significant for the Project site since consecutive high magnitude earthquakes may affect the integrity of the Project facilities.

There have been 13 earthquakes recorded in the Solomon Islands region from January 2012 to May 2012 (EMSC-CSEM 2012). The strongest of these was an earthquake measuring M 6.4 which struck on 14 February 2012.[1]

A tsunami occurred in January 2010 following a M 7.1 earthquake originating approximately 200 km southwest of Santa Isabel Island. Wave heights reached up to 3 m. This tsunami originated from an earthquake along the subduction margins of the Solomon Islands. The Solomon Islands are also susceptible to sustained tsunami waves originating from the surrounding subduction or convergent margins along the Pacific Plate.

Drawback, or the retreat of ocean waters exposing normally submerged areas, is a typical forewarning of a tsunami wave. Drawback begins before the wave arrives at an interval equal to half of the wave’s period. In the event of a tsunami occurrence, the normal warning signs such as ocean withdrawal or drawback may not be present in the Solomon Islands due to the narrow shelf between the islands and the subducting slabs as well as the general behaviour of uplift of the islands during an earthquake event.

4.3.4 Potential Impacts

The various impacts identified encompass geological hazards that may affect the Project and Project impacts that may enhance existing geohazards, soil loss and contamination, land capability modification and short-term to permanent geomorphic change.

The Project components have the potential to impact the geology, geomorphology, and pedology of the Project area, including the following:

- Construction and operation of nickel mine and supporting infrastructure, including:
  - mine areas
  - haul and access roads
  - water supply dams
  - silt traps / sedimentation ponds
  - landfill disposal of general refuse
  - mine industrial area
  - accommodation camp.
- Construction and operation of port facilities.

Project construction and operation activities that have the potential to result in impacts to geology, geomorphology and soils are outlined in the following sections. Further details are provided in the Impact Assessment Report – Geology, Geohazards and Soils.

[1] European-Mediterranean Seismological Centre (Centre Sismologique Euro-Méditerranéen). http://www.emsc-csem.org/Earthquake, accessed 14 May 2012.

4.3.4.1 Soil Contamination

Soil contamination can potentially occur as a problem on several aspects. Contaminants can percolate to a perched aquifer or the groundwater. Contaminants can also find their way into plant tissues via nutrient intake. Animals may likewise be affected if these contaminants find their way into their plant food sources or spring / drinking water sources. Soil contamination may also alter or affect soil composition such that it may no longer be suitable for its previous use or capability. Moreover, accumulation of contaminants in the Project area may impact the health of the mine's workers and suppliers if concentrations of contaminants become substantial.

The common contaminants that can potentially find their way into the soil within the Santa Isabel Island include the substances tabulated in Table 4-4. These substances are commonly associated with hydrocarbons, sewage sludge and industrial materials.

Table 4-4 Common Sources of Soil Contamination (modified from Heinegg et al., 2002)

General Source	Project activities/areas/impacts where general source is present	Contaminants
Hydrocarbons	Use of excavators and heavy machinery for ore extraction Transport of resource via haul roads Vehicular traffic on access roads Use of generators in mine office, accommodation camp, and related general facilities Accidental spills	Lead, zinc, polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, xylene
Treated Wood	Construction of accommodation camp and general facilities Use of wood in drill pads and for batter support/masonry works in mine area	Arsenic, chromium, copper
Sewage Sludge	Sewage disposal site Containment facilities for sewage	Cadmium, copper, zinc, lead
General Commercial/ Industrial Site Use	General mine facilities	PAHs, petroleum products, solvents, lead, and other heavy metals

4.3.4.2 Impacts associated with Acid Sulfate Soils

The impacts related to the release of sulphuric acid due to the disturbance and drainage of acid sulphate soils are applicable only for the port facilities, where earthworks and construction will occur on the coast. Impacts related to the disturbance and drainage of acid sulfate soils include:

- pollution of groundwater and surface water
- failure of soil structure and soil erosion
- corrosion of materials that will be used for the construction of the port facilities such as concrete, steel, iron and aluminium.

4.3.4.3 Soil Erosion and Sedimentation

Soil characteristics and geomorphologic features of the island indicate that most areas of Santa Isabel Island are prone to erosion. Development of mine areas, construction of the water storage facility and other mine facilities, as well as the regular passage of vehicles along roads may increase erosion where project activities are taking place and consequently lead to increased sedimentation downslope or downstream of stripped areas, roads, and other mine facilities, if not mitigated.

4.3.4.4 Geohazards

4.3.4.4.1 Slope Failure

Critical areas that are considered to be susceptible to slope failure include the location of the proposed accommodation areas, Water Storage Facility, Mining Areas and Ports. For the geologic consideration, the Project area has varying degrees of susceptibility according to lithology and degree of weathering in different areas. Clays characteristic of volcanic rocks and corresponding alteration products of ultramafic rocks found in the Project area, stream deposits, and hydrothermally altered rocks are highly prone to weathering and are consequently highly erodible. Lateritic soils with high clay content are also susceptible to slope failure due to low induration.

4.3.4.4.2 Landslide Hazard Rating

The digital terrain model generated from topographic information for Santa Isabel Island indicates slopes are generally undulating to very steep. Slopes with gradients from 3% to 18% (undulating to rolling) account for nearly 43% of the tenement. Slopes with these gradients have low to moderate susceptibility to landslides or slope failure. Slopes with slope gradients greater than 30% (moderately steep to very steep) cover approximately 57% of the tenement. These slopes have a moderate to high susceptibility to failure. Areas bisected by river channels have increased susceptibility to erosion, particularly during periods of high rainfall. Though ultramafic rocks are generally stable, high degrees of weathering and structural features such as conjugate joints, blind faults and alteration may increase susceptibility for slope failure. The landslide hazard map for the Project area is shown in Figure 4-14.

Figure 4-14 Landslide Hazard Rating Map

4.3.4.4.3 Ash Fall

The Solomon Islands, due to it's location within the Pacific Ring of Fire and subduction zones bounding the island, are dotted with several active and inactive volcanoes. Refer to Impact Assessment Report – Geology, Geohazards and Soils for details on locations and further significance to the Project. Volcanic ash refers to fine particles of fragmented volcanic rock and volcanic glass typically measuring 2 mm and less in diameter (equivalent to very coarse sand and finer or 1.0 Phi and lower). Coarser particles may be vesicular allowing the particles to disperse great distances. Due to this property, ash falls are the most widespread of potential volcanic hazards.

Ash fall refers to the dispersion and eventual deposition of volcanic ash. The aerial extent of ash cloud may range from 1,000 km^2 to 10,000 km^2 with at least 10 cm thick ash blanketing the affected areas during a large eruption. Potential risks associated with the ash fall hazard that may impact Santa Isabel Island include respiratory distress of the workers due to inhalation of ash particles and damage to aircrafts such as the helicopter and local inter-island carriers, which may lead to fatal crashes.

4.3.5 Impact Assessment

A risk assessment of potential impacts for geology, geohazards and soils is presented in Table 4-5.

Table 4-5 Assessment of Potential Impacts on Geology, Geohazards and Soils

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance No Mitigation	Mitigation / Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Short-term change in landform will occur for areas where temporary construction camps, waste containment areas and motorpools will be erected				•	•	•	Negative	Local	Low	Short-Term	Definite	Medium	Medium	Slope remediation, topsoil management and progressive rehabilitation, and engineering measures will be considered to address this impact.	Low	High
Loss of topsoil may potentially occur for areas where there are construction and mining activities and increased human and vehicular traffic.	•	•		•	•	•	Negative	Local	Medium	Medium to Long-Term	Highly Probable	Medium	Medium	Topsoil management and progressive rehabilitation will be considered to address this impact.	Low	High
Release of sulphuric acid from the disturbance, drainage and oxidation of acid sulphate soils may result to loss and failure of soil structure and corrosion of materials that will be used in construction of the port.			•				Negative	Local	High	Medium Term	Highly Probable	Medium	Medium	If acid sulphate soils are encountered, the disturbance and release of acid from acid sulphate soils will be addressed through earthworks planning, acid control through addition of lime and water quality monitoring. Additional soil testing within the Port areas may be necessary to identify areas to be avoided or that may require treatment.	Low	High

Table 4-5 Assessment of Potential Impacts on Geology, Geohazards and Soils

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance No Mitigation	Mitigation / Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Construction on high-angle slopes may induce landslides in susceptible areas.			•	•	•		Negative	Local	High	Short-Term	Probable	High	High	Slope remediation, engineering design and engineering measures will be considered to address this impact.	Low	High
Soil contamination from hydrocarbon or motor oil spills or leaks, improper disposal of masonry wastes such as wood and metal and improper disposal of other solid, liquid and domestic wastes.	•	•	•	•	•	•	Negative	Local	Medium	Short-Term to Long-Term	Highly Probable	Medium	Medium	Workplace practices will be implemented such as: regular check, repair and maintenance of vehicles and equipment; appropriate collection, storage disposal for waste and hazardous materials; and spill cleanup kits available.	Low	High
Loss of soil through erosion of disturbed areas.	•	•	•	•	•	•	Negative	Local	Medium	Medium to Long-Term	Highly Probable	Medium	Medium	Application of erosion and sediment control measures will be considered during construction and operations.	Low	High
Landform change will occur in areas where mine-related facilities will be erected such as the accommodation camp, stockpile areas, administration areas and haul roads.		•		•		•	Negative	Local	Medium	Long-Term	Highly Probable	Medium	Medium	Facilities that will be dismantled or decommissioned post-mining will be identified. These can be considered to be turn-over to the landowners and/or government.	Low	High
Permanent landform change will occur in the mining areas and	•	•				•	Negative	Local	High	Long-Term	Definite	High	High	Mine areas will be rehabilitated to a stable	Low	High

Table 4-5 Assessment of Potential Impacts on Geology, Geohazards and Soils

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance No Mitigation	Mitigation / Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
general access roads.														landform.		
Mining and road construction on high-angle slopes, areas defined in the landslide susceptibility rating as moderate to high hazard, or areas with structural weaknesses or fractures encountered may induce landslides.	•					•	Negative	Local	High	Long-Term	Probable	High	High	Slope remediation, engineering design and engineering measures will be considered to address this impact.	Low	High

4.3.6 Mitigation Measures

4.3.6.1 Soil contamination

Workplace practices will be regularly implemented to prevent soil contamination. Examples include the following:

- using drip pans underneath stationary vehicles or equipment to catch oil or lubricant leaks from the machine or engine
- regular maintenance and repair of vehicles and equipment to check and repair leaks
- ready hydrocarbon clean-up materials such as organic dispersants, absorbent cloth, and waste bins to quickly clean and contain accidental spills
- installing trash bins for biodegradable, non-biodegradable, and recyclable wastes and enforcing waste segregation among site workers
- enforcing waste collection from drill pads and packaging these to be transported back to camp for proper waste disposal
- secondary containment of fuel storage.

Geomembranes can be used as a protective barrier to line landfills and waste disposal sites to prevent the contaminants percolating to the substrate and to the groundwater. Bunds can also be constructed around fuel storage areas to contain potential leaks.

4.3.6.2 Impacts associated with Acid Sulphate Soils

Prior to construction, the proposed earthworks method that will be conducted will be determined to assess the volume of soil that may be disturbed and the depth of disturbance to the soil. The earthworks will be done in accordance with engineering designs to minimize the area that will be disturbed at one time. Assessment of the risk of disturbing will be undertaken prior to port construction. Where risk of disturbance of potentially acid sulphate soils is identified, pH of soils and/or runoff from these areas will be monitored. Where there is determined to be a risk of disturbance, avoidance will occur where possible, or otherwise, treatment of soils will be undertaken.

Additional soil testing within the port areas may be necessary for better understanding of the risks of disturbing acid sulphate soils and areas where avoidance or treatment may be required. Testing and treatment trials of on-site soils can be done prior to treating in-situ.

4.3.6.3 Soil Erosion and Sedimentation

Engineering design and measures will be integrated and implemented during the construction, development, and operations of the mining areas, haul roads, and associated facilities to stabilize the soil. Construction will be carried out in phases to minimize the area that will be disturbed. Mining will be carried out in blocks or parcels to minimize the area that will be disturbed. Progressive rehabilitation in the form of push and doze backfilling of soil and revegetation will be conducted as mining progresses. Silt and sediment traps will also be constructed proximal to where construction and earthmoving activities during construction and mining areas and haul roads during operations to minimize sedimentation in downslope areas.

4.3.6.4 Topsoil Management and Progressive Rehabilitation

Progressive rehabilitation will be carried out during the construction and operation periods. Mining will be carried out in panels. Soils that will be excavated from the panels will be set aside. These soils will be pushed and dozed onto a mined-out parcel to allow revegetation to occur. In cases where the volume of soils is insufficient to backfill the mined areas to the natural slope, the soils will be stabilized.

SMM Solomon has also developed topsoil conservation and management schemes to address fertility and land capability concerns post-mining. The topsoil conservation plan includes the application of mulch to improve soil organic matter content post-mining and regrading of soil to the most stable configuration.

It is not possible to completely backfill each mine area and return it to pre-mining topographic and geomorphic conditions. Progressive rehabilitation through reforestation and topsoil conservation shall be applied to ensure the mine area is as stable as pre-mining conditions as possible. A MRCP has also been formulated to address impacts to land form and geomorphology. This MRCP is under development and will be completed prior to construction and renewed every five years.

4.3.6.5 Preventative Slope Remediation for Landform Change

Preventative slope remediation could be used to address impacts to the project and environment brought about by short-term and long-term landform change. In contrast with engineering measures and design criteria, preventative slope remediation reduces the risks of failures associated with landform change through removal of problematic slopes. In contrast, engineering controls involve the stabilization and structural improvement of existing large areas of critically steep or unstable slopes, which cannot be addressed simply by in situ regrading of substrate or removal of critically steep slopes.

Preventive slope remediation involves removal of overburden or unstable surfaces. Rocks or soils will be removed along their bedding planes or fractures to leave the stable unweathered surface. Rocks with conjugate fractures that cut across each other will be wholly removed to expose a stable unbroken surface. Overburden or soils deposited at steep angles or with minimal basal support will be removed to expose a relatively flat, compacted surface.

4.3.6.6 Application of Recommended Engineering Designs and Engineering Measures to Address Slope Instability and Geomorphic Change

Engineering measures to restore disturbed land areas and slopes during construction activities will be implemented in areas where no further construction or earthworks will be undertaken. These measures may include the application of recommended excavation or slope gradient and configuration, construction or installation of surface drainage channels or culverts to allow control of water and minimize erosion, and the use of slope protection.

Detailed slope stability analyses will be conducted to confirm assessments and hazard ratings assigned to the project site from ongoing geotechnical work. Results of the analyses will be integrated in the final design of project facilities. Detailed slope stability analyses of the mine areas will also be conducted. The results of these analyses will be integrated to the mining method.

Observance of safe working slope gradient and placement of engineering measures will be implemented in susceptible areas where mining will occur (mining areas, Water Storage Facility, haul roads, and stockpiles during construction and operation). Slopes and mining areas will be made stable throughout the life of the Project. In addition to engineering measures, the perimeter of the mine areas will be secured with physical barriers such as retaining walls, rock bolting and gabions, to ensure employee safety.

4.3.6.7 Geohazards

An Emergency Response Plan (ERP) will be formulated prior to the commencement of construction. The ERP will include the risk assessment for the earthquake, volcanic eruption, and tsunami-related hazards and consequently the risk management to address these hazards. The ERP will include the roles of SMM Solomon, the stakeholders (employees and residents), and the region (government) in response to a natural disaster. Functional groups that will address important roles such as notification, evacuation, and first aid will be formed under the ERP and trained as required for emergency preparedness.

Notification procedures such as alarms will also be discussed under the ERP. Hazard ratings maps from this Environmental Impact Assessment can be published and integrated in the ERP for the guidance of SMM Solomon and the project's stakeholders.

4.4 Surface Water Quality and Flows

The section describes:

- the quality of surface waters and sediment in the freshwater streams/rivers and marine/estuarine waters likely to be affected by the Project
- the potential direct and indirect impacts on surface water quality and flows from the construction and operation of the Project
- proposed mitigation measures for protecting or enhancing surface water quality and flows.

Further details are provided in the Impact Assessment Report – Surface Water Quality and Flows.

4.4.1 Standards Applied

Refer to Section 4.1.2 for key legislation relating to impacts on surface water quality and flows in the Solomon Islands.

A number of specific standards that were applied during field studies and the impact assessment are listed in the Impact Assessment Report – Surface Water Quality and Flows. These include international standards, WHO guidelines and Australian and New Zealand standards and guidelines.

4.4.2 Methodology

The environmental values related to surface water quality and flows were described based on monthly water quality monitoring of freshwater streams, sedimentation rate monitoring in marine waters, a baseline field survey of freshwater and marine surface waters (in conjunction with the ecological surveys) and the available literature on surface water quality and flows in the region. Water quality monitoring of freshwater streams and sedimentation rate monitoring in marine waters is ongoing; the data set used for this assessment extends from June 2010 to December 2011 for water quality and September 2010 to December 2011 for sedimentation rates. The baseline survey was undertaken from 15 to 21 September 2010.

The locations of the monthly freshwater water quality monitoring sites are shown in Figure 4-15. Eleven freshwater sites were surveyed at Santa Isabel Island. Sites were chosen by SMM Solomon to enable adequate coverage of major watercourses and existing water quality impacts in the Project area, and were based on the Project Description and scope at the time of survey. Sites included the downstream receiving environments for impacts likely to be associated with the construction and operation of the mine. The final locations of the sites within the selected watercourses were based on a number of factors, including terrain, access and suitability for flow monitoring.

Field surveys assessed *in situ* water quality (pH, electrical conductivity, dissolved oxygen, temperature and turbidity) and the concentration of potential contaminants and other variables in the water column and sediment (metals and metalloids, total nitrogen, total phosphorus and oxides of nitrogen, sulphate, calcium, chloride, magnesium, potassium and sodium, total organic carbon, hardness, chemical oxygen demand and alkalinity). The monthly water monitoring surveys also assessed flow rate in stream and river sites.

In the absence of local water quality guidelines, water quality results were compared to the Queensland Water Quality Guideline (QWQG) values for slightly to moderately disturbed lowland freshwaters ($<$150 m elevation) in the Queensland Wet Tropics region (Department of Environment and Resource Management [DERM] 2009b) and the ANZECC & ARMCANZ guideline values for slightly to moderately disturbed lowland streams in tropical Australia (ANZECC & ARMCANZ 2000).

Freshwater and marine surface sediment samples were analysed for the concentration of metals and metalloids, exchangeable cations, calcium, chloride, magnesium, potassium, sodium, sulphate, sulphide, total organic carbon and nutrients, and for particle size distribution. In the absence of local sediment quality guidelines, results were compared to the Australian Interim Sediment Quality Guidelines (ISQG) (ANZECC & ARMCANZ 2000).

Methods for the assessment of surface water quality and flows, including the guideline values and limitations of the baseline survey, are further described in the Impact Assessment Report – Surface Water Quality and Flows.

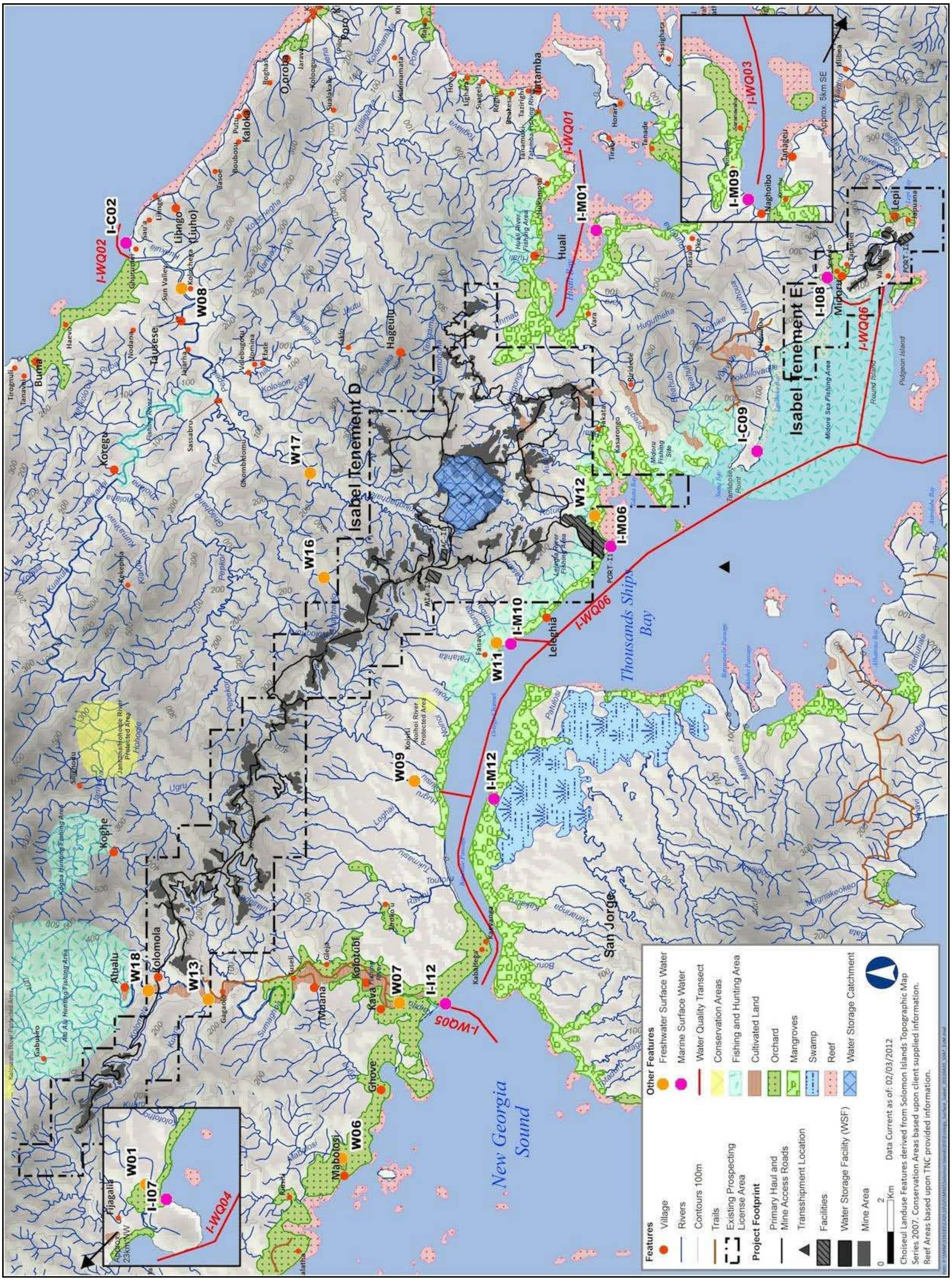

Figure 4-15 Freshwater and Marine Baseline Survey Sites at Santa Isabel Island

4.4.3 Existing Values

4.4.3.1 Overview

The Project area is divided into two tenements, Tenement D and Tenement E.

Isabel Tenement D is characterised by a central steep ridge, dividing the drainage into two major directions. The southern side of the ridge is drained by a number of large rivers which flow to New Georgia Sound and Thousand Ships Bay in the south. The northern side of the ridge is drained by several large mountain streams, which generally run to the east/northeast. The northern mountain streams form tributaries to the Kuakula River, which drains into the Pacific Ocean on the north-eastern side of Santa Isabel Island.

Tenement E is located at the southern side of a ridge, to the south-east of Tenement D. The ridge is drained by several small streams, which flow to New Georgia Sound in the south.

The marine survey area at Santa Isabel included the dominant marine habitats in proximity to the proposed port facilities, and within the estuarine receiving waters of the following rivers likely to be affected by land-based activities of the Project: Hugru River, Kaipito River, Kolongongoe River, Koloseeru River, Kuakulu River, Laolonga River, Mablosi River and the Rotue River.

4.4.3.2 Freshwater Surface Waters

Based on the survey results, the quality of freshwaters within the survey area were assessed as moderate to high. Water quality is primarily related to adjacent land use (e.g. clearing for village gardens and commercial logging), human activities (e.g. waste disposal) and site-specific geology (i.e. mineral-rich soils). Proximity to cleared areas is considered to be the main influence on water quality.

Several water quality parameters were outside of the guideline ranges; however, most of the streams and rivers within the survey area generally had clean and clear water, which promotes the growth and health of aquatic plants. Turbidity was high in the Kaipito River during the baseline field survey, and was high on occasion at several sites during monitoring surveys. Mean turbidity (average of continuously logged data) was also high in November and December 2010 in the Kaipito River and Kuakula River. This was likely to be linked to runoff containing sediment following heavy rain and the proximity of these water quality monitoring sites to crop plantations.

Electrical conductivity was above the guideline range at most sites during monitoring surveys. High electrical conductivity is often associated with low flow conditions or tidal influence.

Significant variation in both flow velocity and flow volume was observed during monitoring surveys. This variability was likely caused by the frequent heavy rain showers that occur on Santa Isabel Island.

Metals were detected in the water at all sites in varying concentrations; the metals detected are generally abundant elements. Median concentrations of aluminium, chromium, copper and vanadium were above the guideline ranges.

Sediment quality within the freshwater survey area was generally good; concentrations of metals (with the exception of total chromium, copper and nickel) and major ions were generally low at most sites. The Kaipito River had poor sediment quality due to a high concentration of nutrients, which was likely related to human wastes, and possibly washing activities. The relative concentration of metals, major ions and nutrients in the freshwater sediment at each site are likely to be due to site-specific geology (i.e. mineral-rich soils in the relevant catchment).

4.4.3.3 Marine Surface Waters

Based on the survey results, the quality of marine surface waters within the survey area were assessed as moderate to good, and typical of tropical inshore waters. Marine surface water quality of the survey area was primarily related to rainfall and site-specific geology; although land use (e.g. clearing for village gardens and commercial logging) and human activities (e.g. waste disposal) influenced the water quality at some sites.

Turbidity in marine waters was generally low during the baseline survey; however, turbidity was higher following periods of heavy rainfall. The Kuakula River mouth delivers the highest sediment loads to marine waters within the survey area. Sediment-laden runoff from rivers was likely due to upstream clearing for logging roads and village gardens.

Metals were detected in the water at all sites in varying concentrations; the metals detected were generally naturally abundant elements. Concentrations of cobalt, copper, zinc, chromium and nickel were above the guideline ranges at several sites.

The quality of the marine sediments within the survey area is generally good. However, sediment quality was moderately poor at sites in Huali Bay and Takata Bay, near the Koloseeru River mouth due to high concentrations of several metals, and at the Midoru logging camp due to high concentrations of nutrients and the presence of petroleum hydrocarbons.

4.4.4 Potential Impacts

4.4.4.1 Construction Phase

Construction of the mine areas and supporting infrastructure has the potential to result in the following impacts to freshwater surface water quality:

- Increased turbidity and subsequent sedimentation due to vegetation clearing, earthworks and construction of waterway crossings.
- Loss of catchment area and changes to freshwater flows due to the construction of the mine area, water storage facility, ponds for sediment capture and supporting infrastructure, including installation of water crossings.
- Spills of hydrocarbons and other potential contaminants from operation of vehicles and mine machinery.
- Increased litter and waste entering streams and rivers.

Port construction activities are likely to include excavation, spoil handling, pile driving and reclamation. These activities have the potential to result in the following impacts to marine surface water quality:

- Increased turbidity and subsequent sedimentation due to port construction activities (listed above) and runoff from construction of waterway crossings, vegetation clearing, earthworks and other mining activities.
- Nutrient enrichment through stormwater runoff and disturbance of nutrient-rich marine sediment during excavation and reclamation for the port facilities.
- Disturbance of acid sulphate or potential acid sulphate sediment or contaminated sediment if excavation and reclamation is undertaken for the port facilities.
- Spills of hydrocarbons and other potential contaminants from operation of vehicles, mine machinery, port vessels and inadequate storage facilities.
- Increased litter and waste entering marine waters.

4.4.4.2 Operations Phase

Operation of the mine and supporting infrastructure has the potential to result in the following impacts to freshwater surface water quality:

- Increased turbidity and subsequent sedimentation due to vegetation clearing and earthworks.
- Loss of catchment areas and changes to freshwater flow.
- Spills of hydrocarbons and other potential contaminants from operation of vehicles, mine machinery and inadequate storage and handling.
- Nutrient enrichment through stormwater runoff and discharge of wastewater.
- Acid mine drainage and associated loss of aquatic life.
- Increased litter and waste entering streams and rivers.

Port operation has the potential to result in the following impacts to marine surface waters:

- Increased turbidity and subsequent sedimentation due to suspension of fine sediments by vessels.
- Spills of hydrocarbons, nickel ore and other potential contaminants, including potential risk of spills if vessels are grounded.
- Increased leaching of antifoulant paints due to increased vessel traffic around port areas and potential grounding of vessels.
- Increased litter and waste entering marine waters.

Further details on potential impacts are available in the Impact Assessment Report – Surface Water Quality and Flows.

4.4.5 *Impact Assessment*

Table 4-6 Assessment of Potential Impacts on Freshwater Surface Water Quality

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Increased turbidity and subsequent sedimentation	•	•		•	•	•	Negative	Local	High	Long	Highly Probable	High	High	Standard best practice approach for erosion and sediment control measures implemented for design, construction and operation of mine and supporting infrastructure. Staging vegetation clearing and earthworks. Progressively rehabilitating and revegetating post-mine landforms.	Medium to High[1]	Medium
Loss of catchment area	•	•		•	•	•	Negative	Local	Medium to High	Medium to Long	Highly Probable	Medium to High	Medium to High	Use a standard best practice approach for the construction and maintenance construction and maintenance of drainage lines and gullies, including appropriate design and installation of culverts in stream barriers. Remediation of catchments.	Low to Medium	Medium
Changes to flow regimes	•	•		•	•	•	Negative	Local	Medium	Long	Highly Probable	Medium	Medium	Use a standard best practice approach for the design, construction and maintenance of drainage lines and gullies, including appropriate design and installation of culverts in stream barriers. Discharges from sediment control dams to coincide with natural flows. Remediation of catchments.	Low	Medium
Spills of hydrocarbons and other potential contaminants														Develop and implement a management plan for fuel, oil, ore and chemical handling in accordance with international standards and guidelines including optimising volume of stored fuel, secure storage and control measures for stockpile runoff.)		
Hydrocarbons	•	•		•	•	•	Negative	Local	High	Long	Probable	High	High		Medium	Medium
Nickel ore	•	•				•	Negative	Local	Medium	Long	Probable	Medium	Medium		Medium	Medium

Table 4-6 Assessment of Potential Impacts on Freshwater Surface Water Quality

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Nutrient enrichment	•	•		•	•	•	Negative	Local	Low	Medium	Probable	Low	Low	Best practice approaches to erosion and sediment control and treatment of wastewater to WHO standards.	Low	Medium
Acid mine drainage	•				•	•	Negative	Local	High	Long	Probable	High	High	Rigorous testing of sediments to be disturbed by mining areas. Development of an acid mine drainage management plan where necessary, based on accepted best practices, including: specialised handling procedures for potentially acid generating materials, amendments or additives and effective surface water management.	Medium	Low
Litter and waste	•	•	•	•	•	•	Negative	Local	Low	Long	Highly Probable	Low	Low	Design and implement a plan that uses current international best practice approach for litter/waste disposal and storage.	Low	Medium
Impacts to freshwater surface water quality in protected areas and hunting/fishing areas downstream of mining activities	•	•		•	•	•	Negative	Local	Medium to High	Medium to Long	Highly Probable	Medium to High	Medium to High	Implementation of mitigation measures described for impacts relating to: increased turbidity and sedimentation, loss of catchment area and changes to flow regimes, spills of hydrocarbons, nickel ore and other contaminants, acid mine drainage and litter/waste.	Medium	Medium

[1] Significance of impact will be refined following additional monitoring of potentially impacted ecosystems.

Table 4-7 Assessment of Potential Impacts on Marine Surface Water Quality

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Increased turbidity and subsequent sedimentation	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High	Standard best practice erosion and sediment control measures implemented for design, construction and operation of mine, ports (including dredging and spoil handling) and supporting infrastructure. Development and implementation of a dredge management plan.	Medium to High[1]	High
Spills of hydrocarbons and other potential contaminants														Fuel, oil, ore and chemical handling to be undertaken in accordance with standard best practice including secure storage, control measures for stockpile runoff, and implementation of a handling and spill management plan.		
Hydrocarbons	•	•	•	•	•	•	Negative	Regional	High	Long	Probable	High	High		Medium	Medium
Nickel ore	•	•	•			•	Negative	Local	High	Long	Probable	High	High		Medium to High[1]	Medium
Nutrient enrichment	•	•	•	•	•	•	Negative	Local	Medium	Medium	Probable	Medium	Medium	Develop and implement a management plan for erosion and sediment control, stormwater management and treatment of wastewater to international standards.	Low	Medium

Table 4-7 Assessment of Potential Impacts on Marine Surface Water Quality

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Disturbance of contaminated marine and coastal sediments																
Acid sulphate or potential acid sulphate			•		•	•	Negative	Local	High	Long	Probable	Medium	Medium	Rigorous testing of marine and coastal sediments to be disturbed. Development of an acid sulphate management plan, where necessary.	Low to Medium[2]	Low
Other contaminants			•		•	•	Negative	Local	Medium	Long	Improbable	Medium	Low		Low [2]	Medium
Altered marine hydrodynamics and subsequent flushing, erosion and sedimentation			•		•		Negative	Local	Low	Long	Highly Probable	Low	Low	To be assessed during the design phase following model outputs by Project engineers.	Low	Medium
Antifoul leaching																
Copper			•		•	•	Negative	Local	Medium	Long	Probable	Medium	Medium	Restrictions on use of antifoulant paints containing tributyltin compounds in line with international standards and conventions. EMP to include plans to eliminate the introduction of tributyltin or copper compounds as a result of painting, paint removal, cleaning, sand blasting or waste disposal operations, or runoff from such facilities.	Low	Medium
Tributyltin			•		•	•	Negative	Local	Medium	Long	Probable	Medium	Medium		Low	Medium
Litter and waste	•	•	•	•	•	•	Negative	Regional	Low	Long	Highly Probable	Medium	Medium	Standard best practice approach to waste processing, disposal and storage.	Low	Medium

Table 4-7 Assessment of Potential Impacts on Marine Surface Water Quality

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to the Midoru Sea Fishing Area	•	•	•	•	•	•	Negative	Local	Low	Medium	Probable	Low	Low	Implementation of mitigation measures described for impacts relating to increased turbidity and sedimentation.	Low	Medium

[1] Significance of impact will be refined following additional monitoring of potentially impacted ecosystems.

[2] Significance of impact will be refined following additional sediment sampling

4.4.6 Mitigation Measures

The development of the EMP, and rigorous site management in accordance with current best practice offer significant opportunities to minimise potential impacts to surface waters. Details of mitigation measures are provided in Chapter 5 and the Impact Assessment Report – Surface Water Quality and Flows.

4.4.6.1 Increased Turbidity and Subsequent Sedimentation

4.4.6.1.1 Mines and Supporting Infrastructure

Mitigation measures to reduce the risk of impact associated with increased turbidity and sedimentation during mine construction and operation will consider standard practices, including:

- obtaining sign-off from a site supervisor that drainage and erosion control measures are in place prior to vegetation clearing and earthworks
- erosion and sediment control measures including drainage ditches, diversions, chutes, pocket ponds, infiltration trenches and ponds, sediment control ponds and dams, contour banks and ditches
- staging vegetation clearing and earthworks over the life of the mine
- sheeting haul rods with a target gradient of 1 in 10 to reduce erosion
- progressively rehabilitating and revegetating post mine landforms
- choosing dry periods, where possible, to conduct earthworks for construction of stream crossings or diversions
- capturing and containing mine water on-site in open mine areas to use for dust suppression, where possible
- using contour banks, ditches or similar structures across clear slopes to direct runoff towards surrounding vegetation and away from streams
- ensuring washdown facilities are provided for heavy equipment and light vehicles in a stand-alone facility and that residual wastes are collected and removed to the Project landfill or an accredited facility
- using progressive rehabilitation and revegetation

4.4.6.1.2 Port Areas

Mitigation measures to reduce the risk of impact associated with increased turbidity and sedimentation during port construction and operation will consider standard practices, including:

- port design, construction and operation including sediment control measures, such as a network of open drains to direct surface water to sediment control ponds (which will be unlined and include a filter dam, spillway and dewatering system) and vehicle wash facilities
- reducing sediment-laden runoff and turbidity in streams
- if excavation and reclamation work is required:
    - developing and implementing a management plan (as part of the EMP) with pre-determined ‘cease work’ trigger values for turbidity
    - effectively isolating sediment disturbance areas

4.4.6.2 Loss of Catchment Area and Changes to Flow Regimes

Mitigation measures to reduce the risk of impact associated with loss of catchment area will consider standard practices, including:

- constructing and maintaining drainage lines and gullies
- coinciding discharges from sediment control dams with natural flows
- remediation of catchments.

Mitigation measures to reduce the risk of impact associated with changes to freshwater flow regimes will consider standard practices, including:

- appropriate design and installation of culverts in stream barriers
- maintaining drainage lines, gullies and culverts.

4.4.6.3 Spills of Hydrocarbons, Nickel Ore and Other Potential Contaminants

4.4.6.3.1 Hydrocarbons and Other Potential Contaminants

Mitigation measures to reduce the risk of impacts associated with spills of potential contaminants during mine construction and operation will consider standard practices, including:

- developing and implementing a materials handling and spill management plan
- immediate containment and clean-up of any fuel, oil or chemical spills using spill kits that will be available on site
- recording hydrocarbon losses and all spills over 20 L and promptly reporting these incidences to the mine's Environmental Officer
- optimising the volume of stored fuel, oil or chemicals, with stores located in secure areas
- providing washdown facilities for light vehicles and machinery
- providing secondary containment of stored fuels, oils and lubricants.
- providing automatic shut off of nozzles on fuelling equipment.

4.4.6.3.2 Nickel Ore

Mitigation measures to reduce the risk of impact associated with spills of nickel ore during mine operation will consider standard practices, including:

- designing drainage around stockpiles to prevent stockpiles from being inundated with stormwater during rainfall events
- implementing stockpile runoff control measures in accordance with the sediment and erosion control plan, such as a network of open drains to direct surface water to sediment control ponds.

4.4.6.4 Nutrient Enrichment and Other Contaminants

4.4.6.4.1 Stormwater Run-off and Wastewater Management

Mitigation measures to reduce the risk of impacts associated with nutrient enrichment and other contaminants associated with stormwater run-off and wastewater management will consider standard practices, including:

- retaining stormwater as noted in Section 4.4.6.1
- controlling erosion during vegetation clearing and earthworks as outlined
- treating wastewaster in accordance with WHO standards.

4.4.6.4.2 Sediment Disturbance

Mitigation measures to reduce the risk of disturbing nutrient rich sediments or contaminated sediments in port areas are as follows:

- any required sediment disturbance for the port development follows mitigation measures from Section 4.4.6.1.2
- stormwater is retained in accordance with mitigation measures outlined in Section 4.4.6.1.2
- erosion is controlled during vegetation clearing and earthworks as outlined in Section 4.4.6.1.1

4.4.6.5 Acid Mine Drainage

Rigorous testing of the sediments to be disturbed by mine areas will be undertaken, and where necessary, an acid mine drainage management plan will be implemented based on recommendations in the Global Acid Rock Drainage Guide (International Network for Acid Prevention [INAP] 2009).

Mitigation measures to reduce the risk of impacts associated with the formation and transport of acid mine drainage and metal leaching may include:

- specialised handling procedures for potentially acid generating materials
- amendments or additives on potentially acid generating waste rock, such as limestone, organic materials or bactericides, and effective surface water management.

4.4.6.6 Disturbance of Acid Sulphate or Potential Acid Sulphate Sediment

Mitigation measures to reduce the risk of impact associated with acid sulphate soils will consider standard practices, including:

- rigorous testing of the marine sediments to be disturbed
- development of an acid sulphate sediment management plan, where necessary.

4.4.6.7 Altered Marine Hydrodynamics and Subsequent Flushing, Erosion and Sedimentation

Mitigation measures to reduce the risk of impact associated with altered marine hydrodynamics will include port design and development of the EMP. The extent of impact will be assessed during the detailed design phase.

4.4.6.8 Antifoul Leaching

Mitigation measures to reduce the risk of impact associated with antifoul leaching will consider standard practices, including:

- restricting the use of antifoul paints containing tributyltin compounds
- management plans that eliminate the introduction of tributyltin compounds as a result of painting, paint removal, cleaning, sandblasting or waste disposal operations, or run-off from such facilities (IMO 2002).

Further analysis of marine sediments proposed for disturbance will be completed during the detailed design phase, to determine the current concentration (if any) of antifoulant contaminants in sediments of the proposed port areas.

4.4.6.9 Litter and Waste

Mitigation measures to reduce the risk of impact associated with litter and waste will consider standard best practices, including:

- designated areas for holding of refuse
- appropriate disposal as described in Section 4.13.

4.4.6.10 Surface Water Quality and Flow Monitoring

Monitoring programs will be designed to detect changes in *in situ* water quality, water flow, and the concentration of potential contaminants in the water column and sediment, and compliment freshwater and marine ecology monitoring where practical.

Water quality and flow will be monitored in accordance with best practice and will be based on the baseline survey methods as outlined in the Impact Assessment Report – Surface Water Quality and Flows.

Monitoring will be undertaken during both construction and operation, and after operation until conditions return to background (i.e. that established by the baseline survey and/or prior to disturbance). Monitoring will inform management of potential issues and refine the EMP.

4.4.6.10.1 Turbidity Monitoring During Construction of Mining Area and Infrastructure

Monitoring of turbidity will be undertaken for streams downstream of sediment disturbance such as clearing for roads and mining activities, and when constructing permanent or temporary stream crossings.

4.4.6.10.2 Turbidity Monitoring During Port Construction

During sediment disturbance (including for during port construction (e.g. pile driving), the extent of the turbidity plume will be monitored to confirm that plumes do not reach ecologically sensitive areas including coral reefs (growing at most river mouths) or have a negative sustained impact on seagrass (growing at some river mouths). Should plumes reach and are sustained at pre-determined sensitive sites sediment disturbance will cease until turbidity returns to background levels.

4.4.6.10.3 Monitoring During Mine Operation

During mine operation, routine water and sediment quality monitoring will inform management of potential issues and allow the EMP to be refined. Recommended monitoring parameters include a suite of variables including (but not limited to) water temperature, turbidity, salinity, pH, dissolved oxygen, TSS, nutrients, total and dissolved metals, hydrocarbons and pesticides.

4.4.6.10.4 Sediment and Water Supply Dams

Water and sediment quality in the sediment control dams and water storage facility will be monitored to:

- confirm the suitability of the water for consumption/use
- confirm water quality in the event of release to the receiving environment.

The timing of monitoring may need to vary depending on the results and the season. For example, water quality will be more likely to vary during wet periods than during dry periods. As such, monitoring frequencies may need to be higher during wet periods than during dry periods.

4.4.6.10.5 Changes to Flow Regimes

Monthly monitoring of flow and water quality will be undertaken (or data loggers installed) in streams with potentially altered flows, that are downstream of areas exhibiting loss of catchment area due to mining activity and in association with stream barriers.

4.5 Groundwater

This section describes:

- the groundwater monitoring wells established in Isabel Tenement D and Isabel Tenement E
- the quality of groundwater resources in Isabel Tenement D and Isabel Tenement E
- the potential impacts of the Project on groundwater resources of Santa Isabel Island
- measures to mitigate potential impacts of the Project on groundwater resources.

Further details are provided in the Impact Assessment Report – Groundwater.

4.5.1 Standards Applied

The sampling, characterisation and objectives related to groundwater quality and its availability were based on consideration of the following standards and principles.

Sampling procedures and methods of analysis were based on:

- ISO 5667-1: 2006 Water quality - Sampling - Part 1: Guidance on the design of sampling programmes and sampling techniques.
- ISO 5667-3: 2003 Water quality - Sampling - Part 3: Guidance on the preservation and handling of water samples.
- ISO 5667-11: 2009 Water quality - Sampling - Part 11: Guidance on sampling of groundwaters.
- AS/NZS 2031: 2001 Selection of containers and preservation of water samples for microbiological analysis.
- Sampling guidelines from the Minimum Construction Requirements for Water Bores in Australia.

Groundwater quality laboratory results were characterised using:

- WHO Guidelines for Drinking Water Quality 4th edition (WHO 2011).
- Australian Drinking Water Standards (NHMRC and NRMMC 2011).

Groundwater quality and availability were in alignment with:

- IFC General EHS Guidelines.
- IFC EHS Guidelines for Mining.
- IFC EHS Guidelines for Water and Sanitation.

The following above IFC EHS objectives will ensure the Project:

- maintains adequate local water supply (of groundwater where applicable) for all human endeavours – direct consumption, agriculture, aquaculture, social amenity, and cultural amenity
- maintains 'pre-project' local water quality by appropriate planning and management of all discharges to receiving waters, including groundwater
- gives specific attention to the treatment of sanitary wastes, reducing wherever possible any existing high levels of faecal contamination.

4.5.2 Methodology

Existing drill holes were field surveyed in October 2011. A total of eight drill holes were identified for groundwater monitoring well conversions and were installed October to November 2011. Three rounds of sampling activity for the eight monitoring wells were conducted from December 2011 to February 2012. The monitoring wells were spread across the Project area to ensure that representative mine areas were sampled.

In addition to the eight monitoring wells, spring water from three villages (Leleghia, Lepi in Isabel Tenement D and Midoru in Isabel Tenement E) was also sampled. Spring water is groundwater originating from fractured rocks that meet the surface typically at slopes. The spring waters sampled are also sources of community water for other nearby villages. Figure 4-16 shows the locations of groundwater monitoring wells and sampling points for Isabel Tenement D and Isabel Tenement E.

Further details on the installation and monitoring of groundwater wells, including *in situ* and laboratory analysis of groundwater and tap water samples are provided in the Impact Assessment Report – Groundwater.

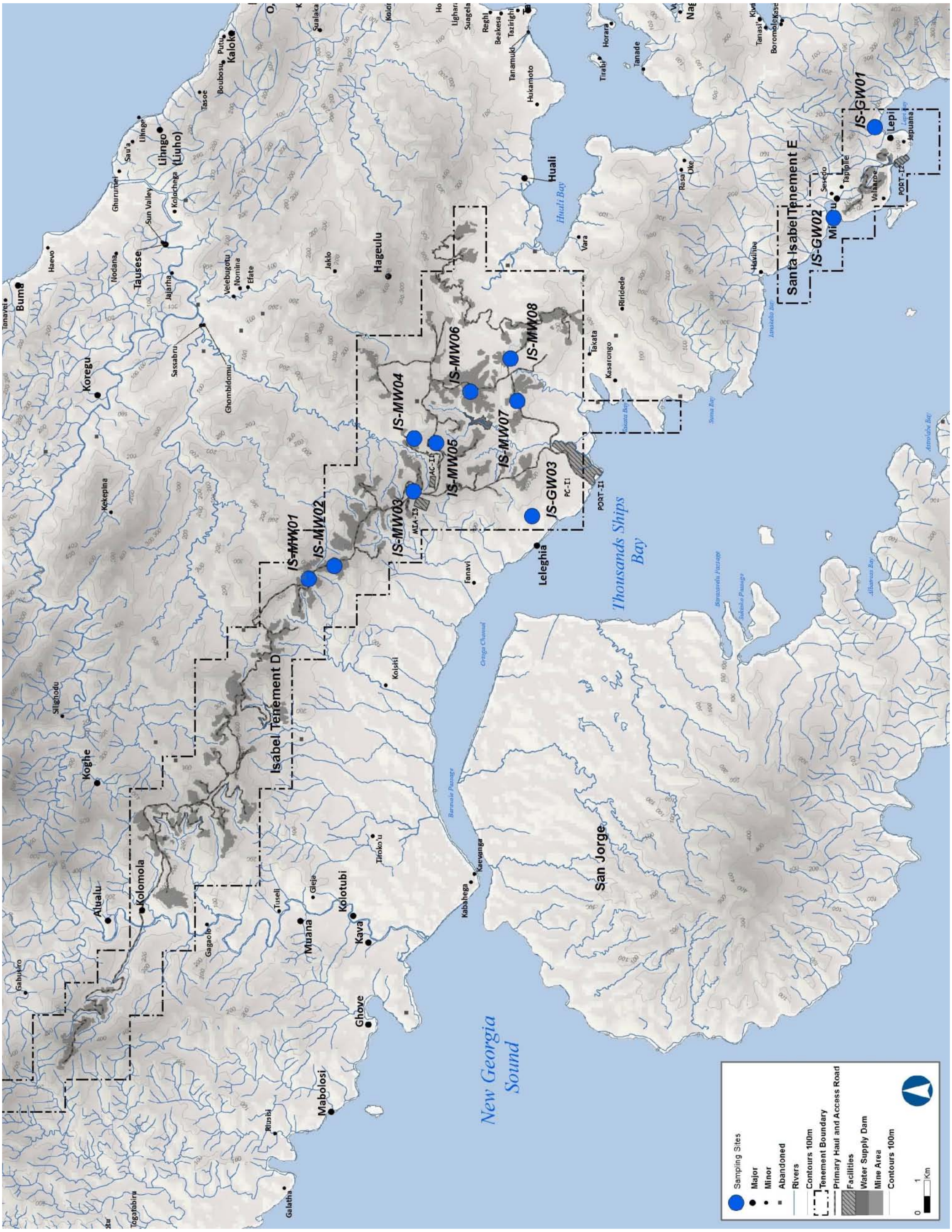

Figure 4-16 Monitoring Well and Groundwater Sampling Locations for Isabel Tenement D and Isabel Tenement E

4.5.3 Existing Values

The topography of the land defines the physical limit of groundwater resources for Santa Isabel Island. The numerous ridges and network of rivers have contributed to the formation of discontinuous aquifers or groundwater systems. The steep gradient also contributes to fast groundwater flows and deep groundwater lenses below the land's surface.

The chemical composition of the groundwater is the result of the composition of the water that enters the groundwater aquifer and the chemical reactions that occur with the minerals present in the water bearing zone of the reservoir rock (Jordana and Batista 2004).

4.5.3.1 In situ Parameters

Groundwater was sourced at depths of 0.54 to 18.72 m from the top of each well. The static water level (SWL) in monitoring wells IS-MW01and IS-MW02 fluctuated by 2.57 m, IS-MW03 by 2.23 m, IS-MW06 and ISMW-9 by 1.99 m with the remaining monitoring wells having water fluctuations less than 1.25 m.

Groundwater pH of 6.2 to 7.7 was generally within the guideline range (6.5 - 8.5).

Groundwater temperature varied from 24 to 29°C.

The concentration of total dissolved solids was within the acceptable range for groundwater samples from all monitoring wells.

The concentration of dissolved oxygen ranged between 1.61 mg/L and 8.63 mg/L.

4.5.3.2 Laboratory Analytical Results

Laboratory results from the three rounds (December 2011, January 2012 and February 2012) of groundwater sampling from monitoring wells (IS-MW01 to IS-MW08) and spring water sites (IS-GW0, IS-GW02, IS-GW03) are represented in Table 4-8, summarised below.

Table 4-8 Groundwater Quality Physical Data

Sample ID	Australian Drinking Water Standard 2000	MW01			MW02			MW03			MW04		
Date Sampled	**Acceptable Ranges**	**2 Dec 2011**	**23 Jan 2012**	**24 Feb 2012**	**7 Dec 2011**	**23 Jan 2012**	**24 Feb 2012**	**7 Dec 2011**	**23 Jan 2012**	**24 Feb 2012**	**3 Dec 2011**	**24 Jan 2012**	**25 Feb 2012**
Static Water Level (meters from top of well)	No prescribed limits	**7.4**	**9.97**	**8.82**	**18.72**	**15.97**	**17.85**	**7.19**	**4.86**	**5.15**	**3.80**	**4.72**	**3.70**
DO, mg/L	No prescribed limits	7.84	7.63	6.78	3.51	1.61	2.17	8.36	3.86	5.17	8.87	4.23	5.17
		6.50	7.79	6.56	3.38	1.62	1.85	8.33	3.88	4.68	8.08	3.54	3.25
		7.20	7.54	7.12	3.17	1.57	3.17	7.15	3.75	5.13	7.88	3.21	3.54
Average		**7.18**	**7.65**	**6.82**	**3.35**	**1.60**	**2.40**	**7.95**	**3.83**	**4.99**	**8.28**	**3.66**	**3.98**
EC, µS/cm	No prescribed limits	56.3	63.7	75.4	194.2	215.0	184.5	164.4	125.4	154.3	54.6	76.8	68.5
		59.4	66.8	73.2	216.0	379.90	178.6	171.1	125.3	157.3	56.1	77.4	67.9
		60.6	67.2	69.3	190.0	369.90	189.3	160.6	124.9	146.3	57.5	78.3	64.3
Average		**58.76**	**65.9**	**72.63**	**200.06**	**376.13**	**184.13**	**165.37**	**125.2**	**152.63**	**56.07**	**77.5**	**66.9**
TDS, mg/L	<80 - Excellent	36.65	48.3	57.8	146.75	238.90	143.2	123.5	101.7	89.5	33.4	60.1	57.4
	80-500 - Good	40.39	44.5	62.3	156.2	240.70	143.2	125.7	95.6	99.4	37.8	59.3	50.2
		46.90	47.3	59.7	156.4	234.90	135.6	118.7	120.3	100.3	39.8	58.4	48.5
Average		**41.31**	**46.7**	**59.93**	**153.11**	**238.17**	**140.67**	**122.63**	**105.87**	**96.4**	**37.0**	**59.27**	**52.03**
Temperature °C	No prescribed limits	24.7	24.3	27.5	25.2	24.9	27.3	25.4	25.6	25.3	26.3	27.3	27.1
		24.4	24.2	27.1	24.9	25.0	27.1	25.3	25.5	26.4	26.7	27.3	26.9
		25.4	24.5	26.8	25.1	24.1	27.0	25.9	25.5	26.5	27.1	27.1	26.8
Average		**24.83**	**24.33**	**27.13**	**25.07**	**24.67**	**27.13**	**25.53**	**25.53**	**26.07**	**26.7**	**27.23**	**26.93**
pH	6.5-8.5	7.45	7.15	7.18	7.21	6.98	7.15	6.66	7.15	7.13	6.63	7.01	7.12
		7.35	7.18	7.21	7.07	7.12	7.15	6.65	7.27	7.23	6.60	7.15	7.02

Sample ID	Australian Drinking Water Standard 2000	MW01			MW02			MW03			MW04		
		7.25	7.21	7.15	7.18	7.19	7.12	7.01	7.11	7.20	6.58	7.16	7.04
Average		**7.35**	**7.18**	**7.18**	**7.15**	**7.10**	**7.14**	**6.77**	**7.18**	**7.18**	**6.60**	**7.11**	**7.06**
Static Water Level (meters from top of well)	No prescribed limits	**1.30**	**2.54**	**1.95**	**8.7**	**10.69**	**9.51**	**5.84**	**5.80**	**5.77**	**2.53**	**0.99**	**0.54**
DO, mg/L	No prescribed limits	7.02	3.10	4.32	8.25	2.68	3.12	8.26	8.26	7.15	7.60	4.12	6.17
		6.98	3.26	4.13	8.63	2.64	3.14	7.87	7.87	7.83	6.74	2.98	6.55
		6.15	3.48	3.98	7.89	2.60	3.17	7.60	7.60	7.56	6.55	3,54	7.13
Average		**6.72**	**3.28**	**4.14**	**8.26**	**2.64**	**3.14**	**7.91**	**7.91**	**7.51**	**6.96**	**3.55**	**6.62**
EC, µS/cm	No prescribed limits	43.20	34.70	54.3	88.00	108.00	98.5	33.20	33.20	86.5	21.60	55.1	67.5
		44.80	34.70	47.5	88.50	108.50	99.5	33.40	33.40	87.4	22.20	54.9	69.4
		48.90	32.90	48.7	86.90	108.70	97.9	34.10	34.10	89.5	22.40	55.2	72.3
Average		**45.63**	**34.10**	**50.17**	**87.80**	**108.40**	**98.6**	**33.57**	**33.57**	**87.8**	**22.07**	**55.07**	**69.73**
TDS, mg/L	<80 - Excellent	23.4	26.5	26.7	53.2	84.3	78.6	23.4	21.6	25.4	14.3	38.6	43.5
	80-500 - Good	25.4	27.6	28.6	56.4	76.5	79.4	21.4	21.9	27.8	16.7	39.5	45.6
		26.5	28.5	28.9	55.6	79.8	78.9	21.7	21.5	29.4	15.4	45.2	46.7
Average		**25.1**	**27.53**	**28.07**	**55.07**	**80.2**	**78.97**	**22.17**	**21.67**	**27.53**	**15.47**	**41.1**	**45.27**
Temperature°C	No prescribed limits	25.20	24.90	27.1	26.50	26.00	27.5	28.10	26.60	27.1	28.70	27.2	28.1
		25.10	24.70	26.8	26.30	26.00	26.9	28.40	26.90	26.9	28.90	27.2	28.4
		24.10	25.30	28.6	26.50	26.10	28.0	28.00	26.80	26.8	29.00	27.0	27.9
Average		**24.80**	**24.97**	**27.5**	**26.43**	**26.03**	**27.47**	**28.17**	**26.77**	**26.93**	**28.87**	**27.13**	**28.13**
pH	6.5-8.5	6.17	7.17	7.11	7.27	7.11	7.11	6.35	7.34	7.12	7.27	7.12	7.15
		6.38	7.19	7.11	7.27	7.11	7.11	6.35	7.34	7.12	7.27	7.12	7.68
		6.25	7.12	7.13	7.06	7.18	7.15	6.29	7.27	7.15	7.09	7.15	7.56

Sample ID	Australian Drinking Water Standard 2000	MW01			MW02			MW03			MW04		
Average		**6.27**	**7.16**	**7.08**	**7.17**	**7.36**	**7.14**	**6.29**	**7.29**	**7.13**	**7.13**	**7.10**	**7.46**

Notes:

SWL - Static Water Level; mTOW - meters from top of well; GME - Groundwater Monitoring Event; n/a - not applicable

Concentrations of dissolved arsenic, barium, chromium, cobalt, copper, manganese, zinc and tin detected in monitoring wells or spring samples were below guideline values.

Concentrations of dissolved boron, beryllium, molybdenum, selenium, vanadium and mercury were below the laboratory limits of reporting at all sites.

Concentrations of other dissolved metals that exceeded their respective guideline values included:

- Aluminium in IS-MW03 and IS-MW04 for January 2012 sampling.
- Cadmium in IS-MW08 for December 2011 sampling.
- Chromium in IS-MW03 and IS-MW04 for January 2012 sampling.
- Lead in IS-MW02 and IS-MW04 for December 2011 and February 2012 sampling. IS-MW04 for January 2012 and MW05 for December sampling.
- Nickel in IS-MW01 and IS-MW04 for all three sampling events. IS-MW03 in February 2012 sampling, IS-MW06 in January and February 2012 sampling, and IS-MW07 in December 2011 and January 2012 sampling.

None of the average concentrations of any of the parameters analysed exceeded the guideline value except for nickel. The high nickel concentrations are natural and characteristic of the baseline groundwater conditions.

Alkalinity was below the guideline range for all groundwater and spring water samples.

4.5.4 Potential Impacts

The following components of the Project have the potential to impact the quality of groundwater for potable use:

- Construction and operation of the nickel mine and supporting infrastructure, including:
  - Mine areas
  - Stockpile and lay down areas
  - Water and sewage treatment facilities and stormwater management facilities
  - Water supply facilities
  - Water storage dams for contaminated water
  - Fuel and hazardous chemicals (reagents) storage facilities
  - Landfill disposal of general refuse.
- Construction and operation of port areas, including:
  - Limonite and saprolite ore stockyards
  - Oil-water separator and a sediment pit
  - Service buildings
  - Material storage areas for imported bulk material and export waste, which includes fuel and diesel storage tanks, and hazardous wastes storage containers.

Project construction and operation activities that have the potential to impact the quality of groundwaters are outlined in the following sections.

4.5.4.1 Chemicals of Potential Concern to Groundwater Systems

Intrusion of contaminants of potential concern (e.g. hydrocarbons, industrial lubricants and reagents, and other wastes) can cause a decline in groundwater quality and can alter groundwater flow, depth and hydraulic conductivity. Intrusion of contaminants can directly affect villages that utilise potable groundwater (including future users) and can affect the quality of surface waters downstream from groundwater springs.

4.5.4.1.1 Hydrocarbons

Spills of fuel and maintenance oil used to supply generators to power the accommodation camp and for operation of vehicles, helicopters, boats, heavy equipment and port vessels may impact groundwater. Spills of hydrocarbons on soils can percolate down to shallow groundwaters, creating a stagnant or migrating phase-separated hydrocarbon and/or dissolved plume.

Cracks and openings in soil (such as open drill holes) can facilitate the incursion of hydrocarbons into groundwater, whereas the impervious base rock below the top soil may contain and prevent deeper intrusion of contaminants into deeper substrata. During exploration drilling, base rock was encountered at 2.7 to 26.7 m below the ground surface. No permeable layer was observed below the bed rock.

Phase-separated and dissolved hydrocarbons in groundwater can disseminate widely over time. Whilst remediation is possible, its success is a factor of the geology, volume of spill and depth to groundwater.

4.5.4.1.2 Other Waste Materials

Sludge collected from the wastewater treatment plants and oil-water separators can contain high concentrations of potential contaminants. Solvents, chemicals and maintenance workshop wastes may also be potential sources of contaminants to groundwater if spills occur over soils.

4.5.4.2 Groundwater Flow Alteration

The stripping or removal of overburden and topsoil, and building the Project facilities, can alter the direction of groundwater flow by causing a downward stress on groundwater aquifers.

4.5.5 Impact Assessment

An assessment of potential impacts on groundwater quality and flow is presented in Table 4-9.

Table 4-9 Assessment of Potential Impacts on Groundwater

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance No Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Chemicals of Potential Concern (COPCs) such as waste fuel, industrial lubricants, motor oils, paints, and other hydrocarbons may accidentally be spilled, percolate through the soil, and affect groundwater quality by changing the baseline values of physico-chemical parameters measured.		•	•	•	•	•	Negative	Local	Medium	Medium to Long Term	Probable	Medium	Medium	Spillages will be prevented through implementation of the SMM Solomon Waste Management Plan and work practices that involve collection of COPCs, installation of bunds, and Groundwater monitoring. Refer to Section 4.5.6.	Low	High
Groundwater flow may be temporarily reduced due to earthmoving activities and groundwater use during construction.		•		•	•	•	Negative	Local	Medium	Short Term	Probable	Medium	Medium	Progressive rehabilitation will be carried out to maintain or restore natural groundwater flow. Refer to Section 4.5.6.2.	Low	High
Groundwater flow may be temporarily reduced and altered due to mining in areas where groundwater is shallow.	•					•	Negative	Local	Medium	Short to Long Term	Probable	Medium	Medium	Progressive rehabilitation will be carried out to maintain or restore natural groundwater flow. Groundwater monitoring will also be conducted to monitor flow. Refer to Section 4.5.6.2 and 4.5.6.3.	Low	

4.5.6 *Mitigation Measures*

The development of the Environmental Management Plan and rigorous site management in accordance with current best practice offer significant opportunities to minimise potential impacts to groundwater.

4.5.6.1 *Prevention of Groundwater Contamination*

The introduction of contaminants into groundwater will be prevented by:

- periodically checking equipment and machinery for leaks
- placing drip pans underneath equipment to collect hydrocarbon leaks or unavoidable motor oil drips
- fitting drill holes or groundwater monitoring wells with non-reactive covers when not in use
- implementing a Waste Management Plan to prevent spillages of wastes
- constructing bunds around fuel storage areas to contain 110% of the maximum capacity of the largest storage tank or container of hydrocarbons or waste fuel
- implementing a Spill Prevention Plan
- placing smaller fuel, oil and/or lubricant containers within secondary containment systems
- maintaining equipment to minimise or eliminate fuel and oil leaks.

4.5.6.2 *Progressive Rehabilitation*

Natural groundwater flow will be maintained and restored by restoring soil cover and allowing water to infiltrate the substrate. Progressive rehabilitation measures will be carried out during construction and operation of the mine areas and facilities. Mining will occur in panels, with excavated soils set aside. These soils will be pushed and dozed onto a mined-out parcel to allow revegetation to occur. In cases where soil volume is insufficient to backfill the mined areas to the natural slope, the soils will be stabilised.

4.5.6.3 *Groundwater Monitoring Plan*

Following the completion of the groundwater baseline dataset, a trending analysis will be performed to establish the baseline condition and quality of groundwater in the Project area.

A Groundwater Monitoring Plan will also be utilised and regularly updated based on the results of groundwater monitoring where necessary (refer to Chapter 5).

Additional groundwater monitoring wells will be installed near the landfill and waste water treatment facilities to monitor groundwater quality, depth and flow over the course of the construction and operations phase.

4.5.6.4 *Remedial Alternatives*

The following remediation strategies can be applied to clean up toxicants in groundwater, should it be required:

- installation of a pump and treat system
- installation of a multi-phase extraction system
- biological remediation
- remediation via monitored natural attenuation
- dig and haul.

4.6 Community Water Supply

The section describes:

- existing water sources, collection and supply systems in communities located within and adjacent to the Project area.
- current water usage and needs, and future requirements.
- existing water quality of the community water supply sources in terms of aesthetics, bacterial, chemical and bio-physical characteristics.
- potential impacts on community water from the Project activities.
- mitigation measures to protect community water from the identified potential impacts.

4.6.1 Regulatory Agencies

The following regulatory agencies are involved in managing water resources and providing safe drinking water and sanitation in the Solomon Islands:

- Water Resources Division of the Ministry of Mines, Energy and Rural Electrification manages the country's water resources.
- Environmental Health Division of the Ministry of Health and Medical Services implements the Rural Water Supply and Sanitation Program that provides safe water and sanitation to rural communities.
- Solomon Islands Water Authority is in charge of servicing safe water and providing wastewater treatment to urban population.

4.6.2 Standards Applied

The resources were used to interpret results or surveys or indirectly referenced in the formulation of mitigation measures or applicable best practices for the protection of community water sources in the Project impact areas.

- In the absence of water quality guidelines in the Solomon Islands, World Health Organization – Guidelines for Drinking Water Quality, 2011 (WHO-GDWQ 4th Edition 2011) were referenced for bacteriological, bio-physical and chemical constituents present in water samples taken from representative drinking water sources. Earlier versions (WHO-GDWQ 3rd Edition, 2004 and WHO-GDWQ 2nd Edition, 1997) were utilized for the selection of sampling sites and evaluating the results against guideline values.
- International Organization for Standardization, is the largest developer and publisher of international standards. Applicable to water and community are the following standards:
    - ISO 5667-1:2006 Water quality – Part 1: Guidance on the design of sampling programmes and sampling techniques
    - ISO 5667-5:2006 Water quality – Part 5: Guidance on the sampling of drinking water and water used for food and beverage processing
    - AS/NZS 2031:2001 Selection of containers and preservation of water samples for microbiological analysis
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) and Queensland Water Quality Guidelines (QWQG) (Queensland Department of Environment and Resource Management [DERM]), 2009 were used in the interpretation of the results of the surface water baseline study (Hatch, 2010).

4.6.3 Methodology

The existing valuation of community water supplies were described based on literature and secondary data reviews, such as baseline study reports prepared by Hatch in 2010 and 2011, the results of the water quality monitoring by SMM Solomon, and other technical documents including Impact Assessment Reports prepared for this EIS to characterise community water supply.

This information was supported by results of key information interviews, stakeholder consultations and workshops, visual surveys and walk-throughs. Villages surveyed included Koghe, Lepi, Kolomola, Tatamba, Huali, Leleghia, Kolotubi, Koisisi, Midoru, Alu Alu, Tausese, Silighodu and Fanavi.

The community water sampling program occurred in November 2011 and February 2012. Site selection was based on the following information:

- best international practice standards
- information from the baseline study report
- hydrological desktop survey of the proposed infrastructure works and their potential impacts on the water catchments
- input from the social impact assessment and cultural heritage team specialists
- site visit surveys.

Drinking water quality monitoring stations were located in the following villages: Lepi, Japuana, Midoru, Sesedo, Gagaolo, Kolomola, Fanavi, Leleghia, Takutu and Tanatahi.

Field sampling collection was in accordance with ISO and AS/NZS standards. Analysis of chemical parameters was done at the ALS Laboratory in Brisbane, Australia (accredited by the National Association of Testing Authorities, Australia (NATA) and to ISO 17025:2005). Bacterial samples were tested at an in-field laboratory due to the short time frame required for analysis and the remote location.

The equipment used to quantify total coliforms and *E. coli* (the Colilert test kit, supplied by IDEXX) was identified as the only commercial microbiological methods included in *Standard Methods for Examination of Water and Wastewater, 20th Edition*, a globally accepted industry standard.

Drinking water quality parameters were chosen based on the World Health Organization drinking water guidelines. Physical, microbial and chemical parameters were chosen to establish baseline community water conditions. Physical characteristics included the following:

- electrical conductivity / total dissolved solids
- turbidity or total suspended solids
- total organic carbon.

Microbacterial parameters include *E. coli* and total coliform.

Based on the geological composition of the soil, drinking water guidelines and best international practices, the following chemical analytes were tested from community water sources:

- dissolved metals and total metals, including aluminium, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, boron, iron
- dissolved mercury and total recoverable mercury
- hexavalent chromium
- total cyanide.

Surface water quality monitoring of 38 river sites on Santa Isabel Island (not necessarily used for drinking water) were assessed for location, width, depth, distance from the river mouth, speed, water clarity, sediment type, fish presence, vegetation type, and coral reef and bedrock presence. Water quality samples were also taken downstream. Of these 38 sites, 13 were chosen for annual monitoring.

The selection of monitoring sites was guided by the following:

- best international practice
- the results of the baseline study which took place in 2010
- hydrological desktop surveys of the proposed infrastructure works and their potential impact on the water catchments
- input from the social impact assessment and cultural heritage team findings
- community water surveys that took place in November-December 2011.

Water sources that are far from the communities were not selected because of associated time constraints and difficulty of access.

Table 4-10 lists the selected drinking water quality monitoring stations in Santa Isabel Island. The sampling sites are indicted in Figure 4-15.

Table 4-10 Drinking Water Quality Monitoring Stations on Santa Isabel Island

Community	Sampling Site / Sampling Point	GPS Coordinates (UTM style, m)	
		x (m)	y (m)
Isabel Tenement D			
Lepi	Source – Dam	585534	9061346
	Lepi – Tap 1	585364	9060988
	Lepi – Tap 2	585177	9060878
Japuana	Source – Dam	585351	9060402
	Tap	585406	9060338
Midoru	Tap	583057	9062442
Sesedo	Source – Dam	583265	9062151
	Tap	583368	9062472
Isabel Tenement E			
Gagaolo	Tap	561414	9081746
Kolomola	Tap	561535	9083278
Fanavi	Source – Stream	571700	9073740
Leleghia	Source – Stream	573472	9071840
	Tap	573233	9071666
Takutu	Tap	583081	9071749
Tanatahi	Source – Stream	582116	9073031

Groundwater monitoring occurred at sites throughout the tenements to establish the potential for groundwater to be used as an alternative drinking water supply for communities.

4.6.4 Existing Values

Approximately 65% of the rural population in the Solomon Islands has access to safe drinking water and 18% have access to sanitation services, such as toilets. Data provided on the regional level by the Buala Hospital indicated that 87% of the Santa Isabel Island population had access to sources of safe drinking water and 16% had access to sanitation services.

The quality of drinking water is a major concern in the Solomon Islands as surface water resources are susceptible to contamination. Demand for potable water and adequate sanitation coverage has increased as the population has grown.

4.6.4.1 Water Usage

Community water is mainly used for agricultural, industrial and domestic reasons. Subsistence farming is prevalent on Santa Isabel Island but farms are rain-fed, thus not drawing water from community water sources.

Small mining and logging camps and small manufacturing industries represent industries present in the province. No records of water usage exist, however industrial water demand is expected to increase as development continues.

Domestic water usage includes water for drinking, cooking, washing, laundry and sanitation. This is the most significant use of community water in the province.

4.6.4.2 Water Sources

Communities mostly depend on rainfall to replenish water supplies. Without substantial water storage reservoirs, many community members indicated that at times the taps ran dry and they were forced to seek out alternative water sources located at a distance from the village. Collection of rainwater in storage tanks is undertaken in some villages, but high capital outlay prevents widespread installation and use of such facilities.

4.6.4.3 Water Collection

Community water sources generally come from small streams located close to villages, generally from 200 m to 1 km. Water is collected in a number of ways.

- A dam or weir collects water from a small stream. A small diameter polyethylene pipe is inserted into the dam or weir and the water is gravity fed to the village
- In some villages, water is further conveyed into a distribution system. This typically consists of communal standpipes shared by 3 to 5 households. Some standpipes are fitted with valves to control flow, otherwise water flows freely.
- In some instances, community members fetch water in containers from taps or from streams.
- During rainfall events, community members indicated that they stored rainwater or previously collected water in small containers to avoid using the silty, muddy water from streams.

4.6.4.4 Water Quality

All water supply streams easily became silty and turbid during rainfall events.

Water samples tested for physical characteristics such as electrical conductivity, total dissolved solids, total suspended solids and total organic carbon are summarised below:

- Suspended solids for most samples were below the limit of reporting or undetected, except for those collected in Lepi (February 2012), Leleghia, Lepi and Midoru (November 2011)

- There is no guideline provided by WHO 2011 for electrical conductivity (EC) or total organic carbon (TOC). The highest EC reading was taken in Lepi (251 μS/cm, February 2012). The highest TOC result was taken in Fanavi (3 mg/L, February 2012).

E. coli (faecal coliforms) and total coliforms were present in all water samples tested, indicating faecal contamination of drinking water sources. The WHO guidelines for drinking water quality indicate that *E. coli* must not detectable in any 100-mL sample. Coliforms may be present and grow in biofilms in the drinking-water distribution systems including the polyethylene pipes that connect the water source to the village supply stand pipes. Ingestion of water of this quality may bring health risks. In the absence of specific studies, the number of health cases (morbidity or mortality) directly attributable to unsafe drinking water could not be confirmed.

Chemical parameters such as dissolved metals, total metals, dissolved mercury, total recoverable mercury, hexavalent chromium and total cyanide all fell below WHO 2011 guidelines.

No clear anthropogenic impacts on water quality were observed by the surface water quality baseline study. The majority of designated water quality parameters were within the applicable guidelines, except for *E.* coli (faecal coliforms) total nitrogen. This parameter was observed to be high at half of all survey sites, possibly due to agricultural runoff, sewage contamination and/or naturally high nitrogen content in the soils.

Some communities did not allow access during the second round of water sampling that occurred in February 2012.

Table 4-11 Bacterial Test Results of Community Water Samples Taken on Santa Isabel Island (November 2011)

Sample Name	Total Coliform	*E. coli*	Date Sampled	Date Counted
Lepi Village 2	>200.5	6.4	24-Nov	25-Nov
	>200.5	3.1	24-Nov	25-Nov
Japuana Tap	>200.5	47.8	24-Nov	25-Nov
	>200.5	42.9	24-Nov	25-Nov
Veranaue Stream	>200.5	15.0	24-Nov	25-Nov
	>200.5	16.4	24-Nov	25-Nov
Lepi Village 1	>200.5	94.5	24-Nov	25-Nov
	>200.5	78.2	24-Nov	25-Nov
Tanatahi Farm	>200.5	69.7	24-Nov	25-Nov
	>200.5	27.1	24-Nov	25-Nov
Lepi –Dam	>200.5	69.7	24-Nov	25-Nov
	>200.5	62.4	24-Nov	25-Nov
Japuana Source	>200.5	53.1	24-Nov	25-Nov
	>200.5	>200.5	24-Nov	25-Nov
Takutu – Tap	>200.5	27.1	24-Nov	25-Nov
	>200.5	19.2	24-Nov	25-Nov

Sample Name	Total Coliform	*E. coli*	Date Sampled	Date Counted
Sesedo – Dam	>200.5	4.2	23-Nov	24-Nov
	20.7	1.0	23-Nov	24-Nov
Sesedo – Tap	>200.5	1.0	23-Nov	24-Nov
	1.0	<1	23-Nov	24-Nov
Leleghia – Tap	78.2	28.8	23-Nov	24-Nov
	129.8	28.8	23-Nov	24-Nov
Midoru - Tap	>200.5	78.2	23-Nov	24-Nov
	56.0	36.4	23-Nov	24-Nov
Leleghia – Source	118.4	19.2	23-Nov	24-Nov
	-	-	-	-
Kolomola – Tap	>200.5	4.2	28-Nov	29-Nov
	>200.5	5.3	28-Nov	29-Nov
Gagaolo – Stream	>200.5	13.7	28-Nov	29-Nov
	>200.5	8.7	28-Nov	29-Nov
Kolomola - Source	144.5	4.2	28-Nov	29-Nov
	>200.5	3.1	28-Nov	29-Nov

- Indictates an equipment malfunction – incubation was interrupted hence results were ignored.

Table 4-12 Bacterial Test Results of Community Water Samples Taken on Santa Isabel Island (February 2012)

Sample Name	Total Coliform	*E. coli*	Date Sampled	Date Counted
Tanatahi Farm	165.2	38.4	28-Feb	29-Feb
	>200.5	38.4	28-Feb	29-Feb
Takutu – Tap	200.5	40.6	28-Feb	29-Feb
	>200.5	34.4	28-Feb	29-Feb
Lepi – Dam	>200.5	2.0	28-Feb	29-Feb
	>200.5	4.2	28-Feb	29-Feb
Lepi Village 1	200.5	8.7	28-Feb	29-Feb
	>200.5	6.4	28-Feb	29-Feb
Lepi Village 2	65.9	6.4	28-Feb	29-Feb
	47.8	6.4	28-Feb	29-Feb
Japuana – Dam	>200.5	101.3	28-Feb	28-Feb
	>200.5	8.7	28-Feb	29-Feb
Japuana – Tap[A]	-	-	-	-

Sample Name	Total Coliform	*E. coli*	Date Sampled	Date Counted
	200.5	13.7	29-Feb	1-Mar
Midoru – Tap	＞200.5	50.4	29-Feb	1-Mar
	＞200.5	15.0	29-Feb	1-Mar
Sesedo – Dam	25.4	7.5	29-Feb	1-Mar
	109.1	12.4	29-Feb	1-Mar
Sesedo –Tap[B]	47.8	1.0	29-Feb	1-Mar
	-	-	-	-
Tapipile – Tap	78.2	＜1	29-Feb	1-Mar
	144.5	3.1	29-Feb	1-Mar
Leleghia – Tap	＞200.5	33.8	29-Feb	1-Mar
	＞200.5	20.7	29-Feb	1-Mar
Leleghia – Source	＞200.5	35.4	29-Feb	1-Mar
	＞200.5	17.8	29-Feb	1-Mar
Fanavi - Source	＞200.5	40.6	29-Feb	1-Mar
	＞200.5	30.6	29-Feb	1-Mar

A – Sample was damaged in the tray sealer.

B – Sample was completely spilled in the esky while traveling back to camp.

4.6.5 *Potential Impacts*

Construction and operation of the facilities supporting the mining activities has the potential to impact the quality and quantity of community water supplies. The following sections summarise the potential impacts of the Project on community water.

4.6.5.1 Contamination by Hydrocarbons and Other Potential Contaminants

Community water supply sources may be contaminated by accidental spills from Project sites, particularly during periods of high rainfall. Construction materials and quantities of fuel and lubricants will be transported by trucks and barges. Improper handling and accidental spills of hydrocarbons and hazardous and chemical materials during construction and operations may affect the quality of surface water and groundwater. These may be transported through surface runoff during heavy rainfall or by percolation from soil surface to groundwater. Leachate from landfilled waste, if permeated to the soil, may also affect the aesthetics and physico-chemical compositions of water. Note that all the villages' primary sources of water are the streams and rivers that mostly have their headwaters inside the Project area.

Hydrocarbon contamination of community water via spills may alter water quality. Potential contamination of volatile compounds such as benzene, ethylbenzene, toluene and xylenes is of particular concern as these substances are carcinogens by nature. Oil sheens on water are an indication of potential hydrocarbon contamination and would render water unfit for drinking. As water is also used for bathing, washing and cleaning, excessive concentrations of hydrocarbons in water may cause irritation and discomfort upon contact.

4.6.5.2 *Contamination by Faecal Wastes, Litter, Food Scraps and Other Solid Wastes*

Faecal waste, litter, food scraps and other solid wastes from Project sites upstream of surface water sources have the potential to contaminate the community water supply sources. Contamination may also result from improperly maintained toilets and pit latrines, effluent discharges from wastewater treatment plants and solid wastes generated by humans.

Litter and waste may potentially impact the quality of drinking water and may become a viable habitat for bacteria strains that may have adverse effects on human health. Not only is the odour and taste affected, but also the microbial content, especially when domestic wastes have contact with the community water source. Decaying wastes can become a host to pathogens that may affect the quality of water.

4.6.5.3 *Increased Sedimentation or Turbidity*

Increase in sedimentation or turbidity in surface water and community water supply is expected to result due to earthmoving activities, vehicular and human traffic, and excavations. Some of the mining infrastructures and facilities will occur near streams and rivers. Construction of these facilities requires excavation and loose sediments (dusts) may be carried by air to the surface waters.

Heavy rainfall may cause surface runoff, carrying loose sediments towards the villages where nearby community water sources are located. Deposition of sediments makes the water turbid and unfit for drinking and consumption. Furthermore, many toxic organic chemicals, heavy metals and nutrients are physically and/or chemically adsorbed by clay, so an increase of sediment loading can also lead to increased deposition of these toxic substances. This can result in further negative impacts such as eutrophication, and potential adverse effects to human health where these surface waters are used for drinking.

4.6.5.4 *Competition for Water Sources*

Supply of water for the Project activities will be sourced from proximal watercourses. Supplementary uses for construction and operation activities will significantly affect the demand for water supply.

A safe, reliable supply of water is required to meet the demands of the accommodation camp, vehicle wash, staff facilities, ports, firefighting and dust suppression. The total annual Project deman is estimated as 210 ML. Community water sources using the same river flows as proposed for the Project have the potential to be diminished.

4.6.5.5 *Introduction of Waterborne Diseases due to Workforce Influx*

Due to ingress of workers and suppliers to the Project area, waterborne diseases may be introduced to the community water supply, resulting in diseases in humans and livestock. Pathogens may be transmitted by either direct or indirect contact, airborne rates or through faecal-oral routes. There is a high probability of contaminating supply water, especially drinking water, if poor sanitation continues and personal hygiene is not applied. Currently, community water supply sources on Santa Isabel Island have high concentrations of *E. coli* and increased human activity may heighten pathogen accumulation and transmission.

4.6.5.6 *Reduction in River Flow and Alteration of River Hydrodynamics*

Earthmoving activities have the potential to reduce water flow to nearby water sources. Construction of mining facilities such as dams and roads may become a barrier to the natural flow of groundwater and surface water. Hydrodynamics may be altered and water may be diverted to other areas to fill up the void created by the excavations. The volume of water currently available to villages from their customary source may be reduced as proximal watercourses will be used by the mining operation for the raw water required for the camps, main mining infrastructures, port sites and other ancillary uses such as fire fighting, dust suppression, and vehicle washing.

Slow flow velocity may lead to deposition of metals, which may affect the chemical composition of the water. Increased concentrations of metals in water, when ingested, may pose adverse effects to human health. Extended periods of low flow may also lead to increased nutrients and other potential contaminants, higher electrical conductivity and reduced dissolved oxygen.

Changes in flow direction may occur due to changes in land use. Currently, some of the streams are being used as sources of water by the villages. Construction of mining infrastructures and facilities may block or act as barrier in the flow regime of the surface water; this in turn will alter the direction of the water.

Groundwater hydraulic conductivity and hydrodynamics of groundwater and surface water may also be affected by post-operation activities. The mine area backfill materials may alter characteristics and loose compaction, thus groundwater transmissivity may change.

4.6.5.7 Other Changes in Water Quality and Aesthetics

The introduction of the chemicals of potential concern, especially heavy metals, during the life cycle of the mining activities may alter the physico-chemical composition of water. Introduction of soluble components may make the water more acidic.

Alkalinity defines the buffering or neutralizing capacity of water. Most alkalinity in surface water comes from calcium carbonate ($CaCO_3$) being leached from rocks and soil. This process is enhanced if the rocks and soil have been broken up for any reason, such as mining. The pH of water running through pipes should not be too low because the pipes will corrode. This would allow the infusion of lead and copper into the drinking water supply and may bring about negative health effects. Also, water with very low pH that is used for bathing may remove too much oil from the skin, making the skin dry and itchy.

4.6.6 Impact Assessment

An assessment of potential impacts on community water supply is presented in Table 4-13.

Table 4-13 Assessment of Potential Impacts on Community Water

Potential Impact	Facility				Stage		Status	Extent	Duration	Intensity	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Contamination with hydrocarbons and other potential contaminants	•	•		•	•		Negative	Local	Medium	Medium	Probable	Medium	Medium	Spill prevention and management procedures. Appropriate storage of potential contaminants. Staff training for hydrocarbons and emergency response.	Low	Medium
	•	•		•		•	Negative	Local	Long	Medium	Probable	Medium	Medium		Low	High
Contamination of surface water with faecal wastes, litter, food scraps and other solid wastes	•	•		•	•		Negative	Local	Medium	Medium	Probable	Medium	Medium	Implementation of Waste Management Plan	Low	Medium
	•	•		•		•	Negative	Local	Long	Medium	Probable	Medium	Medium		Low	High
Increased sedimentation or turbidity	•	•		•	•		Negative	Local	Medium	High	Probable	High	High	Erosion control measures such as silt traps and sedimentation ponds. Dust suppression. Staged mining approach.	Medium	High
	•	•		•		•	Negative	Local	Long	High	Probable	High	High		Medium	Medium
Increased competition for water sources	•	•		•	•	•	Negative	Local	Long	High	Probable	High	High	Hydrologic surveys and modelling. Community consultation.	Low	Medium

Table 4-13 Assessment of Potential Impacts on Community Water

Potential Impact	Facility				Stage		Status	Extent	Duration	Intensity	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Reduction in flow and alteration of river dynamics	•	•		•	•	•	Negative	Local	Long	High	Probable	High	High	Hydrologic surveys and modelling. Water diversion channel for WSF.	Medium	Medium
Introduction of pathogens to community water supply	•	•		•	•		Negative	Local	Medium	High	Probable	High	High	Water supply monitoring plan.	Low	Medium
	•	•		•		•	Negative	Regional	Long	High	Probable	High	High		Medium	Medium
Other changes to water quality and aesthetics	•	•		•		•	Negative	Local	Long	Medium	Probable	Medium	Medium	Spill prevention and management procedures. Appropriate storage of potential contaminants. Erosion control measures such as silt traps and sedimentation ponds. Dust suppression. Staged mining approach.	Low	High

4.6.7 *Mitigation Measures*

The following mitigation measures were identified to reduce potential impacts stemming from the operation and construction phases of the Project.

4.6.7.1 Contamination with Hydrocarbons and Other Potential Contaminants

Spill prevention and management procedures will be implemented to prevent the introduction of pollutants and accidental spills. This will include collection of hydrocarbons from equipment through drip pans in work areas, covering drill holes with properly fitted non-reactive covers when not in use, storage of waste fuel and lubricants in sealed canisters, and use of lining around the drill holes to catch wastes. All potential pollutant materials, including fuels, lubricants, greases and reagents will be appropriately stored in bunded facilities. There will be secondary containment of all fuels and lubricants.

Hydrocarbon spill response kits will be strategically placed across the Project area. Training in hydrocarbon and emergency response will be implemented as part of the standard operating procedure. All vehicles and equipment will be kept maintained and in good working order to prevent leaks and spills.

4.6.7.2 Contamination with Faecal Wastes, Litter, Food Scraps and Other Solid Wastes

A Waste Management Plan will be strictly implemented to prevent pollution by Project activities of adjacent water bodies. This will include sewage treatment and recycling, composting and appropriate disposal of other waste materials.

A waste education and awareness program will be implemented for all Project personnel and visitors to the Project site.

4.6.7.3 Increased Sedimentation or Turbidity

Erosion control measures will be implemented to minimise sediments eroding to surface water bodies and eventually to proximal community water supplies.

Construction and land disturbance of mining areas will be also conducted in phases to minimise the total land area disturbed at any given time. Silt traps and sedimentation ponds will also be installed near major work areas and adjacent streams to prevent fine-grained sediments from being transported downstream.

A comprehensive Water Management Plan will be prepared to address the water and sediment impacts that may arise from the Project (refer to Chapter 5).

4.6.7.4 Increased Competition for Water Sources

Additional water sources for villages will be explored in consultation with affected stakeholders. This may include the use of water supply facilities or existing springs to supplement affected community water sources.

The WSF will be designed to include a diversion channel to divert water required to sustain rivers flowing downstream. Detailed hydrologic survey and modelling will also be conducted to identify water recharge areas, river flows, water sources, and related information to come up with a water balance for the Project and appropriate dam design. The design will take into consideration the potential of the WSF to be an alternative water source for the downstream villages.

If, in the unlikely event that it becomes apparent that the community water supply is adversely affected because of the Project, and the WSF is not able to satisfy both the Project and the downstream users, this will be known well in advance. In such a case, close consultation with the communities will be undertaken to arrive at a mutually agreeable solution.

4.6.7.5 Reduction in River Flow and Alteration of River Hydrodynamics

See mitigation measures described in Section 4.6.7.4.

4.6.7.6 *Introduction of Waterborne Diseases and Pathogens to Water Supplies*

A Waste Management Plan will be strictly implemented to prevent pollution by Project activities of adjacent water bodies. This will include sewage treatment and recycling, composting and appropriate disposal of other waste materials. Prevention of areas of stagnant standing water that could potentially support the spread of mosquitoes will occur.

A waste education and awareness program will be implemented for all Project personnel and visitors to the Project site.

4.6.7.7 *Other Changes in Water Quality and Aesthetics*

A Waste Management Plan will be strictly implemented to prevent pollution by Project activities of adjacent water bodies. This will include sewage treatment and recycling, composting and appropriate disposal of other waste materials.

A waste education and awareness program will be implemented for all Project personnel and visitors to the Project site.

Erosion control measures will be implemented to minimise sediments eroding to surface water bodies and eventually to proximal community water supplies.

Construction and land disturbance of mining areas will be also conducted in phases to minimise the total land area disturbed at any given time. Silt traps and sedimentation ponds will also be installed near major work areas and adjacent streams to prevent fine-grained sediments from being transported downstream.

A comprehensive Water Management Plan will be prepared to address the water and sediment impacts that may arise from the Project (refer to Chapter 5).

4.6.7.8 *Water Quality and Supply Monitoring and Management Plans*

4.6.7.8.1 Water Supply Monitoring Plan

A water supply monitoring plan will be developed to monitor physical, chemical and microbiological parameters of the water, both for surface water and groundwater. The monitoring plan will include sampling locations for village/community water supplies that have the potential to be affected by the Project. The analytic parameters to be analysed are those that are already established in the current baseline monitoring programs, including:

- *in situ* parameters (pH, temperature, electrical conductivity, oxidation-reduction potential)
- alkalinity/acidity, total hardness, total dissolved solids and total suspended solids, total organic carbon
- dissolved metals
- nutrients; total phosphorus, reactive phosphate, total nitrogen (total Kjeldahl nitrogen, nitrate, nitrite, ammonia)
- hexavalent chromium, total and dissolved mercury
- total coliforms and *E. coli*

The frequency and parameters will be subject to the requirements of the detailed water supply monitoring plan that will be developed as part of the Environmental Management Plan, and will be reviewed and revised throughout the construction, operations and closure phases as more water quality data becomes available.

Monitoring will continue until the risk to spring flows, surface water and groundwater quality as a result of the Project is considered to have ceased.

4.6.7.8.2 Water Management Plan

The Water Management Plan will include current status of water consumption, key issues and risk with future water usage, especially during operation of the mine and the future water resource for the downstream communities that are dependent on water sources occurring within the Project area.

The Water Management Plan will also identify water sources and quantities, water supply management, water conservation, and other aspects critical to water supply and distribution. The management plan will consider maximising the reuse of waste water; maximising recycling of process waters; minimising importation of freshwater, minimising discharge of waste water and establishing contingency plans using a risk-based approach. Refer to Chapter 5 for more detailed information.

4.6.7.8.3 Coordination With Water Agencies and Government

Treatment of drinking water may be considered as community water supplies currently have detectable coliform and *E. coli*. Stakeholder engagement may be conducted to discuss community sanitation and the potential installation of Watsan facilities (water treatment and sanitation facilities).

4.6.7.8.4 Water Balance

A water balance study will be prepared for the Project to address all activities that require the use of water in the context of climatic conditions. Results from the water balance would form input into the preparation of Project design and scheduling of operations.

4.7 Freshwater Ecology

This section describes:

- the environmental value of the freshwater habitats and biota occurring and likely to occur in the waterways affected by the Project (including downstream waters)
- the potential direct and indirect impacts on freshwater ecosystems from the construction and operation of the Project
- proposed mitigation measures for protecting or enhancing freshwater ecological values.

Further details are provided in the Impact Assessment Report – Freshwater Surface Water Ecology.

4.7.1 Standards Applied

The resources used to inform the survey design, methodology and data analysis are described in the Impact Assessment Report – Freshwater Ecology.

4.7.2 Methodology

The environmental values related to freshwater ecology were described based on a baseline field survey and literature available on freshwater ecology in the region. The baseline field survey was undertaken from 15th to 21st September 2010, and included an assessment of aquatic habitat, consisting of aquatic floral (macrophyte) and faunal (macroinvertebrates, macrocrustaceans and fish) communities at 11 sites on major watercourses within the Project area.

The locations of the baseline survey sites are shown in Figure 4-17. Sites were chosen by SMM Solomon to ensure adequate coverage of major watercourses and existing water quality impacts in the Project area, and were based on the Project Description and scope at the time of survey. Sites included the downstream receiving environments for impacts likely to be associated with the construction and operation of the mine. The final locations of the sites within the selected watercourses were based on a number of factors, including terrain and access.

Methods for the assessment of freshwater ecosystems, including the limitations of the baseline survey, are further described in the Impact Assessment Report – Freshwater Ecology.

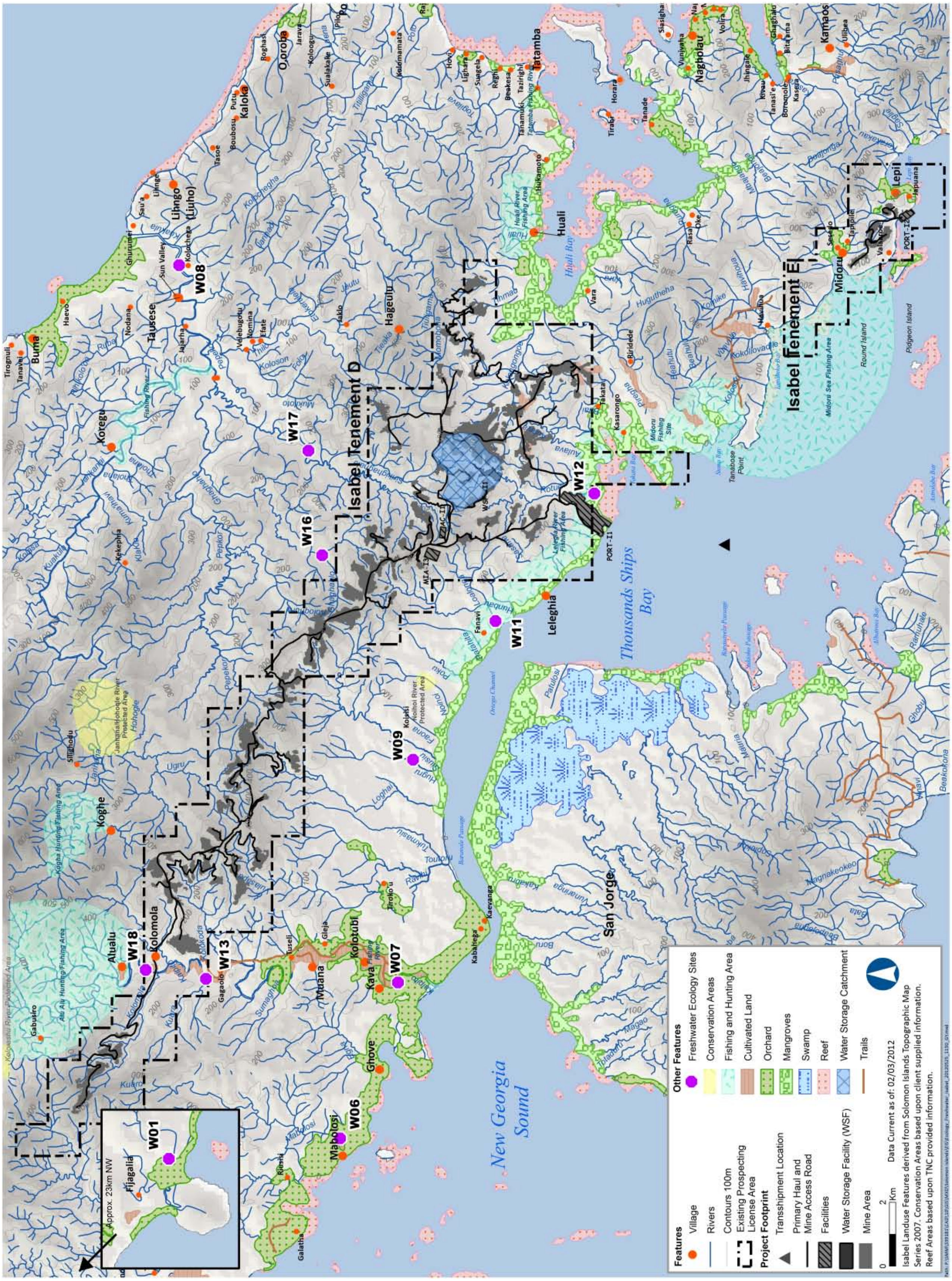

Figure 4-17 Santa Isabel Island Freshwater Survey Sites

4.7.3 Existing Values

4.7.3.1 Overview

The environmental values of freshwater ecosystems within the Santa Isabel Island survey area are high, and consistent with those of the wider Solomon Islands region. During the baseline survey, high environmental values were primarily related to the perennial nature of most waterways, which provides environmental flow, typically good water quality and connectivity for the movement of aquatic biota along waterways.

4.7.3.2 Habitat for Aquatic Fauna

The overall condition of freshwater ecosystems in the Solomon Islands is excellent. During the baseline survey, the diversity of habitats was very high at most sites, and included cobbles and boulders, large woody debris, undercut banks, detritus, trailing bank vegetation and/or overhanging vegetation. There were bars at most sites, typically along the edges of the channel or upstream of obstructions such as large woody debris.

The physical characteristics of existing riparian and aquatic habitat had been modified in some areas by land clearing for logging roads and local village gardens, however, this clearing was limited in extent and occurrence. Banks were stable at most sites, due to dense vegetation and the presence of rocky substrate. Stream bed substrates were predominantly cobbles, pebbles and gravel, with some sand and silt/clay.

4.7.3.3 Aquatic Flora

Waterways within the survey area supported a high diversity of aquatic flora. Twenty species of macrophytes were recorded; most sites had several species and a moderate total cover of 10 to 60% (see Table 4-14). No known exotic species were recorded during the baseline survey.

Macrophytes are not listed under Solomon Islands legislation. None of the macrophyte species identified in the survey area are listed on the IUCN Red List of Threatened Species.

Table 4-14 Percent Cover and Diversity of Aquatic Flora at Each Survey Site

Taxonomic Family *Latin name*	Site / Location							
	W01	W07	W08	W11	W12	W13	W17	W18
	lower Koloseeru	lower Kaipito	lower Kuakula	lower Loalonga	lower Rotue	mid Kaipito	mid Sirikigha-ghale	upper Kaipito
Amaranthaceae								
Alternanthera ficoidea	1	1	–	–	–	–	–	–
Convolvulaceae								
Ipomea aquatica	–	–	3	–	–	–	–	–
Cyperaceae								
Cyperus iria	1	1	–	–	–	1	–	1
Cyperus polystachyos	2	–	–	–	–	–	–	–
Cyperus sp.1	1	1	–	–	–	2	–	2
Cyperus sp.2	–	1	–	–	–	1	–	1
Cyperus sp.3	–	1	–	–	–	2	–	–
Machaerina mariscoides	–	–	–	–	2	–	–	–
Schoenus sp.	–	–	–	–	–	–	–	–
Scleria polycarpa	–	–	–	–	1	–	–	–
Nymphaeaceae								
Nymphaea pubescens	0.3	–	–	–	–	–	–	–
Onagraceae								
Ludwigia sp.	3	1	–	–	–	1	–	0.4

Taxonomic Family *Latin name*	Site / Location							
	W01	W07	W08	W11	W12	W13	W17	W18
Poaceae								
Urochloa mutica	4	8	56	–	–	7	–	2
Fimbristylis dichotoma	–	1	–		–	2	–	1
Fimbrstylis littoralis	2							
Polygonaceae								
Persicaria dicepiens	0.2	1	–	–	–	1	–	–
Unknown sp.1	–	–	–	4	50	–	–	–
Scrophulariaceae								
Celosia argentea	–	2	–	–	–	0.2	–	1
Lindernia anagallis	–	1	–	–	–	–	–	–
Urticaceae								
Debregeasia sp.	–	–	–	–	–	–	29	–
Total Percent Cover	**14.5**	**19.0**	**59.0**	**4.0**	**53.0**	**17.2**	**29.0**	**8.4**
Taxonomic Diversity	**9**	**11**	**3**	**1**	**3**	**9**	**1**	**7**

Dash (-) indicates species not recorded.

4.7.3.4 Macroinvertebrates

Aquatic macroinvertebrate communities of the Solomon Islands are diverse, with many endemic species. Santa Isabel Island supports some macroinvertebrate taxa that do not occur in other parts of the Solomon Islands (Polhemus et al. 2008).

During the baseline survey, aquatic macroinvertebrate communities were dominated by:

- non-biting midges (family Chironominae and sub-family Tanypodinae)
- freshwater shrimp and prawns (family Atyidae)
- mayflies and mayfly nymphs (families Baetidae and Leptophlebiidae)
- freshwater snails (family Neritidae)
- caddisflies (family Polycentropodidae)

Aquatic caterpillars (family Pyralidae) and net spinning caddis (family Hydropsychidae) were also prevalent in bed and riffle habitat. These families are typically widespread and can occur in a variety of habitats, from fast-flowing streams and rivers to lakes (Gooderham and Tsyrlin 2002). They can be found in ecosystems that range from disturbed conditions to undisturbed conditions (Chessman 2003).

Aquatic macroinvertebrate parameters in stream bed, edge and riffle habitats at each site are presented in Table 4-15. Overall, macroinvertebrate communities were the most diverse and abundant, and included several PET taxa (pollution-sensitive invertebrate taxa), in:

- riffle habitat[2] at site W13 (mid Kaipito River; 19 taxa)
- stream bed and stream edge habitat at site W16 (upper Ghaghalo River; 23 taxa)
- bed and edge habitat at site W17 (mid Sirikighaghale River; 24 to 25 taxa).

Macroinvertebrate communities were least abundant and diverse at site W06 (lower Mablosi River; 4 taxa).

[2] A shallow, coarse-bedded length of stream with breaking water.

There were no PET taxa in:

- bed or edge habitats at sites W09 (lower Hugru River) and W11 (lower Loalonga River)
- bed habitat at sites W06 (lower Mablosi River) and W08 (lower Kuakula River)
- edge habitat at sites W13 (mid Kaipito River) and W18 (upper Kaipito River).

Table 4-15 Aquatic Macroinvertebrate Parameters in Stream Bed, Edge and Riffle Habitats at Each Site

Habitat/Site	Location	Indices		
		Mean Abundance (±SE)	Total Taxonomic Richness	Total PET Taxa
Bed				
W01	lower Koloseeru River	19.0 ±2.5	10	4
W06	lower Mablosi River	1.6 ±0.8	4	0
W07	lower Kaipito River	26.0 ±8.0	13	4
W08	lower Kuakula River	3.0 ±1.1	5	0
W09	lower Hugru River	4.8 ±1.2	7	0
W11	lower Loalonga River	14.8 ±7.0	10	0
W12	lower Rotue River	17.6 ±7.7	8	1
W13	mid Kaipito River	44.4 ±14.5	12	6
W16	upper Ghaghalo River	49.6 ±20.4	23	8
W17	mid Sirikighaghale River	53.0 ±18.2	24	7
W18	upper Kaipito River	45.8 ±8.5	14	6
Edge				
W01	lower Koloseeru River	26.2 ±9.7	13	2
W06	lower Mablosi River	10.4 ±3.9	14	4
W07	lower Kaipito River	13.8 ±6.3	8	1
W08	lower Kuakula River	9.6 ±1.7	9	2
W09	lower Hugru River	6.8 ±2.6	8	0
W11	lower Loalonga River	7.8 ±1.9	10	0
W12	lower Rotue River	11.2 ±5.0	9	1
W13	mid Kaipito River	3.0 ±0.8	9	0
W16	upper Ghaghalo River	23.8 ±10.2	23	8
W17	mid Sirikighaghale River	53.8 ±15.0	25	6
W18	upper Kaipito River	2.2 ±1.2	6	0
Riffle[1]				
W13	mid Kaipito River	44.0±12.7	19	6

[1] Riffle habitat was not present at all sites
Dash (-) indicates species not recorded.

4.7.3.5 *Macrocrustaceans and Fish*

Macrocrustaceans that are known to inhabit rivers and streams of the Solomon Islands include freshwater prawns (*Macrobrachium* spp.), shrimps (*Palaemon* spp., *Caridina* spp.) and crabs (*Varuna* spp.) (Boseto and Jenkins 2007). The total taxonomic richness and abundance of macrocrustacean communities at each site is presented in Table 4-16. Macrocrustaceans were caught at six of the 11 survey sites. Of these sites, the abundance of macrocrustaceans was highest at site W13 (mid Kaipito River; 165 individuals caught) and lowest at site W08 (lower Kuakula River; one individual caught).

Table 4-16 Total Taxonomic Richness and Abundance of Macrocrustacean Communities at Each Site

Site	Location	Total Taxonomic Richness	Total Abundance
W01	lower Koloseeru River	–	–
W06	lower Mablosi River	–	–
W07	lower Kaipito River	2	9
W08	lower Kuakula River	1	1
W09	lower Hugru River	–	–
W11	lower Loalonga River	–	–
W12	lower Rotue River	–	–
W13	mid Kaipito River	3	165
W16	upper Ghaghalo River	4	44
W17	mid Sirikighaghale River	2	20
W18	upper Kaipito River	3	56

Dash (–) indicates macrocrustaceans not recorded.

Forty-four fish species from ten families were recorded during the baseline survey (shown in Table 4-17). The most common and abundant species was the spotted flagtail (*Kuhlia marginate*). No known exotic species were recorded.

Table 4-17 Freshwater Fish in the Survey Area at Santa Isabel Island

Family	Species	Common Name
Ambassidae	*Ambassis vachelli*	Vachelli's glass perchlet
Anguillidae	*Anguilla* sp.	freshwater eel
Apogonidae	*Apogon hyalosoma*	mangrove cardinalfish
Eleotridae	*Belobranchus belobranchus*	throat spined gudgeon
	Eleotris sp.1	–
	Eleotris sp.2	–
	Mogurnda adspersa	purple spotted gudgeon
	Mogurnda sp.	–
	Ophioeleotris hoedti	snakehead gudgeon
	Oxyeleotris aruensis	aru gudgeon
Gobiidae	*Glossogobius celebius*	Celebes goby
	Glossogobius sp.1	–
	Sicyopus discordipinnis	–
	Sicyopus mystax	–
	Sicyopterus micrurus	clinging goby
	Sicyopterus sp.	–
	Stiphodon atratus	–
	Stiphodon rutilaureus	–
	Stiphodon semoni	neon goby
	Stiphodon sp.	–
	Unknown sp. 1	–
	Unknown sp. 2	–
	Unknown sp. 3	–
Kuhliidae	*Kuhlia marginata*	spotted flagtail
	Kuhlia rupestris	jungle perch
Muraenidae	*Gymnothorax polyuranodon*	freshwater moray eel
Syngnathidae	*Microphis brachyurus*	short tailed pipefish

Family	Species	Common Name
Terapontidae	*Mesopristes argenteus*	silver grunter
Toxotidae	*Toxotes jaculatrix*	banded archerfish

Total taxonomic richness, total abundance and percent life stages of fish communities at each site are presented in Table 4-16. Differences in taxonomic richness across sites were likely to be due to the differences in habitat availability at each site and the positioning of the sites across both upper and lower reaches of the catchment. The highest richness was at site W01 (lower Koloseeru River) and site W11 (lower Loalonga River) where there were 16 species.

The lowest richness was at site W16 (upper Ghaghalo River), a shallow, straight channel in the upper reaches of the catchment, where only three species were recorded.

Table 4-18 Total Taxonomic Richness, Abundance and Life Stages of Each Fish at Each Site

Site	Location	Total Taxonomic Richness	Total Abundance	Life Stage (% of catch)		
				Adult	Intermediate	Juvenile
W01	lower Koloseeru River	16	265	46.0	23.0	30.9
W06	lower Mablosi River	10	155	31.6	29.7	38.7
W07	lower Kaipito River	5	30	46.7	53.3	0.0
W08	lower Kuakula River	5	34	44.1	44.1	11.8
W09	lower Hugru River	11	111	47.7	47.7	4.5
W11	lower Loalonga River	16	278	88.8	7.9	3.2
W12	lower Rotue River	10	93	40.9	31.2	28.0
W13	mid Kaipito River	9	57	21.1	28.1	50.9
W16	upper Ghaghalo River	3	3	33.3	0.0	66.7
W17	mid Sirikighaghale River	9	63	93.7	4.8	1.6
W18	upper Kaipito River	6	30	10.0	26.7	63.3

4.7.3.6 *Species of Conservation Significance*

Freshwater fish species are not listed under Solomon Islands legislation. However, two of the 44 species caught in the survey area are listed on the IUCN Red List of Threatened Species:

- the spotted flagtail (*Kuhlia marginata*) is listed as 'lower risk/least concern[3]', and
- the spotted scat (*Scatophagus argus*) is listed as 'least concern'.

Spotted flagtails were common and abundant in the survey area, found at eight of the 11 survey sites. Spotted scat were uncommon, found at two survey sites.

[3] Refer to Section 4.8.1 for definition of "Least Concerned".

The spotted flagtail has been recorded around the Indo-Pacific region, including Taiwan, Philippines, Indonesia and other Pacific islands. It typically inhabits moderately deep (1.5 to 3 m), rocky, unshaded, flowing midland streams, migrating between freshwaters and the ocean to breed (Pethiyagoda 1991). There is little information available on the species; however, the closely related jungle perch (*Kuhlia rupestris*) is an omnivore that feeds on smaller live fish and crustaceans (Australia New Guinea Fishes Association 2003).

The spotted scat is found around the Indo-Pacific region, from Japan to New Guinea and south-eastern Australia. Juveniles develop in freshwater environments and migrate to brackish/marine waters, often near mangroves, as they mature (Merrick 1996). They are omnivorous, indiscriminate feeders that consume invertebrates, small fish and detritus. The spotted scat is eaten by people throughout the Indo-Pacific (Merrick and Schmida 1984) and is a popular aquarium fish (Allen et al. 2002).

A comprehensive study of freshwater fishes was undertaken on seven of the largest islands in the Solomon Islands in 2004 and 2005. A total of 43 species from 14 families were recorded (Polhemus et al. 2008), which is higher than the number of species and families recorded in this survey. Other studies, at Choiseul Island (in 2005 and 2006), and on the uninhabited Tetepare Island (in 2006), recorded 32 species from 15 families and 60 species from 29 families, respectively (Boseto and Jenkins 2007; Boseto et al. 2007). In addition, a recent study completed at Choiseul Island for SMM Solomon in 2010, recorded 29 species from 14 families (frc environmental 2012b).

There have been no reports or observations of introduced fish species in the rivers and streams of Santa Isabel Island.

4.7.3.7 Protected Areas

Protected areas located within and downstream of the Project area are shown in Figure 4-22.

There are no nationally or provincially protected areas that include freshwater habitats within the Project area (Figure 4-22). However, local villagers identified three locally protected areas that include freshwater habitats downstream of the Project area. These protected areas include:

- an area on the Koloraghu River to the north-east of Alu Alu downstream of the Project area; the purpose of this conservation area is to protect fish stocks in local rivers for future generations and for local festivals
- an area which begins to the east of Silighodu and runs to the south-east of Silighodu around the Jarihana River down to Hohogle River; the purpose of this conservation area is to protect fish stocks in local rivers for future generations and for local festivals, and
- an area on the Noinoi River, to the south-east of Kosisi; the purpose of this conservation area is to protect aquatic fauna.

Local villagers also identified seven important areas utilised for fishing, within and downstream of the Project area.

- Alu Alu Hunting/Fishing area, within and downstream of the north-western portion of Tenement D
- Koghe Hunting/Fishing area, to the north and downstream of Tenement D
- Lelegia River Fishing Area in the south-east portion of Tenement D
- Huali River Fishing Area, near the village of Huali, to the east of Tenement D
- Tatamba Fishing River, near the village of Tatamba, to the east of Tenement D
- Midoru Fishing Sites; one of which extends into the southern portion of Tenement D, and

- A Fishing River in the mid reaches of the Kaipito River.

The national framework for conservation in the Solomon Islands is provided in the *Protected Areas Act (draft) 2012*, which allows for the declaration and management of protected areas or areas where special measures need to be taken to conserve biological diversity. Also relevant is the is the *Wildlife Protection and Management Act 1998*, which allows for the protection of endangered flora and fauna. Regional regulations include the *Isabel Province Resource Management and Environmental Protection Ordnance 2006*, which addresses issues around the protection of flora and fauna and reinforces the right for customary groups to make their policies regarding the use of resources regarding the use of resources within their land and to seek Isabel provincial government protection of wildlife and natural resources. Local communities may also identify and manage areas for conservation of locally important natural resources.

Under the international Convention on Biological Diversity (CBD), the Solomon Islands Government has committed to a target of protecting 10% of the original extent of each ecosystem type (features important for biological and cultural resources) in the Solomon Islands.

To improve the potential for resilience to future climate change, Lipsett-Moore et al. (2010) recommend that the CBD target be increased to 20% protection of each ecosystem type as an insurance policy for vulnerable communities, and increasing targets to 95% protection for conservation features most vulnerable to climate change (e.g. turtle nesting beaches) or crucially important to local communities (e.g. transient fish spawning aggregations). Priority conservation areas had not been recommended for Santa Isabel Island at the time of writing.

4.7.4 Potential Impacts

Construction and operation of the nickel mine and supporting infrastructure such as roads and the accommodation camp, MIA and WSF have the potential, without mitigation, to impact the ecology of freshwater ecosystems. Specifically:

Tenement D

- mine areas; including erosion and sediment control
- ore transportation and ore handling (mine to port); including primary haul roads, ore stockpiles (within 1 km of mining operations) and mine access roads
- Mining Industrial Area (MIA-I3); including workshop and vehicle maintenance area, vehicle wash area, waste transfer facility, sewage treatment plant and fuel and hazardous chemical storage facility
- accommodation camp (AC-I1); located adjacent to MIA-I3
- Water Storage Facility (WSF-I1); in the upper reaches of the Rotue River to supply Port-I1, MIA-I3 and AC-I1
- utilities infrastructure; water, sewage, power and communications
- landfill
- borrow pits
- surface water management.

Tenement E

- mining areas; including erosion and sediment control
- ore transportation and ore handling (mine to port); including primary haul roads, ore stockpiles (within 1 km of mining operations) and mine access roads

- borrow pits.

Project construction and operation activities that have the potential to result in impacts to freshwater ecosystems are outlined in the following sections. Further details are provided in the Impact Assessment Report – Freshwater Surface Water Ecology.

4.7.4.1 *Increased Turbidity and Subsequent Sedimentation*

Vegetation clearing and earthworks will be required for the construction and operation of the mine and supporting infrastructure. There is a high potential for soil erosion following vegetation clearing and earthworks due to the intense rainfall, fine soils and steep topography of the Project area. Erosion of soils is likely to lead to increased turbidity in receiving streams. Construction of permanent and temporary stream crossings along haul and access roads may also disturb sediment, leading to localised increases in turbidity and sediment deposition.

The deposition of fine sediments in streams can decrease channel bed roughness and diversity of in-stream habitat and may result in existing pools being filled with sediment. In-stream habitat (e.g. woody debris, cobbles and boulders) is an important habitat component and territory marker for many freshwater fish and macroinvertebrates. Many species live on or around in-stream habitat as it provides shelter from high temperatures, water currents and predators; contributes organic matter to the system; and is important for successful reproduction. Freshwater fish often spawn either on in-stream vegetation or on hard surfaces like cobbles, boulders, and woody debris.

Increased turbidity may also adversely affect submerged macrophytes as the light required for photosynthesis is reduced. Reduced light penetration in turbid waters can also lead to a reduction in temperature throughout the water column (DNR 1998), which can have flow-on effects to biological processes such as decomposition of organic matter.

Small, infrequent increases in turbidity are unlikely to have a significant impact on freshwater biota within, and downstream of the Project area. However, substantial and prolonged increases in turbidity could adversely impact the health, feeding and breeding ecology of some macroinvertebrate and fish species. This may lead to a decline in the abundance and diversity of macroinvertebrate and fish communities in the streams, and potentially predators such as birds, reptiles and small mammals.

4.7.4.2 *Loss of Catchment Area and Changes to Flow Regimes and Connectivity*

The potential loss of catchment area due to construction of the mine areas (particularly mine areas), the WSF, sediment ponds and supporting infrastructure (including the installation of stream crossings and diversions) will alter water flow in the Project area. Due to the perennial nature of streams in the Project area, changes to the flow regime, and the timing and magnitude of flows in streams, have the potential to impact aquatic biota.

Reductions in flow can create waterway barriers that prevent or impede movements of aquatic fauna such as fish. Construction of structures within a stream (such as dams and waterway crossings) can also provide physical barriers to aquatic fauna movement. Fish species that migrate up- and downstream between different habitats at particular stages of their life cycle, or different times of the year, are most likely to be affected by changes to flow regimes and waterway barriers. An example of a migratory species from the region is the spotted flagtail, which is listed on the IUCN Red List of Threatened Species. During the baseline survey, spotted flagtails were recorded at a site located within the proposed WSF.

The proposed location of WSF in the lower reaches of the Loangasoa River will lead to a significant reduction in the magnitude of downstream flows. It will also provide a physical barrier to fish movement.

4.7.4.3 Loss of Habitat for Aquatic Fauna

Vegetation clearing and earthworks near and within streams may decrease the amount of habitat for aquatic fauna. Similarly, construction of water infrastructure such as the WSF, sediment ponds and stream diversions will result in a decrease in the abundance and/or diversity of aquatic habitat. Aquatic fauna use a variety of in-stream and off-stream structures for habitat including large and small woody debris, stream bed and banks, macrophytes, detritus, tree roots, boulders, undercut banks, and in-stream, overhanging and trailing bank vegetation, which were all found in the survey area.

A decrease in the abundance or diversity of available habitat for aquatic fauna may lead to a decline in the abundance and diversity of both macroinvertebrate and fish communities in the impacted streams, and potentially predators such as birds, reptiles and small mammals.

4.7.4.4 Spills of Hydrocarbons, Nickel Ore and Other Potential Contaminants

4.7.4.4.1 Hydrocarbons

Fuel and oil required for the operation of vehicles and mine machinery present a risk to freshwater biota if spills enter freshwater streams. Spilt hydrocarbons and other contaminants are most likely to enter streams when there are construction activities adjacent to streams or via an accidental spill near a stream crossing. Heavy equipment refuelling facilities and light vehicle refuelling facilities will be located within the MIA.

Both diesel and petrol are toxic to biota at relatively low concentrations and are likely to form a layer on the surface of the water. Once incorporated in the sediment, the degradation of oils is significantly slowed, and hydrocarbons may persist in sediments for some time (Boehm et al. 1987 and Struck et al. 1993, both cited in Nicodem et al. 1997). The extent of impact to aquatic flora and fauna is typically determined by the duration of exposure (van Gelder-Ottway 1976), with chronic (long-term) contamination during operation likely to pose a greater risk than acute (short-term) contamination during construction.

A significant fuel spill (in the order of tens or hundreds of litres) is likely to have a locally significant impact on freshwater biota. The quantity spilt and the volume of water and extent of mixing (turbulence) in the receiving environment are the most significant factors influencing the severity of impact.

4.7.4.4.2 Nickel Ore

Spilt nickel ore, and run-off from nickel ore stockpiles, has the potential to impact freshwater biota through water quality as discussed in Section 4.4. Nickel toxicity reduces photosynthesis and growth of algae, and adverse effects of excess nickel have been observed in crustaceans and fish (U.S. Environmental Protection Agency [USEPA] 1975) include surfacing, rapid mouth movements, convulsions and loss of equilibrium in fishes (Khangarot and Ray 1990). Ionic nickel is lethal to sensitive aquatic species at concentrations of 11 to 113 μg/L (Eisler 1998). Although aquatic biota can accumulate nickel from their surroundings, there is little evidence that nickel bioaccumulates along food chains (National Research Council of Canada [NRCC] 1981; WHO 1991).

4.7.4.5 Nutrient Enrichment and Other Contaminants

Nutrients and other contaminants may be introduced into the freshwater environment via stormwater runoff or wastewater (sewage) releases. A wastewater treatment plant will be located at MIA-I3.

Metals have been detected in the water column at all SMM Solomon water quality monitoring sites, in varying concentrations (see Impact Assessment Report – Surface Water Quality and Flows). Median concentrations of aluminium, chromium, copper, nickel and vanadium in the water and/or sediment were above the guideline ranges at several sites (see Impact Assessment Report – Surface Water Quality and Flows). Also, these metals are generally naturally abundant elements. The concentration of phosphorus was high compared to the guideline value at half the sites surveyed.

4.7.4.5.1 Nutrient Enrichment

Nutrient inputs can lead to blooms of phytoplankton or macroalgae, which produce dissolved oxygen in the water when photosynthesising during the day, and consume the dissolved oxygen at night through respiration. This can cause dissolved oxygen to be reduced to low concentrations overnight, which can be toxic to fish and other freshwater biota.

Given the perennial nature of the streams in the Project area, there is unlikely to be any major negative impacts to freshwater biota due to nutrient enrichment from stormwater and/or treated wastewater run-off; any minor impacts will be of a temporary and reversible nature.

4.7.4.6 Other Contaminants

Other contaminants may be introduced with stormwater runoff, particularly metals such as nickel and chromium from the mining area. Further assessment of potential contaminants is recommended during the detailed design phase.

4.7.4.7 Acid Mine Drainage

Acid mine drainage (also referred to as acid rock drainage or ARD) commonly forms as a result of natural geochemical processes that oxidise metal sulphides exposed at the earth's surface by mining. Acid mine drainage can contribute to the physical, chemical and biological degradation of stream habitats. Waters contaminated by acid mine drainage may have pH as low as 2.0 to 4.5, and contain elevated levels of metals – both are toxic to aquatic biota. As a result, streams affected by acid mine drainage typically exhibit both low species richness and abundance (Warner 1971; Jennings et al. 2008).

Pelagic and benthic biota can be exposed to metal-rich precipitates by direct physical contact and/or by ingestion of contaminated sediments and food items. When fish are exposed directly to metals and H^+ ions (i.e. low pH water) through their gills (either through acute or chronic exposure) it can cause impaired respiration (Jennings et al. 2008). Further assessment of impact to freshwater biota in the Project area will be completed during the detailed design phase.

Acid mine drainage can also impact physical habitat. A common weathering product of sulphide oxidation is the formation of iron hydroxide (a red / orange coloured precipitate), which can discolour water and smother biota on the stream bed. Smothering can reduce the availability of clean gravel and cobbles used by fish for spawning, and reducing prey items such as benthic macroinvertebrates (Hill 1974; Jennings et al. 2008).

4.7.4.8 Increased Mosquito and Biting Midge Breeding

The Project has the potential to temporarily create new breeding habitat for mosquito and biting midge in the form of the WSF, stormwater drains, retention basins, sediment control ponds, wastewater treatment plants, water treatment plants, rainwater tanks and other infrastructure such as roof guttering and rainwater collected in man-made containers. Mosquitoes prefer to breed in shallow, stagnant vegetated waterways where females can lay eggs in mud or on vegetation, hence breeding will be concentrated in the margins of dams and shallow sections of wetlands.

Impacts to human health associated with increased prevalence of mosquito and biting midge may include an increase in the number of people affected by mosquito-borne diseases/viruses, such as malaria and dengue fever.

4.7.4.9 Litter and Waste

Litter and waste associated with the construction and operation of the mines and infrastructure has the potential to contribute to the degradation of water quality and negatively impact freshwater biota. Litter and waste contributes to habitat degradation and can impact the diversity and abundance of ecological communities, such as freshwater fish communities (Collares-Periera & Cowx 2004).

4.7.4.10 Impacts to Threatened Species

Spotted flagtails (listed as 'lower risk' on the IUCN Red List of Threatened Species) were relatively common and abundant in the survey area. The spotted scat (listed as 'least concern' on the IUCN Red List of Threatened Species) was uncommon in the survey area, recorded at only two sites; W09 (lower Hugru River) and W11 (lower Loalonga River).

Impacts to populations of spotted flagtail and spotted scat are likely where the passage of these fish between fresh and oceanic waters is impeded due to changes to flow regime and/or the disruption of flow. Local populations may also be affected by loss of habitat due to vegetation clearing and earthworks, and loss of habitat quality and/or diversity due to the deposition of fine sediments. Deposition of fine sediments may also lead to a decline in the abundance of prey (e.g. crustaceans and other aquatic invertebrates) for spotted flagtails and spotted scat.

4.7.4.11 Impacts to Protected Areas

There are no officially protected areas within the Project area; however, there are three locally protected areas that are located downstream from proposed mining activities (see Section 4.7.3.7). Impacts to the locally protected area on the Noinoi River are likely to be negligible given that runoff from upstream mining activities are unlikely to enter the catchment area for the Noinoi River. However, increased turbidity and sedimentation may occur in the Jarihana, Hohogle and Koloraghu Rivers as a result of upstream vegetation clearing, construction of haul roads and mining activities. Fishing/hunting areas within and downstream of the Project area may also be subject to increased turbidity and sedimentation.

The Lelegia River Fishing Area, Aluau Hunting/Fishing Area, Huali River Fishing Area and Tatamba Fishing River may also be subject to the impacts described in the following sections:

- Section 4.7.6.1
- Section 4.7.6.2
- Section 4.7.6.3
- Section 4.7.6.4
- Section 4.7.6.5
- Section 4.7.6.6
- Section 4.7.6.8.

4.7.5 Impact Assessment

A risk assessment of potential impacts on freshwater ecology is presented in Table 4-19.

Table 4-19 Assessment of Potential Impacts on Freshwater Ecosystems

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Increased turbidity and subsequent sedimentation	•	•		•	•	•	Negative	Local	High	Long	Highly Probable	High	High	Develop and implement a management plan that incorporates professional advice based on current best practice approaches for erosion and sediment control measures designed for the prevailing rainfall conditions, and implemented for design, construction and operation of mine and supporting infrastructure. Staging vegetation clearing and earthworks. Progressively rehabilitating and revegetating post-mine landforms.	Medium to High[1]	Low
Loss of catchment area and changes to flow regimes and connectivity	•	•		•	•	•	Negative	Local to Regional	Medium to High	Medium to Long	Highly Probable	Medium to High	Medium to High	Use a standard best practice approach for the construction and maintenance of drainage lines and gullies, that is appropriately designed and constructed by professional engineers, including the installation of stream diversions and culverts for stream crossings. Discharges from sediment control dams and release of environmental flows from the WSF. Remediation of catchments.	Low to Medium[1]	Medium
Loss of habitat for aquatic fauna due to vegetation clearing and earthworks	•	•		•	•	•	Negative	Local	Medium	Long	Highly Probable	Medium	Medium	Salvage of habitat such as woody debris, riparian flora and boulders, during construction and operation of mine and infrastructure, for use in progressive rehabilitation of streams post-mining.	Medium	Medium
Spills of contaminants Hydrocarbons and other potential contaminants	•	•		•	•	•	Negative	Local	High	Long	Probable	High	High	Fuel, oil, ore and chemical handling to be undertaken in accordance with standard practices including secure storage, bunding, control measures for stockpile runoff, and implementation of a handling and spill management plan. Optimising the volume of stored fuel, oil or chemicals, with stores located in secure areas.	Medium	Medium
Nickel ore	•	•				•	Negative	Local	Medium	Long	Probable	Medium	Medium		Medium	Low
Nutrient enrichment				•	•	•	Negative	Local	Low	Medium	Probable	Low	Low	Standard best practice approach for erosion and sediment control, stormwater management and treatment of wastewater to WHO standards.	Low	Medium
Acid mine drainage	•				•	•	Negative	Regional	High	Long	Probable	High	High	Rigorous testing of soils to be disturbed in mine areas.	Medium	Low

Table 4-19 Assessment of Potential Impacts on Freshwater Ecosystems

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
														Development of an acid mine drainage management plan where necessary, including: specialised handling procedures for potentially acid generating materials, amendments or additives and effective surface water management.		
Increased mosquito and biting midge breeding	•		•	•	•	•	Negative	Regional	Low	Long	Probable	Medium	Medium	Minimising the extent of shallow water and aquatic vegetation in waterways. Natural control using native larvivorous fishes (which feed on mosquito larvae), where required.	Low to Medium[1]	Medium
Litter and waste	•	•	•	•	•	•	Negative	Local	Low	Long	Highly Probable	Low	Low	Design and implement a plan that uses current international best practice approach for litter/waste disposal and storage.	Low	Medium
Impacts to species of conservation significance; spotted flagtail and spotted scat	•	•		•	•	•	Negative	Regional	Medium	Long	Probable	High	High	Implement mitigation measures described for impacts relating to: increased turbidity and sedimentation, loss of catchment area and changes to flow regimes and loss of habitat for aquatic fauna.	Medium	Medium
Impacts to freshwater ecosystems in protected areas and hunting/fishing areas downstream of mining activities	•	•		•	•	•	Negative	Local	Medium to High	Medium to Long	Highly Probable	Medium to High	Medium to High	Implement mitigation measures for impacts relating to increased turbidity and sedimentation, loss of catchment area and changes to flow regimes, spills of hydrocarbons, nickel ore and other potential contaminants, nutrient enrichment, acid mine drainage and litter and waste.	Medium	Medium

4.7.6 *Mitigation Measures*

The development of the EMP, and rigorous site management in accordance with current best practice, offer significant opportunities to minimise potential impacts to freshwater ecosystems. A management plan to establish cease work trigger values in consideration of protecting the aquatic ecosystems is another management option , as is stormwater management. Details of mitigation measures are provided in Chapter 5 and the Impact Assessment Report – Freshwater Surface Water Ecology.

4.7.6.1 *Increased Turbidity and Subsequent Sedimentation*

Mitigation measures to reduce the risk of impact associated with increased turbidity and sedimentation during mine construction and operation will consider standard practices, including:

- obtaining sign-off from a site supervisor that drainage and erosion control measures are in place prior to vegetation clearing and earthworks
- erosion and sediment control measures including drainage ditches, diversions, chutes, pocket ponds, infiltration trenches and ponds, sediment control ponds and dams, contour banks and ditches and a washdown facilities for vehicles and machinery
- staging vegetation clearing and earthworks over the life of the mine
- sheeting haul rods with a target gradient of 1 in 10
- progressively rehabilitating and revegetating post mine landforms.

4.7.6.2 *Loss of Catchment Area and Changes to Flow Regimes and Connectivity*

Mitigation measures to reduce the risk of impact associated with loss of catchment area, waterway barriers and changes to flow regimes will consider standard practices, including:

- constructing and maintaining drainage lines and gullies
- coinciding discharges from sediment control dams with natural flows
- remediation of catchments.

Mitigation measures to reduce the risk of impact associated with changes to freshwater flow regimes will consider standard practices, including:

- appropriate design and installation of culverts in stream barriers
- maintaining drainage lines, gullies and culverts.

4.7.6.3 *Loss of Habitat for Aquatic Fauna*

Impacts to aquatic fauna due to the loss of habitat will be reduced where habitat such as woody debris, riparian flora and boulders cleared during earthworks, are used:

- to improve freshwater habitat in other waterways
- during progressive rehabilitation of streams post-mining.

4.7.6.4 *Spills of Hydrocarbons, Nickel Ore and Other Potential Contaminants*

4.7.6.4.1 Hydrocarbons and Other Potential Contaminants

Mitigation measures to reduce the risk of impacts associated with spills of potential contaminants during mine construction and operation will consider standard best-practice approaches, including:

- developing and implementing a handling and spill management plan
- immediate containment and clean-up of any fuel, oil or chemical spills using spill kits
- optimising the volume of stored fuel, oil or chemicals, with stores located in secure areas

- providing washdown facilities for light vehicles and machinery.

4.7.6.4.2 Nickel Ore

Mitigation measures to reduce the risk of impact associated with spills of nickel ore during mine operation will consider standard practices, including:

- designing drainage around stockpiles to prevent stockpiles from being inundated with stormwater during rainfall events
- implementing stockpile runoff control measures in accordance with the sediment and erosion control plan, such as a network of open drains to direct surface water to sediment control ponds.

4.7.6.5 Nutrient Enrichment and Other Contaminants

Mitigation measures to reduce the risk of impacts associated with nutrient enrichment and other contaminants associated with stormwater run-off and wastewater management will consider standard practices, including:

- erosion and sediment control as outlined in Section 4.7.6.1
- treatment of all wastewater (sewage) to WHO standards.

4.7.6.6 Acid Mine Drainage

Rigorous testing of the sediments to be disturbed by mining areas will be undertaken, and where necessary, an acid mine drainage management plan will be implemented prior to each area being mined based on recommendations in the Global Acid Rock Drainage Guide (International Network for Acid Prevention [INAP] 2009).

Mitigation measures to reduce the risk of impacts associated with the formation and transport of acid mine drainage and metal leaching will be in accordance with standard best practices, and may include:

- specialised handling procedures for potentially acid generating materials
- amendments or additives on potentially acid generating waste rock, such as limestone, organic materials or bactericides
- effective surface water management.

4.7.6.7 Increased Mosquito and Biting Midge Breeding

Mitigation measures to reduce the risk of impacts associated with increased mosquito and biting midge breeding may include:

- reducing the extent of shallow water and aquatic vegetation in waterways
- natural control in water storages using native larvivorous fishes (which feed on mosquito larvae).

4.7.6.8 Litter and Waste

Mitigation measures to reduce the risk of impact associated with litter and waste will be in accordance with standard best practices, including:

- designated areas for holding of refuse
- appropriate disposal.

4.7.6.9 Impacts to Threatened Species

Mitigation measures to reduce the risk of impacts associated with threatened species will include:

- designing stream crossings and diversions to facilitate fish passage
- maintaining appropriate water (environmental) flows from the WSF

- using boulders and woody debris salvaged during vegetation clearing and earthworks to provide additional habitat in other waterways.

4.7.6.10 Impacts to Protected Areas

Mining activities will not be undertaken in any of the identified protected areas.

Mitigation measures to reduce the risk of impacts to freshwater ecosystems in protected areas (e.g. Jarihana, Hohogle and Koloraghu Rivers) or in fishing/hunting areas (e.g. The Lelegia River Fishing Area, Aluau Hunting/Fishing Area, Huali River Fishing Area and Tatamba Fishing River) downstream of the Project area are discussed in:

- Section 4.7.6.1
- Section 4.7.6.2
- Section 4.7.6.3
- Section 4.7.6.4
- Section 4.7.6.5
- Section 4.7.6.6
- Section 4.7.6.8.

4.7.6.11 Freshwater Ecosystem Monitoring

Freshwater ecosystem monitoring programs will be designed to detect changes in the condition, abundance and distribution of freshwater biota and compliment surface water and sediment quality and marine ecology monitoring where practical.

Monitoring of freshwater ecosystems will be based on the baseline survey methods for assessment of freshwater communities, as outlined in the Impact Assessment Report – Freshwater Surface Water Ecology. Surveys of aquatic habitat, aquatic flora, macroinvertebrates, macrocrustaceans and fish will be undertaken for streams and rivers:

- downstream of sediment disturbance such as clearing for roads, construction of permanent or temporary stream crossings, and during mining activities
- downstream of potentially altered flows (i.e. downstream of areas where catchment area has been lost due to mining activity, and in association with stream barriers such as dams, weirs and crossings)
- at locations upstream of disturbances or within streams in nearby catchments that are unlikely to be affected by construction and operation of the mine facilities.

Monitoring will be undertaken during both construction and operation, and after operation until conditions return to background conditions (i.e., that established by the baseline survey and/or prior to disturbance).

4.8 Marine Ecology

This section describes:

- the environmental values of the aquatic habitats, flora and fauna occurring and likely to occur in the marine and estuarine environments likely to be affected by the Project
- the potential direct and indirect impacts on marine ecosystems from the construction and operation of the Project
- proposed mitigation measures for protecting or enhancing marine ecological values.

Further details are provided in the Impact Assessment Report – Marine Ecology.

4.8.1 Standards Applied

The resources used to inform the survey design, methodology and data analysis are described in Impact Assessment Report – Marine Ecology.

4.8.1.1 IUCN Red List Categories and Criteria

The IUCN Red List Categories and Criteria have been used to classify species according to their extinction risk. The environmental values of this report have been classified under the following IUCN Categories (IUCN, 2001):

- Extinct (EX): when there is no reasonable doubt that the last individual has died.
- Extinct in the Wild (EW): when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range.
- Critically Endangered (CR): when the best available evidence indicates that it meets any of the criteria for Critically Endangered and it is therefore considered to be facing an extremely high risk of extinction in the wild.
- Endangered (EN): when the best available evidence indicates that it meets any of the criteria for Endangered and it is therefore considered to be facing a very high risk of extinction in the wild.
- Vulnerable (VU): when the best available evidence indicates that it meets any of the criteria for Vulnerable and it is therefore considered to be facing a high risk of extinction in the wild.
- Near threatened (NT): when it does not qualify for the above now but is likely to qualify for a threatened category in the future.
- Least Concern (LC): when it does not qualify for CR, EN, VU or NT. Widespread and abundant taxa are included in this category.
- Data Deficient (DD): when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.
- Not Evaluated (NE): when it has not yet been evaluated against the criteria.

4.8.2 Methodology

The environmental values related to marine ecosystems were described based on a baseline field survey and available literature assessing the ecology of marine ecosystems in the region. The baseline survey was undertaken from 15th to 21st September 2010, and included an assessment of dominant habitats (coral reefs, mangrove forests and seagrass meadows) and indicator fauna (infaunal and epifaunal benthic invertebrates and fishes). The marine survey area at Santa Isabel Island included ecosystems downstream of the areas proposed for mining and in proximity to proposed infrastructure (e.g. port facilities). The locations of the baseline survey sites are shown in Figure 4-18.

Meetings and interviews were also undertaken to gain an understanding of local artisanal, and marine and freshwater commercial fisheries[4]. This information was supplemented with field observations (e.g. local fishermen's catch and local markets) and data collected from community consultation meetings. Fish, crustacean and bivalve specimens were obtained from local fishermen for analysis of contaminants.

Methods for the assessment of marine ecosystems, including the limitations of the baseline survey, are further described in the Impact Assessment Report – Marine Ecology.

[4] Including the Solomon Islands Ministry for Fisheries and Marine Resources; A. Carlos on 22 June 2010

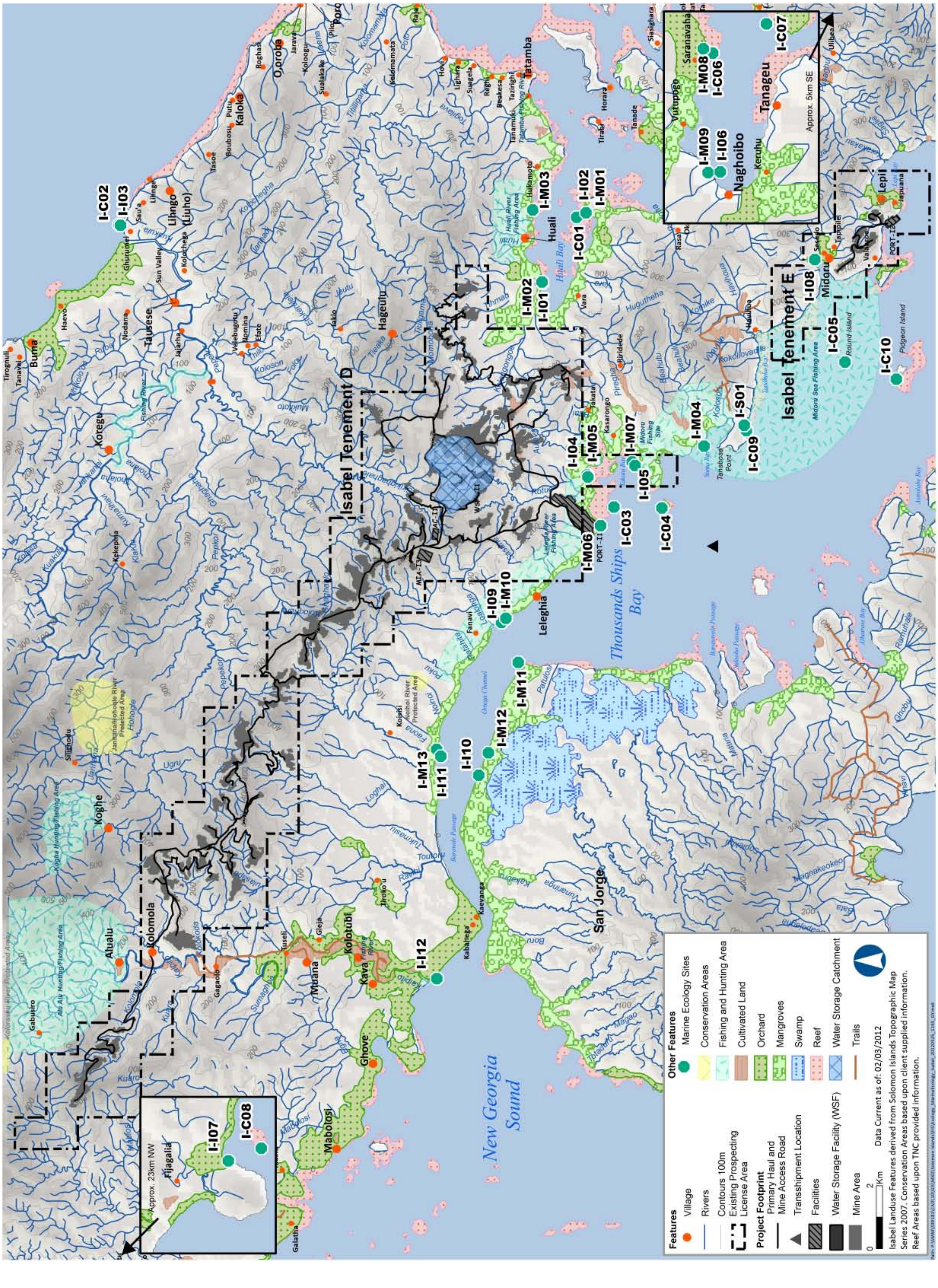

Figure 4-18 Santa Isabel Island Marine Survey Sites

4.8.3 *Existing Values*

4.8.3.1 *Overview*

Marine ecosystems of the survey area are dominated by extensive mangrove forests and coral reefs, together with rocky and sandy shorelines, seagrass meadows and bare substrate. These marine ecosystems support diverse floral and faunal communities and have high environmental value. During the baseline survey, habitat condition was mostly good with some degradation due to human influences (e.g. mangrove clearing and some siltation of reefs due to sediment-laden run-off from rivers downstream of logging tracks). No known exotic biota were identified.

4.8.3.2 *Coral Reefs*

The Solomon Islands are located in the Coral Triangle, which is recognised as a global coral diversity hotspot.

Coral reefs fringe the shoreline throughout most of the survey area. During the baseline survey corals within the survey area were generally in good condition. The cover of hard corals varied at coral reefs within the survey area, and ranged from approximately 3% at the Kuakula River mouth, to 57% in southern Takata Bay. Hard corals dominated the coral communities, particularly branching, massive and sub-massive growth forms from the families:

- Acroporidae (*Acropora* spp.)
- Poritidae (*Porites* spp.)
- Faviidae (*Favia* spp. and *Favites* spp.).

Soft corals were uncommon, but were dominated by the family Alcyoniidae (*Sinularia* spp., *Sarcophyton* spp. and *Lobophyton* spp.) where present.

Macroalgae cover at coral reefs varied within the survey area (<1 to 11%), and common species included:

- *Caulerpa racemosa*
- *Chlorodesmis fastigiata*
- *Dictyota* sp.
- *Halimeda* spp. (*H. discoidea* and *H. micronesica*),
- *Padina gymnospora*
- *Sargassum* spp.
- *Turbinaria* sp.

These macroalgae and corals are typical of coral reef communities of the region.

Silt was a common component of coral reef substrates at reefs located near river mouths. This fine sediment was likely to have been introduced into rivers by sediment-laden run-off from cleared areas (e.g. logging tracks) following rainfall, and subsequently settled out of the water column onto reef surfaces (predominantly turf algae). The cover of silt on reef surfaces was particularly high (~66%) at a coral reef near the Kuakula River mouth.

Coral reefs near and within the proposed Port-I1 in southern Takata Bay sites (I-C03 and I-C04) comprised ~37 to 57% live hard corals and ~11 to 18% dead corals. Silt covered ~5 to 9% of the reef surfaces at these sites.

4.8.3.3 *Mangrove Forests*

Mangrove forests of the Solomon Islands are relatively diverse; 25 species have been recorded (Ramohia and da Wheya 2002). This represents approximately 50% of the 45 known mangrove species in the Australasia region (Duke 2006).

Mangrove forests dominate the south-east shoreline of Santa Isabel Island. At the time of survey, mangrove forests were of fair to good health, with some areas of poor condition or dieback. The only notable exception was at site I-M10 (Loalonga River mouth), where 70% of mangrove trees were felled to expand a village. Small areas of natural dieback were also evident due to disturbances such as wind action, wave action (eroding shores and undercutting mangrove trees) and the falling of old trees.

Most of the mangrove forests surveyed provided good fish habitat, having moderate amounts of structural habitat for fauna and periodic tidal inundation. A total of 12 species of mangroves were recorded within the survey area, typically dominated by:

- *Rhizophora stylosa* (long-style stilt mangrove)
- *Rhizophora apiculata* (corky stilt mangrove)
- *Bruguiera exaristata* (rib-fruited orange mangrove)
- *Bruguiera gymnorrhiza* (large-leafed orange mangrove)
- *Ceriops tagal (*rib-fruited yellow mangrove)

4.8.3.4 *Seagrass Meadows*

The diversity of seagrass in the Solomon Islands is high with eight seagrass species identified within the survey area at Santa Isabel Island. Approximately 535 ha of seagrass has previously been found around Santa Isabel Island (McKenzie et al. 2006). Seagrass meadows within the survey area comprise meadows of *Enhalus acoroides* (tape seagrass) in Ortega Channel, and a small meadow of mixed sub-tidal seagrasses near Tanabosu Point. Seagrass cover at Tanabosu Point was relatively sparse, covering approximately 36% of the substrate. At least eight species of seagrass were recorded; the dominant species were *Enhalus acoroides* and *Thalassia hemprichii* together with *Zostera muelleri* and *Halodule uninervis*. Macroalgal coverage in the seagrass meadows was low (<1%).

4.8.3.5 *Soft Sediment Benthos*

Benthic infaunal communities live in the sediment, and are typically dominated by polychaetes (worms), bivalves (mussels) and gastropods (snails). These animals are prey items for many larger invertebrates and fish species, including species important to local artisanal fisheries. Bivalves (e.g. mudshells) and gastropods (e.g. trochus) of the survey area are also important to artisanal fisheries.

Benthic infaunal invertebrate richness and abundance were lowest near the Midoru logging camp (2 taxa, 51 individuals per m^2), and greatest at Takata Bay (11 taxa, 403 individuals per m^2). Water and sediment quality were relatively poor near the Midoru logging camp, and this may have contributed to the low species richness and abundance of benthic invertebrates at this site (refer to Impact Assessment Report - Surface Water Quality and Flows).

4.8.3.6 *Fish and Fisheries*

An estimated 1019 coral reef fish species have been identified from the Solomon Islands region. The most common fish families recorded at coral reef sites in the survey area were Labridae (wrasse) and Pomacentridae (damselfish), together with Chaetodontidae (butterflyfish) and Scaridae (parrotfish). These families are typical of reef fish communities of the region.

Several species of marine reptile (including turtles, marine snakes and the saltwater crocodile) and marine mammal (including dugong, nine species of dolphin and eight species of whale) have been recorded in the Solomon Islands (Skewes 1990, Green et al. 2006, Blaber and Milton 1990; cited in Kool et al. 2010).

There are no large-scale commercial fisheries that operate within the Project area. However, many species occurring within the survey area are important to the local artisanal fishery. These species are listed in Table 4-20.

Table 4-20 Species Caught by Local Artisanal Fisheries in the Survey Area

Species	Common Name
Fishes	
family Acanthuridae	surgeonfish
Anguilla spp.	eel
Aprion virescens	jobfish
Sphyraena spp.	barracuda
Caranx sexfasciatus	big eye trevally (locally referred to as mumoola)
Carangoides gymnostethus	bludger
subclass Elasmobranchii	sharks and stingray
family Holocentridae	soldierfish
Istiophorus platypterus	sailfish
family Labridae	wrasse
Lethrinus spp.	emperor
Lutjanus malabaricus	scarlet sea perch
Lutjanus spp.	snapper
Plectorhinchus spp.	sweetlips
Plectropomus spp.	coral trout (locally referred to as red fish)
Sarda spp.	bonito
Scarus spp.	parrotfish
Scomberomorus spp.	mackerel
Seriola spp.	kingfish
Thunnus sp.	tuna
–	silverfish (a local term for a collective of juvenile estuarine species captured in freshwater reaches during migration)
Molluscs	
Order Octopoda	octopus
Order Sepiida	cuttlefish
Order Teuthida	squid
Pinctada spp.	oyster
Polymesoda erosa	mangrove cockle
Pyrazus ebeninus	mud whelk
Tectus pyramis	–
Trachycardium vertebratum	heart cockle
Tridacna sp.	giant clam
Trochus niloticus	–
Trochus maculatus	trochus
Crustaceans	
Panulirus spp.	crayfish

Species	Common Name
Scylla spp.	mud crab
Echinoderms	
Class Echinoidea	sea urchin
Holothuria scabra	sandfish (beche-de-mere)
Algae	
Caulerpa lentillifera	seagrapes
Reptiles	
Caretta caretta	loggerhead turtle
Chelonia mydas	green turtle
Crocodylus porosus	saltwater crocodile
Dermochelys coriacea	leatherback turtle
Eretmochelys imbricata	hawksbill turtle
Lepidochelys olivacea	olive ridley turtle
Mammals	
Tursiops spp.	dolphin
Balaenoptera borealis	sei whale
Physeter macrocephalus	sperm whale

Concentrations of several metals were high in tissue of marine biota collected from the survey area, including aluminium, arsenic, barium, chromium, cobalt, copper, iron, molybdenum, nickel, tin, and zinc.

The concentration of arsenic in marine biota tissue was high in most samples, compared to the Australian New Zealand Food Standards Code guideline values in most survey areas[5] (FSANZ 2011). Arsenic in the marine environment is likely to be associated with marine geology and submarine volcanic activity, given the low levels of human activity in the area. It is considered unlikely that the Project will increase concentrations of arsenic in the marine environment.

4.8.3.7 Species of Conservation Significance

4.8.3.7.1 Marine Flora

Marine plants are not protected under Solomon Islands legislation.

Most mangrove species recorded in the survey area are listed under the IUCN Red List of Threatened Species as species of 'least concern'; *Bruguiera exaristata* and *B. gymnorrhiza* are not listed. All seagrass species recorded in the survey area are listed under the IUCN Red List of Threatened Species as species of 'least concern'.

4.8.3.7.2 Marine Fauna

All marine fauna are potentially important to subsistence fisheries, and particularly important resources are provided some protection under the Solomon Islands *Fisheries Act 1998* and *Wildlife Protection and Management Act 1998*. These include:

- sandfish (beche-de-mer)
- trochus (or turban) shells (*Trochus* spp. and *Tectus pyramis*)
- clams from the genus *Tridacna* or *Hippopus* (harvested from the wild)
- oyster shells from the genus *Pinctada*
- crayfish from the genus *Panulirus*

[5] A separate review of arsenic in marine biota tissue determined that the concentrations of arsenic recorded in the baseline survey were unlikely to be harmful to human health.

- coconut crabs (*Birgus latro*)
- turtles
- crocodiles (harvested from the wild).

Several of these taxa are also listed under the IUCN Red List of Threatened Species:

- *Dermochelys coriacea* (leatherback turtle) is listed as 'critically endangered'
- *Chelonia mydas* (green turtle) and *Caretta caretta* (loggerhead turtle) are listed as 'endangered'
- *Tridacna derasa* (smooth giant clam) and *Tridacna gigas* (giant clam) are listed as 'vulnerable'
- *Hippopus hippopus* (horseshoe clam), *Hippopus porcellanus* (China clam),*Tridacna maxima* (rugose giant clam) and *Tridacna squamosal* (fluted giant clam) are listed as 'lower risk' / 'conservation dependent'
- *Tridacna crocea* (burrowing clam) and *Crocodylus porosus* (saltwater crocodile) are listed as 'lower risk' / 'least concern'
- *Panulirus femoristriga* (white-whiskered coral crayfish), *Panulirus ornatus* (ornate spiny lobster) and *Panulirus penicillatus* (pronghorn spiny lobster) are listed as 'least concern'.

Village leaders often ban the harvest of sandfish on a reef for a period of months or years, together with other species as discussed in Section 4.8.3.8 (Lipsett-Moore, et al. 2010).

Benthic infaunal invertebrates, fish, marine mammals and other marine reptiles (sea snakes) are not protected under Solomon Islands legislation. However many species of fish, mammals and reptiles are protected by landowners in protected areas, and are listed as 'critically endangered', 'endangered' or 'vulnerable' under the IUCN Red List of Threatened Species.

There are 503 species from the taxonomic class Anthozoa (corals and sea anemones) that are listed on the IUCN Red List of Threatened Species as occurring in the Solomon Islands region. Of these 503 species:

- Four are listed as 'endangered'
- 130 are 'vulnerable'
- 141 are 'near threatened'
- 27 are 'data deficient'
- 201 are of 'least concern'.

There are 335 species from the taxonomic classes Actinopterygii (ray-finned fishes) and Chondrichthyes (cartilaginous fishes – sharks and rays) that are listed on the IUCN Red List of Threatened Species as occurring in the Solomon Islands region. Of these 335 species:

- One is listed as 'endangered'
- 15 are 'vulnerable'
- 21 are 'near threatened'
- 26 are 'data deficient'
- 272 are of 'least concern'.

There are at least 40 species of marine flora and fauna listed on the IUCN Red List of Threatened Species that occur, or may occur on occasion, in the survey area. These include:

- ten mangrove species
- eight seagrass species
- seven fish species important to local artisanal fisheries
- six mollusc species important to local artisanal fisheries
- six reptile species, including five turtle species and one crocodile species, and
- three marine mammal species, including dugong and two species of whale.

4.8.3.8 *Protected Areas*

Locally protected areas and important marine areas within and adjacent to the Project area that were identified by villagers during the baseline survey are shown in Figure 4-17. All conservation areas for Santa Isabel are protected by the local communities and not protected under law by the *Protected Areas Act 2010*.

During the baseline survey, local villagers identified an important fishing area adjacent to Tenement E; the Midoru Sea Fishing Area within Thousand Ships Bay.

Under the international Convention on Biological Diversity (CBD), of which the Solomon Islands is a signatory, the Solomon Islands Government is required to set aside 10% of the Solomon Islands in protected areas. Lipsett-Moore et al. (2010) recommends that 20% of the Solomon Islands and 95% of the conservation features most vulnerable to climate change (e.g. turtle nesting beaches) or crucially important to local communities (e.g. transient fish spawning aggregations) be conserved in protected areas to allow for climate change. Priority conservation areas had not been recommended for Santa Isabel Island at the time of writing.

4.8.4 *Potential Impacts*

The following components of the Project have the potential to impact marine ecosystems:

- construction and operation of the mine areas and supporting infrastructure such as roads and accommodation camp (mostly indirect impacts via freshwater systems)
- construction and operation of two port areas:
  - Port-I1, located in northern Takata Bay (main port for ore handling)
  - Port-I2, located West of Lepi Bay.

Project construction and operation activities that have the potential to result in impacts to marine ecology are outlined in the following sections. Further details are provided in the Impact Assessment Report – Marine Ecology.

4.8.4.1 *Increased Turbidity and Subsequent Sedimentation*

Vegetation clearing and earthworks will be required for the construction (and operation) of several components of the mines and supporting infrastructure. There is a high potential for soil erosion following vegetation clearing and earthworks due to the intense rainfall, fine soils and steep topography of the Project area. Construction of permanent and temporary waterway crossings along haul and access roads may also disturb sediment, leading to localised increases in turbidity and sediment deposition. Increased turbidity in the receiving marine waters could lead to negative impacts on marine biota.

Increased turbidity and sedimentation will also occur during port construction from activities such as excavation, reclamation and pile driving, and from potential dredging. Localised increases in turbidity and sedimentation caused by vessel operation and manoeuvring in shallow waters is also likely. Fine particles remain suspended longer than coarser particles, and are likely to be carried further before settling out of the water column. The risk of increased turbidity following sediment disturbance is high at the proposed Port-I1 area.

Clear waters are important for the functioning of marine ecosystems, particularly coral reefs and seagrass meadows. Turbidity in marine waters was typically less than 5 NTU during the baseline survey .

The effects of increased turbidity and sedimentation on marine communities are outlined in the sections following.

4.8.4.1.1 Coral Reefs

The effects of increased turbidity and sedimentation on coral reefs can range from mild coral stress with subtle changes in reef community structure to outright coral mortality and ecological collapse (Raaymakers and Oliver 1993). Loss of coral reef is likely to impact marine fauna as coral reefs provide important habitat for many species, many of which are relied upon for food in the Project area. Loss of large areas of coral reef is likely to affect the productivity of fisheries in the region.

The common coral species in the inshore waters of the survey area (e.g. near river mouths) are considered moderately sensitive to the effects of increased sedimentation and turbidity. Corals inhabiting inshore waters are generally more efficient at sediment clearance than those species typically inhabiting offshore waters, and can therefore generally withstand deposition of sediment better than offshore species (Salvat 1987).

Coral communities near the proposed port areas and river mouths downstream of mining activities are most likely to be affected by increased turbidity, including:

- corals in proximity to Port-I1 (northern Takata Bay) and Port-I2 (west of Lepi Bay)
- corals in proximity to the Kuakula river mouth, capturing runoff from most of the northern portion of Tenement D
- corals in Huali Bay, capturing runoff from the eastern portion of Tenement D and draining through the Kolongongoe River
- reef flat and forereef in proximity to Cockatoo Island, capturing runoff from Tenement E

4.8.4.1.2 Mangrove Forests

Mangroves are generally considered to be tolerant to the effects of increased turbidity and sedimentation (DHI 2010). Mangroves can be positively impacted by sedimentation, because sediment deposition forms new intertidal mud or sand banks suitable for mangrove colonisation.

4.8.4.1.3 Seagrass Meadows and Macroalgae

Seagrass meadows and macroalgae stabilise marine sediment, produce and trap detritus, and provide shelter and refuge for resident and transient adult and juvenile fishes and invertebrates such as crustaceans and cephalopods. Most of these species are an important food source in the Project area, and others are the preferred foods of these species.

Seagrasses and macroalgae are generally considered to be moderately tolerant to the effects of increased turbidity and sedimentation (DHI 2010). The mixed seagrass meadows recorded near Tanabosu Point may be negatively impacted by increased low light levels (particularly when total suspended solids exceed 10 mg/L) for extended periods of time (i.e. longer than the existing exposure to sediment-laden stormwater runoff following heavy rain).

These seagrass meadows may also be smothered by substantial sedimentation. However colonising species such as *H. ovalis* and *H. uninervis* are likely to re-colonise the meadows when favourable conditions return.

4.8.4.1.4 Soft Sediment Benthos

Increased turbidity may impact the respiration and feeding of a variety of benthic macroinvertebrate taxa, leading to declines in abundance, species diversity and productivity. The deposition of fine sediment over existing substrate is likely to influence the community structure of benthic infauna, with the abundance of filter feeding and gilled fauna likely to decline.

Soft sediment habitat is widespread in the survey area. The loss of small areas of habitat (due to smothering) is not likely to be significant on a regional scale, particularly as it is likely to be reversible when favourable conditions return.

4.8.4.1.5 Fishes and Other Vertebrates

The impact of increased turbidity and sedimentation on fishes and other vertebrates is largely dependant on the impacts to their biological habitats (e.g. coral reefs, mangroves and seagrasses). The direct effect of increased turbidity and sedimentation on fish and other vertebrates is likely to be minimal, primarily because mobile fauna tend to avoid unfavourable environments and the turbid areas will be localised. Where movement of fauna is not restricted, fauna may move away from turbid areas, leading to localised impacts on ecological communities and a decline in subsistence fisheries resources.

4.8.4.2 Spills of Hydrocarbons and Nickel Ore

4.8.4.2.1 Hydrocarbons

Fuel and oil required for the operation of vehicles, mine machinery and port vessels present a risk to marine biota if spills enter marine waters (or streams/rivers), or if a vessel becomes grounded.

Both diesel and petrol are toxic to marine biota at relatively low concentrations. The extent of impact is typically determined by the duration of exposure (van Gelder-Ottway 1976), with chronic (long-term) contamination during operation likely to pose a greater risk than acute (short-term) contamination during construction. Oil spills could lead to the direct mortality of animals (e.g. respiratory damage from breathing toxic vapours; fouling of body surfaces or ingesting of oiled prey) (Dobbs and Authority 2001; Smith 1997).

Chronic oil contamination (e.g. from small refuelling spills and outboard motors) can have sub-lethal effects on marine vertebrates such as immuno-suppression, reproductive impairment, developmental/behavioural abnormalities, and disease (including tumours) (Dobbs and Authority 2001).

A significant fuel spill in a marine environment (in the order of tens or hundreds of litres) is likely to have a locally significant impact on marine biota. The quantity spilt and the volume of water and extent of mixing (turbulence) in the receiving environment are the most significant factors influencing the severity of impact.

4.8.4.2.2 Nickel Ore

Spilt nickel ore has the potential to impact marine biota. Experiments using nickel ores from New Caledonia and Indonesia reported that long-term leaching of these ores with seawater released nickel and hexavalent chromium in sufficient concentrations to potentially impact marine biota (Florence et al. 1994). Nickel ore may also smother benthic communities such as coral reefs, infaunal invertebrates and seagrasses.

Florence et al. (1994) reported that nickel ores from New Caledonia and Indonesia were not highly toxic if spilt in the quantities predicted during handling of the ores associated with barging. A conservative maximum safe concentration of the nickel ores in seawater is 0.1 g/L (Florence et al. 1994), although this concentration should be assessed for the local area based on background levels in sediment.

4.8.4.3 Nutrient Enrichment and Other Contaminants

Nutrients and other contaminants may be introduced into the marine environment via stormwater run-off or wastewater (sewage) releases. Wastewater treatment plants will be located at the accommodation camp, MIA and at Port-C1.1. Sediment disturbance during the construction of the ports, by the operation and manoeuvring of ships in shallow waters, and during potential dredging, may release nutrients from the sediment.

Further analysis of potential nutrient enrichment and other contaminants (associated with stormwater, sewage, dredging or sediment disturbance) will be completed during the detailed design phase.

Nutrient inputs can lead to blooms of phytoplankton or macroalgae, which produce dissolved oxygen in the water when photosynthesising during the day, and consume the dissolved oxygen at night through respiration. This can cause dissolved oxygen to be reduced to low concentrations overnight, which can be toxic to fish and other marine biota. The concentration of total nitrogen was relatively high (~4000 mg/kg) in marine sediment at a site close to the proposed Port-C1.1 (site C-M02 eastern Ologholata Harbour).

The effects of nutrient enrichment on marine communities are outlined in the sections following.

4.8.4.3.1 Coral Reefs

Increased nutrient concentrations can have a range of non-lethal impacts on hard corals including stunting coral growth and decreasing larval settlement. By reducing growth and larval settlement, the high concentration of nutrients may prevent the recovery of corals that have suffered some form of acute stress (e.g. bleaching or physical damage) (Hughes et al. 2007; Koop et al. 2001).

In areas of nutrient enrichment, corals may be out-competed by macroalgae (Lapointe 1997), particularly if nutrient enrichment is accompanied by a significant reduction in herbivores (McCook et al. 2001). Reefs dominated by algae often have lower fish stocks, less tourism appeal and lower coral biodiversity than coral-dominated reefs (McCook 1999).

4.8.4.3.2 Mangrove Forests

Increased nutrients can have positive impacts on the productivity of mangrove forests as there is commonly an increase in growth and productivity associated with low levels of nutrient enrichment (e.g. Clough et al. 1983; Dunstan 1990; McLaughlin 1987; Onuf et al. 1977).

Nutrient enrichment can also negatively impact mangrove forests. As a consequence of enhanced growth due to increased nutrient supply, the uptake of other toxic chemicals by mangroves may be increased (Duke et al. 2003).

4.8.4.3.3 Seagrass Meadows and Macroalgae

Moderate amounts of additional nutrients in the water column can increase seagrass growth (McRoy and Helfferich 1980). However, as macroalgae are more efficient at absorbing nutrients from the water column than seagrasses (or coral), nutrient enrichment can lead to an increase in macroalgal growth at the expense of seagrasses (Koop et al. 2001; Lapointe 1997; McCook 1999; Wheeler and Weidner 1983; Zimmerman and Kremer 1986). Consequently, benthic macroalgae may overgrow and displace seagrass, while drift and epiphytic algae may physically shade seagrass, reducing seagrass growth and distribution (Maier and Pregnall 1990; Silberstein and McComb 1986; Tomasko and Lapointe 1991; Twilley et al. 1985). Epiphytic algae may also reduce the diffusive exchange of dissolved nutrients and gases on leaf surfaces (Neckles et al. 1993; Twilley et al. 1985).

4.8.4.3.4 Soft Sediment Benthos

The trophic structure of benthic marine invertebrate communities often changes with increased concentrations of nutrients, resulting in communities that are dominated by small opportunistic deposit feeders. In eutrophic estuaries, deposit feeding spionid and capitellid polychaete worms often tend to be the most abundant groups (ANZECC and ARMCANZ 2000).

Changes in soft sediment community composition may lead to a decline in fisheries resources (e.g. populations of mangrove and heart cockle).

4.8.4.4 Disturbance of Acid Sulphate or Potential Acid Sulphate Sediment or Contaminated Sediment

4.8.4.4.1 Acid Sulphate Soils

Disturbance of marine sediment during dredging or other port construction activities may expose potential acid sulphate sediment to oxidising conditions, which can reduce the pH of the receiving waters. Potential acid sulphate soil typically occurs under mangrove forests and in sands deposited in protected low-energy environments such as barrier estuaries and coastal lakes (Department of Environment and Resource Management [DERM] 2011).

The effects of acidification on marine biota is poorly understood, however sudden acidification can cause fish-kills, disease and other disturbances (Sammut and Fraser 1993). Chronic low-level acidity resulting from exposure of acid sulphate soils may result in decreased vigour and increased incidence of disease in marine biota.

4.8.4.4.2 Other Contaminants

Sediment disturbance may alter other aspects of water quality, which may in turn negatively affect marine biota, for example:

- contaminated waters have been known to cause reproductive disorders, immune deficiencies, tumours and cyst development in marine mammals, especially when they are stressed (Schaffelke et al. 2001)
- contaminants can also increase susceptibility to diseases in turtles (Dobbs and Authority 2001) such as the fibro-papillomatosis virus (Bell 2003).

Further analysis of sediments proposed for disturbance will be completed during the detailed design phase.

4.8.4.5 Loss of Marine Habitat

Construction of Port-I1.1 and Port I1.2, barge landings, mooring piles, navigation channels (if required) and navigation markers may involve the direct loss of small areas of mangroves, corals, unvegetated soft sediments, and seagrass. Vessel groundings may also directly impact marine habitat.

Mangroves, coral and seagrass provide complex and varied marine habitats that support a wide range of vertebrate and invertebrate species, many of which are an important food source for local villagers. The extent of loss of each habitat will be determined during the detailed design phase.

4.8.4.5.1 Coral Reefs

Coral reefs are found in proximity to Port-I1 and Port-I2. The reef lying directly under the port footprint would be lost during construction of these ports[6], and it is likely that the corals near to the ports would be indirectly lost due to localised turbidity and sedimentation caused by vessel operation and manoeuvring. Removal of coral reefs can have a localised affect on coastline protection, however it is considered likely that the hard structures of the port will protect shorelines from wave action and subsequent erosion.

[6] The total area of coral reef within the footprints of Port-I1 and Port-I2, if any, was not available at the time of writing and will be determined during the detailed design phase.

It is unlikely that the loss of small areas of coral will affect fisheries in the region, as fish will likely migrate to nearby reefs. However, the loss of coral reef and the alteration of hydrodynamics as a result of the port can affect larval recruitment in the local area, which could affect the community composition and growth of nearby reefs. Where this does occur, there may be impacts to local fisheries.

Corals are likely to be lost as a result of drilling and pile driving activities during construction. Further details on the extent of loss will be determined during the detailed design phase.

4.8.4.5.2 Mangrove Forests

Mangrove forests grow at the proposed Port-I.1 and Port-I.2. Mangrove clearing has the potential to increase erosion of the foreshore and reduce sediment trapping (by mangrove aerial roots and pneumatophores), leading to increased turbidity and subsequent sedimentation in adjacent waters. Given that mangrove forests are well represented on Santa Isabel Island, it is unlikely that the removal of small areas of mangroves will have a significant impact on fisheries, in either a local or regional context.

4.8.4.5.3 Seagrass Meadows and Macroalgae

Seagrass meadows are found in north-east Thousand Ships Bay and Ortega Channel and may be found in proximity to Port-I1. These meadows may be lost due to direct disturbance or the effects of increased turbidity and sedimentation. The loss of small portions of seagrass meadow during the construction or operation of Port-I1 is unlikely to have an ecologically significant impact on fisheries, or on species of conservation significance that feed on seagrass (such as turtles and dugong), as the extent of loss is likely to be small and fauna would likely migrate to other nearby seagrass meadows to feed.

4.8.4.5.4 Soft Sediment Benthos

There is soft sediment habitat at all proposed port sites and it is likely to underlay navigation markers and navigation channels. Loss of a small area of soft sediment benthos is unlikely to significantly impact fisheries productivity on a local or regional scale, as this habitat is well represented in the survey area.

4.8.4.6 Altered Marine Hydrodynamics and Subsequent Flushing, Erosion and Sedimentation

Port developments may alter hydrodynamics of adjacent marine waters, which could alter tidal flushing and water quality and modify areas of sediment erosion and deposition. These changes may impact water (and sediment) quality and the availability of habitat especially if sediment deposition smothers corals and seagrass. The extent of impact will be assessed during the detailed design phase, based on model outputs by Project engineers.

4.8.4.7 Gain of Artificial Habitat for Marine Biota

While small areas of coral reef and mangroves will be lost, the proposed ports, ferry terminals and moorings will add a degree of physical complexity to the intertidal and shallow sub-tidal habitat of the Project area. The hard surfaces may provide substrate for species of algae, hard and soft corals, sponges, ascidians and a variety of other sessile benthic invertebrates. In turn, this benthic community will provide shelter and food for a variety of fishes and other fauna. The structures may also provide overhead structures (shade), which is important for attracting many fish species (de la Moriniere et al. 2004; Verweii et al. 2006). However, the function of the structures, and the fish species supported, will differ from the natural habitats to be lost, and as such will not directly replace the habitat that is lost.

4.8.4.8 *Increased Noise, Vibration and Human Activity*

Construction of the port areas, including barge landings, moorings, navigation channels (if required) and navigation markers, and operation of the port areas will result in increased noise and vibrations from increased vessel traffic and activities such as dredging and pile driving. This is highly likely to disturb marine mammals and reptiles (e.g. dolphins, dugongs, turtles and saltwater crocodiles), which may initially move away from the area. However, this is likely to be a short-term response, and they are likely to return once the activity-intensive construction period has ceased, where habitat is available (noting that some habitat for these species will be lost as a result of construction of the port).

Increased vessel traffic during construction and operation of the ports will result in more frequent interactions between vessels and marine mammals and reptiles, and possibly 'boat strikes'. Marine mammals and reptiles may initially respond to boats by altering their behaviour (e.g. changing swimming direction or reducing time spent resting) (Hodgson and Marsh 2007), and long-term effects may include displacement to deeper waters.

Increased human activity on and directly adjacent to turtle nesting beaches can negatively impact nesting activity. At the time of writing, there was no readily available information about the location of turtle nesting beaches, if any, in the survey area.

The waters of the Project area do not support significant feeding grounds (seagrass meadows) for dugong or green turtles. However there are feeding grounds for loggerhead and hawksbill turtles (coral reefs), dolphins (river mouths and open water) and saltwater crocodiles (mangroves and river mouths) near the proposed port areas. Given the small proportion of these habitats to be affected by port activity, it is likely that fauna would move to neighbouring habitat and be largely unaffected in the long term.

Impacts to marine fauna due to noise, vibration and human activities are likely to be low.

4.8.4.9 *Antifoul Leaching*

Increased vessel traffic around port areas may result in increased leaching of antifoulant paints such as copper and tributyltin, which are toxic to marine biota. Antifoulants may also be transferred directly to benthic habitats (including coral reefs and soft sediment benthos) in the event of a vessel grounding. In open waters, antifoulants are unlikely to accumulate in concentrations toxic to marine biota. However, in estuaries and ports, the currents, water depth and water residence times are substantially less and copper and tributyltin may settle out of the water column and accumulate within the sediment. The half-life of tributyltin (i.e. the time it takes for half of a given quantity to degrade) can be as short as six hours in seawater, but longer than three years if it becomes incorporated within sediment (Batley 2000).

Further analysis of sediments proposed for dredging and disturbance will be completed during the detailed design phase, to inform the EMP.

4.8.4.10 *Introduced Marine Pests*

The introduction of exotic marine flora and fauna can threaten the integrity of natural communities, including threatening rare and endangered species, the viability of living resource-based industries and human health (Hayes et al. 2005; Hutchings et al. 2002). The introduction of marine species through ballast water and hull fouling have been identified in virtually all regions of the world. However, many of the species that are translocated through shipping activities have minimal effects on receiving environments, with effects often limited to the nuisance fouling of hard structures (Hayes et al. 2005). However, if highly competitive species are introduced to surrounding reef structures, they could compete with local species and alter the ecology of the reef system.

4.8.4.11 Litter and Waste

Litter and waste associated with the construction and operation of the mine areas and infrastructure (primarily ports) has the potential to contribute to the degradation of water quality and negatively impact marine biota such as marine mammals and reptiles. For example, entanglement in debris can lead to death from asphyxiation, abrasion, infection or reduced ability to feed or avoid predators (Smith 1997). This is a particular concern with sea turtles. Ingestion of debris such as plastic bags may occur if the animal mistakes the debris for prey, and can cause fatal blockages in the animal's digestive system (Smith 1997).

4.8.4.12 Increased Fishing Pressure

A significant workforce of skilled labour will be required to construct and operate the mine and infrastructure. As a result, the quantity of fish and invertebrates (e.g. cockle shells) harvested by local villagers to sell to the SMM Solomon mine camps may increase. This is likely to put pressure on the fisheries resources in waters close to the mining camps, which over time, could lead to the depletion of marine resources and/or shifts in ecological communities (e.g. overharvesting of herbivorous fish can increase macroalgal coverage at the expense of coral growth [Hughes et al. 2007]) in the local area. Overharvesting has the potential to significantly impact ecological communities, however impacts will be low where fisheries resources are managed effectively (e.g. through protected areas).

4.8.4.13 Impacts to Species of Conservation Significance

Invertebrates of conservation significance (trochus, clams, pearl oysters, sandfish, crayfish, coconut crabs and mud crab) can be directly impacted by activities such as port construction (including dredging if necessary). Vertebrates of conservation significance (turtles, saltwater crocodiles, dolphins and milk fish) can be directly impacted by activities such as dredging, noise, vibration and boat strike. All fauna can be indirectly impacted via under-utilised habitat loss or degraded water quality and/or food sources.

Impacts associated with dredging, noise, vibration and boat strike are considered manageable where an effective EMP is developed. The indirect effects on fauna of conservation significance are likely to be minimal, primarily because impacts will be localised and mobile fauna tend to avoid unfavourable environments and move to nearby habitats to source food.

Impacts that relate to species of conservation significance are further discussed in:

- Section 4.8.4.1
- Section 4.8.4.4
- Section 4.8.4.5
- Section 4.8.4.8
- Section 4.8.4.12.

4.8.4.14 Impacts to Protected Areas

There are no marine protected areas in the survey area. However, the Midoru Sea Fishing Area may be indirectly impacted by runoff from mining areas in Tenement E, as discussed in Section 4.8.6.1.

4.8.5 Impact Assessment

A risk assessment of potential impacts on marine ecosystems is presented in Table 4-21.

Table 4-21 Assessment of Potential Impacts on Marine Ecosystems

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Increased turbidity and subsequent sedimentation														Erosion and sediment control measures implemented for design, construction and operation of mine, ports (including dredging, spoil handling, silt curtains) and supporting infrastructure. Development and implementation of a dredge management plan if dredging is required.		
Seagrasses and macroalgae	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High		Medium to High[1]	Low
Mangroves	•	•	•	•	•	•	Neutral or Positive	Local	Medium	Long	Probable	Low	Low		Low	Medium
Corals	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High		Medium to High[1]	Medium
Soft sediment benthos	•	•	•	•	•	•	Negative	Local	Medium	Long	Highly Probable	Medium	Medium		Low to Medium[1]	Medium
Fish and other vertebrates	•	•	•	•	•	•	Negative	Regional	Low	Long	Probable	Medium	Low		Low	Medium
Spills of hydrocarbons and nickel ore	•	•	•	•	•	•								Fuel, oil, ore and chemical handling to be undertaken in accordance with standard best practice including secure storage, control measures for stockpile run-off, and implementation of a handling and spill management plan.		
Hydrocarbons	•	•	•	•	•	•	Negative	Regional	High	Long	Probable	High	High		Medium	Medium
Nickel ore	•	•	•		•	•	Negative	Local	High	Long	Probable	High	High		Medium to High[1]	Medium
Nutrient enrichment														Erosion and sediment control, stormwater management and treatment of wastewater. Development and implementation of a waste water management plan and dredge management plan if dredging required.		
Seagrasses and macroalgae	•		•	•	•	•	Negative	Local	Medium	Medium	Probable	Medium	Medium		Low	Medium
Mangroves	•		•	•	•	•	Positive or Negative	Local	Low	Medium	Probable	Low	Low		Low	Medium
Corals	•		•	•	•	•	Negative	Local	Medium	Medium	Probable	Medium	Medium		Low	Medium
Soft sediment benthos	•		•	•	•	•	Negative	Local	Low	Medium	Probable	Low	Low		Low	Medium

Table 4-21 Assessment of Potential Impacts on Marine Ecosystems

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Disturbance of contaminated marine sediments during port construction and operation														Rigorous testing of coastal and marine sediments to be disturbed. Development of an acid sulphate management plan, where necessary.		
Acid sulphate or potential acid sulphate			•	•	•		Negative	Local	High	Medium	Probable	Medium	Medium		Low to Medium[2]	Low
Other contaminants			•			•	Negative	Local	Medium	Long	Improbable	Medium	Low		Low	Medium
Loss of Marine Habitat														Avoidance of sensitive marine habitats, where possible, during port design and construction. Consultation with stakeholders and relevant agencies regarding environmental offsets or compensatory activities to address remaining impacts.		
Direct loss through reclamation and dredging (if required) for port areas			•		•		Negative	Local	Medium	Long	Definite	Medium	High		Medium	Medium
Indirect loss through altered marine hydrodynamics and subsequent flushing, erosion, sedimentation and impacts to larval recruitment			•		•	•	Negative	Local	Medium	Long	Definite	Medium	High		Medium	Low
Gain of artificial habitat for marine biota			•			•	Positive	Local	Medium	Long	Definite	Medium	High	Positive impact, no Mitigation required.	NA	Medium
Increased noise, vibration and human activity			•		•	•	Negative	Local	Medium	Short	Highly probable	Low	Low	Enforcement of speed limits around port areas to reduce boat strikes. Use of bubble curtains and jackets, and pile cap cushions to manage noise from activities such as pile driving, during construction of port facilities.	Low	Medium

Table 4-21 Assessment of Potential Impacts on Marine Ecosystems

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
Antifoul leaching														EMP to include plans to eliminate the introduction of tributyltin or copper compounds as a result of painting, paint removal, cleaning, sand blasting or waste disposal operations, or run-off from such facilities.		
Copper			•		•	•	Negative	Local	Medium	Long	Probable	Low	Low		Low	Medium
Tributyltin			•		•	•	Negative	Local	Medium	Long	Probable	Low	Low		Low	Medium
Introduced marine pests			•		•	•	Negative	Regional	Low	Long	Improbable	Medium	Low	Management of hull fouling. Implementation of ballast water management plan, including exchange of ballast water in open ocean.	Low	Medium
Litter and waste	•	•	•	•	•	•	Negative	Regional	Low	Long	Highly Probable	Low	Low	Standard best practice waste disposal and storage of waters.	Low	Medium
Increased fishing pressure				•	•	•	Negative	Regional	Medium	Long	Improbable	High	High	Management of trade between local fishermen and SMM Solomon. Working with stakeholders to manage fishing resources. Implementation of a no fishing policy for Project personnel.	Low to Medium[1]	Low

Table 4-21 Assessment of Potential Impacts on Marine Ecosystems

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to species of conservation significance														Implementation of mitigation measures described for impacts relating to: increased turbidity and sedimentation, disturbance of acid sulphate or potential acid sulphate sediment, direct loss of marine biota, increased noise, vibration and human activity and increased fishing pressure.		
Seagrasses	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High		Medium to High[1]	Low
Mangroves	•	•	•	•	•	•	Neutral or Positive	Local	Medium	Long	Probable	Low	Low		Low	Medium
Corals	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High		Medium to High[1]	Medium
Fish	•	•	•	•	•	•	Negative	Regional	Low	Long	Probable	Medium	Low		Low	Medium
Molluscs	•	•	•	•	•	•	Negative	Local	Medium	Long	Probable	Medium	Medium		Low	Medium
Reptiles	•	•	•	•	•	•	Negative	Regional	Low	Short	Highly Probable	Low	Low		Low	Medium
Mammals	•	•	•	•	•	•	Negative	Regional	Low	Short	Highly Probable	Low	Low		Low	Medium
Impacts to protected areas (Guere Marine Protected Area and Kozongangara Fishing Area)	•	•	•	•	•	•	Negative	Local	Medium	Long	Probable	Medium	Medium	Implementation of mitigation measures described for impacts relating to: increased turbidity and sedimentation, spills of hydrocarbons and nickel ore, disturbance of acid sulphate or potential acid sulphate sediment and litter and waste.	Low	Medium

4.8.6 *Mitigation Measures*

The development of the EMP, and rigorous site management in accordance with current best practice offer significant opportunities to minimise potential impacts to marine ecosystems. Details of mitigation measures are provided in Chapter 5 and the Impact Assessment Report – Marine Ecology.

4.8.6.1 *Increased Turbidity and Subsequent Sedimentation*

The following mitigation measures will reduce the risk of impacts associated with increased turbidity and sedimentation during Project construction and operation. Further analysis of marine sediments proposed for disturbance will be completed during the detailed design phase, to refine the EMP.

4.8.6.1.1 Mines and Supporting Infrastructure

Mitigation measures to reduce the risk of impact associated with increased turbidity and sedimentation during mine construction and operation will consider standard practices, including:

- obtaining sign-off from a site supervisor that drainage and erosion control measures are in place prior to vegetation clearing and earthworks
- erosion and sediment control measures including drainage ditches, diversions, chutes, pocket ponds, infiltration trenches and ponds, sediment control ponds and dams, contour banks and ditches and a washdown facilities for vehicles and machinery
- staging vegetation clearing and earthworks over the life of the mine
- sheeting haul roads with a target gradient of 1 in 10
- progressively rehabilitating and revegetating post mine landforms.

4.8.6.1.2 Port Areas

Mitigation measures to reduce the risk of impact associated with increased turbidity and sedimentation during port construction and operation will consider standard practices, including:

- port design, construction and operation including sediment control measures such as a network of open drains to direct surface water to sediment control ponds (which will be unlined and include a filter dam, spillway and dewatering system) and vehicle wash facilities
- if dredging is required:
  - a dredge management plan (as part of the EMP) with pre-determined 'cease work' trigger values for turbidity will be developed and implemented (where trigger values are based on turbidity and ecological data from baseline monitoring and take into account hydrological and sediment fate modelling)
  - sediment disturbance areas will be effectively 'isolated', using silt curtains, oil spill booms, bunding, trenching and/or similar technologies
  - all dredging and spoil handling activities will be undertaken in accordance with standard practices under the London Convention 1972 (LV-72) and its 1996 protocol, and in consideration of Australia's National Assessment Guidelines for Dredging (Department of Environment, Water Heritage and the Arts [DEWHA] 2009).

4.8.6.2 *Spills of Hydrocarbons and Nickel Ore*

4.8.6.2.1 Hydrocarbons and Other Potential Contaminants

Mitigation measures to reduce the risk of impacts associated with spills of potential contaminants during mine construction and operation will consider standard practices, including:

- developing and implementing a handling and spill management plan
- immediate containment and clean-up of any fuel, oil or chemical spills using spill kits
- optimising the volume of stored fuel, oil or chemicals, with stores located in secure areas
- providing washdown facilities for light vehicles and machinery
- providing secondary containment of storage for fuel, oil and lubricants .

4.8.6.2.2 Nickel Ore

Mitigation measures to reduce the risk of impact associated with spills of nickel ore during mine operation will consider standard practices, including:

- designing drainage around stockpiles to prevent stockpiles from being inundated with stormwater during rainfall events
- implementing stockpile runoff control measures in accordance with the sediment and erosion control plan, such as a network of open drains to direct surface water to sediment control ponds
- designing and implementing a spill response procedure in the event of a large spill of nickel ore to the marine environment.

4.8.6.3 *Nutrient Enrichment and Other Contaminants*

4.8.6.3.1 Stormwater Run-off and Wastewater Management

Mitigation measures to reduce the risk of impacts associated with nutrient enrichment and other contaminants associated with stormwater run-off and wastewater management consider standard practices, including:

- erosion and sediment control as outlined in Section 4.8.6.1
- treatment of all wastewater (sewage) to WHO standards.

4.8.6.3.2 Sediment Disturbance

Mitigation measures to reduce the risk of impacts associated with nutrient enrichment and other contaminants associated with sediment disturbance is outlined in Section 4.8.6.1.

4.8.6.4 *Disturbance of Acid Sulphate or Potential Acid Sulphate Sediment*

Mitigation measures to reduce the risk of impact associated with acid sulphate soils will consider standard practices, including:

- rigorous testing of the marine sediments to be disturbed
- development of an acid sulphate sediment management plan, where necessary.

4.8.6.5 *Loss of Marine Habitat*

Direct loss of marine flora and fauna will be minimised by considering the location of the port areas to avoid sensitive ecological communities. SMM Solomon will liaise with local stakeholders to minimise the loss of fishing resources. Environmental offsets or compensatory activities may be used to address any remaining impacts. Options to offset loss of fishing grounds and fisheries habitat due to the construction of the ports will be discussed, and will be considering when addressing habitat loss.

4.8.6.6 *Altered Marine Hydrodynamics and Subsequent Flushing, Erosion and Sedimentation*

Mitigation measures to reduce the risk of impact associated with altered marine hydrodynamics will consider standard best practices, including port design and development of the EMP. The extent of impacts will be assessed during the detailed design phase.

4.8.6.7 *Increased Noise, Vibration and Human Activity*

Mitigation measures to reduce the risk of impact associated with increased noise, vibration and human activity will consider practices, including:

- enforcement of appropriate speed limits around the port areas to reduce boat strikes
- using bubble curtains and jackets, and pile cap cushions to manage noise from activities such as pile driving, during construction of the port facilities.

4.8.6.8 *Antifoul Leaching*

Mitigation measures to reduce the risk of impact associated with antifoul leaching will consider standard best practices, including management plans that eliminate the introduction of tributyltin compounds as a result of painting, paint removal, cleaning, sandblasting or waste disposal operations, or run-off from such facilities (IMO 2002).

Further analysis of marine sediments proposed for disturbance will be completed during the detailed design phase, to determine the current concentration (if any) of antifoulant contaminants in sediments of the proposed port areas.

4.8.6.9 *Introduced Marine Pests*

Mitigation measures to reduce the risk of impact associated with introduced marine pests will consider standard practices, including:

- managing hull fouling (to control potential introduction of invasive species)
- exchanging ballast water in the open ocean to reduce the risk of introducing invasive marine species (McConnell 2002)
- implementing a ballast water management plan (IMO 2011).

4.8.6.10 *Litter and Waste*

Mitigation measures to reduce the risk of impact associated with litter and waste will consider standard best practices, including:

- designated areas for holding of refuse
- appropriate disposal.

4.8.6.11 *Increased Fishing Pressure*

Mitigation measures to reduce the risk of impact associated with increased fishing pressure will be include:

- management of trade between local fisherman and SMM Solomon
- working with local stakeholders to manage fishing resources (e.g. through protected areas)
- implementing a no fishing/hunting policy for Project personnel.

4.8.6.12 *Impacts to Species of Conservation Significance*

Mitigation measures to reduce the risk of impact associated with species of conservation significance (trochus, clams, oysters, sand fish, crayfish, coconut crabs, mud crab, turtles, saltwater crocodiles, dolphins and milk fish) are described in:

- Section 4.8.6.1
- Section 4.8.6.4
- Section 4.8.6.5
- Section 4.8.6.7
- Section 4.8.6.11

4.8.6.13 *Impacts to Protected Areas*

Mitigation measures to reduce the risk of impact to protected areas downstream of major rivers draining mining areas are described in Section 4.8.6.1.

4.8.6.14 *Marine Ecosystem Monitoring*

A marine ecology monitoring program will be designed to detect changes in the condition, abundance and distribution of marine biota and compliment surface water and sediment quality and freshwater ecology monitoring where practical.

Monitoring of marine ecosystems will be based on the baseline survey methods for assessment of marine communities outlined in the Impact Assessment Report – Marine Ecology. Surveys will be undertaken for the following communities:

- coral reefs
- mangrove forests
- seagrass meadows
- benthic infaunal invertebrates
- fish and fisheries.

Surveys will be undertaken at locations:

- downstream of sediment disturbance such as clearing for roads and mining (i.e. near river mouths)
- in marine ecosystems adjacent to port areas
- at comparative locations (i.e. that are unlikely to be affected by construction and operation of the mine and ports).

Monitoring will be undertaken during both construction and operation, and after operation until conditions returns to background conditions (i.e. that established by the baseline survey and/or prior to disturbance). Marine ecology monitoring surveys and routine water and sediment quality monitoring will inform management of potential issues and allow the EMP to be refined.

4.9 Terrestrial Ecology

This section describes:

- the existing terrestrial ecological values within the Project area at Santa Isabel Island
- potential impacts of the Project on the ecological values within the Project area
- measures to mitigate potential impacts to ecological values.

Further details are provided in the Impact Assessment Report – Terrestrial Ecology.

4.9.1 Methodology

Terrestrial flora and fauna in the Project area were assessed during two field surveys in August to October 2010 and October to November 2011. Survey sites covered the major vegetation communities that characterise the Project area and the proposed locations of the Project mine areas and facilities. To maximise the number of recorded species, survey sites focused on areas that were most likely to contain high biodiversity (e.g., old growth forest areas). A total of 15 flora quadrat locations and nine terrestrial fauna sampling sites were surveyed within the Project area (excluding sites where incidental observations were recorded). The locations of flora and fauna survey sites are shown in Figure 4-19 and Figure 4-20, respectively.

To compliment the field surveys, a review of literature, data and other previous reports relevant to terrestrial ecosystems on Santa Isabel Island was undertaken. The review aimed to identify species likely to occur in the habitats within the Project area, with particular emphasis on threatened, endemic and regionally significant species.

Flora and fauna species of conservation significance were categorised as:

- "very likely to occur" if they were recorded in the nearby islands of Choiseul, Bougainville, Buka and New Georgia
- "possible to occur" if they have an extensive distributional range that is likely to include Santa Isabel Island (e.g. recorded from New Georgia, Vella Lavella and Vangunu (group of islands south of Santa Isabel and Choiseul), extending to eastern islands like Guadalcanal, Malaita, Florida and Russell)
- "unlikely but still possible to occur" if they have previously been recorded from a single type locality (excluding Santa Isabel Island) or from a few islands within the Solomon Islands but still have the potential to occur on Santa Isabel Island
- "unlikely to occur", if specialists were unable to discount new range extensions for these species
- "very unlikely to occur" if they are either single island endemics or species that occur on several relatively close islands that are geographically far from Santa Isabel Island.

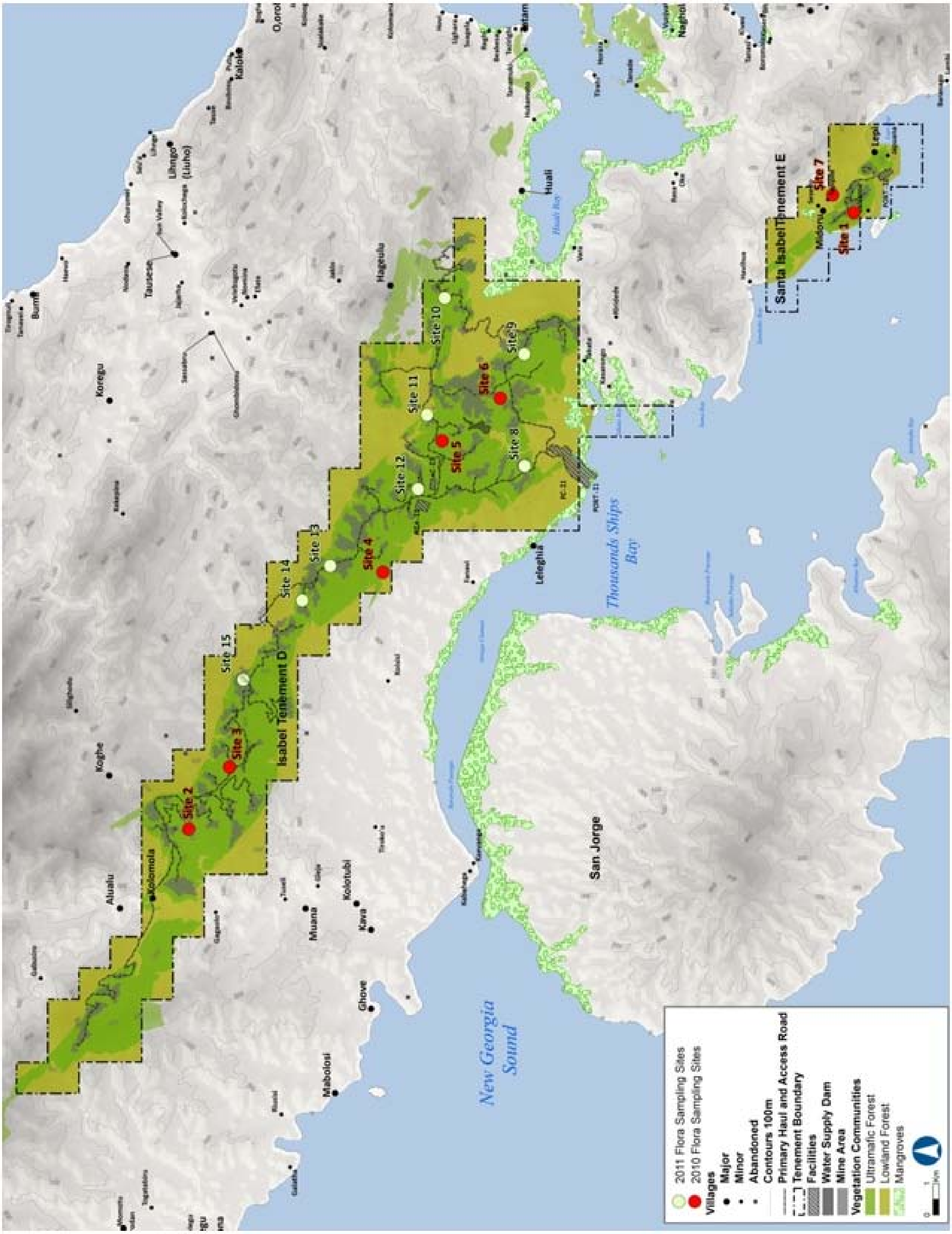

Figure 4-19 Locations of Flora Survey Sites

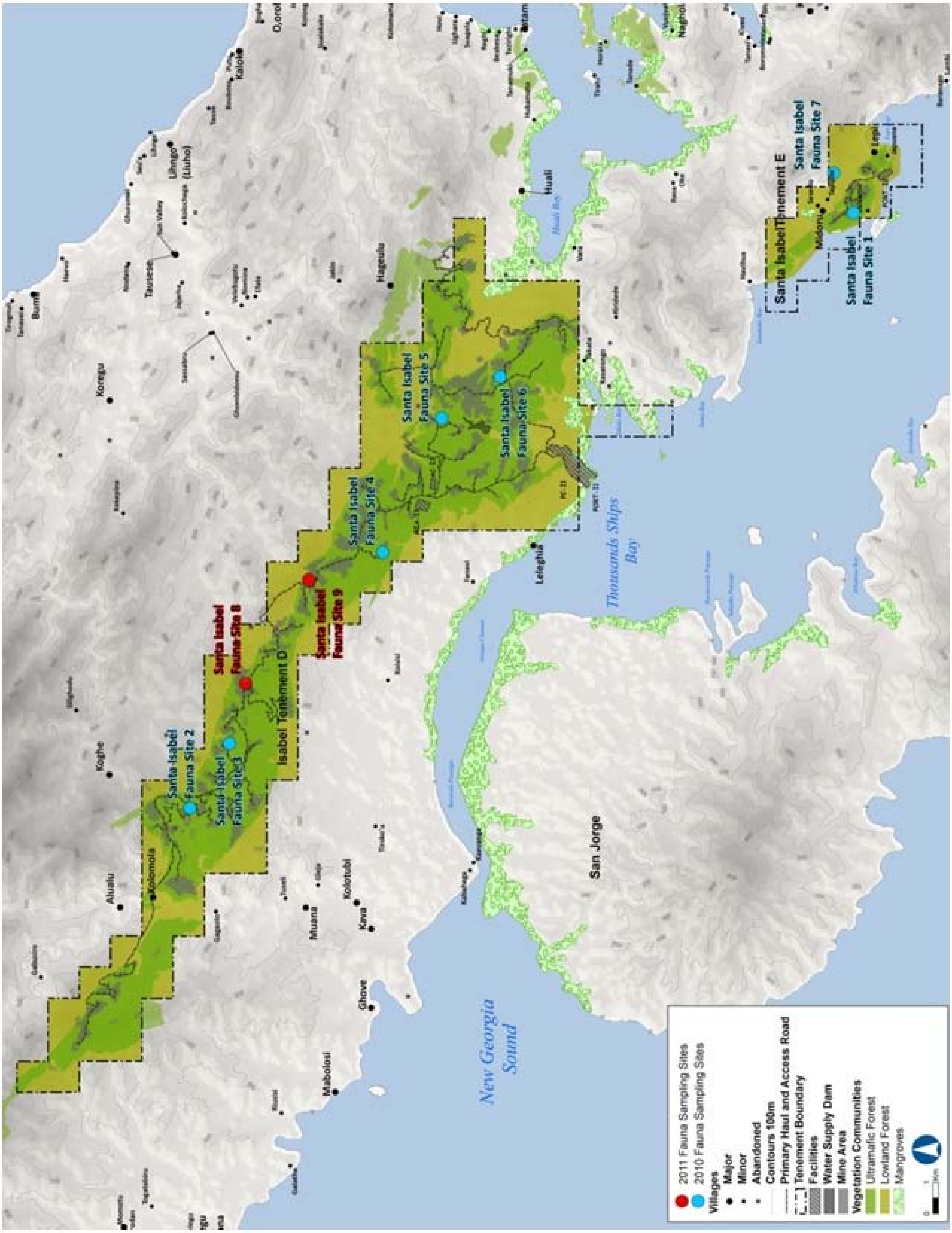

Figure 4-20 Locations of Fauna Survey Sites

Species were considered noteworthy if they possessed at least one of the following key characteristics:

- categorized as globally threatened (i.e., Vulnerable, Endangered or Critically Endangered) based on the IUCN Red List of Threatened Species and/or local Solomon Islands legislation
- restricted distribution range (e.g., Bougainville, Buka, and/or selected islands in the Solomon Islands)
- heavily hunted by locals for food
- relatively immobile (i.e., species very sensitive to changes in their environment).

Noteworthy species can be used as environmental health indicators within the Project area during monitoring activities. Methods for the assessment of terrestrial ecosystems, including the limitations of the baseline surveys, are further described in the Impact Assessment Report – Terrestrial Ecology.

4.9.2 Existing Values

4.9.2.1 Overview

Among the Pacific Island countries, the terrestrial wildlife fauna of the Solomon Islands is considered one of the most diverse with a high concentration of species found nowhere else in the world (endemics). To date, literature for the Solomon Islands indicate at least 389 terrestrial fauna species[7]. Of these, 153 species (39%) are endemics and 39 species are listed on the IUCN Red List of Threatened Species (including two amphibian species, two reptiles, 17 birds and 18 mammals). The diversity of flora is equally rich with an estimated total of 5,000 species for the entire Solomon Islands (including records of 22 species of gymnosperms, 2,821 angiosperms and 367 pteridophytes) (Hancock and Henderson, 1988 and Coleman et al. 1965).

The Project area is highly diverse in terms of terrestrial fauna and flora. Historical records and previous studies indicate there are at least 211 terrestrial fauna species on Santa Isabel Island, comprised of 23 amphibians, 38 reptiles, 126 birds and 24 mammals. Of these, three species are endemic to Santa Isabel Island, eight are confirmed threatened species (i.e. listed on the IUCN Red List of Threatened Species), six are threatened species that are very likely to occur, and three are threatened species that are possibly present. The occurrence of the nine threatened species, that were either very likely to occur or possibly present, on Santa Isabel Island were gauged based on their current distribution, former land connections among islands and habitat similarities.

While floral communities on Santa Isabel Island are under-explored, the proportion and abundance of native flora is anticipated to be well represented in the Project area as many of its forested areas are relatively intact.

4.9.2.2 Major Vegetation Communities

Over 75% of the vegetation within the Project area is old growth forest. Approximately 24% of the Project area was, or is currently being used by local village communities as croplands (approximately1,681 ha) or unlicensed commercial forest (approximately 1,214 ha). There are no recorded previous or ongoing licensed commercial logging concessions within the Project area. Areas of cropland and commercial forest used by local communities are shown in Figure 4-21.

[7] Total based on: amphibians from Menzies (2006) and Brown & Richards (2008) = 23 species; reptiles from McCoy (2006) = 76 species excluding marine turtles; birds from Doughty *et al.* (1999) = 238 species; and mammals from Flannery (1995) = 52 species.

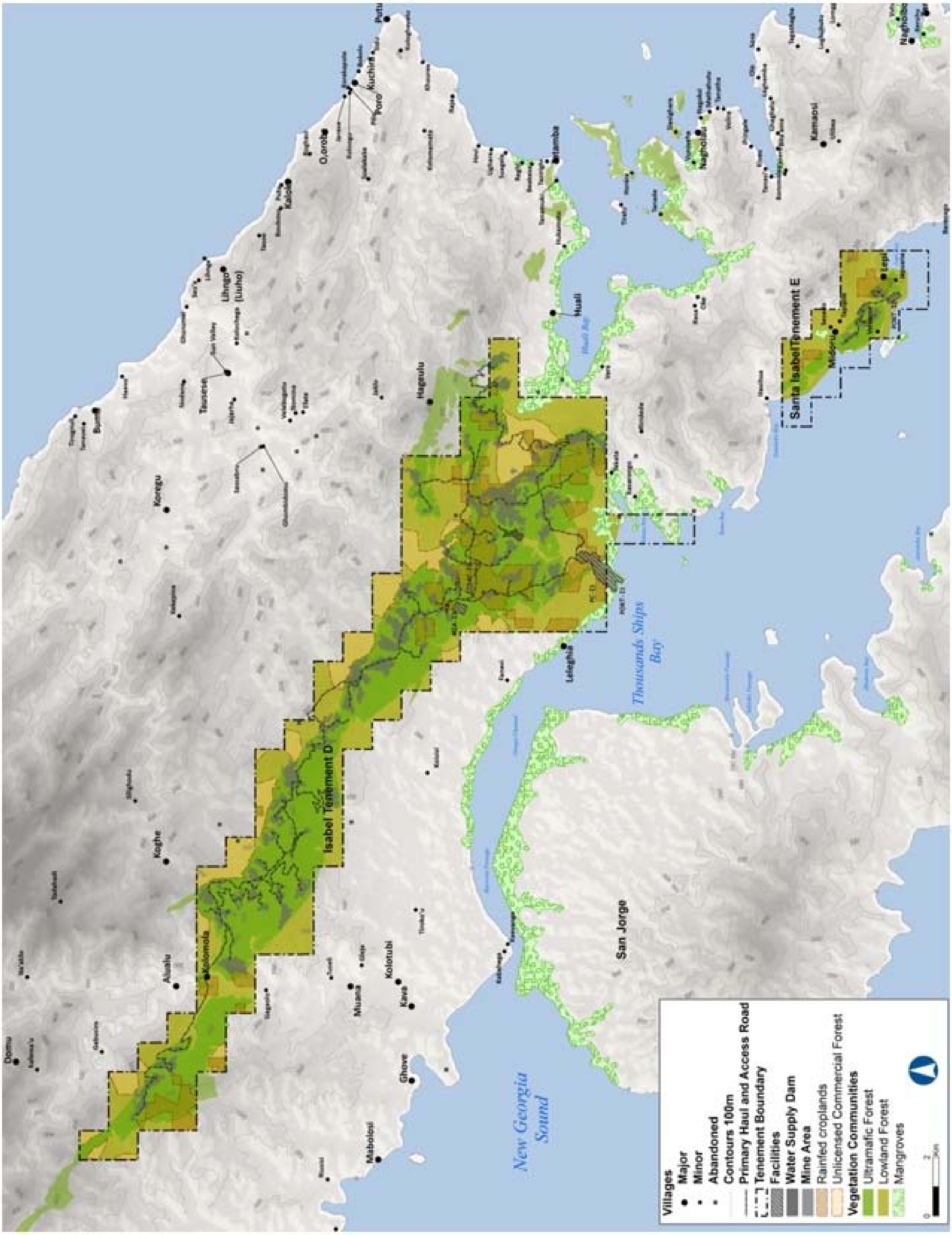

Figure 4-21 Areas of Cropland and Commercial Forest Used by Local Communities

Two major vegetation communities were identified within the Project area

- Forest over ultramafic/ultrabasic rocks (i.e., ironwood forest), which strongly aligns to the geology of the Project area, with a large portion of vegetation growing on soils derived from ultrabasic/ultramafic rocks. This forest type represents about 54% or 6,602 ha of the total Project area. *Xanthostemon melanoxylon* (ironwood) is the dominant species within this forest type. It can be found as monotypic (single species) stands of small-statured trees or freely intermixed as large canopy trees with *Gymnostoma sp*., *Dacrydium sp*., *Podocarpus sp*. and two distinct species of palms (*Hydriastele hombronii* and *Actinorhtyis calapparia*).
- Lowland rainforest, which generally occurs in flat areas along the Santa Isabel Island coast, extending to the lowland ridges or hills (to 500 m above sea level). Its low-lying distribution makes it easily accessible and exposed to anthropogenic disturbance, hence regrowth and secondary growth portions are common. This forest type represents about 45% or 5,475 ha of the total Project area. The lowland rainforest predominantly comprises A*stronidium sp*. and *Finschia sp*.. Where lowland rainforest meets forest over ultrabasic/ultramafic rocks, *Xanthostemon sp*., *Hydriastele sp*. and *Gymnostoma sp*. are present but found in much reduced numbers

4.9.2.3 Flora

A total of 162 morpho-species of vascular plants were identified from the specimens collected within the Project area. Most of the species recorded occur within the Papuasian-Solomon Islands (found in West and East New Guinea – Irian Jaya and Papua New Guinea), and Papuasian-Indomalayan region. Only five of the species recorded are endemic to the Solomon Islands. The floral assemblage of the Project area is similar to floral assemblages found in Papua New Guinea and the Indo-Malayan region.

Three species recorded within the Project area (*Calophyllum obscurum* from Site 6, *Diospyros insularis* from Site 5, and *Gonystylus macrophyllus* from Site 14) are listed on the 2011 IUCN Red List of Threatened Species. A possible new species of mistletoe (*Decaisnina sp*.) collected from Site 10 may prove completely new to science.

4.9.2.3.1 Flora Species of Conservation Significance

There are 27 plant species listed under the IUCN Red List of Threatened Species for the entire Solomon Islands. Table 4-22 lists the known distribution of each species listed on the IUCN Red List of Threatened Species (based on historical collections) and their potential to occur on Santa Isabel Island (including within the Project area).

Geographically, most of the islands are separated by narrow sea channels where animal-mediated seed dispersal for relevant species may occur (e.g. species of the genera *Agathis*, *Aglaia*, *Burckella*, *Calophyllum*, *Livistona*, *Myristica*, and *Terminalia*). Santa Isabel Island has also been linked (by former land connections) with other islands (e.g. Buka, Bougainville, Choiseul) during the late Pleistocene times.

Table 4-22 Flora Species of Conservation Significance and their Potential to Occur on Santa Isabel Island

Species	Distribution Record	Habitat Preference	Potential to Occur on Santa Isabel Island
Agathis macrophylla (Lindl.) Mast	Occurs in Solomon Islands (Sta. Cruz)	Lowland forest	Unlikely but still possible
Aglaia brasii Merr & Perry	Solomons, Southeast Asia, Northern Australia and the Pacific	Lowland forest	Possible
Aglaia flavida Merr & Perry	Solomons, Southeast Asia, Northern Australia and the Pacific	Lowland forest	Possible
Aglaia parksii A.C. Sm.	Solomons, Southeast Asia, Northern Australia and the Pacific	Lowland forest	Possible
Aglaia parviflora C. DC	Moluccas, New Guinea, Solomon Islands	Lowland forest	Possible
Aglaia rubrivenia Merr & Perry	Endemic to Solomon Islands	Lowland forest	Possible
Aglaia saltatorum A.C. Sm	Solomon Islands (Sta. Cruz)	Lowland forest	Unlikely but still possible
Aglaia samoensis A. Gray	Solomon Islands (Sta. Cruz)	Lowland forest	Unlikely but still possible
Aglaia silvestris (M. Roem.) Merr.	Solomon Islands	Lowland forest	Possible
Archidendron oblongum (Hemsl.) de Wit	Endemic to Solomon Islands	Lowland forest (alluvial valleys)	Possible
Burckella sorei Royen	Bougainville and Guadalcanal	Lowland forest	Unlikely but still possible
Calophyllum confusum P.F. Stevens	Solomon Islands (New Georgia)	Lowland forest	Unlikely but still possible
Calophyllum obscurum Stevens	Solomon Islands (Choiseul, Santa Isabel and Malaita)	Lowland forest (ridges and coral platforms)	Recorded
Cycas bouganivilleana	Solomon Islands, Bougainville, New Britain Islands	Coastal beach forest	Unlikely but still possible
Diospyros insularis Bakh.	Solomon Islands and New Ireland	Lowland forest	Recorded
Gonystylus macrophyllus (Miq.) A Shaw	Solomon islands (Choiseul and New Georgia)	Lowland forest up to 1,500 m asl	Recorded
Intsia bijuga (Colebr.) Kuntze	Madagascar, Indian Ocean Islands, tropical Asia through Malesia to Northern Australia, Melanesia and Micronesia	Inland from coastal forest	Possible
Livistona woodfordii Ridl.	Solomon Islands (Nggela Island)	Lowland and swamp forests	Unlikely but still possible
Mangifera altissima Blanco	Philippines, Sulawesi, Lesser Sunda Isls, Moluccas, New Guinea, Solomon Islands (Guadalcanal)	Lowland forest	Possible
Mastixiodendron stoddardii Merr. & Perry	New Britain and Solomon Islands	Lowland forest	Possible
Myristica globosa Warb.	Solomon Islands	Lowland forest up to 1,200 m asl	Possible
Myristica guadalcanalensis Sinclair	Solomon Islands (Guadalcanal,	Lowland forest	Unlikely but still

Species	Distribution Record	Habitat Preference	Potential to Occur on Santa Isabel Island
	Renell, Malaita)		possible
Myristica petiolata A.C. Sm.	Solomon Islands (Santa Isabel and Big Nggela Island)	Lowland forest	Possible
Myristica xylocarpa W.J. de Wilde	Solomon Islands (Santa Isabel Island, San Cristobal and Guadalcanal)	Lowland forest	Possible
Podocarpus glaucus Foxw.	Data deficient	Data deficient	Data deficient
Pterocarpus indicus Willd.	Myanmar, Thailand, Cambodia, Ryukyus, Philippines, along Bismarck Archipelago, Vanuatu, Solomon Islands, Caroline Islands	Lowland forest	Possible
Terminalia rerei Coode	Solomon Islands (San Cristobal and Guadalcanal)	Lowland forest	Unlikely but still possible

4.9.2.4 *Fauna*

The diversity of fauna within the Project area is relatively high with a total of 93 species (i.e. 16 amphibians, 25 reptiles, 47 birds and five mammals) recorded during the baseline surveys. This represents at least 44% of the species known to occur on Santa Isabel Island (refer to Table 4-23).

Table 4-23 Comparison of Species Recorded

Wildlife Taxa	Number of Species		
	This Study (Project Area)	Santa Isabel Island	Solomon Island
Amphibians	16	23	23
Reptiles	25	38	76
Birds	47	126	238
Mammals	5	24	52
Total	93	211	389

An overwhelming majority of recorded species (71 species or 76% of the total) belong to one of the following sub-categories: very common, common, fairly common, moderately common and abundant. Two species recorded during the field surveys, *Palmatorappia solomonis* (Solomon Islands palm frog) and *Nesasio solomonensis* (Fearful owl), are listed on the IUCN Red List of Threatened Species.

The Project area exhibits high endemicity, with 34 of the recorded species (36% of the total) and three of the recorded subspecies found only in the Solomon Islands. The remaining 55 recorded species (59% of the total) are native to the Solomon Islands but are not endemics. One of the species recorded has been introduced to the Solomon Islands.

4.9.2.4.1 Noteworthy Fauna Species

There were 37 noteworthy species recorded in the Project area, including nine amphibians, ten reptiles, 13 birds and five mammals (refer to Table 4-24). Except for eleven species extending from Bougainville and/or Buka, all are endemic to the Solomon Islands.

Table 4-24 Noteworthy Fauna Species

Scientific Names		Common Names	Site/s Recorded	Reason/s for Inclusion
Amphibians				
1	*Batrachylodes elegans*	Elegant sticky-toed frog	All fauna survey sites	Restricted range: Bougainville, Choiseul and Santa Isabel Island Relatively immobile species
2	*Batrachylodes vertebralis*	Fauro sticky-toed frog	All fauna survey sites	Restricted range: endemic to Solomon Islands except San Cristobal Relatively immobile species
3	*Platymantis guppyi*	Solomon Islands giant tree frog	All fauna survey sites	Restricted range: endemic to Solomon Islands except New Georgia and San Cristobal Relatively immobile species
4	*Platymantis weberi*	Weber's wrinkled ground frog	All fauna survey sites	Restricted range: endemic to Solomon Islands except San Cristobal Relatively immobile species
5	*Platymantis solomonis*	Solomon wrinkled ground frog	Fauna survey sites 2 to 9	Restricted range: endemic to Solomon Islands except Guadalcanal and San Cristobal Relatively immobile species
6	*Ceratobatrachus guentheri*	Guenther's triangle frog	All fauna survey sites	Restricted range: endemic to Solomon Islands except San Cristobal Relatively immobile species
7	*Discodeles bufoniformis*	Warty webbed frog	Fauna survey sites 2 to 9	Restricted range: endemic to Solomon Islands except Guadalcanal and San Cristobal Relatively immobile species
8	*Palmatorappia solomonis*	Solomon Islands palm frog	Fauna survey sites 2 to 9	Restricted range: Buka, Bougainville, Choiseul, Santa Isabel and probably other major islands Globally threatened species Relatively immobile species
9	*Batrachylodes trossulus*	Torakino sticky-toed frog	Fauna survey sites 1 to 7	Restricted range: endemic to Bougainville, Choiseul, Santa Isabel Relatively immobile species
Reptiles				
10	*Emoia pseudocyanura*	Solomons blue-tailed skink	All fauna survey sites	Restricted range: endemic to Solomon Islands Relatively immobile species
11	*Emoia flavigularis*	Yellow-throated skink	All fauna survey sites	Restricted range: endemic to Solomon Islands Relatively immobile species
12	*Tribolonotus blanchardi*	Blanchard's helmet skink	Recorded from previous and/or historical studies	Restricted range: Bougainville, Choiseul, Santa Isabel and Nggela Globally threatened species Relatively immobile species
13	*Corucia zebrata*	Prehensile-tailed skink	All fauna survey sites except sites 8 and 9	Restricted range: endemic to Solomon Islands Globally threatened species Relatively immobile species
14	*Sphenomorphus concinnatus*	Elegant forest skink	All fauna survey sites	Restricted range: endemic to Solomon Islands Relatively immobile species
15	*Sphenomorphus woodfordi*	Woodford's skink	All fauna survey sites	Restricted range: endemic to Solomon Islands Relatively immobile species
16	*Cyrtodactylus solomonensis*	Not available	All fauna survey sites	Restricted range: endemic to Solomon Islands Relatively immobile species
17	*Loveridgelaps elapoides*	Solomons black-banded krait	All fauna survey sites except site 2	Restricted range: endemic to Solomon Islands Relatively immobile species
18	*Parapistocalamus hedigeri*	Hediger's snake	Fauna survey sites 2 to 9	Restricted range: endemic to Solomon Islands Relatively immobile species
19	*Salomonelaps par*	Solomons red krait	All fauna survey sites	Restricted range: endemic to Solomon Islands Relatively immobile species
Birds				
20	*Cactua ducorpsii*	Ducorp's cockatoo	All fauna survey sites	Restricted range: endemic to Solomon Islands

Scientific Names		Common Names	Site/s Recorded	Reason/s for Inclusion
21	*Myzomela lafargei*	Scarlet naped myzomela	Fauna survey sites 8 and 9	Restricted range: endemic to northern Solomon Islands of Buka, Santa Isabel, Choiseul and the Shortland Group
22	*Nesasio solomonensis*	Fearful owl	Fauna survey site 9	Restricted range: Bougainville, Choiseul and Santa Isabel Globally threatened species.
23	*Todirhamphus leucopygius*	Ultramarine kingfisher	All fauna survey sites	Restricted range: endemic to islands of Choiseul, Santa Isabel, Florida, Guadalcanal, Malaita, Makira and Ugi
24	*Monarcha castaneiventris*	Chestnut bellied monarch	Fauna survey sites 8 and 9	Restricted range: endemic to central Solomon Islands of Choiseul, Santa Isabel and Guadalcanal
25	*Monarcha barbatus*	Black and white monarch	Fauna survey sites 8 and 9	Restricted range: endemic to islands of Bougainville, Choiseul, Santa Isabel, Florida and Guadalcanal
26	*Coracina caledonica*	Melanesian cuckoo shrike	Fauna survey sites 8 and 9	Restricted range: endemic to Solomon Islands
27	*Coracina holopolia*	Solomon cuckoo shrike	Fauna survey site 9	Restricted range: endemic to Solomon Islands
28	*Zosterops metcalfii*	Yellow throated white eye	Fauna survey sites 8 and 9	Restricted range: endemic to Solomon Islands
29	*Dicaeum aeneum*	Midget flowerpecker	Fauna survey sites 8 and 9	Restricted range: endemic to Solomon Islands
30	*Rhipidura cockerelii*	White winged fantail	Fauna survey sites 8 and 9	Restricted range: endemic to Solomon Islands
31	*Haliaeetus sanfordi*	Solomon sea eagle	Recorded from previous and/or historical studies	Restricted range: endemic to Solomon Islands Globally threatened species
32	*Accipiter imitator*	Imitator sparrowhawk	Recorded from previous and/or historical studies	Restricted range: Bougainville, Choiseul and Santa Isabel Globally threatened species
Mammals				
33	*Dobsonia inermis*	Solomons bare-backed fruit bat	Fauna survey site 9	Restricted range: Solomon Islands and Bougainville Heavily hunted by the locals for food
34	*Melonycteris woodfordi*	Woodford's blossom bat	Fauna survey sites 8 and 9	Restricted range: Solomon Islands, Bougainville and Buka Heavily hunted by the locals for food
35	*Nyctimene bougainville*	Solomons tube-nosed bat	Fauna survey sites 8 and 9	Restricted range: Solomon Islands and Bougainville Heavily hunted by the locals for food
36	*Pteralopex atrata*	Guadalcanal monkey-faced bat	Recorded from previous and/or historical studies	Restricted range: endemic to New Georgia, Santa Isabel and Guadalcanal Globally threatened species Heavily hunted by the locals for food
37	*Pteropus mahaganus*	Sanborn's flying fox	Recorded from previous and/or historical studies	Restricted range: endemic to Bougainville and Santa Isabel Globally threatened species Heavily hunted by the locals for food

4.9.2.4.2 Fauna Species of Conservation Significance

There are 39 animal species listed under the IUCN Red List of Threatened Species for the entire Solomon Islands. Table 4-25 lists the known distribution of each species (based on historical collections) and their potential to occur on Santa Isabel Island (including within the Project area). See Section 4.9.1 for a description of the categories used in the assessment.

There are at least nine confirmed threatened species within Santa Isabel Island. Of these, two were recorded by the current study within the Project area. Nine additional threatened species (i.e. six species that are very likely to occur and three that are possibly present) have the potential to occur on Santa Isabel Island and the Project area based on known range distribution and habitat preference.

Table 4-25 Fauna Species of Conservation Significance and their Potential to Occur on Santa Isabel Island

Scientific Names		Common Names	Distribution Record	Habitat Preference	IUCN 2011 Status	Potential to Occur on Santa Isabel Island
Amphibians						
1	*Litoria lutea*	Solomon Islands tree frog	Northern Solomon Islands from Buka to New Georgia	Arboreal utilizing lowland tropical rainforest	Vulnerable	Very likely
2	*Palmatorappia solomonis*	Solomon Islands palm frog	Buka, Bougainville, Choiseul and Santa Isabel	Arboreal utilizing lowland tropical rainforest	Vulnerable	Recorded *
Reptiles						
3	*Emoia isolata*	Bellona skink	Endemic to Bellona Island, Solomon Islands	Very common in both forested and semi-cleared areas with some form of canopy	Vulnerable	Very unlikely
4	*Tribolonotus blanchardi*	Blanchard's helmet skink	Bougainville, Choiseul, Santa Isabel and Nggela	Requires very moist conditions in river valleys or under stones and piles of dead leaves and other debris in wet stream beds. In Bougainville, it requires montane habitat	Vulnerable	Recorded**
Birds						
5	*Accipiter imitator*	Imitator sparrowhawk	Bougainville, Choiseul and Santa Isabel	Prefers lowland forest and forest edges up to 1,000 m asl	Vulnerable	Recorded**
6	*Actenoides bougainvillei*	Moustached kingfisher	A.b.bougainvillea in Bougainville and A.b. excelsa in Guadalcanal	Requires mature forested areas from 900 to 1,000 m asl	Vulnerable	Very unlikely
7	*Aplonis brunneicapillus*	White-eye starling	Bougainville, Choiseul, Rendova and Guadalcanal	Prefers lowland swamp forest and hill forest	Endangered	Very likely
8	*Charmosyna palmarum*	Palm lorikeet	Endemic to Santa Cruz Islands and Vanuatu	Requires montane habitat (>1,000 m asl)	Vulnerable	Very unlikely
9	*Clytorhynchus santaecrusis*	Santa Cruz shrikebill	Endemic to Nendo in the Santa Cruz Islands	Requires forested area	Vulnerable	Very unlikely
10	*Columba pallidiceps*	Yellow-legged pigeon	Bismarck Archipelago, Bougainville, Choiseul, Guadalcanal and San Cristobal	Recorded in both old growth forest and mature secondary forest	Vulnerable	Very likely
11	*Ducula brenchleyi*	Chesnut-bellied imperial pigeon	Guadalcanal, San Cristobal and Malaita	Requires old growth forest	Vulnerable	Very unlikely
12	*Gallicolumba sanctaecrucis*	Santa Cruz ground-dove	Santa Cruz Islands	Inhabits forested areas and patches of remnant forest	Endangered	Very unlikely
13	*Gallinula silvestris*	Makira moorhen	San Cristobal. Last recorded in 1953.	Lowland forested areas	Critically Endangered	Very unlikely
14	*Haliaeetus sanfordi*	Solomon sea-eagle	All major islands of the Solomon	In coastal areas, and inshore waters and tidal	Vulnerable	Very likely

Scientific Names		Common Names	Distribution Record	Habitat Preference	IUCN 2011 Status	Potential to Occur on Santa Isabel Island
			Islands	flats to montane forest		
15	*Nesasio solomonensis*	Fearful owl	Bougainville, Choiseul, Santa Isabel and Santa Cruz	Lowland old growth forest and mature secondary forest	Vulnerable	Recorded *
16	*Numenius tahitiensis*	Bristle-thighed curlew	Migratory species to Santa Cruz	Coastal areas, tidal flats, sand bars, offshore islands and grasslands	Vulnerable	Possible
17	*Phylloscopus amoenus*	Sombre leaf-warbler	Endemic to Kulambangara Island	Montane forest at >1,000 m asl	Vulnerable	Very unlikely
18	*Pitta anerythra*	Black faced pitta	Bougainville, Choiseul, Santa Isabel and Santa Cruz	Forested areas in valleys and alluvial plains, regrowth thickets and forest remnants	Vulnerable	Recorded**
19	*Rhipidura malaitae*	Malaita fantail	Endemic to Malaita	Montane forest above 900 m asl.	Vulnerable	Very unlikely
20	*Zoothera turipavae*	Guadalcanal thrush	Guadalcanal	Montane to mossy forest at elevation range of 1,450 to 1,500 m asl	Vulnerable	Very unlikely
21	*Zosterops luteirostris*	Splendid white-eye	Endemic to Ghizo	Mature secondary forest	Endangered	Very unlikely
Mammals						
22	*Hipposideros demissus*	Makira leaf-nosed bat	San Cristobal	Requires caves as roosting area	Vulnerable	Very unlikely
23	*Pteralopex anceps*	Bougainville monkey-faced bat	Buka, Bougainville and Choiseul	There is no data regarding diet, habitat and reproduction.	Endangered	Very likely
24	*Pteralopex atrata*	Guadalcanal monkey-faced bat	New Georgia, Santa Isabel and Guadalcanal	Possibly dependent on old growth forest and tree hollows	Endangered	Recorded**
25	*Pteralopex flanneryi*	Greater monkey-faced bat	No available information	Old growth forest in the lowland	Critically Endangered	Cannot be determined
26	*Pteralopex pulchra*	Montane monkey-faced bat	Known from a single specimen from Guadalcanal	Requires primary mossy to montane forest	Critically Endangered	Very unlikely
27	*Pteralopex taki*	New Georgia monkey-faced bat	New Georgia and Vangunu Islands	Moist mature lowland forest	Endangered	Very unlikely
28	*Pteropus cognatus*	Makira flying fox	San Cristobal	Habitat unknown.	Endangered	Very unlikely
29	*Pteropus mahaganus*	Sanborn's flying fox	Bougainville and Santa Isabel	From coconut plantation to lowland forest	Vulnerable	Recorded**
30	*Pteropus nitendiensis*	Temotu flying fox	Nendo and Tomotu Neo	Roosts in mangrove areas and forages in old growth and mature secondary forest	Endangered	Very unlikely
31	*Pteropus rennelli*	Rennell flying fox	Rennell Island. Poorly known	Habitat unknown	Vulnerable	Very unlikely
32	*Pteropus tuberculatus*	Vanikoro flying fox	Vanikoro in the Santa Cruz Islands	Habitat unknown	Critically Endangered	Very unlikely
33	*Pteropus woodfordi*	Dwarf flying fox	Malaita, Guadalcanal, Florida, Russell, Vella Lavella,	Coconut plantation, lowland gardens and mature forest stands		Possible

Scientific Names		Common Names	Distribution Record	Habitat Preference	IUCN 2011 Status	Potential to Occur on Santa Isabel Island
			Kolumbangara, New Georgia and Vangunu			
34	*Solomys ponceleti*	Poncelet's giant rat	Bougainville and Choiseul	Possibly swamp forest	Vulnerable	Very likely
35	*Solomys salebrosus*	Bougainville giant rat	Bougainville and Choiseul	Tropical moist forest	Endangered	Possible
36	*Solomys sapientis*	Isabel giant rat	Endemic to Santa Isabel	Tropical moist forest	Endangered	Recorded**
37	*Uromys imperator*	Emperor rat	Last recorded in 1888 from Guadalcanal	Lowland forest near the coast	Critically Endangered	Very unlikely
38	*Uromys porculus*	Guadalcanal rat	Last recorded in 1888 from Guadalcanal	Cave dwelling. Vegetation type preferred unknown	Critically Endangered	Very unlikely
39	*Uromys rex*	King rat	Endemic to Guadalcanal	Tropical moist forest	Endangered	Very unlikely

* recorded in this study

** recorded by other historical and/or previous studies

4.9.2.5 Protected Areas

There are three protected/conservation areas near but completely outside of the Project area (i.e. specifically near Tenement D) on Santa Isabel Island (refer to Figure 4-22). These are:

- Kolarashu River Protected Area (219 ha), which is approximately 1.3 km from the nearest boundary of Tenement D
- Janhana/Hohoqle River Protected Area (394 ha), which is approximately 2.3 km from Tenement D
- Noihoi River Protected Area (25 ha), which is approximately 1.1 km from Tenement D.

These protected/conservation areas have a combined area of 638 ha. SMM Solomon development activities will not cover any portion of these protected areas.

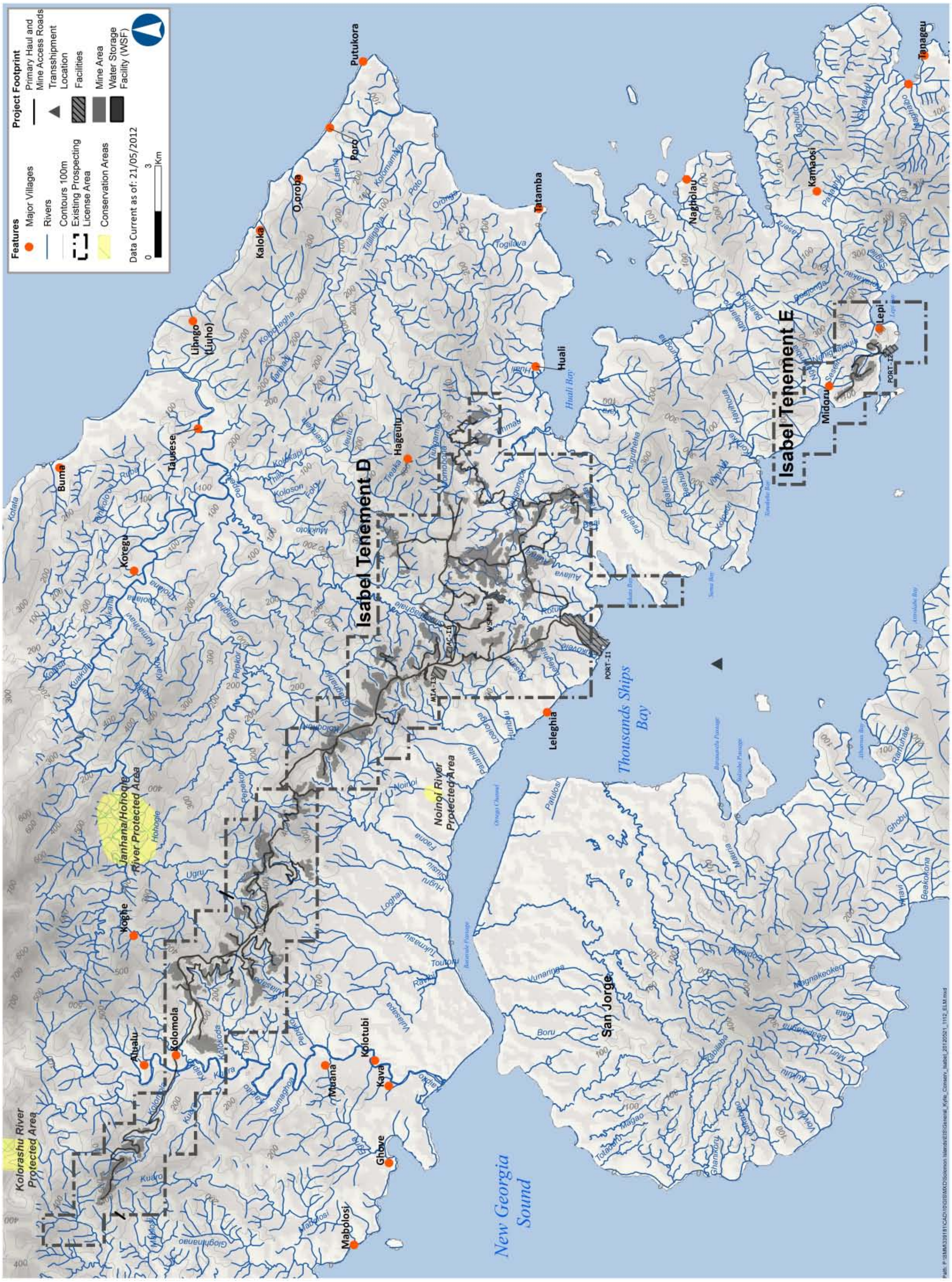

Figure 4-22 Protected Conservation Areas Tenement D

4.9.3 *Potential Impacts*

The following components of the Project have the potential to impact terrestrial ecosystems:

- Mine areas
- Ore transport and handling
- Port areas
- General infrastructure areas.

Project construction and operation activities that have the potential to result in direct and indirect impacts to terrestrial flora and fauna are outlined in the following sections. Further details are provided in the Impact Assessment Report – Terrestrial Ecology.

4.9.3.1 Vegetation Clearing Resulting in Habitat Transformation and/or Loss

Habitat removal will be the most significant unavoidable impact of the Project to terrestrial ecosystems. Approximately 1,461 ha (i.e. 1,409 within Tenement D and 52 ha within Tenement E) will be cleared of vegetation. This disturbance area represents about 12% of the total Project area and less than 0.5% of Santa Isabel Island. Vegetation to be cleared includes forest over ultramafic/ultrabasic rocks (ironwood forest), lowland rainforest, and mangrove stands. Some areas have been previously cleared for croplands or commercial foresting. Once 'mined-out', all mine areas will undergo restoration of appropriate sustainable ecosystems by revegetation with locally adapted plant species or suitable introduced species.

Impacts to terrestrial ecology as a result of habitat removal will extend beyond the life of mine. The intensity of the impact will be high since the Project area is predominantly thickly vegetated. Terrestrial biodiversity is likely to be reduced as some habitat (including plants and other sessile organisms) will be destroyed.

Highly mobile animals (e.g. birds, bats and some other mammals) are likely to move away from impacted areas. Animals that are relatively immobile or have limited dispersal abilities, such as amphibians, some reptiles and young individuals, would have difficulty escaping any significant changes and may be subject to direct mortality.

4.9.3.2 Habitat Fragmentation

Habitat fragmentation is the process where habitats that were once contiguous become divided into fragments that are isolated from each other by development or otherwise non-forest habitat (Lindenmayer and Fischer 2006). This new dividing habitat type is often artificial and inhospitable to the species remaining within the fragments (Bennett 1990). The ecological impacts of habitat fragmentation include:

- reduction in the total area of the habitat
- increase in the relative amount of edge (non-forested areas surrounding a forest patch)
- decrease in the amount of interior habitat (refers to remaining forested areas away from edge)
- isolation of one habitat fragment from other areas of habitat
- decrease in the average size of each patch of habitat.

Habitat fragmentation will reduce the total habitat area for wildlife and may lead to crowding and increased competition among individuals and species, as mobile animals (especially birds and mammals) retreat into remnant patches of habitat (Lindenmayer and Fischer 2006). Genetic isolation may also result as populations become disconnected from other populations and/or individuals. This may lead to inbreeding and genetic drift, potentially resulting in population decline. Species that require large areas of interior habitat cannot persist when there is an increase in the area of edge and decrease in amount of interior habitat. Populations of these species may slowly decrease if they are unable to move between forest fragments.

Impacts as a result of unavoidable habitat fragmentation will extend beyond the life of mine. Overall, the intensity of the impact will be high as the Project area is predominantly thickly and contiguously vegetated.

4.9.3.3 Edge Effects

Habitat fragmentation also leads to 'edge effects', which refer to impacts that occur at the interface between natural habitats (particularly forests) and disturbed or developed land (Yahner 1988). Once an edge is created between forest and a cleared area, changes to ecological processes within the vegetation can extend between 10 m and 100 m from the edge (Yahner 1988). These include microclimatic changes in light, temperature, humidity and wind, which can favour a suite of different species and therefore cause significant changes to the ecology of the patch (Lindenmayer and Fischer 2006). For example, increases in ambient temperature and humidity in patches may be unfavourable to some amphibian and reptile species; populations of invasive flora and fauna species may increase and there may be less cover for prey to avoid predators (Lindenmayer and Fischer 2006). Edge effects are especially pronounced in small habitat fragments as the effects may extend throughout the entire patch. Small habitat fragments are, therefore, unfavourable for species which require interior habitat.

Predation often increases at the edge of cleared areas as these areas are more accessible to predators and provide less shelter/cover for prey. Increased predation pressure may lead to a continuous decline in the prey population, affecting the local food web.

Due to edge effects, indirect impacts of vegetation clearing will extend beyond the mine footprint into areas of forest that are being retained. Edge effects will be more pronounced where habitats are more fragmented. Similar to habitat removal and fragmentation, this impact is unavoidable and the intensity is high as the areas proposed for clearing are predominantly thickly and contiguously vegetated. Impacts as a result of edge effects will extend beyond the life of mine.

4.9.3.4 Pollution

Improper handling and disposal of wastes (e.g., domestic waste, construction waste, waste rock, sludge and discharge from water and waste water treatment plants) and improper containment and handling of fuel and hazardous substances can lead to the contamination and pollution of soil, surface or groundwater, or plant systems within and surrounding the mine areas, workshop and vehicle maintenance areas, vehicle washdown areas, waste water facilities, fuel and hazardous chemicals (reagents) storage facilities, administration areas, solid waste management areas, laboratories, accommodation and construction camps, landfill, and quarry borrow pits.

Spilled or discarded pollutants may enter the food chain, potentially leading to bioaccumulation of the pollutant and/or mortality of organisms. People who consume organisms containing pollutants may also be affected. Non-lethal dosages of contaminants can also impede physiological functions (e.g. egg shell thickness in some bird species), potentially leading to unsuccessful breeding for some organisms, and a decline in population.

Ingestion of plastic debris has detrimental consequences for fauna, including gastrointestinal blockages (Baird and Hooker 2000), ulceration (Fry et al. 1987), internal perforation, and death (Mascarenhas et al. 2004). Landfills attract scavengers including introduced species such as rats, which are known to have caused dramatic changes to many ecological systems worldwide, including the displacement and extinction of native species.

4.9.3.5 *Overhunting and Uncontrolled Vegetation Clearing due to Population Influx*

Overhunting for food and uncontrolled vegetation clearing for agriculture and/or settlements may occur as a result of the expected population influx to Santa Isabel Island. Whilst overhunting and uncontrolled vegetation clearing may not reduce flora and fauna populations to threatened levels, a significant reduction in population densities may occur at the local level. Local extinction may result where populations are unable to recover.

4.9.3.6 *Noise Emissions*

The Project has the potential to generate significant noise during construction and operation. This includes noise generated by clearing machinery, vehicles and mining trucks, excavation machinery, any blasting, and generators and other machinery used in the daily operations and infrastructure areas. The noise created during construction and operation is likely to affect a wide range of species and the value of the habitats that remain after vegetation clearing.

While noisy areas may be avoided by mobile animals, this leads to reduced habitat through avoidance of otherwise favourable habitats (AMEC Americas Limited 2005). Noise produced by human activities can affect an animal's physiology and behaviour. If such noise becomes a chronic stress, it can be detrimental to an animal's energy budget, reproductive success and long-term survival. Noise also affects the way that animal-created sounds are heard and interpreted by other animals, including mating calls, territorial calls and alarm calls. Interference with these calls can lead to reduced reproductive success and/or mortality (AMEC Americas Limited 2005).

4.9.3.7 *Artificial Light*

Artificial lights utilised during night time operations may adversely affect nocturnal species, such as giant rats, some amphibians, some reptiles, owls, nightjars and bats, including through direct glare, periodic increased illumination and temporary unexpected fluctuations (e.g. passing vehicle lights) (Longcore and Rich 2004). Light pollution can trigger behavioural and physiological responses in fauna, including:

- an extension of diurnal or crepuscular foraging behaviour into the night-time period where some species will continue to forage due to artificial lights
- a disruption of seasonal day length cues which trigger critical behaviours (Longcore and Rich 2004)
- temporary blindness and disorientation (sometimes lasting hours)
- a disruption to predator-prey relationships.

These responses may lead to problems such as changes to breeding and forage patterns, therefore population decline and even permanent injury or death.

4.9.3.8 *Vehicle Strike*

The Project will require the construction of roads and tracks for accessibility (approximately 2.19 km^2) and the use of high numbers of vehicles during construction and operation. Vehicles may strike animals crossing these tracks, leading to injury and/or mortality.

4.9.3.9 *Fugitive Dust*

Construction and mining activities will generate fugitive dust that can accumulate on leaf surfaces, inhibiting photosynthesis, respiration and transpiration processes. Dust may also cause blockage and damage to stomata, shading, and abrasion of leaf surfaces or cuticles. Stressed plants are more susceptible to pathogens and other disturbance, and are more likely to be subject to increased mortality; decreased productivity and changes in community structure may then result (Farmer 1993).

Poor plant health also affects fauna species that depend on them either as a source of food and/or habitat. Dusty leaves and fruit are less palatable to fauna species, and changes in plant health and/or community structure can reduce the habitat available to fauna.

Due to the high rainfall within the Project area, the intensity of impact due to fugitive dust is likely to be low.

4.9.3.10 *Increased Soil Erosion*

Soil erosion may increase due to clearing, earthworks and mining in the Project area. During wet periods, large volumes of rain can wash away disturbed earth, particularly along access roads. Aquatic and riparian ecosystems, including amphibian and reptile species habitats, are likely to be most affected where turbidity and sedimentation increases occur in streams.

Erosion also reduces the water holding capacity of soil and results in rapid water runoff and reduced soil organic matter. Loss of nutrients and valuable soil biota can result in reduced biomass productivity in ecosystems. Ultimately, this has a profound effect on the diversity of plants, animals, microbes and other forms of life present in the ecosystem.

4.9.3.11 *Introduction of Invasive, Weed, Feral Animal and/or Exotic Species*

Transport of construction materials, equipment and other general supplies for use in the construction and operation of the Project has the potential to introduce invasive forms of fauna and weed species. Ships and imported materials and machinery have the greatest potential to facilitate accidental introduction of invasive species. Once introduced to the island, vehicle movements may further facilitate their dispersal into the interior of the Project area.

Invasive species can rapidly establish in new habitats, particularly where they have few or no predators. Invasive species can displace native species and eventually dominate the entire local habitat by being a direct predator or a major competitor for food, shelter and habitat. Some invasive species may also serve as carriers of zoonotic disease (e.g. rabies, leptospirosis, salmonellosis, etc.), which may affect both fauna and humans.

4.9.4 Impact Assessment

A risk assessment of the potential impacts to terrestrial ecosystems is presented in Table 4-26.

Table 4-26 Assessment of Potential Impacts on Terrestrial Ecosystems

Potential Impacts	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Habitat removal resulting in habitat transformation and/or loss	•	•	•	•	•	•	Negative	Local	High	Long	Definite	High	High	Clearly identify limits of clearing on plans and on the ground (by using flagging tapes and signage) during construction and operation; SMM Solomon to prepare a pre-clearing plan; Critical fauna habitats located within the tenement will be identified and avoided where possible; Implementation of staged mining and progressive rehabilitation; Potential regeneration/ revegetation of commercial forest as offsets if needed; Establishment of nurseries as source of seedlings and wildlings for rehabilitation; Exclusion of protected or conservation areas from the mine lease area; Prepare and implement an environmental	Medium	High

Table 4-26 Assessment of Potential Impacts on Terrestrial Ecosystems

Potential Impacts	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
														education program to highlight the value of biodiversity.		
Habitat fragmentation and resulting edge effects reducing habitat value of the remaining forests around a given development facility	•	•	•	•	•	•	Negative	Local	High	Long	Definite	High	High	Regeneration/revegetation of commercial forest offsets; Maintain forested areas between mine sites as ecological corridors.	Medium	High
Pollution	•	•	•	•	•	•	Negative	Local	High	Long	Unlikely	High	Medium	All potential pollutant materials will be appropriately stored; SMM Solomon will develop and implement a Waste Management Plan to manage various wastes that will be generated.	Low	High
Over hunting and uncontrolled vegetation clearing due to population influx	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High	A strict no hunting and forest clearing procedure will be implemented by SMM Solomon among its personnel.	Low	High
Generation of excessive noise pushing fauna into interior habitat,	•	•	•	•	•	•	Negative	Local	Medium	Short	Definite	High	High	Limit the speed of vehicles on internal roads; Schedule equipment	Low	High

Table 4-26 Assessment of Potential Impacts on Terrestrial Ecosystems

Potential Impacts	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
reducing fauna usage and disturbing fauna behavior														movements wherever possible to avoid sensitive times (e.g. night time); Maintain internal roads in good working order; Ensure all vehicles, plant and machinery are maintained in proper working order to avoid unnecessary engine, motor or muffler noise; Make sure all vehicle and plant operators are aware of the location of sensitive receptors and the measures required for limiting noise where possible.		
Increased level of artificial light	•		•	•	•	•	Negative	Local	Low	Medium	Definite	Low	Low	If feasible: use anti-glare lighting to minimise disruption to vision of nocturnal wildlife (e.g. bats, owls, giant rats.); use anti-glare lighting sleeves or shields to control/manage direction of light from source; use light source with directional lighting and	Low	High

Table 4-26 Assessment of Potential Impacts on Terrestrial Ecosystems

Potential Impacts	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
														screens to focus light on operations.		
Vehicle strikes		•			•	•	Negative	Local	Medium	Long	Highly Probable	Medium	Medium	Road rules will be clearly conveyed through driver training and strictly enforced as a component of the Project safety policies and procedures; Specific mitigation to be designed and implemented if required for possible areas where frequency of wildlife strikes is high.	Low	High
Accidental introduction of invasive, weed, feral animal and/or exotic species	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High	Ensure national quarantine legislative requirements are applied; SMM Solomon will develop and implement local quarantine procedure plan.	Medium	Medium

4.9.5 Mitigation Measures

4.9.5.1 Vegetation Clearing, Habitat Fragmentation and Edge Effects

Mitigation measures to reduce the risk of impact associated with habitat removal, fragmentation and edge effects during mine construction and operation will include:

- exclusion of protected or conservation areas from the mine lease area
- staged mining and progressive rehabilitation
- clear identification of limits of clearing on plans and on the ground (using flagging and signage)
- preparation of a pre-clearing plan prior to construction and operation that details clearing protocols to reduce impacts to surrounding habitats and fauna
- rapid critical fauna habitat assessment at locations proposed for supporting infrastructure to check for habitat for fauna, particularly endemic and threatened species
- establishment of nurseries to raise seedlings and wildlings for future revegetation activities
- where possible, transport of habitat features such as large logs and boulders to create new fauna refuge sites
- decommissioning and dismantling of select facilities to revert the land to its original use (in accordance with the Project's Mine Rehabilitation and Closure Plan)
- rehabilitation of areas to include forest regeneration and revegetation techniques
- offset options to compensate for mine blocks that cannot be readily restored through regeneration/revegetation of logged over areas within the Project area
- vegetation and threatened species monitoring
- development of an environmental education package for both personnel and communities.

4.9.5.2 Pollution

Mitigation measures to reduce the risk of impact associated with pollution of local habitats during mine construction and operation will include:

- appropriate storage, handling and disposal of all potential pollutant materials
- implementation of a Waste Management Plan.

4.9.5.3 Overhunting and Uncontrolled Vegetation Clearing due to Population Influx

Mitigation measures to reduce the risk of impact associated with over hunting and uncontrolled clearing due to population influx during mine construction and operation will include:

- enforcement of a strict no hunting and forest clearing procedure for SMM Solomon personnel
- development of an environmental education package for both personnel and communities to highlight the importance of biodiversity and practical tips on how individuals can participate in conservation.

4.9.5.4 Noise Emissions

Mitigation measures to reduce the risk of impact associated with noise generated during mine construction and operation activities will include:

- limiting the speed of vehicles on internal roads
- scheduling equipment movements wherever possible to avoid sensitive times (e.g. night time)
- maintaining internal roads in good working order

- ensuring all vehicles, plant and machinery are maintained in proper working order to avoid unnecessary engine, motor or muffler noise
- making sure all vehicle and plant operators are aware of the location of sensitive receptors and the measures required for limiting noise where possible.

4.9.5.5 *Artificial Light*

Mitigation measures to reduce the risk of impact associated with artificial light during mine construction and operation will include:

- anti-glare lighting to minimise disruption to the vision of nocturnal wildlife (e.g., bats, owls, giant rats), where feasible
- use of anti-glare sleeves or shields to control/manage the direction of light from vehicle headlights, if feasible
- use of light sources with directional lighting and screens to concentrate light on operations, where feasible
- relocation of wildlife attracted to lighting sources to their natural habitat and away from Project facilities.

4.9.5.6 *Vehicle Strike*

Mitigation measures to reduce the risk of impact associated with vehicle strikes during mine construction and operation will include:

- limiting vehicle speed, setting and enforcing speed limits on all roads
- recording wildlife accidents to determine the species prone to vehicle strikes, specific areas where accidents commonly take place, and at what time
- in strike prone areas, use of exclusion fences, culvert crossings, suppression of attractive vegetation that could provide food/shelter/nesting sites to fauna.
- displaying signs to drivers where fauna regularly cross roads/tracks
- enforcement of road rules
- driver training.

4.9.5.7 *Fugitive Dust*

Mitigation measures to reduce the risk of impact associated with fugitive dust during mine construction and operation will include:

- watering working surfaces
- utilising boundary water sprays while excavating, where feasible
- minimising drop height
- maintaining ore moisture above relevant Dust Extinction Moisture Level
- minimising works during high wind periods.

4.9.5.8 *Increased Soil Erosion*

Mitigation measures to reduce the risk of impact associated with excessive soil erosion during mine construction and operation will include:

- stabilising the soil using effective engineering design and measures

- staging clearing, construction and mining, and mining in blocks/parcels to minimise the total area to be disturbed at any one time
- progressive rehabilitation including backfilling, topsoil management, natural regeneration and/or revegetation
- use of silt and sediment traps proximal to construction and earthmoving activities to minimise sedimentation in downslope areas.

4.9.5.9 Introduction of Invasive, Weed, Feral Animal and/or Exotic Species

Mitigation measures to reduce the risk of impact associated with accidental introduction of invasive species, weed, feral animals and/or exotic species during mine construction and operation will include:

- Ensuring compliance with national quarantine requirements
- development and implementation of a local quarantine procedure plan to detect and prevent introduction of invasive species, weed, feral animals and/or exotic species
- undertaking environmental monitoring surveys to detect invasive, weed, feral animal and/or exotic species. If introduced species are detected, an investigation will be carried-out to ascertain the species, place of origin and possible mode of transfer.

4.10 Air Quality

This section describes:

- the existing ambient air environment experienced on Santa Isabel Island, determined by baseline air quality monitoring, soil testing results and local meteorological data
- the potential air quality impacts from the Project, including predicted pollutant ground level concentrations resulting from air dispersion modelling
- the potential greenhouse gas (GHG) footprint of the Project
- measures to mitigate and/or manage potential impacts.

4.10.1 Standards Applied

The Solomon Islands Government has enacted two pieces of legislation that are specifically relevant to the air quality of the Project - the *Environment Act 1998* and the *Mines and Minerals Act 1996*. Due to the limited definition of air quality assessment criteria in Solomon Island legislation, other jurisdictional criteria were applied in the assessment of air quality. These are summarized below:

- The IFC/ World Bank General Environmental, Health, and Safety (EHS) guidelines for ambient air quality applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. It provides information about common techniques for emissions mitigation and management that may be applied to a range of industry sectors. It also provides specific guidance for assessment and monitoring of impacts, and details sources of documents to help estimate air emissions from various processes and to operate air dispersion models.
- The IFC EHS Guideline for Mining is applicable to underground and open-pit mining, alluvial mining, solution mining, and marine dredging. Note that extraction of raw materials for construction products are addressed in other EHS Guidelines. The Guideline for Mining provides a basic description of potential air quality impacts as a result of mining operations, as well as some of the mitigation measures available to alleviate the impacts. It also provides general and industry-specific examples of good international industry practice. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards.
- The WHO Guidelines for Air Quality assist countries derive their own national air quality standards to help protect human health from air pollution. The guidelines are technologically feasible and consider socio-economic and cultural constraints. They provide a basis for protecting public health from the adverse effects of air pollution, and for eliminating or reducing to minimum, air pollutants likely to be hazardous to human health. While these Guidelines provide background information for nations engaged in setting air quality standards, they are not intended to be used as standards. When translating the guidelines to standards, prevailing exposure levels and environmental, social, economic and cultural conditions in a nation or region should be taken into account. In certain circumstances, there may be valid reasons to pursue policies that will result in pollutant concentrations above the guideline values.

- The United States *Clean Air Act 1963* requires the United States Environmental Protection Agency (US EPA) to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. Primary standards provide public health protection, including protecting the health of 'sensitive' populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. The USEPA has set National Ambient Air Quality Standards for six principal pollutants, called criteria pollutants, which are carbon monoxide (CO), lead, nitrogen dioxide (NO2), ozone, particulates (as PM2.5 and PM10), and sulfur dioxide (SO2). Of these criteria pollutants, particulates and heavy metals are considered to be the most relevant to the proposed SMM activities.
- In Australia, the *National Environment Protection Measure for Ambient Air Quality* (Air NEPM) sets national standards for the six key air pollutants to which most Australians are exposed: carbon monoxide, ozone, sulphur dioxide, nitrogen dioxide, lead and particles; as well as maximum exceedance levels of each standard.
- In Queensland, Australia, the *Environmental Protection Act 1994* provides for the management of the air environment. Air quality guidelines are specified in the Queensland *Environment Protection (Air) Policy 2008* (EPP (Air)).
- In New South Wales (NSW), Australia, the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) lists the statutory methods for modelling and assessing emissions of air pollutants from ambient environments. The Approved Methods outlines the requirements for developing air dispersion modelling methodology, analysing meteorological data, and the criteria applicable when considering the potential impacts as a result of operations at the site.
- The key international guidelines for the quantification of greenhouse gas (GHG) emissions on the Project come from the 2004 *The Greenhouse Gas Protocol*, of the World Business Council for Sustainable Development (WBCSD) and the World Resource Institute (WRI).

In Australia, the following standards are generally applied to the setup and collection of meteorological data:

- *Standards Australia AS 3580.14 – 2011: Methods for Sampling and Analysis; Part 14: Meteorological monitoring for ambient air quality monitoring applications*
- *United States Environmental Protection Agency (USEPA) EPA-454/R-99-005: Meteorological Guidance for Regulatory Modelling Applications.*

4.10.2 Methodology

Potential impacts from the mining operations on Santa Isabel are based around the comparison of predicted cumulative dust concentrations at potentially affected receptors with regulatory criteria which are aimed at protecting human health. The methodology adopted for the air quality assessment of Project activities are described in the following sections.

4.10.2.1 Pollutants of potential concern

Pollutants of potential concern to locals living in the area surrounding the Project area and workers on the Project area itself were identified. These included:

- total suspended particulates (TSP), less than 50 microns
- particulate matter less than 10 microns (PM_{10} and $PM_{2.5}$)
- deposited dust

- heavy metals (arsenic, copper, lead, zinc, chromium, cadmium and nickel).

There was no evidence of naturally occurring asbestos in the Project area thus it was excluded from the assessment. Combustible pollutants (NO_X, CO, SO_2 and particulates) were also excluded. While concentrations of these combustible pollutants would likely increase due to Project vehicles and generators, the overall increase was considered relatively minor (particularly as they would be interspersed over a large area). As such, combustion emissions were not considered in the assessment, the exception being exhaust particulate emissions from haul trucks.

4.10.2.2 *Air Quality Criteria*

In the absence of local air quality criteria, the Queensland assessment criteria were adopted as the primary source of criteria. Where a criterion was not reported in the Queensland assessment criteria, the NSW criterion was used. A summary of the criteria used in the assessment is provided in Table 4-27.

Table 4-27 Project-Specific Air Quality Impact Assessment Criteria

Pollutant	Averaging Period	Criteria	Units	Source
$PM_{2.5}$	24 hours	25	µg/m³	DERM (2008)
	Annual	8	µg/m³	DERM (2008)
PM_{10}	24 hour maximum	50	µg/m³	DERM (2008)
	Annual	30	µg/m³	OEH (2005)
TSP	Annual	90	µg/m³	DERM (2008)
Deposited dust	Annual	4 (total)	g/m².month	OEH (2005)
	Annual	2 (maximum increase)	g/m².month	OEH (2005)
Arsenic	Annual	6	µg/m³	DERM (2008)
Cadmium	Annual	5	µg/m³	DERM (2008)
Chromium VI	1 hour	90	µg/m³	OEH (2005)
Copper	1 hour	18,000	µg/m³	OEH (2005)
Nickel	Annual	20	µg/m³	DERM (2008)
Zinc	1 hour	90,000	µg/m³	OEH (2005)
Lead	Annual	5,000	µg/m³	DERM (2008)

4.10.2.3 *Air Dispersion Model*

The CALPUFF dispersion model was used in the air quality impact assessment. The model is a non-steady-state, three-dimensional Gaussian puff model. Inputs into the model included meteorology, terrain data, modelling scenarios (to represent different stages and rates of mining excavation), source characteristics and emissions inventory. The model domain chosen was 30 km x 30 km, with a resolution of 1,000 m. The modelling time was a year (8,760 hours).

The following operational activities, distributed across 24 hours per day and 365 day per year, were included as emission sources for each scenario in the dispersion modelling:

- Overburden excavation:
  - excavation of overburden dump to temporary stockpiles
  - loading temporary stockpile material onto short haul trucks
  - haulage to temporary stockpiles
  - dumping onto temporary stockpiles

    - windblown dust from temporary stockpiles
    - reclamation from stockpile and loading into short haul trucks
    - haulage of reclaimed material to void
    - dumping of material into void
    - use of bulldozer in void.
- Ore extraction:
    - excavation and dumping of ore on temporary void stockpiles
    - loading stockpiles onto short haul trucks
    - haulage to intermediate ore stockpiles
    - dumping onto intermediate stockpiles
    - windblown dust from intermediate stockpiles
    - reclamation of ore from intermediate stockpiles and loading onto short haul trucks
    - haulage to port
    - dumping ore at port (into screening plant)
    - screening plant
    - wind erosion of port ore stockpiles
    - reclamation of ore from post screening stockpiles
    - dumping ore onto barges
    - use of bulldozer at port stockpiles.

4.10.2.4 Sensitive Receptors

Sensitive receptors to air quality are those places where people work and/or live. The air quality impact assessment considered 120 villages located within the proximity of the Project area.

Table 4-28 lists the receptors considered by this investigation.

Table 4-28 Dispersion Modelling Receptor Locations – Santa Isabel

Receptor No.	Easting	Northing	Receptor Elevation (m)
1	551500	9083901	28.4
2	342963	9178580	20.6
3	334989	9180295	16.6
4	332340	9180407	425.2
5	336369	9180531	11.5
6	557800	9076901	11.5
7	331057.5	9181445	383.0
8	328814.4	9182041	473.2
9	326571.3	9182638	89.9
10	324328.2	9183234	505.9
11	559300	9091701	465.3
12	322085.1	9183831	19.7
13	319842	9184427	31.5
14	317598.9	9185024	27.3
15	315355.8	9185620	67.9
16	561200	9077401	11.5
17	313112.7	9186217	21.5
18	310869.6	9186813	195.4
19	308626.5	9187410	53.3
20	306383.4	9188006	38.7
21	562200	9073701	21.1
22	304140.3	9188603	11.7
23	301897.2	9189199	31.5
24	299654.1	9189796	586.9
25	297411	9190392	838.7
26	565300	9085301	261.5
27	295167.9	9190989	412.1
28	292924.8	9191585	388.5
29	290681.7	9192182	31.5
30	288438.6	9192778	184.1
31	569900	9091601	406.9
32	286195.5	9193375	341.5
33	283952.4	9193971	52.0
34	281709.3	9194568	21.5
35	279466.2	9195164	11.5
36	572000	9093101	230.2
37	277223.1	9195761	11.6
38	274980	9196357	11.5
39	272736.9	9196954	207.0
40	270493.8	9197550	16.5
41	575700	9091701	11.5
42	268250.7	9198147	11.5
43	266007.6	9198743	41.3
44	263764.5	9199340	11.5
45	261521.4	9199936	21.5
46	579400	9082101	21.5
47	259278.3	9200533	22.8
48	257035.2	9201129	93.9
49	254792.1	9201726	26.4
50	252549	9202322	60.0
51	580600	9080601	22.9
52	250305.9	9202919	11.9
53	248062.8	9203515	400.5
54	245819.7	9204112	20.6
55	243576.6	9204708	20.8
56	581100	9077901	162.8
57	241333.5	9205305	91.5
58	239090.4	9205901	11.5
59	236847.3	9206498	20.0
60	234604.2	9207094	21.5

Receptor No.	Easting	Northing	Receptor Elevation (m)
61	582200	9070401	21.5
62	232361.1	9207691	26.1
63	230118	9208287	16.2
64	227874.9	9208884	29.8
65	225631.8	9209480	18.1
66	583700	9062301	51.6
67	223388.7	9210077	11.5
68	221145.6	9210673	38.6
69	218902.5	9211270	16.5
70	216659.4	9211866	20.7
71	585100	9084201	90.7
72	214416.3	9212463	31.4
73	212173.2	9213059	33.4
74	209930.1	9213656	127.6
75	207687	9214252	11.5
76	586300	9071701	11.5
77	205443.9	9214849	173.4
78	203200.8	9215445	40.3
79	200957.7	9216042	23.4
80	198714.6	9216638	182.1
81	587600	9058201	18.0
82	196471.5	9217235	11.5
83	194228.4	9217831	21.4
84	191985.3	9218428	42.4
85	189742.2	9219024	69.9
86	588500	9081101	111.7
87	187499.1	9219621	5.6
88	185256	9220217	191.2
89	183012.9	9220814	46.5
90	180769.8	9221410	2.5
91	588600	9064601	11.5
92	178526.7	9222007	21.5
93	176283.6	9222603	17.0
94	174040.5	9223200	21.5
95	171797.4	9223796	21.5
96	588900	9064801	19.2
97	169554.3	9224393	13.4
98	167311.2	9224989	15.0
99	165068.1	9225586	11.5
100	162825	9226182	11.5
101	589400	9080401	106.5
102	160581.9	9226779	41.5
103	158338.8	9227375	11.5
104	156095.7	9227972	43.2
105	153852.6	9228568	11.5
106	589700	9074601	11.5
107	151609.5	9229165	121.5
108	149366.4	9229761	50.6
109	147123.3	9230358	55.8
110	144880.2	9230954	11.5
111	590200	9067901	66.2
112	142637.1	9231551	52.7
113	140394	9232147	62.9
114	138150.9	9232744	105.3
115	135907.8	9233340	26.6
116	590900	9066701	16.9
117	133664.7	9233937	21.3
118	131421.6	9234533	173.5
119	129178.5	9235130	5.0
120	126935.4	9235726	5.0

4.10.2.5 Cumulative Impacts

A baseline ambient air quality monitoring program was used to measure the air quality at selected local villages to quantify the existing air quality. A representative background pollutant concentration from the baseline study was added to the predicted ground level pollutant concentrations to generate potential cumulative pollutant concentrations, which were used to assess the impacts of the Project.

4.10.2.6 Greenhouse Gas Emissions

GHG emissions estimates for Santa Isabel Island were calculated using general guidance from the WRI Greenhouse Gas Protocol (WBCSD and WRI 2004) in conjunction with applicable UNFCCC (2011) methodological calculation tools, IPCC (2003) *Good Practice Guidance for Land Use, Land-Use Change and Forestry (LULUCF)* and IPCC (2006) Tier 1 methods.

Scope 1 and Scope 2 GHG emissions from sources including fossil fuel consumption and land use change for the Project's operations on Santa Isabel Island were calculated. Further details on the methodologies employed to calculate greenhouse gas estimates, including the parameters applied to the GHG emissions model, and key assumptions, are presented in the Report - Climate Change and GHG Emissions.

4.10.3 Existing Values

The Solomon Islands have relatively few sources of pollution. The main sources of pollution are combustion emissions from the burning of solid fuels.

Climatic conditions affecting air quality in the Solomon Islands include diurnal variation in winds, with wind speeds increasing during the morning and peaking in the afternoon, and with lighter winds or calm conditions occurring at night. Katabatic wind flow can occur at night in mountainous or hilly areas where cool, dense air flows downhill. The katabatic winds can combine with land breeze effects to generate offshore winds of up to 20 km/hour in the early morning hours. Calm winds are more frequent in the periods between the two seasons.

Results of the baseline ambient air quality monitoring program (i.e. the background concentrations adopted for the cumulative assessment) were as follows:

- PM_{10} 24-hour peak (based on the 70^{th} percentile concentration) = 27.7 $\mu g/m^3$
- PM_{10} annual average concentration = 25 $\mu g/m^3$
- $PM_{2.5}$ 24-hour peak = 10.1 $\mu g/m^3$
- $PM_{2.5}$ annual average concentration = 10 $\mu g/m^3$
- TSP annual average concentration = 69.2 $\mu g/m^3$

4.10.4 Potential Impacts

The primary potential sources of particulate pollution are listed below:

- bulk excavation of soil and rock
- stockpiling and stockpile management of soil and ore
- preparation and processing of ore
- wind generated dust from dirt haul roads, exposed soil and ore stockpiles
- wheel generated dust from haul routes
- loading trucks and trains for ore export.

Construction activities were considered to be short-term and intermittent in nature. The emissions from mining and associated operational activities were assumed to be greater than those of the construction period; as such, modelling operational impacts was considered to provide a more representative assessment of worst case impacts. The potential impacts from construction activities were therefore not assessed.

4.10.4.1 Amenity Impacts (TSP and Dust Deposition)

One exceedance of the impact assessment criteria was predicted. Impacts were predicted to be above the amenity criteria of 90 µg/m^3 for TSP for the village of Valaaroe. This elevated coarse particulate impact is expected to be due to the proximity of the village to the mining activities and the predominant wind direction, which would be expected to blow winds from the mining and port activities toward the village.

The representative worst case scenario predicted no exceedances of the impact assessment criteria.

4.10.4.2 Health Impacts (PM_{10}, $PM_{2.5}$ and Heavy Metals)

Based on the results of the dispersion modelling, adverse effects on air quality may occur at a number of villages surrounding the mining and port related activities on Santa Isabel Island. The impacts predicted by the modelling are associated with simple mining techniques that result in multiple handling of both overburden and ore, as well as wheel generated dust from haul roads.

Further analysis of the predicted concentrations was undertaken to try and further understand the potential for exceedances at Santa Isabel Island. For each receptor that is predicted to experience a worst case exceedance during the modelling year, the daily average PM_{10} concentration was predicted for the full year of data (365 days). For each receptor, the number of cumulative 24 hour average exceedances was determined. Of these 24 hour exceedances, the number that occur during the wet season were identified. As wet season predictions have a lower likelihood of occurring in reality (due to the wet season increasing source moisture contents and decreasing background dust), the likelihood of a number of dry days in a row is low with the likelihood of corresponding dry roads being equally low.

Of the 120 receptors included in the dispersion modelling for Santa Isabel Island, three are predicted to experience cumulative dust concentrations higher than the adopted criteria. Of those three receptors, there are 52 occurrences where predicted 24 hour average cumulative concentrations exceed the criteria. Of the 52 occurrences, 40 (or 77%) occur during the wet season, suggesting a low likelihood of exceedances occurring in reality.

4.10.4.3 Greenhouse Gas Footprint

The Project's development in Santa Isabel Island will make a significant contribution to total GHG emissions for the Solomon Islands. During the 45 year full life cycle of the Project the average yearly emissions were estimate to be 46,237 tCO_2-e.

In 2001, the Solomon Island completed their Initial National Communication to UNFCCC based on 1994 data. The annual emissions for the Solomon Islands were estimated at 322,580 tCO_2-e (Solomon Island National Government 2001). Based on this data, annual emissions from the Project are currently equivalent to approximately 14% of the Solomon Islands 'Top Down Approach' emissions based on the 1994 data.

However, it is important to note that the 1994 National GHG Inventory data only reports CO_2 emissions from the energy sector. It lacks data for GHG emissions from land use change and forestry, industries, manufacturers and construction, agriculture, and waste management (Solomon Island National Government 2001). It is therefore considered highly likely that the Project contribution to National emissions from the Isabel Tenement D and Isabel Tenement E will be significantly lower than 14%.

Details of the fossil fuels consumed by year of the Project; the origins of fossil fuel GHG emissions during the Project; land use, land use change and forestry GHG emissions; and methane emissions from waste water treatment and sanitary landfill are presented in the Report – Climate Change And GHG Emissions.

4.10.5 Impact Assessment

A risk assessment of potential impacts is presented in Table 4-29.

Table 4-29 Assessment of Potential Impacts on Air Quality

Potential Impact	Facility				Stage		Status	Extent	Duration	Intensity	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Emission of dust from construction of roads, port and infrastructure			•	•	•		Negative	Local	Short Term	Medium	Probable	Medium	Medium	Apply water or other measures to material being worked and modify operations to suite conditions.	Low	Low
Emission of dust from material excavation and truck loading	•				•	•	Negative	Local	Short Term	High	Highly Probable	High	High	Apply water or other measures to material being worked and modify operations to suite conditions.	Medium	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Medium	
Emission of dust from dumping material onto stockpile or into void	•				•	•	Negative	Local	Short Term	High	Highly Probable	Medium	Medium	Modify operations to suite conditions.	Medium	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	
Emission of dust from stockpile caused by wind erosion	•		•		•	•	Negative	Local	Short Term	Medium	Probable	Medium	Medium	Water and /or cover stockpiles, install wind breaks	Low	Low
									Long Term	Medium	Highly Probable	Low	Low		Low	
Emission of dust from machinery working stockpiles or voids	•		•		•	•	Negative	Local	Short Term	High	Highly probable	Medium	Medium	Water material, modify operations to suite conditions.	Medium	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	
Emission of dust from reclaiming stockpiles and loading onto short haul trucks	•	•			•	•	Negative	Local	Short Term	High	Highly Probable	Medium	Medium	Water material, modify operations to suite conditions.	Medium	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	

Table 4-29 Assessment of Potential Impacts on Air Quality

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Duration	Intensity	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance with Mitigation	Confidence Level
Emission of dust from road vehicles agitating soil while hauling material on unsealed roads		•			•	•	Negative	Local	Short Term	High	Highly Probable	High	High	Minimise road length, haul trips and truck speeds. Apply water or surfactants to roads.	High/Medium (see discussion below)	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	
Emission of dust from dumping ore into screening plant			•			•	Negative	Local	Short Term	High	Highly Probable	Medium	Medium	Modify operations to suite conditions.	Medium	Low
									Long- Term	Medium	Highly probable	Medium	Medium		Low	
Emission of dust from screening plant operations			•	•		•	Negative	Local	Short Term	High	Probable	Medium	Medium	Nil Mitigation	Medium	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	
Emission of dust from loading ore onto barge			•			•	Negative	Local	Short Term	Medium	Highly Probable	Medium	Medium	Cover / water loading area.	Medium	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	
Emission of dust from loading ore from barge to ship			•			•	Negative	Local	Short Term	Low	Improbable	Low	Low	Cover / water loading area.	Low	Low
									Long Term	Medium	Highly Probable	Medium	Medium		Low	

4.10.6 Mitigation Measures

Mitigation measures that apply to the impacts listed in Table 4-29 are described in Table 4-30.

Mitigation measures range from physical modifications of the Project area and equipment to procedural plans to be implemented relating to operations. Table 4-30 describes the possible measures available to the Project from which a combination of measures will be chosen; not all measures must be applied. The choice of measures will be based upon the following aspects:

- Ability to implement – not all of the measures may be achievable for the Project.
- Cost versus effectiveness– the cost of each measure will be assessed against the effectiveness of the measure. Typically, those measures that provide the most efficient mitigation for the least cost will be chosen first.
- Mobility – the nature of the Project location is nomadic, with the mining area constantly changing. Permanent mitigation measures such as wind breaks formed from soil may, therefore, not be an acceptable option for mitigation.

The mitigation measures will be dependent on a number of factors, including the final design of the mining plan, equipment used and mining locations. The chosen measures may, therefore, differ between scenarios or over time, meaning that mitigation measures for one location/time may not be those best suited to others.

Table 4-30 Potential Mitigation Measures

Potential Impact	Mitigation/ Management Actions
Emission of dust from construction of roads, port and infrastructure	Water surface of material to be worked Utilise boundary water sprays while excavating Minimise drop height Minimise works during dry/high wind periods Cover stockpiles at end of shift or during windy/dry conditions Control roadway use i.e. defined road access to minimise dust Follow mitigation in following sections for similar activities
Emission of dust from material excavation and truck loading	Water surface of material to be worked Utilise boundary water sprays while excavating Minimise drop height Maintain ore moisture above relevant Dust Extinction Moisture Level Minimise works during dry/high wind periods Mine ore at locations in close proximity to receptors during wet/cool periods
Emission of dust from dumping material onto stockpile or into void	Minimise drop height Water material to be moved Minimise works during dry/high wind periods
Emission of dust from stockpile caused by wind erosion	Water stockpiles Install windbreaks Cover stockpiles at end of shift or during windy/dry conditions
Emission of dust from machinery working stockpiles or voids	Minimise machine use Water material to be worked Minimise dusty work during dry/high wind periods
Emission of dust from reclaiming stockpiles and loading onto short haul trucks	Minimise drop height Water material to be moved Minimise works during dry/high wind periods
Emission of dust from road vehicles agitating soil while hauling material on unsealed roads	Minimise haul road length Utilise water trucks on haul roads Apply surfactants to roads Use haul trucks with larger capacity to minimise required

Potential Impact	Mitigation/ Management Actions
	vehicle trips Seal haul roads where possible Limit haul road speeds Control roadway use i.e. defined road access to minimise dust Dust monitoring at selected locations along haul road
Emission of particulates from vehicles, machinery and generators	Proper vehicle/generator maintenance for reducing emissions
Emission of dust from dumping ore into screening plant	Minimise drop height Water material to be moved Minimise works during dry/high wind periods Enclose and ventilate dumping location
Emission of dust from screening plant operations	Use water sprays
Emission of dust from loading ore onto barge	Minimise drop height Water material to be moved Use water sprays over barge opening Minimise works during dry/high wind periods Cover loading area
Emission of dust from loading ore from barge to ship	Minimise drop height Water material to be moved Use water sprays over barge and ship opening Minimise works during dry/high wind periods Cover loading area

4.10.6.1 Greenhouse Gas Footprint

The Project will exceed the 25,000 tonnes of CO_2-equivalent annually emission limit as per IFC Performance Standards PS3. Therefore it will be necessary to incorporate monitoring procedures to quantify scope 1 and scope 2 GHG emissions.

A comprehensive monitoring plan will be established by the Project to report GHG emissions. This information will be developed as per recognised international standards and will be provided to the Solomon Islands Government to assist in meeting their future UNFCCC National Communications.

Mitigation measures to reduce GHG emissions include:

- Potential applicability for Clean Development Mechanism projects with carbon offset opportunities.
- Potential mitigation of Project GHG emissions with carbon offset opportunities through the management, protection and restoration of 'Blue Carbon'. Blue carbon describes marine and coastal vegetation such as mangrove forests and seagrass meadows that have the capacity to sequester atmospheric carbon dioxide. Such coastal vegetation can sequester carbon dioxide more effectively and more permanently than terrestrial plants and has the added benefits of providing fish and nursery habitats, as well as protection from tropical cyclones, storm surges and coastal erosion.
- Potential mitigation of Project GHG emissions by possible contribution to Rehabilitation Management Planning, and a possible alternate energy source from the production and use of Biochar. Biochar could offer long term soil carbon sequestration (Biochar sequestration) with carbon offset opportunities, remediation of soil and improvement of soil fertility, and production of bioenergy (as syngas, bio-oils or heat).

4.11 Noise

The objectives of this assessment are as follows:

- describe the existing acoustic environment in the Project area
- establish constructional and operational noise objectives for the Project
- identify and assess potential impacts from noise on sensitive receptors in the Project area
- recommend mitigation measures to minimise potential impacts from noise occurring from the Project activities.

4.11.1 Legislative Framework

The following standards were used to establish noise objectives for the Project:

- IFC Noise Management Guidelines, 2007
- ISO 1996-2:2007 – Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels
- BS 5228-1:2009 – Code of practice for noise and vibration control on construction and open sites – Part 1: Noise

4.11.2 Methodology

4.11.2.1 Ambient noise monitoring

All noise monitoring was undertaken by staff trained in the conduct of environmental noise measurements. A data collection program was undertaken to represent existing ambient background noise conditions.

Unattended baseline sound level measurements were taken at six locations, three at Santa Isabel Tenement D and three at Santa Isabel Tenement E, adjacent to the proposed Project area, for seven days between 23 November 2011 and 18 December 2011 (refer to Figure 4-23).

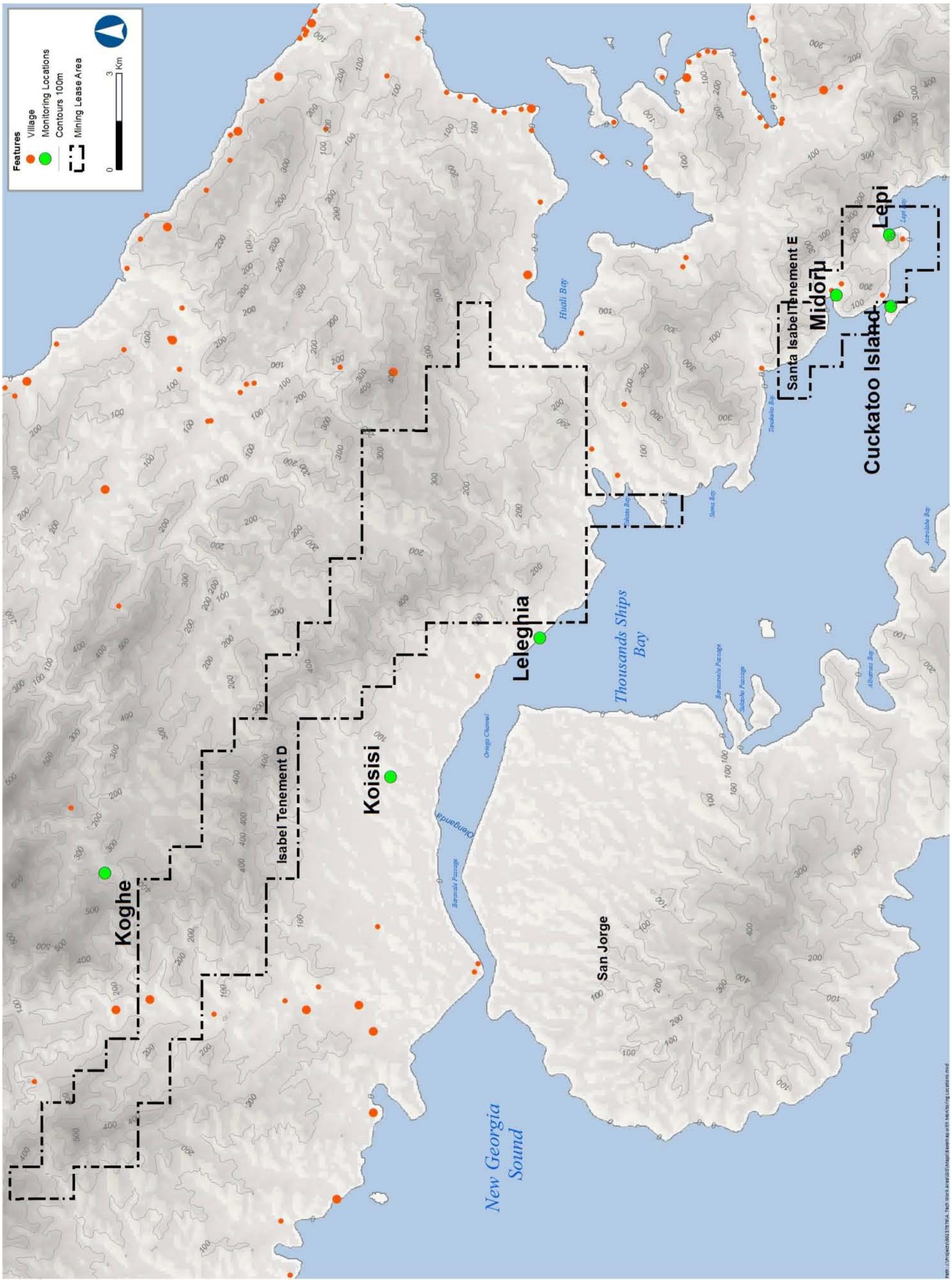

Figure 4-23 Noise Monitoring Locations on Santa Isabel Island

Rion NL-21 environmental noise loggers were used for unattended noise logging. Attended measurements were completed using a Svantek SVAN 948 sound level meter. All sound level loggers and meters recorded noise data for the L_{A1}, L_{A10}, L_{A90}, L_{Aeq} and L_{Amax} descriptors at 15 minute intervals and were field calibrated using an acoustic calibrator both before and after noise measurements to monitor drifts in calibration.

All noise equipment was chosen in accordance with IFC Guidelines and were calibrated in accordance with current National Association of Testing Authorities (NATA Australia) at the time of use.

Meteorological data (rainfall, wind speed) during the field study period were collected at automatic weather stations situated on Santa Isabel Island. Noise measurements were processed and any noise from extraneous sources (i.e. generators, watercraft, aircraft, adverse weather conditions, etc.) were removed.

4.11.2.2 Noise prediction modelling

A three-dimensional noise model of the proposed Project area was created in SoundPLAN Version 7.0 environmental noise monitoring software. The CONCAWE prediction method within SoundPLAN was used to model environmental noise emission from the Project site. Ground topography information was provided by Hatch on 19 January 2012. Locations of villages and other sensitive receptors were based on shapefiles provided by Hatch on 27 February 2012.

4.11.2.3 Noise impact assessment

Noise impacts focused on the typical worst case scenario, assuming 24 hour/day, 7 day/week operations. Limitations and exclusions of the report are provided in greater detail in the Noise Impact Assessment – Noise.

4.11.3 Existing Values

The following noise sensitive receptors were identified within or surrounding the Project area:

- village dwellings, comprising single and double-storey weatherboard houses and traditional village huts
- primary school and secondary school facilities located in the villages
- places of worship in the villages
- hospitals and clinic areas in the villages

Noise monitoring results to characterise ambient noise levels at the six monitoring locations are shown in Table 4-31.

Table 4-31 Ambient Noise Levels

Location	**Tenement**	**Minimum Background Noise Levels (min$L_{A90, 1 hour}$)(dBA)**	
		Day (L_{A90})	**Night (L_{A90})**
Midoru	Isabel E	41	47
Lepi	Isabel E	35	42
Cockatoo	Isabel E	33	36
Isabel E Average		**34**	**39**
Leleghia	Isabel D	33	39
Koisisi	Isabel D	33	40
Koghe	Isabel D	37	40
Isabel D Average		**34**	**40**

Measured sound levels at all monitoring locations were generally similar in characteristics. The background noise environment typically comprised natural noise sources (birds, insects, human activity, domestic animals and weather effects). Villages were exposed to short periods of noise from vehicles (boats, helicopters) and small petrol power generators.

Monitoring data indicated that background noise levels were typically higher at night than during the daytime due to high levels of insect noise at night-time.

The following noise criteria for the Project, provided in Table 4-32, were established based on the average background noise results determined during monitoring of all six locations in accordance with the applicable IFC Guidelines.

Table 4-32 Summary of Recommended Project Operational Noise Criteria

Receptor	Maximum Noise Levels ($L_{Aeq(1h)}$) (dBA)	
	Day time 07:00 – 22:00	Night time 22:00 – 07:00
IFC Maximum Noise Levels ($L_{Aeq(1h)}$)	55	45
Average Measured Background L_{A90} + 3 dB ($L_{Aeq(1h)}$)	$(34+3)=37$	$(42+3)=45$

The most stringent criterion of $L_{Aeq(1h)}$ 37 dB(A) was applied to establish noise criteria, an approach consistent with recommended noise objectives for industrial and mining developments in other parts of the world.

4.11.4 Potential Impacts

Potential sound levels from Project activities were predicted from noise modeling for mine operations and associated infrastructure. Equipment sound power levels used in the noise modeling were based on that of typical machinery from an internal (AECOM) database and measurements taken at similar mining and mineral processing operations.

The modelling identified that noise emissions from mobile equipment involved in ore transport and equipment operating during the operations phase are the key sources of potential impacts.

Modeling results have been prepared for five different points in time based on the current timeline of the Project:

- Scenario 1: Assessment of the Project operations between years 0 – 6 for the mine and supporting infrastructure areas and activities
- Scenario 2: Assessment of the Project operations between years 7- 12 for the mine and supporting infrastructure areas and activities
- Scenario 3: Assessment of the Project operations between years 13 - 18 for the mine and supporting infrastructure areas and activities
- Scenario 4: Assessment of the Project operations between years 19 - 23 for the mine and supporting infrastructure areas and activities
- Scenario 5: Assessment of worst case noise emission of the Port area and activities assuming full operation for the life span of the Project

Each scenario is considered to represent a point in time that would generate typical maximum operational noise into surrounding areas. In each scenario, modeling used worst-case sound propagation weather conditions.

Table 4-33 presents the results of noise modelling for noise emissions from the Project at Isabel Tenement D.

Noise sensitive receiver locations where a noise emission from a scenario exceeds the recommended project criteria have been listed in the tables below. Forecast exceedances are shown along with the specific activity responsible and the specific scenarios of concern.

Table 4-33 Isabel Tenement D Summary of Projected Received Sound Levels

Affected Location	Forecast Noise Level, $L_{Aeq, 1h}$ dB				Distance from Tenement Boundary (m)	Dominant noise source (Scenario)
	Scenario 1	Scenario 2	Scenario 3	Scenario 4		
Alu Alu	<20	<20	32	**40**	688	Haul Roads (4)
Fanavi	**41**	**41**	**41**	**40**	1,600	Haul Roads (1,2,3,4)
Gagaolo	<20	<20	39	38	375	Combined Haul Roads * Mine Areas (3,4)
Hageulu	27	30	**42**	**42**	1,031	Mine Areas (3,4)
Hirosare	<20	<20	74	63	Inside Tenement	Haul Roads & Mine Areas (3,4)
Huali	<20	<20	32	38	1,471	Haul Roads & Mine Areas (4)
Hut	28	**45**	**46**	**44**	Inside Tenement	Haul Roads & Mine Areas (2,3) Haul Roads (4)
Hut	<20	25	**48**	**44**	Inside Tenement	Haul Roads & Mine Areas (3,4)
Koleta Primary School	37	**40**	**41**	37	211	Mine Areas (2,3)
Kologhjogha	23	29	**42**	**45**	606	Haul Roads (1,2,3)
Koleta Primary School	23	29	**42**	**45**	211	Combined Haul Roads * Mine Areas (3,4)
Kolomola	<20	<20	39	**56**	Inside Tenement	Combined Haul Roads * Mine Areas (3,4)
Leleghia	37	39	**40**	36	479	Mine Areas (3)
Piregha	29	29	37	**41**	1,011	Mine Areas (4)
Riridede	25	27	**40**	39	1,200	Mine Areas (3,4)
Takata	34	33	**46**	**48**	185	Mine Areas (3,4)
Tinakle	**57**	**57**	**60**	**57**	Inside Tenement	Haul Roads (1,2,4) Mine Areas (3)
Tuotungo	**40**	**40**	**43**	**45**	Inside Tenement	Haul Roads (1,2) Combined Haul Roads & Mine Areas (3,4)
Vara	<20	20	34	38	1,052	Combined Haul Roads & Mine Areas (4)
Varadaki	<20	30	**49**	32	291	Mine Areas (3)
Veranaue	27	33	**46**	**51**	181	Mine Areas (3) Haul Roads & Mine Areas (4)

*Forecast exceedance.

The operation of the mining areas is expected to have the following exceedances:

- Scenario 1: noise levels at three locations are predicted to exceed the Project criteria by up to 20 dB(A)
- Scenario 2: noise levels at six locations are predicted to exceed the Project criteria by up to 20 dB(A)
- Scenario 3: noise levels at 17 locations are predicted to exceed the Project criteria by up to 37 dB(A)
- Scenario 4: noise levels at 18 locations are predicted to exceed the Project criteria by up to 26 dB(A)

Table 4-34 presents the results of noise modeling under the same worst case meteorological conditions for the residential locations and other village facilities at Santa Isabel Tenement E.

Table 4-34 Mining Areas and Infrastructure Results Summary for Isabel Tenement E

Affected Location	Forecast Noise Level, $L_{Aeq,\,1h}$ dB				Distance from Tenement Boundary (m)	Dominant noise source (Scenario)
	Scenario 1	Scenario 2	Scenario 3	Scenario 4		
Japuana	N/A	**39**	N/A	N/A	Inside Tenement	Mine Area (2)
Cockatoo Camp	N/A	**49**	N/A	N/A	282	Mine Area (2)
Midoru	N/A	**55**	N/A	N/A	Inside Tenement	Mine Area (2)
Valaaroe	N/A	**51**	N/A	N/A	Inside Tenement	Mine Area (2)
Lepi	N/A	**54**	N/A	N/A	Inside Tenement	Mine Area (2)

- Scenario 1: activities are not planned for Isabel Tenement E during this time period
- Scenario 2: noise levels at all seven potential receiver locations are predicted to exceed the Project criteria by up to 18 dB(A)
- Scenario 3: activities are not planned for Isabel Tenement E during this time period
- Scenario 4: activities are not planned for Isabel Tenement E during this time period

Noise emission from the operation of the Project is likely to have a significant impact at a number of sensitive receptor locations. A total of 28 sensitive locations across Tenements D and E are forecast to be exposed to noise levels in excess of the recommended Project criteria. Table 4-35 presents a summary of the range of forecast noise level exceedances across both Tenements.

Table 4-35 Isabel Tenement E – Forecast Operational Noise Exceedences

Forecast Exceedance above Recommended Project Criteria	Relative Impact	Number of affected receivers for the Mining Tenement		Total Number of Affected Villages
		Isabel D	Isabel E	
3 dB(A) or less for all modelled scenarios	Low	6	1	7
4 to 8 dB(A) for at least one modelled scenario	Moderate	7	0	7
9 to 15 dB(A) for at least one modelled scenario	High	5	3	8
15 dB(A) or greater for at least one modelled scenario	Very High	3	3	6

A forecast exceedance of less than 3 dB(A) is considered minor. Exceedances of between 4 and 8 dB(A) are likely to result in noise levels that are clearly audible at sensitive receptors. Noise levels are likely to fall within the upper limit provided by the IFC Guidelines.

Exceedance levels more than 9 dB(A) above the recommended criteria are likely to have a significant impact on noise sensitive receptors. Mitigation will be required to reduce these noise levels.

Predictions of operational noise emissions from the port facilities are forecast to comply with the recommended Project criterion at the nearest sensitive receivers.

Construction activities will use some similar mobile equipment to that proposed for the mining activity. However, the equipment requirements for construction activities will be less than for operation activities. As such, construction noise impacts are likely to be lower than the forecast operational noise levels at noise sensitive receivers. No modelling was undertaken for the construction activities.

4.11.5 Impact Assessment

Table 4-36 Assessment of Potential Impacts on Noise

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Noise Emission from Mine and Associated Infrastructure to sensitive receivers	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	Very High[1]	High	Level 4[2]	Nil	Moderate
														Level 3[2]	Low	
														Level 2[2]	Medium	
														Level 1[2]	High	
												High[1]	High	Level 3[2]	Nil	Moderate
														Level 2[2]	Low	
														Level 1[2]	Medium	
								Regional	High	Long	Highly Probable	Moderate	Moderate	Level 2[2]	Nil	Moderate
														Level 1[2]	Low	
Noise Emission from Haul Roads to sensitive receivers		•			•	•	Negative	Local	High	Long	Highly Probable	Very High[1]	High	Level 4[2]	Nil	Moderate
														Level 3[2]	Low	
														Level 2[2]	Medium	
														Level 1[2]	High	
												High[1]	High	Level 3[2]	Nil	Moderate
														Level 2[2]	Low	
														Level 1[2]	Medium	
								Regional	High	Long	Highly Probable	Moderate	Moderate	Level 2[2]	Nil	Moderate
														Level 1[2]	Low	

[1] Refer to the Figures presented in Section 4.11.4 showing the forecast noise impacts on sensitive receptors.
[2] Refer to the proposed mitigation levels in Table 4.11.4.

4.11.6 Mitigation Measures

Noise emissions from mining activities are forecast to result in sound levels that exceed the recommended Project criteria at 28 locations over the life of the Project. The sensitive receptors where noise levels exceed the Project criteria typically lie within 1.5 km of the proposed operations. As such, a minimum set back distance of at least 1.5 km should be maintained between mining operations and sensitive receptors to avoid noise impacts. Where this cannot be maintained, mitigation measures in Table 4-37 should be considered. In all cases, provision of low noise equipment shall be used to minimise the potential exceedance of recommended Project criteria. This is to be preferred in place of add-on controls to all residential buildings as it reduces the external sound levels around buildings.

Table 4-37 Santa Isabel Tenement E – Forecast Operational Noise Exceedences

Forecast Exceedance	Magnitude of Impact	Level of Mitigation	Proposed Mitigation Options
3 dB(A) or less	Low	1	Controlled design speeds in and around mine and stockpile areas, minimisation of the gradient of roads, use of noise management techniques per Section 4.11.6.1.
Between 4 & 8 dB(A)	Medium	2	Construction of stockpiles, noise barriers or earth berms close to the noise source to block the line of sight, use of low-noise equipment, installation of advanced engine and exhaust noise control equipment.
Between 9 & 15 dB(A)	High	3	Construction of large noise barriers, earth berms or stockpiles to surround mine operations AND selection of low noise equipment or use of advanced noise control techniques, provision of building upgrades to affected receptors.
Above 15 dB(A)	Very High	4	Provision of significant acoustic isolation to the facades of houses within affected areas, acquisition or relocation of the village.

The highest mitigation option (Level 4) is the most effective and would be required to reduce the impacts from the six most affected villages from "very high" impacts to "nil" impacts.

Where the required mitigation cannot be provided, the preceding level of mitigation should be considered. The following residual impacts have been identified in Table 4-38.

Table 4-38 Forecast Residual Impacts

Forecast Exceedance Above Project Criteria	Predicted Impact Before Mitigation	Level of Mitigation	Impact - After Mitigation
3 dB(A) or less	Low	1	Nil
Between 4 & 8 dB(A)	Medium	2	Nil
		1	Low
Between 9 & 15 dB(A)	High	3	Nil
		2	Low
		1	Medium
Above 15 dB(A)	Very High	4	Nil for treated villages, unchanged for untreated villages
		3	Low
		2	Medium
		1	High

The primary haul roads proposed for the Project area pass in close proximity (within 100 m) of a number of villages, forecasted to result in noise levels up to 37 dB(A) over criteria. Where possible, haul roads will be set back by 1.3 km in flat terrain from the nearest village. Where location of the haul roads near sensitive receptors is unavoidable, the measures presented in Table 4-39 can be undertaken.

Table 4-39 Primary Haul Roads – Proposed Mitigation Options

Forecast Exceedance	Magnitude of Impact	Level of Mitigation	Proposed Mitigation Options
3 dB(A) or less	Low	1	Good vehicles and equipment, good maintenance procedures, regular grading and maintenance of roads
Between 4 & 8 dB(A)	Medium	2	Use of low-noise vehicles, installation of advanced truck engine and exhaust noise control equipment, construction of noise barriers or earth berms blocking the line of sight to the village
Between 9 & 15 dB(A)	High	3	Construction of high noise barriers or earth berms 1-2m higher than necessary to block the line of sight, modification of haul routes, provision of building upgrades to affected receptors
Above 15 dB(A)	Very High	4	Construction of very high noise barriers or earth berms 3-4 m above the line of sight, modification of haul routes, acquisition or relocation of the village

Specific noise mitigation strategies for port operations have not been provided because noise emissions are expected to comply with the recommended Project noise criteria. Best practice management techniques should still be included to minimise any potential and unnecessary impacts to sensitive receptors.

4.11.6.1 Noise Management Plan

The development, implementation and enforcement of a Noise Management Plan for the Project will be undertaken during construction and operation stages. This will ensure that the issue of controlling environmental noise to sensitive receptors is continually reviewed and managed. The following mitigation measures will be considered in the Noise Management Plan (see Chapter 5).

4.11.6.1.1 Site Management

The following best practice management practices will be considered as part of day-to-day operations of the Project to control noise emissions:

- Limiting the speed of vehicles on Project roads.
- Scheduling equipment movements wherever possible to avoid sensitive times (e.g. avoid night time movements where possible).
- Regularly maintaining internal roads in good working order with smooth services and rapid repair of potholes where possible.
- Replacement of standard, tonal reversing alarm beepers on mobile equipment with a lower-impact alarm such as a "Backalarm" broadband noise device.
- Ensuring all vehicles, plant and machinery are regularly maintained to avoid unnecessary engine, motor or muffler noise.
- Making sure all vehicle and plant operators are aware of the location of sensitive receptors and the measures required for limiting noise emissions where possible.
- Limiting operation and construction hours to 07:00 to 22:00 where practicable. Activities undertaken outside of these hours will be minimised, particularly those with significant noise impacts such as road construction or drilling.
- Keeping local village residents informed of when any noisy construction works will occur.
- Selecting and locating site access roads as far away from noise-sensitive receptors as possible.
- Careful selection of the relative locations of the main infrastructure and stockpiles to ensure minimal disruption to sensitive receivers. For example, stockpiles can act as barriers to sound propagation.
- No unnecessary idling or high throttling of vehicles and plant.
- Fitting all engine exhausts with suitable and well-maintained mufflers/silencers.
- Locating noisy fixed plant in a suitable acoustic enclosures away from residential locations.
- Designing haul routes to minimise the requirement to reverse vehicles (in order to reduce the noise from reversing signals).
- Implementing worksite induction training to educate staff on noise sensitive issues.

4.11.6.1.2 Equipment Management

The following best management practices for equipment operation will be considered as part of day-to-day operations of the Project to control noise emissions:

- Selection of low noise plant and equipment.
- Compliance with the manufacturer's noise specifications will be confirmed when the equipment arrives at site and during commissioning. Testing for compliance will be carried out periodically during operation.

- Equipment will be well maintained and fitted with adequately maintained silencers which meet the design specifications.
- Silencers and enclosures will be kept intact; rotating plants will be balanced, loose bolts tightened, frictional noise reduced through lubrication and cutting noise reduced by keeping equipment sharp.
- Dozers fitted with articulated buckets will be rubber-lined at the contact points to ensure that noise levels are minimised during the release of materials, where practicable
- Resonance will be avoided where possible e.g. changing the speed of machines.

4.11.6.1.3 Community and Complaints Management

The Social Impact Management Plan (SIMP) and Grievance Procedure will be implemented to assist in avoiding and managing complaints arising from the Project noise emissions. Refer to Chapter 5 for details of the SIMP and Grievance Procedure.

4.11.6.1.4 Noise Monitoring

A noise monitoring program will actively monitor noise emissions from the Project and allow for noise issues to be dealt with before a potential problem arises. Noise monitoring will be the responsibility of SMM Solomon and will be carried out by suitably trained personnel at intervals to be determined during the development of the Noise Management Plan (refer to Chapter 5).

The noise monitoring program will be used to:

- assess whether an item or a particular process, new or old, is complying with the Project noise criterion or if noise control measures are functioning as planned
- confirm that the Project noise criteria are being met at potentially affected sensitive receivers
- address complaints from a nearby sensitive receiver.

4.12 Visual Amenity

This section describes the:

- existing visual character of Santa Isabel Island in the proximity of the Project area
- potential visual amenity impacts from the Project on local village communities
- proposed mitigation measures for minimising the potential visual amenity impacts.

Further details are provided in the Impact Assessment Report – Visual Amenity.

4.12.1 Methodology

Assessment of the impact of Project activities and infrastructure on visual amenity was based on photographs of the locations of major Project infrastructure components and overlaid with a graphical representation of these components digitally superimposed on the photographs. The criteria in Table 4-40 were applied to determine the visual impact of the Project infrastructure from these photographed locations.

Table 4-40 Visual Amenity Impact Factors

Criteria	Description
Landscape absorption capacity	The extent of natural screening from topography and vegetation (%).
Horizontal and vertical visual effects	The extent to which the proposed Project component would cover the primary field of view (typically up to 160º) of an observer looking directly at the component, in both the horizontal and vertical planes. Minor extent - < 20º Moderate extent - 20º to 90º Major extent - > 90º
Distance from Project component	The distance from the Project component (km).

A subjective assessment was undertaken based on the following categories of visual amenity impact shown in Table 4-41.

Table 4-41 Categories of Visual Amenity

Impact	Definition
Very High	The viewpoint is less than 1 km from, and the observer's field of view is wholly dominated by, the Project component with no screening topography or vegetation.
High	The viewpoint is less than 1 km from the Project component but there is some (at least 25%) screening from topography or vegetation within the observer's field of view.
Moderate	The viewpoint is less than 1 km from the Project component but there is substantial (at least 50%) screening from topography or vegetation within the observer's field of view.
Moderate	The viewpoint is more than 1 km from the Project component and there is some (at least 25%) screening from topography or vegetation within the observer's field of view.
Low	The viewpoint is more than 2 km from the Project component and there is some (at least 25%) screening from topography or vegetation within the observer's field of view.
Low	The viewpoint is less than 2 km from the Project component but there is substantial (at least 50%) screening from topography or vegetation within the observer's field of view.
Very Low	The viewpoint is more than 2 km from the Project component and there is at least 90% screening from topography or vegetation within the observer's field of view.

4.12.2 Existing Values

4.12.2.1 Landscape Character

The existing character of the landscape on Santa Isabel Island in the proximity of the Project activities and infrastructure components primarily comprises coastal forest, lowland communities and upslope rainforest. Almost all of the upslope rainforest is "old growth". Rainforest is typically dominated by *Casuarina* sp., iron wood and other canopy species (e.g. palms) approximately 40 m in height. The understory is dense and comprises mainly young trees and other saplings as well as small palms and ferns. Leaf litter, composed mainly of decaying leaves and some twigs and fallen logs, almost entirely covers the forest floor.

4.12.2.2 Local Communities

Local communities vary in size from small settlements of up to 15 people, typically three or four family groups, to comparatively large villages of more than 300 people. Local communities will be the sensitive receptors to any changes in visual amenity.

Maps of local communities located in the general area of Isabel Tenement D and Isabel Tenement E are provided in Figure 4-24 and Figure 4-25.

The villages further investigated to determine the potential visual amenity impacts are those villages located:

- in or on the boundary of SMM Solomon Tenement lease area
- in or near an area that may or will be impacted by Project infrastructure (i.e. mine areas, roads, ports and the accommodation camp)
- along rivers downstream from the mining activities.

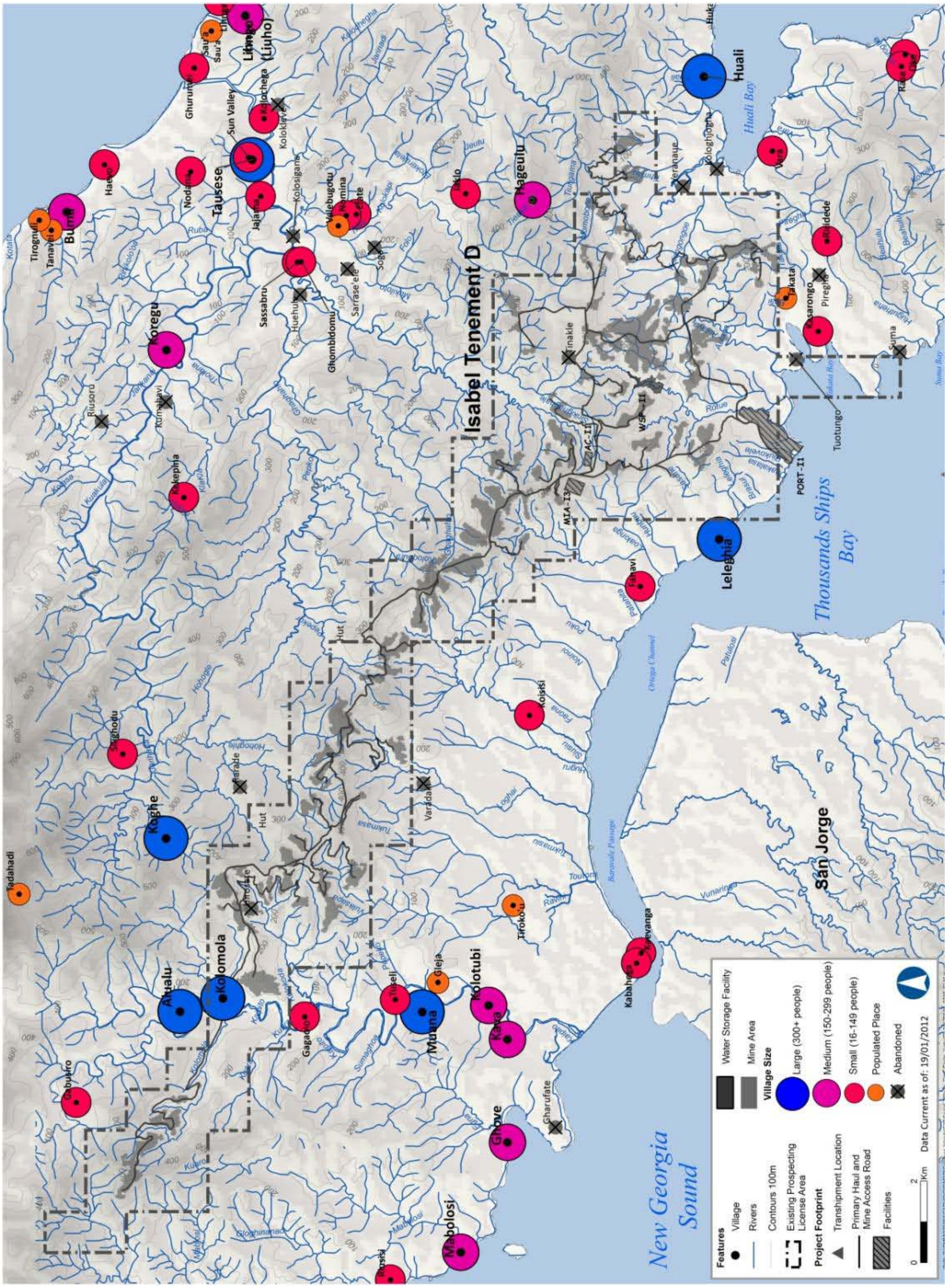

Figure 4-24 Villages in the General Area of Project Activities and Infrastructure on Isabel Tenement D

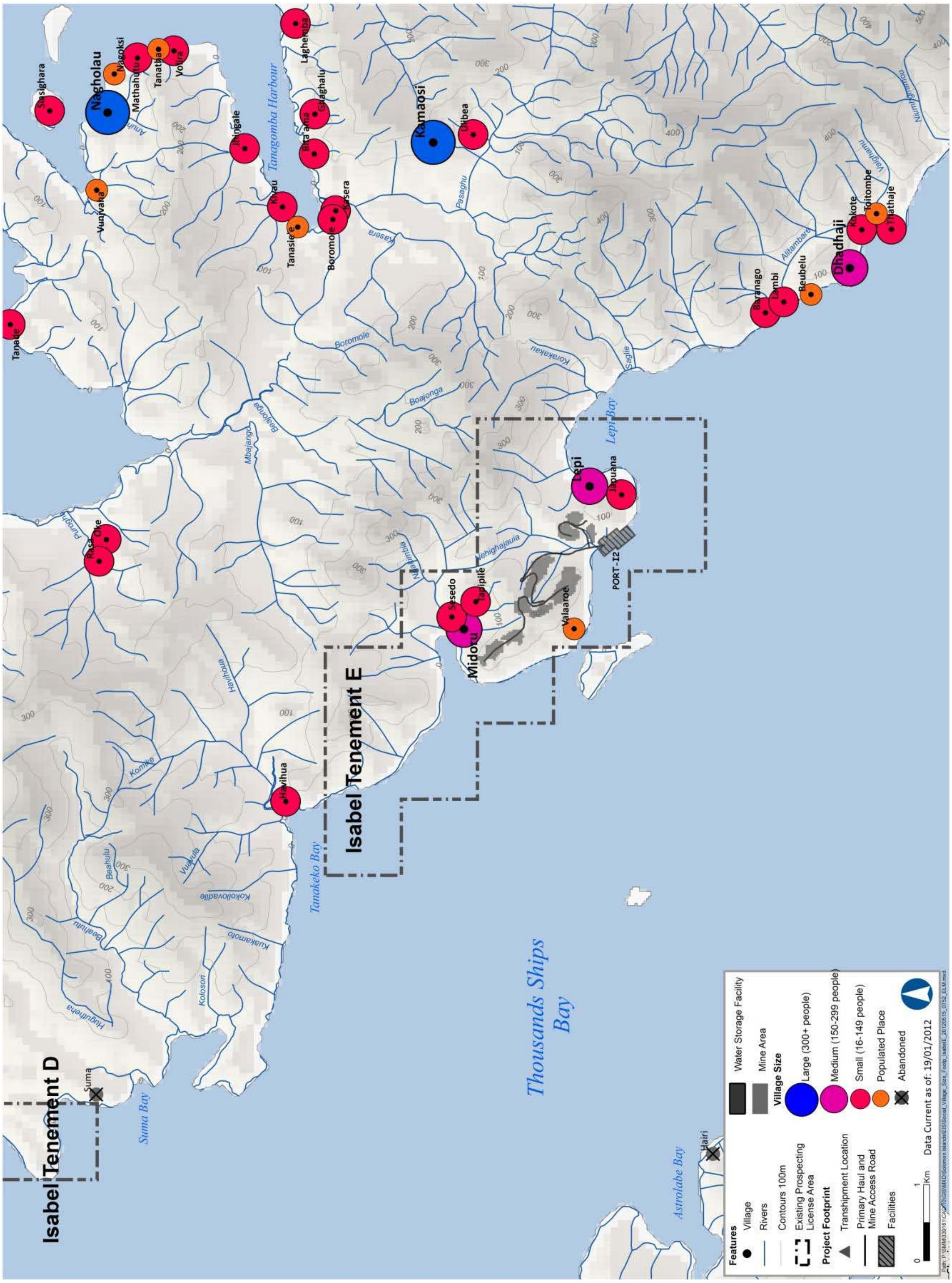

Figure 4-25 Villages in the General Area of Project Activities and Infrastructure on Isabel Tenement E

4.12.3 Potential Impacts

4.12.3.1 Key Project Components Affecting Visual Amenity

The key Project components that may have an impact on visual amenity include:

- mine areas
- MIA including administration buildings, industrial buildings, workshops and vehicle maintenance facilities, parking and helipad
- mine roads and primary haul roads
- accommodation camp
- quarries and borrow pits (if required)
- landfill site and waste management site
- water storage facility and pipelines
- ports (including barges/ships).

Figure 4-26 provides a visual representation of the likely Project footprint in the vicinity of the Port-I1 location.

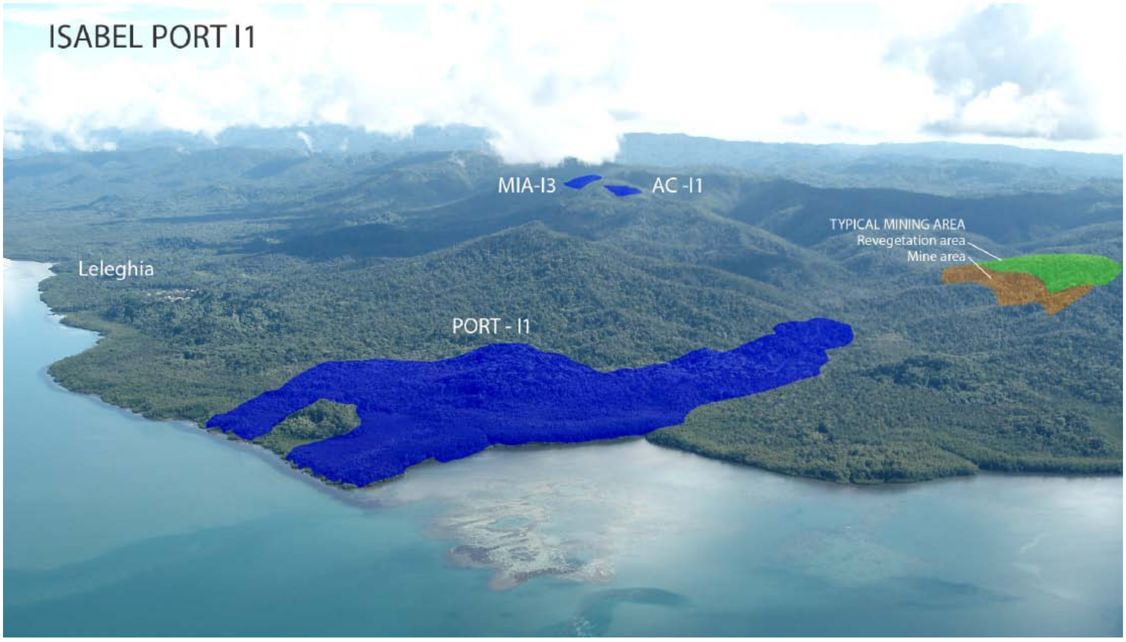

Figure 4-26 Visual Representation of an Aerial View of the Project Footprint from Takata Bay

Additional figures showing the likely key Project footprint from a selection of locations is provided in the Impact Assessment Report – Visual Amenity.

4.12.3.2 Potentially Affected Locations

The mine areas and much of the proposed haul, facility access and service road length will be constructed in rainforest. The ports and associated infrastructure will mainly be located within coastal forest, with some of this area being already disturbed land.

The majority of the communities investigated, including those located near the port sites, are located on or near the coastline and are typically surrounded by tall vegetation, garden areas and/or hills.

Project infrastructure and mine areas will therefore be generally less visible in the immediate vicinity of a village than embayments (particularly in respect of port infrastructure) or where these Project components are located in elevated areas of the landscape.

The communities most likely to experience an appreciable effect on local visual amenity are those within 2 km of Project infrastructure. Specific Project components, for example mine areas on hillsides, may be expected to be visible from some communities located more than 3 km away. However, the resulting impact on visual amenity would be significantly reduced as proximity recedes. The extent of area being mined at any one time will be limited, as mining will proceed on the basis of clearing a total of up to 60 hectares per year together with rehabilitation of mined areas being progressively undertaken.

Villages located in the general vicinity of major port infrastructure, and therefore may potentially be impacted with respect to visual amenity, are for:

- Tenement D (Port-I1): Leleghia (a large village of at least 300 people) and the very small settlements of Kasarongo and Takata
- Tenement E (Port-I2): Lepi (a medium sized village of between 150 and 299 people) and Japuana and Valaaroe (small settlements of between 16 and 149 people).

The visual impact of port sites relates not only to the major infrastructure to be established, but also to the movement of barges and ships during loading and materials supply. Light spill during night operations is also a consideration as it may impact the visual amenity of some sensitive receptors.

Other villages within 3 km of Project components that may be impacted visually by active mine areas, Project infrastructure and roads are for:

- Tenement D: Muana, Kolomola, Alualu, Koghe, Hageulu, Huali and Koisisi (all large villages of at least 300 people) and the small settlements of Vara, Kolghjogha, Veranaue, Riridede, Fanavi (Loalonga), Tupasaki/Tesuli, Gagaolo and Gabusiro
- Tenement E: Midoru (a medium sized village of between 150 and 299 people) and Havihua, Sesedo and Tapipile (small settlements of between 16 and 149 people).

The visual impact of mine areas, Project infrastructure and roads on these villages will vary substantially according to their distance from these components, the local topography and the extent of vegetation screening.

Significant viewpoints to consider in relation to these villages include those from the village area and from offshore locations during boat trips. Figure 4-27 and Figure 4-28 provide a visual representation of the likely Project footprint that may result from the development of the Project.

Note that Figure 4-27 and Figure 4-28 are aalso only illustrative representations and may not be indicative of the final view from that location.

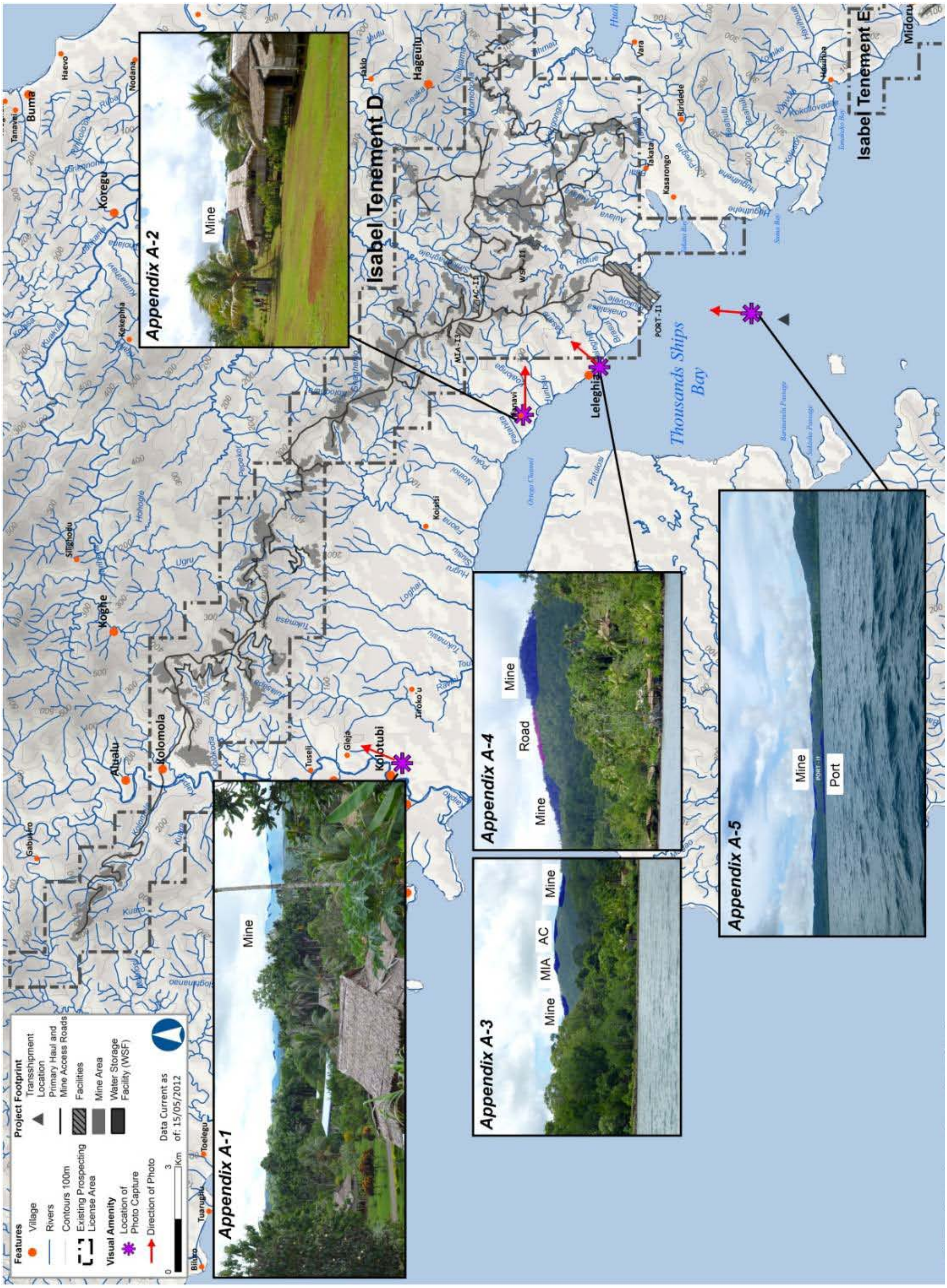

Figure 4-27 Illustrative Representation of the Potential Project Areas Visible for Tenement D from Selected Locations

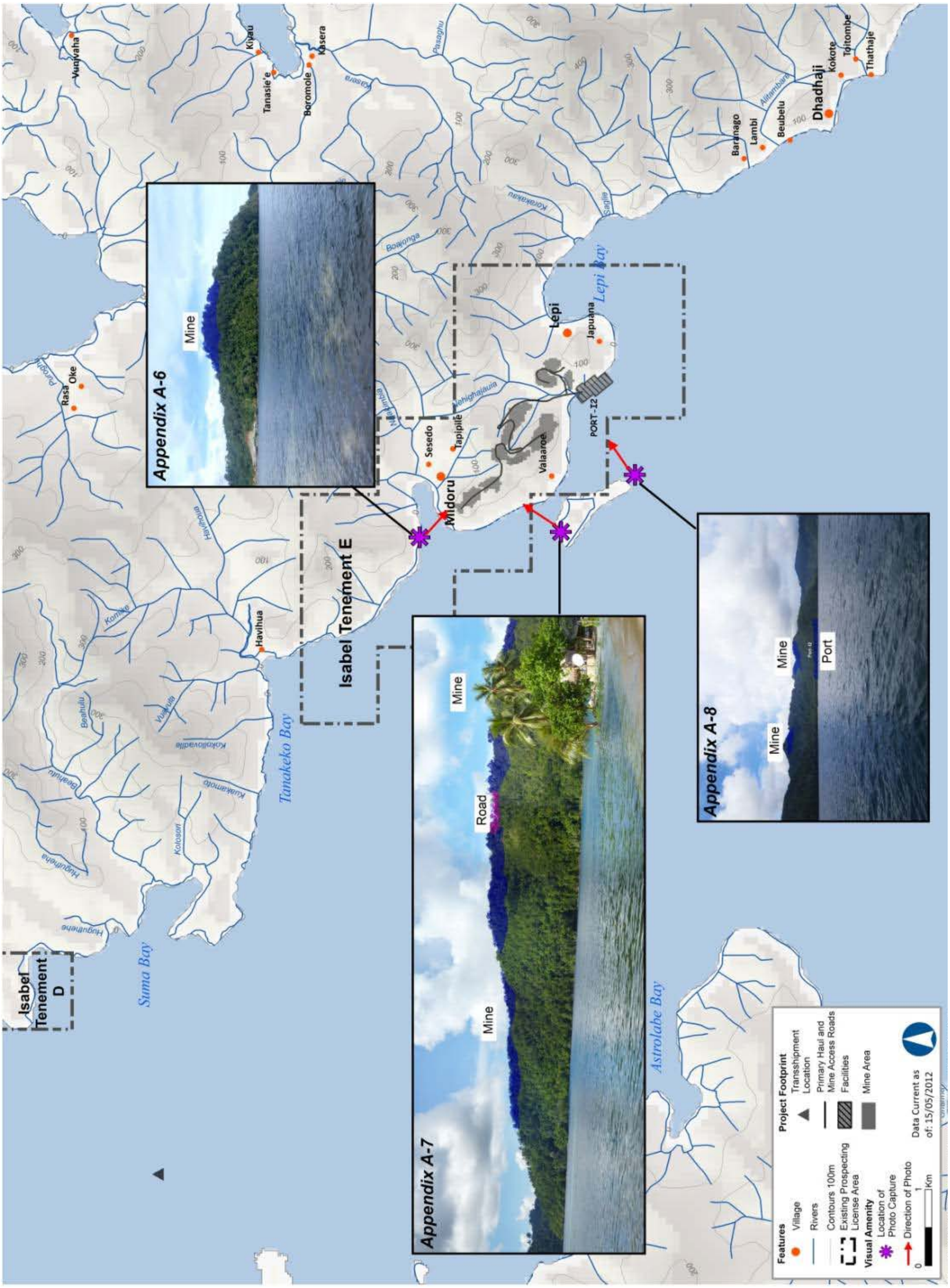

Figure 4-28 Illustrative Representation of the Potential Project Areas Visible for Tenement E from Selected Locations

4.12.4 *Impact Assessment*

An assessment of potential visual amenity impacts to local villages is presented in Table 4-42. The locations have been identified as being within 3 km of the proposed Project infrastructure and therefore having potential for impact on visual amenity.

Table 4-42 Assessed Visual Amenity Impact

Viewpoint Location (Tenement)	Project Component	Assessment Criteria			Assessed Impact
		Landscape Absorption Capacity	Horizontal & Vertical Visual Effects	Distance from Components	
Fanavi (D)	Mine Area MIA-I3 Roads	>50%	Moderate	>2 km	Low
Takata (D)	Mine Area Port-I1 Roads	>50%	Moderate	<1 km	Moderate
Kasarongo (D)	Port-I1 Roads	>50%	Moderate	>2 km	Low
Leleghia (D)	Mine Area Port-I1 Roads	>50%	Major	>1 km	Moderate
Takata Bay (D)	Mine Area Port- I1	Nil	Major	<1 km	Very High
Muana/ Tuseli (D)	Mine Area Roads	>50%	Minor	>2 km	Low
Gagaolo (D)	Mine Area Roads	<50%	Minor	<1 km	Moderate
Kolomola (D)	Mine Area Roads	>25%	Moderate	<1 km	High
Alualu (D)	Mine Area Roads	>50%	Minor	<2 km	Low
Gabusiro (D)	Mine Area Roads	>90%	Minor	<2 km	Low
Koghe (D)	Mine Area Roads	>50%	Minor	<2 km	Low
Hageulu (D)	Mine Area Roads	>50%	Minor	<2 km	Low
Huali (D)	Mine Area Roads	>90%	Moderate	>2 km	Low
Kolghjogha/ Veranaue/ Vara(D)	Mine Area Roads	>50%	Minor	>2 km	Low
Ririrede (D)	Mine Area Roads	>90%	Minor	<2 km	Low
Koisisi (D)	Mine Area Roads	>50%	Moderate	>2 km	Very Low
Midoru/ Sesedo/ Tapipile (E)	Mine Area Roads	>50%	Moderate	<2 km	Low
Lepi/ Japuana (E)	Mine Area Roads	>50%	Moderate	<2 km	Low
Havihua (E)	Mine Area Roads	>50%	Moderate	<2 km	Low
Lepi Bay (E)	Mine Area Port-I2	Nil	Major	<1 km	Very High

Mapping was undertaken, displaying Project areas which are potentially visible from selected locations including villages and bays (refer to Impact Assessment Report – Visual Amenity.)

The visual amenity impact in most village locations is likely to be low to moderate. An exception is Kolomola, which although being situated in a river valley, is located close to an ore deposit that will be subject to mining. Views from Takata Bay and Lepi Bay will also be dominated by port infrastructure (Port-I1 and Port-I2, respectively) and the visual amenity impact on local people fishing or transiting the area by boat will be very high but limited to the period of transit.

Light spill impacts are likely to be caused by night lighting used by road and marine vehicles, ports, accommodation camp, mine areas and other associated infrastructure. The more Project activities conducted at night the greater the extent of the impact associated with light spill.

Light spill has the potential to cause both beneficial and adverse impacts on local communities. Bright light spill at night could have a negative impact on the quality of sleep of local people and could make fishing and hunting more difficult. Alternatively, light spill could potentially assist local people to travel more easily at night and could provide additional visual assistance for people engaged in activities such as hunting and fishing.

While there is a potential for visual impact from dust generated by operation of mining areas, roads and port ore loading facilities, the impacts are likely to be minimal due to active dust management measures, including watering of operational areas, stockpiled ore and Project roads as required.

4.12.5 Mitigation Measures

Strategies to mitigate or manage impacts on visual amenity and protect landscape values include:

- Minimising clearing required for infrastructure construction and operation to only the extent required to establish these facilities.
- Retaining vegetation close to infrastructure boundaries to provide visual screening.
- Rehabilitation of areas cleared or otherwise disturbed for construction purposes (i.e. those areas not required to be permanently cleared).
- Progressive rehabilitation of mining areas as mine operations proceed, to minimise the exposed area visible at any one time.
- Minimising the footprint of Project infrastructure wherever feasible.
- Selecting colours for buildings and major structures that blend with the background landscape.
- Using low glare and/or directional lighting, light barriers and diffusers to mitigate light impact.
- Landscaping major infrastructure areas including the accommodation camp and MIA.

4.13 Waste Management

This section describes:

- the existing environmental values relating to current waste generation and disposal activities within the Project area
- waste generation likely to occur from Project activities
- the potential direct and indirect impacts of waste generation, storage, handling and disposal during the construction and operation of the Project
- proposed mitigation measures to protect or enhance existing environmental values.

Further details are provided in the Impact Assessment Report – Waste Management.

4.13.1 Methodology

The existing environmental values were described based on information collected during site visits and literature available on waste management in the Solomon Islands. International best practice for waste management uses a hierarchy of options from most preferred to least preferred: waste prevention, waste reduction, waste re-use, waste recycling, energy recovery and waste disposal.

4.13.2 Existing Values

Solid waste is an emerging problem in the Pacific Islands, however there is a general lack of baseline data for the area. Collection systems are usually limited to urban centres and are not always consistent or reliable. Waste disposal technology in the Solomon Islands currently consists of open dumps, burning and incineration. Recycling in the Pacific Islands is difficult due to high shipping costs, small recyclable flows and difficult operating environment for machinery. Currently, there are no recycling activities within the Solomon Islands for the following waste streams: paper/cardboard, glass, plastics (including foam), lead-acid batteries, used oil, tyres and organic wastes (composting).

Reports from site visits to Honiara confirmed that burning of waste in empty oil drums occurred on a regular basis along with burning of waste in the open dump in Ranadi. It was noted on Santa Isabel Island that households generated a minimal amount of rubbish, most of which was food waste. There was no regular rubbish collection nor was there a general dumping area. Some litter was disposed of to the water and gathered at the shoreline. Other waste streams were disposed of through burning.

4.13.3 Waste Characterisation, Types and Quantities

This report characterises waste as any solid, liquid or solid hazardous material that is being discarded by disposal (e.g. landfill or dumping), recycling, burning or incineration.

Non-hazardous solid waste includes the following: food waste, inert construction/demolition materials, scrap metal, scrap steel, plastics, paper/cardboard, glass, tyres, packaging materials, sewage sludge (may or may not be hazardous depending on its characteristics), empty motor and hydraulic oil drums, grease, etc.

Hazardous waste shares one or more of the following qualities: ignitibility, corrosivity, reactivity, toxicity or other physical, chemical, or biological characteristics that may pose a potential risk to human health or the environment if improperly managed.

Hazardous waste types expected to occur during the construction and operation phase of the Project include the following: waste oil (motor, transmission and lubrication), hydraulic waste oil, engine coolant, paint, solvent, used oil filters, batteries, explosives, fire retardants and extinguishers, other impacted packaging, biomedical waste (bandages, dressings, compresses, syringes, etc.), grease trap and oil/water separation unit, laboratory waste and electronic waste.

Waste types and estimated quantities expected to be generated during the construction and operation phases of the Project are listed in Table 4-43.

It should be noted that these are estimates based on preliminary data, and that regular waste audits will be conducted throughout the construction and operation phases to inform and update the Waste Management Plan.

Table 4-43 Waste Type and Quantity Expected During Construction and Operation

Waste Type	Quantity (t/yr)		Percentage of Total Construction Waste	Percentage of Total Operation Waste
	Construction	Operation		
Solid Non-Hazardous Waste				
Food waste	452	212	31.9	23.8
Inert construction/demolition materials	351	116	24.8	13.0
Scrap metal, scrap steel	187	53	13.2	6.0
Plastics	45.2	21.2	3.2	2.4
Paper/cardboard	48	31	3.4	3.5
Glass	1.2	0.9	0.1	0.1
Tyres	98	242	6.9	27.2
Packaging materials	81	27	5.7	3.0
Treated or untreated sewage sludge	47	32	3.3	3.6
Empty drums for motor and hydraulic oil, grease, etc.	33	42	2.3	4.7
Hazardous Waste				
Waste oil (motor, transmission and lubrication)	19.5	21	1.4	2.4
Hydraulic waste oil	11	29	0.8	3.3
Engine coolant	1.1	2.1	0.1	0.2
Paint	0.16	0.02	0.01	0.002
Solvent	2	0.2	0.1	0.02
Used oil filters	6	8	0.4	0.9
Batteries	0.06	0.02	0.004	0.002
Explosives	5.1	10.2	0.4	1.1
Fire retardants & extinguishers	0.3	0.2	0.02	0.02
Other impacted packaging	2	12	0.1	1.3
Biomedical waste (bandages, dressings, compresses, syringes, etc.)	0.4	0.2	0.03	0.02
Grease trap & waste from oil/water separation unit	22	25	1.6	2.8
Laboratory waste	1	3	0.1	0.3
Electronic waste	1.2	2	0.1	0.2
Total Estimated Quantity	**1415.22**	**890.04**		

4.13.4 Potential Impacts

Construction and operation of the mine and associated infrastructure works generate wastes which have the potential to result in the following impacts:

- land and water contamination from solid non-hazardous and hazardous waste spills
- conservation of natural resources from reuse and recycling of potential waste materials
- changes in land use
- impacts to visual amenity

- impacts from noise
- decreased air quality
- impacts to public health and safety
- loss and disturbance of habitat for flora and fauna
- litter pollution (i.e. waste that has not been properly handled, stored, transported or disposed of).

These impacts are discussed in further detail in the following sections.

4.13.4.1 Land Contamination

There is potential for land contamination from solid non-hazardous and hazardous waste spills. Due to the nature of the waste, impacts associated with a hazardous waste spill are more severe than those of a non hazardous waste spill. If a spill were to occur during handling, storage, transport or disposal, soil quality would decrease and land would devalue from the contamination. Remediation of the affected areas would be costly and may represent a change in land use.

4.13.4.2 Water Contamination

Accidental spills of solid non-hazardous and especially hazardous waste have the potential to contaminate surface water, groundwater and community water, impacting the public health and safety of communities using these sources, creating a loss and disturbance to flora and fauna and the livelihood of community members. Failure of the landfill lining could lead to contamination of groundwater and subsequently, surface water and community water. A waste spill during transportation for offsite disposal would also potentially cause marine pollution.

4.13.4.3 Increased Demands for Natural Resources

The Project will create greater demands for natural resources. Reusing and recycling materials lessens the demands on energy, water and other natural resources used to create new items, in turn limiting the loss and disturbance to flora and fauna within and external to the Project area.

4.13.4.4 Change in Land Use

Developing the land to use for waste storage and landfill disposal represents a long term change in land use. A change in land use can also be the result of land contamination from a hazardous waste spill.

4.13.4.5 Impacts to Visual Amenity

Litter pollution has a limited negative visual impact. Waste storage facilities and a landfill may be unsightly. Stockpiles have a negative visual impact, however the viewshed is limited.

4.13.4.6 Impacts from Increased Noise

Noise from the general operations of waste transport equipment may be a nuisance to sensitive receptors.

4.13.4.7 Decreased Air Quality

Odour from the waste storage facilities and landfill may impact sensitive receptors. Odour from litter pollution may also be a nuisance. A failure of the containment of hazardous waste during handling, storage or transport may impact air quality and in turn public health and safety. Biogases, mainly methane, carbon dioxide and other trace gases are produced from landfills. Methane and carbon dioxide are greenhouse gases which contribute may contribute to global warming and climate change.

4.13.4.8 Impacts to Health and Safety

Hazardous waste represents a serious health and safety risk. Chemicals can be harmful if inhaled or consumed and could cause burns if spilled. Litter pollution can also be a health and safety hazard.

Discarded vessels as litter or in uncovered storage facilities may provide a breeding site for mosquitoes.

4.13.4.9 Loss and Disturbance of Flora and Fauna

Stored waste may attract pests, vermin and may be a breeding site for mosquitoes. Flora and fauna are impacted by the loss and disturbance of their natural habitats. A solid non-hazardous waste and/or a hazardous waste spill could cause loss and disturbance of habitat, poisoning and relocation of flora and fauna. Seed viability may decrease or cease. Inadequate fencing of waste storage facilities and the landfill may cause poisoning of fauna.

4.13.4.10 Litter Pollution

Waste that is not properly handled, stored, transported and disposed of in the appropriate areas has the potential to impact land, water, visual amenity, air quality, public health and safety and flora and fauna.

4.13.5 Impact Assessment

A risk assessment of potential impacts of waste on the environment is presented in Table 4-44.

Table 4-44 Assessment of Potential Impacts of Waste on the Environment

Potential Impact	Facility		Stage				Status	Extent	Intensity	Duration	Probability	Consequence no mitigation	Significance with no mitigation	Mitigation / Management Actions	Significance with mitigation	Confidence level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Land contamination	•	•	•	•	•	•	Negative	Local	High	Long Term	Probable	High	High	International best practice for waste storage, treatment and disposal to minimise risk of contamination. Hazardous waste to be stored and disposed of appropriately. Spill management kits, personal protective equipment, MSDS and relevant operator instructions/emergency procedures available. Record all incidents such as accidental spills, safety incidents, etc. Inspect waste storage facilities regularly. Personnel trained appropriately. The rehabilitation and decommissioning plan should address the landfill and waste storage facilities. Upon decommissioning, the waste facilities will be rehabilitated and subject to contaminated land assessment.	Low	Medium
Water contamination	•	•	•	•	•	•	Negative	Local to Regional	High	Long Term	Probable	High	High	See Mitigations for Land Contamination. All waste storage areas to have rainfall runoff collection drains, containment berms and appropriate treatment before disposal. No uncontrolled discharges from the landfill or waste storage facilities. A groundwater quality monitoring programme shall be implemented. Prevent spills from entering the general stormwater management system. Waste oils to be skimmed routinely. Oil/water separators should be used and routinely cleaned.	Low	Medium

Table 4-44 Assessment of Potential Impacts of Waste on the Environment

Potential Impact	Facility		Stage				Status	Extent	Intensity	Duration	Probability	Consequence no mitigation	Significance with no mitigation	Mitigation / Management Actions	Significance with mitigation	Confidence level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
														Record all incidents. Proper reporting protocols should be implemented.		
Conservation of natural resources	•	•	•	•	•	•	Negative	Local	Low	Long Term	Probable	Medium	Low	Encourage waste segregation, reuse and recycling to help conserve resources. Record waste quantities to identify better waste minimisation strategies and perform regular and timely waste audits. Implement staff training programme. Appropriate signage for waste segregation. Investigate local and export markets for recyclables and implement where feasible. Enforcement of waste separation by a waste manager.	Low	Medium
Change in land use (landfill)				•	•	•	Negative	Local	High	Long Term	Definite	High	High	Consult with stakeholders about location of landfill and use of landfill area after decommissioning. Upon decommissioning, the waste storage facilities will be rehabilitated and subject to a contaminated land assessment over the lifetime of the landfill. Implement leachate and groundwater monitoring programme.	Medi um	Medium
Impact from landfill and waste storage facilities on visual amenity				•	•	•	Negative	Local	Medium	Long Term	Highly Probable	Medium	Medium	Store waste in appropriate receptacles and in designated waste storage areas. Cover landfill daily. Selective landscaping to improve visual amenity surrounding the landfill. Ensure waste storage facilities and landfill are fenced off and secured from the general public.	Low	Medium
Impacts from noise of general operations of	•	•	•	•	•	•	Negative	Local to Regional	Low	Long Term	Highly Probable	Medium	Medium	Consult with any nearby receptors about the potential for noise nuisance.	Low	Medium

Table 4-44 Assessment of Potential Impacts of Waste on the Environment

Potential Impact	Facility		Stage				Status	Extent	Intensity	Duration	Probability	Consequence no mitigation	Significance with no mitigation	Mitigation / Management Actions	Significance with mitigation	Confidence level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
waste collection equipment														Purchase waste transport equipment to have the lowest practical sound power levels. Maintain equipment regularly. Some equipment and vehicles to be fitted with noise control devices. Waste collection, transport and landfill operations shall occur during daylight hours.		
Decreased air quality				•	•	•	Negative	Local to Regional	Medium	Long Term	Probable	Medium to High	Medium to High	Provide sufficient ventilation to allow dispersion of odour and air emissions in waste receptacles and other applicable areas. Compact and cover waste promptly after discharge to landfill. Minimise open tipping face area. Restrict tipping activities during periods of adverse weather. Seal sump covers. Aerate landfill leachate storage areas. Record all incidents. Inspect waste storage facilities regularly. Food waste to be stored appropriately. Install gas collection and monitoring system of landfill.	Low	Medium
Health and safety	•	•	•	•	•	•	Negative	Local	High	Long Term	Probable	High	High	Food waste to be stored in covered waste receptacles. Ensure waste storage facilities and the landfill is fenced off and secured. Personnel to be trained in waste management procedures. Provide sufficient ventilation in waste receptacles	Low	Medium

Table 4-44 Assessment of Potential Impacts of Waste on the Environment

Potential Impact	Facility		Stage				Status	Extent	Intensity	Duration	Probability	Consequence no mitigation	Significance with no mitigation	Mitigation / Management Actions	Significance with mitigation	Confidence level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
														and other applicable areas. Provide personal protective equipment, operator instructions, emergency procedures and MSDS. Ensure no ignition sources are within the vicinity of any hazardous material areas. Record all incidents. Inspect waste storage facilities regularly. All hazardous materials received/stored and transported offsite to be recorded. Provide an emergency response unit.		
Loss and disturbance of habitat to flora and fauna				•	•	•	Negative	Local	High	Long Term	Definite	High	High	Avoid disturbance to vegetation with significant ecological value or minimise impacts where possible in siting the facilities. Fence off and secure applicable areas to limit access by fauna. Follow recommendations regarding the handling, storage, transport and disposal of hazardous materials.	Low	Medium
Litter pollution	•	•	•	•	•	•	Negative	Local	Medium	Long Term	Definite	Medium	Medium	Ongoing education regarding waste management procedures regarding littering to be provided to staff. Regular litter collection. Timely collection of waste from various generation points. Ensure transport of all wastes is carried out in a manner such that dust and litter pollution does not result. Food waste to be stored in covered waste receptacles to prevent odours.	Low	Medium

4.13.6 *Mitigation Measures*

The development and implementation of a Waste Management Plan and rigorous site management in accordance with ICMM international best practice and IFC standards offers significant opportunities to minimise impacts from waste. Further details of mitigation measures are provided in Chapter 5 and the Impact Assessment Report - Waste Management.

Negative impacts to environmental and social values will be mitigated in accordance with the following hierarchy:

- Waste prevention and reduction – Careful project planning and waste avoidance in the purchasing policy ensures materials brought on-site are minimised. Extra materials can be returned to the supplier or utilised by other local users.
- Waste re-use – Solvents, metals and oils from catalysts can be recovered and reused for a secondary purpose. Vegetation waste and overburden can be reused for rehabilitation. Consultation with the community regarding the reuse and recycling of waste streams would identify possible local markets for solid non-hazardous waste.
- Waste recycling – Recyclable materials can be purchased in preference to non-recyclable materials, and recovered where feasible.
- Energy recovery – Few opportunities exist to recover energy from Project waste. Methane gas produced from landfill may be collected and converted into a fuel source if gas production is sufficient to warrant installation of collection devices.
- Disposal – Waste materials that remain after the implementation of feasible waste prevention, reduction, reuse, recycling and energy recovery methods will be treated and disposed of within a sanitary landfill as per IFC guidelines. Incineration of medical waste from the Project will occur at the medical incinerator located in Honiara.

Mitigation measures for each of the identified impacts are detailed in the sections following.

4.13.6.1 *Land Contamination*

The risk of land contamination from solid non-hazardous waste and hazardous waste spills will be reduced by implementing the following mitigation strategies:

- Waste transfer stations will consist of concrete half-walls and concrete floors to minimise risk of contamination.
- Oil filters will be stored in marked containers that allows the oil to drain out but not escape from storage.
- Hazardous waste will be temporarily stored in a secure, signed and impervious location.
- Hazardous waste will be removed and transported by appropriately trained staff members and appropriately licensed facility offsite on a regularly scheduled basis.
- No waste will be buried or disposed to land onsite outside of approved waste disposal facilities.
- Unknown substances will be identified before disposal.
- Storage tanks and drum storages will be bunded in accordance with applicable standards.
- Storage areas will be appropriately located and signed in accordance with applicable standards.
- Design of bulk storage containment will be resistant to all sources of corrosion (particularly product spills).
- Design of storage will be suitable for conditions of use.

- Transfer of hazardous liquids will be undertaken in accordance with the applicable standards and in an area that is bunded and impervious.
- Spill management kits, personal protective equipment and relevant operator instructions/emergency procedures will be made available at all fuel transfer points and hazardous chemical storage facilities along with proper reporting protocols.
- Material Safety and Data Sheets (MSDS) will be kept onsite with multiple translations provided for the multicultural workforce members.
- All incidents such as accidental spills and safety incidents will be recorded.
- Waste storage facilities will be inspected regularly.
- Personnel using hazardous goods will be trained in accordance with the applicable standards.
- Waste tracking will be undertaken and a nominated waste manager will be responsible.
- The rehabilitation and decommissioning plan will address the landfill and waste storage facilities.
- Upon decommissioning, the waste facilities will be rehabilitated and subject to contaminated land assessment.

4.13.6.2 Water Contamination

In addition to those mitigation measures described in Section 4.13.6.1, the following mitigation strategies will be employed to reduce the risk of impact of water contamination from solid non-hazardous waste and hazardous waste spills:

- All waste storage areas will have rainfall runoff collection drains, containment berms and appropriate treatment before disposal.
- Uncontrolled discharges from the landfill or waste storage facilities will be avoided.
- Waste spills will be prevented from entering the general stormwater management system.
- Waste oils will be skimmed routinely from temporary oily wastewater ponds and stored in onsite waste oil tanks for offsite disposal.
- Waste storage facilities will be inspected regularly.
- Spill management kits, personal protective equipment and relevant operator instructions/emergency procedures will be made available at all fuel transfer points and hazardous chemical storage facilities along with proper reporting protocols.

4.13.6.3 Natural Resources

Reusing and recycling materials leads to a decreased demand on energy, water and natural resources. The following mitigation strategies will be implemented to increase reuse and recycling:

- Encourage waste segregation, water reuse and recycling to help conserve resources.
- Record waste quantities to identify better waste minimisation strategies and perform regular and timely waste audits.
- Implement staff training programme for waste management.
- Appropriate signage to be posted regarding waste segregation to allow better storage and sorting of recyclables.
- Investigate local and export markets for recyclables and implement where feasible.

- Enforcement of waste separation by a waste manager.

4.13.6.4 *Land Use*

The development of land for use as waste storage facilities and a landfill can be mitigated by the following measures:

- Consult with stakeholders about location of landfill.
- Consult with stakeholders about use of landfill area after decommissioning.
- Upon decommissioning, the waste storage facilities will be rehabilitated and subject to a contaminated land assessment over the lifetime of the landfill.
- Regular leachate and groundwater monitoring for areas potentially impacted by the landfill shall occur.
- Ensure waste storage facilities and landfill are fenced off from the general public.

4.13.6.5 *Visual Amenity*

Waste storage facilities and the landfill may be unsightly and negatively impact visual amenity. The following mitigation measures are recommended:

- Store waste in appropriate receptacles and in designated waste storage areas.
- Cover landfill daily.
- Selective landscaping to improve visual amenity surrounding the landfill.
- Ensure waste storage facilities and landfill are fenced off and secured from the general public.

4.13.6.6 *Noise*

Noise from the general operations of waste transport equipment will be mitigated by the following strategies:

- Consult with any nearby receptors about the potential for noise nuisance.
- Purchase waste transport equipment with the lowest sound power levels as reasonably practical.
- Maintain equipment regularly to minimise noise.
- Where necessary, equipment/vehicles to be fitted with noise control devices.
- Noise limits to be observed and measured outdoors at sensitive receptors.
- Waste collection, transport and landfill operations shall occur during daylight hours.

4.13.6.7 *Air Quality*

Odour and dust from waste storage receptacles, facilities and the landfill can be mitigated by the following measures:

- Compact and cover waste promptly after discharge from the vehicle delivering the waste.
- Minimise open tipping face area.
- Restrict tipping activities during periods of adverse weather.
- Seal sump covers.
- Aerate landfill leachate storage areas.
- Select location of waste transfer facilities and the landfill with consideration for the proximity to sensitive receptors and transport routes.

- Record all incidents.
- Inspect waste storage facilities regularly.
- Food waste to be stored in covered waste receptacles to prevent odours.
- Ensure transport of all wastes is carried out in a manner such that dust and litter pollution does not result (e.g. covered loads) and is undertaken by trained staff.
- Install gas collection and monitoring system of landfill.
- Provide sufficient ventilation to allow dispersion of odour and air emissions.
- Segregate corrosive substances from incompatible materials that may react dangerously.
- Follow requirements regarding the handling, storage, transport and disposal of hazardous materials.

4.13.6.8 Health and Safety

The following mitigation strategies can be implemented to reduce the impact of waste on health and safety:

- Food waste to be stored in covered waste receptacles to prevent health and safety concerns.
- Ensure waste storage facilities and the landfill is fenced off and secured to prevent access by the general public.
- Personnel to be trained in waste management procedures.
- Include a training section on waste management in the general induction process.
- Provide general ongoing education regarding proper segregation of waste.
- Provide sufficient ventilation in waste receptacles and other applicable areas to allow dispersion of odours and air emissions.
- Provide personal protective equipment (PPE) and relevant operator instructions and emergency procedures at all hazardous materials locations.
- Ensure no ignition sources are within the vicinity of any hazardous material areas.
- Record all incidents.
- Inspect waste storage facilities regularly.
- All hazardous materials received/stored and transported offsite to be recorded.
- Provide an emergency response unit.
- Material Safety Data Sheets to be kept onsite with multiple translations provided for the multicultural workforce members.
- Follow requirements regarding the handling, storage, transport and disposal of hazardous materials.

4.13.6.9 Flora and Fauna

The following mitigation measures can reduce the impact on flora and fauna:

- Avoid disturbance to vegetation with significant ecological value or minimise impacts where possible in siting the facilities.

- Fence off and secure applicable areas (i.e. landfill, waste storage facilities) to limit access by fauna.
- Follow recommendations regarding the handling, storage, transport and disposal of hazardous materials.

4.13.6.10 Litter Pollution

The following mitigation measures can decrease litter pollution:

- Ongoing education regarding waste management procedures and rules regarding littering to be provided to staff.
- Regular litter collection.
- Timely collection of waste from various generation points.
- Ensure transport of all wastes is carried out in a manner such that dust and litter pollution does not result (e.g. covered loads) and is undertaken by trained staff.
- Food waste to be stored in covered waste receptacles to prevent odours.

4.14 Transport

This section describes:

- the existing land, sea and air transport networks and linkages, within the Project area and surrounding areas
- the potential direct and indirect impacts of the proposed changes to transport infrastructure and traffic during the construction and operation of the Project
- proposed mitigation measures for minimising impacts to the community and environment.

Further details are provided in the Impact Assessment Report – Transport.

4.14.1 Methodology

The existing transportation functions for the region were described based on a review of available and relevant plans, literature and local knowledge of the Project area.

4.14.2 Existing Values

4.14.2.1 Land Transport

Santa Isabel Island has a network of nearly 40 km of public road. However, less than 24 km of this network is maintainable as engineered road and the balance is in poor condition. The road network is confined to the southeast part of Santa Isabel Island. The existing road network comprises: connecting roads in the vicinity of Buala (the administrative centre of Isabel Province), (total of 16 km in poor condition), Kaevanga Road (13 km, in maintainable condition), Koghe to Vavarenitu Road (5.5 km, in maintainable condition) and Jarihana Road (5 km, in maintainable condition).

Logging tracks are relatively widespread across Santa Isabel Island, but these are generally not well constructed and are therefore subject to erosion and deterioration over time.

4.14.2.2 Sea Transport

The Solomon Islands National Transport Plan 2010 states that a program of wharf construction and navigation aid provision in the Solomon Islands in recent years has significantly increased the number of new wharves and rehabilitated existing wharves. The program is still currently being implemented. Table 4-45 lists the wharves on Santa Isabel Island and their current condition.

Table 4-45 Wharves on Santa Isabel Island

Name	Condition
Ghojoruru Wharf	Repair needed
Kaevanga Wharf	Repair needed
Tatamba Wharf	Needs replacement
Kia Wharf	Repair needed
Buala Wharf	Repair needed
Susubona	Needs replacement
Samasodu	New wharf
Sigana	New wharf
Alladyce	Maintainable

The general condition of the domestic shipping fleet is poor and many ships are old. Existing ship repair facilities are run down and lack capacity.

4.14.2.3 *Air Transport*

Solomon Airlines is the sole operator of scheduled air services in the Solomon Islands and services a domestic network of 24 destinations from Honiara, including Fera (Buala) and Suavanao on Santa Isabel Island. There are also scheduled international flights to Brisbane, Port Vila and Nadi. Increasing competition from fast ferry services is encouraging the airline to operate on a more commercial basis, including revision of fare and schedule policies.

4.14.3 Project Transport

The Project's primary transportation functions are:

- ore transport and handling, including haulage from mine to port and barge transfer from port to ship
- haul, infrastructure facility access and service roads for the transport of people, goods and materials for Project construction, operation and maintenance activities
- staff transport to and from Santa Isabel Island from Honiara.

4.14.3.1 *Project Roads and Drainage*

The proposed Project transportation infrastructure will comprise of an ore haulage, facility access and service road network and port facilities at two locations. Temporary mine access and bench access roads will also be constructed for mobile equipment and haul trucks to access the active working areas. Quarries and borrow areas used in Project construction will also require access roads of a similar standard. The primary haul/access road networks proposed to be constructed for Isabel Tenement D and Isabel Tenement E are shown in Figure 4-29 and Figure 4-30 respectively (minor service roads are not shown).

The roads will be constructed of crushed rock and comprehensive erosion and sediment control structures. Sediment control will focus on preventing erosion "at source" with the use of techniques such as erosion control matting, tackifiers, hydromulching and revegetation. All roads will include table and diversion drains to control and direct surface water runoff to suitable waterways and/or culverts placed under the road. Generally, all Project roads will comply with the Austroads suite of guides for Rural Road design and/or the Queensland Transport and Main Roads Design Manuals.

A summary of the road types proposed for the Project is provided in Table 4-46. All roads are proposed to be unsealed.

Table 4-46 Road Category

Category	Purpose	Road Width (excl. berms, drainage)	Maximum Road Gradient
Haul Road	Transporting ore from mined areas to ports for export	14.5 m – for primary haul roads 8 m – for mine access roads 6 m – for bench access roads	Generally 10% max
Facilities Access Road	Connecting MIA, port and Camp	10 m - for buses, maintenance and supply vehicles	Generally 10% max
Service Road	Occasional/infrequent maintenance of remote infrastructure	8 m - for light maintenance vehicles	Generally 12% max

4.14.3.2 *Ore Transport and Handling*

Ore at each mine area will be transported by a short haul fleet consisting of 85 t excavators, 35 t all terrain dump trucks (ATDs) and dozers to temporary stockpiles located within 1 km of the mine area. The Run-of-Mine (ROM) limonite and saprolite ores will be delivered separately using a network of haul roads, to the port areas for stockpiling by a long haul fleet consisting of conventional 20 t dump trucks top loaded by 85 t excavators.

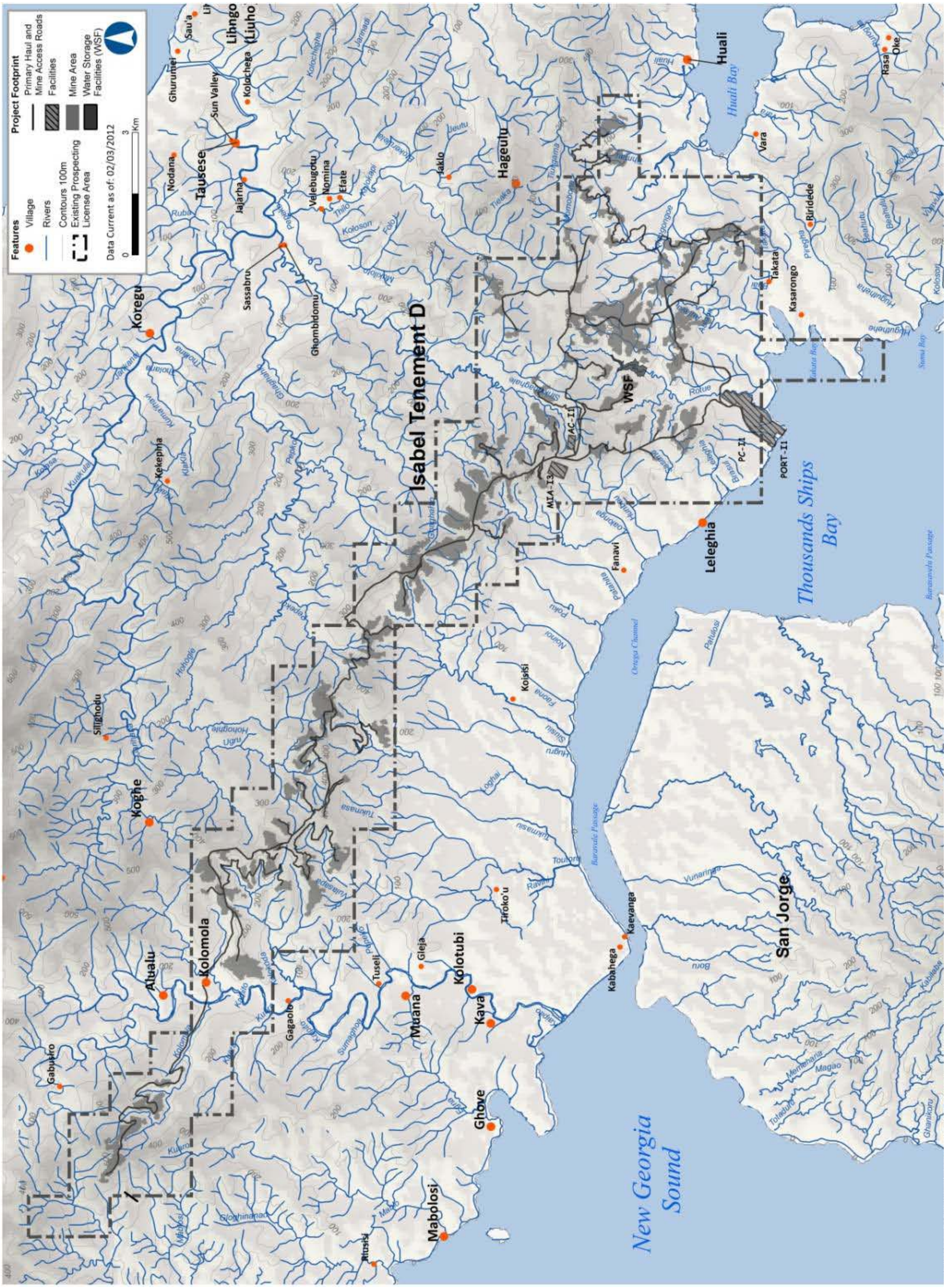

Figure 4-29 Project Road Network – Santa Isabel Tenement D

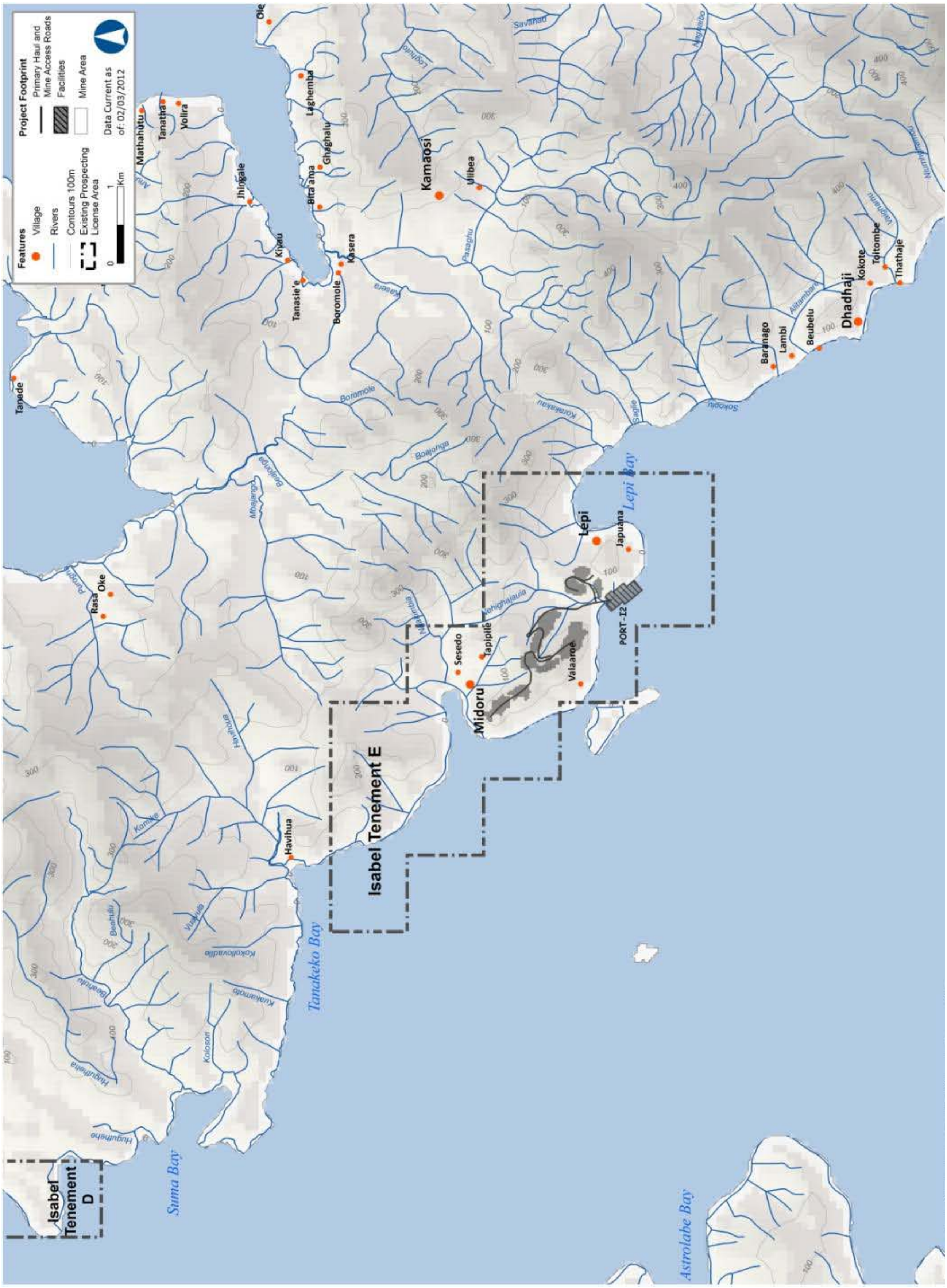

Figure 4-30 Project Road Network – Santa Isabel Tenement E

The limonite and saprolite ore will be then be loaded onto barges by haul trucks, which will drive directly onto the LCT decks to dump the ore. The barges transport the ore to the ocean going vessels (OGVs) moored at the transhipment locations for overseas export (EIS battery limits).

Two port sites (Port-I1 and Port-I2) will be developed on Santa Isabel Island. Port-I1 which will function as the main port for the island and will be located on the northern side of Takata Bay. Port-I2 will be utilised as a satellite port and will be located west of Lepi Bay. These ports will accommodate ore handling and export infrastructure as well as handling and storage facilities for general cargo.

An overview of facility and ore movement flow is shown in Figure 4-31.

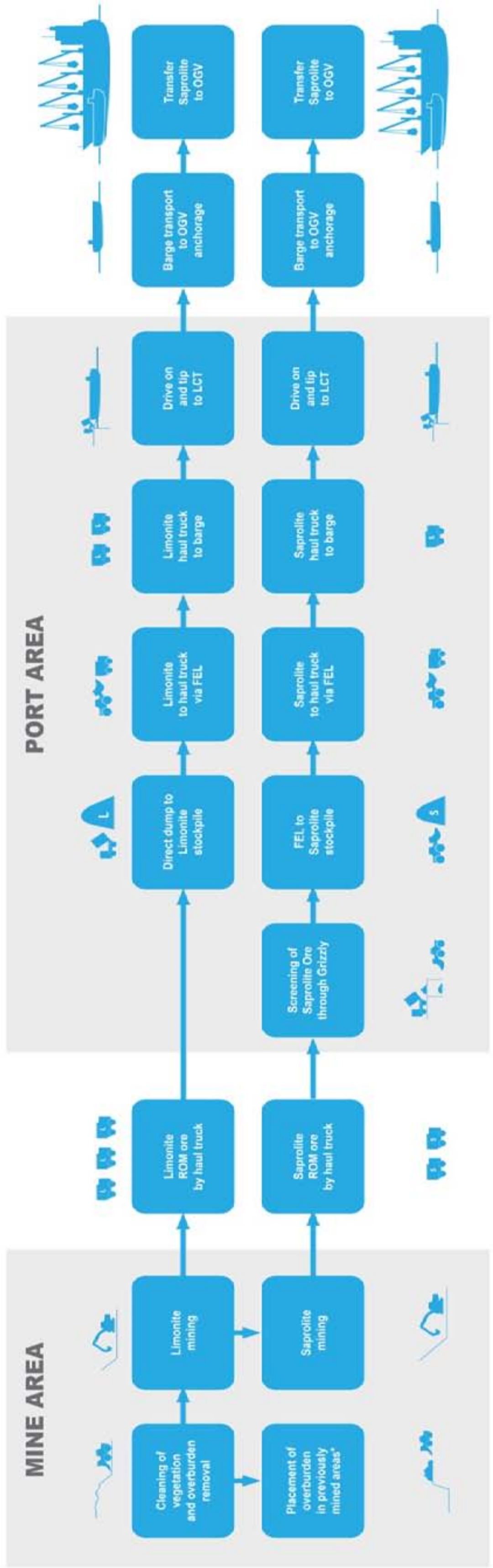

Figure 4-31 Overview of Ore Movement Flow

4.14.3.3 Staff Transportation

Staff transportation to and from the Project area will utilise public airline and air charter services, together with dedicated fast ferry services on long term charter operating from the international airport and the port of Honiara respectively, and buses for ground transit.

The estimated number of onsite personnel will increase from low numbers early in the construction phase of up to 500. The stable operating workforce level of up to 600 personnel will be achieved in the first year of full operation.

4.14.4 Potential Impacts

4.14.4.1 Erosion

The high annual rainfall and typically steep slopes on much of Santa Isabel Island represents a significant risk of erosion and sediment movement from any area cleared of vegetation, unless suitable drainage and surface protection is provided.

Sediment transport and deposition would adversely impact coastal marine ecosystems including coral reef formations. An increase in water turbidity and smothering of coral and other marine organisms would be the primary impacts.

4.14.4.2 Dust Generation

Dust is unlikely to represent a significant impact due to the high rainfall consistently experienced in the Project area which will generally maintain moisture levels in the road sheeting. However, ore haulage roads in particular will tend to dry out during even brief periods of no rainfall through the movement of haul trucks and other heavy vehicles and equipment.

This is unlikely to directly affect local village populations which are generally located some distance from the Project roads. Nevertheless, excessive dust levels would have an impact on visual amenity. Traffic safety is also a consideration if dust levels impact the vehicle driver's visibility.

Dust can also have the following impacts on flora:

- accumulation on leaf surfaces, inhibiting photosynthesis, respiration and transpiration processes
- physical effects on plants such as blockage and damage to stomata, shading, abrasion of leaf surface or cuticle, which may lead to cumulative effects and decreased plant health
- greater susceptibility of plants to pathogens and other disturbance
- decreased productivity and changes in community structure.

Refer to the Impact Assessment Report – Terrestrial Ecology for further information on the potential impacts of dust to terrestrial ecology.

4.14.4.3 Noise

The Project has the potential to generate significant noise during both construction and operation phases. In respect of transportation activities, this includes noise generated by vehicular traffic, particularly ore haulage trucks and daily port operations. Noise can impact the Project workforce and local communities, particularly during night operations.

Noise also has potential to affect a wide range of fauna species and habitat value. Some animals are likely to move in response to noise, while others may suffer stress or adverse behavioural alterations.

4.14.4.4 Air Emissions

The operation of light and heavy vehicles, machinery and mobile equipment will generate exhaust emissions, typically from the combustion of diesel fuel.

4.14.4.5 Spills

There will be a substantial quantity of fuels and oils, as well as various chemical substances, which will be transported by sea to the Project ports and hence to the MIAs and mining areas during both construction and operation phases. There is accordingly a risk of cargo spills that, if not adequately dealt with, would be detrimental to local ecosystems and possibly to local communities.

This is particularly the case for spills of oil and hazardous or toxic materials. Both diesel and petrol are toxic to freshwater and marine biota at relatively low concentrations. The extent of impact is typically determined by the duration of exposure, with chronic (long-term) contamination during operation likely to pose a greater risk than acute (short-term) contamination during construction.

Spills of nickel ore has the potential to impact marine water quality and biota through long-term leaching of nickel and chromium. Spills of ore may also smother benthic communities such as coral reefs, invertebrates and seagrasses.

There is also a risk of spills from the road transport of dangerous and hazardous goods.

4.14.4.6 Traffic Conflicts

4.14.4.6.1 Roads

Conflicts between Project vehicles and third party vehicles are unlikely to occur during the Project life, as the Project road network is private and not for public vehicle use, and also as there are few third party vehicles present in the general Project area. An exception may be if vehicles associated with logging activities utilise the Project roads without authorisation from SMM Solomon.

A more significant impact may be conflict between Project vehicles and local pedestrians. While use of the Project roads by local people will not be encouraged due to safety concerns, it is likely that the roads will be used for access to forest and garden areas and to other communities.

Project roads outside the main infrastructure areas will not be lit at night; however, it is unlikely that people will be walking along these roads after dark.

4.14.4.6.2 Shipping

Marine access to SMM Solomon facilities at Santa Isabel Island, including SMM Solomon ports, commercial ports and transhipment locations, will place heavy demands on the SMM Solomon port management and government authorities. Shipping will also impact use of the areas by locals as traffic increases.

Marine traffic will include up to 100 OGVs and over 2,000 loaded LCT movements per year (with an equal number of unloaded LCT movements returning to port), as well as daily passenger ferry traffic, fuel and general cargo transportation. There will be potential for conflict between these Project shipping movements and local marine traffic, particularly in the vicinity of the port sites.

Loaded LCT ore barges will, on average, depart the Port-I1 wharf for the OGV anchorage approximately every two hours over the 12 hour operational loading shift and every 10 hours at Port-I2. There will also be regular coastal barge delivery of containers, breakbulk goods and materials to both ports at varying intervals of up to a week. A small general purpose service boat will also be based at Port-I1.

Additionally, the fast ferry service to the ports for staff transportation will create potential for conflict including collisions with local marine traffic.

4.14.4.7 Clearing of Vegetation

Loss of vegetation is a potential impact caused by the establishment of Project road infrastructure. The loss of vegetation increases the potential for invasive plant species thereby changing the composition of the native vegetation in the area. It also increases the potential for erosion and sedimentation downslope (loss of soil integrity and structure) of the cleared area.

The vegetation proposed to be cleared during the construction phase comprises of coastal forest, lowland communities and upslope rainforest. Almost all of the upslope rainforest is “old growth”. Rainforest is typically dominated by *Casuarina* sp., iron wood and other canopy species (e.g., palms) approximately 30-40 m in height. The understory is dense and comprises mainly young trees and other saplings as well as small palms and ferns. Leaf litter, composed mainly of decaying leaves and some twigs and fallen logs, almost entirely covers the forest floor.

The ports and associated infrastructure will mainly impact the coastal forest and be in part located on disturbed land, while much of the proposed haul, facility access and service road length will be constructed in rainforest. As the Project operation proceeds over time, some additional roads will be constructed to enable new mining areas to be established and mined, resulting in an incremental increase in the area of cleared vegetation.

The amount of area to be cleared for the construction of roads will be a relatively minor component, approximately 10% of the 6,153 hectare total area on Santa Isabel Island proposed to be cleared for the Project. Clearing for mining areas, water storage facility, mine industrial area, accommodation camp and ports will comprise the bulk of this total area.

4.14.4.8 Loss of Terrestrial Fauna

There is potential for loss of fauna due to vehicle strike, particularly during night operations, as well as from the reduction in habitat due to vegetation clearing and habitat disturbance from both construction and operation activities.

The impact of vehicle strike is difficult to quantify as there is no information available on the wildlife strike rate from existing logging and general traffic movements.

It could be expected that the haulage of ore at night would represent the most significant risk in this respect due to traffic frequency, headlight glare and nocturnal fauna movements.

The clearing of vegetation for linear infrastructure such as roads may also fragment habitats and create “edge effects”, extending the impact on fauna into the adjacent undisturbed areas.

Dust generated by traffic movements may indirectly affect fauna species through its impact on plants, either as a source of food or as habitat. Dust on the leaves and fruit of plants decreases their palatability to fauna species and any adverse effect on the health of trees or a changed community structure results in a reduction in the amount of available habitat. Refer to section 4.9.3 for discussion on this impact.

4.14.4.9 Weeds and Plant Diseases

The construction of roads and the resulting traffic will provide a potential for the introduction and spread of weeds and plant diseases into the natural environment.

4.14.4.10 Provision of and Increased Use in Existing Transport Linkages

As noted in Section 4.14.3, there are few existing land transport linkages in the Project area and these are primarily former log loading ports and logging tracks. The establishment of major port and road infrastructure for the Project is unlikely to have a significant adverse impact on these existing linkages, provided that the transport interfaces (e.g. where Project roads intersect existing tracks) are adequately managed in design and operation.

There will also be a positive benefit to local people from the provision of a 15-20 person capacity community fast ferry service which will provide the opportunity for safe, rapid travel between communities including a modest cargo capacity.

4.14.5 Impact Assessment

A summary of the potential impacts and their significance based on the above criteria is provided in Table 4-47.

Table 4-47 Assessment of Potential Impacts on Transport

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability (with no mitigation)	Consequence	Significance (with no mitigation)	Mitigation / Management Actions	Significance (with mitigation)	Confidence level
	Mine	Haulage	Port	Infrastructure	Construction	Operations										
Erosion and sedimentation		•	•	•	•	•	Negative	Local	High	Short Term	Highly Probable	Low	Low	Roads will be routed to avoid excessive gradients and will incorporate effective drainage management and sediment control structures. Maintenance of roads will be undertaken.	Low	High
Dust generation		•	•	•	•	•	Negative	Local	Medium	Short Term	Probable	Low	Low	Use of water trucks to spray roads for dust suppression where required.	Low	High
Noise		•	•	•	•	•	Negative	Local	Medium	Short Term	Probable	Low	Low	All vehicles and mobile equipment will be fitted with exhaust muffling devices to ensure compliance with relevant environmental and occupational health standards.	Low	High
Air emissions		•	•	•	•	•	Negative	Local	Low	Short Term	Probable	Low	Low	New, modern, fuel efficient vehicles and equipment with low emission ratings will be used. Vehicles and equipment will be serviced and maintained.	Low	High
Pollutants / spills		•	•	•	•	•	Negative	Local	Medium	Short Term	Probable	Low	Low	Transport of materials will be undertaken in accordance with all relevant requirements of national and provincial government regulation and international law. Ports will have containment and cleanup equipment. Implementation of an emergency spill response plan. Implementation of international best practice port management, including handling nickel ores.	Low	High
Traffic conflicts (includes shipping)		•	•	•	•	•	Negative	Local	Medium	Short Term	Probable	Low	Low	Drivers will be required to demonstrate competence and hold a valid licence. Road rules will be conveyed and enforced. Roads will be signed. Harbour traffic will be controlled by SMM Solomon Port Management.	Low	High
Vegetation clearing		•	•	•	•	•	Negative	Local	Medium	Long Term	Definite	Medium	High	Minimise area to be cleared for road construction.	Low	High
Loss of terrestrial fauna		•	•	•	•	•	Negative	Local	Medium	Long Term	Highly Probable	Medium	Medium	Slow vehicle speeds will minimise potential impacts. Immediate road environs including embankments and berms will be revegetated.	Low	High
Weeds, disease		•	•	•	•	•	Negative	Local	Low	Long Term	Probable	Low	Low	Quarantine procedures and inspections at receiving ports will be implemented to minimise the risk of importing exotic weeds and plant diseases. Vehicle wash facilities will be used.	Low	High
Increased use of transport linkages		•	•	•	•	•	Positive	Regional	Medium	Long Term	Probable	High	High	The Project will use dedicated LCT barges to deliver goods and materials to Project ports and a contracted Project ferry service for staff transportation. A community ferry service to be run by a third party will provide the opportunity for safe, rapid travel.	Low	High

4.14.6 Mitigation Measures

4.14.6.1 Erosion

To minimise the potential impacts caused from erosion, the Project roads will be routed to avoid excessive gradients, constructed with gravel sheeting and include effective drainage management structures to channel runoff away from the road surfaces. The roads will also be maintained and re-sheeted as required to continue to meet Project transportation requirements over the Project life.

Drainage facilities for all road categories will be designed to address sediment issues at the source where possible and include culverts, pipe networks and open drains as well as sediment control devices such as containment basins, decanters and rock check dams. All facilities will be designed for a 5% probability of overtopping, consistent with common hazard rating approaches.

4.14.6.2 Dust Generation

The generation of dust is likely to be minor, due to the high rainfall consistently experienced in the Project area. An appropriate strategy will be the use of water trucks to spray roads and hence reduce the potential for dust generation.

4.14.6.3 Noise

The Project has the potential to generate significant noise during both construction and operation phases. To minimise the associated impacts, all vehicles and mobile equipment will be fitted with mufflers. The haul road between Port-I1, MIA-I3 and the accommodation camp, which will be located upslope from Leleghia, will be routed on the lee side of the ridgeline to reduce noise transmission.

4.14.6.4 Air Emissions

Emissions from transport are not expected to have a significant impact on air quality, however an appropriate strategy to minimise this impact will be to use, where possible, new, fuel efficient vehicles and equipment with low emission ratings and ensure that these are serviced and maintained according to the manufacturer's recommendations. Fully equipped and staffed mechanical workshops will be incorporated in the MIA for this purpose and will be supported by fleet servicing trucks.

4.14.6.5 Spills

Fuels, oils and other chemical spills are potential impacts resulting from transportation of product and goods, required for the Project. To minimise this risk, sea transport of dangerous and hazardous materials will be undertaken in accordance with all relevant requirements of national and provincial government regulation and international law. Hazardous cargo imported as breakbulk or in ISO containers will need to comply with the International Maritime Dangerous Goods Code. Unpacking and storage facilities will be provided in accordance with national and or internationally accepted practice.

The Project ports will provide and maintain spill kits capable of addressing fuel and oil spills and operating personnel will be trained in responding to such an emergency situation.

Implementation of international best practice port management, including handling nickel ores, will effectively minimise this risk.

Good engineering road design, the use of modern fuel transport vehicles and safe material handling practices will be employed to minimise this risk. Any spills will be addressed through containment and cleanup, including the responsible disposal of any contaminated soil, to reinstate the spillage area.

4.14.6.6 Traffic Conflicts

4.14.6.6.1 Roads

To reduce this risk of road traffic conflicts as far as possible, all drivers of vehicles travelling on the Project roads will be required to demonstrate competence and hold a valid licence for the category of vehicle being driven. Control of vehicle access to the Project roads will be applied at source, while unauthorised third parties driving vehicles on Project roads will be prosecuted. Road rules will be clearly conveyed through driver training and strictly enforced as a component of the Project safety policies and procedures.

All Project vehicles will be in good working conditions including provision of lights and roof or cab mounted orange warning flashers. Each vehicle will be clearly identified using a unique reflective number adhered to each side of the vehicle.

Pedestrian traffic will not be specifically catered for in the design of most Project roads, although the road pavement widths of between 8 m and 15 m will allow the reasonable passage of pedestrians separate from vehicular traffic. Roads within the MIA, ports and accommodation camp, which will cater for some workforce pedestrian movements, will be appropriately signed and marked to minimise the risk of vehicle/pedestrian conflict.

4.14.6.6.2 Shipping

Harbour traffic will be controlled by SMM Solomon port management to minimise the risks of marine collisions through arrivals scheduling, radio communication with vessels and marked navigation areas.

4.14.6.7 Clearing of Vegetation

The loss of vegetation as a result of clearing to establish Project road infrastructure will be staged over the 23 year life of the Project. The staged development process for roads will minimise the total area of road infrastructure open at any one time therefore assisting in minimising the potential for establishment of invasive non-native plant species and erosion.

The linear nature of road infrastructure will mitigate the impact of vegetation loss.

Consistent with the drainage management strategy to minimise sediment generation at source, any areas of vegetation unavoidably cleared during the construction of Project roads and that are not trafficable or part of the drainage system (for example embankments and safety berms) will be reinstated through hydromulching and revegetation.

The overall loss of vegetation, due to the development of Project infrastructure, will be minimised through the following:

- A portion of the proposed road infrastructure will be located along old logging roads in areas that have been previously disturbed.
- The roads will be constructed, where possible, ahead of the construction equipment to limit the need for additional working right-of-ways (ROWs) beside the planned road allowance, or where required working allowance will be located immediately adjacent to the planned road allowance and limited to no greater than 5 m over the planned road allowance. Working ROWs have been accounted for, according to road types (i.e., haul, mine, service, facilities) in the total area of disturbance.
- Roads will be constructed only as required immediately ahead of the development of new mining areas (with possible exception of primary haul roads) and will be immediately rehabilitated, (graded and revegetated with acceptable species (native and non-invasive only) following completion of mining activities for each specific area.
- No Project infrastructure is proposed to be constructed within a declared protected area.

4.14.6.8 Loss of Terrestrial Fauna

The proposed tenement areas do not include any areas identified and declared for conservation or protection or as critical habitats.

Speed limits will be posted to minimise potential impact on terrestrial fauna caused by traffic conflicts.

Fragmentation and "edge effects" will be reduced by revegetating the immediate road environs including embankments and berms.

4.14.6.9 Weeds and Plant Diseases

The primary off-site strategy to avoid this risk will be quarantine procedures and inspections at receiving ports to minimise the risk of importing exotic weeds and plant diseases.

Vehicle wash facilities utilising raw water sourced from the local water supply will be used to minimise the spread of plant diseases and weeds. These facilities will be installed in the port, MIA and accommodation camp areas and used variously for light and heavy vehicles, containers and mobile equipment. An oil/water separator and a sediment pit will be provided to manage wastewater, with residual wastes collected and removed to the Project landfill or an accredited facility where required.

4.14.6.10 Provision of and Increased Use of Existing Transport Linkages

Transport interfaces, where Project roads intersect existing tracks, will be adequately managed in design and operation to minimise impacts on existing transport linkages.

The Project will use dedicated LCT barges to deliver goods and materials to Project ports and a contracted fast ferry service for staff transportation and will not rely on the existing cargo and passenger services to any appreciable extent, thereby avoiding adverse impacts.

Project personnel will utilise both commercial and charter air services for travel to and from the Project site, where necessary.

4.15 Society and Community

The Social Impact Assessment (SIA) undertaken for the Project on Santa Isabel Island is described in this section and includes:

- existing social and community values in the Project area
- an assessment of the potential social impacts that may arise as a result of the Project
- mitigating measures to minimise or enhance the identified potential impacts.

Further information is provided in the Impact Assessment Report – Social and Community.

4.15.1 Methodology

The SIA was undertaken using two methods of data collection:

- desktop research
- baseline field surveys and consultations.

Field surveys and consultation work to collect primary data for this Report was undertaken over an 18 month period. Baseline social profiling was undertaken by the Hatch Social Impact Team between June-October 2010. Social Impact Assessment Consultations with key stakeholder groups were conducted between August – November 2011 by Hatch and AECOM. The analysis of impacts was conducted by both Hatch and AECOM staff. Refer to Figure 4-32 to Figure 4-35 consultation locations and types.

It is important to note that consultation with people affected by the Project was often undertaken in larger 'hub' villages. In many instances, residents from smaller villages travelled short distances to the nearest hub village to participate in EIS consultations.

SIA field work studies were undertaken in various locations in Isabel Province and Guadalcanal Province and additional consultations were also conducted in Buala, the capital of Isabel Province. Consultations included meetings with the Premier and other provincial government representatives, provincial police, staff at Buala hospital, and local tourism industry providers.

The possible social and community impacts of the Project were identified using the baseline studies, desktop research, and field data as reference. The impact identification process considers both the construction and operational phases of the Project.

The process followed to assess the impacts that the Project may have on social values comprised of four steps:

- potential impacts were identified and assessed
- the nature, magnitude, extent and duration of potentially significant impacts were predicted
- mitigation measures that could be implemented to reduce the severity or significance of the impacts of the project were identified
- the significance of the impact after the mitigation measures have been implemented was evaluated.

The local communities identified within or in the vicinity of Isabel Tenement D and E have been categorised as Priority 1 or Priority 2 for consultation purposed. Priority 1 are these villages (or settlements) which are more likely to be impacted by Project activities. For further information refer to the Report – Public Consultation included in the attachments to the EIS.

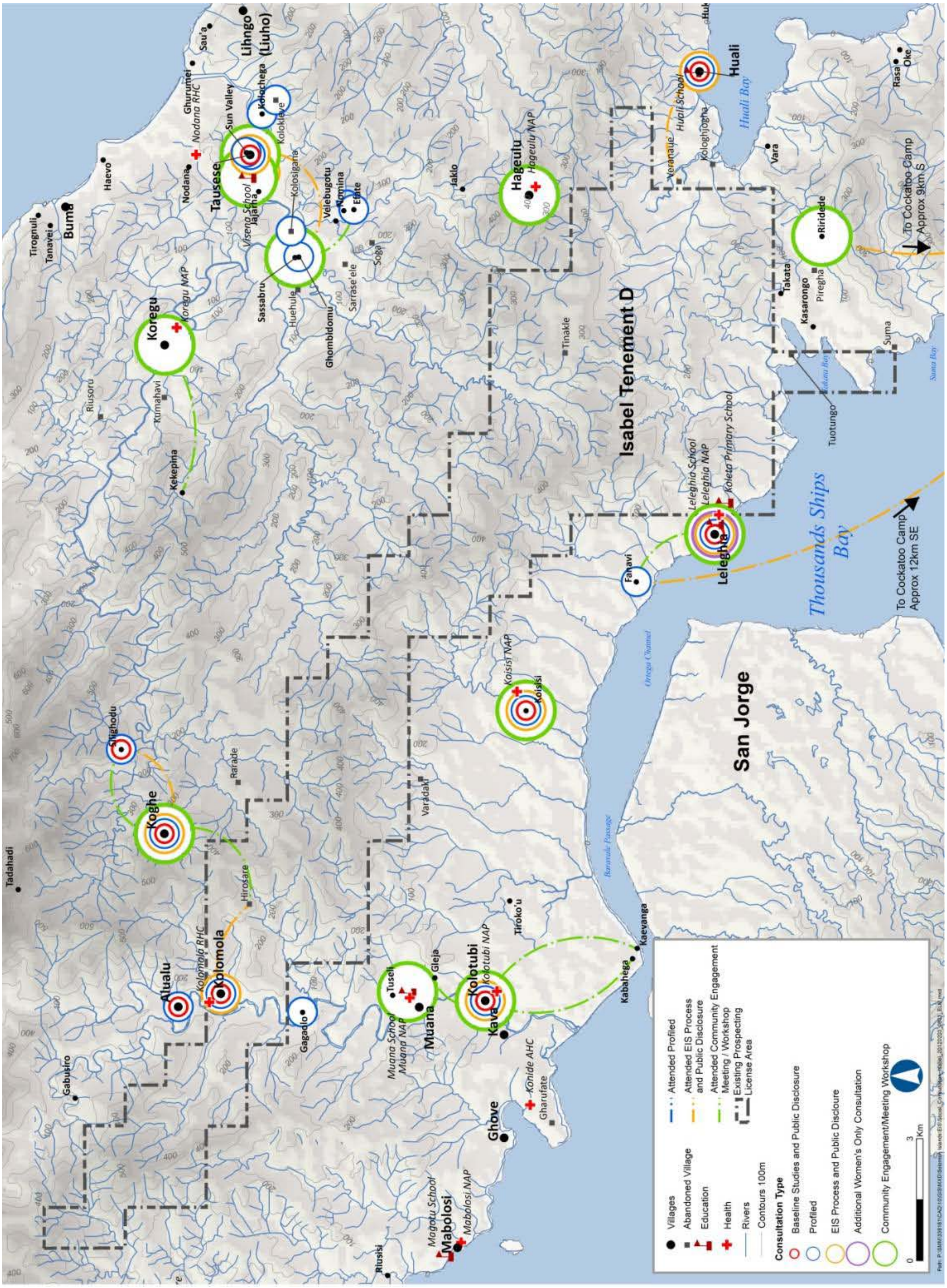

Figure 4-32 Baseline and EIS Consultations with Project-Affected Villages Conducted by Hatch on Isabel Tenement D, 2010–2011

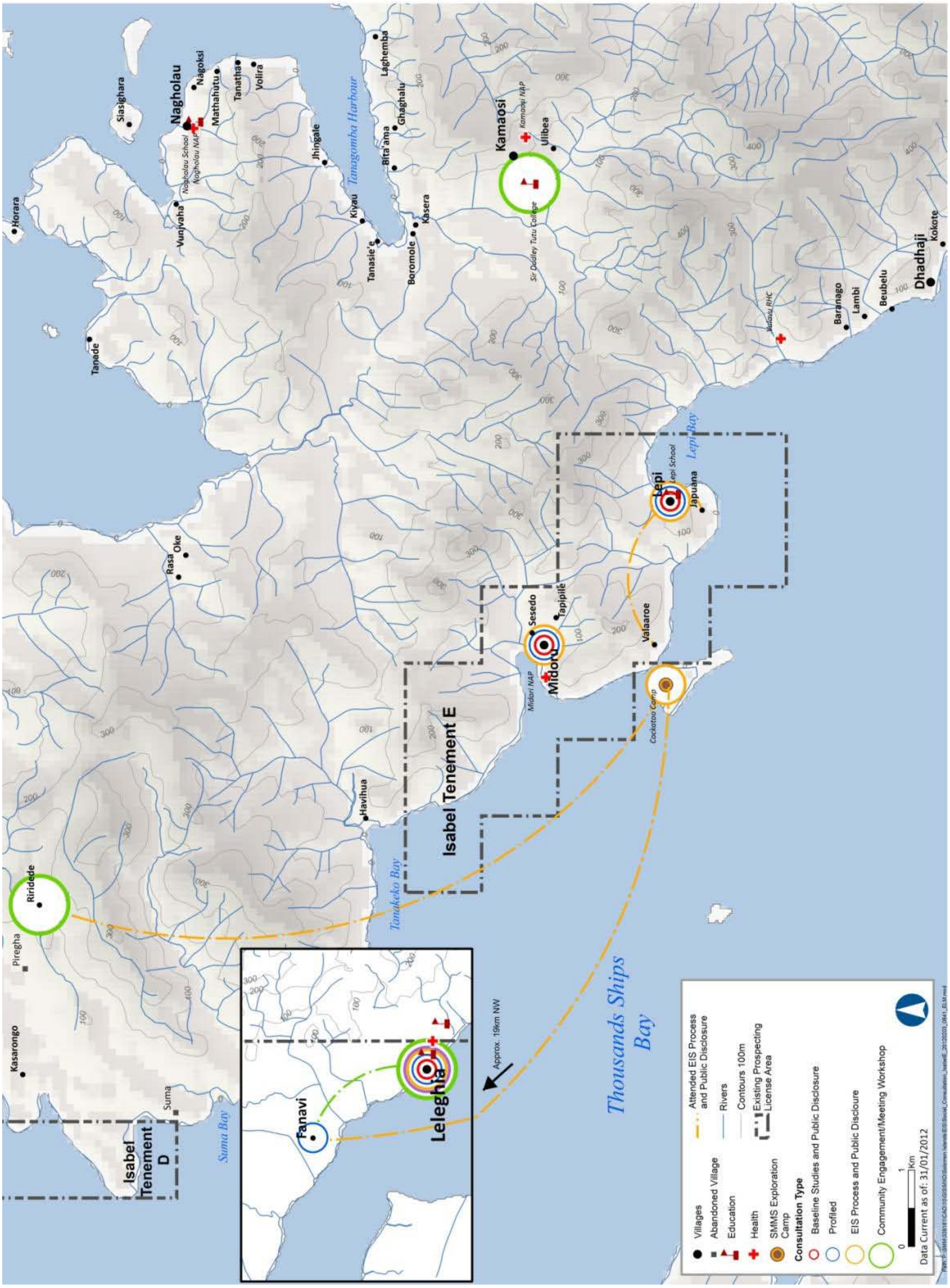

Figure 4-33 Baseline and EIS Consultations with Project-Affected Villages Conducted by Hatch on Isabel Tenement E, 2010-2011

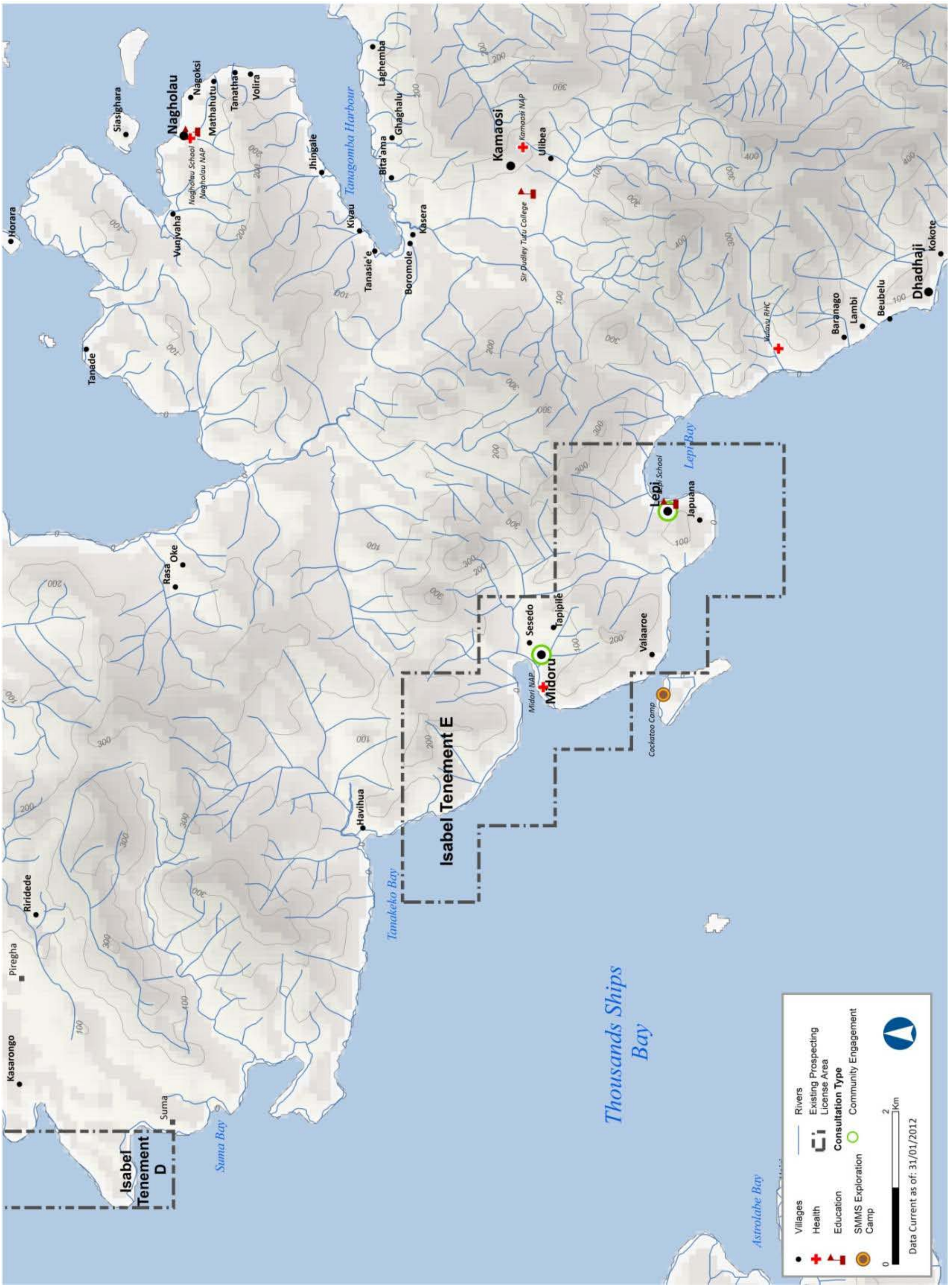

Figure 4-34 EIS Consultation Workshops, Meetings and Surveys Conducted by AECOM on Isabel Tenement E in 2011

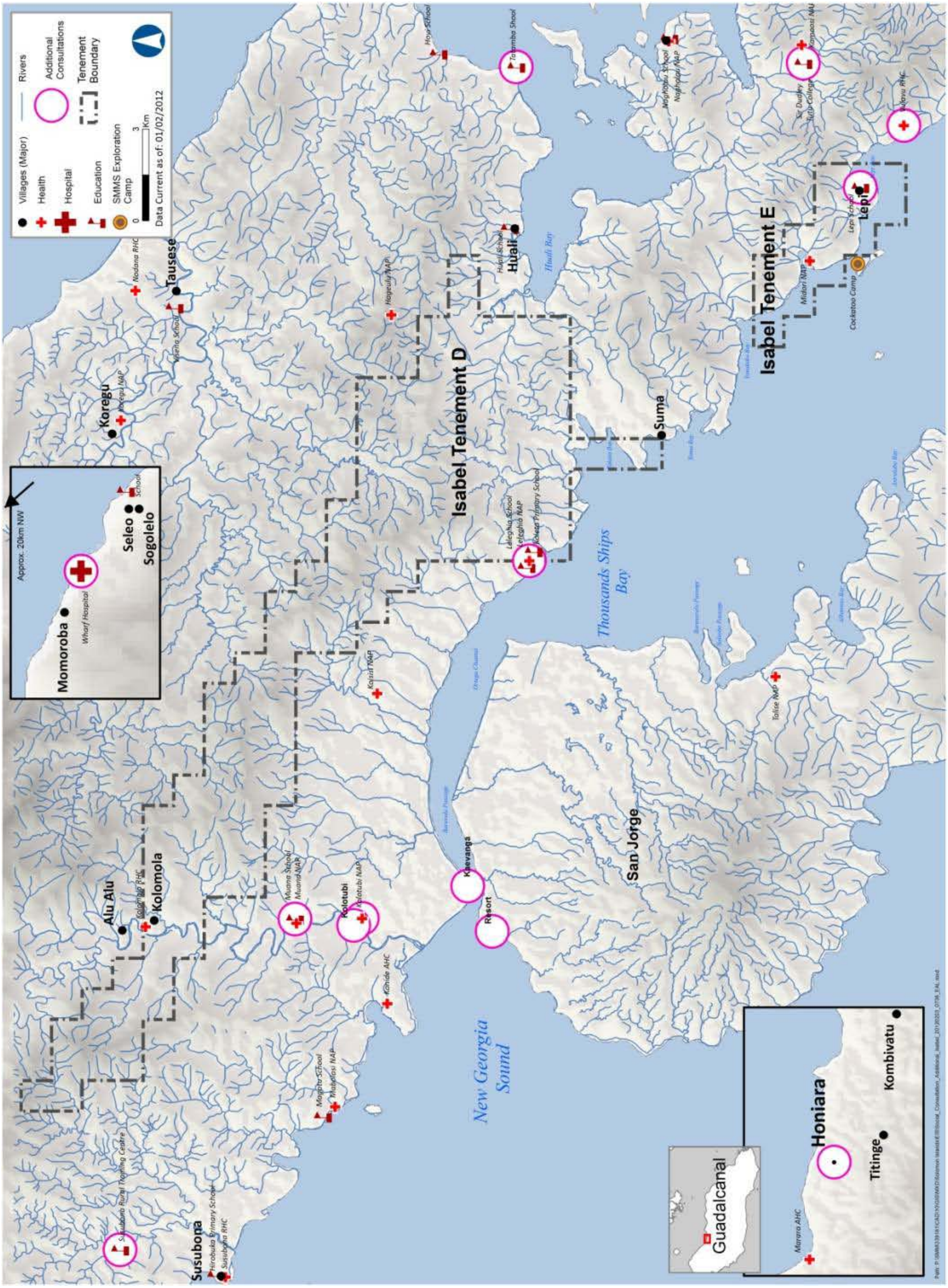

Figure 4-35 Social Service Provider Consultations Conducted by Hatch, 2011

4.15.2 *Existing Values*

The existing social profile is discussed under national and provincial subsections:

Solomon Islands – National Profile:

- Population and Demographics
- Political Situation
- Gender Roles
- Social Infrastructure
- Education

Santa Isabel Island:

- Downstream Communities
- Demographics
- Ethnicity
- Language
- Religion
- Social Structures and Norms
- Cultural Values
- Family Structure and Gender Roles
- Social Services
- Existing Social Issues and Conditions

The National Context section provides the background and frame of reference from which to compare and understand the social values and conditions on Santa Isabel Island.

4.15.2.1 Solomon Islands – National Context

4.15.2.1.1 Population and Demographics

The population of the Solomon Islands is spread over 347 of 922 islands, and is ethnically heterogeneous, with over 300 cultural and linguistic groups. In 2009, the total population of the Solomon Islands was 515,870 people of which 93.3% are Melanesian. The majority of households (87%) are situated in rural areas and 17% in urban areas (SISO 2011).

In 2009, the average annual population growth rate was 2.3% with young people under 14 years of age representing the largest section of the population. Men comprised 51% of the total population and women 49% (SISO 2011).

Most of the population is reliant on a semi-subsistence lifestyle (Jansen et al. 2006) with limited numbers engaged in paid employment.

Religion is central to the lives of Solomon Islanders. Trends over the past decades display a transition from traditional religious practices towards the Christian faith. Almost 100% of Solomon Islands people now identify themselves as Christian (Jansen et al. 2006).

The Solomon Islands is recognised as an under-developed nation with minimal access to most basic services. Available data suggests approximately 25% of the Solomon Islands' population were living below the poverty line in 2007 and were undernourished or food deprived (Asian Development Bank 2010).

4.15.2.1.2 Political Situation

There are two levels of government administration. National and Provincial (DPGCD 2006) Government administration, is largely centralised and is administered by the National Government Ministries from Honiara.

There are ten administrative areas in the Solomon Islands. The Provinces are administered by elected Administrative Assemblies, whereas the Town of Honiara is administered by the Honiara Town Council. The ten administrative areas support around 50 parliamentary constituencies (Nelson and Maggah 2004) and 183 wards (SISO 2009).

4.15.2.1.3 Gender Roles

Gender roles remain distinct in Solomon Islander society particularly in rural areas. Traditional values and practices which promote ancestor and male worship known as 'Kastom' still dictate what are acceptable social norms and behaviours for women today(JICA 2010).

The Church, headed mainly by men, has tended to reinforce women's traditional gender role rather than challenge it (Maetala 2008).

Today, even though women are still recognised as the legitimate customary owners of land in some parts of the nation, this is not formally acknowledged in legislation. This has eroded the position of women as landowners in matrilineal societies (Monson 2010; Maetala 2008).

4.15.2.1.4 Social Infrastructure

Health

- Health care reform has been underway since 2007. A framework for the nation's health care reform is outlined in the Solomon Islands' National Health Strategic Plan 2006–2010 (AusAid 2007).
- The state of the health care system in the Solomon Islands is considered poor due to it being under-funded, under-resourced (staff, equipment and medical supplies) and lacking infrastructure (Hatch 2011). Seven of the nine provinces have a public hospital.

Education

- The Solomon Islands have one of the lowest rates of adult literacy in the Asia Pacific region. UNESCO estimates adult literacy rates of between 25 and 40 per cent, largely due to the low school enrolment, low primary school attendance rates, high dropout rates (prior to completing primary school) and the inability of half of those who complete primary school to continue on to secondary school.
- The Solomon Islands has more than 610 primary schools providing schooling for around 60,000 children, and 135 secondary schools providing schooling for 27,000 children and teaching staff numbers are reported to be around 4,000 (MEHRD 2004).
- The secondary school system in the Solomon Islands includes three types of secondary schools: National, Provincial and Community. Access to secondary school education is improving with the introduction of additional Community High Schools (UN 2002) and dedicated Provincial Education Action Plans.
- Formal Technical Vocational Education and Training (TVET) programs and other non-formal forms of education and training are offered throughout the nation.

- The Early Childhood Education (ECE) Program was introduced in the Solomon Islands in 1996 and currently there are more than 352 Early Childhood Centres in the Solomon Islands, providing early childhood education to over 8,656 children (MEHRD 2004).

4.15.2.1.5 Santa Isabel Island

4.15.2.1.6 Project Area

There are a number of populated villages which are situated in close proximity to proposed mining areas. In Tenement D villages located in close proximity to mining areas and most likely to be impacted by mining and transportation activities include: Kolomola Village and Gagaolo settlement.

In Tenement E, populated villages located in close proximity to mining areas include Midoru, Lepi and Japuana Villages.

There are a number of villages in the Project area that are downstream from proposed mining areas. Downsteam communities to the north of Tenement D include: Gagaolo, Tuseli, Muana, Gleja, Kolotubi and Kava all situated along the banks of the Kapito River. The villages of Fanavi and Koisisi are also situated downstream from potential mine sites.

Demographics

- Isabel Province is sparsely populated with a population density of around six people per square kilometre. Recent population and housing census data indicates that Isabel Province had a total population of 26,158 in 2009. This was equivalent to around 5.7% of the total population of the Solomon Islands at that time (pop. 515,870) (SISO 2011).
- In 2009, 96.3% of people living in Isabel Province resided in rural areas and 3.7% resided in urban areas.
- In 2009, the population of Isabel Province grew at a rate of 2.5%, compared to 2.3% overall for the Solomon Islands. This represented the fifth highest average annual growth rate of the Provinces in the Solomon Islands.
- In urban areas, the annual growth rate in Isabel Province was 7.7% compared to much lower annual growth rates in rural areas at 4.7%. This suggests migration to Buala, the capital.
- Twelve villages were surveyed during baseline studies in 2011 on Santa Isabel Island and were found to have populations varying between 92 and 800 people per village. Of those surveyed, Kolomola, the largest village surveyed estimated they had a population of 800 residents whereas the smallest village, Silighodu, estimated that they had 92 members.
- Overall estimated data suggests men make up approximately 52% of the population and women 48% within villages in the Project area[10]. Previous census data does show a higher sex ratio at birth for men than women which may account to some extent (Shcoorl 2002) for this difference.

Ethnicity

- The people of Isabel Province are largely of Melanesian descent with two villages reporting a small number of residents of Polynesian descent through marriage.

Language

- There are eight previously recorded local Isabel languages found in the literature on Isabel Province. Cheke Holo is spoken by over half of the population (White et al. 1988) and is the main language of the local people in the Project area. There are two main dialects including Maringe and Hograno. Pijin and English are also spoken. Pijin is used commonly when conducting business.

[10] Kolomola village removed in the calculation of this figure.

- Site visits during EIS baseline studies in 2010 found that English although not widely spoken, did appear to be the main written language taught in local schools.

Religion

- The Church plays a major role in the daily lives of the people of Santa Isabel Island. Church services are held regularly in local villages on the Island. However, the transition from a subsistence based economy toward a cash based society is causing some angst for those who view it as a threat to the church's influence and the current Island lifestyle (Hatch 2011).
- The populations of villages visited in and around the Project area on Santa Isabel Island were largely affiliated with the Anglican Church of Melanesia and to a lesser extent with the Episcopal Church (also Anglican affiliated).

4.15.2.1.7 Social Structures and Norms

There are four levels of governance found in Isabel Province:

Government – Isabel Province

- The Provincial Government in Isabel Province is the administrative arm of the National Government, responsible for administering any funds provided, as well as managing and maintaining provincial infrastructure, health, education, policing services and overall business development for the Province.
- Isabel Province has three constituencies: Hograno/Kia/Havulei; Maringe/Kokota and Gao/Bugotu, each with one parliamentary representative who sits in the National Parliament for a period of up to four years.
- Over the last few years, the Provincial Government of Isabel has faced significant challenges. The lack of communication and transport infrastructure in Isabel Province has made it difficult for the Provincial Government and administrators to monitor and manage service delivery at a community level.

Isabel Council of Chiefs

- The ICC is the umbrella organisation which represents the eight houses of chiefs within Isabel Province: Bugotu, Hograno, Katova, Kia, Havulei, Kokota, Maringe, and Gao (Marau cited in White 2004). It is organised in line with electoral boundaries and is made up of three nominated chairpersons, representing each of the three constituencies, within which the eight district House of Chiefs exist (Maetela 2008; White 2004). Within the district House of Chiefs, there are numerous chiefs. The chiefs speak on behalf of land owning groups. They work in a voluntary capacity to resolve land disputes, solve community problems and guide development projects.

Clan and Village Governance

- The Chiefdom system is recognised at both the Clan and Village level in Isabel Province. The tribal leader is the head of the Clan. The tribal leader inherits decision making powers due to being born into a land owner lineage. The role is for life and is generally held by men.
- In contrast, the village chief has authority to adjudicate daily on community matters. The village chief is appointed through a majority vote process by the village and is usually selected based on recognized leadership and desirable personal characteristics displayed at both the family and community level.
- The Tribal Leader sits above the Village Chief and is called upon only in instances where the Village Chief is unable to resolve a particular matter. Issues of this nature include murder, adultery and land disputes.

The Church's Role in Governance

- The Church is a very important institution in the Solomon Islands. Through its teachings, it not only provides spiritual guidance, but is also central to personal and communal identity. At the "grass roots" level, in the villages where the vast majority of Solomon Islanders still live, it carries great influence over the daily lives of residents. The power structures at the village level are usually located in the organisational structures of the Church. The village chiefs are usually identified with the Church as Elders, or senior members of vestry committees, or clergy.

4.15.2.1.8 Cultural Values

Traditionally, strong family and community ties are the social systems that provide security and support to rural households in the Solomon Islands. Typically any food produced from crop gardens and income from food and cash cropping is shared. Most households are expected to contribute to their communities. This contribution may take the form of school fees, celebrations, feasts and other common village activities. Individual wealth accumulation to improve village quality of life is not viewed as a priority.

4.15.2.1.9 Family Structure and Gender Roles

Santa Isabel society is organised along matrilineal lines and land ownership is held by women and passed down from mother to daughter. Power and leadership roles however, remain largely vested in men, as male chiefs govern village affairs and land issues in civil society. Women are generally involved in home, church and subsistence activities such as gardening, fishing and marketing. Maintenance of home vegetables is an essential activity for rural livelihood and women perform daily gardening duties to provide for their family.

4.15.2.1.10 Social Services

Health Services

- The only local hospital on Santa Isabel Island is Buala Hospital, located at the Provincial capital on the central eastern coast of Santa Isabel Island. Buala Hospital offers 24 hour hospital coverage. The six clinics attached to the hospital run from 7.30am to 4.30pm and offer after hours services as required. These clinics consist of an antenatal clinic, a non-communicable disease clinic, an eye clinic, a dental clinic and two outpatient clinics (Hatch 2010).
- In addition to Buala Hospital, there are five Area Health Centres (AHC), 11 Rural Health Clinics (RHC), 14 Nurse Aid Posts (NAP) and three School Dispensaries (Hatch 2010).

Education Services

- There are four levels of education available on Santa Isabel Island: early childhood, primary, secondary and vocational education and training in RTCs. No tertiary education is available on Santa Isabel Island.
- There are approximately 45 early childhood education centres, 25 primary schools, three community high schools and two provincial secondary schools and 3 Rural Training Centres (Digest of Education Statistics 2005, in Isabel Provincial Office of Education, 2007).
- Poverty and a shortage of schools is a factor which often prevents around 25 percent of children starting school in Isabel Province (IPEO 2007).
- Surveys and assessments show low levels of literacy and suggest that there is a significant need to improve educational standards and services in the Province.

4.15.2.2 *Policing Services*

The police headquarters and all policing services for Santa Isabel Island are situated in the Provincial Capital, Buala with the exception of one policing post on the western tip of the Island. There are 23 police staff, stationed In Buala, including community police officers, lawyers and administration staff. Community police patrol communities twice a month to maintain a police presence.

RAMSI has a presence on Santa Isabel Island and is supporting police efforts within the Province through the provision of training and advice, assistance with record keeping and auditing systems and fuel. Fuel supply shortages are a major issue for Santa Isabel Island policing services.

Major areas of crime reported in 2009 included:

- offences against property (stealing and damage)
- offences against people (including common assault, unlawful wounding, grievous bodily harm, murder, etc)
- offences against morality (including domestic violence, rape, child sexual abuse).

4.15.2.3 *Accommodation and Tourism*

Tourism in Isabel Province is limited. The closest tourist operation to the Project area is Kaolo Resort, a small resort located on San Jorge Island opposite Kaevanga Village. The resort faces north-west so its visual amenity will not be impacted by the Project. The resort may benefit from increased passing trade if the SMM Solomon Nickel Project goes ahead.

There is significant opportunity to develop tourism ventures in a number of areas on Santa Isabel Island but development of the tourism industry will require:

- improving image in target markets
- transport services and infrastructure improvement, including international air links (reduction of their costs) and in the reliability of inter-islands air services and their cost
- awareness of the relationship between the environment and successful tourism development
- resolution of land disputes
- upgraded skills in the sector.

The potential for tourism and in particular eco-tourism has been recognised by the Ministry for Tourism and the Solomon Island Visitors Bureau and plans are being developed to develop and maximise the benefits of the Solomon Island's pristine estuarine and inland waters and natural undisturbed forests. Potential tourism sites have been identified around Kolomola, Kolotubi and Midoru areas which are inside the existing exploration tenement areas.

4.15.2.4 *Existing Social Issues and Conditions*

4.15.2.4.1 Social Change Arising from Development

There has recently been a shift from traditional agricultural communities in Solomon Islands to a cash economy. Despite this transition, rural livelihoods in Isabel Province remain predominantly subsistence based. Currently, the cash economy assists rural people to supplement their subsistence lifestyles and insulate themselves during periods of poor crop yield.

The rural cash economy in the Solomon Islands has not yet developed to the extent that families are able to earn enough from their paid employment or marketing activities to sustain themselves.

Population growth, unsustainable resource use and the introduction of the cash economy is putting increased pressure on natural resources, including agricultural land, forests, rivers, streams, and marine life (Jansen et al. 2006; Hatch 2010).

4.15.2.4.2 Youth and Urban Drift

The Solomon Islands' population is experiencing a 'youth bulge' and high rates of youth unemployment. Increasingly, young people are being attracted to urban areas in search of potential job opportunities. Local people on Santa Isabel Island reported that the ever-increasing migration of young people to urban areas is also having a negative impact and weakening the social structures of rural communities

4.15.3 Potential Impacts

4.15.3.1 Disturbance to daily lives and activities of local villages

The greatest social changes and disruptions to local lifestyles will come with the increased activities and expected population influx during the construction period. In particular, local people were very concerned about the environmental impacts that the Project would have on the air, water and land and the associated impacts on their lifestyle, food security and long term health.

The villages most likely to be impacted by construction activities are: Leleghia, Kolomola and Gagaolo in Tenement D; and Japuana and Lepi villages in Tenement E. The development of a port and associated roads to the east of Leleghia, and to the west of Japuana is likely to increase noise, light, and traffic in the area during construction. Whereas, mining and road work activities are likely to impact on Kolomola and Gagaolo during the construction period.

Relocation of two villages is a possibility if ore deposits nearby are mined; Kolomola Village in tenement D and Midoru Village in tenement E.

The Project has the potential to generate elevated levels of noise, dust, vibration and light spill. Elevated levels of noise will occur as a result of vehicle traffic, haulage trucks and machinery required during the construction and operational phases of the Project.

The Project may cause disruptions or restrictions to the usual intra-community migration patterns of local landowners within their own customary lands and/or local villagers relocating to other village sites.

4.15.3.2 Social Inequality

If the Project proceeds, land owners will be compensated for land access whereas those who are not landowners will receive no compensation which will lead to an immediate social divide. Those employed on the Project or in supporting services will receive a regular wage whereas other local people not formally engaged in paid employment will not. This is likely to create an immediate division within society between the 'haves' (the affluent) and the 'have nots' (those who are reliant on subsistence activities).

Those with limited employment prospects due to age, frailty, child rearing responsibilities, illness or disability will not have the same opportunities to be fully engaged in paid work as others. This is likely to increase the divide between those who have cash money and those who do not, because project impacts are likely to cause some price inflation in the local economy and an increased reliance on cash and store-bought foods (refer to the Impact Assessment Report – Socio-economics in the attachments to the EIS).

4.15.3.3 Gender Inequality

Isabel women reported that they were generally not included in village governance or other public decision-making bodies, which is generally left to their men (Hatch 2010). Given the status and roles of women in Isabel society, and the types of jobs provided by the Project, it is probable that in the short-term men are more likely to experience the direct employment benefits offered by the Project than are women, with the exception of cleaning and laundry work (which are jobs typically carried out by women in Isabel Society).

Without intervention to promote benefits and opportunities for women, the existing gender inequalities which exist in Isabel society will become more pronounced.

Over time however, if opportunities are opened up to women and gender stereotypes are successfully challenged, women are likely to be able to improve their economic status and participate more fully in the public realm.

4.15.3.4 Improvements to transport options and linkages

Positive impacts associated with Project improvements to road infrastructure in the Project area include better roads for public use on the island after mining. Better roads will facilitate quicker and easier access to other villages and important markets, services and port areas.

Negative impacts associated with improvements to road infrastructure may be increased injuries and deaths due to collisions of people and vehicles as local people are not used to traffic and may not be alert to the dangers of walking on roads used by vehicles.

The influx of a large workforce associated with the Project could also put pressure on current air and sea carriers and escalate the cost of transport for local people.

4.15.3.5 Loss of flora and fauna for social uses

Clearing of land for Project infrastructure or mines will require the clearing of trees, bushes and other flora. Loss of large areas where this flora exists will impact the local people's ability to rely on the natural environment to sustain their needs.

Local Isabel people expressed concern about the loss of important flora such as Tubi trees (*Xanthostemon melanoxylon*). This endemic species is of great traditional importance to the people of Santa Isabel Island, being used for walking sticks and, particularly, carved posts used to decorate buildings (Hancock & Henderson cited in Wilson & Pitisopa 2007).

Exploitation of the nickel deposits by SMM Solomon Limited could have a significant impact on the island's remaining *Tubi* populations (Wilson & Pitisopia 2007) as they are mainly found in low diversity lowland forest on ultramafic-derived soils.

Three conservation areas have been identified by local people: Noinoi River to the southeast of Koisisi Village; an area on the Kolorashu River to the northeast of Alualu Village; and a sizeable piece of land which begins to the east of Silighodu and runs to the southeast of Silighodu around the Jarihana River down to Hohogle River. None of the areas identified for conservation are in zones which have been identified for Project infrastructure. This suggests there is no competing need for land and waterways which may cause problems. To date, Project design has incorporated the identified local conservation areas identified by local conservation people in order to avoid or minimise impacts to those areas. Refer to Figure 4-39 for protected areas.

4.15.3.6 Increase in general standard of living

Community consultation indicated a number expectations which included:

- improvements in housing and social infrastructure
- improvements to health and associated services
- increased access to education and training opportunities
- increased business development opportunities
- improved local employment opportunities for all, including women and youth.

Without the Project it is unlikely that these benefits would arise for the local communities in the Project area.

4.15.3.7 *Population increase*

During peak construction up to 500 workers will be required. Some of these will come from the Philippines and other overseas locations and will be mobilised to and from Santa Isabel Island in accordance with their roster arrangements. Additional pressures will be caused by people from other islands who will come to Santa Isabel Island with the expectation of securing employment. Some Solomon Islanders who live on the other islands but may have links through kinship or marriage with those indigenous to Santa Isabel Island will also re-locate to the island in the hope of using their relationship ties to be employed as part of the mine workforce.

Should rapid population influx occur as a result of the Project, without proper mitigation strategies it has the potential to result in the following:

- overcrowding within existing communities
- temporary squatter settlements
- population imbalance associated with higher demand for a younger male construction workforce
- increased demand on social infrastructure i.e. health and education services
- increased pressure on current air and sea carriers leading to an escalation in the cost of transport for local people
- a move away from local traditional lifestyle and cultural practices (local Isabel people associated rapid population influx with potential loss of respect for customary rights and traditional ways. This opinion was based on previous experiences with population influx from logging projects in the area).
- increased incidence of disease
- increased incidence of obesity and other health problems caused by an increase in availability and consumption of processed foods
- social disharmony arising from ethnic tensions, increased anti-social behaviour and increased crime and violence caused by jealousy and resentment toward those who have more money or employment prospects, or towards those who inter-marry with others from different tribes or ethnic groups.

4.15.3.8 *Increased demand on local social services and infrastructure*

An influx of workers from other provinces and/or other countries along with general inter-island population influx arising as a result of project opportunities, will increase demand for and on local social services such as health, education, policing and other social infrastructure in the Project area.

4.15.3.9 *Increased anti-social behaviour*

Villagers on Santa Isabel Island reported that the logging industry (and to a lesser extent the employment of exploration workers by SMM Solomon) has had a negative impact on their lifestyles as it has brought undesirable social behaviours:

- drunkenness caused by irresponsible consumption of alcohol
- increase in single Mothers as local girls become involved with workers who subsequently do not take responsibility for any ensuing offspring
- increase in sexually and other transmitted diseases
- erosion of traditional values as local youths are influenced by the values and behaviours of imported workers.

These impacts are anticipated by Santa Isabel Islanders to be aggravated by the influx of foreign workers for the construction phase of the mine.

4.15.3.10 Gender imbalance in local population

Within the Project area, the villages closest to Project infrastructure, particularly the accommodation camp and mining areas are more likely to be impacted by the influx of a largely male construction workforce. In tenement D, the village of Leleghia, is more likely to be impacted than other villages as it is situated in relatively close proximity to the port and associated road and sea transport routes for the project. The villages of Kolomola and Gagaolo may also be impacted if the deposit situated in close proximity to these villages is exploited, the associated mine road will also pass through both villages.

In tenement E, the Villages of Midoru, Japuana and Lepi are all likely to be impacted by the influx of construction workers due to their close proximity to proposed port and mine areas.

Based on estimated data collected in 2010, a gender imbalance already exists in Leleghia Village (male 214, female 136) and this will be further exacerbated by the influx of an additional population of men to the Province. Leleghia Village is a Priority 1 village located in Tenement D, it is in close proximity to the port area and relatively close to the proposed accommodation camp and mining industrial areas.

4.15.3.11 Loss of and/or restricted access to port site areas

The establishment of the Project and in particular the port construction activities will create a number of challenges associated with accessibility to land and waterways which are currently used for accessing villages, hunting, fishing, gardening and other livelihood activities.

During the construction period it is possible that some access restrictions will be imposed on sea and land routes normally utilised by local people travelling in or near a number of areas. Due to mining some people such as local fishermen will experience delays when accessing local fishing grounds or travelling within the proposed Port.

No known gardens are located within the tenement boundaries. However, in the event that a garden is located within these boundaries, any potential loss of gardens as a result of the Project will need to be addressed with the landowners and affected people through negotiation of Surface Access Rights and as per section 32 of the Mines and Minerals Act. Collaboration with relevant landowners, affected community and organisations (i.e. specialist local agricultural agencies) may be required to identify suitable sites to establish new garden areas.

4.15.3.12 Access and usage of old mining areas and/or infrastructure

Communities should be participants in decisions about post-mine site usage. Revegetation is just one option that is available for old mine site areas. If the site is stable and poses no health and safety risks, there is potential for the area to be used for other purposes (i.e. farming, recreational, housing, social services, etc.). Given that the Project area has limited cleared areas for housing, social and recreational infrastructure, consideration should be given to alternative uses for old mine site areas.

4.15.4 Impact Assessment

A risk assessment of potential impacts to existing communities and society is presented in Table 4-48.

Table 4-48 Assessment of Potential Impacts on Existing Communities and Society

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
6.1.1 Disturbance to daily lives and activities of local villagers	•	•	•	•	•	•	Negative	Local	Medium (short-term) Low (long-term)	Short-term (high) Long-term (low)	Highly Probable	Medium	Medium	Ongoing communication about the impacts associated with the construction period prior to construction; and mining activities prior to operations. Implementation of Grievance Procedure. Avoid mining ore bodies that would result in the relocation of a village . Loss of gardens will need to be addressed with landowner and affected people through a negotiation of surface access rights as per Section 32 of the Mines and Minerals Act.	Low	High
6.1.2 Social Inequality					•	•	Negative	Local & Regional	Medium	Long-term	Probable	Medium	Medium	Collaborate with relevant organisations (such as government, church and community leaders) to develop strategies and programs to address potential social inequality.	Low	High
6.1.3 Increased transport options and linkages		•	•	•	•	•	Positive	Local & Regional	High	Long-term	Highly Probable	High	High	No mitigation strategy required.	Medium	High

Table 4-48 Assessment of Potential Impacts on Existing Communities and Society

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
		•	•	•	•	•	Negative	Local & Regional	High	Long-term	Highly Probable	High	High	Education process to inform local people about the transport timetable on both water and land to ensure safety. Joint initiatives with relevant organisations to develop strategies to address smooth transition of Project and public transport issues and shared facilities (where appropriate). Have a transport plan in place well in advance of commencement of construction.	Medium	High
6.1.4 Gender Inequality		•	•	•	•	•	Negative	Local & Regional	High	Short-term	Highly Probable	Medium	High	Targeted employment opportunities for women. Introduction of Women's Leadership Training. Joint initiatives with partner organisations and local women's groups to address gender inequality. Ensure gender specific accommodation and ablutions available to cater for women.	Medium	High
		•	•	•	•	•	Positive	Local &Regional	High	Long-term	Highly Probable	High	High	No mitigation required	High	High

Table 4-48 Assessment of Potential Impacts on Existing Communities and Society

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
6.1.5 Loss of Flora and Fauna for social use	•	•	•	•	•	•	Negative	Local	Medium	Permanent	Probable	Medium	Medium	Work jointly with relevant government officials (environment and forestry) and landowners to ensure minimal impacts to Tubi trees and other important flora of social importance such as medicinal herbs . Impacts to fauna of social importance (i.e. freshwater fish stocks) is done selectively with due consideration to the environment and living creatures.	Low-Medium	Medium
6.1.6 Increase in General Standard of Living					•	•	Positive	Local and Regional	Medium	Long-Term	Probable	High	High	No mitigation required	High	High
6.1.7 Population Increase	•	•	•	•	•	•	Positive	Local and Regional	Medium	Long-Term	Highly Probable	High	High	No mitigation required	High	Medium
	•	•	•	•	•	•	Negative	Local and Regional	High	Long-Term	Highly Probable	High	High	Collaborate with Government, traditional governance structures and landowners to address informal influx issues and associated impacts. See mitigation strategies listed in the Impact Assessment Report - Workforce Influx.	Medium	Medium

Table 4-48 Assessment of Potential Impacts on Existing Communities and Society

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
6.1.8 Increased demand for social services and infrastructure					•	•	Negative	Local and Regional	High	Long-Term	Highly Probable	High	High	Provision of health services and training to all SMM employees. Collaborate with relevant organisations to develop strategies to increase local social services. Project to provide a stand alone health service within the accommodation camp.	Medium	High
6.1.9 Increased anti-social behaviour					•	•	Negative	Local and Regional	High	Long-Term	Probable	High	High	Work with local government, churches, leaders and NGO's to develop strategies to minimise anti-social behaviours, adverse health and safety impacts and law and order issues	Medium	High
6.1.10 Gender imbalance in local population	•	•	•	•	•	•	Neutral	Local	High	Short-Term	Probable	Low	Low	Recruit and train women	Low	Medium
6.1.11 Loss of, or restricted access to, Port Areas		•	•		•	•	Negative	Local	High	Long-Term	Highly Probable	High	High	Early and ongoing communication with affected communities to discuss the possible construction and operation related shipping activities and the impact of the Port exclusion zone. Consider logistical strategies to	Low	High

Table 4-48 Assessment of Potential Impacts on Existing Communities and Society

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation/ Management Actions	Significance With Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
														achieve safe access for local people to their home, village, schools and thoroughfare to important river fishing and garden areas in the vicinity of the Port		
6.1.14 Access and Usage of old mining areas and/or infrastructure	•	•	•	•		•	Positive	Local	Medium	Long-'term	Probable	Medium	Medium	Identify infrastructure to be left intact post mine closure in consultation with local communities and government.	Medium/ High	High

4.15.5 Mitigation Measures

Proposed mitigation measures, of provincial and national legislation and international guidelines, are to reduce negative impacts and optimise positive impacts to meet the requirements outlined below.

4.15.5.1.1 Disturbance to Daily Lives and Activities of Local Villagers

Mitigation measures to minimise the disturbance to the daily lives and activities of local villagers could include:

- Ongoing information and education about impacts, benefits and mitigation at key milestones during the Project. Communication via local newsletters, radio, presentations, and via a Local Stakeholder Reference Group made up of representatives from local villages and tribal groups will assist with information dissemination.
- Implementation of a Grievance Procedure. Information and education about the Grievance Procedure will also be given.
- Loss of gardens will need to be addressed with landowner and affected people through negotiation of surface access rights and as per section 32 of the *Mines and Minerals Act*.
- Work with relevant landowners, affected community and organisations (i.e. specialist local agricultural agencies) to identify suitable sites and re-establish new garden areas if required.
- Develop and implement a Stakeholder Engagement Plan for both the construction and operations phases to ensure local people are regularly engaged and informed about:
  - What to expect prior to and during the construction and operations phases.
  - Project benefits (i.e. employment, procurement and education/training provided).
  - Social investments made by SMM Solomon through joint community development initiatives.
- Ensure provision for ongoing monitoring and annual independent auditing of project affected people's concerns about Project impacts.
- Maximise opportunities and initiatives for collaboration with local people to enhance their livelihoods and lifestyles.
- Work with other relevant organisations to address social impact issues and implement strategies and initiatives to minimise those impacts.
- Transition from operations to decommissioning and closure will require special management strategies to be in place prior to closure. These should be outlined in both a preliminary closure plan and in more detail in the final closure plan.
- Introduce measures to ensure that all Project contractors and sub-contractors minimise disruption and harm to local communities in the Project area. For example:
  - Dust suppression using water sprays on un-surfaced roads and earthwork sites as required.
  - Noise control by use of construction equipment with proper muffler systems.
  - High intensity, intermittent noise impacts will be limited to day time activities only and coordinated with local residents as required.
  - Directional lighting and light barriers and diffusers will be used to mitigate light impacts on local communities.

4.15.5.1.2 Social Inequality

Explore opportunities for joint initiatives with relevant organisations (such as government, church, community leaders and employment, education and training institutions) to develop strategies and programs to address potential social inequality issues.

Initiatives may include:

- Education and training for jobs for local people with additional training in financial planning, management and governance.
- Special initiatives for vulnerable groups.
- Joint initiatives with local chiefs, women's organisations and churches to actively retain and promote the existing social values of community support and neighbourliness.

Initiatives should aim to target support for the wider general community (not just landowners) in the Project area and the Province of Isabel. Provision for initiatives aimed at building capacity and self sufficiency among vulnerable groups should be included.

Where this is not possible (due to limitations associated with vulnerability), joint collaboration with partner organisations to encourage and/or assist local welfare groups to address these needs through grants and funding as appropriate.

4.15.5.1.3 Improvements to Transport Linkages

Ongoing communication with transport regulators and operators to minimise adverse impacts on local transport services.

Joint initiatives with relevant organisations to develop strategies to address existing and future Project and public transport issues and shared facilities (where appropriate).

Implementation of management plans to manage transport issues and social impact issues.

4.15.5.1.4 Gender Inequality

Explore joint initiatives with relevant organisations and local women to address gender inequality that might arise as a result of lack of access to Project benefits for local women in project affected communities.

Initiatives to promote capacity among local women could consider:

- Employment and training women.
- Self esteem and empowerment programs.
- Community facilities and activities for women.
- Sponsorship of women into employment education and training (in particularly young women).
- Governance and financial management programs.

See also Impact Assessment Report – Socio-economics which highlights initiatives including:

- Assisting women to develop and expand local gardens.
- Providing business development, support, and training and micro-finance funds to assist local women to start up their own local businesses.

4.15.5.1.5 Loss of Flora for Social Uses

- Work jointly with relevant government officials (environment/forestry) and land owners to ensure that clearing and felling of Tubi trees and other flora of social importance such as medicinal herbs is done selectively with due consideration to the environment. Only areas to be mined will be cleared.
- Implement re-vegetation program (in particular revegetate and replace flora used for special purposes).
- Work jointly with relevant local people, consultants or specialists, and relevant agencies to conduct further studies into preserving local freshwater food sources particularly in the identified conservation areas.

4.15.5.1.6 Population Increase

Work with government, traditional governance structures and landowners to address informal influx issues and associated impacts.

Initiatives to prevent influx by informal settlers are preferable and will provide the greatest mitigation of this impact and may include:

- An employment strategy, which ensures that people from other provinces, pursuing employment on the Project must apply through an SMM Solomon employment office on Santa Isabel Island.
- A Training Plan which includes training programs in other Provinces.
- Engineering design should include accommodation for all members of the workforce, especially during construction whether they are local workers or not. Accommodation should also include additional rooms for visiting managers and trainees receiving short-term on the job training.
- Collaborate with relevant organisations to support and promote local culture, language, traditional craft, dance and important traditional celebrations, etc.
- Compulsory Cultural Awareness Program for all staff.

4.15.5.1.7 Increased Demand for Social Services and Infrastructure

Mitigation measures to address increased demand for Social Services and Infrastructure include:

- Provision of health services and training to all SMM Solomon employees.
- Work with relevant organisations to develop strategies to increase the provision of local social services.
- Work with relevant organisations to develop strategies to increase the provision of local social services and minimise any damage to existing community infrastructure by project activities.

4.15.5.1.8 Increased Anti-Social Behaviour

Mitigation measures to address increased anti-social behaviour include:

- Collaborating with relevant organisations including local churches and youth organisations to develop strategies to minimise anti-social behaviour. Strategies may include:
    - alternative recreational activities particularly those involving young people.
    - developing an Information Education Campaign (IEC) program to promote strong family values both within the communities and within the schools. Working with chiefs and local law enforcement to prevent anti-social behaviour.
- Initiatives to improve border control security to lessen unplanned immigration.

- Discouraging the irresponsible consumption of alcohol by prescribing desirable behaviours in the accommodation camp and/or implementing testing procedures to ensure people are fit for work.
- Developing a family friendly culture by having policies and procedures that allow workers to attend to family responsibilities.
- Encouraging traditional values and cultural practices by incorporating them in the workplace where possible.
- Providing all on-site staff with comprehensive cross cultural awareness training run by a community liaison officer selected from Santa Isabel Island.
- Working with relevant organisations, particularly specialist organisations, to:
  - develop strategies to minimise unsafe sexual practices and manage the spread of communicable sexually transmitted diseases
  - minimise the impacts associated with the gender inequality that may occur during construction phase
  - work with law enforcement agencies to achieve an increased police presence in the Project area to reduce crime and violence, and
  - employment of private security officers to provide Project security.

4.15.5.1.9 Gender Imbalance in Local Population

Mitigation measures to address the any gender balance in population include:

- Recruitment strategy giving opportunities to women.
- Training for local women to build skills and capacity.

4.15.5.1.10 Loss of Existing Access Routes and Garden Areas at Port Site

Mitigation measures to address the loss of garden areas and access to community sites include:

- Communication about loss of access to port site lands and waters and associated health and safety risks associated with trespass.
- SMM Solomon to create an alternative access route for local people to the lands beyond the port site beyond the port exclusion zone.
- Damage to and loss of access to port site lands and waters by land owners and local people will need to be negotiated as part of negotiation of surface access rights as per Solomon Island legislation.

4.15.5.1.11 Access and Usage of Old Mining Areas and/or Infrastructure

Identify infrastructure to be left intact post-mine closure in consultation with local communities and government.

Strategies may include:

- Re-establishing vegetation identified by the local communities and land owners where feasible (i.e. trees or other flora important for social use, housing, craft, medicine, etc.).
- Conversion of land to other social uses (i.e. farming, pasture land, residential, recreational, commercial or industrial land) where it is safe to do so.

4.16 Cultural Heritage

This section describes:

- The known cultural heritage values within SMM Solomon's tenements on Santa Isabel Island.
- The potential impacts to the cultural heritage values that may result from the Project.
- Mitigation measures for protecting or enhancing the cultural heritage values.

Further details are provided in the Impact Assessment Report – Cultural Heritage.

4.16.1 Legislative Framework

The Solomon Islands *Environmental Act 1998* is brief in its requirements concerning cultural heritage where an EIS is being carried out. The sole requirement states that a survey be carried out concerning National Heritage items or traditional artefacts in Section 23 (SIG 1998) of the Environment Act.

The *Isabel Province Preservation of Culture Ordinance* outlines the process which must be abided by in relation to development in the province and cultural heritage. The Provincial Ordinance, Section 8 (1), dictates that the register of protected places must be consulted and that an inspection of the proposed development area must be carried out prior to the development of the area.

As no further specifications are dictated by legislation, international standards were applied for the purposes of the EIS and the cultural heritage surveys.

Permission was sought from every landowning group who is a signatory to the Surface Access Agreement (SAA) for the existing tenements prior to undertaking the cultural heritage surveys. No cultural heritage sites were visited without the consent of the tribe or clan on whose land it lays. For the areas within the tenements where no consent was given by the landowning tribe or clan for the cultural heritage survey to be carried out, the area was not surveyed. Once permission is negotiated and given by these landowners, the Impact Assessment Report – Cultural Heritage will be updated.

Currently, the report that has been compiled does not fully meet international standards, however once the ethnography and the remainder of the archaeological data have been collected, and the Impact Assessment Report – Cultural Heritage has been updated, it will meet international and best practice standards.

4.16.2 Standards Applied

The following international standards and guidelines were taken into account when conducting the impact assessment of the Project on the cultural heritage within SMM Solomon's tenements:

- As its parent company, Sumitomo Metal Mining Co. Ltd., is a signatory of the ICMM, SMM Solomon subscribes to the responsible extraction and production of minerals and metals and recognises that mining activities will affect the land, territories, resources and way of life of Indigenous peoples (ICMM 2010). ICMM members recognise the right of Solomon Islanders to maintain their culture including their cultural heritage whether tangible or intangible (ICMM 2010; IFC 2011). ICMM and its members subscribe to the UN Guidelines on the Protection of the Cultural Heritage of Indigenous Peoples, which focuses on ensuring the protection of Indigenous knowledge, intangible heritage, tangible heritage and the promotion of their cultural expressions that are generally collectively maintained and inter-generational in nature (UN 2008).
- International Finance Corporation (IFC) policy and performance standards refer to the social and environmental assessment and management system, labour and working conditions, pollution prevention and abatement, community health, safety and security, land acquisition and involuntary resettlement, biodiversity conservation and sustainable natural resource management, Indigenous peoples and cultural heritage.

- Performance standard 8 endeavours to protect cultural heritage from the adverse impact of project activities and supports its preservation (IFC 2011). It also promotes the equitable sharing of benefits from the use of cultural heritage in projects (IFC 2011). The standard also recognises the importance of cultural heritage for current and future generations and it is consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage (UN 1975).
- The Equator Principles (EP) are a credit risk management framework for determining, assessing and managing environmental and social risk in project finance transactions (TEPA 2011). The EP are based on the IFC standards on social and environmental sustainability and on the World Bank Group Environmental, Health and Safety Guidelines.

4.16.3 Methodology

The existing cultural heritage values within the Project area have been assessed based on:

- Desktop research, where a series of databases were used to identify relevant papers, documents and books containing information pertaining to cultural practices and the archaeology of Melanesia, the Solomon Islands and Santa Isabel Island. Further research was carried out through reliable websites, the provincial and national legislation and all relevant international standards.
- Field surveys were carried out by John Keopo (a native Solomon Island expert) and AECOM Philippines specialist and SMM Solomon community liaison officers with the assistance of tribes and clans.

The field surveys focused on the areas most likely to be affected by the Project. This included prioritising areas impacted by the mine footprint, including:

- mine areas
- mine ore handling and transportation
- mine Infrastructure
- port facilities.

The field surveys and community consultation were carried out by the following SMM Solomon team:

- Mr. John Keopo, consultant archaeologist to SMM Solomon.
- Ms. Ame Garong, AECOM Philippines archaeologist.
- Mr. Alber Husin, AECOM Philippines anthropologist.
- Dr. Nestor Castro, AECOM Philippines archaeologist.

The team also included SMM Solomon community liaison officers who accompanied the teams throughout the fieldwork. The team also included members of the tribe or clan who were selected by the Chief of the tribe or clan as guides. Fieldwork was undertaken in late 2011 and early 2012.

4.16.3.1 Community Consultation

A number of communities in or surrounding Isabel Tenement E were consulted during the community consultation process.

Table 4-49 Communities consulted during the community consultation process

Date	Community
24 November 2011	Lepi Village
25 November 2011	Leleghia Village
27 November 2011	Midoru Village
29 November 2011	Kaevanga Village
07 December 2011	Kosisi Village
07 December 2011	Hagheulu Village
08 December 2011	Talise Village

The community consultations were run in conjunction with the land use and tenure team. They aimed to inform the community of the schedule and process in place to conduct the field surveys for the cultural heritage study and the development of a CHMP.

4.16.3.2 Field Surveys

The purpose of the field surveys was to conduct interviews with the tribal and clan chiefs as well as with knowledgeable elders and women; intensive field surveys including site visits to cultural heritage sites were also conducted. The collection of both archaeological and ethnographic data is central to cultural heritage field surveys.

The field surveys were carried out in Tenement E with Thogokama tribe. Table 4-50 lists the members of the tribe who participated in the field survey.

Table 4-50 Members of Thogokama Tribe who Participated on the Archaeological Field Survey Work on Santa Isabel Island

Date	Name of Participants	Title	Village
28/11/2011	Forest Biko	Chief	Lepi
28/11/2011	Brian Alisa	Member of Thogokama tribe	Lepi
28/11/2011	Ben Devi	Chief	Lepi
28/11/2011	Nicholas Love	Member of Thogokama tribe	Lepi
30/11/2011	Colwin Pitu	Chief	Midoru
30/11/2011	Alfred Mono	Chief	Midoru
30/11/2011	William Sele	Member of Thogokama tribe	Lepi
30/11/2011	Colwin Vikea	Member of Thogokama tribe	Lepi/Midoru
30/11/2011	Nicholas Supa	Member of Thogokama tribe	Midoru

There are a number of landowning tribes within SMM Solomon's tenements D and E which were identified during the land use and tenure fieldwork (refer to Impact Assessment Report - Land Use and Tenure).

A total coverage for the whole tenement area on Santa Isabel Island was not possible during the archaeological field work in 2011. This was due to local issues such as, tribal land disputes amongst the local communities, absentee of tribal chiefs and several chairpersons. Movement of the local communities for the preparation of Christmas season.

The landowning tribes are located within the Project area:

1. Thogokama.
2. Logokama.
3. Vihuvunagu.
4. Posomogo.
5. Roughukama.
6. Naprufunei/Namhirufunel.
7. Fafago.

The boundaries of landowning tribes in and surrounding Isabel Tenement D and Isabel Tenement E, based on the current Land and Access Agreement records, are shown is Figure 4-36.

Methods for the assessment of cultural heritage values, including confidentiality restrictions, limitations and exclusions, are further described in the Impact Assessment Report- Cultural Heritage.

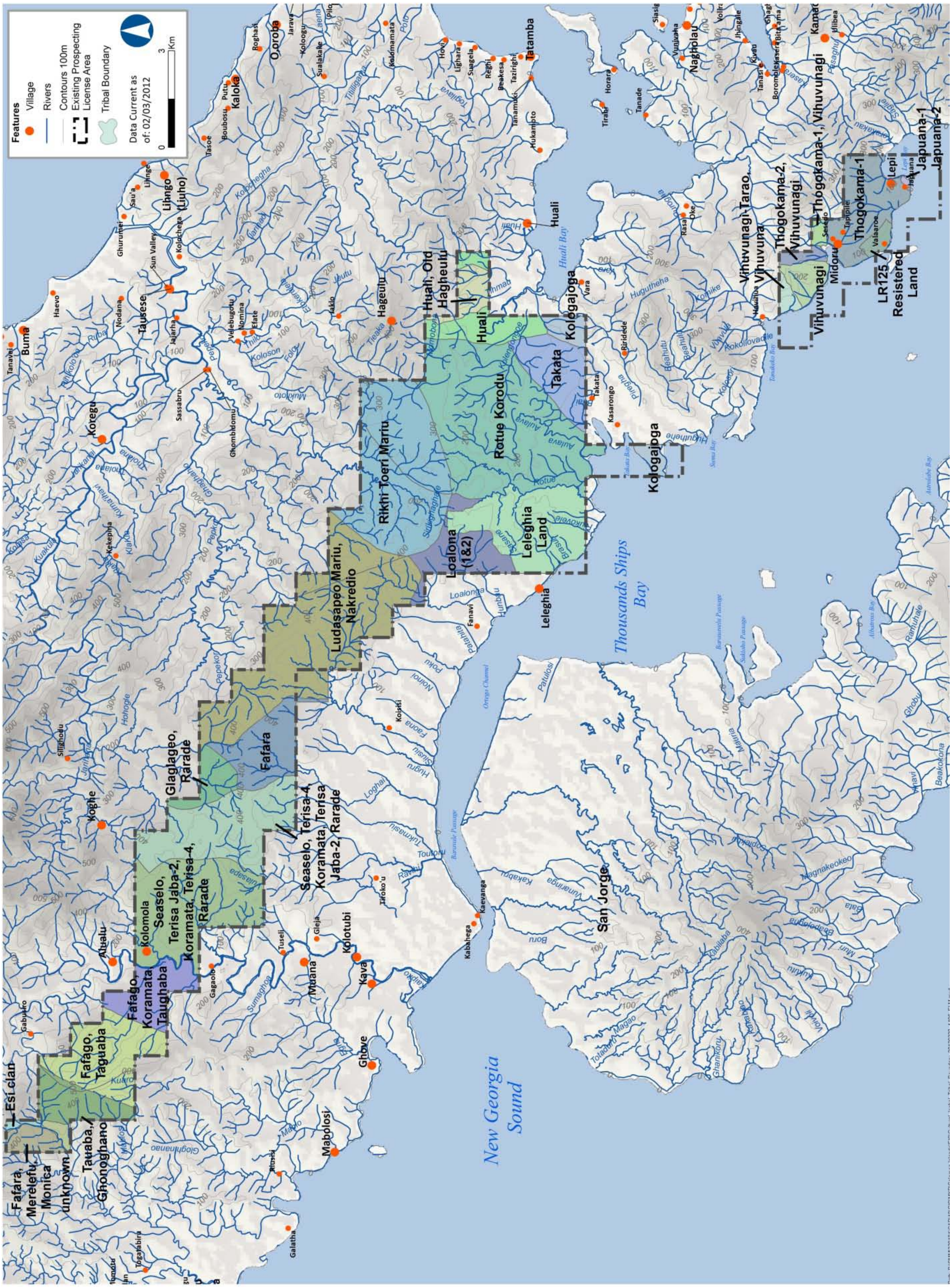

Figure 4-36 Boundaries of tribes in and surrounding Isabel Tenements D and E

4.16.4 Existing Values

The existing values for the cultural heritage of SMM Solomon's tenements can be divided into values for tangible (archaeological) and values for intangible (ethnographic) heritage. Consequently, there are two sides to cultural heritage surveys and conducting this type of survey requires input from both archaeologists and anthropologists. More detailed archaeological and ethnographic surveys are still to be carried out and the values for cultural heritage further defined.

In the Solomon Islands, cultural heritage sites may include, but are not limited to the following: burial sites, places of worship, archaeological remains, sacred burial sites (tambu sites), caves, traditional boundary markers, battle grounds, cultivation areas, etc.

Cultural heritage sites in the Solomon Islands, including Santa Isabel Island are protected and are not typically disclosed to individuals outside of the individual tribes and clans. In order to gather data for the cultural heritage assessment in the tenement areas, non-disclosure agreements need to be signed between the Project and each village, tribe or clan. These agreements require that the location, description and significance of the sites not be made public, and as such these details have been omitted from this document.

As referenced in the Impact Assessment Report – AECOM Consulting has prepared a confidential report of findings during field work undertaken. This assessment is based on these findings.

There have been six archaeological sites identified and verified in Tenement E that are located in areas where they may be potentially impacted by the Project, however, further research must be carried out to determine the size of each site and the Project's potential impact upon them. Similarly, there are an additional ten unverified sites in Tenement E which must be subjected to cultural heritage in order to determine their size and the Project's potential impact upon them.

In Tenement D, there are 61 unverified sites identified and 59 of these are located on mineral deposits of interest to SMM Solomon or in areas designated for support infrastructure. A full cultural heritage survey must be carried out in Tenement D in order to determine the impact of the Project upon them and any other cultural heritage sites as directed by the landowning tribes and clans.

SMM Solomon employees identified a series of areas as potential cultural heritage sites during exploration of both tenements. The majority of the sites are archaeological sites which are located in the vicinity of the saprolite or limonite deposits. The SMM Solomon personnel who collected the information are not trained in cultural heritage management, archaeological methods or ethnographic methods, as such, the sites have been labelled *"unverified"* pending a full cultural heritage survey. It must be noted that the locations have not been verified and further fieldwork by both archaeological and anthropologists must be carried out in the area prior to the construction phase of the Project.

Some of the sites identified do not fall under the strict classification of cultural heritage. It is expected that this list will change once a full cultural heritage survey has been carried out.

4.16.5 Potential Impacts

A non-disclosure agreement confidentiality prohibits publication of the location, description and significance of cultural heritage sites within the tenement areas. As a result, the potential impacts on individual sites have been omitted from this document. For the purpose of this report, the potential impacts to cultural heritage within the tenement areas have been grouped below as follows:

- Irreversible damage of known cultural heritage sites.
- Irreversible damage or disturbance of unknown cultural heritage sites (chance finds).

It is noted that in order to properly determine the impact to cultural heritage, first an assessment of each individual site is required, followed by a cumulative assessment which considers the total impact to affected communities. Identification and assessment of the potential impacts provided in this document is therefore considered incomplete. However, this limitation is a result of the requirements put in place by the communities themselves.

4.16.5.1 Irreversible Damage or Disturbance of Known Cultural Heritage

Irreversible damage or disturbance of known cultural heritage sites, whether tangible or intangible, may lead to the loss of world heritage and Solomon Islands heritage.

In terms of archaeological significance, settlement sites provide high potential for yielding future insights into the nature and antiquity of Santa Isabel Island cultural heritage through the likelihood of (dateable) subsurface cultural materials. Mortuary and shell valuable sites are likewise of high archaeological significance.

In terms of ethnographic significance, language and the oral tradition attached to the cultural heritage sites provide in-depth insights into everyday lives of the inhabitants of Santa Isabel Island. They are also singularly important in identifying the origin of settlement patterns and migration of Melanesian traditions through the South Pacific. As well, providing a rich and complex history of the ancestors of the inhabitants in the area, the oral histories provide a complex kinship matrix which is yet to be explored in depth.

4.16.5.2 Irreversible Damage or Disturbance of Unknown Cultural Heritage (Chance Finds)

During earthmoving activities, the irreversible damage or disturbances of unknown cultural heritage sites is possible. This may lead to the loss of world heritage and Solomon Islands heritage.

4.16.6 *Impact Assessment*

A risk assessment of potential impacts to cultural heritage is presented in the table below. As discussed above, the confidentiality of individual cultural heritage sites within the tenement areas and limited fieldwork to date has led to. The potential impacts to cultural heritage have been grouped into two categories: (1) known cultural heritage sites, and (2) unknown cultural heritage sites (chance finds).

Table 4-51 Assessment of Potential Impacts on Cultural Heritage

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Irreversible damage of known cultural heritage sites.	•	•	•	•	•	•	Negative	National	High	Permanent	Improbable	High	High	A site significance matrix may facilitate in preventing the accidental damage or disturbance of known cultural heritage sites of significance and will be addressed in the cultural heritage management plan.	Medium	Medium
Irreversible damage or disturbance to unknown cultural heritage sites.	•	•	•	•	•	•	Negative	National	High	Permanent	Definite	High	High	Monitors will screen areas during earth disturbing activities to identify and document sites prior to further action.	Medium	Medium

4.16.7 Mitigation Measures

Mitigation measures to protect cultural heritage, as determined according to provincial and national legislation and international guidelines, are outlined below. Further details are provided in the Cultural Heritage Management Plan in Chapter 5.

4.16.7.1 *Irreversible Damage of Known Cultural Heritage*

A site significance matrix will assist in preventing the irreversible damage or disturbance of known cultural heritage sites and will be the basis for the development of site specific cultural heritage management plans. The matrix will:

- be developed by a suitably qualified archaeologist and a suitably qualified anthropologist
- be developed by the cultural heritage specialists and the landowning tribe or clan
- contain a detailed record of the significance of each site taking into account:
    - the perceptions of significance expressed by landowners
    - the scientific, historical, educational, and aesthetic significance of the site.
- be the basis for the site specific cultural heritage plan
- where avoidance is not practicable, outline a process of negotiation for the landowning tribes.

Due to limitations imposed by the confidentiality agreements between the Project and local communities, a site significance matrix has not been presented here. In addition, as mentioned in Section 4.16.5, the data collected to date requires verification and further investigation by qualified personnel. As a result, this should be considered a preliminary list of mitigation and management measures, which will be updated and expanded once detailed field surveys have been completed.

4.16.7.2 *Irreversible Damage or Disturbance to Unknown Cultural Heritage Sites (Chance Finds)*

A monitoring program will ensure that chance finds are not irreversibly damaged and/or disturbed during any of the earth moving activities to be carried out throughout the Project. Monitor(s) should:

- be selected by the tribe or clan on whose land the earth disturbance is occurring. Where a land dispute is in progress, a monitor from each tribe or clan claiming the area will be present
- be knowledgeable in all aspects of cultural heritage relating to his or her tribe
- be knowledgeable and enforce site specific cultural heritage management plans
- be knowledgeable in all aspects of the procedures and management of previously unknown cultural heritage sites.

4.17 Land Use and Tenure

This section describes:

- existing land use and tenure values within the Project area
- the potential impacts from the operation and construction phases of the Project
- the mitigation measures to protect existing land use and tenure values.

4.17.1 Methodology

The existing land use and tenure values within the Project have been assessed based on:

- Desktop research, where a series of databases were used to identify relevant papers, documents and books containing information regarding land use and tenure in Melanesia and the Solomon Islands including Santa Isabel Island. While there are few works which discuss Santa Isabel Island specifically, a large number of sources were identified as relevant and are referenced in this report. Further research was carried out via the internet through relevant and reliable websites. This information is also used and referenced in this report.

The Land Use and Tenure baseline study produced by Hatch Associates was also consulted in the planning stages of this report.

- Fieldwork, which included two blocks of site visits by both Hatch and AECOM Philippines. The fieldwork was carried out by both companies independently and the AECOM Philippines Land Use and Tenure Report were taken into account throughout this document (Appendix A).

Qualitative and quantitative data was collected through a series of ethnographic interviews with tribal, clan and village chiefs and knowledgeable elders from project affected villages in Isabel Tenement D and Isabel Tenement E (refer to Table 4-52).

Table 4-52 Chiefs and Community Representatives Interviewed

Tribe/Clan/Village	Designation	Name	Village of Residence of Chief
Tribe	Thogokama Tribal Chief (Bugotu House of Chiefs)	Agnes Kou	Lepi
Village	Community member	Jesse Lezi	Lepi
Village	Number 1 Chief of Midoru	Colin Pitu	Midoru
Village	Village Chief	Aldin Auro	Leleghia
Village	Chairman of the Community of Vulavu Village	Steve "Carlos" Thagimana	Vulavu
Village	Elder Chief, Deputy Chairman of the Community	John Edwards	Vulavu
Village	N/A	Mr. Lot Jnr. and community representatives	Kosisi
Tribe	Posamago Tribal Chief	John Selwin Hiro	Huali
Village	Village Chief (Huali Village House of Chiefs)	Samuel Genora	Huali
Tribal	Tribal Chief, Chairman (Hograno House of Chiefs)	Johnson Leamana	Kolotubi

4.17.2 Existing Values

4.17.2.1 Tenure

Land tenure within the Project area is defined in terms of tribal kinship, including land boundaries, customary management of land and seas and the regulation and maintenance of these boundaries. Tribal boundaries, the roles of tribal chiefs and the governance of villages fall under the kinship system, although Western governance has been incorporated across the area.

Foukona (2007) indicates that 26% of Isabel province is either government registered land or land that has been surveyed by the Government but remains unregistered because of land disputes. In 2001, it was estimated that almost 75% of Isabel province was customary land owned by local tribes. The land directly opposite Cockatoo Camp is the only registered land (LR125) within SMM Solomon's tenements. The customary owners reside at Valaaroe village.

The Solomon Islands Government recognises customary land ownership, and customary land is owned jointly by the tribes and clans and the Solomon Islands Government. Further, all minerals above ground or underground are considered to be owned by the people of the Solomon Islands and the Government of the Solomon Islands pursuant to the Mines and Minerals Bill 1990 (SIG 1996) and the Mines and Minerals Act 1996 (SIG 1996).

Currently, the customary owners of SMM Solomon's tenements have input into the decision over who enters their land and for what purpose. There are a large number of legal precedents in the Solomon Islands relating to the expulsion of logging companies from customary land because of the objections of the customary owners.

SMM Solomon entered into a SAA with some of the tribes and clans who are the land owners of the tenement on Santa Isabel Island. However, because of land conflict and cultural bias, these boundaries are incomplete and some of the tribes and clans have been excluded. If a resolution to the tribal and clan boundaries is not reached, the Solomon Islands Government may, pursuant to the Mines and Minerals Bill of 1990 (SIG 1996) and Mines and Minerals Act 1996, compulsorily acquire tribal and clan lands in the public interest.

Santa Isabel Island is divided into four language areas or districts; each language area contains several tribes which at times are referred to as clans by the landowners. Santa Isabel Island has eight tribes, the chiefs of each forming the Santa Isabel Council of Chiefs, which is presided over by the Paramount Chief of Santa Isabel.

Tribal chiefs are customarily men, however the people of Santa Isabel follow a matrilocal tenure and kinship system where the ownership of land is transferred through women. Where there are no women in a family, the landowning matriarch of the family may adopt a female relative in order for the land to be kept within the family.

Each family is considered to be a clan and each clan is presided over by a clan chief or spokesperson. Within Tenements D and E, there are approximately thirty-three clans. Most unresolved land disputes occur at the clan level.

Tribal and clan boundaries traditionally run along geographic features however historical cultural and land compensation transactions have blurred these lines, causing a series of disagreements and disputes over property limits. Due to a number of reasons, including compensation for logging, the tribes and clans have had to determine exact boundary or border locations, a process which is still taking place in Tenements D and E.

The introduction of Western governance has also influenced the kastom governance of tribes and villages. Village chiefs are elected by the community based on their ability to act on behalf of the community, their experience working within the Solomon Islands Government or their education levels achieved according to Western culture. A village chief's lineage is also taken into account, with some villages preferring to elect chiefs within the chiefly line. Refer to Figure 4-37.

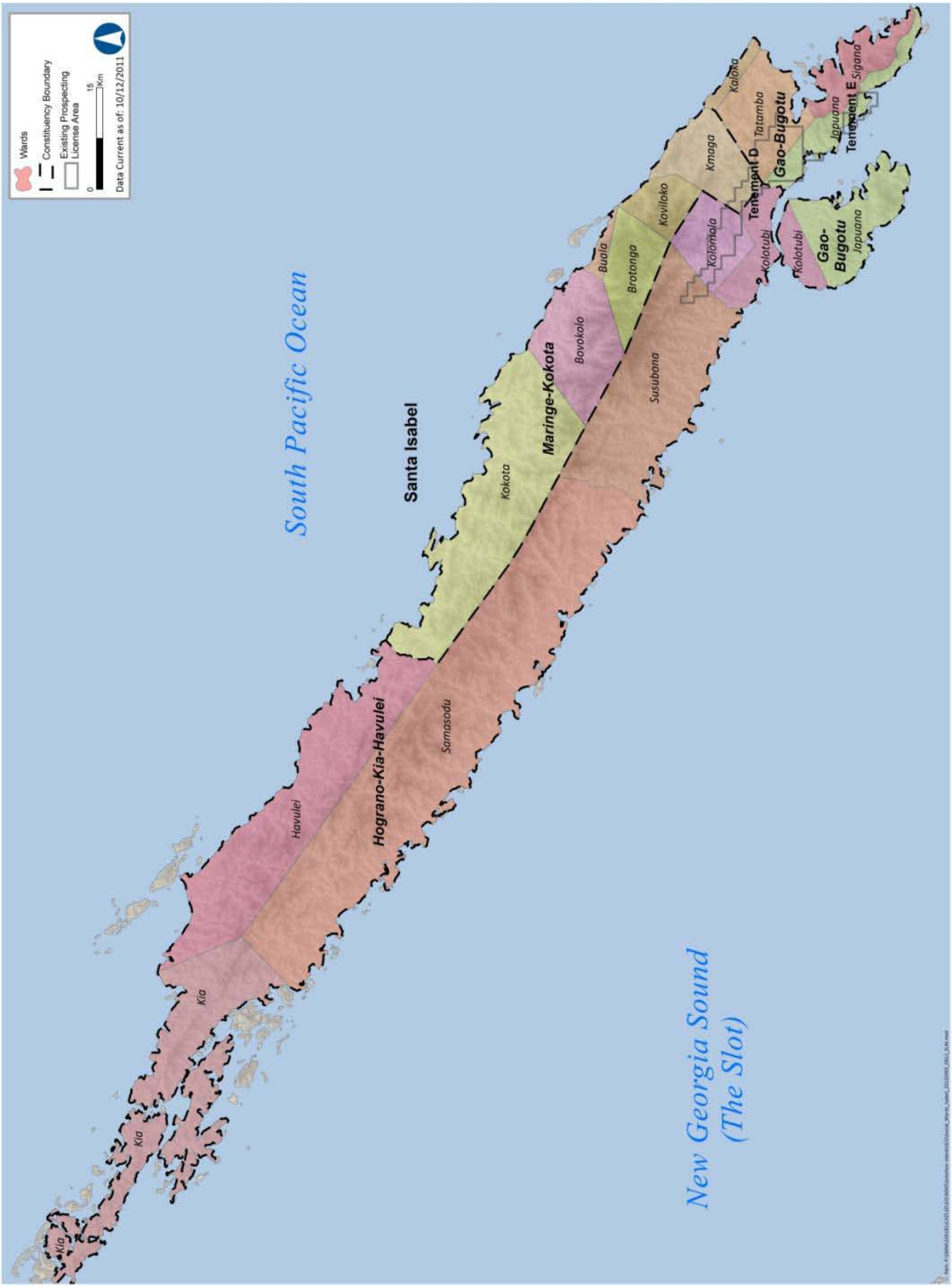

Figure 4-37 Administrative Constituencies and Wards of Isabel Province, Santa Isabel Island

4.17.3 Land Use

Customary land use in Santa Isabel Island has traditionally included subsistence horticulture, hunting, fishing, travel and religious purposes (T. Jansen et al. 2006; T. Jansen, Mullen, B.F., Pollard, A. A., Maemouri, R.K., Watoto, C. & Iramu, E. 2006; J. Jansen and Sirikolo 2010; Kwa'ioloa and Burt 1997; McFee 1965; Miller 1980; Philsooph 1971; H. W. Scheffler 1926-1981). These land uses have been slightly altered by the introduction of Western style governance, cash economy, logging, colonialism and prospecting.

Logging roads, gravel roads and walking bush tracks are used for transport in the Project area. Marine transportation is generally by outboard motor boats and customary canoes. Existing roads within SMM Solomon's tenement are those constructed by logging companies, some all weather roads constructed by non-government organisations, gravel roads constructed through the Solomon Islands Roads Project and bush tracks.

The main use of land within SMM Solomon's tenement is for subsistence horticulture. Each family is allocated a plot or garden for food production. Crops are harvested daily by the women for domestic consumption. The main crops grown include; taro, sweet potato, yam, cassava, banana, pineapple, coconut, betel nut, peanut, rice and tobacco. The heavy gardening work; clearing and planting of garden areas, is carried out by the men. Crop rotation cycles are used inland where the soil lacks nutrients. Excess crops are usually sold locally in a very small scale allowing for less than 1% of cash income (MPGRD 2001).

The agricultural industry within the Project area consists of the cultivation of rice, tobacco, coffee, coconuts and the processing of copra. The majority of crops used by villagers were introduced some 4,000 years ago from South East Asia (Grant and Miller 2004). The cultivation of coconuts and the processing of copra make up the remainder of the agricultural industry within SMM Solomon's tenements on Santa Isabel Island. Agricultural expansion has been identified as an area of development within Isabel Province.

The cultivation of plantations is a practice which has been in place since the arrival of the missions in the early 1900's. There are a number of small plantations in use throughout SMM Solomon's tenement in Santa Isabel Island. Plantation crops can vary, with the most common being coconuts for the production of copra, tobacco, betel nut, kava and sago plantations.

Plantations are usually perceived as being owned by the community, however they are usually managed by an individual who pays compensation to the community for use of the land. Plantation owners typically employ local community members to work during harvest time. This is one the main sources of income for communities within SMM Solomon's tenements.

Hunting, fishing and shellfish gathering is intensively practiced throughout SMM Solomon's tenements on Santa Isabel Island, and is strictly carried out within tribal lands. Crayfish, eel, prawns, mud crab, mangrove cockle, turtle, oysters, sea cucumber form part of the catch. Opossum, pig, chicken, lizard and flying fox are hunted.

Goods and packaged food may be purchased throughout SMM Solomon's tenements in a variety of places such as village trade stores, canteens, markets and co-operatives. The market at Kaevanga is a key trading and market area for excess crops from village gardens and plantations in Tenement D and Tenement E. Produce traded and sold in Kaevanga is marketed to Honiara through the cargo and passenger boats such as the Isabella and Ortega. Excess produce from fishing and hunting activities are also sold at the market.

Villages are clusters of dwellings within tribal land; customarily the villages house a single tribe. However, some larger villages may include two or more tribes. Villages can vary in size from two dwellings through to fifty dwellings.

Village houses are customarily built from light materials of thatched sago, nipa or coconut leaves with posts and beams crafted from local hardwood trees such as tubi trees (Ironwood). The sourcing of building materials and the construction of the structures are usually carried out by the men. There are some structures in villages built from concrete, iron sheets or corrugated iron, these include: churches, meeting houses, schools and health clinics.

Isabel Province is the second largest producer of export logs in the Solomon Islands, second only to Choiseul Province. As early as 1995, the status of forest lands and logging in the country has been categorised as under a 'critical state' (Bennett 1995). Currently, formal logging operations are being undertaken in Tenement E within the areas of Midoru Village and Lepi Village, which commenced in 2009. Formal logging is also occurring within Tenement D in the area near Kosisi Village. Logging is a source of income for some tribes. Generally, the rehabilitation of logged areas has not taken place.

4.17.4 Potential Impacts

The potential impacts from the construction and operation phases of the Project are listed below.

4.17.4.1 Tribes and Clans

- The development of an inaccurate SAA will lead to further land disputes if it is not based on the tribal system rather than the clan or village system.

4.17.4.2 Village Governance

- The village governance systems could be further eroded by the influence of Western style governance structures. The Project will have particular governance structures in place and will set up organisational policies and procedures to manage the relationship between the company and the landowners. Company governance structures and organisational policies and procedures are likely to follow Western business management practices and may not correspond with customary governance.
- The village governance systems in place within SMM Solomon's tenements are not flexible enough to allow for new residents (who are not being incorporated through marriage) to acquire land. This could lead to increased land disputes.
- Population influx associated with mining and mining related activities will introduce new customs and habits which will cause friction with the landowning communities.

4.17.4.3 Land Ownership

- The determination of geographical boundaries through the legal system for the purposes of mining does not allow for the customary transference of land through the matrilocal land tenure system.
- Royalties from mining and mining related activities may not be evenly distributed in the community.
- The land ownership systems in place within SMM Solomon's tenements are not conducive to the transference of land from the customary land owners to new residents (the sale of land is not part of kastom).
- There will be an increased demand for land resulting from population influx associated with general mining activity, which could impact current ownership structures.

4.17.4.4 Land Disputes

- The land ownership systems in place within SMM Solomon's tenements are not conducive to population influx and the introduction of new residents associated with general mining activity, which may cause further land disputes with new residents.
- There will be an increased demand for land resulting from population influx associated with general mining activity, which could aggravate land disputes.

- While land is no longer used as compensation, it was historically used for the resolution of land disputes. The Melanesian idea of compensation may be affected by the introduction of the Western idea of compensation.
- Compulsory land acquisition may lead to the dissolution of the kastom land tenure system.

4.17.4.5 *Subsistence Horticulture*

- The loss of potential garden areas (where swidden horticulture is practiced) to mining and mining related activities and the use of garden plots may decrease the quality of crops as well as the quality of the soils.
- Loss of existing garden areas (particularly the alluvial areas on the banks of the rivers) because of mining and mining related activities. The loss of garden areas may reduce the quantity of fresh produce available and accelerate the change from a customary diet to the consumption of processed foods.
- Population influx may introduce new crops which may have an impact on the customary staple diets of tribal and clan members.
- Population influx may decrease the areas in which gardens can be located and result in a shortening of the fallow cycle, leading to land degradation.
- Population influx may increase demand for crops and customary subsistence horticulture may be replace by commercial agricultural practices.

4.17.4.6 *Agriculture*

- Mining and mining related activities may interfere with the Provincial Government's plans to develop agriculture within SMM Solomon's tenements.

4.17.4.7 *Plantations*

- The destruction of plantations by mining related activities may result in a loss of the main source of cash income within SMM Solomon's tenements.

4.17.4.8 *Hunting, Fishing and Shell Gathering*

- Clearing of land and the increase of traffic into the interior of SMM Solomon's tenements may have an impact on hunting areas and the habitat and population of pigs.
- The development of the Project, particularly marine traffic and population influx, may have an impact on the availability and quality of natural resources fishing and shellfish gathering.
- An increase in the demand for certain fish, shellfish or terrestrial animals which are not customarily consumed may lead to resource depletion, particularly as there has been no history of management of those resources.

4.17.4.9 *Canteens, Stores and Markets*

- The development of SMM Solomon's tenement may increase product availability in trade stores and shipping companies.
- Population influx may increase the demand for food supplies and commodities which may accelerate the change from a customary diet to the consumption of processed foods.
- The development of SMM Solomon's tenement may reduce the area in which subsistence gardens can be located thereby increasing the need for more food supplies and commodities in trade stores and shipping companies.
- The development of SMM Solomon's tenement may reduce hunting and fishing areas thereby creating demand in the variety of products sold by trade stores and shipping companies.

- The potential introduction of new products, particularly consumables, into SMM Solomon's tenement may impact the current daily routine and to a certain extent, on cultural practices.

4.17.4.10 Villages

- The village of Kolomola is inside the boundaries of Tenement D and may be negatively affected by mining or mining related activities.
- The availability of materials used for construction of villages may be diminished by mining and mining related activities.
- The potential relocation of villages affected by mining or mining activities can be the cause of land disputes.
- There may be a potential reduction in suitable sites for new villages within the tenement.

4.17.4.11 Logging and Deforestation

- Clearing within SMM Solomon's tenements may be regulated and controlled in areas where mining is to occur.
- The tribes or clans may have a more significant input into the rehabilitation of mined areas where SMM Solomon has accessed the saprolite and limonite.

4.17.4.12 Infrastructure

- Potential development and construction of access roads may facilitate travel through the interior of the island whether on foot or through introduced forms of transport.
- The development of SMM Solomon's tenements may increase the incidences of general infrastructure.

4.17.5 Impact Assessment

Table 4-53 Assessment of Potential Impacts on Land Use and Tenure

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to tribes and clans	•	•	•	•	•	•	Negative	Local	High	Permanent	Highly Probable	High	High	SMM prefers to work collaboratively with the tribes and clans and the Solomon Islands Government to address land tenure issues relating to tribe and clan kinship systems.	Medium	Medium
Impacts to village governance	•	•	•	•	•	•	Negative	Local	Medium	Permanent	Highly Probable	Medium	Medium	Employ residents from the tenement area. Co-operate with the provincial government in order to ensure only licensed operators exist within the tenement area. Cross cultural training program for SMM Solomon employees and contractors (See Cultural Heritage Management Plan). Encourage members of the tribes and clans within SMM Solomon's tenement to participate in the cross cultural activities as instructors. Implement restriction of access to villages to SMM Solomon employees who are not members of the landowning tribes.	Medium	Low

Table 4-53 Assessment of Potential Impacts on Land Use and Tenure

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to land ownership	•	•	•	•	•	•	Negative	Local		Permanent	Definite	High	High	Employ residents from the tenement area. Co-operate with the provincial government in order to ensure only licensed operators exist within the tenement area. Cross cultural training program for SMM Solomon employees and contractors (See Cultural Heritage Management Plan). Encourage members of the tribes and clans within SMM Solomon's tenement to participate in the cross cultural activities as instructors.	Medium	Medium
Impacts to land disputes	•	•	•	•	•	•	Negative	Local		Permanent	Highly Probable	High	High	SMM prefers to work collaboratively with the tribes and clans and the Solomon Islands Government to address land tenure issues relating to tribe and clan kinship systems. Co-operate with the provincial government in order to ensure only licensed operators exist within the tenement area. Cross cultural training program for SMM Solomon employees and contractors (See Cultural Heritage Management Plan). Encourage members of the tribes and clans within SMM Solomon's tenement to participate in the cross cultural activities as instructors.	Medium	Medium

Table 4-53 Assessment of Potential Impacts on Land Use and Tenure

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to subsistence horticulture	•	•	•	•	•	•	Negative	Local		Long term	Highly Probable	High	High	The loss of subsistence gardening related areas will be negotiated as per the Surface Access Rights Agreement (SAR) and/or the mining lease agreement. Employ residents from the tenement area and limit employment of non-residents (see Impact Assessment Report – Workforce Influx). Co-operate with the provincial government in order to ensure only licensed operators exist within the tenement area. Cross cultural training program for SMM Solomon employees and contractors (See Cultural Heritage Management Plan). Encourage members of the tribes and clans within SMM Solomon's tenement to participate in the cross cultural activities as instructors (See Cultural Heritage Management Plan).	Medium	Medium
Impacts to agriculture	•	•	•	•	•	•	Negative	Local	High	Long term	Highly Probable	High	High	The loss of designated areas for agriculture will be negotiated as per the Surface Access Rights Agreement (SAR) and/or the mining lease agreement.	Medium	Medium
Impacts to plantations	•	•	•	•	•	•	Negative	Local	High	Long term	Highly Probable	High	High	The loss of plantations and plantation related areas will be negotiated as per the Surface Access Rights Agreement (SAR) and/or the mining lease agreement.	Medium	Medium

Table 4-53 Assessment of Potential Impacts on Land Use and Tenure

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to hunting, fishing and shellfish gathering.	•	•	•	•	•	•	Negative	Local		Long Term	Highly Probable	High	High	The loss of subsistence related areas will be negotiated as per the Surface Access Rights Agreement (SAR) and/or the mining lease agreement. Restrictions for SMM Solomon employees can be developed and implemented in relation to recreational fishing, shellfish gathering and hunting as recreational activities.	Medium	Medium
Impacts to canteens, stores and markets.	•	•	•	•	•	•	Negative	Regional		Long Term	Probable	High	High	SMM Solomon may ascertain that any food not available within the tenement is sourced by SMM Solomon from elsewhere to avoid undue stress in local producers and retailers and to avoid high prices and unfair competition. Restrictions on alcohol consumption for SMM Solomon workers can be implemented to avoid an increase on the black market sale of alcoholic products. It may be advisable to restrict access to villages for SMM Solomon for workers who are not members of the landowning tribes within the tenements.	Medium	Medium

Table 4-53 Assessment of Potential Impacts on Land Use and Tenure

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Confidence Level	Significance with Mitigation
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impacts to villages	•	•	•	•	•	•	Negative	Local	High	Long Term	Probable	High	High	While it may not be possible to prevent the reduction of suitable sites for new villages within SMM Solomon's tenement, it may be possible to suggest suitable places once the Project has begun. All relocation related activities must follow international guidelines and recommendations and to achieve best practice at least.	Medium	Medium
Impacts to logging and deforestation	•	•	•	•	•	•	Positive	Local		Long Term	Probable	Medium	Medium	Any clearing of Project areas will include consultation with the landowning tribes and clans. Encourage tribe and clan participation during the clearing and rehabilitation stages.	Medium	Medium
Impacts to infrastructure	•	•	•	•	•	•	Positive	Local	Low	Long Term	Probable	Medium	Medium	The construction of roads takes into account current village locations, gardening areas and cultural heritage sites as well as the outcome of consultation with the tribes and clans within SMM Solomon's tenement. The influx of a cash economy will positively impact the development of new infrastructure within the tenements.	Medium	Medium

4.17.6 *Mitigation Measures*

Proposed mitigation measures, determined according to provincial and national and international guidelines, are outlined below.

4.17.6.1 *Tribes and Clans*

SMM Solomon prefers to work collaboratively with the tribes and clans and the Solomon Islands Government to address land tenure issues relating to tribe and clan kinship systems.

4.17.6.2 *Village Governance*

A cross cultural training program for SMM Solomon employees and contractors may be developed by SMM Solomon liaison officer in conjunction with a suitably qualified cultural heritage specialist (See Cultural Heritage Management Plan). The cross cultural training program would:

- Be conducted with every SMM Solomon employee and consultant prior to the commencement of any type of work on-site.
- Include protocols for visiting villages and surrounding lands and forests which may have significant cultural heritage values.
- Discuss the purchase protocols of locally produced items and products.
- Instruct in the protocols of hunting, fishing and gathering within tribal and clan lands.
- Provide an overview of Melanesian culture with a focus on the tribes and clans with SMM Solomon's tenement.

Members of the tribes and clans within SMM Solomon's tenement may be encouraged to participate in the cross cultural activities as instructors.

It may be advisable for SMM Solomon to:

- Limit the employment of non-residents of the tenement area.
- Limit the employment of residents of the tenement who are not members of a clan or tribe within the tenement. It may be advisable to seek recommendations from each tribal and clan chief when employing workers.
- Restrict access to villages for SMM Solomon for workers who are not members of the landowning tribes within the tenements.

4.17.6.3 *Land Ownership*

The determination of boundaries through the legal system is a possibility and its benefits far outweigh any impacts. It may be advisable for SMM Solomon to limit:

- The employment of non-residents of the tenement area.
- The employment of residents of the tenement who are not members of a clan or tribe within the tenement. It may be advisable to seek recommendations from each tribal and clan chief when employing workers.

It is advisable that the female landowners are involved in the determination of legal boundaries to ensure the matrilocal land tenure system is continued.

A provision in the Surface Access Rights Agreement (SAR) and/or the mining lease agreement may also be included to ensure the community benefits from mining and mining related activities.

As outlined above, a cross cultural training program for SMM Solomon employees and contractors may be developed (Section 4.17.6.2) by an SMM Solomon liaison officer in conjunction with a suitably qualified cultural heritage specialist (see Cultural Heritage Management Plan in Chapter 5).

The cross cultural training would:

- Be conducted with every SMM Solomon employee and consultant prior to the commencement of any type of work on site.
- Include protocols for visiting villages and surrounding lands and forests which may have significant cultural heritage values.
- Discuss the purchase potential of local produced items and products.
- Instruct in the purchase protocols of hunting, fishing and gathering withi tribal and clan lands.
- Provide an overview of Melanesian culture with a focus on the tribes and clans within SMM Solomon's tenements.

Members of the tribes and clans within SMM Solomon's tenements may be encourages to participate in the cross cultural activities as instructors.

4.17.6.4 Land Disputes

SMM Solomon prefers to work collaboratively with the tribes and clans and the Solomon Islands Government to address land tenure issues relating to tribe and clan kinship systems.

The determination of boundaries through the legal system is a high possibility and its benefits far outweigh any impacts that the introductions of static boundaries bring. It may be advisable for SMM Solomon to limit:

- The employment of non-residents of the tenement area.
- The employment of residents of the tenement who are not members of a clan or tribe within the tenement. It may be advisable to seek recommendations from each tribal and clan chief when employing workers.

SMM Solomon can also co-operate with the provincial government in order to ensure only licensed operators exist within the tenement area.

As outlined above, a cross cultural training program for SMM Solomon employees and contractors may be developed (Section 4.17.6.2).

4.17.6.5 Subsistence Horticulture

The loss of subsistence gardening related areas will be negotiated as per the SAR and/or the mining lease agreement.

It may be advisable for SMM Solomon to limit:

- The employment of non-residents of the tenement area.
- The employment of residents of the tenement who are not members of a clan or tribe within the tenement. It may be advisable to seek recommendations from each tribal and clan chief when employing workers.

As outlined above, a cross cultural training program for SMM Solomon employees and contractors may be developed (Section 4.17.6.2).

4.17.6.6 Agriculture

The loss of designated areas for agriculture will be negotiated as per the SAR and/or the mining lease agreement.

4.17.6.7 Plantations

The loss of plantations and plantation related areas will be negotiated as per the SAR and/or the mining lease agreement.

4.17.6.8 Hunting, Fishing and Shellfish Gathering

The loss of subsistence related areas will be negotiated as per the SAR and/or the mining lease agreement.

SMM Solomon could collaborate with the Provincial Government to extend the small-holder agricultural sector on Santa Isabel Island prior to construction. They can also encourage the tribes and clans within the tenement to protect the local hunting, fishing and shellfish gathering areas.

Restrictions for SMM Solomon employees can be developed and implemented in relation to recreational fishing, shellfish gathering and hunting as recreational activities.

4.17.6.9 Canteens, Stores and Markets

SMM Solomon may ascertain that any food not available within the tenement is sourced by SMM Solomon from elsewhere to avoid undue stress to local producers and retailers and to avoid high prices and unfair competition.

Restrictions on alcohol consumption for SMM Solomon workers can be implemented to avoid and increase in the black market sale of alcoholic products.

It may be advisable to restrict access to villages for SMM Solomon for workers who are not members of the landowning tribes within the tenements.

4.17.6.10 Villages

While it may not be possible to prevent the reduction of suitable sites for new villages within SMM Solomon's tenement, it may be possible to suggest suitable places once the Project has begun.

All relocation related activities must follow international guidelines and recommendations and achieve best practice. Negotiation with relevant chiefs should commence as soon as possible, should relocation be a necessity. A social impact assessment of relocation activities must be carried out by a social impact specialist and a new village site identified by the relevant village, the tribal chiefs and SMM Solomon.

4.17.6.11 Logging and Deforestation

Before the commencement of the clearing of the Project areas, it may be possible to include the tribes and clans in the discussions of how the areas may be cleared. Some tribes and clans run their own logging businesses and it may be possible to engage them in this aspect of the Project. This is a way of ensuring tribal and clan participation during the clearing and rehabilitation stages.

The MRCP for the mining area should be created in conjunction and with the input of the tribes and clans.

4.17.6.12 Infrastructure

The construction of roads takes into account current village locations, gardening areas and cultural heritage sites as well as the outcome of consultation with the tribes and clans within SMM Solomon's tenement.

The influx of a cash economy will positively impact the development of new infrastructure within the tenements.

4.18 Socio-Economics

This section describes the existing socio-economic values within SMM Solomon's Isabel Tenement D and Isabel Tenement E including:

- the local economy
- small and medium enterprises
- employment
- household income
- agriculture
- forestry
- fisheries and aquaculture
- tourism
- economic development
- the potential positive and socio-economic impacts that may result from the Project

This section also assesses the significance of those impacts and proposes measures to enhance positive impacts and mitigate negative impacts.

Note that this section does not address the economic effects of the Project on the provincial and national economy (refer to Impact Assessment Report - Economics) nor the potential socio-economic effects of the Project on society and community in Project-impacted communities (refer to Impact Assessment Report – Social and Community).

Further details are provided in the Impact Assessment Report – Socio-economics.

4.18.1 Methodology

Data was collected using:

- desktop analysis
- village workshops and consultation-meetings
- key informant interviews
- site surveys and appraisals
- secondary data gathering (reports, papers and studies from government and non-government organisations).

The study area consists of villages within or in close proximity to Isabel Tenements D and E. The villages are located in seven of the southern Wards including: Japuana, Kmaga, Kolomola, Kolotubi, Sigana, Susubona and Tatamba Wards. The combined population of these wards in 2009 was 12,350 which represents nearly half (47.3%) of the population of Isabel province (SISO, 2011).

Fieldwork survey and consultation work was undertaken over an 18 month period with people who reside within or in close proximity to the Project area. Baseline social profiling was undertaken by Hatch Associates Social Impact Team between June-October 2010. Social impact assessment consultations with key stakeholder groups were conducted between August and November 2011 by Hatch and AECOM.

Stakeholder engagement workshops were conducted in centrally located 'hub' villages, with representatives attending from surrounding villages. Men and women were separated during consultations in order to facilitate open expression of views/opinions on the following workshop topics:

- lifestyle and sense of place and community
- education and training for employment
- livelihood, land use and business development
- natural environment
- health, housing and work influx.

4.18.2 Existing Values

4.18.2.1 Solomon Islands

The economy of the Solomon Islands was negatively impacted by the civil unrest that occurred between 2000 and 2005. Employment, education, health, tourism, and economic development in the logging, mining, and fishing industries were all disrupted.

The current economy is dependent on primary industries such as agriculture, forestry, and fishing and in particular timber exports, which have contributed significantly to economic growth in recent years (ADB, 2010).

The logging industry, which is a major export and source of Government revenue, is reportedly progressing at an unsustainable rate and it is predicted that the economic contribution from this industry will begin eroding by 2012 (Gay, 2009). The Solomon Islands Government is now looking to alternative industries such as mining, tourism, agriculture and fishing for economic growth opportunities.

Copra, palm oil and mining are becoming important sources of employment and revenue while the fishing industry offers positive prospects for export and domestic economic expansion in the domestic and foreign markets.

The Solomon Islands has opportunities to attract international tourism, having pristine tropical ecosystems, beautiful scenery and diverse cultures. However, the sector is relatively underdeveloped when compared to other Oceania states and accounts for less than two percent of GDP (IMF, 2011b). Possible reasons include the recent political turmoil experienced, travelling logistics limitations, as well as the tsunami of 2007 (Crawford, 2012).

Foreign direct investment (FDI) in the Solomon Islands increased by 24% in 2010 after a decline of 74% in 2009 (CBSI, 2010). Future FDI streams are anticipated to come from the tourism, fisheries and mining industries.

Formal employment in the Solomon Islands rose between 2009 and 2010 by 33.7% as a result of funding received from the Solomon Islands National Provident Fund (CBSI, 2010). The labour force engaged exclusively in wage-earning activities is 14% with approximately 71.4% of the economically active population engaged in non-monetary work in villages, principally subsistence farming (CBSI, 2010).

In 2005/06 the Solomon Islands had a basic needs poverty incidence rate of 22.7% of the population (UNDP, 2008). The incidence of poverty was more prevalent in households in Honiara (24.6%) than in provincial urban households (11.2%) (UNDP, 2008).

SME's in the Solomon Islands are limited both in scope and activity. Small enterprises include agriculture, timber supply, fish products, copra, cocoa and related support services. Business service companies include customs and shipping agents, insurers, business associations, information technology, taxation, marketing and advertising specialists. Solomon Islands media provides a variety of television and radio channels and daily newspapers, with access and delivery based in Honiara.

The main industries are geared toward the local market, including the food processing sector, which produces such items as rice, biscuits, beer, and confectionery. Other manufacturers produce twisted tobacco, corrugated roofing sheets, nails, fibre canoes and tanks, timber, and buttons (Hatch, 2010).

4.18.2.2 Isabel Province

A 2009 census reported a population of 26,158 in Isabel Province, equivalent to 5.7 percent of the nation's population of 515,870 people (SISO, 2011).

The road system is not well developed and provides only limited accessibility for villages. Canoes, many with outboard motors, are the primary mode of travel for fishing and sea transport. There are various wharves and jetties around the Island, but no international port (Rural Development Division, 2001).

The supply of electricity in Isabel Province is limited with power generators providing electricity to schools, churches and provincial substations around the Province. Most households rely on traditional energy sources such as firewood, coconut oil, and coconut husk (Rural Development Division, 2001). A small number of households have small solar panels that provide limited power for household lighting.

The local economy in the Project area is characterised by subsistence activities including farming (gardening and coconut plantations), small-scale animal husbandry, and fishing. However, local people are increasingly engaging in the wage economy.

A number of Small to Medium sized enterprises operate on Santa Isabel Island including: retail trade, rest houses, transport, and financial institutions. There are three companies run by the Provincial Government: the Isabel Development Company (shipping services), the Isabel Timber Company and the Isabel Development Authority (financial arm of the Province).

The processing and manufacturing sector in the Province includes coconut oil milling, peanut and coffee processing, and furniture making. There are also opportunities for the establishment of downstream industries to provide value-added products (such as fruit juice making, baton making, and food processing) (Rural Development Division, 2001).

There are 3,233 people employed in Isabel Province in the labour force and an additional 7,200 engaged in subsistence activities (agriculture, fishing and marine harvesting) (SISO, 2011).

The majority of inhabitants of Isabel Province are subsistence farmers and the sale of surplus produce supplements household incomes. Extensive logging of Isabel Province and several years of mining exploration has seen a gradual transition from the subsistence economy to the cash economy. This change in the economic base likely to increase if the Project proceeds.

The average total income generated by villages consulted within or near to Isabel Tenement D ranged from SBD$100 to SBD$5,000 per household per year. In tenement E, most households' income comes from fishing, and subsistence farming. Households on Santa Isabel Island tend to spend their annual household income on food (i.e. mainly on cereal and cereal products), which is typical of most rural communities in the Solomon Islands.

4.18.2.2.1 Agriculture

Large agricultural crop growing areas are located around Kolotubi, Tausese/Koregu and to the north and south of Buala. Copra is the main agricultural crop providing employment and household income for the residents of Santa Isabel Island. There are seven copra buying centres on the Island. Kolomola, a village located within Isabel Tenement D in the central highlands plants. Coffee is grown and processed in the village then shipped to Honiara for further processing. A commercial pineapple crop has been recently developed at Koghe near Isabel Tenement D.

Nearly all villages on Santa Isabel Island grow root crops, including: sweet potato, cassava, taro, giant taro and yam. These are important staple food crops and any surplus is sold at markets. Sweet potato is the most widely grown root crop. Some fruit farms have been established and are a potential source of income that could be considered further (Rural Development Division 2001).

Cava production is a recently introduced crop occurring mainly within Isabel Province, although there are new plantings in other provinces. Betel nut is a crop with a traditional value and purpose in the culture of the Solomon Islands. Cava is not traditionally consumed in the Solomon Islands, betel nut is used both recreationally and as an appetite suppressant. The village of Kolotubi which is south of Isabel Tenement D is engaged in small scale rice farming. Cocoa is also produced as a means of income generation, but is not as prevalent as copra due to poor shipping and agriculture services (Rural Development Division, 2001b).

Animal husbandry is not practiced on the island although pigs and chickens are kept domestically.

4.18.2.2.2 Forestry

The logging industry is a major source of economic activity due to the abundance of forest cover (once 90%, now estimated to be around 75%) and most logs are directly exported overseas (Gay 2009; Pauku 2009). Logging exports accounted for 46% of all exports in 2011 (CBSI 2012). Log production rose from 1.4 million cubic meters in 2010 to 1.9 million cubic meters in 2011, due to high international demand for log, and increased log prices. Isabel Province is the leading log producer in the country and contributes 35% of total production.

4.18.2.2.3 Fisheries

The fisheries sector is important many villages and households rely on fishing for subsistence living, and the sustainable management of these resources is vital to food security. Only 30 percent of households in Isabel Province engage in commercial fishing activities. Commercial fish products are sold in three fisheries centres throughout the Isabel Province, located at Tatamba in Gao/Bugotu, Kia in Hograno/Kia/Havulei, and Buala in Maringe/Kokota. The main constraints on the Island's fishing sector are lack of suitable transport to markets and lack of qualified staff for fishing centres.

4.18.2.2.4 Tourism

Tourism is in its infancy on Santa Isabel Island. It has much to offer in terms of environmental and cultural diversity but is hampered by a lack of infrastructure, with minimal accommodation options (mainly village stay or small retreats), little road infrastructure, power and communication utilities available.

There is significant opportunity to develop tourism ventures in a number of areas on the Island but development of the tourism industry will require improvements in marketing, transport infrastructure, resolution of land disputes and training of tourism operators.

The Project has the potential to generate significant economic benefits for Isabel Province and the Solomon Islands in the form of employment, business opportunities, and revenue from tax and royalty payments.

However, the Project will likely result in changes to subsistence activities currently practised by local people. It will be important to monitor food security, promote livelihood restoration, and create alternative economic options amongst affected villages.

Villages in Isabel Province are currently characterised by low literacy levels and limited access to higher-level education qualifications and technical skills; this may limit local employment opportunities for Isabel people.

There is significant potential to further develop the agricultural and fisheries sectors but a number of constraints currently restrict this opportunity including:

- accessibility to both local and international markets, and transport
- limited knowledge of how to value add to their product
- limited financial institutions and financing arrangements.

The Project is expected to generate high levels of economic activity. Local business development opportunities can be maximised if appropriate measures are taken by the Project and the provincial and national government.

4.18.3 Potential Impacts

The potential socio-economic impacts of the Project are described in the following section. Further details of the potential impacts are provided in the Impact Assessment Report – Socio-economics.

4.18.3.1 Employment

Local employment opportunities may be limited due to inadequate levels of education and skills on the island. A training program will need to be established very early in the Project as local people are unlikely to have prior experience in the mining-industry.

4.18.3.2 Household Incomes

Increases in household incomes are expected due to direct employment from the Project or business activities stimulated by the Project. This is a positive economic impact of the Project that may be further enhanced by measures aimed to maximise employment of local workers and/or local procurement of Project goods and services.

4.18.3.3 Change to Relative Wages

The Project will create positive economic opportunities previously not available on Santa Isabel Island. The wages to be offered by the Project are likely to be greater than the wages offered elsewhere in the Province given the low levels of economic development and the limited wage-earning opportunities. This is a positive impact for residents employed by the Project and local businesses.

An increase in wages may also result in increased competition for labour resources across all industries, which may result in valuable human resources shifting away from forms of employment which benefit the broader community (e.g., teaching, community services). The potential for this impact to occur will be highest where local unemployment is low and wage variations are high.

4.18.3.4 Structure of the Local Economy

The introduction of a cash-based economy may cause a structural change in the local economy. Wage earners may abandon subsistence forms of employment, such as tending to gardens, and become dependent on cash incomes to purchase goods and services. The impact of this transitional shift is likely to be both positive and negative across households and is expected to be applicable in the short to medium term only as the economy moves to a cash-based structure.

4.18.3.5 *Education and Training Opportunities*

The Project will generate an increased demand for skilled and unskilled labour to undertake the construction and operational phases of the Project. At present Isabel people possess low levels of literacy and numeracy but the introduction of the Project may bring about increased opportunities in education and training.

4.18.3.6 *Inflation*

The inflow of cash from Project wages and increased business revenues is expected to cause an increased demand and shortage of supply for consumables in the short to medium term, and result in increased prices within this time frame. An inflationary effect would negatively impact households that do not benefit directly from the wage economy and/or are not self-reliant in food production. In the longer term this shortage of supply would be expected to be met and inflation to level out. A negative impact would only occur if inflationary pressures come from imported commodities (i.e. crude oil or fertiliser).

4.18.3.7 *Land Area Available for Gardening or Resource Harvesting*

Land required for the development of the Project (for roads, Project facilities, and the mine) will become temporarily unavailable for other uses such as gardening, harvesting of forest resources, hunting and freshwater fishing. Since the well-being of local communities is closely linked to the ability to engage in subsistence food production. This may potentially cause negative impacts for some households.

In the longer term, improved access may increase the area available for gardening and agricultural activities. This issue will be considered prior to the finalisation of the MRCP.

4.18.3.8 *Harvesting of Marine Resources*

Port construction, increased marine traffic and potential fuel spills may reduce the ability of local residents to harvest marine resources in affected areas and may in turn affect food security, local livelihoods, and well-being. This is a negative impact that may require monitoring during the development and operation of the Project.

4.18.3.9 *Transport Opportunities*

Roads constructed by the Project will be dedicated to Project-related activities and safety concerns will exclude local people from using these roads. Further arrangements whereby selected Project roads could be safely used by local people may be explored. The Project may also create opportunities for marine transport services such as the community ferry to be run by a third party.

4.18.4 Impact Assessment

A risk assessment of potential socio-economic impacts on Santa Isabel Island communities is presented in Table 4-54.

Table 4-54 Assessment of Potential Impacts on Socio-Economics

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence No Mitigation	Significance No Mitigation	Mitigation/Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Impact to Employment	•	•	•	•	•	•	Positive	Local, Regional and National	High	Long	Highly Probable	High	High		High	High
Impact to Household Incomes	•	•	•	•	•	•	Positive	Local to Regional	Medium	Medium to Long Term	Highly Probable	High	Medium		High	High
Impact to Relative Wages	•	•	•	•	•	•	Negative	Local and Regional	Medium	Medium	Probable	Medium	High	Project wages to be suitably comparative to the type of work and to other industries. Refer to Section 4.18.5.3.	Medium	Medium
Impact to Structure of Local Economy							Negative	Local	Medium	Short Term	Probable	Low	Low	Provide education on food production to maintain subsistence living. Refer to Section 4.18.5.4.	Low	Medium
Impact to Structure of Local Economy							Positive	Local	High	Long Term	Probable	High	High		High	Medium
Impact to Education and Training Opportunities.	•	•	•	•	•	•	Positive	Local and Regional	Medium	Medium	Probable	Medium	Medium		High	Medium
Impact to Land Area Available for Gardening or Resource Harvesting	•	•	•	•	•	•	Negative	Local	Medium	Medium	Probable	High	High	Refer to Section 4.18.5.7.	Medium	Medium
Impact to Harvesting of Marine Resources.		•	•		•	•	Negative	Local	Medium	Medium	Probable	High	High	Monitor marine environment in areas affected by port construction and/or shipping. Implement measures to minimise or remove any impacts associated with the Project. Refer to Section 4.18.5.8.	Medium	Medium
Impact to Local Transport.		•				•	Positive	Local	Medium	Medium	Probable	Medium	Medium		Medium	Medium

4.18.5 Mitigation Measures

The measures that may be implemented enhance the positive socio-economic impacts and mitigate the negative socio-economic impacts are described below.

4.18.5.1 Employment

The Project will make efforts to prioritise local and national workers in the hiring process. It will be necessary to engage expatriate workers with specialised skills and experience for the construction phase of the Project. Efforts to train local workers for Project employment will be made, including a skills development and training program and specific targets for local employment by the Project.

4.18.5.2 Household Incomes

Guidance may be provided to members of local communities employed by, or engaged as suppliers to the Project (or to those receiving compensation payments) in regards to the responsible management of financial resources (e.g. wages, revenue). This could be done in partnership with suitable financial institutions (e.g., local banks, credit unions) or other community-based organisations (e.g. churches, government and NGOs).

4.18.5.3 Change to Relative Wages

Project-employed individuals will receive wages that are suitable to the type of work and comparative to other industries within the Solomon Islands. This will mitigate against the effects of potential wage distortion effects in the local economy and across industries competing locally in the Solomon Islands for labour resources.

4.18.5.4 Structure of the Local Economy

Education relating to the need to maintain food production for household's consumption (subsistence living) – especially where there are household members not fully engaged in paid employment – can be provided.

4.18.5.5 Business Opportunities

In order to encourage continued local agricultural production and food security, SMM Solomon wishes to establish links with suitable government, non-government and donor agencies (e.g. Japanese and Australian international cooperation agencies, World Bank and United Nations Development Program) to identify, implement and encourage suitable rural development projects in local communities.

In addition, SMM Solomon may develop or encourage poverty-reduction initiatives involving vulnerable populations groups (e.g., female-headed households, elderly) in partnership with NGOs, and provincial and national government agencies.

SMM Solomon will encourage the development of local enterprises through relevant projects undertaken in partnership with NGOs and provincial or national government. These projects may cover agricultural practices, food safety, catering, and fishing and aquaculture practices. Development of local enterprises may result in the Project engaging local people as reliable suppliers of food (e.g. fresh fruit and vegetables or fish) or other goods and services. Limited economic activity in Isabel Province to date implies that local enterprises may lack some of the skills or experience required for supplying goods and services to the Project, and may lack capital to invest in necessary equipment.

Food for the camp-based workforce may be sourced locally – with preference given to local suppliers, where feasible. SMM Solomon would also like to encourage wider business development in Project-impacted communities and, more broadly, in Isabel Province.

A Local Business and Procurement Plan will be developed for the Project to identify opportunities and challenges for the development of businesses in the Project area. The Plan will outline a strategy for prioritising local suppliers of various goods and services.

4.18.5.6 Educational and Training Opportunities

The Project may provide funds to educational institutions in local communities (e.g. in the form of supplies or scholarships). This investment may result in tangible socio-economic benefits for Project-impacted communities with a population better positioned to take advantage of opportunities generated by the Project (e.g. through better educational and thereby an increase ability to become engaged by the Project) and/or of other business opportunities that may arise as secondary effects of economic activities of the Project at the local or regional level.

4.18.5.7 Land Area Available for Gardening or Resource Harvesting

4.18.5.7.1 Identify and Fund Rural Development Projects

In order to encourage continued local agricultural production and food security, the Project, in cooperation with suitable government, non-government and donor agencies (e.g. Japanese and Australian international cooperation agencies, multilateral agencies such as World Bank and UNDP) will identify, implement and encourage suitable rural development projects in local villages.

Revenues from the Project (in the form of tax and royalty payments) can represent an important benefit to Isabel Province and more broadly to the Solomon Islands as these funds can be used to support infrastructure development projects, improvements in schools and other community infrastructure. Through participation in initiatives industry-government forums aimed to encourage appropriate and beneficial use of revenues from mining, the Project may influence government decision-makers in the Solomon Islands to make appropriate use of Project revenues to maximise the benefits of fiscal/revenue effects (Impact Assessment Report – Economics).

4.18.5.7.2 Rehabilitate Areas Disturbed by Mine Areas or Other Project Activities

The rehabilitation of disturbed forests or agricultural areas will be vital for the re-establishment of certain subsistence activities which originally took place within tenements D and E. Consultation with impacted households is recommended in order to determine the most appropriate methods for rehabilitating land (e.g. some areas may be considered for agricultural production). It may be necessary to negotiate with some households or tribal groups for direct loss of gardens, trees, and harvesting area – in cases where Project activities result in land becoming unavailable for agricultural or other traditional livelihood activities. Economic displacement may result in the need to develop the resettlement action plan (even if physical relocation of households is not required), as per the IFC standards.

It is recommended that a detailed mapping of natural resource use and relevant assets be conducted in order to understand which areas and households may be affected.

Identify Alternative Sites for Gardening, Plantations and Grazing

The Project may assist in the identification of land suitable for gardening, plantations or livestock and assist with the establishment of new agricultural activities for households in communities potentially impacted by the Project. The Project may also support rural development projects to be funded and/or implemented in partnership with relevant organisations. In order to avoid or minimise adverse effects on local food security, it will be important for the Project to assist in identifying mechanisms to support the development of efficient commercial food production locally with agricultural practices that are sustainable and would result in increased productivity in the local food sector. Therefore, rural development and agricultural extension specialists should be engaged early on by the Project to work with local communities to identifying opportunities and develop efficient and sustainable farming practices in communities potentially affected by the Project.

4.18.5.8 Marine Harvesting and Hunting

Construction of port facilities and shipping may have detrimental effects on the local marine environment and consequently on the activity of local people to harvest marine resources in these areas. Monitoring may be conducted to identify adverse effects of the Project on the marine environment. Strengthening the capacity of local people to sustainably manage marine resources is also recommended, through the identification and funding of suitable projects in collaboration with relevant organisations.

4.18.5.9 Transport Opportunities

Further studies will investigate the potential for providing transportation options for local people. Further arrangements, where selected Project roads could be safely used by local people, may be explored.

4.19 Public Health

This section describes:

- Existing health conditions in the Project area
- Potential health impacts from Project activities
- Measures to mitigate the potential impacts

For more detailed information, consult the Impact Assessment Report – Public Health.

4.19.1 Methodology

The health profiles of the Solomon Islands and Santa Isabel Island have been described using the following public health and environmental health indices: mortality, life expectancy, morbidity, nutritional health statuses, existing health infrastructure, resources and services, health issues and prevalent diseases, hygiene and sanitation conditions.

The Impact Assessment Report – Health was informed through review of secondary data, ocular surveys of the villages in the Project area, key informant interviews and stakeholder consultation and workshops. Surveys and workshops were conducted in 2010 during a preliminary baseline study and in October 2011. Key information sources include the 2009 National Census data of the Solomon Islands, the Solomon Islands National Statistics Office, Ministry of Health and Medical Services, the World Health Organization, the United Nations Children's Fund (UNICEF), the Western Pacific Region Health Databank and the World Bank.

4.19.2 Existing Values

This section characterises public health values for the Solomon Islands and Isabel Province.

4.19.2.1 Solomon Islands

The Solomon Islands is classified by the World Bank as a lower-middle income country. UNICEF and the Solomon Island's Ministry of Health and Medical Services indicate the country's current health status is characterised by a high prevalence of infectious diseases (such as malaria, with a total of 40,682 cases and 13 deaths in 2010 (Western Pacific Region Health Databank, WHO 2011), and respiratory diseases) and at the same time, increasing incidence of non-communicable diseases (NCDs) such as cardiovascular diseases.

Rising levels of urbanisation and changing lifestyle due to modernisation are associated with rising levels of NCDs. The Solomon Islands government has scarce resources to mobilise, however external donors and support are available to improve the health conditions.

4.19.2.1.1 Mortality

The World Bank indicates a steady decline in crude death rate from 1960 to 2009, except for periodic fluctuation (1980-1990). From 15.8 per 1,000 population in 1960, the crude death population rate is 5.9 per 1,000 population in 2009.

Infant mortality, under-5 mortality, neonatal mortality and maternal mortality rates have also decreased, shown in Table 4-55.

Table 4-55 Mortality Rates, Solomon Islands, 1960 – 2010

Mortality Rate	1960	1970	1980	1990	2000	2008	2009	2010
Infant mortality rate (per 1000 live births)	112.4	72.9	48.4	35.9	28.4	23.5	23	22.5
Under-5 mortality rate (per 1000 live births)	164.5	101.5	63.1	44.9	34.5	28.1	27.4	26.7
Neonatal mortality rate (per 1000 live births)	-	-	-	18	15	13	13	12
Maternal mortality ratio (per 100,000 live births)	-	-	-	130	110	100	-	-

Information provided by the Western Pacific Region Health Databank listed the following leading causes of mortality in the Solomon Islands as of 2005:

- Cardiovascular diseases
- Malaria
- Neonatal causes
- Neoplasm
- Respiratory diseases (pneumonia as the leading cause)

Adult and under-5 mortality rates and maternal mortality ratio in the Solomon Islands are significantly lower than the global average, however, they are comparatively high in comparison with regional statistics.

4.19.2.1.2 Life Expectancy

Life expectancy of the Solomon Islands population has increased in recent years. Women tend to live longer than men. These trends are shown in Table 4-56.

Table 4-56 Life Expectancy (at Birth), Solomon Islands, 1960-2009

Indicator name	1960	1970	1980	1990	2000	2009
Life expectancy at birth, female (years)	50	55	60	57	64	68
Life expectancy at birth, male (years)	49	54	58	56	62	66
Life expectancy at birth, total (years)	49	54	59	57	63	67

In comparison with global averages, life expectancy is significantly longer, however it is lower contrasting with regional averages.

4.19.2.1.3 Morbidity

The reported leading causes of morbidity (in patient care) in the Solomon Islands in 2009 were as follows:

- Acute respiratory infection (ARI)
- Clinical and presumptive malaria
- Skin disease
- Ear infection
- Yaws (chronic infection of skin, bones or joints)
- Red eye

This indicates a high prevalence of communicable diseases, particularly ARI, malaria and Yaws.

4.19.2.1.4 Nutrition

Obesity is a major health concern among adults in the Solomon Islands and is a significant risk factor for cardiovascular diseases. In 2007, 24% of men were reported as overweight and 5% as obese while 3% of women were reported as overweight and 14.5% as obese. These statistics indicates levels of obesity are higher than regional averages. Prevalence of high Body Mass Index (BMI) was mostly observed amongst men less engaged in physical activities and along women with higher education living in wealthy households.

Malnutrition is a major health concern for children in the Solomon Islands. Children below age 5 in the Solomon Islands are slightly underweight according to WHO growth references. In 2007, the proportion of undernourished children was at 11.8%, and severely undernourished children was at 2.4% of the population. Malnutrition was mainly observed among children who live in rural areas, less wealthy households and with less educated mothers.

4.19.2.1.5 Community Water

Approximately 14% of the urban population have access to water through a distribution system through the Solomon Islands Water Authority (SIWA). The most common sources for drinking water in rural communities are communal standpipes and surface water from streams.

4.19.2.1.6 Sanitation

The majority of the private households in the Solomon Islands (33%) have no toilet facilities and "modern sanitation practices are very rare in the province", according to the Santa Isabel Provincial Development Plan 2011-2014. Sanitary toilet facilities have been linked to the prevention of diseases and epidemics.

4.19.2.1.7 Waste Management

Proper waste management is an important factor in environmental health. Waste is mostly disposed of in households' backyards and open sea (60% and 19% of total households, respectively). Burying and burning are also common options for waste disposal.

4.19.2.1.8 Health Infrastructure and Resources

WHO (2011) notes that the Solomon Islands has a total of eight public and three private hospitals. Faith-based and non-government organisations (NGOs) also provide some health care services on an out-patient basis. The Ministry of Health and Medical Services (MHMS) is the major provider of health care services in the area, administering and managing health services as part of the National Health Strategic Plan.

As of 2009, the Solomon Islands had 118 physicians, 36 dentists, 44 pharmacists, 934 nurses and 126 midwives.

4.19.2.2 Isabel Province

There is a lack of available health statistics and key health indicators for Isabel Province. Data collected from the Santa Isabel Provincial Development Plan 2011-2014 provides the "current status of the province" and indicates the data is sourced from the Buala Hospital in Isabel Province.

4.19.2.2.1 Mortality

Provincial infant mortality rates are higher than the national average (57 per 1,000 live births compared to 55). Maternal mortality rates are significantly lower than the national average(18 compared to 135).

4.19.2.2.2 Life Expectancy

Life expectancy in the Isabel Province is 60.4 years for women and 59.6 years for men.

4.19.2.2.3 Morbidity

Major health issues reported include: ARI, skin disease, influenza, high blood pressure and diabetes. The Santa Isabel Provincial Development Plan 2011-2014 concluded that excluding non-communicable diseases, the reported health conditions were due to poor sanitation practices and poor nutrition. Incidences of infectious diseases are either lower or the same as national averages.

Efforts to control malaria in the Isabel Province in past years have been successful, even though the Solomon Islands ranks highly amongst the countries most affected by malaria in the Asia Pacific Region (O'Sullivan 2011).

4.19.2.2.4 Community Water

The primary drinking water sources in the Isabel Province are communal standpipe (64%), rainwater storage tanks (11%) and streams (10%). These sources are vulnerable to contamination, especially during the rainy season. They are also susceptible to drought. In many of the villages, the water distribution system was either damaged or not working.

Results from field tests on the drinking water of communities within and adjacent to the Project area (included in further detail in the Impact Assessment – Community Water) indicate all samples tested showed presence of *E. coli* and total coliform.

4.19.2.2.5 Sanitation

The majority of Isabel Province households are without access to a modern toilet and proper sanitation facilities. 57% of total private households listed "other" as their main toilet facility – possible meaning open defecation or dumping into different bodies of water.

4.19.2.2.6 Waste Management

Most private households dispose of solid wastes in their backyard (69%) while others (22.5%) resort to open sea dumping.

4.19.2.2.7 Health Infrastructure

The only hospital in the Isabel Province is located in Buala. The 45-bed hospital provides dental, radiological, pharmaceutical, laboratory, health education, environmental health and anti-malaria services. Villages without health care facilities rely on services provided by visiting nurses or by traveling to another community. Poor weather preventing sea transportation and limited road infrastructure hinder access to health care services in the province.

The ratio of health care workers to the total population in Isabel Province is 1:511, compared to the national ratio of 1:321.

4.19.3 Potential Impacts

Project activities have the potential to impact public health values. The following sections summarises the potential impacts.

4.19.3.1 Increase in Incidence of Disease

The incidence of communicable and non-communicable diseases would likely increase with the influx of workforce in the Project area. This could lead to a rise in the occurrence of infectious diseases associated with higher population density, such as acute respiratory infection (ARI), tuberculosis, malaria, diarrhoea, human immunodeficiency virus (HIV)/acquired immodeficiency syndrome (AIDS) and other sexually transmitted infections (STIs).

The generation of waste could increase the occurrence of infectious diseases such as respiratory illnesses and waterborne diseases.

Increased economic activity and purchasing power could alter lifestyle, consumption patterns and dietary habits of the population. Collectively, these shifts could lead to the rise of lifestyle diseases, such as diabetes, cancer and cardiovascular diseases.

4.19.3.2 Accidents and Injuries/Occupational Health and Safety Hazards

Various Project activities, such as the transportation of materials and operation of heavy equipment, pose a risk of accidents and injuries. Workers in the Project may be exposed to occupational and health hazards due to the nature of their work.

4.19.3.3 Increased Demand for Health Services

With the influx of workforce, demand for health services will increase. Given that the current health care system in the Solomon Islands has a limited capacity, this has the potential to impinging upon the existing health care system for the country as more people seek necessary health care services.

4.19.3.4 Contamination of Traditional Food Sources

Possible contamination of traditional food sources may occur due to the introduction of metals and chemicals through accidental release, posing a significant health risk.

4.19.3.5 Alteration of Food Production/Gathering Process and Food Consumption

The development of industries in a predominantly rural area could shift the economic structure and employment patterns of the population. In the process of the working population shifting from a generally informal sector to the formal sector and relying less on subsistence farming, the population may engage in less traditional farming and fishing activities, altering the food production and gathering process. This may have considerable impact on the food consumption, dietary patterns and nutritional status of the population.

4.19.3.6 Exposure to Dust Pollution, Noise and Vibration

Construction activities such as site clearing, transportation of construction materials and heavy equipment could generate dust and extreme noise. Likewise, operation activities will be continual over 24 hours, potentially affecting the community adversely, especially during night time. Ear infections were a reported health issue in some villages, which may be aggravated by the noise, dust and vibration of the Project activities.

4.19.3.7 Exposure to Solid, Liquid and Hazardous Wastes

The generation of solid, liquid (i.e. untreated wastewater, stormwater runoff) and hazardous waste may have an impact on the health of the population within and adjacent to the Project area if accidentally released. These wastes could also potentially contaminate the environment and community resources.

In the mining of base nickel ores, the presence of chromite ore in the form of dust waste, a major source of chromium in the disturbed soils, should be investigated. While Chromium 3 is a trace element essential to humans, Chomium 6 is toxic and carcinogenic.

4.19.3.8 Water Contamination and Potential Decrease in Water Supply

Contamination of water sources due to faecal wastes, litter, food scraps and other solid wastes may occur due to Project activities. Contamination may also occur from hydrocarbons and other chemicals of potential concern due to accidental spills in the mining areas, access roads and accommodation camps, particularly during periods of high rainfall.

Due to an increase in demand of water for industrial use, supply may decrease. Increased human activity during construction and operation in the area may contaminate the water supply.

4.19.4 Impact Assessment

Table 4-57 Assessment of Potential Impacts on Public Health

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Increase in incidence of diseases The influx of migrants could lead to the rise of infectious diseases associated with higher population density such as acute respiratory infection (ARI), tuberculosis, malaria, diarrhoea, human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) and other sexually transmitted diseases (STDs)	•	•	•	•	•	•	Negative	Local and Regional	Short Term	Medium	Probable	Low	Low	**Prevention, control and disease management measures** Conduct Information Education and Communication (IEC) campaign activities to relevant stakeholders in the impact villages to raise awareness of the community on the Project and to inform the local residents of the potential health-related risks. Seek collaboration with relevant organizations in the design and proper implementation of health promotion and disease prevention programs such as health programs for management of lifestyle diseases (e.g. diabetes, cancer and cardiovascular diseases), infectious disease (e.g. malaria and tuberculosis) control program and STD/HIV-AIDS prevention programs. Refer to Section 4.19.5.1.	Low	High
Accidents and injuries In laying the foundation of the mining areas and project facilities, excavation will be done in the area. The construction site could lead to possible occupational	•	•	•	•	•	•	Negative	Local	Short Term	Low	Probable	Low	Low	**Implementation of effective and efficient Occupational Safety and Health (OSH) programs** Design and implement an Occupational Safety Health Program (OSHP) integrating the following components Provide Personal Protective Equipment (PPE) to all employees		

Table 4-57 Assessment of Potential Impacts on Public Health

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
and health hazards to the workers. Transportation of construction materials and heavy equipment could also pose the risk of accidents and injuries.														in the project site. Establish company clinic and ensure that it can manage and respond to cases of accidents and injuries. While there has been no indication of the presence of chromium as yet in the baseline studies, it would be important to include a monitoring programme for its presence in the soil spoils from the mining sites. Refer to Section 4.19.5.2.		
Increased Demand for Health Services In the light of the possible increase in disease incidence, additional demand will impinge upon the existing health care system of the country as more people seek necessary health care services.	•	•	•	•	•	•	Negative and Positive	Local and Regional	Short Term	Low	Probable	Low	Low	**Provision of Health Extension Services** Establish health extension services for the community based on a realistic corporate social responsibility (CSR) program. Provide health infrastructure support such as ambulances, health clinics and health care professionals. Refer to Section 4.19.5.3.		
Waste generation The project would generate solid, liquid and hazardous wastes such as dust, water supply contaminants, solid and hazardous wastes, untreated	•	•	•	•	•	•	Negative	Local and Regional	Short Term	Medium	Highly Probable	Low	Low	**Waste management and pollution control** Continuously monitor the proper management of the generated wastes and pollutants throughout the duration of the Project. General wastes will be collected and		

Table 4-57 Assessment of Potential Impacts on Public Health

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
sewage surface water runoff, and wastewater.														transported to the Project landfill located on the island or transported in containers and shipped off-site (island) with regular cargo service to an accredited disposal facility. All hazardous wastes will be collected separately, stored in secured areas, and disposed at an accredited and registered facility off of the island. Refer to Section 4.19.5.5.		
Extreme Noise and Vibration Construction activities such as site clearing, transportation of construction materials and heavy equipment of the Project would generate noise and vibration.	•	•	•	•	•	•	Negative	Local	Short Term	Low	Probable	Low	Low	**Reduction and Control of Extreme Noise and Vibration** Ensure that noise reduction measures are in place (e.g. use of low noise equipment/ shielding) Minimize extreme noise during night time. Provide PPEs to employees of the Project. Refer to Section 4.19.5.6.		
Exposure to solid, liquid and hazardous wastes The exposure of the project employees and the nearby communities to solid, liquid and hazardous wastes could increase their vulnerability to certain illnesses such as	•	•	•	•	•	•	Negative	Local and Regional	Short Term	Medium	Probable	Low	Low	**Waste management and pollution control** Continuously monitor the proper management of the generated wastes and pollutants throughout the duration of the Project. General wastes will be collected and transported to the Project landfill located on the island or transported in containers and shipped off-site (island) with regular cargo		

Table 4-57 Assessment of Potential Impacts on Public Health

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
respiratory, water-borne and non-communicable diseases (e.g. certain types of cancer).														service to an accredited disposal facility. All hazardous wastes will be collected separately, stored in secured areas, and disposed at an accredited and registered facility off of the island. Refer to Section 4.19.5.5.		
Water contamination and potential decrease in water supply Water contamination may occur as the Project activities ensue. Project construction may affect the main sources of drinking water (e.g. ground water and surface water) in some communities. Likewise, environmental health status could be negatively affected with the wastes generated by the Project.	•	•	•	•	•	•	Negative	Local, Regional and National	Short Term	Medium	Probable	Medium	Medium	**Mitigating Measures on Waste Management and Pollution Control** Integrate the provisions of adequate water supply, sanitation and waste disposal facilities in the whole project duration. General wastes will be collected and transported to the Project landfill located on the island or transported in containers and shipped off-site (island) with regular cargo service to an accredited disposal facility. All hazardous wastes will be collected separately, stored in secured areas, and disposed at an accredited and registered facility off of the island. Refer to Section 4.19.5.5.		
Additional health infrastructure/ facilities The presence of the Project in the area could also be an opportunity to expand available health services that will	•	•	•	•		•	Positive	Local and Regional	Long Term	Medium	Probable	High	High	**Enhancement and improvement of basic health utilities/ resources** Expansion of water supply in the distributed system by providing clean and safe drinking water to the workers and staff of the Project. Potable water supply will be provided at the		

Table 4-57 Assessment of Potential Impacts on Public Health

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
accommodate the health care needs of the workers and staff of the Project.														accommodation camps, and at the staff facilities at mine sites and Port sites. Possible introduction of water treatment facility to the Project area could improve the current environmental health status of the area.		
Improvement of Basic Utilities and Resources The additional infrastructure requirements of the Project entail the improvement of basic utilities such as the expansion of water supply in the distributed system.	•	•	•	•		•	Positive	Local and Regional	Long Term	Medium	Probable	High	High	**Enhancement and Improvement of Basic Utilities/Resources** Expansion of water supply in the distributed system by providing clean and safe drinking water to the population. Potable water supply will be provided at the accommodation camps, and at the staff facilities at mine sites and Port sites.		
Contamination of traditional food sources Contamination of traditional food could result from the introduction of substances to the food production and gathering process.	•	•	•	•		•	Negative	Local and Regional	Long Term	Medium	Probable	High	High	**Waste management and pollution control** Continuously monitor the proper management of the generated wastes and pollutants throughout the duration of the Project. General wastes will be collected and transported to the Project landfill located on the island or transported in containers and shipped off-site (island) with regular cargo service to an accredited disposal facility. All hazardous wastes will be collected separately, stored in secured areas and disposed at an accredited and registered facility off of the island.		

Table 4-57 Assessment of Potential Impacts on Public Health

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Alteration of food production/gathering process and food consumption The introduction of the Project in could result to a shift towards the employment of the working population to the formal sector from a generally informal sector, hence becoming less dependent to subsistence agriculture and production. The working population may engage less in traditional farming and fishing activities altering as a result the food production and gathering process.	•	•	•	•		•	Negative	Local, Regional and National	Long Term	Medium	Probable	High	High	**Support to local agriculture and food production** Collaboration with relevant organizations regarding training and educational campaign could be explored to address potential impact of the alteration of food production and gathering process. The educational campaign can be conducted in agricultural villages to equip farmers with technological know-how in increasing yield of production.		

4.19.5 Mitigation Measures

The following section recommends measures to mitigate potential impacts caused by Project activities.

4.19.5.1 Prevention, Control and Disease Management Measures

To mitigate the potential rise in the prevalence of communicable and non-communicable diseases, management measures for the community and employees of the Project have been recommended.

4.19.5.1.1 Community Measures

- Conduct Information, Education and Communication (IEC) campaign activities to relevant stakeholders in the impact villages to raise awareness of the community on the Project and to inform the local residents of potential health-related risks.
- Seek collaboration with relevant organisations in the design and implementation of health promotion and diseases prevention programs, such as management of lifestyle diseases, an infectious diseases control program and sexually transmitted diseases-HIV/AIDS prevention programs.

4.19.5.1.2 Employee Measures

- Include pre-employment health screening as part of company requirements on recruitment and hiring.
- Conduct annual physical examinations (APE) to continually monitor employee health status.
- Design and implement effective health promotion and disease prevention programs.
- Ensure the first aid clinic is well-equipped and health personnel are properly trained.

4.19.5.2 Implementation of Effective and Efficient Occupational Health and Safety (OHS) Programs

- Design and implement an OHS program covering occupational health, industrial hygiene, environmental protection, safety control and emergency preparedness.
- Provide personal protective equipment (PPE) to all employees on site.
- Instigate a chromium monitoring program.
- Implement control measures that will intervene against the routes of exposure and entry of chromium to the workers.

4.19.5.3 Enhancement and Improvement of Basic Health Utilities/Resources

- Provide potable water to Project personnel.
- Introduce a water treatment facility to the Project area to improve current environmental health concerns.

4.19.5.4 Support Local Agriculture and Food Production

- Collaborate with relevant organisation regarding training and educational campaigns to address potential impacts from the alteration of the food production and gathering process.

4.19.5.5 Waste Management and Pollution Control

- Ensure that proper waste management occurs on site.
- General wastes will be collected and transported to the Project landfill or transported in containers and shipped off-site to an accredited disposal facility.
- All hazardous wastes will be collected separately, stored in secure areas and disposed of at an accredited facility off-site.

4.19.5.6 *Reduction and Control of Dust and Extreme Noise*

- Ensure noise reduction measures are in place.
- Minimise extreme noise during night time.
- Provide PPEs to employees of the Project.
- Use water suppression to control dust generation.

4.20 Workforce Influx

This section describes:

- the requirement for a suitably skilled workforce to construct and operate a nickel mining operation on Santa Isabel Island
- the potential impacts of mobilising a large workforce on the island
- the proposed mitigation measures for minimising the impacts of the workforce on the environment and the community of Santa Isabel Island.

Further details are provided in the Impact Assessment Report – Workforce Influx.

4.20.1 Legislation

The following section describes the legislation relevant to workforce influx in areas potentially impacted by the Project.

4.20.1.1 Immigration Requirements

All entrants who wish to reside and work in the Solomon Islands must have two distinct authorisations; a valid permit that allows them to enter and reside in the Solomon Islands and a work permit (valid for a maximum of two years, renewable) which authorises the holder to undertake employment, business or research in the Solomon Islands.

The permit to enter and reside in the Solomon Islands is issued by the Ministry of Immigration and is valid for two years and the work permit is issued by the Commissioner of Labour. There are a number of requirements that must be satisfied as part of the application process in order to attain the permits.

4.20.1.2 Industrial Relations

SMM Solomon has developed a number of policies and procedures relating to the employment of local Solomon Islander people and these will form the basis of their people management strategy for the Project. Additional policies and procedures will be developed to account for the management of a blended workforce comprised of an expatriate cohort and local employees being trained to assume roles in the long run as per the localisation plan. SMM Solomon would like to, where possible, employ and encourage the employment of local workforce participants.

The main expatriate workforce will be engaged and managed by the appointed construction contractor with reference to the policies and procedures of SMM Solomon and the industrial legal framework of the Solomon Islands to ensure equity and consistency in the management of workers and their conditions on the site. A collective agreement may be developed with the relevant parties to engage and manage the local workforce during construction and operations.

The *Labour Act* 1996 and revisions pertains to employment of workers and establishes the requirements of employers to provide workers with acceptable working conditions, health and accommodation, rations, etc. There are particular sections in the *Labour Act 1996* that need to be adhered to in relation to the employment of women and young persons.

4.20.2 Methodology

The assessment of workforce influx was based on a desktop analysis of existing reports and other pertinent information, in consultation with Project engineers and specialists. Public consultation was conducted on Santa Isabel Island within local villages. One of the topics discussed was workforce influx.

Refer to Report – Public Consultation for workforce related perceptions, interests and concerns of the local people.

4.20.3 Construction Workforce

A significant workforce of skilled labour will be required to construct the infrastructure and facilities associated with the development of the Solomon Islands Nickel Project.

SMM Solomon is committed to employing local people to work on the Project where possible. However, due to the limited availability of a skilled, experienced workforce on Santa Isabel Island it is anticipated that SMM Solomon will source most of its construction labour force from overseas. It is essential the workforce is trained and experienced in industrial scale construction for the effective completion of the Project within schedule and budget and to minimise any occupational safety risks. A fly-in/fly-out (FIFO) workforce is likely to be engaged from the Philippines, Malaysia, Indonesia or other international locations.

A workforce from Japan and other international locations will contribute to the workforce in management positions.

A localisation plan will be prepared detailing how local residents from Santa Isabel Island can be trained and developed to assume some positions during construction and the expected timeframe for the transition. A training program will be developed as part of this plan to train local people in skilled work such as road building and maintenance.

In addition, local contractors may bid for smaller contract packages. These packages are yet to be defined.

4.20.3.1 Construction Workforce Size

Table 4-58 estimates the number of personnel required during the construction period with a workforce peak of up to 500 personnel from multiple locations.

Table 4-58 Construction Workforce Estimates for Santa Isabel Island

Origin	On-Site Personnel	Roster Type Weeks On/Off
Solomon Islands	47	2 on - 1 off
Immigrant Workforce	313	24 on - 3 off
Japan & Other	65	6 on - 2 off
Total	425	

4.20.3.2 Hours of Work

The normal construction schedule will be six days per week, Monday to Saturday for all personnel. Normal hours of work will be 10 hours per day for all personnel.

4.20.4 Operations Workforce

Initial operations are scheduled with a workforce of up to 600.

A number of management and administration personnel will operate out of Honiara to facilitate consultation with government agencies and other stakeholder groups and manage the procurement and logistics/transport operations.

4.20.4.1 Operations Workforce Size and Roster

Table 4-59 depicts the size and origin of the workforce over the 23 year mine life based on the engineering mine plan (Golder 2012). A decrease in the expatriate workforce will be accompanied by an increase in the employment of Solomon Island Nationals as more local people are trained to assume skilled and professional roles. A number of SMM Solomon employees will be employed over the life cycle of the mine to manage the operations on behalf of the parent company in Japan. From year 24 to year 29, 40 employees will be retained for rehabilitation works.

Table 4-59 Operations Workforce Estimates for Santa Isabel Island Mining Operation

Personnel - Origin	Solomon Islands	Philippines	Japan & Other	Total
Year -1	142	34	1	177
Year 1	463	88	3	554
Year 2	465	86	3	554
Year 3	470	81	3	554
Year 4	474	77	3	554
Year 5	479	72	3	554
Year 6	483	68	3	554
Year 7	457	62	3	522
Year 8	461	58	3	522
Year 9	466	53	3	522
Year 10	470	49	3	522
Year 11	475	44	3	522
Year 12	475	44	3	522
Year 13	478	44	3	525
Year 14	478	44	3	525
Year 15	478	44	3	525
Year 16	538	44	3	585
Year 17	538	44	3	585
Year 18	538	44	3	585
Year 19	547	44	3	594
Year 20	547	44	3	594
Year 21	544	44	3	591
Year 22	541	44	3	588
Year 23	537	44	3	584

The mine will be operated 24 hours per day, seven days per week, and 365 days per year. Shift rosters will be scheduled to meet operational requirements.

4.20.5 Workforce Management

The following section describes recruitment, training, OH&S, logistics and accommodations for the workforce.

4.20.5.1 Recruitment

During construction the main workforce is likely to be engaged from overseas. A number of people from the Solomon Islands may apply for work at the mine during construction and operations. Preference will be given to local people who can prove they originate from Santa Isabel Island. All recruitment will be carried out through a recruitment office on the island.

4.20.5.2 Training

The Project will train local personnel as required to support the short term, intensive construction work and the long term, ongoing post-construction operations and maintenance work. SMM Solomon will develop a localisation plan which seeks to employ permanent residents of Santa Isabel Island where possible.

Partnerships with established, local training providers may be formed so that basic skills in work readiness, Occupational Health and Safety (OH&S), and basic trades' skills may be taught prior to local personnel mobilising to site.

SMM Solomon may collaborate with local community capacity building organisations to supply services or supplies to the Project. Such services may include the provision of training and development programs preferably run by local training providers.

4.20.5.3 Occupational Health & Safety

The safety of the workforce is paramount to the success of the project. Multiple work packages involving the movement of people and equipment will be carried out simultaneously increasing the potential for incidents and accidents.

A safety culture will be developed to manage the health and safety of the workforce, with risk assessments carried out daily and a safety management plan developed to address any potential incidents or accidents. This will be communicated to the workforce.

Preventative measures must also be put in place to avoid the spread of airborne illness and disease to the islands and the communicability of health issues specific to the Solomon Islands.

Fatigue management will be addressed through having both appropriate worker accommodation design and monitoring of rosters.

4.20.5.4 Logistics

A combination of land, air and sea transport will be used to transport workers to the island.

All transport options will be designed to facilitate the shortest commute times possible so that commute times do not adversely affect workers and result in occupational health and safety issues caused by fatigue. All travel options will be designed to ensure minimal impact on local accommodation, supplies and services.

4.20.5.5 Accommodation

The non-local construction workforce will be accommodated initially in a pioneering camp located in a previously disturbed area until the permanent accommodation camp is constructed. The accommodation facility will be designed to accommodate single status male and female workers only.

All non-local operations workforce will be housed in the permanent accommodation camp located in close proximity to the MIA.

Codes of Conduct will be devised and implemented to ensure the behaviour of all camp residents is consistent with a peaceful and harmonious culture conducive to the performance of shift work. Residents of the accommodation camp may be required to remain in the camp at the end of their shifts to eliminate any adverse affects that may arise from mine workers socialising in the villages or port areas.

4.20.6 Potential Impacts

The influx of workers for the construction and operation of the Project has the potential to affect the environment and lifestyles of residents on Santa Isabel Island.

During peak construction up to 500 workers from overseas locations will be mobilised to and from Santa Isabel Island in accordance with their roster arrangements. In addition, people from other islands will come to the island with the expectation of securing work at the mine or to provide the support services that will service the mine. Some Solomon Islanders who live on the other islands but may have links through kinship or marriage with those indigenous to Santa Isabel Island will also re-locate to the island in the hope of using their relationship ties to enter the mine workforce.

Entrepreneurial Islanders will also seek to commence businesses on the island to profit from the influx of workers who will need to purchase goods and services during their stay. Workers may not be permitted to leave the accommodation camp during "week-on" periods. However, there may be no restrictions on the workforce touring locally during "week-off" periods.

Potential impacts to social and environmental values due to workforce influx during the construction and operation of the mine are discussed in the following sections.

4.20.6.1 *Threat to Food Security*

Increase in population will create demand for fresh produce on the island, leading to shortages in supply and possible inflation of prices. People may be encouraged to purchase more processed foods leading to a change in traditional diet.

4.20.6.2 *Increased Health Risks*

An influx of workers from other countries may bring additional illnesses and diseases to the islands.

People may consume products that have not traditionally been consumed due to increased demand for fresh produce grown on the islands. This may lead to an increase in health issues such as diabetes, heart conditions and obesity.

4.20.6.3 *Improved Government Services*

An influx of workers will generate revenue through payroll and income taxation for the Solomon Island Government and provincial governments. This will provide opportunities for government additional health services on the islands, which may lead to improved access to health services and overall improved health. Basic services such as water sanitation, health and education may also be improved, depending on revenue allocation by the Solomon Islands government.

4.20.6.4 *Increased Inter-island Conflicts*

Solomon Island Nationals who live on other islands may choose to relocate to Santa Isabel Province in order to obtain work at the mine. This could create tension with local populations. In addition, importing some of the construction workforce will likely lead to a perception by locals that they are losing job opportunities. Preference will be given to local people with the appropriate skills for construction and operation roles.

4.20.6.5 *Threat to Traditional Values and Cultural Practices*

An influx of workers with different values and life-styles may influence life on the island and may lead to a disintegration of traditional values and cultural practices.

4.20.6.6 *Gender Imbalance*

Mining and construction are traditionally male dominated work areas. The current roles of men and women are traditionally and economically defined on the island with women more likely to be involved in non-cash based activities and men more likely to earn money for their work. Workforce immigration may result in a deepening of this gender imbalance by widening the gap between cash earners and non cash earners. However, in the long term women (non-cash earners) may be positively impacted as they become more accustomed to being trained and recruited for roles in the mining industry and perceptions about male and female roles may change. Earning wages and having cash at their disposal will empower women in society.

4.20.6.7 *Increased Demand for Transport Services*

The influx of a large workforce will put pressure on current air and sea carriers. It may escalate the cost of transport for local people. Refer to Section 4.14 and the Impact Assessment Report – Transport for further impacts associated with transportation.

4.20.6.8 *Tourism Opportunities*

An influx of workers may create a tourism opportunity as workers may wish to visit traditional villages, beaches, diving and surfing areas or World War II historic sites during "week-off" periods.

Local people may be able to expand on current offerings and grow their tourism enterprises. Workers may also create interest in the Solomon Islands as they will return home with reports of the beauty of the islands which may arouse the curiosity of others and create a market.

4.20.6.9 Increased Employment Opportunities, New Skills and Access to Education and Training

The creation of up to 600 jobs in the mining operation during the lifecycle of the mine will provide employment opportunities for the people on Santa Isabel Island.

The mine operation would facilitate the development of skills that had not previously existed on the island. There would be greater access to education and training opportunities for those on the island as the mine would create training placements including apprenticeships and trainee programs.

4.20.6.10 Competition for Skilled Workers

There could be increased competition for skilled workers on the island, as SMM Solomon looks to first, where possible, employ local people with the appropriate skills for construction and operation roles. This may take workers from current industries and creating wage escalation. In particular, skilled workers in key government services on the island may be attracted to the mine if conditions are more favourable. This may create issues for service provision and productivity on Santa Isabel Island.

Lack of skills may present a barrier to employment for some people, creating inequities in the community. This would widen the gap between skilled and un-skilled workers leading to disadvantage and discontent on the island.

4.20.6.11 Increased Pressure on Land Values, Infrastructure and Accommodation

An influx of people wishing to start businesses to provide services and supplies to the mining operation may put pressure on land values, infrastructure and accommodation as they try to set up close to the Project.

4.20.6.12 Anti-social Behaviours

Evidence from other countries such as Australia, Papua New Guinea and South Africa suggests that employment in industry may lead to anti-social behaviours such as:

- intoxication caused by irresponsible consumption of alcohol
- increased instances of single mothers as local girls become involved with workers who subsequently do not take responsibility for any ensuing offspring as they return to their country/place of origin
- increased sexually and other transmitted diseases
- erosion of traditional values as local youths are influenced by the values and behaviours of imported workers
- abandonment of family and community responsibilities leaving more work for those who do not secure paid employment and increasing the burden of work on women and elderly people who are less likely to secure employment
- increase in waste on the island including littering and personal waste matter

These impacts may be aggravated by the influx of foreign workers for the construction and operations phases of the mine.

4.20.6.13 Exodus of Skilled Workforce at Mine Closure

After mine closure and the completion of all rehabilitation work a trained, skilled and experienced workforce will exist. The workforce may emigrate if no suitable work is available which will drain skills from the island and break up families and communities.

4.20.7 Impact Assessment

An assessment of potential impacts is presented in Table 4-60.

Table 4-60 Assessment of Potential Impacts on Workforce Influx

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
Food Security Increase in population may create additional demand for fresh produce on the island, leading to shortages in supply and possible inflation of prices.	•	•	•	•	•	•	Negative	Local	High	Short	Highly Probable	Medium	Medium	Collaborate with provincial government to extend the small holder agricultural sector. Source bulk of produce for Project from outside of Santa Isabel Island. No increase in current levels of trading with local fishermen.	Low	
Health An influx of workers from other countries may bring new illnesses and diseases to the islands. Also, islanders may consume products that have not been part of their traditional diet if fresh produce is in short supply or becomes expensive on the islands. This may lead to an increase in diseases such as diabetes, heart conditions and obesity	•	•	•	•	•	•	Negative	Regional	Medium	Long	Highly Probable	Medium	Medium	Ensure all workers undergo a medical and are fit for work before being hired. Ensure medical facilities are available on-site to treat illnesses. Make provisions for basic medical treatment of local workers and family members in company "Health Policy". Provide education at site on good nutrition and diet and encourage workers to share the information with family and tribal members. Encourage regional health workers and NGOs in their health education programs for women and children.	Low	Medium
Government Services An influx of workers will generate revenue for the government which will allow them to provide additional health services on the islands leading to	•	•	•	•	•	•	Positive	Regional	Medium	Medium	Highly Probable	Medium	Medium	Collaborate with government to secure the provision of additional government services on the island.	Low	Medium

Table 4-60 Assessment of Potential Impacts on Workforce Influx

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
improved access to health services and overall improved health																
Conflict Importing some of the workforce for construction may lead to a perception by islanders that they are losing job opportunities. The influx of people seeking work from neighbouring islands or ex-residents returning to Isabel could cause tension on the island.	•	•	•	•	•	•	Negative	Local	Low	Medium	Probable	Medium	Medium	Recruit locally where possible particularly in the camps and road construction. Provide training for local people where possible. Liaise with government to ensure only licensed operators can start businesses. Have preferred supplier agreements with local people. Collaborate with government to arrange additional security to manage the borders of Santa Isabel Island particularly at Port locations where entrants are likely to disembark. Set up employment centres with appropriate procedures.	Low	Medium
Culture & Tradition An influx of workers with different values and life-styles may influence life on the island and lead to a disintegration of traditional values and cultural practices.	•	•	•	•	•	•	Negative	Regional	High	Permanent	Highly Probable	High	High	Manage the movement of workers around the island. Ensure that migrant workers remain within the camp during rostered-off periods. Ensure workers are transported directly to and from the camp when they arrive or depart for the commencement of their roster. Encourage traditional values and cultural practices in the workplace. Provide cross-cultural training to employees.	Low	Medium
Gender Imbalance Gender gap in employment opportunities may	•	•	•	•	•	•	Negative	Local	Medium	Short	Probable	Medium	Medium	Actively recruit women for all positions to improve equity in the workplace. Have an "Equal Opportunity Policy" and set targets for	Low	Medium

Table 4-60 Assessment of Potential Impacts on Workforce Influx

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
discriminate against women.														the employment of women. Joint initiatives with partner organisations and local women's groups to address gender inequality issues Training for local women to build skills Implementation of CSR Strategy and Grievance Procedure.		
Gender Equity In the long term women will be better off as it becomes more accepted for women to occupy all roles in mining							Positive	Local & Regional	High	Long	Highly Probable	High	High	N/A	High	High
Transport Services The influx of a large workforce will put pressure on current air and sea carriers. It may escalate transport costs for local people.	•	•	•	•	•	•	Negative	National	High	Short	Highly Probable	High	High	Have a transport plan in place well in advance of commencement of construction.	Low	Medium
Tourism Local people may be able to expand on current tourism activities or commence new ones as more people come to Santa Isabel Island and wish to explore the island.	•	•	•	•	•	•	Positive	Regional	Low	Long term	Probable	Medium	Medium	Encourage local people to expand regional tourism activities.	High	Medium
Competition for skilled workers	•	•	•	•	•	•	Negative	Local	Low	Short	Probable	High	High	Establish criteria required to gain employment on the Project to inform other industries where	Medium	Medium

Table 4-60 Assessment of Potential Impacts on Workforce Influx

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Could be increased competition for skilled workers on the island, taking workers from current industries and creating wage escalation.														competition may exist and further promote job applications by eligible workforce participants. Project wages to be suitably comparative to the type of work and to other industries. Work with local training and education providers.		
Increased pressure on land, infrastructure etc. Influx of people wishing to start businesses to provide services and supplies to the mining operation may increase the pressure on land, infrastructure and accommodation.	•	•	•	•	•	•	Negative	National	Medium	Medium	Highly Probable	High	High	Collaborate with the government to ensure only licensed operators can start businesses on Santa Isabel Island and to prevent informal settlers from setting up in the area. Have preferred supplier agreements run by local people.	Medium	Medium
Anti-social behaviours Workers may spend their cash income earned at the mine on alcohol which can lead to a range of anti-social behaviours,	•	•	•	•	•	•	Negative	Local	High	Long	Highly Probable	High	High	Discourage the irresponsible consumption of alcohol by prescribing desirable behaviours in the camp and /or implementing testing procedures to ensure people are fit for work. Develop a family friendly culture by having policies and procedures that allow workers to attend to family responsibilities. Develop an IEC (information, education, communication) program to promote strong family values. Work with chiefs and local law enforcement to prevent anti-social behavior. Encourage traditional values and cultural practices by incorporating them in the	Medium	Medium

Table 4-60 Assessment of Potential Impacts on Workforce Influx

Potential Impact	Facility: Mine	Facility: Haulage	Facility: Port	Facility: Infrastructure	Stage: Construction	Stage: Operation	Status	Extent	Intensity	Duration	Probability	Consequence no Mitigation	Significance no Mitigation	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
														workplace where possible. Provide all on-site staff with comprehensive cross cultural awareness training run by a community liaison officer selected from Santa Isabel Island.		
After mine closure and the completion of all rehabilitation work a trained, skilled and experienced workforce will exist. The workforce may emigrate if no suitable work is available which will drain skills from the island and break up families and communities.	•	•	•	•	•	•	Negative	Local	High	Permanent	Highly Probable	High	High	Collaborate with Government to identify other projects coming on line where people may be re-deployed. Mine closure plan to include strategy for up-skilling and outplacement of workers.	Low	Medium

4.20.8 Mitigation Measures

Negative impacts arising from the influx of workers will be avoided where possible. The following mitigation measures will be incorporated into the EMP (refer to Chapter 5) to minimise any potential adverse affects arising from the influx of workers to Santa Isabel Island.

4.20.8.1 Threat to Food Security

Mitigation measures to minimise the threat to food security include:

- collaborating with the local community and other stakeholders to extend the small-holder agricultural sector on the island
- sourcing the bulk of the produce required for the mine camps outside of Santa Isabel Island
- not increasing current levels of trading with local fishermen for marine and freshwater resources

4.20.8.2 Increased Health Risks

Mitigation measures to address increased health risks include:

- ensuring all workers undergo a medical before being hired
- ensuring medical facilities are available on-site to treat illnesses
- providing education on good nutrition and diet and encouraging workers to share the information with family and tribal members. Encouraging regional health workers in their health education programs

4.20.8.3 Improved Government Services

SMM Solomon will collaborate with the Solomon Islands Government to secure the provision of additional Government services on Santa Isabel Island.

4.20.8.4 Increased Intra-island Conflict

Mitigation measures to reduce the risk of intra-island conflict include:

- recruiting local people where possible
- providing training to local people where possible
- SMM Solomon will only contract licensed operators on Santa Isabel Island
- having preferred supplier agreements with local operators
- collaborating with the Government to arrange security to manage the borders of Santa Isabel Island, particularly at port locations where entrants are likely to disembark
- having competitive processes for employing people
- setting up employment assessment centers on the islands and ensuring all potential employees come through the assessment centre
- setting criteria for employment

4.20.8.5 Threat to Traditional Values and Cultural Practices

Mitigation measure to reduce the risk of threats to traditional values and cultural practices include:

- managing the movement of workers around the island
- requiring workers to remain in accommodation camps during "week-on" periods
- ensuring workers are transported directly to and from the camp when they arrive or depart for the commencement of their roster (refer to Section 4.14 and the Impact Assessment Report – Transport for further transport information)

- encouraging traditional values and cultural practices by incorporating them into the workplace where possible
- providing all on-site staff with comprehensive cross cultural training run by a community liaison officer selected from Santa Isabel Island

4.20.8.6 *Gender Imbalance*

Potential gender imbalances will be addressed by:

- recruiting women where possible by having an "Equal Employment Opportunity" Policy and setting targets for the employment of women
- joint initiatives with partner organisations and local women's groups to address gender inequality issues
- training local women to build skills and capacity
- implementation of EMP, including the management of social and community values
- ensuring women have access to training for all roles in the mining industry
- ensuring accommodation and ablution facilities are available for women

4.20.8.7 *Increased Demand for Transport Services*

SMM Solomon will have a transport plan in place well in advance of commencement of construction.

4.20.8.8 *Competition for Skilled Workers*

Impacts due to competition for skilled workers will be mitigated by:

- establish criteria required to gain employment on the Project to inform other industries of where competition may be and promote job applications by eligible workforce participants
- having Project employees receive wages commensurate with the type of work being performed and comparative to other industries, thus mitigating against wage distortion effects in the local economy across industries competing for labour resources
- setting criteria for entry into traineeships and apprenticeships to extend accessibility as appropriate
- working with local training and education facilities to align curricula with the entry requirements for mine training programs

4.20.8.9 *Increased Pressure on Land Values, Infrastructure and Accommodation*

Mitigation measures to reduce the pressure on land values, infrastructure and accommodation will include:

- SMM Solomon will only contract licensed operators on Santa Isabel Island
- having preferred supplier agreements with local goods and services providers

4.20.8.10 *Anti-social Behaviours*

Anti-social behaviours will be discouraged by:

- discouraging the irresponsible consumption of alcohol by prescribing desirable behaviours in the camp and/or implementing testing procedures to ensure people are fit for work
- developing a family friendly culture by having policies and procedures that allow workers to attend to family responsibilities

- developing an IEC program to promote strong family values within both communities and schools
- working with chiefs and local law enforcement to prevent anti-social behaviour
- encouraging traditional values and cultural practices by incorporating them in the workplace where possible

4.21 Economics

This section describes and assesses the economic impacts of the Project within the national economy of the Solomon Islands and the regional economy of Isabel Province. It provides:

- a summary of the key legislation that applies to the economic assessment was conducted
- a macro-economic overview of the economy of the Solomon Islands
- a macro-economic overview of the economy of Isabel Province
- an assessment of the Project's fiscal impact, macro-economic impact and external impacts (both positive and negative)
- potential mitigation measures aimed to minimise the negative external potential impacts and enhance the external positive potential impacts of the Project.

Further details are provided in the Impact Assessment Report - Economics.

4.21.1 Legislative Framework

The key legislation that applies to the economic impacts of the Project include:

- The *Mines and Minerals (Royalties) Regulations 2011* which regulate mining royalties. Under the Regulations the holder of a mining lease or building materials permit shall pay royalties to the government for any mineral obtained pursuant to the lease or permit.
- The *Income Tax Act 1965 (*1996 revision*)* which sets out the tax regime relevant to mining activities in the Solomon Islands. The Act makes provision for corporate tax on the profit of companies, personal income tax, withholding of tax for non-residents, additional profit tax and dividend tax. Refer to the Impact Assessment Report - Economics for the specifications of the Act.
- The *Goods Tax Act 1992* (1996 revision) which sets out a 10% tax on domestic products and a 15% tax on foreign products, unless the goods are exempted under a mining list or there is a broader exemption.
- The *Customs and Excise Act 1960* which makes provision for variable taxes on imports. There is provision for exemption from import tax under a mining list for a period. A potential exemption may be negotiated in the Mining Agreement. It also makes provision for export duty or alternatively, royalties payable.
- The *Sales Tax Act 1996* which sets out a 5-10% tax on services and goods purchased from a locally registered provider in the Solomon Islands (e.g., 5% for professional services). This tax is non-refundable and cannot be offset, however the government can grant full, selective or conditional exemptions.
- The *Stamp Duties Act 1996* (revision) which sets out variable nominal fees levied on registered agreements and titles.
- The *Foreign Investment Act 2005* which cancels prior authorisation requirements to open a business but maintains constraints and controls. Under the Act government approval is required for the importation of capital; repatriation of capital; transfer of profits, dividends, interest and royalties; borrowing of overseas funds; settlement of intercompany accounts; overseas transfer of the proceeds from sales of Solomon Islands assets; and direct investment overseas.
- The *Labour Act 1996* which sets out standards for the care of workers, the minimum wage, payment of wages and hours of work. It also sets out work permit requirements. Under the Act the minimum hourly wage in 2011 was SB$8/hr, the standard working week is 45 hours (5 x 9 hr), a 150% loading for overtime and work on Saturday and Sunday applies and a 200% loading for overtime and work on public holidays applies.

4.21.1.1 Proposed change to relevant legislation

This assessment of economic impacts has been based on the assumption that current tax law will be reformed according to proposals made by the Solomon Islands Government (August 2011) and the International Monetary Fund (IMF) (December 2011). The IMF has made recommendations to the government on the formulation of a new mining tax regime including integration of mining taxation into the Income Tax Act and other legislation. The new tax regime is intended to provide a fair sharing of risk and reward between the government and the investors and is intended to be applicable to all new mining projects (avoiding negotiation of ad hoc fiscal arrangements for a specific mine). The government committed to formulating a new mining taxation regime, drafting amendments to relevant tax legislation and implementing the new taxation regime. In March 2012, the Government of Solomon Islands released a framework based on the IMF proposed regime. This framework, currently referred to as the Natural Resource Tax Framework, has not been gazetted and is consequently not used in the analysis of potential Project impacts.

4.21.2 Standards Applied

The assessment of economic impacts is consistent with the national and international legislative standards listed below:

- The World Bank Environmental Assessment Sourcebook and the Environmental Assessment Sourcebook- Update No. 23 – Economic Analysis and Environmental Assessment. These documents provide practical guidance for environmental assessment including current methods and practices of economic evaluation of environmental cost and benefits. This is in alignment with the World Bank's Operational Policy on Environmental Assessment (OP 4.01) which states "... environmental costs and benefits should be quantified to the extent possible, and economic values should be attached where feasible."
- The cost-benefit analysis (CBA) followed international best practices in CBA methodology, specifically the:
    - European Union Guide to CBA of investment projects (EU 1997)
    - Millennium Ecosystem Assessment, Framework for Assessment of Ecosystems and Human Well-Being to address ecosystem service impacts (refer to http://www.maweb.org/en/index.aspx).

4.21.3 Methodology

The study followed a cost-benefit analysis (CBA) approach. This enabled the incorporation of financial and economic project impacts (costs and benefits) into a single analysis framework. This analysis framework is also compatible with standard business planning requirements. A discounted cash flow (DCF) analysis was conducted on the revenues and costs associated with the Project and the outputs used to estimate macro-economic impacts on the economy of the Solomon Islands.

Secondary data for the study was sourced from published papers and studies/reports prepared by government and non-government organisations (e.g., international development institutions). The key data sources for the financial analysis included:

- the Project's prefeasibility study (Golder Associates 2011)
- the International Monetary Fund
- the International Labour Organization
- Solomon Islands Ministry of Provincial Government and Rural Development
- Solomon Islands Ministry of Foreign Affairs and External Trade
- Food and Agriculture Organization of the United Nations
- Solomon Islands National Statistics Office (SINSO).

The macro-economic overview provides an overview of the economy of the Solomon Islands. It contextualises the economic setting within which the Project area is located.

The economic analysis quantifies the Project's macro-economic impacts. The analysis uses the outputs of the financial analysis to estimate the effect of Project spending within the Solomon Islands on the national economy. This includes for example, royalties paid to government, local employment costs and purchase of local good and services.

Aside from the potential financial impacts associated with the Project, there are a number of potential social and ecological impacts. The costs and benefits associated with the latter impacts were not quantified in monetary terms, but were dealt with in a qualitative manner.

4.21.3.1 Limitations of the assessment

The economic impact assessment is subject to the following limitations and exclusions:

- There is variation in international nickel and cobalt prices which significantly affect estimates of the financial viability of the Project.
- There is also uncertainty about the application of the Solomon Islands' mining tax regime to the Project which required certain assumptions to be made with respect to the value of tax revenue accruing to the Solomon Islands Government.

Further information on the methodology, details of the economic analysis and limitations of the study, are presented in the Impact Assessment Report – Economics.

4.21.4 Existing Values

4.21.4.1 Macro-economic Overview of the Solomon Islands

The Solomon Islands is a small, open economy, which is vulnerable to external demand shocks in terms of trade volatility and exchange rates. The country is one of the poorest countries in the Pacific Region and is classified as a lower middle-income country by the World Bank (2011a). The majority of the population relies on agriculture, forestry and fisheries for at least a portion of their livelihoods.

According to the IMF World Economic Outlook Database (2011), GDP in current US$ prices for the Solomon Islands was US$840 million for 2011. Over 75% of the country's labour force is engaged in subsistence farming and fishing.

Gross domestic product (GDP) per capita was approximately US$1,553 in 2011 (IMF World Economic Outlook Database 2012), well below the regional average of $2,817 (See Figure 4-38).

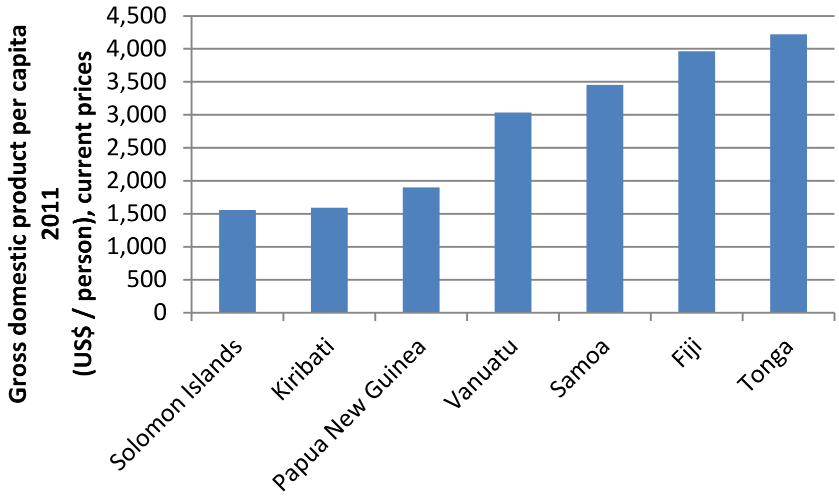

Figure 4-38 GDP Per Capita (current US$ prices) for Selected Oceania States in 2011
Source: IMF World Economic Outlook Database 2012

4.21.4.1.1 Growth Projections

Economic growth reports for the Solomon Islands are reported in the following section in both US Dollar or Solomon Island Dollar and real or nominal terms depending on the reporting body.

The IMF reports that the economy of the Solomon Islands grew by 24% in 2011 in current US Dollar terms. This strength follows a 13% expansion in 2010, after a 2% contraction induced by the global economic downturn in 2009. The IMF forecasts a growth of 17% in 2012 (IMF World Economic Outlook Database 2012). Tourism and the Gold Ridge gold mine were each estimated to contribute up to 2% of 2011 growth (IMF 2011b; World Bank 2011b). In spite of this, the greater government spending (including through donor-funded projects) contributed most of the expansion in the Solomon Islands' non-forestry, non-mining economy in 2011 (World Bank 2011b).

Comparatively, the Central Bank of the Solomon Islands (CBSI) reports a 17% nominal (10.7% real) GDP growth in 2011 and a 17.8% nominal (7.1% real) growth in nominal GDP in 2010, as measured in nominal Solomon Island Dollar terms (CBSI 2012). The main contributors to the expansion in real GDP in 2011 were forestry (4.5%), mining (1.7%) and others (agriculture, telecommunications & transport, fisheries and construction) (4.5%) (CBSI 2012).

4.21.4.1.2 Key Economic Sectors

The key economic sectors of the Solomon Islands include:

- Agriculture – Agriculture is an important source of income for many households. This sector involves more people than any other economic activity and helps preserve local tradition. Of particular importance to the agricultural sector are (Gay 2009); cocoa, copra and palm oil. Other cash crops include, coffee, spice, kava, beetle nut, rice and various horticultural crops.
- Fisheries and Aquaculture – The fisheries sector is an important contributor to the economy of the Solomon Islands. It is seen as a strategically important sector (particularly the industrial tuna sector), which is capable of filling the gap as foreign exchange earnings from logging decline over the future. Small-scale fisheries and aquaculture have less potential for foreign exchange earnings, but contribute significantly to the country's food security and to the livelihoods of the rural population. Total fish catch in 2011, increased by 32% to 28,195 tons from 2010.
- Forestry – Hill forests cover most of the Solomon Islands, especially Guadalcanal, Malaita, Western Province, Isabel Province, Choiseul Province and Makira (Hatch, 2011). The logging industry is a major source of economic activity due to the abundance of forest cover (once 90%, now estimated to be around 75%). Most logs are directly exported overseas (Gay, 2009; Pauku, 2009). Logging exports accounted for 46% of all exports in 2011 (CBSI 2012).
- Mining – The mining sector has gained momentum in recent years and is expected to play an increasingly important role in the economy (IMF 2011a). At present, Gold Ridge mine, operated by Allied Gold, is the sole operating mine in the Solomon Islands. However, more than 120 prospecting mining licenses, mainly gold and nickel, have been issued up to October 2011. About three quarters of these licenses are related to offshore mining explorations, and about two thirds were issued in 2011 alone (IMF 2011a).
- Manufacturing – The tuna-canning operation run by Soltai Fishing and Processing was once the largest single employer in the country. The scaling down of this plant has had a significant impact on the domestic economy. There are a few other manufacturing operations in the Solomon Islands, but these are on a relatively small scale. They include food and beverages (flour mill, brewery, soft-drink production), fibreglass boats, timber products, building materials and a limited range of clothing for the local market. Only very limited volumes of manufactured products are exported from the Solomon Islands including simply processed timber, vegetable oils, coconut oil, coffee and handicrafts.

- Tourism – The tourism sector is relatively underdeveloped when compared to other Oceania states and accounts for less than 2% of GDP (IMF 2011b). Possible reasons include the recent political turmoil experienced, travelling logistics limitations and the tsunami of 2007. There was an increase in visitor arrivals registered during 2011 up to 22,941 visitors which is 12% higher than 2010.
- Aid – While not considered an economic sector, the contribution of donor aid to the GDP of Solomon Islands is significant. In 2011 the Government received $108 million in grants and a further $32 million from the National Transport Fund (CBSI 2012).

4.21.4.1.3 Employment

Unemployment is a major issue in the Solomon Islands. The total national workforce was 214,610 in 2009 of which only 81,195 people (or 38% of the workforce) were employed formally. The total national workforce was 214,610 in 2009 of which only 81,195 people (or 38% of the workforce) were employed formally. A large portion of the employment is centred on the Primary industries (agriculture, hunting, forestry and mining sectors) (22%) followed by manufacturing (20%), Education (12%), Public administration (12%) and the Wholesale & Retail trade sector (11%).

4.21.4.1.4 Trade

The balance in trade in goods deficit reduced in 2011 to $23 million from $1,102 million deficit in 2010 as a result of a 75% growth in exports (CBSI 2012). Buoyed by a strong commodity price, exports are projected to grow through to 2012. Mineral exports are expected to provide the bulk of this growth, while logging which is strong in the medium term will begin to decrease after 2012. Gross international reserves increased to US$355 million (6 months imports) in June 2011 from less than US$100 million in mid-2009 (IMF 2011b). Buoyed by a strong commodity price, exports are projected to grow through to 2012.

4.21.4.2 The Local Economy of Santa Isabel Island

The population of Isabel Province was 20,198 in 1999 which represented less than 5% of the total population of the Solomon Islands (SINSO 1999). The vast majority of the population lives in a rural subsistence area while the remainder lives in Buala (the administrative centre of Isabel Province). The data presented here on employment and economic value were sourced from Government of Solomon Islands (2011).

According to the 2009 census, 59% of the population of the Province are engaged in subsistence activity.. Local people produce root crops, fruits and cabbage and rear pigs and chickens. The majority of these activities are for own consumption with surpluses sold in local markets. As in other provinces, subsistence fishing is a principal occupation.

Economic activities in the province are extremely limited. Agriculture is the main source of income and employment (28% of employees) in Isabel Province. The main agricultural (cash) crops on Santa Isabel Islands are copra and coca. Several other agricultural activities occur including the production of spices, livestock, rice and fruits.

There is a large potential for timber exploitation in the Province and due to strong commodity prices this trend is set to continue. The logging industry is a major source of economic activity on Santa Isabel Island due to the abundance of forest cover (once 90%, now estimated to be around 75%). Most logs are directly exported (Hatch 2011).

Commercial fishing involving fish, shellfish, shark find and beche de mere (sea cucumber) accounts for 10% of employed persons.

4.21.5 *Potential Impacts*

This section of the report assesses economic impacts that may arise from the Project. The impacts relate to:

- The fiscal effect – which refers to the effect of the proposed Project on government expenditure and revenue collection. The fiscal effect was estimated by adding all project expenditures that accrue as fiscal income to the Solomon Islands Government, i.e. the sum of all royalties and other taxes payable to the government.
- Macro-economic impacts. The key macro-economic indicator used in this study is GDP. The impact on the Solomon Islands GPD has been estimated by adding the Project's employment costs (i.e. all income earned by the country from wages and profits retained in the form of taxes, rent and interest income) and the fiscal effect.
- External benefits and costs – refer to those that impact on the community and the environment. Whilst these costs can be easily identified that are difficult to quantify and value. The external benefits and costs associated with the Project include:
    - external benefits – capacity building through training and community liaison, local purchasing of goods and services and infrastructure development.
    - external costs or negative externalities – refers to negative impacts on ecosystem services such as regulating services (e.g., water purification, air quality regulation, climate regulation, etc.), provisioning services (ecosystem 'goods' such as food, fuels, fibres, biochemicals, etc.) and cultural services (religious, spiritual, inspirational and aesthetic well-being derived from the ecosystem). A quantitative assessment of these impacts has not been attempted in this report as it is outside the scope of the assessment.

These impacts are detailed in the following sections.

4.21.5.1 *Fiscal Effect*

The fiscal effect has been estimated based on the assumption that the current tax law will be reformed as part of the proposed mining tax regime.

The Project is estimated to contribute between US$3.4 and US$3.8 million per year in tax revenues to the Solomon Islands Government. The net present value (NPV) of the total fiscal effect for the life of the mine is positive and varies as set out in Table 4-61.

Table 4-61 NPV of the Fiscal Effect of the Project on the Solomon Islands Economy, expressed in US$ million

Discount rate	NPV (US$ million)
0.0%	89.0
6.0%	43.7
8.0%	36.0
10.0%	30.2

4.21.5.2 *Macro-economic Impacts*

The economic analysis shows that the Project is highly beneficial to the macro-economy and may increase country GDP and employment opportunities. Specifically, the Project may:

- Increase the Solomon Islands' GDP on average by 0.3% per year over the life of the Project. This is equivalent to GDP NPVs as set out in Table 4-62 below, varying between US$47.8-139.1.
- Increase employment opportunities in Isabel Province by up to 20% by year 10. Household income will increase to US$2.47 million per year by project maturity and US$45.9 million over the life of the mine.

Table 4-62 NPV of the Macro-economic Effect of the Project as Measured in Contribution to the Solomon Islands' GDP, expressed in US$ million

Discount rate	NPV (US$ million)
0.0%	139.1
6.0%	68.7
8.0%	56.8
10.0%	47.8

4.21.5.3 Positive External Impacts

The following external benefits flowing from the project have been identified:

- Training – the Project will provide significant expenditure on training of Solomon Island (national) employees. The total direct and indirect cost of training of Solomon Island employees is estimated to be US$1.8 million over the life of the mine.
- Expenditure in local businesses – It is anticipated that the Project could purchase fresh food products from local suppliers. A preliminary estimate of between US$1 to US$2 per staff member per day has been assumed. This would amount to US$0.27-0.53 million per year or US$12.2 million over the life of the mine.
- Expenditure by expatriate personnel on Santa Isabel Island may benefit the local accommodation, restaurant and retail trade sector. However, the value of this expenditure has not been estimated.
- Constraints to the economic development of the Isabel Province identified by the Solomon Islands Government include the lack of critical development infrastructure such as international port facilities, a suitable road system and power supply system and a lack of linkages to export markets. The development of port facilities and other infrastructure may relieve local economic development constraints related to these constraints.

4.21.5.4 Negative External Impacts

It is acknowledged that the Project may impact on a variety of ecosystem services. These impacts are ideally assessed through a corporate ecosystem valuation using guidelines provided by the World Business Council for Sustainable Development (refer to WBCSD 2010). This type of quantitative assessment is outside the scope of the economic assessment undertaken for the Project. A qualitative impact ('losses in ecosystem services') has been included in the impact assessment (see Table 4-63) to capture this impact and the assigned 'low' confidence level captures the absence of quantitative data on the impact.

4.21.6 Impact Assessment

A risk assessment of potential economic impacts is presented in Table 4-63.

Table 4-63 Assessment of Potential Economic Impacts of the Project

Potential Impact	Facility				Stage		Status	Extent	Intensity	Duration	Probability	Consequence (no Mitigation)	Significance (no Mitigation)	Mitigation / Management Actions	Significance with Mitigation	Confidence Level
	Mine	Haulage	Port	Infrastructure	Construction	Operation										
Fiscal effect – increased revenue earned by the Government of the Solomon Islands through tax revenues	•	•	•	•	•		Positive	National	Medium-High	Short Term	Highly Probable	High	High	Not applicable	High	Medium
	•	•	•	•		•	Positive	National	Medium to High	Long Term	Highly Probable	High	High	Not applicable	High	Medium
Macro-economic impacts – increased GDP through economic rents earned (including land rents, royalties, other taxes, and employment created)	•	•	•	•	•		Positive	National	Medium-High	Short Term	Highly Probable	Medium	High	Not applicable	High	Medium
	•	•	•	•		•	Positive	National	Medium to High	Long Term	Highly Probable	High	High	Not applicable	High	High
Increased employment	•	•	•	•	•		Positive	Regional	Medium to High	Short Term	Highly Probable	High	High	Not applicable	High	Medium
	•	•	•	•		•	Positive	Regional	High	Long Term	Probable	High	High	Not applicable	High	High
Increased training and investment in education	•	•	•	•	•		Positive	National	High	Short Term	Highly Probable	High	High	Not applicable	High	Medium
	•	•	•	•		•	Positive	Regional	Medium to High	Long Term	Probable	High	High	Not applicable	High	High
Increased expenditure in businesses	•	•	•	•	•		Positive	National	Low to Medium	Short Term	Probable	High	High	Not applicable	High	Medium
	•	•	•	•		•	Positive	Regional	Medium to High	Long Term	Probable	High	High	Not applicable	High	Medium
Improvements in infrastructure development	•	•	•	•	•		Positive	Regional	High	Long Term	Probable	High	High	Not applicable	High	Medium
	•	•	•	•		•	Positive	Local	Low	Long Term	Highly Probable	High	High	Not applicable	High	Medium
Losses in ecosystem services	•	•	•	•	•		Negative	Regional	Medium	Long Term	Probable	Medium to High	Medium to High	Outside scope of assessment.	Low	Low
	•	•	•	•		•	Negative	Regional	Medium	Long Term	Probable	High	High	Outside scope of assessment.	Low	Low

4.21.7 Mitigation Measures

Mitigation measures for the losses in ecosystem services are outside the scope of an economics assessment. Instead, various mitigation measures for limiting impacts to ecosystem services have been proposed in the accompanying ecology studies. Refer to Impact Assessment Report - Terrestrial Ecology; Impact Assessment Report - Marine Ecology; and Impact Assessment Report - Freshwater Surface Water Ecology.

4.22 Cumulative Impact Assessment

Cumulative impacts refer to two or more individual effects which, when considered together, are considerable or compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or a number of separate projects. (California Environmental Quality Act (CEQA) Guidelines, Section 15355).

This cumulative impact assessment considers the potential compounding effects of the Solomon Islands Nickel Project and other current or proposed projects/activities/industries on the environment, the people and the economy of Santa Isabel Island. It assesses the impacts of the Project and their interaction with the impacts of other current and planned projects on the Island.

The scope for this cumulative impact assessment included the key impacts identified:

- in the Project area and its immediate surrounds
- associated with other projects/activities/industries that are separate but interrelated to the Project
- associated with other projects/activities/industries or publically known potential future projects where plans were available.

Further details are provided in the Impact Assessment Report – Cumulative Impacts.

4.22.1 Methodology

This analysis of cumulative impacts considers the impacts from a life-of-project perspective taking into account the nature, scale, intensity, duration and frequency of the impacts on environmental and social values.

Desktop research was undertaken to identify other developments planned for Santa Isabel Island and internet searches were conducted to access information. Stakeholder consultation on Santa Isabel Island and at Honiara included requests for information about current and planned future projects for Santa Isabel Island. This cumulative impact assessment identifies:

- potential key direct and indirect impacts associated with the Project, as presented in each of the Impact Assessment Reports and the nature (positive or negative) of these impacts
- appropriate spatial boundaries for analysis of cumulative impacts
- appropriate temporal boundaries for analysis of cumulative impacts, considering short term, medium term and long term impacts
- the relationship of impacts of the existing, approved or proposed projects to each other
- mitigation measures that could be implemented to reduce the severity or significance of the cumulative impacts of the project.

4.22.2 Other Projects and Activities

On Santa Isabel Island four existing industries/activities (agriculture, forestry, fishing and tourism) were identified as likely to produce cumulative impacts when assessed in conjunction with the Project. In addition, one potential future mining project was identified outside the existing tenement which if developed could contribute to cumulative impacts.

4.22.2.1 Agriculture

The Solomon Islands has abundant natural resources that provide subsistence livelihoods for a population of approximately 500,000 people. Although the soil is not generally suitable for agriculture (refer to Impact Assessment Report – Geology, Geohazards and Soils), the agriculture sector provide the foundation for rural growth. In Isabel Province the agriculture sector is limited to smallholder agricultural activities that provide subsistence livelihoods for the island's population. Excess crops are sold to earn cash for goods and services that cannot be produced locally (e.g. processed foods such as rice and noodles, kerosene and school fees).

Agricultural products include coconuts, cocoa, palm oil, coffee, spices, kava, betel nut, rice and livestock. Agriculture is an important source of income for many households, and important exports include copra and palm oil. A major impediment to growing the rural sector is the expense involved in developing the necessary infrastructure and services that support agricultural development (Solomon Islands Agriculture & Rural Development Strategy 2007). Any agricultural expansion will be an extension of current areas rather than a large-scale new development.

Local people have been experimenting with various crops such as rice which may prove suitable to soil and climate conditions on Santa Isabel Island. There are extensive crop plantation areas along the Kaipito River producing crops such as rice and coconuts. Kava is also grown and coffee processing was carried out near the Village of Kolomola. This is no longer operating but there are plans to re-start operations at an unspecified time in the future.

4.22.2.2 Forestry

The logging industry is an important source of jobs, and of tax and duty revenues to both national and provincial government. While forestry activity is not extensive on Santa Isabel Island it is a significant operation and evidence from consultation with villages adjacent to logging areas indicates that there is concern about the impacts of logging on the environment and the community.

There are concerns over the rate of logging such as sustainability and environment degradation; the issue of fair returns on this renewable natural resource; the distribution of benefits among landowners, the provincial government and national government, and the enforcement of regulations regarding reforestation and local milling of logs.

Specific information on the future development of the foresty industry was not available at the time of this study.

4.22.2.3 Tourism

The provincial government on Santa Isabel Island has identified eco-tourism as one of the areas for economic development potential on the island. The government is also concerned about the potential of current logging activities on the island and its effects on the visual beauty of the island and is leading to environmental degradation, making the island less attractive as an eco-tourism destination.

The cumulative visual impact of agriculture, forestry and mining on Santa Isabel Island is likely to be most evident from a distance. Hence, tourists being flown or ferried to the island may see the effects of these activities on the landscape before actually reaching the island therefore they may therefore form a negative view of the island.

4.22.2.4 Mining

There are two mineralised areas in close proximity to Isabel Tenement D and Isabel Tenement E which have the potential to be developed for mining activities. One mineralised area is between the prospecting licenses held by SMM Solomon, the other is on the neighbouring San Jorge Island. Both SMM Solomon and the Australian based company Axiom Mining Ltd claim to hold valid prospecting rights over those tenements, and the title holding is subject to litigation in the local courts. The ultimate lease holder intends on developing the tenement areas which hold significant nickel resources and therefore may contribute to the impacts forecasted in the EIS.

4.22.2.5 Fishing

The potential cumulative impacts of fishing were considered. However, fishing is part of the subsistence lifestyle and primarily conducted for domestic purposes. Currently there are no commercial fishing activities that would overlap within the Project activities, therefore no cumulative impacts were identified.

4.22.3 Potential Cumulative Impacts

4.22.3.1 Net Change of Habitat and Loss of Biodiversity

The potential cumulative impacts identified from the impact assessment are:

- net change of habitat and loss of biodiversity
- improvements in transport infrastructure
- increased traffic and shipping
- increased deforestation
- reduction of water quality
- loss of food security and change in traditional diet
- accelerated growth of cash economy
- increased land disputes
- gender inequality
- changes in traditional values and customary practices
- visual impacts
- increased demand for skilled workers
- increased noise

Further details are provided on these potential cumulative impacts in the following section.

Commercial forestry and agriculture has led to widespread habitat loss, transformation or loss and fragmentation which has impacted on native and endemic species.

Clearing land within the tenement may lead to more loss of habitat and changes in the ecosystem which may ultimately result in various plant and animal species becoming locally endangered. Additional clearing for other planned projects would compound this impact. Vehicle strikes in the tenement are likely to have a high impact on fauna.

4.22.3.2 Effects on Transport and Infrastructure

Government plans to improve infrastructure and services which may be complemented by certain project infrastructure and provide both the incentive and mechanism for implementing some of the plans outlined in the Solomon Islands National Transport Plan 2010.

A potential negative cumulative impact from additional roads is increased traffic flow, leading to land use conflicts, safety issues and health concerns. Overall there will likely be a positive cumulative impact associated with the project with improved transport linkages and greater revenue intake by existing commercial operators.

4.22.3.3 *Increase in Deforestation*

In order to develop the Tenements for mining, forested areas will need to be cleared. Deforestation on the island is proficient and predictions are that the island will be logged out by 2015 (Asia-Pacific Forestry Sector Outlook Study II, 2009).

Clearing of the land for the mining operation could commence as early as 2014 as part of the mine pre-construction activities. The construction phase is a fixed timeframe, but land clearing would be on-going for the life of the Project at a rate of approximately 60 hectares per year.

Current logging activities have been highlighted in a number of reports for being unsustainable and resulting in environmental degradation (Solomon Islands Forestry Outlook Study). Additional clearing for the mining operation has the potential to intensify this impact if it is not planned and executed in a sustainable manner with appropriate rehabilitation to replace the lost forest habitat.

4.22.3.4 Sedimentation and Reduction of Water Quality

The earthworks and vegetation clearing for the Project may compound the current impact of clearing by the forestry industry. The potential impacts include higher sediment runoff into streams which would increase freshwater and marine turbidity. Any additional clearing by future projects or expanded activities from current activities may multiply these impacts.

There is a risk of a cargo (fuel, oil, chemicals) spill that, if not adequately dealt with, would be detrimental to local ecosystems and possibly to local communities. This could be aggravated by similar spills from other developments and industries however this is unlikely as the tenements and surrounding areas are undeveloped.

Clearing and earthworks activity in the region of the Kaipito River may have an impact on crops grown in the area if water quality used for irrigation deteriorates. This may affect the quality of the crops grown. Crop areas may be reduced in size resulting in reduced quantities of the crops grown.

4.22.3.5 Loss of Food Security and Change in Traditional Diet

Commercial forestry has contribute to increased pressures on food security on Santa Isabel Island and with a new mining operation removing a potentially significant area of land used for agriculture, this may lead to increased pressures on food supply, particularly with high regional population growth forecasts. A high influx of construction personnel may influence the price of local commodities also enhancing potential food security risks. Local people may choose to sell more of their produce when prices rise and purchase more processed food which could ultimately lead to a change in the traditional diet and potentially cause health issues. Any future eco-tourism developments may also contribute to the loss of food security.

4.22.3.6 Acceleration of the Growth of the Cash Economy

Positive impacts include having more money available to spend on necessities such as food, housing, health and education and reducing the reliance on government and donor agencies.

Workers may choose to spend their earnings on alcohol, drugs and cigarettes, potentially leading to an increase in health and social problems. This may compound the social problems being experienced on the island which have been attributed to the growth of a cash based economy.

4.22.3.7 Land Disputes

Land disputes are prevalent throughout the communities in Santa Isabel Island and these have been aggravated by government policy. The addition of Mining Leases is already leading to disagreements between tribes and clans over land ownership.

4.22.3.8 Gender Inequity

Men are predominantly employed in forestry with women having a marginal role in the operation of forestry operations leading to increased inequities between the sexes in provincial society.

Women could be further marginalised and have limited opportunities to participate in a cash based economy if they do not have the same opportunity to be employed by the Project as men.

This impact may be balanced out with employment of women in the agricultural and ecotourism industries.

4.22.3.9 Changes in Traditional Values and Customary Practices

The influence of a modern lifestyle, money and alcohol has led to changes in the behaviour of young people in the villages. The traditional values of respect for elders, community properties and customs are being lost.

Many of these changes have been attributed to the influx of workers for the logging industry and could be exacerbated by influences brought by additional Project personnel from other countries and islands with different values and experiences.

4.22.3.10 Visual Impact

The development of the mine areas will be scattered over the tenement area and could have a significant visual impact detracting from the natural beauty of the island. Adding visual impacts from the logging industry and agricultural activities increases cumulative visual impact on local communities and visitors to Santa Isabel Island. The island's reputation may be impacted as perceptions of the island as a pristine, undisturbed natural travel destination may change.

4.22.3.11 Increased Demand for Skilled Workers

A new mining development would require a skilled and experienced workforce and the capacity to provide this on Santa Isabel Island is limited. Skilled workers currently employed in other businesses and industries may become scarce or limited due to escalating wages, creating more inequity in the community.

Tensions could erupt if there was an influx of skilled workers from other islands that have a history of conflict with Santa Isabel Island.

A positive impact would be the availability of an experienced, skilled workforce on the island to undertake any new projects/developments that may arise at the end of the Project life.

4.22.3.12 Noise

Noise impacts have been assessed for the Project as high without mitigation. This could also be exacerbated by logging and by further mine developments in the area, in particular at the villages of Takata, Kasaongo and Riridede which are located close to Isabel Tenement D and within the areas where future mining developments are being proposed.

4.22.4 Impact Assessment

A risk assessment of potential cumulative impacts is presented in Table 4-64.

Table 4-64 Assessment of Potential Cumulative Impacts

Cumulative Impacts – Summary of impacts on environmental, social and economic values for all categories																		
Post, existing and proposed project or activities:		**Surface Water Quality**	**Groundwater**	**Land and Geology**	**Soil**	**Surface Water Ecology**	**Terrestrial Ecology**	**Marine Ecology**	**Air Quality**	**Noise**	**Cultural Heritage**	**Visual Amenity**	**Waste Management**	**Land Use & Tenure**	**Workforce Influx**	**Social and Socio-economic**	**Health**	**Water Supply and Sanitation**
Agriculture	Construction	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓		✓
	Operations	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓		✓
Forestry	Construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	Operations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Tourism	Construction			✓										✓	✓	✓	✓	✓
	Operations			✓										✓	✓	✓	✓	✓
Mining Projects	Construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Operations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Overall assessment of impact significance/level of risk		M	M	L	M	M	L	L	L	H	L	M	L	H	L+M	M+H*	M	L

H= High / M=Medium / L=Low

* Indicates a positive impact

4.22.5 Mitigation Measures

Measures to be implemented by SMM Solomon with the objective of minimising the Project's contribution to cumulative impacts are described below.

4.22.5.1 Net Change of Habitat and Loss of Biodiversity

Develop and implement a pre-clearing plan before commencing land clearing for the Project. Minimise clearing disturbance by identifying boundaries for clearing areas on plans and through surveys on the ground.

Where feasible, move habitat features such as large logs and boulders to adjacent areas to allow their continuation as potential fauna refuge sites.

Monitor flora and fauna to determine whether and how they are being affected by activity in the area. Implement a company "No hunting and forest clearing policy" for Project personnel within the tenement.

Collaborate with the government, industry and other agencies on environmental education. Protect identified high conservation areas.

4.22.5.2 Effects on Transport and Infrastructure

Implement a transport plan prior to the commencement of construction that would include:

- planning of roads and ports to link up with current infrastructure and allow public access/use where possible
- contract bulk carrying services for mine deliveries
- contract ferry services to transport workers and allow use by local people where feasible (Impact Assessment Report – Transport).

4.22.5.3 Increase in Deforestation

Determine best practice clearing practices that can be used to clear the tenement producing mutual benefits for stakeholders and the environment. Consultation with relevant governments and landowners will be undertaken where appropriate.

Undertake progressive rehabilitation during the Project life by implementing the Mine Rehabilitation and Closure Plan.

4.22.5.4 Sediment and Water Contamination Control

Planning and implementation of erosion and sediment control measures based on recognised international standards and industry best management practice at the design, construction and operation of mine, ports and supporting infrastructure to reduce the risk of sediment-laden runoff to the receiving environment. Mitigation measures to reduce the potential impacts with increased turbidity and sedimentation that may occur during mine construction and operation would include:

- establishment of pre-determined 'cease work' trigger values for turbidity
- implementation of erosion and sediment control measures prior to the commencement of activities in all Project areas
- staging vegetation clearing and earthworks over the life of the Project
- designing sheet haul roads with appropriate materials
- progressively rehabilitating and revegetating completed mine areas
- appropriately designed and installed culverts to allow unimpeded movement of natural watercourses or drainage features across Project roads

- maintenance of drainage lines, gullies and culverts.

The development and operation of the Port facilities has the potential to increase turbidity and sedimentation in local marine systems through excavation, reclamation and pile driving. This will be mitigated by applying good international industry practice stormwater management plan during the construction and operation phases, where applicable.

In order to prevent and mitigate cargo spills, good international industry practice will be undertaken to transfer ore, hazardous liquids and other chemicals. Spill management kits and relevant operator instructions will be made available at all fuel transfer points and hazardous chemical storage facilities along with proper reporting protocols.

4.22.5.5 Food Security and Change in Traditional Diet

Collaborate with the community to allow cropping on selected areas of the proposed Mining Lease using the mine schedule and the MRCP to identify areas for suitable cropping.

Seek alternative suppliers for food for Project personnel.

Collaborate with health educators to encourage local people and Project personnel to maintain a healthy traditional diet.

Develop a local purchasing strategy and implement with care while monitoring and evaluating local inflationary effects.

Have a company "No fishing and hunting" policy for the immigrant workforce during construction to preserve food resources for local people.

4.22.5.6 Acceleration of the Growth of a Cash Economy

Collaborate with government and recognised community leaders to invest some benefits from mining back into the local economy to increase self-sufficiency in the provision of vital services such as housing, health and education.

Collaborate with education and health officials to develop financial education programs that teach people how to budget and use cash to improve their quality of life and build wealth. The development and implementation of prevention programs for Project personnel targeted at excessive alcohol and drug use is recommended.

4.22.5.7 Land Disputes

Land acquisition and compensation agreements between customary landowners, the central government and mining operators are a condition preceding the issue of mining lease, so land ownership disputes (if any) are expected to be resolved by the time the project is to be developed. However, disputes may arise as a result of misunderstandings or misappropriation of compensation, creating cumulative impacts in all project categories.

4.22.5.8 Gender Inequity

An equal opportunity employment policy will be developed to:

- ensure women have access to training for available mining industry roles
- ensure accommodation and ablution facilities are available for women
- allow male employees to attend to their family and community responsibilities.

An exemption to Section 39 of the *Labour Act 1996* to allow women to work night shifts will be sought. Have family friendly policies so that male employees can attend to their family and community responsibilities.

4.22.5.9 *Changes in Traditional Values and Customary Practices*

Manage the movement of Project personnel around the island, for that proportion of the workforce who will be expatriates. Ensure that Project personnel remain within the accommodation camp when not working. Ensure personnel are transported directly to and from the accommodation camp when they arrive or depart for the commencement of their roster. It is recommended that a cross cultural training program for SMM Solomon employees and contractors be developed by an SMM Solomon liaison officer in conjunction with a suitably qualified cultural heritage specialist.

Cultural development initiatives such as partnerships with the tribes and clans and non-government organisations with a view to develop museums, art galleries, crafts and cultural research within Santa Isabel Island, as well as potential partnerships with the Solomon Islands Museum be explored and developed.

4.22.5.10 *Visual Impact*

Ensure the EMP is implemented to minimise any potential visual impacts such as:

- align roads behind ridgelines wherever feasible
- retain vegetation close to infrastructure boundaries to provide visual screening
- minimise road and service corridor clearing
- rehabilitate land cleared for Project construction purposes
- select colour schemes for buildings and major structures that blend with the background landscape
- use low glare and/or directional lighting, light barriers and diffusers to mitigate light impacts
- landscape major infrastructure areas including the accommodation camp and mine industrial area (Impact Assessment Report – Visual Amenity).

4.22.5.11 *Increased Demand for Skilled Workers*

Maintain parity with national wage scales. Liaise with Goldridge (the only mine operation currently operating in the Solomon Islands) and use this as a benchmark.

Set an employment policy to prioritise the employment of people from Santa Isabel Island and communicate this through various communication channels (radio, newspaper, government, chiefs).

Partner with local training and education providers to facilitate improvements in the education and training system.

4.22.5.12 *Noise*

Noise mitigation measures will be implemented for both the Project construction and operation stages to ensure that the issue of controlling environmental noise to sensitive receptors is continually reviewed and managed. Noise mitigation measures include:

- control vehicle speeds in and around the Project area
- minimisation of the gradient of roads
- community updates on location of activities
- construction of noise barriers or earth berms close to the noise source to block the line of sight
- use of low-noise equipment, installation of advanced engine and exhaust noise control equipment
- the selection of low noise equipment or use of advanced noise control techniques and the provision of building upgrades to affected receptors.

4.23 Conservation Strategy

SMM Solomon aims to ensure that pressures, impacts and mitigation measures relating to the Project are adequately addressed to protect and conserve the marine and terrestrial biodiversity. This section describes the design strategies to be implemented by SMM Solomon to avoid conflicts between Project impacts and conservation priorities for freshwater, marine and terrestrial ecosystems.

The Solomon Islands are a signatory to the international Convention on Biological Diversity (CBD), which requires the Solomon Islands Government to set aside at least 10% of the Solomon Islands in protected areas. The development of the Solomon Islands National Biodiversity Action Plan (SINBSAP) is a response to the CBD commitment and also provides constructive direction (SINBSAP, 2008). The SINBSAP outlines the framework to ensure long-term sustainability of biodiversity in Solomon Islands.

The national framework for conservation in the Solomon Islands is provided in the *Protected Areas Act (draft) 2012*, which allows for the declaration and management of protected areas or areas where special measures need to be taken to conserve biological diversity. Also relevant is the is the *Wildlife Protection and Management Act 1998*, which allows for the protection of endangered flora and fauna. Regional regulations include the *Isabel Province Resource Management and Environmental Protection Ordnance 2006*, which addresses issues around the protection of flora and fauna and reinforces the right for customary groups to make their policies regarding the use of resources regarding the use of resources within their land and to seek Isabel provincial government protection of wildlife and natural resources. Local communities may also identify and manage areas for conservation of locally important natural resources.

The Choiseul Ridges to Reefs Conservation Plan (Lipsett-Moore et al. 2010) provides an example of conservation planning that can guide conservation efforts throughout the Solomon Islands. Participatory mapping was used to identify threats to biodiversity and to map areas of conservation opportunity, such as sites that are proposed but not yet declared as protected areas and sites already managed by communities for some natural resources. The biodiversity of Choiseul Province was represented by three conservation features: terrestrial habitats, marine habitats and locally identified conservation features (Lipsett-Moore et al. 2010).

There is currently no formal conservation plan for Santa Isabel Island, although a similar process, as adopted for Choiseul Province, is planned for Isabel Province by The Nature Conservancy (TNC). Potential conservation priority areas for Isabel Province were identified for Tenement D and Tenement E and surrounding areas using the approach described below.

4.23.1 Methodology

4.23.1.1 Overview

SMM Solomon has taken steps to align with the conservation planning process followed to create the Choiseul Ridges to Reefs Conservation Plan (Lipsett-Moore et al. 2011). The following steps were undertaken:

1. Identifying conservation priorities by combining the relevant freshwater and marine resource data collected during EIS baseline studies with the existing locally managed hunting and fishing areas identified in the vicinity of the Project area on Santa Isabel Island.

2. Mapping the locations of all relevant Project features including roads, mine areas, stockpiling areas, ports, MIA, WSF and accommodation camp.

3. Considering potential areas of conflict by classifying major river catchments as areas of low, medium and high priority for conservation, and by comparing the identified conservation values with the location of Project features (i.e. the Project footprint and the scope and duration of likely direct and indirect impacts to terrestrial, freshwater and marine resources).

4. Application of measures and monitoring effects to reduce impacts where Project activities will occur and addressing the remaining impacts using environmental offsets after efforts have been undertaken to avoid and/or minimise the direct loss of terrestrial, freshwater and marine biota.

Steps 1 to 3 are described in the sections following. Details of mitigation measures to reduce the environmental impacts identified, including environmental offsets, are presented in Chapter 5.

4.23.1.2 Identifying Conservation Priorities

Information on locally managed protected areas, including key hunting and fishing areas used by local communities, was sourced during community consultation meetings undertaken during the baseline surveys.

River catchment boundaries were delineated using ArcGIS Spatial Analyst Tools. River datasets were derived from a combination of sources including information supplied by SMM Solomon and information digitised from the Solomon Island Topographic Map series. Features were generally captured at the 1:50,000 scale. The digital elevation model for the Solomon Islands was provided by SRTM.PROCESSED SRTM DATA VERSION 4.1. This data is sampled at 3 arc-seconds, which is 1/1200th of a degree of latitude and longitude, or about 90 meters (295 feet).

The overall value of freshwater and marine ecosystems within and downstream of the Project area is high. In order to prioritise conservation efforts, the relative environmental value of each major river catchment (including the environmental values of marine ecosystems downstream of each catchment) was determined using an assessment matrix compiled from baseline field survey data.

The relative conservation value of each major catchment was assessed by rating the following parameters as contributing either a low, moderate, high or very high value to the overall environmental value of each catchment:

- Freshwater ecosystems (refer to Section 4.7 for further details on each parameter)[11]:
  - water and sediment quality – laboratory analysis and *in situ* data
  - macroinvertebrate communities – abundance, taxonomic richness and richness of pollution-sensitive taxa
  - freshwater macrocrustacean communities – taxonomic richness
  - freshwater fish communities – taxonomic richness
  - aquatic flora – abundance and taxonomic richness
  - habitat bioassessment scores
  - threatened species – presence/absence
  - hunting and fishing areas
- Marine ecosystems (refer to Section 4.8 for further details on each parameter)[12]
  - water and sediment quality – laboratory analysis and *in situ* data
  - coral reefs – percent cover live/dead coral
  - mangrove forests – taxonomic richness, percent cover live trees, percent cover dead trees and tree health

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[11] Data is based on one or two survey sites per catchment. Freshwater ecosystems were not surveyed for every river catchment – for these catchments, a conservative approach was taken and ecosystems were assumed to have 'very high' environmental value.

[12] Data for each parameter was not available for marine ecosystems downstream of every river catchment. Refer to marine survey site map in Section 4.8 for locations of marine communities surveyed. Where data was not available, but communities (e.g. coral reefs, mangroves) were known to exist downstream of the catchment, a conservative approach was taken and the community was assumed to have 'very high' environmental value.

- benthic infaunal invertebrates – abundance and taxonomic richness
- fish communities – taxonomic richness
- seagrass meadows – taxonomic richness, percent cover
- hunting and fishing areas.

The relative conservation priority for each catchment was considered based on the environmental value ratings of the baseline data described above. Input of terrestrial parameters and consideration of cultural heritage sites will need to be undertaken in the future to contribute to conservation plans.

4.23.1.3 Identifying Project Features

The locations of all relevant Project features including roads, mine areas, water storage facility, ports, MIA and accommodation camp were mapped, and the areas of disturbance calculated.

4.23.1.4 Identifying Potential Areas of Conflict

Areas where Project features overlapped or were identified within or in close proximity to the catchment were identified by comparing the relative conservation priority and the direct disturbance areas due to Project activities, roads and facilities for each catchment.

4.23.2 Results of Analysis

4.23.2.1 Conservation Priorities

Figure 4-39 shows the identified key hunting and fishing grounds locally managed in the vicinity of the Project area including:

- Alualu Hunting/Fishing Area
- Kogha Hunting/Fishing Area
- Fishing River, in the mid reaches of the Kaipito River
- Lelegia River Fishing Area
- Midoru Fishing Site and Midoru Sea Fishing Area
- Huali River Fishing Area
- Tatamba Fishing River.

Details of these freshwater, marine and terrestrial areas are described in Section 4.7, Section 4.8 and Section 4.9 respectively.

There are no protected areas declared under Solomon Islands legislation within or in the vicinity of the Project area (Isabel Tenement D and Isabel Tenement E). Three locally managed protected areas in the vicinity of the Project area, as shown on Figure 4-39, are:

- Kolorashu River Protected Area: an area of 219 ha on the Koloraghu River to the northeast of the village of Alualu. The purpose of this conservation area is to protect fish stocks in local rivers for future generations and for local festivals.
- Janhana/Hohogle River Protected Area: an area of 394 ha to the southeast of the village of Silighodu and located downstream of the confluence of the Jarihana and Hohogle Rivers. The purpose of this conservation area is to protect fish stocks in local rivers for future generations and for local festivals.
- Noinoi River Protected Area: an area of 25 ha on the Noinoi River to the southeast of the village of Koisisi. The purpose of this conservation area is to protect aquatic fauna.

Major river catchment boundaries are also shown in Figure 4-39. The relative conservation priorities for ecosystems within and downstream of major river catchments, based on baseline survey data are shown in Table 4-65.

All rivers were considered to be a high to very high priority for conservation. Some of the rivers shown on Figure 4-39 were not assessed during the baseline survey and therefore are not included in Table 4-65. However, ecosystems within and downstream of these rivers were assumed to be of very high conservation value.

Table 4-65 Relative Conservation Priorities for Ecosystems Within and Downstream of Major River Catchments Based on Baseline Survey Data

Major Catchment	Freshwater Ecosystems[1]	Downstream Marine Ecosystems[1]
Rotue	High	Very High
Kolongongoe	No data	Very High
Siusiu	No data	Very High
Huali	No data	Very High
Loalonga	Very High	High
Kaipito	Very High	High
Kuakula lower	Very High	High
Kuakula upper	Very High	No data
Tuape	Very High	No data
Hugru	High	No data
Mablosi	High	No data
Ngakimba	No data	High

[1] Where limited or no baseline information exists for freshwater or marine ecosystems, the relative conservation priority is assumed to be 'Very High'.

Priority conservation areas such as those described for Choiseul Island in the Choiseul Ridges to Reefs Conservation Plan (Lipsett-Moore et al. 2011) were not available at the time of writing, however these priority areas will be taken into consideration when the data becomes available, together with any protected areas subsequently declared under the Solomon Islands legislation and listed on the register of protected areas.

SMM Solomon, if requested, would like to participate in future conservation planning for Santa Isabel Island as was undertaken for the Choiseul Island and will provide EIS and baseline field survey results for freshwater, marine and terrestrial ecology and water quality monitoring data to inform any conservation planning that may be undertaken.

It should be noted that the level of information regarding terrestrial conservation values is not as good as that available for aquatic conservation values. Santa Isabel Island has a low scientific collection density and for the most part remains botanically underexplored.

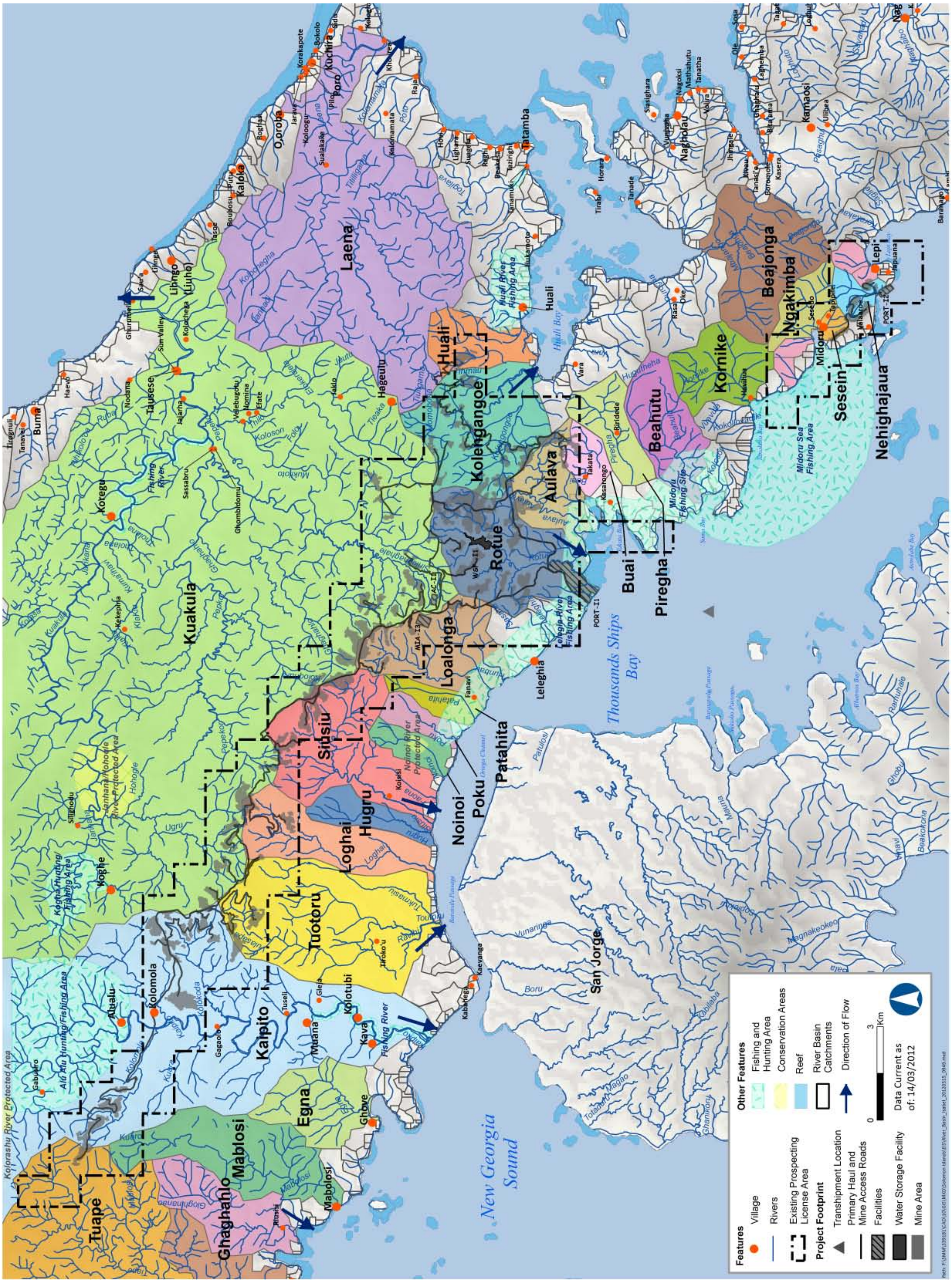

Figure 4-39 Major River Catchments and Identified Hunting/Fishing and Protected Areas in and adjacent to the Project Area

4.23.2.2 Potentially Impacting Project Features

The proportion of each river catchment that is likely to be directly disturbed by potential Project activity is presented in Table 4-66. The proportion of each catchment to be directly disturbed is between <1% and 26%.

Table 4-66 Proportion of Each Catchment Likely to be Directly Disturbed by Potential Mining Activity

Major Catchment	Approximate Total Catchment Surface Area (ha)	Tenement Affecting Catchment	Approximate Total Disturbed Catchment Surface Area[1] (ha)	Approximate Percent Disturbed Catchment Surface Area (%)
Rotue	1367	D	358	26
Nehighajaua	167	E	34	20
Sesein	75	E	8	11
Kolongongoe	1389	D	152	11
Aulava	569	D	57	10
Siusiu	1477	D	112	8
Loalonga	1025	D	77	8
Buai	233	D	15	6
Loghai	939	D	43	5
Huali	493	D	20	4
Tuotoru	2243	D	53	2
Kuakula	22152	D	323	1
Kaipito	15604	D	217	1
Tuape	5307	D	12	<1
Laena	5230	D	1	<1

[1] Total disturbed area over life of mine. Disturbance area includes mine areas, roads (with 10 m and 5 m buffer either side of the centreline), facilities and WSF.

Catchments that have a greater proportion of surface area disturbed and vegetation cleared by mining activities are at a higher risk of being impacted by turbidity and sedimentation in freshwater streams/rivers and within receiving marine environments than catchments that have a lower proportion of their surface area disturbed.

4.23.2.3 Potential Areas of Conflict

As described above, any river catchment within which Project activities are occurring has the potential to be impacted in some way, most likely through indirect effects caused by turbid run-off. Those catchments with the higher percentage of catchment area disturbed include those around the Port-I1 and Port-I2, mine areas between Port-I1 and the MIA and accommodation camp facilities.

Impacts to the locally managed protected area within the Noinoi River catchment (Noinoi River Protected Area) are likely to be negligible as no Project activities are occurring within this catchment. Similarly, potential impacts to the Kolorashu River Protected Area (Kaipito catchment) will be negligible as it is located upstream of any Project activities. Potential indirect impacts (increased turbidity and sedimentation) may occur to the Janhana/Hohogle Protection Area as a result upstream vegetation clearing, construction of haul roads and Project activities occurring intermittently from approximately year 10 through to year 17 of the Project.

Fishing/hunting areas within and downstream of the Project area may also be subject to indirect impacts such as turbidity and sedimentation, loss of catchment area and changes to flow regimes, loss of habitat for aquatic and terrestrial fauna, spills of hydrocarbons and nickel ore, nutrient enrichment, acid mine drainage and litter and waste pollution.

4.23.3 Applying Mitigation Strategies

SMM Solomon recognises the environmental value of the freshwater, marine and terrestrial ecosystems within and downstream of the Project area, including the services these ecosystems provide to local communities (e.g. fisheries and hunting areas are relied upon for food). In keeping with the mitigation hierarchy outlined in Chapter 1, SMM Solomon has committed to an overall mitigation strategy to minimise both direct and indirect impacts to aquatic and terrestrial biodiversity and habitats by minimising the area of land to be disturbed at any one time. This integrates a number of mitigation measures including:

- undertaking a staged mining approach to minimise habitat and soil disturbance at any one time during the life of the Project
- controlling erosion and sediment transport during all phases of the Project
- undertaking a progressive rehabilitation strategy.

These strategies are detailed in the following sections.

Mitigation measures to address the specific indirect potential impacts listed in the previous section have been outlined in Sections 4.7, 4.8 and 4.9.

4.23.3.1 Staged Mining Approach

SMM Solomon aims to minimise both direct and indirect impacts to aquatic and terrestrial ecosystems by minimising the area of land to be disturbed at any one time. This includes development of mining areas in benches, and the development of pre-clearing plans prior to commencing land clearing, to delineate the area to be cleared and to limit the time of exposure of the disturbed areas to the elements. Wherever practical, the topsoil and root system of the vegetation will not be unduly disturbed to assist in the rapid regeneration of the area and to minimise the potential for the establishment of undesirable invasive vegetation species. Disturbed areas not required for further use by the Project will be rehabilitated and re-vegetated as soon as possible.

Table 4-67 provides the approximate area of land disturbed in mine areas each year over the life of the mine. Figure 4-40 to Figure 4-43 graphically illustrates the mining schedule.

The terrestrial ecology impact assessment concluded that the implementation of mitigation measures described will avoid substantial net loss of habitat and species. The design of the Project may result in some significant gains to conservation by providing management strategies and allowing regeneration of vegetation within the Project area.

Approximately 12% of the total Project area (Isabel Tenement D and Isabel Tenement E) will be disturbed over the life of the Project. The Project area will be managed by SMM Solomon during the life of the Project with all protected/conservation areas, declared under Solomon Islands legislation, excluded from Project development. As the Project activities will occur in designated locations, the remaining untouched large tracks of vegetation within the Project area (88% or 11,333 ha) will be managed and informally conserved by SMM Solomon thereby ensuring that these areas continue to serve as biodiversity refuges.

Table 4-67 Area of Disturbance in Mine Areas By Year Over the Life of Project Mine

Year	Approximate Disturbed Area (ha)
0	2.94
1	26.63
2	42.88
3	43.50
4	50.25
5	41.44
6	46.75
7	40.69
8	48.50
9	57.06
10	42.25
11	46.75
12	59.38
13	39.38
14	43.44
15	70.44
16	42.06
17	79.88
18	65.13
19	71.62
20	74.94
21	89.19
22	76.94
23	30.94
Total	1232.94

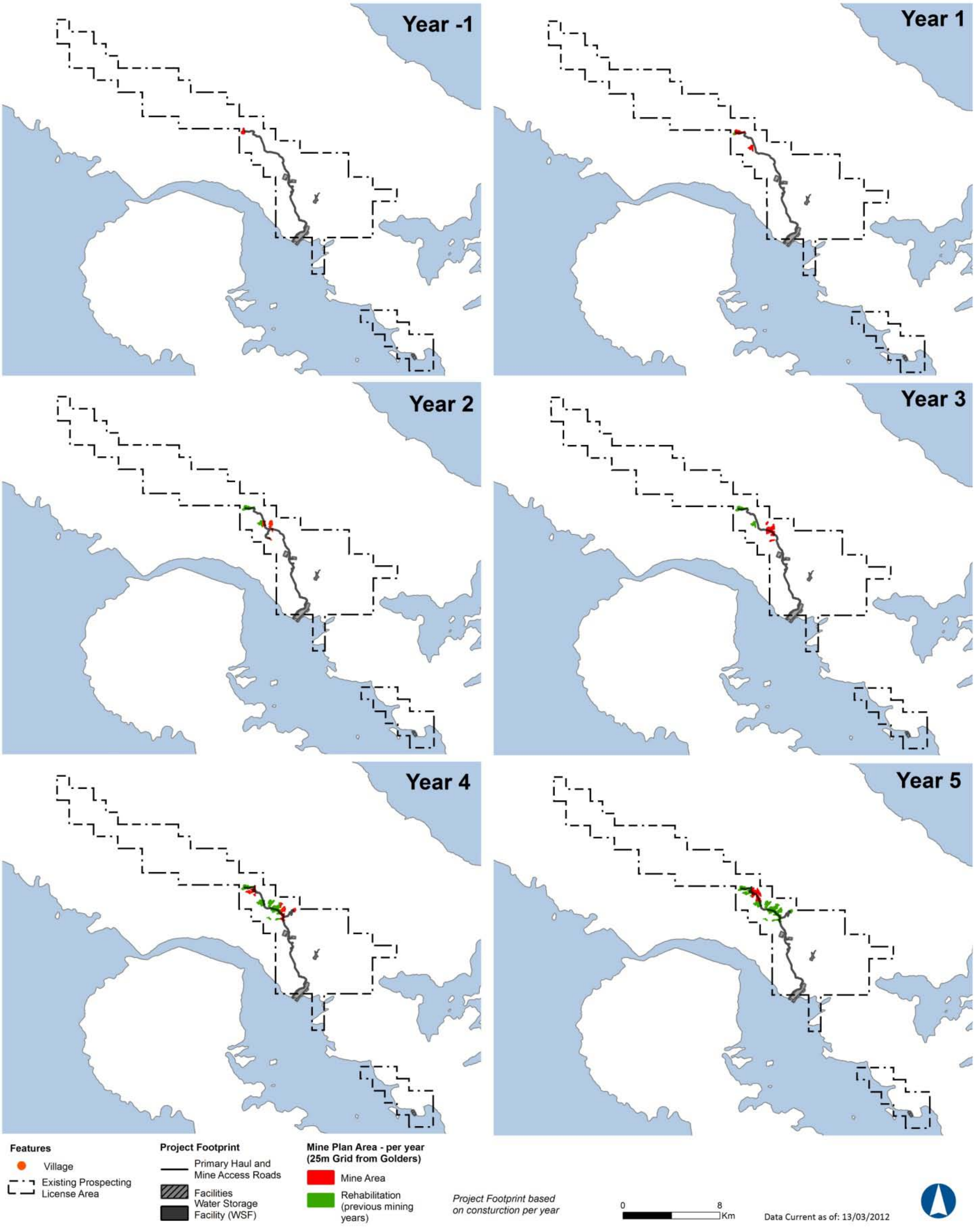

Figure 4-40 Mining Rehabilitation Areas in Years 0 to 5

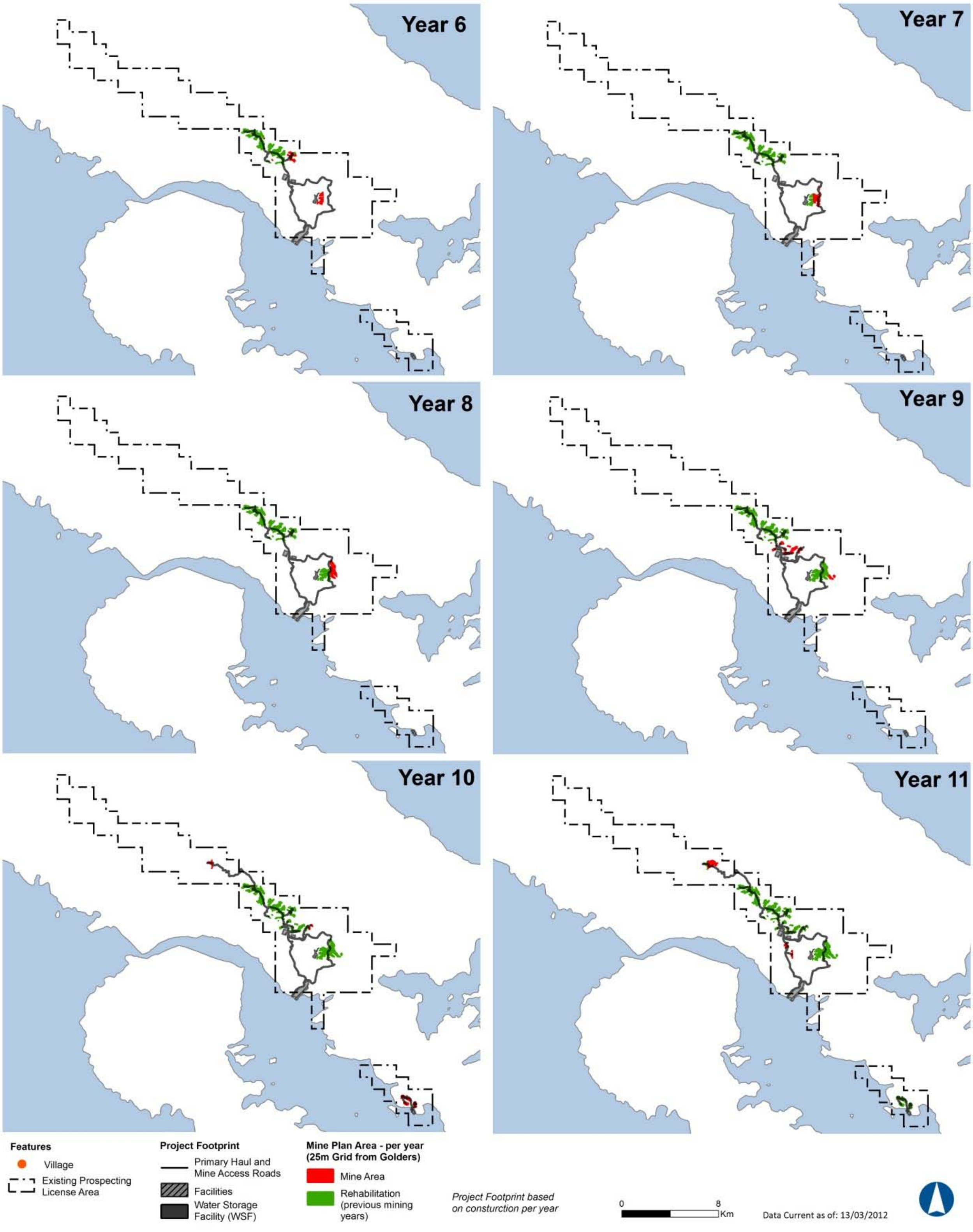

Figure 4-41 Mining Rehabilitation Areas in Years 6 to 11

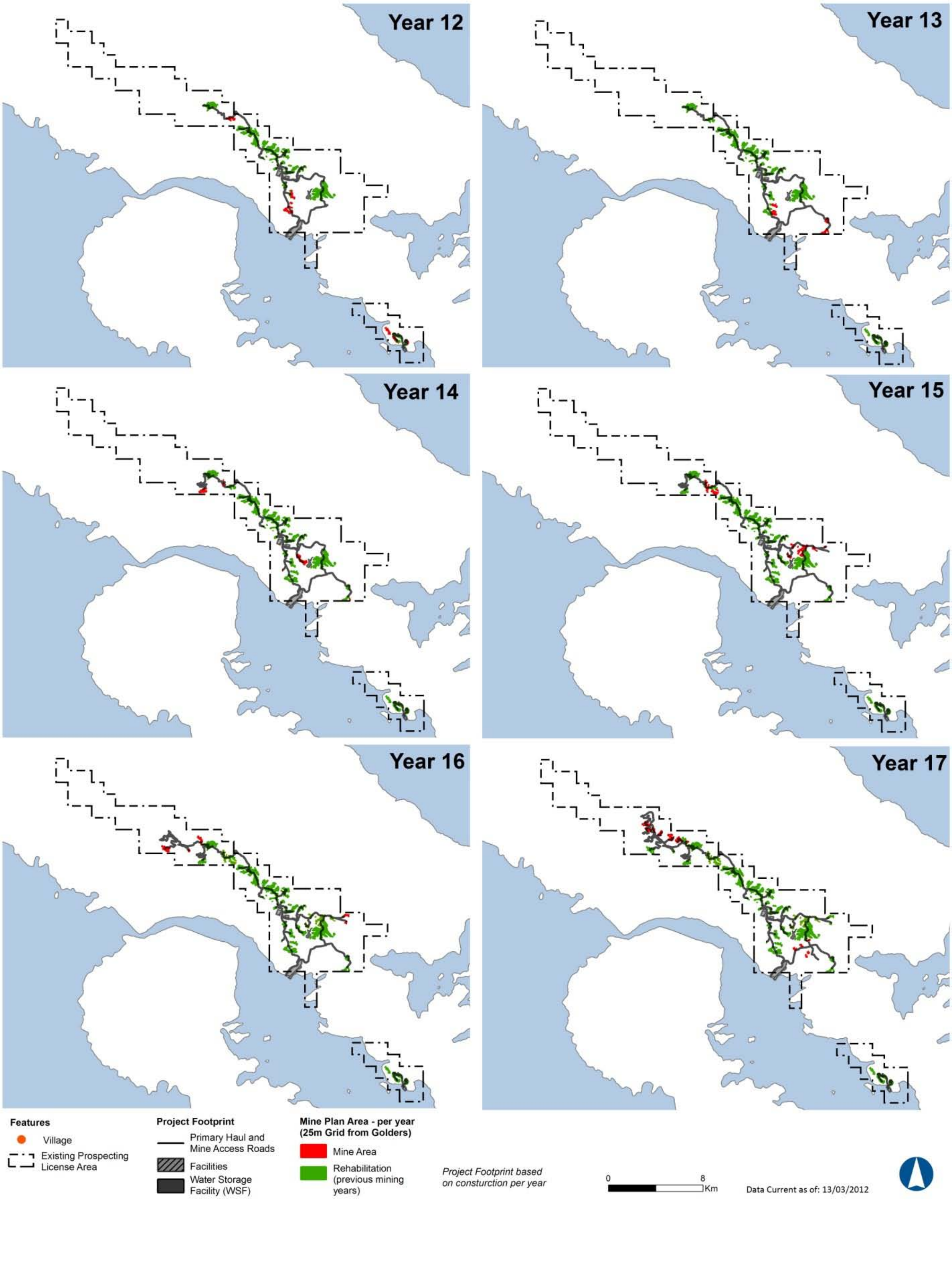

Figure 4-42 Mining Rehabilitation Areas in Years 12 to 17

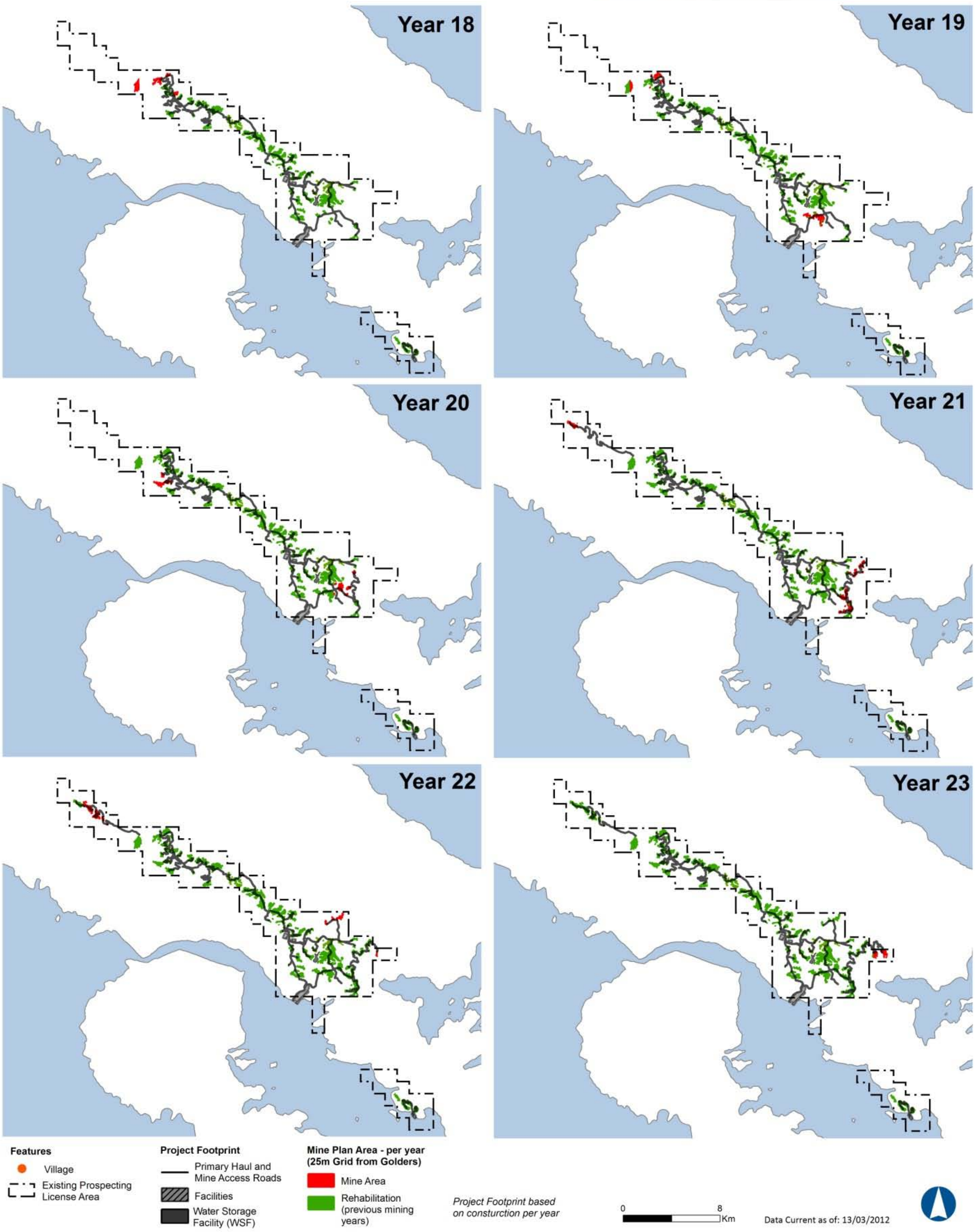

Figure 4-43 Mining Rehabilitation Areas in Years 18 to 23

4.23.3.2 *Erosion and Sediment Control*

The following principles have been adopted by the Project in designing the surface water management facilities and controls:

- Provision of an acceptable degree of protection against flooding for the Project facilities.
- Limit the size of catchment area to limit the concentration of flows.
- Limit the areas of disturbance.
- Diversion of surface water from undisturbed areas around the Project facilities to minimise potentially affected watercourses.
- Development of a robust revegetation/rehabilitation plan to minimise movement of sediment from disturbed areas.
- Provision of adequate drainage facilities to convey surface water from both disturbed and undisturbed catchments.
- Provision of sediment ponds or other structures for larger disturbed areas such as the Port sites, accommodation camp, roads and MIA to reduce the sediment load in drainage facilities prior to discharge.
- Capture of runoff from disturbed areas with potential for contamination and treatment of runoff prior to discharge.

Sediment and erosion controls, based on the above principles, adopted by the Project have been designed to allow for the prevention 'at source', where possible, followed by the removal of any sediment as close as possible to the source. Erosion control measures to be used at source will include the use of erosion control matting, tackifiers, and hydromulching/revegetation. These measures will be supported by sediment control measures, such as decanters and rock check dams, further downstream in the channels with the end result of minimising the need for, and size of, the sediment ponds required for each facility.

Sediment and erosion control measures, such as check dams and rock rip-rap protection will be developed in the road drainage systems to limit the detrimental impact of the road construction and operation on the surrounding areas. Sediment decanters will be constructed in association with cross drainage culverts in areas of lower relief in order to limit the volume of sediment transported into the downstream watercourses.

4.23.3.3 *Progressive Rehabilitation*

Mine rehabilitation and closure planning began early in the planning and design stages of the Project to ensure that the environmental considerations for the Project are adequately addressed. The preliminary Mine Rehabilitation and Closure Plan (MRCP), described in Chapter 3, is considered a dynamic document and will be updated as the Project progresses through both planning and implementation phases.

The environmental objectives of rehabilitation and closure activities are to:

- protect the environment over the long term
- achieve physical stability as soon as possible following the area's useful life thereby reducing or eliminating long term environmental impacts
- minimise long-term requirements for active site care and maintenance during the post-closure period (e.g. water collection and treatment)
- reclaim disturbed land surfaces to a stable condition that is compatible with agreed post-Project land uses

- restore watercourses to a stable condition to achieve water quantity and quality objectives in the long term.

The progressive rehabilitation, closure, and post-closure monitoring/maintenance process for the Project is planned as:

- Progressive rehabilitation to be conducted throughout the life of the Project including the post-construction phase and throughout the operations phase. Rehabilitation will include:
  - grading of completed mine areas and other Project areas no longer required for operations to stabilise disturbed areas and to match the surrounding topography
  - implementation of appropriate erosion and sediment control as required
  - spreading of topsoil and application of soil treatment as required
  - revegetation through natural regeneration, supplementary planting or provision of an area suitable for agricultural activity.
- Project closure which will include removal of Project infrastructure and facilities, subject to prior end use agreement, stabilisation of landforms and final rehabilitation of completed mine areas and other areas disturbed by Project activities or facilities which are no longer required.
- Post-closure maintenance and monitoring of rehabilitated areas until surrender of mining leases.

The overall goal for reclamation and re-vegetation of the mine areas is to ensure short-term and long-term erosion control, ensure land-use compatibility with surrounding land uses, and to ensure successful revegetation of all reclaimed areas or reclaim lands for other beneficial uses (e.g. agronomics, horticulture, biodiversity). The sequencing of the rehabilitation activities for the completed mine areas will be conducted as follows:

- Regrading to resemble the surrounding landscape.
- Implementing sediment and erosion control (temporary and long term).
- Re-application of topsoil removed from the bench below (or temporarily stockpiled within the area currently in operation) to provide the required growing medium for the successful reestablishment of vegetation.
- Revegetation to restore native plants with traditional/cultural and economic importance, and/or natural forest regeneration. Vegetation also protects topsoil from further erosion and improves water quality with future benefits derived from timber resources, recreation sites and faunal habitats (N&S Consulting 2012). While emphasis will be placed on reestablishment of native vegetation and regeneration, consultations with Project stakeholders will investigate the potential for the establishment of agronomic/horticultural crops in the rehabilitated mine areas. A plant nursery will be established as an integral component of the overall rehabilitation/closure planning for the Project. One main nursery and a number of satellite nurseries, to facilitate the rehabilitation efforts of the completed mine areas located in remote areas of the tenement, will be provided for both seedling production and research.

Monitoring of the progressive rehabilitation and closure/rehabilitation of mine areas and Project facilities will be conducted to confirm the effectiveness of the rehabilitation activities. The objective of the monitoring program will be to demonstrate stable or improving conditions over the life of the Project operations (progressive rehabilitation), closure/decommissioning and post-closure. The environmental monitoring program, for closure and post-closure will be based on the monitoring program for operations, with appropriate refinements to address closure monitoring.

4.23.4 *Summary of Conservation Strategy*

The Solomon Islands are a signatory to the international Convention on Biological Diversity (CBD), which requires the Solomon Islands Government to set aside at least 10% of the Solomon Islands in protected areas. The Solomon Islands National Biodiversity Action Plan (SINBSAP) outlines the framework to ensure long term sustainability of biodiversity in Solomon Islands.

The Project design has, wherever practical, attempted to balance the needs of the development with conserving or enhancing existing social, cultural and ecological values within and around the Project area.

SMM Solomon recognises the high conservation values of areas such as the Janhana/Hohogle River Protected Area and other fishing and hunting grounds which may be potentially impacted indirectly by Project activities occurring within the same catchment. SMM Solomon is committed to protecting such areas by applying the mitigation hierarchy to:

- Prevent disturbance and impacts through mine planning – approximately 88% of the Project area will be protected from development during the Project life
- implement all practical measures to minimise potential impacts including minimising the area disturbed by the Project at any one time, and consideration of surrendering ore deposits if necessary
- design progressive and final rehabilitation programs to offset potential impacts.

As more information becomes available, environmental offsets or conservation programs may be used to address any remaining impacts to areas of high conservation value. Any offset areas identified by SMM Solomon will be initially surveyed to assess the existing ecological values and a monitoring program will be developed to determine the created or restored ecological values.