Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Volume II - ESIA
Chapter 1 - Introduction

September 2023

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1 Introduction

1.1 Overview

The Government of Grenada (GoG) is actively seeking to reduce Grenada's dependence on imported fossil fuel for electricity generation, by exploring and increasing the use of renewable energy options. Of the options under consideration, geothermal is considered the most promising to replace existing diesel power generation, due to the significant geothermal potential indicated on mainland Grenada[1] (sufficient to support a 15MWe power plant in the first instance), and given that geothermal power is continuous renewable power, which is available for baseload electricity production (unlike power generated by variable renewable sources such as solar or wind).

With technical assistance from the governments of Japan and New Zealand, and funding provided by the Caribbean Development Bank (CDB), GoG has been investigating potential geothermal sources on mainland Grenada. Following a series of studies and surface-based investigations completed over several years, the Geothermal Energy Development Project is currently focusing on the exploratory test drilling phase (hereafter referred to as 'the Project') and now requires an internationally compliant Environmental and Social Impact Assessment (ESIA).

1.2 Purpose of the ESIA

ESIA is a process that enables the environmental and social effects of a project to be understood. Through this, mitigation is developed, and the level and nature of the effect can be determined. An understanding of the environmental and social baseline is required, and this is compared with the scheme design and works proposed. Using professional judgement and a defined methodology, a conclusion can therefore be made regarding the level of likely impacts and effects that the project will have on the existing environmental and social baseline.

In order to proceed with exploratory test drilling, Grenada national approvals are required along with international finance, which requires an ESIA to be delivered in accordance with international standards.

On 16 January 2019, following a competitive international procurement process, the Ministry of Infrastructure Development, Public Utilities, Energy, Transport and Implementation contracted Mott MacDonald to conduct an ESIA for the exploratory drilling phase[2]. Mott MacDonald is an international multidisciplinary consultancy and has significant experience in delivering international ESIAs across the world on energy infrastructure projects including geothermal.

The ESIA is to be undertaken in accordance with GoG national laws, regulations and guidelines for environmental and social protection and the International Finance Corporation's (IFC) Performance Standards (PS), associated PS Guidance Notes, and the World Bank Group Environmental Health and Safety (EHS) Guidelines (2007).

[1] Based on preliminary, surface-based investigations already carried out

[2] Contract number 01/2019 between Ministry of Infrastructure Development, Public Utilities, Energy, Transport and Implementation of Grenada, and Mott MacDonald, signed on 16 January 2019

1.3 Project background

In 2015, responding to requests from GoG, the New Zealand Ministry for Foreign Affairs and Trade (MFAT) and Japan International Cooperation Agency (JICA) funded technical assistance (TA) to execute preliminary surface-based exploration activities in Grenada which indicated the presence of underground geothermal reservoirs that could potentially support utility-scale power generation. The TA activities included a pre-feasibility assessment, environmental and social preliminary scoping exercise, and a preliminary drilling plan which was produced in 2016.

Seven locations were initially identified as possible drilling locations for deep slim hole exploration wells. This list was refined to a shortlist of three locations, following an initial assessment of water requirements and accessibility of the sites.

In 2016, Jacobs New Zealand Limited (Jacobs) undertook an infrastructure assessment to confirm the feasibility of access to the three shortlisted areas. As part of this study, one of the key aspects identified was the provision of a reliable water supply. In 2018, Jacobs subsequently produced an Exploration Drilling Plan, Water Resources Assessment and Drilling Site Definition Report. The Drilling Site Definition Report (dated 23 July 2018) further refined the proposed drilling site options, detailed water requirements and well pad locations. The report identified four possible drilling locations (Site B: Castle Hill, Site C: Tricolar, Site D: Barique, Site F: Florida/Plaisance). Subsequent analysis narrowed down the two preferred sites to:

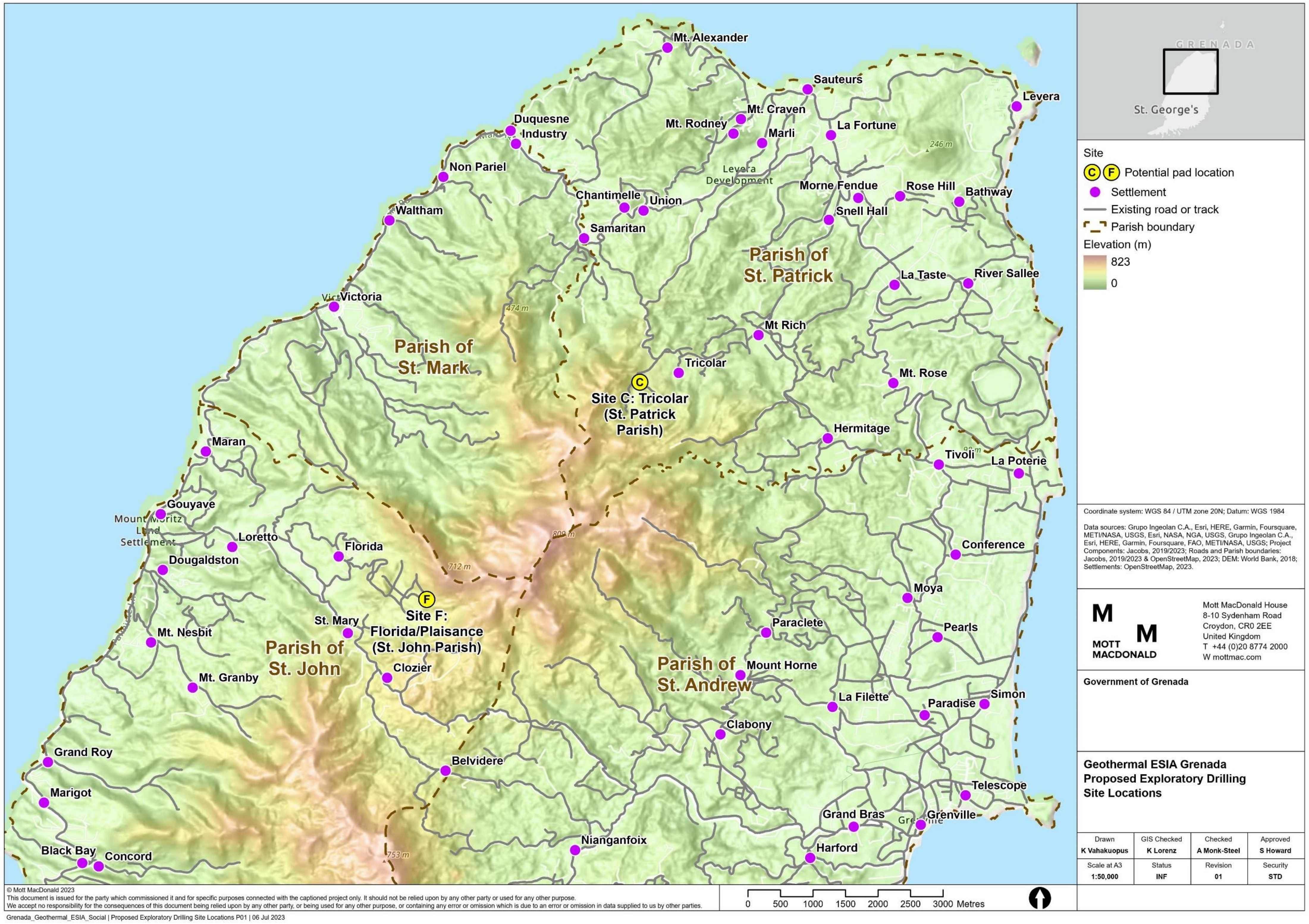
- Site C: Tricolar (St. Patrick Parish)
- Site F: Florida/Plaisance (St. John Parish)

Subsequent to the ESIA Scoping Consultation, further engineering review and analysis by Jacobs resulted in modifications to the proposed well pad at Site C (Tricolar).

1.4 Overview of Project locations

The two selected exploratory drilling pad locations are identified in Figure 1.1 and are described further in Sections 1.4.1 and 1.4.2.

Figure 1.1: Proposed exploratory drilling site locations



Source: Mott MacDonald

1.4.1 Site C: Tricolar

Site C (Tricolar), is located to the north-east of Mount St Catherine. The site is generally well concealed with some areas currently cultivated for banana and nutmeg (amongst others) and surrounded by more mature secondary vegetation/forest habitat.

Figure 1.2: Photograph of site C (well pad location)

Source: Mott MacDonald water quality monitoring survey, June 2023

Figure 1.3: Photograph of site C (well pad location)

Source: Mott MacDonald water quality monitoring survey, June 2023

Figure 1.4: Photograph of site C (pump station location)

Source: Mott MacDonald water quality monitoring survey, June 2023

Figure 1.5: Photograph of site C (pump station location)

Source: Mott MacDonald water quality monitoring survey, June 2023

1.4.2 Site F: Florida/Plaisance

Site F (Florida/Plaisance) is situated to the southwest of Mount St Catherine and borders a forested area, which is also partly used as a plantation. The proposed pad location is reasonably flat with a slight incline. The land is currently used for some low-level agriculture. An access track runs through the middle of the site.

Figure 1.6: Photograph of site F

Source: Mott MacDonald ESIA scoping site visit 2019

Figure 1.7: Photograph of site F

Source: Mott MacDonald ESIA scoping site visit 2019

Figure 1.8: Photograph of site F (banana plantation)

Source: Mott MacDonald ESIA scoping site visit 2019

Figure 1.9: Photograph of site F (cocoa plantation)

Source: Mott MacDonald ESIA scoping site visit 2019

1.5 Structure of the ESIA

The overall ESIA structure is presented as follows:

- Volume I – Non-Technical Summary (NTS)
- Volume II – Environmental and Social Impact Assessment (ESIA)
- Volume III – Stakeholder Engagement Plan (SEP)
- Volume IV – Livelihood Restoration Framework (LRF)
- Volume V – Environmental and Social Management Plan (ESMP)

1.6 Structure of this ESIA report

This document is Volume II and presents the main Environmental and Social Impact Assessment (ESIA). The ESIA structure is presented in Table 1.1.

Table 1.1: Volume II (main ESIA) structure

No.	Chapter	Description of Content
1	Introduction	Presents a brief project overview, description of key stakeholder, and purpose of the ESIA study and report
2	Project description	Describes the project, its main elements and activities for construction and operation
3	Project need and analysis of alternatives	Presents the purpose and rationale of the project and summarises the different project alternatives for providing the energy and alternatives project sites and designs, including the no project alternative.
4	Policy, legal and institutional framework	Defines key national policy, legislation and international lender guidelines applicable to the project, as well as key national institutions
5	Information disclosure, consultation and participation	Provides an overview of the consultation processes and results
6	ESIA process and methodology	Sets out the stages of the ESIA, key assumptions and methodologies for undertaking the ESIA
7 - 16	Baseline, impact assessment and mitigation measures	Presents the baseline, impact assessment and mitigation measures for each of the following topics: ● 7 Socio-economic and cultural ● 8 Biodiversity ● 9 Water resources ● 10 Noise and vibration ● 11 Air quality ● 12 Landscape and visual ● 13 Traffic and transport ● 14 Waste and materials management ● 15 Geology soils and erosion ● 16 Cumulative impacts
17	Summary and conclusions	Presents key residual impacts and conclusions of the ESIA
18	References	Presents reference list

1.7 Project proponent

The Government of Grenada (GoG), represented by the Ministry of Climate Resilience, the Environment and Renewable Energy wishes to pursue the exploration and, if exploration is successful, the subsequent development of a potential geothermal resource and has requested support in the form of grant funding to undertake the drilling of two slim-hole exploration wells.

Successful exploration will allow the Government to delineate and gazette a geothermal resource area and then assign the development rights for this area to a legal entity through a process of competitive bidding. This legal entity would then complete any additional drilling required, develop the steam field, and design, construct, commission and operate the power plant.

1.7.1 Contracting structure

For the exploration drilling phase, the project intends to issue multiple contracts. An infrastructure development contract will deliver the necessary infrastructure (access roads, water supply, well pads and ancillary facilities) to support the drilling activity. A separate package of contracts will cover the provision of a specialised drilling rig and other equipment and services necessary for drilling and testing of the wells.

1.8 Project contact details

Table 1.2 presents the contact details regarding the ESIA.

Table 1.2: ESIA contact details

Information	Government of Grenada	Mott MacDonald
Name	Herbert A Samuel	Andrew Day
Position	Project Coordinator Geothermal Energy	ESIA Project Manager
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Volume II - ESIA
Chapter 2 - Project description

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Contents

2 Project description

2.1 Overview

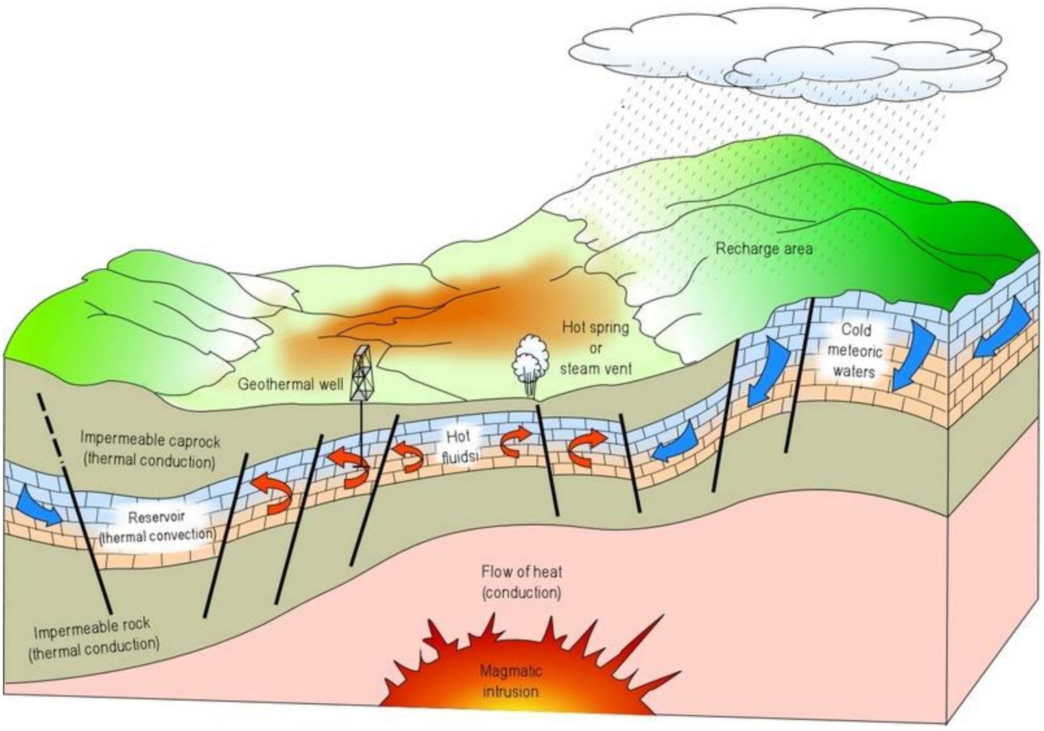
This chapter provides an overall description of the proposed project. It is structured as follows:

- Geothermal power production
- Geothermal development stages
- Exploration stage activities
- Project Definition

2.2 Geothermal power production

Geothermal power generation involves drilling deep production and reinjection wells into the earth's crust to harness the thermal energy contained in existing underground reservoirs of geothermal waters or steam as outlined in Figure 2.1 below. These reservoirs are naturally-occurring thermal systems that may be located thousands of meters below the surface.

Figure 2.1: Schematic representation of a geothermal energy source



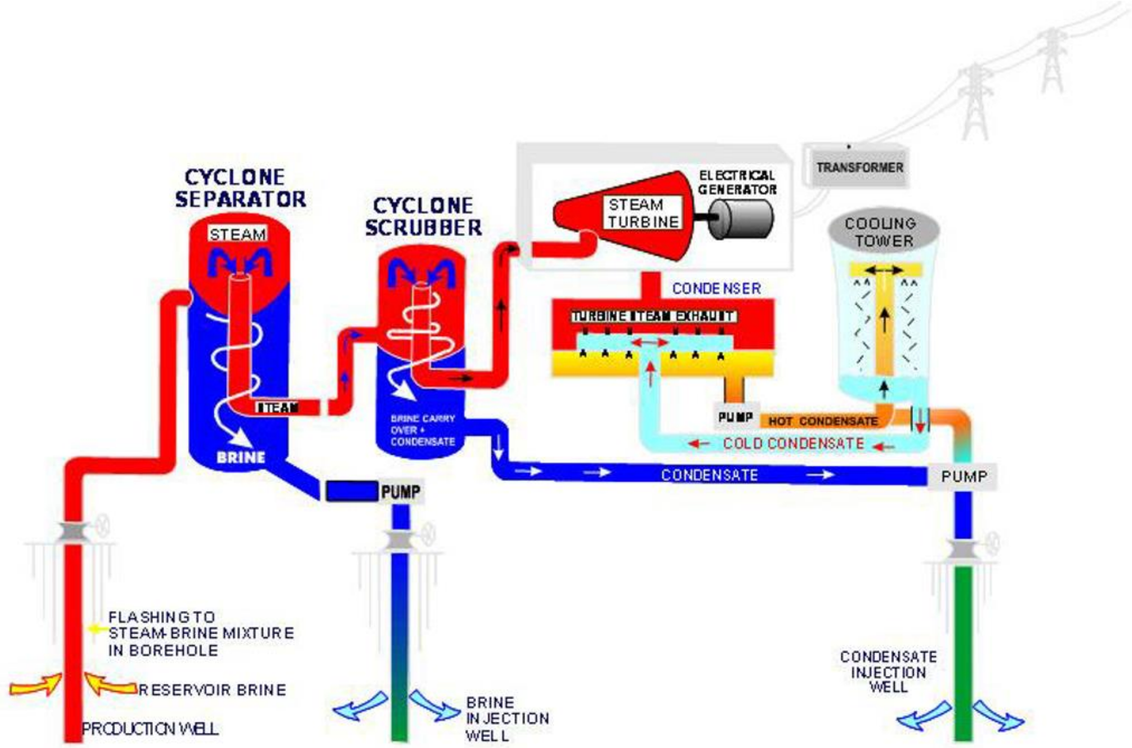
Source: Istituto di Geoscienze e Georisorse, CNR, Italy 2004

For geothermal power production, wells are commonly drilled in a group of wells at one platform, with each platform typically comprising two to five wells. The production wells bring high-pressure geothermal fluid (a mixture of water, dissolved gases and minerals and steam), to the surface where the steam can be separated and used to power steam turbines to produce electricity. Brine and condensate removed by the separators are returned via the reinjection wells to the reservoir. It is important to note that this is a completely different process to hydraulic fracturing or "fracking", which is an extraction technique for oil and gas wells in which underground rock layers are deliberately fractured by pumping high-pressure fluids into holes drilled into the rock. No fracking techniques will be used for Grenada's exploration drilling.

Figure 2.2 presents a high-level summary of the overall geothermal plant process for a flash-type geothermal plant which may be the applicable design type for this project. Other technologies are available and would be considered in more detail upon confirmation of a viable geothermal source. There are two main parts:

- The power plant, comprised of steam turbines, electrical generators, condensers and cooling towers, where the extracted steam is used to generate electricity;
- The steam field (including the steam field above ground system (SAGS): where the geothermal fluids are extracted, processed and subsequently re-injected to the reservoir.

Figure 2.2: Indicative diagram of flash type geothermal power plant process



Source: Mott MacDonald

2.3 Geothermal development project phases

The overall Grenada Geothermal development project is comprised of five key phases which are described in Table 2.1. Phase 2 **(in bold below)** is the current phase of the Project.

Table 2.1: Phases of the geothermal programme

No.	Phase	Commentary	Status	Within this ESIA scope?
1	Surface Exploration & Conceptualization	Presence of a geothermal source indicated based on surface exploration studies	Complete	No
2	**Exploration Drilling**	**Exploration drilling programme proposed to be undertaken for two exploratory wells (one**	**Current planned activity (and the**	**Yes**

No.	Phase	Commentary	Status	Within this ESIA scope?
		at site C and one at site F) which intends to confirm the existence of, and to characterise the geothermal source and assess its viability for power generation.	**scope of this ESIA)**	
3	Appraisal Drilling and Bankability	Full size appraisal wells are drilled to the point where debt funded developers are satisfied that the Project is technically and commercially feasible.	Pending	No
4	Production drilling and geothermal power plant construction	Remaining full size production and reinjection wells (if any) are drilled. Steamfield is constructed which captures two phase (steam/brine) flow from the production wells, (b) separates the steam from the brine, (c) sends clean (dry) steam to the power plant and (d) reinjects spent brine and excess power station steam condensate in the reinjection well(s) Building, commissioning, testing and putting in to service the power plant and associated power transmission line	Pending	No
5	Operation	Developer successfully manager operates and maintains the geothermal reservoir, steamfield, power plant and transmission lines and exports electricity to the offtaker.	Pending	No

Source: Jacobs

This phased approach is typical for a small-scale geothermal development like the Grenada Geothermal Development Project. If the initial drilling is successful, the next phase of the process would be full size appraisal drilling, which would aim to expand understanding about the geothermal reservoir size, chemistry well productivity, and also understand how the system would behave under production.

This ESIA only covers the exploratory drilling phase of the project.

2.4 Exploration phase activities

As outlined in section 2.3, the purpose of the exploration component of the Project is to confirm the existence of geothermal resource suitable for power production. Therefore, this ESIA only considers the exploratory test drilling phase of the project. The power production phase is not within the scope of this ESIA and would be subject to its own ESIA process.

For the purposes of the ESIA, the exploration phase can be split into three key sub-phases (see Table 2.2), defined as:

- Site establishment (construction phase)
- Exploratory drilling (operations phase)
- Site closure (decommissioning phase)

Table 2.2: Exploration phase activities to be considered in this ESIA

Site establishment "Construction phase"	Exploratory drilling "Operations phase"	Site closure (temporary closure)[1] "Decommissioning phase"
• Upgrade of access roads and widening of pinch points at existing roads where required • Site clearance • Construction of well pads including water and mud sumps • Construction of water intake and pump stations • Construction of temporary water pipeline to supply well pads • Temporary materials storage yard • Transportation of drilling rig and associated equipment and installation on site	• Exploratory drilling works • Pumping of water / drilling muds • Materials and waste handling during operations • Drilling rig and ancillary equipment maintenance • Geological sampling and analysis • Well testing	• Dismantling and removal of drilling equipment • Restoration of temporary work sites and other areas

Source: Jacobs

Note: Establishment of a workers' accommodation is not anticipated currently. If this is identified as needed, this will be part of the construction stage.

2.5 Project definition

2.5.1 Key project components

The key project components of the exploratory drilling phase are listed below:

- Access roads (new ones and upgrade of existing ones)
- Drilling well pad site C and drilling well pad site F
- Water supply infrastructure

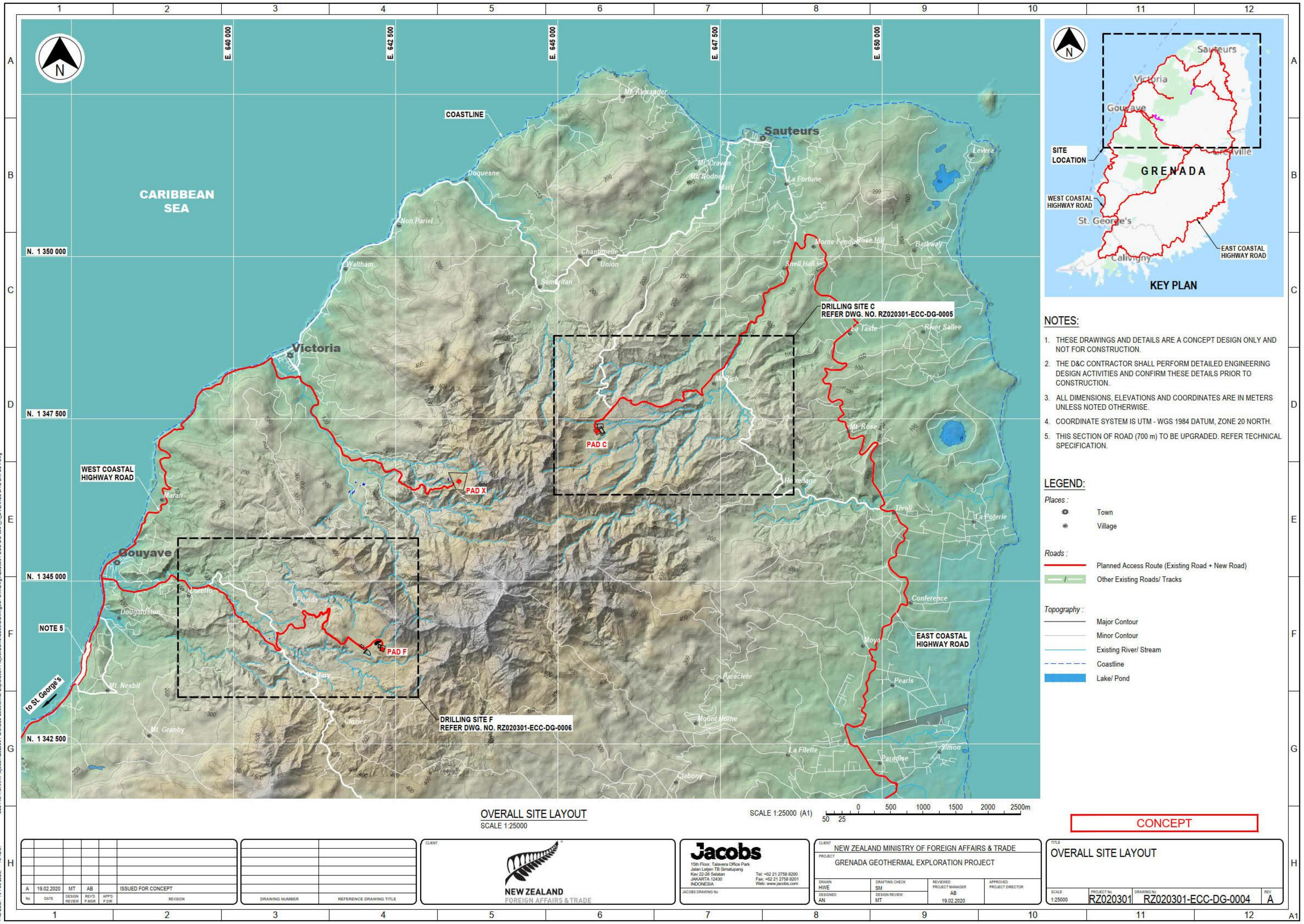
The footprint of these key project components is also referred to 'project area' within this ESIA.

Figure 2.3 presents the general site location map (concept layout plan).

The concept plan for these key project components is summarised further below. Prior to construction, a detailed engineering design will be performed to confirm this plan.

[1] If geothermal resource is not confirmed, infrastructure will be decommissioned, removed, and site will be restored to pre-drilling conditions. However, the upgraded access road will remain in place.

Figure 2.3: General site location map and access routes (sites C and F) - concept layout plan



Source: Jacobs. Overall site layout Rev A. 19 February 2020.

Note: According to the GoG, the section of road (700m) referred to in 'Note 5' has been upgraded by the roads department and no further upgrade is required at this stage.

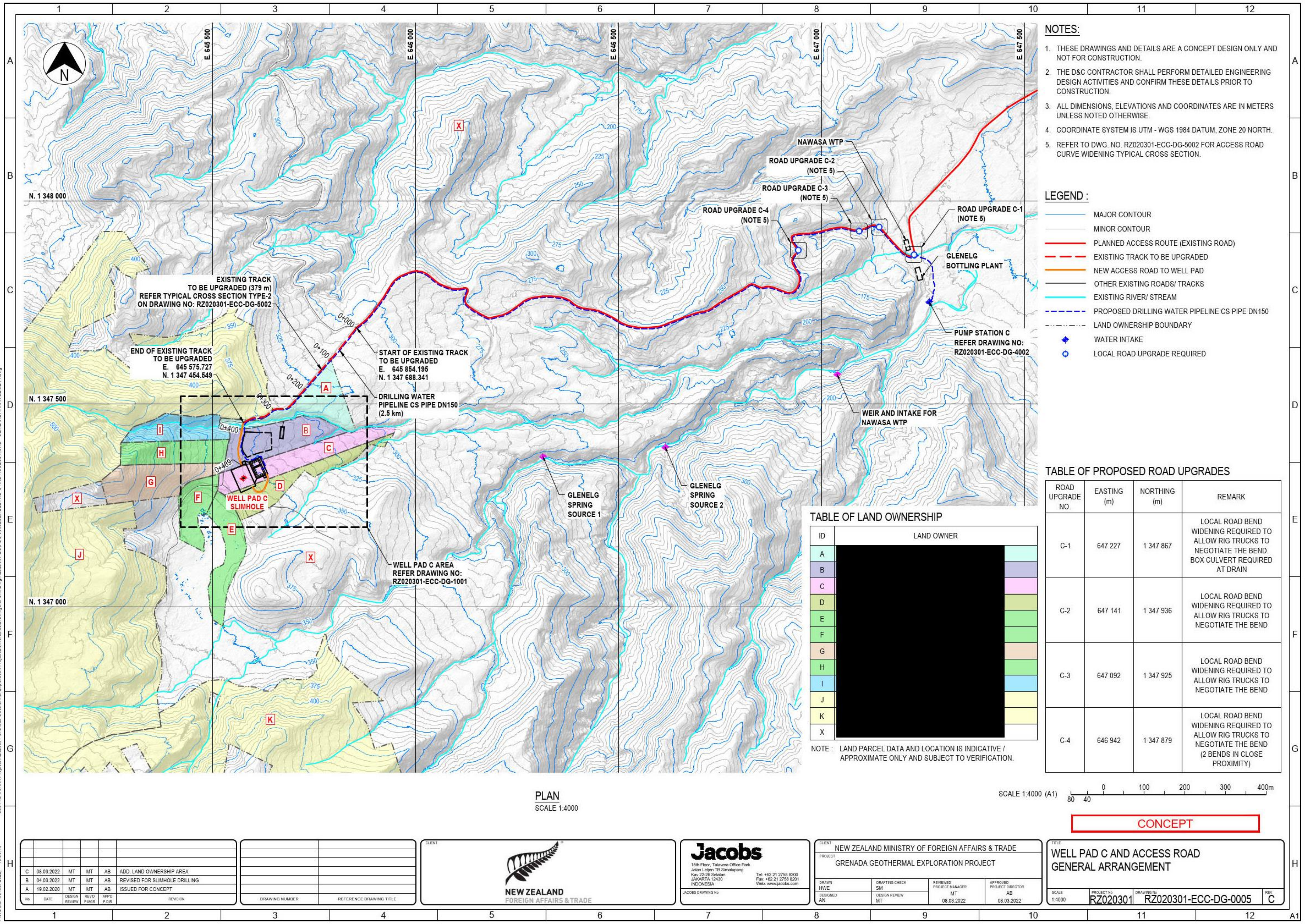
2.5.1.1 Access roads

New access roads and improvements will include:

- Upgrading of access tracks leading up to each of the sites (approximately 400m at site C and 1650m at site F)
- New roads within the sites (approximately 150m at Site C and 400m at Site F) to provide access to well pads from the access track.
- Some minor road corner widenings will be required at various locations on the public roads.

The general arrangement for access road (concept layout plan) is illustrated in Figure 2.4 and Figure 2.5 below.

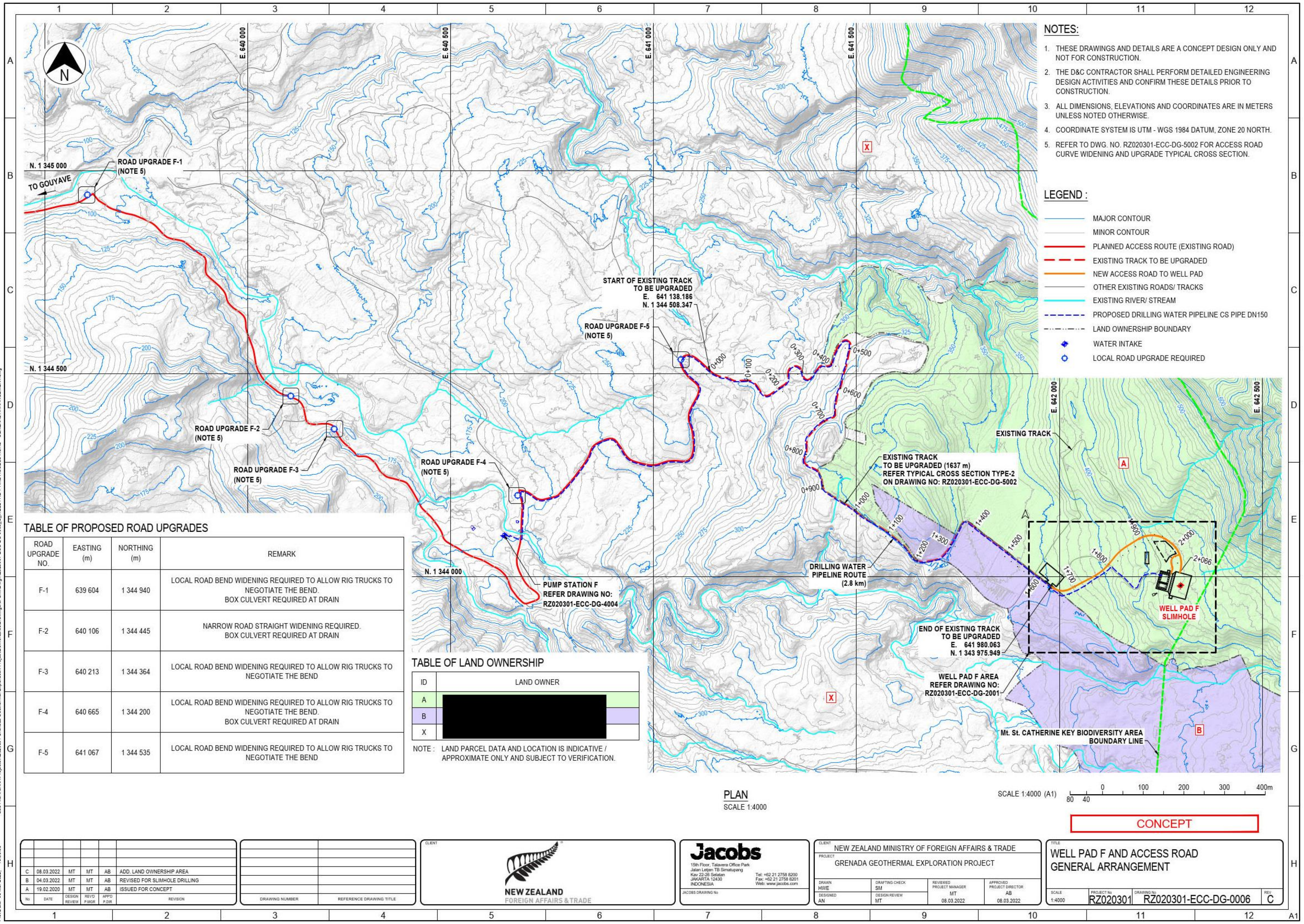
Figure 2.4: Access road general arrangement (site C) - concept layout plan



Source: Jacobs. Well pad C and access road general arrangement. Rev C. 08 March 2022.

Note: (1) Landowner names omitted for data privacy. (2) This figure also illustrates the water supply pipelines that will be established from the water intake station to the well pad.

Figure 2.5: Access road general arrangement (site F) - concept layout plan



Source: Jacobs. Well pad F and access road general arrangement. Rev C. 08 March 2022.

Note: (1) Landowner names omitted for data privacy. (2) This figure also illustrates the water supply pipelines that will be established from the water intake station to the well pad.

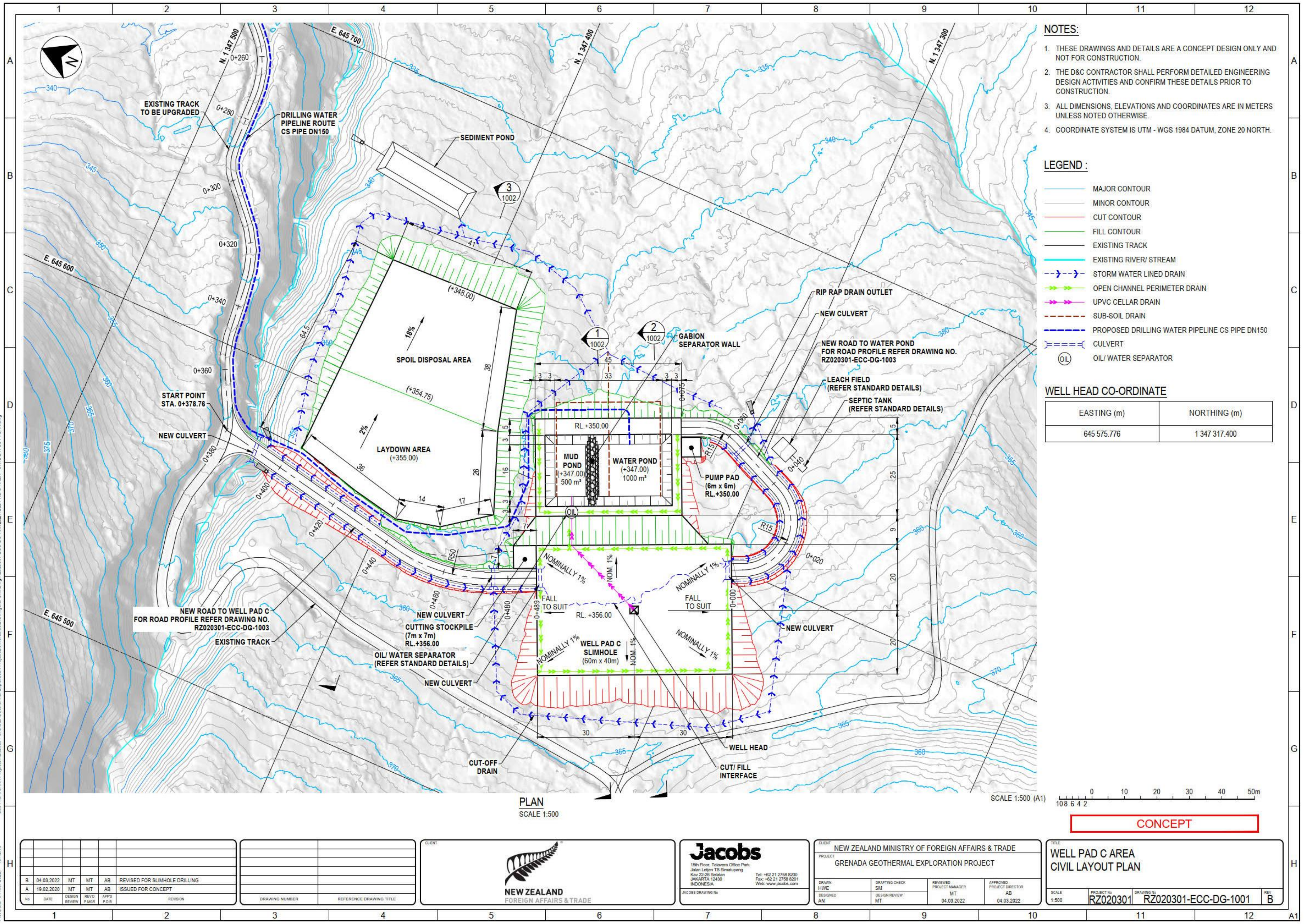
2.5.1.2 Drill site/drilling well pads

The project comprises two well pads (one at site C, one at site F). Each well pad area will accommodate:

- Drilling rig for slimhole drilling
- Storage and laydown areas for drilling equipment and materials
- Parking for service vehicles
- Space for well testing equipment
- Water pond for drilling water storage (1000m^3 capacity)
- Mud pond for disposal of drilling mud and cuttings (500m^3 capacity)
- Containers to accommodate materials and tools sensitive to elements (e.g. cement and additives, mud chemicals, drill bits)
- Diesel generators in containers (assumed 3 x 600kW) with associated fuel tanks (total of 50m^3)
- Site offices (also in containers)

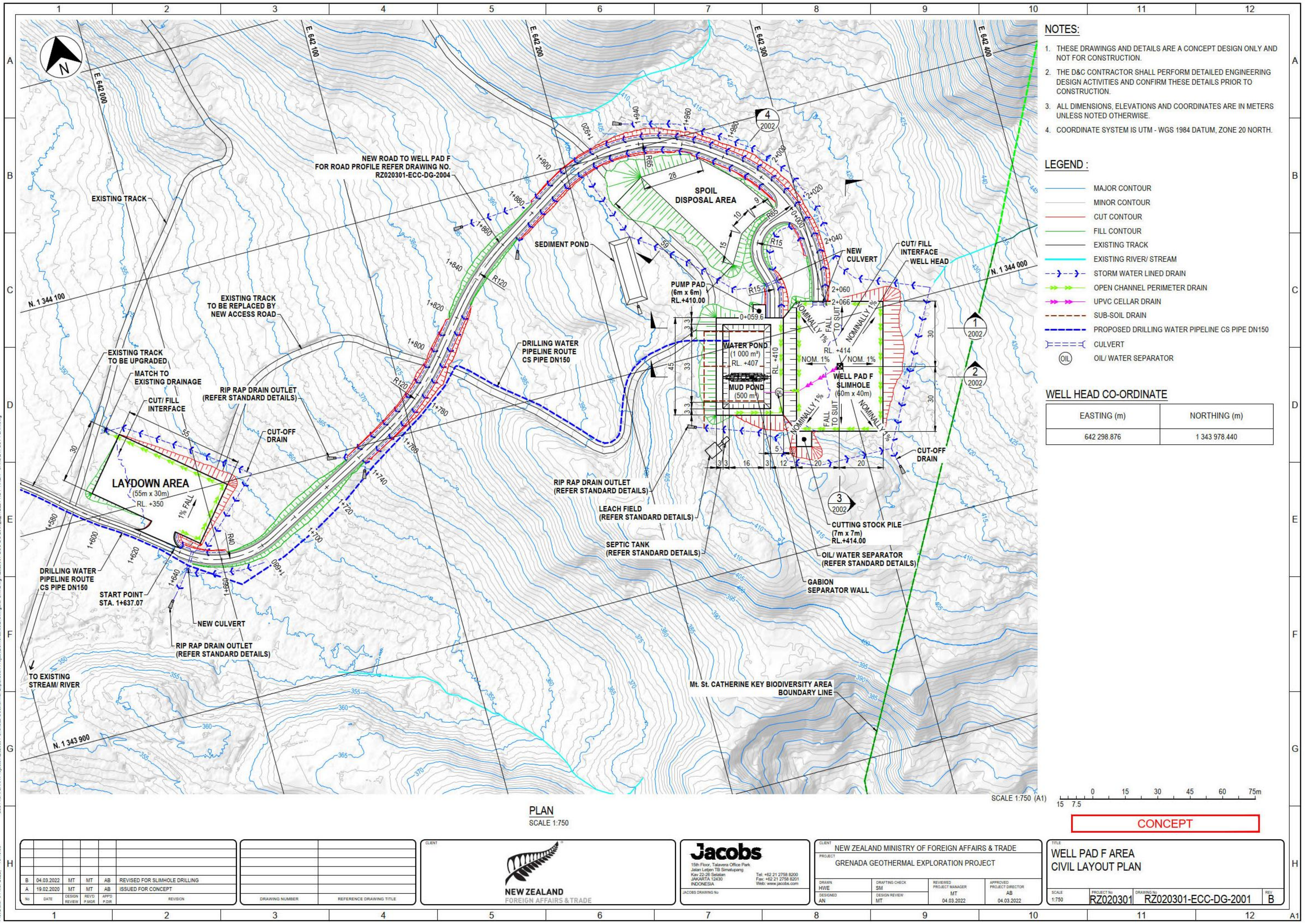
The concept layout plan of the two drilling sites is shown below in Figure 2.6 and Figure 2.7.

Figure 2.6: Layout drawing for well pad at site C - concept layout plan



Source: Jacobs. Well pad C area civil layout plan. 04 March 2022.

Figure 2.7: Layout drawing for well pad at site F - concept layout plan



Source: Jacobs. Well pad F area civil layout plan. 04 March 2022.

2.5.1.3 Water infrastructure

Two water intake & pump stations will be required to supply drilling water to each well pad (one each site). For slimhole drilling, a continuous flow of between 7.5 to 12.5 litres/second is required. To achieve this, 2x100% diesel driven pumps capable of around 220m head shall be provided, with the second, spare pump being stored in the pump station area.

Pump stations will require concrete foundations for pumps and a diesel day tank, and a flood wall.

A small weir (or similar) will be required to maintain a sufficient depth of water (0.8m) to submerge the pump intake.

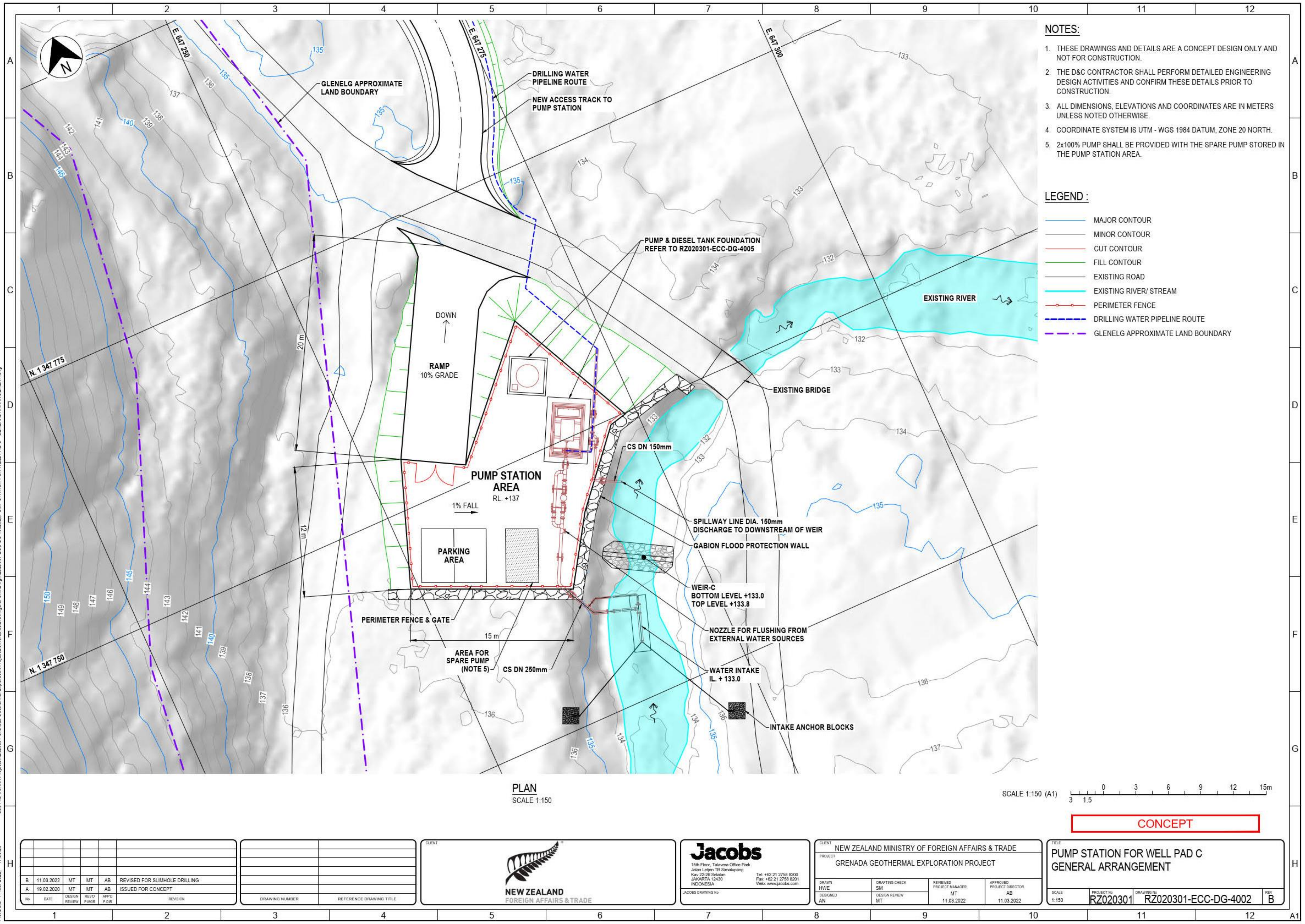
The concept layout plan of the two water intake & pump Stations (at site C and site F) is shown below in Figure 2.8 and Figure 2.9.

From Water Intake Station C to Pad C, a temporary water supply pipeline will be required (approximately 2.5km in length, DN150 pipe). This pipeline will run along the access road (see Figure 2.4 presented previously).

For Water Intake Station F to Pad F a temporary water supply pipeline will be required (approximately 2.8km length, DN150 pipe). This pipeline will also run along the access road (see Figure 2.5).

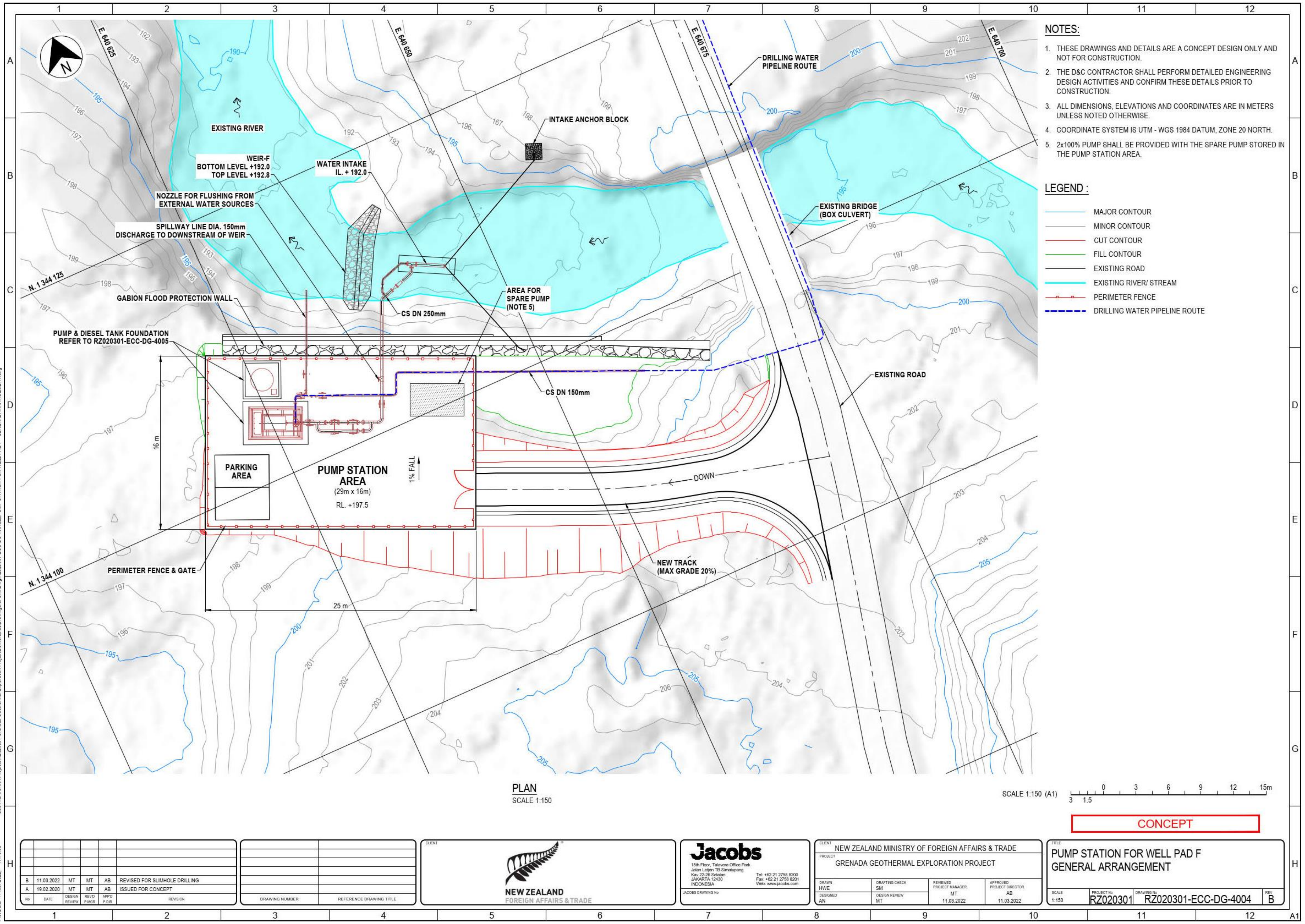
Further details for each of the key Project components and activities are provided in the following sub-sections.

Figure 2.8: Layout drawing for pump station at site C - concept layout plan



Source: Jacobs. Pump station for well pad C general arrangement. 11 March 2022.

Figure 2.9: Layout drawing for pump station at site F - concept layout plan



Source: Jacobs. Pump station for well pad F general arrangement. 11 March 2022.

2.5.2 Site establishment

2.5.2.1 Access improvements and transportation

Drilling equipment and materials will be brought to site from the St George's port. It is estimated that erection of the drilling rig and testing of the wells will require delivery of approximately 20 truckloads, with 10 additional truckloads for drilling support services. Equipment and materials will be transported via existing coastal routes along the east and west coast, and existing local tarmacked roads heading inland to the sites. The final stretches up to the sites will utilise existing agricultural tracks that will be upgraded as required.

Road works on public roads

Some works will be required on public roads from the port in St George's to each of the sites, to widen certain corners. This work is expected to be undertaken by the public authorities.

Road works are expected to be relatively minor in scale and can be done with small equipment. Therefore, road works will not cause substantial disruption to road users.

The land acquisition boundary anticipated by the GoG already comprises the safety setback distance needed for road works and road use by the project activities.

Road upgrades

The last sections up to each site currently comprise gravel / earth tracks which are accessible by four-wheel-drive vehicles and will require upgrading; approximately 400m at site C and 1650m at site F.

The new access roads leading up to the well pads will need to be designed to account for the volume of traffic (truck-mounted rig, drilling materials, rig labour and supervisors) and for rainy-season conditions. The roads will be designed to be appropriate to local civil engineering standards and geotechnical conditions.

Construction works on the access roads should take approximately 1-2 months and will be completed prior to the drilling rig arriving in Grenada.

These upgraded tracks will be gravel roads with a minimum width of 4m, with a maximum preferred slope of <20% and an open channel drainage system. Should site closure occur, the gravel tracks will remain in place as a feeder road for agriculture.

2.5.2.2 Well pads

Each exploratory drill pad will comprise a working area of 60m x 40m plus additional areas for sumps, spoil disposal areas and an additional laydown area of 55m x 30m.

Each site would be constructed following the removal of vegetation, removal of topsoil material (approximately 200mm), cut and fill, grading and laying and compacting of the gravel surface. Earthworks activities will include the excavation of areas for the mud pond and water storage. No blasting will be undertaken during the construction works. Earthwork quantities are expected to be around 10,000 – 12,000 m^3 for each site (site C and site F).

Cut and fill earthworks will take place to form the well pads and sumps. Excess cut volumes will either be reworked into the landscape as fill or placed into spoil disposal area adjacent to the well pad. Sediment control systems will be constructed to direct any silt runoff into sedimentation ponds.

The well pad surface will be a compacted crushed rock pavement of typically 300mm thickness. Slimhole drilling does not typically require a special foundation to support the rig, however a 1.2m deep concrete pit (cellar) will be constructed at the wellhead.

The sump will be designed with two compartments – the first to collect solids, with liquid overflowing to the second. The wastewater sump will be lined and protected from surface storm water inflow by ring ditches. Each site will incorporate appropriate drainage to accommodate heavy flows. The site preparation works will require approximately 10-15 workers. The reservoir and sumps would be expected to be mostly cut into the ground for stability but there will be a small fill berm constructed around part of the perimeter.

Well pad specifications are outlined in Table 2.3. Once the drill rig is transported to site, assembly takes approximately one week.

Table 2.3: Well pad specifications

Item/Component	Specification per site
Well pad dimension	60m x 40m
Total area (including well pad and all site infrastructure)	1.5 - 2 ha
Drill rig dimensions and model	Minimum 200 hp – Trailer mounted rig. Max height 12m when in operation
Assumed drill rig generators	3 x 600kW
Drilling technique	Continuous coring slim hole
Drilling targeted depth	1500m

Source: Jacobs

It is estimated that approximately 250m^3 of drill cuttings will be produced per well pad.

Construction equipment and materials

The machinery and equipment required to execute the various works will be provided by a local contractor. Table 2.4 below presents an estimated list of the construction equipment envisaged to be needed for the exploratory drilling phase works, and Table 2.5 an estimate of site construction materials required.

Table 2.4: Site set up equipment for exploratory drilling phase (per site)

Equipment	Quantity
Motor grader	1
Tractor	1
Tank trucks	2
Dump Trucks	6
Front loader	1
Excavator	5
Vibratory roller	2

Source: Jacobs

Table 2.5: Site setup materials for exploratory drilling phase (per site)

Material	Quantity
Cement for well	58,000 kg
Sand	4,700 m^3
Crushed stone / gravel	6,700 m^3

Material	Quantity
HDPE liner	1,200 m^2
Gabions	500 m^3
Steel rebar	3,500 kg

Source: Jacobs

Sand would likely be imported from another country as sand mining is not allowed in Grenada. Crushed stone/gravel would be available from a local quarry. Concrete will likely be prepared at an on-site batch plant. In terms of construction traffic movements, it is estimated that 10 trucks will visit each site per day.

2.5.2.3 Water pipeline and water infrastructure

The drilling method is slimhole continuous coring and drilling with a maximum flowrate of 12.5 litre/s required. (This drilling technique requires a lower flowrate when compared to rotary well drilling of larger-bore wells.

The intended water source for the exploration drilling is surface water from nearby streams that have sufficient water flow and suitable area to locate intake/pumping stations. Water will be piped up to the well pad water ponds, from where it will be extracted for the drilling operation.

At the water intake/pumping stations, intake pipe shall be fully submerged in the river. The intake pipe will consist of screened pipe and covered with rocks and anchored to maintain intake pipe integrity. It also shall allow backwash to avoid screen plugging.

The water intake pump shall be designed to be easily moved and able to provide sufficient flow and head from the intake to the well pad.

The water pump is diesel engine driven. Diesel fuel for the pump shall be brought to site every 2-3 days. A day tank for 3 days capacity will be provided at each pump station.

Figure 2.8 and Figure 2.9 presented previously illustrate the concept layout plan of the two water intake & pump stations (at site C and site F, respectively).

From the water intake stations to the well pads, temporary water supply pipelines will be established, as discussed before in 2.5.1.3 and illustrated in Figure 2.4 and Figure 2.5. Early pump hydraulic estimates indicate that the pump head required is 220m. Therefore, it is considered that a carbon steel pipe is more suitable for this application. The carbon steel pipe is to be joined using temporary Victaulic style grooved flexible couplings, using 6m lengths at each connection. This is to allow installation flexibility and to accommodate the desired route and flexibility (Figure 2.10).

Figure 2.10: Example of temporary carbon steel water pipeline with connection clamp in geothermal drilling

Source: Jacobs

Potable drinking water will be trucked to site. Portable lavatory facilities will be placed on site, with waste draining to a storage tank or similar, prior to removal from site and disposal.

Table 2.6: Proposed water intake location and pipeline routing

Aspect	Site C	Site F
Proposed surface water intake location	Adjacent to Glenelg bottling plant (downriver of NAWASA water treatment plant offtake)	On main Gouyave – Grenville road at Rosemont, about 2.5km from well pad
Routing of pipeline	2.8km carbon steel pipeline alongside road. One stage pumping with 220m required head	2.5km carbon steel pipe alongside road One stage pumping with 220m required head
Design of water intakes	Simple 0.8m high weir structure to divert flow and maintain water level; and a 3m intake pipe with submerged screen	Simple 0.8m high weir structure to divert flow and maintain water level, and a 3m intake pipe with submerged screen
Water storage reservoir location	1,000 m^3 pond adjacent to well pad	1,000 m^3 pond adjacent to well pad

Source: Jacobs

2.5.2.4 Water requirements during drilling

Water volumes required for the drilling have been estimated by Jacobs (see Table 2.7). The drilling concept is Slimhole continuous coring and drilling, with the maximum water flow supply of 12.5 l/s.

Table 2.7: Water demand during drilling

Parameter	Site C	Site F
Assumed duration of drilling	77 days	77 days
Estimated max water demand during Slimhole drilling	12.5 litres / second	12.5 litres / second
Estimated total water intake required for drilling	43,000m^3	43,000m^3

Source: Jacobs

2.5.3 Exploratory drilling works

The exploratory drilling works stage includes the drilling of deep slimhole wells, the maintenance of drilling equipment and machinery, and the management of drilling mud, cementing of casing, solid and liquid wastes.

The drilling programme will be backed with a strong emphasis on scientific monitoring and testing programmes. These provide the basis for understanding the geothermal resource, how it could perform under production, and costs for delivering the production. It is also imperative for refining the conceptual models already developed by Jacobs, and also developing a robust numerical reservoir model which can be used as a predictive tool to simulate future behaviour of the source.

Drilling operations will be 24 hours a day. Slimhole continuous coring and drilling technology will be used. The drilling activities are undertaken using progressively smaller drill bits as the sections become deeper. Each diameter of the drill will incorporate metal casings. The casings serve several purposes, including prevention of ingress or loss of fluid into or from the well, to control drilling fluids and also to maintain the structure and integrity of the well itself. Cement is pumped into the 'annular' space between the borehole and the casing. The final section of the well will incorporate a perforated liner (not cemented), which will allow geothermal fluid to flow up the well. After completion a valve structure designed to prevent blowouts will be fitted to the wellhead.

A drilling supervisory firm would be responsible for the detailed design and planning of the well. The drilling will be performed using proven geothermal methodologies and in accordance with internationally recognized engineering and safety standards. No fracking techniques will be used.

Preliminary drilling depths are provided in Table 2.8.

Table 2.8: Preliminary well designs

Casing	Description
Drilling Method	Slimhole continuous coring
Conductor	13-3/8" outside diameter (OD) casing set at 4-6 m
Surface	**Casing**: 9-5/8" OD, set at 50 m. **Hole**: 12-1/4 " OD
Intermediate	**Casing**: 7" OD, set at 300 m **Hole**: 8-1/2" OD
Production	**Casing**: 4-1/2" OD, set at 650 m **Hole**: 6-1/8" OD
Liner	**Casing**: 3-1/2" OD, *NW* perforated liner set at 1500 m **Hole**: HQ core hole (3.98" OD)
Measured depth	1500 maximum measured depth (mMD)
Vertical depth	~1350 mVD
Inclination and throw at target depth	30° - Throw of approximately 500m

Source: Jacobs

Mobilisation of the drilling rig and materials will be underway, and roads, well pads, concrete and water supply will be completed by the time the drill rig arrives on site. The specifications of the drill rig are described in Table 2.9.

Table 2.9: Specifications for a typical drilling rig for a continuously cored slimhole

Equipment	General description
Rig	Minimum 200HP slimhole continuous coring rig, includes the following major component systems: • Hoisting • Rotating- rotary table or top driven • Power (AD/DC electrical or mechanical) • Circulating- rig pumps, tanks and drilling fluid conditioning equipment • Blowout prevention equipment
Mud pumps	2x250HP mud pumps
Drilling fluid circulating system	This system enables the drilling fluid to be reused after having been pumped down the drill string and returned to surface. Equipment includes two linear motion shale shakers, desander/ desilter, mud tanks and water tanks.
Air compressors/boosters and hard line	Air compressors will be required if air/aerated fluid is used.
Well control system – blow out preventers (BOP)	Annular preventer, blind ram, pipe ram, choke manifold, accumulator unit (provides stored hydraulic fluid under pressure to operate the BOP), diverter or rotating head. This system ensures the well can be safely shut-in if a ‘kick’ is encountered.
Cementing unit	High pressure cementing pump unit and silos for cement storage and mixing.
Other drilling equipment	Tricone bits, core bits, core rods, core barrel, drill collars and drill pipe, stabilisers, including various over bottom-hole assemblies.
Mud logging equipment	Instrumentation used in capturing monitoring and recording drilling parameters.
Directional drilling equipment	Drilling tools and instrumentation.

Source: Jacobs

2.5.3.1 Management of drilling muds

A significant activity in the drilling phase is the management of the drilling mud. Drilling mud serves many purposes, including as a lubricant that reduces the friction at the cutting bit, assists with transporting cuttings from the wellbore back to the surface, provides borehole stability and assists in keeping the well cool during drilling.

The mud is mainly composed of a slurry of bentonite clay and water and is theoretically recyclable and typically non-hazardous. Bentonite tends to form an impermeable filter cake, which means that as drilling passes through permeable layers, this benign material, due to swelling properties, tends to seal off the layer and is therefore also used to prevent any contamination of voids and aids in partial sealing. It is likely that the mud will also contain other additives such as surfactants that change its viscosity and surface chemistry.

Mud settling ponds (waste sumps) are constructed to contain any discarded mud during the operations. The deeper parts of the well are usually drilled with plain water. The water-based drilling mud with some addition of other chemicals, such as bentonite and surfactants, will be used. For the preparation of the drilling mud, the water pH is raised to approximately 10-11 by addition of sodium hydroxide at the rig tanks. The remainder of the additives are also added and mixed in these tanks prior to being used for drilling.

All drill cuttings and drill fluids would be collected in bins underneath the shale shakers – from here the drill cuttings can either be transported or directed to the waste sump for storage. .

Cuttings from the well will be separated from the drilling fluid at the shale shakers on the rig and fall into a pit/container. From the pit, the cuttings will be removed via a back-hoe and disposed of in either the sump or a designated disposal area. The fluid will gravity flow from the bins to the waste sump, either by a covered trench/ditch or a buried pipe with suitable gradient to allow flow to the sump.

Drilling mud and drilling cuttings from geothermal drilling (which are separated using air/aerated fluid or water-based substances), are typically not classified as hazardous waste. However, continuous daily sampling and laboratory testing of drill mud and drilling cuttings are undertaken as a standard precautionary measure on geothermal drilling sites (the drilling contractor is required to maintain a fully-resourced sampling and testing lab on the site for this purpose). If testing indicates that the drill mud and drilling cuttings material is classified as a hazardous waste it shall be handled and stored (temporarily) and ultimately disposed of off-site by a licensed hazardous waste operator to a licensed hazardous waste management facility. Cuttings classified as non-hazardous have been used for local roading material on past projects or could be spread on site.

2.5.3.2 Geological logging and well testing

Well logging and testing will be carried out by a separate specialist contractor (not the drilling contractor). Data gathered from each well during drilling is used to understand geology and permeability; these will be analysed by on-site geologists. Typical data sets obtained for geoscientific understanding of the source include petrographic analysis, detailed logging of lithology, hydrothermal alteration, drilling parameters and formation imaging surveys.

Once drilling is complete, well completion testing is undertaken to assess the permeability of the well. This process generally takes several weeks. During the testing, the well will be discharged for a sufficient period to determine well productivity (stabilised conditions) and estimates of likely well run-down over time. The well will be discharged into a separator that will enable measurements of flow and enthalpy. Discharge chemistry will be monitored throughout the discharge test to ensure fluid is non-corrosive and to track clearing of drilling fluids. Discharge water, gas and stable isotope samples will be collected under stabilised conditions.

During the well completion test the two-phase geothermal fluid from wells travels to a silencer structure where it is flashed to ambient conditions. The design structure of the silencer is such that not only is the noise level reduced but some of the steam condenses to form boiling hot water (geothermal brine). This brine may contain many different naturally-occurring minerals but especially silicates that crystalize as the temperature drops. This fluid will pass from the silencer and is then piped to the sump.

Drilling residues would be tested and the drilling contractor is required to have in place a handling and disposal plan for any hazardous components that may be identified.

2.5.3.3 Drilling maintenance activities

Routine maintenance will be required on the drilling rig throughout the exploration drilling activities, to ensure efficient drilling with minimal downtime is achieved. It is common for drilling contracts to allow in the order of 30 minutes to an hour per day for ‘rig-servicing’ which is largely comprised of preventative maintenance activities to keep the drilling rig in good working condition. The maintenance is often focused on the top-drive (equipment which rotates the drill string) engines, generators, and tubular handling equipment. These critical items of equipment require constant greasing, monitoring and the occasional replacement of important parts.

2.5.4 Site closure

Due to the characteristics of the exploration phase, as the results can only be established at the end of the phase, two different site closure activities are defined:

- In the case that exploratory results are found to be favourable, preparation for the next stage of the project would occur. The wellhead will be secured and monitored.
- In the case that exploratory results are not favourable: decommissioning and abandonment of the well will occur.

At the end of the exploratory drilling phase, all temporary equipment, and temporary facilities at the platform sites (machinery, warehouses, temporary offices, portable latrines) will be dismantled and removed, and the area cleared of materials and wastes generated during the drilling process.

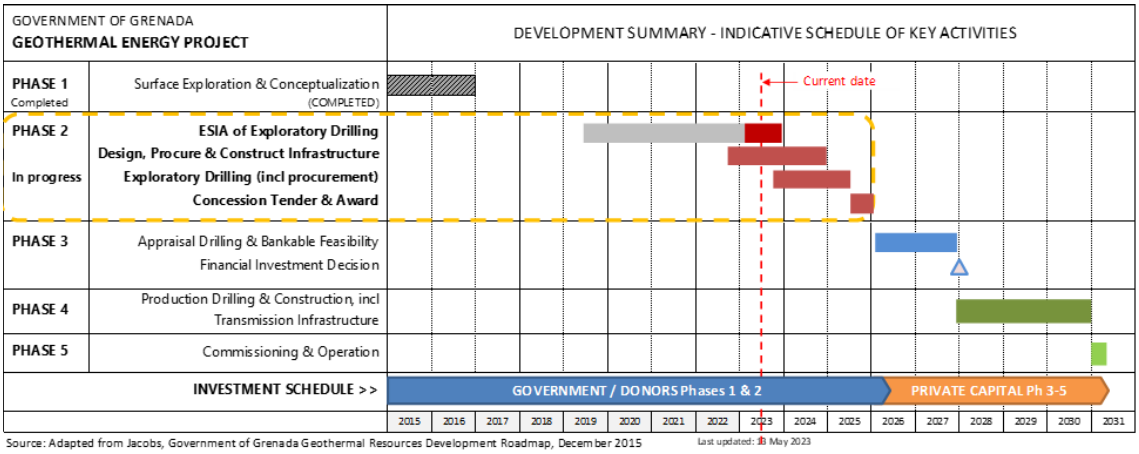
If the exploratory results are not successful and the development of the geothermal source is not considered feasible, then the following site restoration activities will be implemented:

- Site earthworks and access roads will remain as constructed
- Sumps will be decommissioned by filling in (for safety reasons – some of the well pad base-course pavement can be used for this fill) and water supply pipelines removed
- Topsoil will be spread on the remaining well pad area which will be allowed to re-vegetate naturally
- Fencing will be removed
- The wellhead will be plugged and abandoned (P&A) below ground level. A nameplate will be installed on the surface for the record and future reference

2.5.5 Overall geothermal project schedule

Figure 2.11 below outlines the indicative overall geothermal energy project schedule. This ESIA and exploration drilling is part of "Phase 2".

Figure 2.11: Development summary – indicative schedule as of 13 May 2023



Source: Government of Grenada Geothermal Project Coordinator

2.5.6 Exploratory drilling schedule and workforce

The current exploratory drilling schedule is outlined in Table 2.10 below alongside the planned duration of project activities. Drilling will occur sequentially, with Site F expected to be drilled first.

It is expected that the contractor would work in parallel to undertake works on the access road and well pad. Some of the civil works may be undertaken in parallel (i.e., at both sites) dependent upon contractor resources.

During the construction of the roads/well pads, 30-40 workers are expected to be engaged being 50% skilled labour and 50% less-skilled workers/labourers. Labourers will be engaged in essential manual work such as handling materials on site (pushing wheelbarrows, lifting, and laying pipework). These estimates exclude support services such as catering.

During drilling/testing, approximately 23 workers will be engaged; 95% are expected to be highly skilled labour force (foreign international specialists).

During decommissioning, it is estimated that the project will engage 12 workers; 75% will be skilled workers.

Table 2.10: Exploratory drilling schedule

Phase	Activity	Site C	Site F	Estimated workforce numbers per site
Construction phase	Construction	3 months	3 months	30-40
Operations phase	Well drilling	77 days	77 days	15
	Well testing	30 days	30 days	8
Decommissioning phase	Site closure (temporary closure)	1 month	1 month	12

Source: Jacobs

For the purpose of this ESIA, it has been assumed that the site establishment and abandonment activities will be undertaken during normal working hours. Well drilling and testing will require continuous activity 24 hours a day, seven days a week. The personnel who will operate and guarantee the maintenance of the drilling machinery (wellhead, drillers, assistants, mechanics and electricians) will work in crews on two 12-hour shifts.

Table 2.11: Assumed working hours per day

Activity	Hours
Establishment of access and site construction	7am – 7pm
Well drilling	24hrs
Well testing	24hrs
Well abandonment and reclamation	7am – 7pm

Source: Mott MacDonald

2.5.6.1 Worker accommodation

Accommodation for non-local workers is likely to be in rented houses in nearby villages and towns. A project worker accommodation/camp is not deemed necessary at this stage.

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Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

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Chapter 3 - Project need and analysis of alternatives

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Volume II - ESIA
Chapter 3 - Project need and analysis of alternatives

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Contents

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3 Project need and analysis of alternatives

3.1 Overview

This chapter provides a brief background on the need for the Project as well as an assessment of alternatives.

The assessment of alternative sites and technologies has taken account of various criteria including the Project requirements, geological features, existing infrastructure, land use planning, and the potential environmental and social impact. This chapter provides a summary of the design decisions made to date with reference to the above stated criteria.

The Project need has been reviewed in the context of the Grenadian energy policy in addition to economic and market factors in order to evaluate whether there are sufficient drivers to justify development of the Project.

3.2 Project need

Grenada is a tri-island state comprised of the islands of Grenada, Carriacou and Petite Martinique, with a total population of 124,610[1].

Grenada's total energy supply mix is made up of 98% fossil fuels and 2% renewables[2].

Grenada is currently almost entirely reliant on imported fossil fuels (diesel) for electricity generation, leaving it vulnerable to global oil price fluctuations that directly impact the cost of electricity. This global volatility in the price of oil has a strong impact on the retail price of electricity cost at the local market level.

The main electricity consuming sectors are the domestic (households), commercial and industrial/street lighting sectors, with the household sector accounting for approximately 41% and the commercial sector 53% of total electricity consumed in 2022.

The Government of Grenada has approved an updated National Energy Policy (NEP) for 2023-35 which is an update of the original 2011 NEP[3]. The main objectives of the new draft NEP in relation to renewable energy are:

- Intensify the diversification of generation mix and develop a potential of Grenada's indigenous energy resources (geothermal, wind, solar);
- Increasing the share of electricity generated by renewable energy sources, in conjunction with the pledged climate mitigation efforts and the gradual phasing out of fossil fuel;
- Open participation to multiple operators in the electricity supply industry, providing opportunities for competition and liberalization of the generation market leading to no barrier to affordable electricity supply;
- Reduce the national carbon footprint; and

[1] Estimated number for 2021, Pan American Health Organization (PAHO), https://hia.paho.org/en/countries-22/grenada-country-profile, retrieved 11 April 2023

[2] Organización Latinoamericana de Energía (OLADE). 2021 Latin American and the Caribbean Energy Outlook. 2021. Available at: https://www.olade.org/en/publicaciones/panorama-energetico-de-america-latina-y-el-caribe-2021/. Accessed on 2 August 2023.

[3] Draft Goals and Policies of the Updated National Energy Policy (NEP) - Task 3, https://www.gov.gd/pdf/Grenada%20NEP%202022_2035.pdf, retrieved 05 July 2023

- Ease transition toward decentralized production and prioritize self-consumption with net metering enabled by distributed generation and battery and energy storage systems (BESS) both connected to the grid and independent.

The National Sustainable Development Plan (NSDP)[4] is the anchor for Grenada's development agenda and priorities over the period 2020 – 2035.The plan provides a strategic direction to steer the Tri-island State towards achieving Vision 2035: *Grenada, a resilient and prosperous nation, with a conscious and caring citizenry, promoting human dignity, and realizing its full potential through economic, social, and environmental progress for all.* The main targets of the NSDP 2020 – 2035 in relation to energy are:

- Increase renewable energy consumption to 25%;
- By 2035 reduce emissions 45% against 2010 base year;
- More than 50% energy production through renewables by 2035; and
- Reduce greenhouse gas emissions from energy production by 30% relative to 2017 baseline.

Therefore, utilisation of geothermal resources, alongside being a key pillar of Grenada's National Energy Policy 2023 - 2035 is a step forward in resolving energy poverty which critically acts as a barrier to the achievement of the Millennium Development Goals (MDGs). Grenada is also a signatory to international agreements such as the Paris Agreement which aims to respond to global climate change by dealing with greenhouse gas emissions mitigation, adaptation and finance.

The below points summarise the need for the project:

- Geothermal energy, if confirmed, will provide a large quantity of continuous, reliable, renewable energy, which will:
  - Significantly decrease Grenada's reliance on overseas fuel imports,
  - Increase the diversity of energy sources in Grenada, and
  - Help to meet Grenada's ambitious renewable energy targets as set out in its 2023 National Energy Policy

3.3 Analysis of alternatives

3.3.1 No project alternative

This section considers the "no project" alternative, which considers if the project is not implemented.

The "no project" alternative would result in:

- No additional information would be able to be collected on the feasibility of the geothermal potential in Grenada, and the question of whether Grenada has viable geothermal power potential would remain unanswered
- Assuming that there is indeed viable potential, the no project alternative would prevent any such potential from being realised
- This would be a barrier to the achievement of Grenada's renewable energy transition and would prolong the country's dependence on fossil fuels

[4] National Sustainability Development Plan 2020-2035, National Plan Secretariat, available at national-sustainable-development-plan-2020-2035_c1a0b517ea9dfe92299043b723bb207e.pdf (climatepolicyradar.org), retrieved 07 July 2023

3.3.1.1 Economic perspective

The current lack of significant indigenous renewable power sources in Grenada leaves the country open to the volatile fluctuations of global fuel prices. If Grenada is unable to confirm and subsequently utilise geothermal energy for electricity generation, this could lead to affordability issues for the government (if costs are subsidised) or higher electricity costs for consumers and business and can therefore impact upon economic growth and competitiveness. Without the Project other alternative energy generation sources would need to be proposed which both meet the electricity requirements of Grenada, whilst meeting the renewables targets set.

3.3.1.2 Environmental and social perspective

From an environmental perspective, should there be no geothermal project developed in Grenada then the environmental baseline of the proposed Project areas would remain in its existing state. The no project alternative would therefore result in no specific environmental or social impacts on the proposed project areas (beneficial or adverse).

However, the no project alternative would mean that Grenada would likely continue to generate an equivalent amount of electricity based on diesel power for baseload power, which produces polluting air emissions, that the geothermal project could have otherwise offset. Electricity consumers would also continue to be subject to price volatility associated with international fuel imports.

Although the project will occur over a short timescale, should a feasible resource be found and the production phase go ahead, there is the potential that training and employment opportunities could increase, compared to the no project scenario.

3.3.1.3 Conclusion

Geothermal power generation is a key objective of Grenada’s National Energy Policy 2023 - 2035 to support the transition to a more reliable, diversified and low carbon energy generation sector. Therefore, the no project alternative would not satisfy these aims. The no project alternative could lead to continued price volatility, or higher energy prices for the government and consumers.

3.3.2 Alternative locations

In general, the location of a geothermal energy development is restricted to the location(s) where viable geothermal reservoirs are thought to exist, as identified by a phased process of exploration. In 2015, the New Zealand Ministry for Foreign Affairs and Trade (MFAT) and Japan International Cooperation Agency (JICA) funded surface exploration activities in Grenada which identified a geothermal source with the potential to be developed into a resource for electricity generation. This included a pre-feasibility assessment, environmental and social preliminary scoping exercise, and a preliminary drilling plan which was produced in 2016.

In 2015, Jacobs undertook a geothermal investigation including geological, geochemical and geophysical data collection and interpretation in Grenada. The surface studies resulted in the development of two conceptual models of the geothermal resource:

- a shallower system with a northerly outflow and a greater areal extent
- a deep upflow area with a narrower areal extent

The study identified that ideally the main choice of exploration drilling target would have been the centre part of Mt St Catherine. However, this was discounted due to the area’s designation as a forest reserve and respective environmental impacts, as well as logistical concerns (the area is remote, steep and highly vegetated). There are also no access roads into this area, and it was also considered undesirable to provide public road access into this location. Seven areas were therefore initially selected on the periphery of the geothermal resource around the Mt St Catherine, based on both technical and scientific aspects as well as environmental and logistical constraints. The infrastructure assessment carried out in 2016, investigated the seven areas to identify the most suitable for exploratory drilling, and narrowed down the most preferable options to sites, C, D and F. The main basis of the shortlisting of these sites was:

- Flat enough topography to develop the Project
- Existing road access (both via public roads and private roads)
- Access to adequate water supply and water supply cost
- Drill rig transportation routes / access of equipment to the sites
- Simplicity of land ownership

Further refinement of the sites was undertaken by Jacobs in 2018, when the preferred sites of C and F were identified as the most appropriate for a rotary drilling exploratory campaign. Site D was discounted as there was not enough land to develop the space for a rotary drilled wellpad.

Following the ESIA scoping stage, further technical engineering analysis by Jacobs resulted in the refinement of the proposed well pad location at Site C.

3.3.3 Supporting infrastructure

3.3.3.1 Access roads

Access roads for the proposed Project can be split into three main sections:

- Coastal public roads from the port towards the sites
- Public road sections between coastal roads, up to where the public roads end,
- Existing tracks which will be upgraded between the end of the public roads and the wellpad sites.

As part of the infrastructure assessment undertaken in 2016, one of the key considerations was accessibility of the sites to large articulated semi-trailer trucks which will be required to deliver the drilling rig and other construction materials to site. As the drilling rig will be imported at the port in St Georges, there are limited main roads from the capital capable of easily transporting large heavy goods vehicles without significant disruption to traffic or widening. The main coastal roads which travel up the east and west coastlines from St Georges are preferable roads for any large vehicles travelling in Grenada. The road across the centre of the island, via Grand Etang, is not suitable for large trucks. Grand Etang is also a national park and thus avoidance was preferable to limit environmental and social impacts.

The public road routes which lead from the coastal roads towards the sites were also reviewed in the Jacobs infrastructure assessment which identified preliminary routes for the Project to use which limit the amount of works required on public roads (e.g., road widening, encroachment on fences and other obstacles) and therefore social impacts from the routes.

The upgrading of existing tracks up to both well pad sites seeks to minimise the need to create completely new rights of way and will minimise significant vegetation clearance.

3.3.3.2 Water

The source of water for the Project is proposed to be via extraction from nearby streams.

The water pipeline from the intakes will generally follow the access road, thus reducing levels of disturbance to residents, landowners, and habitat disturbance. Laying the water pipeline along the road will seek to avoid impacts to landowners and users. It will also allow for easier access to the pipeline during project use.

In the drilling infrastructure assessment stage, various options were initially considered for the provision of the Project's water supply requirements:

- Run of stream extraction: this method relies on adequate flows being available to meet drilling requirements constantly. A conservative estimate of the available water resources at the proposed intake locations concluded that there would be sufficient flow to meet project needs without impacting upon environmental and social water demands.
- Water delivery by tankers: this option would require at least 8 trucks per day delivering water to the site from a large lake or river. Due to the volume of traffic and the speed at which the water would need to be loaded and unloaded this was considered to be an unfeasible option.
- Seawater extraction and pumping: this option would require significant piping and also multistage pumping due to the distance to the sites. The impacts of the project would also be more widely felt, and this option would also be more costly.

3.3.3.3 Utilities

There is no source of electricity supply at either of the two sites, and thus generators will be required during the exploratory drilling phase. This is a typical method during exploratory drilling campaigns given the short-term nature of the exploratory drilling campaign. Fuel will need to be provided via tanker from St Georges for the fuel needed to operate and run the drill rig, generator and diesel water pumps. Fuel storage tanks will be located at site and water pump locations, and would be suitably bunded and protected.

Potable water for the sites will be in the form of bottled water, as neither site has a potable water source.

3.3.3.4 Port

Due to the exposed nature of the east coast it was determined during the infrastructure assessment that there are no appropriate landing barge points which could be used. Along the west coast, one beach near to Palmiste Bay was considered as an option, however possible interference with local fisherman was identified as a potential constraint. Therefore the St George's port has been proposed as the most suitable port at which the equipment and materials will be imported.

3.3.3.5 Materials and equipment

Local equipment sourcing is an important aspect of determining logistics and cost. There are no geothermal drilling rigs or other related equipment in Grenada and therefore the only option is to import from overseas. Where applicable, construction material will be sourced in Grenada.

3.3.4 Technology alternatives

This section provides a brief overview of alternative technology options that might generally be considered in the context of the objectives of the Project. It is noted that the Grenada National Energy Policy aims to promote and develop a diversified mix of indigenous energy sources, including geothermal, wind and solar.

Table 3.1: Comparison of alternative power generation technologies

Technology	Advantages	Disadvantages
Geothermal power	• Typically, only a small area of land is needed for a large power output • Renewable technology • Continuous (baseload) power • High capacity factors	• Challenge to mobilise private investment due to high upfront risk • Relatively small quantities of emissions of non-condensable gases (eg: hydrogen sulphide and CO2) from geothermal reservoirs

Technology	Advantages	Disadvantages
	• Can contribute to Grenada's target of 20% of all domestic energy usage to originate from renewable energy generation	• Ecological impacts and water impacts dependent upon project site selection
Thermal	• Well-established technology • Continuous (baseload) power • High capacity factors • Can create flexible plant able to respond rapidly to changes in demand-suitable for peaking power generation	• Fuel use has high GHG emissions and associated environmental problems (for example air quality impacts) • Does not align with Grenada's energy policy goals • Does not reduce carbon emissions
Wind	• Renewable technology with CO_2 emissions only considered in lifecycle assessment of equipment manufacture: no CO_2 emissions from general operations • Can contribute to Grenada's target of 20% of all domestic energy usage to originate from renewable energy generation • Potential for wind power appears high at east coast locations	• Typically needs large areas of land and open spaces for large power output • Terrain can constrain locations (transportation of parts and blades) • Turbines sometimes considered as visibly detrimental to surrounding landscapes • Environmental impacts in relation to birds and bats, some noise issues dependent upon project siting • Dependent on wind, allowing little scope for increasing power generation if needed • Intermittent energy source not suitable for base load power
Solar photovoltaic solar	• Typically low maintenance • Renewable technology, with CO_2 emissions only considered in lifecycle assessment of equipment manufacture: no CO_2 emissions from general operations • Can contribute to Grenada's target of 20% of all domestic energy usage to originate from renewable energy generation • Grenada benefits from high number of sunny days, with the strongest solar radiation in the south of the island • Small-scale solar already installed in number of places in Grenada	• Relative inefficiency / square meter meaning large amount of land is often needed, on an Island like Grenada where land is limited • Power production is intermittent unless storage is included Low capacity factors
Hydropower	• Renewable technology, with CO_2 emissions only considered in lifecycle assessment of equipment manufacture: no CO_2 emissions from general operations	• Depending on the facility design, can have significant negative impact on communities up and downstream • Can have significant impacts upon hydrological profile/ river ecology
Waste to energy	• Non-recyclable materials that would go to landfill can be used to generate electricity • Grenada National Energy Policy identifies capacity to develop small plant	• Individual small island states do not necessarily produce sufficient waste feedstock to supply a powerplant • GHG emissions from the process

MOTT MACDONALD

Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Volume II - ESIA
Chapter 4 - Policy, legal and institutional framework

September 2023

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4 Policy, legal and institutional framework

4.1 Overview

This chapter presents both the national and international legal framework for planning and environmental and social protection in Grenada, applicable to a geothermal power project. In addition, reference has been made to relevant international standards, in this instance namely the International Finance Corporation's (IFC) Performance Standards (PS), associated PS Guidance Notes, and the World Bank Group Environmental Health and Safety (EHS) Guidelines (2007). Generally, where national legal standards are not as stringent as international requirements or vice versa, the Project will be required to defer to the most stringent requirement except in cases where national law or regulations have been explicitly identified as taking precedence for the Project.

4.2 National regulatory framework

Grenada is a constitutional monarchy in which the formal Head of State is a Monarch but is limited by the nation's supreme law, the Constitution, which entered into force in 1974. There is an Executive branch, in which King Charles III is the hereditary Chief of State but is represented by the Governor General. The Prime Minister is the Head of Government as well as the leader of the majority party and is appointed by the Governor General after legislative elections. There is also a legislative branch, which has a bicameral parliament that is comprised of the Senate and the House of Representatives.

Grenada's constitution was made on 19 December 1973 and came into operation on 7 February 1974. It covers the fundamental rights and freedoms of citizens to be enjoyed by all as the basis for freedom, justice and human dignity.

In Grenada, there are several government agencies which are responsible for overall land management and environmental protection and a full range of laws, regulations, policies, acts and decrees with the intention of providing the necessary legislative framework for the different agencies dealing with these matters. The ones relevant to this project are summarized in Table 4.1 and discussed in sections 4.2.1 to 4.2.9.

Table 4.1: Summary of key national legislation

Topic	Legislation
Energy and Geothermal	National Energy Policy, 2011
	Draft Goals and Policies of the Updated National Energy Policy (NEP), 2023
	Electricity Supply Act, 2016
	Electricity Supply (Customer Service) Regulations, 2016
	Draft Geothermal Resources Environmental and Planning Regulations, 2011
Environment	Physical Planning and Development Control Act, No 25 of 2002
	Waste Management Act of 2001 (and Solid Waste Management Act of 1995)
	Environmental Levy Act, 1997
	Abatement of Litter Act, 1990
Biodiversity	National Biodiversity Strategy and Action Plan (NBSAP) (2016-2020)
	Forest, Soil and Water Conservation Act, 1984
	National Forest Policy, 1999
	National Parks and Protected Areas Act, 1991
	Grand Etang Forest Reserve Act, 1906

Topic	Legislation
	Birds and Other Wildlife Act, 1957
	Wild Animals and Birds Sanctuary Ordinance, 1964
	National Sustainable Development Plan 2020-2035
	Plan and Policy for a System of National Parks and Protected Areas in Grenada and Carricou, 1988
Water	Water Quality Act, 2005
	National Water and Sewerage Authority Act, 1990
	Final Draft National Water Policy, 2019
Land management	Land Settlement Act, 1969
	Land Transfer Valuation Act, 1992
	Land Acquisition Act, 1998
	Grenada National Land Policy, 2019
Labour	Employment Act, 1999
Human rights	Constitution of Grenada, Part I: Protection of fundamental rights and freedoms, adopted in 1973, reinstated in 1991, and amended in subsequent years
Emergency preparedness	Disaster (Emergency Powers) Act, 1984
	National Disaster Plan, 2005
Cultural heritage	National Trust Act, 1967

Source: Prepared by Ecoengineering and Mott MacDonald in 2023 based on several sources

4.2.1 Energy and Geothermal

4.2.1.1 National Energy Policy, 2011

Grenada's National Energy Policy (GNEP) lays down the Government's objectives for shaping the energy sector in Grenada, in order to 'ensure access to affordable, equitable and reliable energy sources and services to drive and secure national development, and to improve the quality of life for all its citizens'. The GNEP called for a minimum of 20% reduction of GHG emissions from fossil fuel combustions by 2020 and set a specific target for renewable energy – to provide 20% of all domestic energy used for electricity and transport by 2020. It also called for the implementation of various measures to encourage energy efficiency and conservation in energy generation, transport and building sectors. It was centred around seven main principles: energy security; energy independence; energy efficiency, energy conservation, environmental sustainability, sustainable resource exploitation, rational energy prices and energy equity and solidarity.

4.2.1.2 Draft Goals and Policies of the Updated National Energy Policy (NEP), 2023

In 2011 the Grenada National Energy Policy (GNEP) was adopted by the cabinet of the Grenada Government. A new draft energy policy 2023 - 2035 has been developed and approved by the cabinet of the Grenada Government. The main objectives of the new draft National Energy Policy, 2023 in relation to renewable energy are:

- Intensify the diversification of generation mix and develop a potential of Grenada's indigenous energy resources (geothermal, wind, solar);
- Increase the share of electricity generated by renewable energy sources, in conjunction with the pledged climate mitigation efforts and the gradual phasing out of fossil fuel;
- Open participation to multiple operators in the electricity supply industry, providing opportunities for competition and liberalization of the generation market leading to no barrier to affordable electricity supply;
- Reduce the national carbon footprint; and

- Ease transition toward decentralized production and prioritize self-consumption with net metering enables by distributed generation and battery and energy storage systems (BESS) both connected to the grid and independent.

The proposed Geothermal Project is in keeping with the specific target of using renewable energy sources for Grenada.

4.2.1.3 Electricity Supply Act, 2016

This Act repeals and replaces the 1994 Electricity Supply Act. The previous Act allowed for the generation, transmission and distribution of electricity in Grenada by one Company until 2073. The new Act opens the sector to domestic and foreign investment in new projects and facilities for the generation of electricity from renewable energy resources, while preserving the activities of current market participants.

Part II of the Act delineates the roles of the Minister and the new Public Utilities Regulatory Commission in the regulation of the electricity sector. The Public Utilities Regulatory Commission is the independent regulator of all public utilities, but also has additional powers and functions specific to the electricity sector, including the responsibility for all rate-setting, enforcing the terms of all licenses for the supply of electricity, resolving consumer and self-generator complaints, receiving and processing of all license applications, and providing advice, recommendations and assistance to the Minister.

4.2.1.4 Electricity Supply (Customer Service) Regulations, 2016

This Regulation, a subsidiary legislation under the Electricity Supply Act, establishes the terms and conditions on which electricity service is supplied by the Network Licensee to a person who applies for, or has, an account with the Network Licensee for Service. Under these Regulations, the Network Licensee will supply Service in accordance with the Network License; the Electricity Supply Act, 2016 and regulations made under it; the Public Utilities Regulatory Commission Act and regulations made under it; and the rules contained in this Code.

4.2.1.5 Draft Geothermal Resources Environmental and Planning Regulations, 2011

These draft Regulations were made by the Minister under Section 25 of the Physical Planning and Development Control Act, 2002 (see section 4.2.2.1). The Regulations allow the development of geothermal resources while safeguarding the natural environment and the public welfare of Grenada. The regulations require the preparation of an Environmental Impact Assessment for geothermal development, and lists specific requirements that guide the preparation of such a document, including but not limited to qualifications, skills, knowledge, and experience of persons preparing environmental impact assessments for geothermal resource developments and the content of environmental impact assessments for geothermal resource developments.

4.2.2 Environment

4.2.2.1 The Physical Planning and Development Control Act, No 25 of 2002

The Physical Planning and Development Control Act No. 25 of 2002 makes provision for the control of land development and land use management in Grenada. The Physical Planning and Development Authority (PPDA) is set up under the Act with regulatory powers over any development taking place in, on, under or over the land. Part IV of the Act makes provision for Environmental Impact Assessment. Specifically, it states that the Authority (PPDA) can request an EIA in respect of any development application for approval, if the proposed development could significantly affect the environment. The steps involved in an application to apply for Land Development are as follows:

1. The Applicant submits an application for a proposed land development to the PPDA.
2. Within 90 days of receipt of the Application, the PPDA may:
   a. Refuse the proposed development;
   b. Approve the proposed development with or without conditions/restrictions;
   c. Request from the Applicant, further information; or
   d. Require that an Environmental Impact Assessment (EIA) be provided.

With respect to Item 2(c) above, once a request for further information is made, the Applicant has 14 days to provide such information to the PPDA. Upon receipt of such information, the PPU has 90 days to make a determination (grant or refuse permission).

With respect to Item 2(d) above, an EIA may be required once activities under the proposed development include any one of the matters stipulated in Schedule 2 of the Act. Further, Section 25 (4) of the Act states that the Minister may make regulations to determine the requirements of the EIA, including, but not limited to:

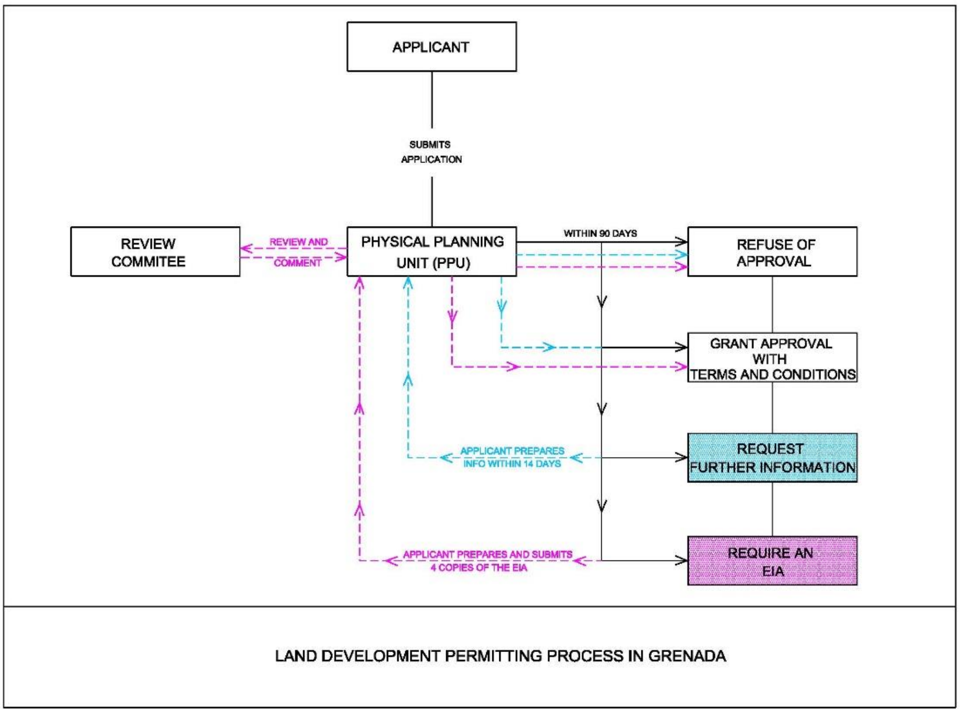
- the procedures for settling the scope of the EIA to be conducted
- the minimum contents of the EIA Report
- the qualifications, skills, knowledge or experience required by persons conducting the EIA
- the procedures for public participation and public scrutiny of the EIA and any report relating to the EIA
- criteria and procedures for review of the EIA Report

Once the PPU issues a request for an EIA, no other agency or department of Government is to issue any license, permit, approval, consent or document of authorization in relation to the Applicant's proposed development unless the PPDA has given approval for such development.

Following the submission of the EIA Report to the PPDA, an established review committee reviews the report, and makes a determination. Once an Applicant has been notified of approval to commence with the proposed development, he/she must do so within 12 months of the date of notice. After this period, the approval will lapse.

Geothermal development activity is classified under No.10 (Hydroelectric projects and power plants), No. 15 (any development generating or potentially generating emissions, aqueous effluent, solid waste, noise, vibration or radioactive discharges) and No.18 (Any development in wetlands, marine parks, national parks, conservation areas, environmental protection areas or other sensitive environmental areas), and will thus require the preparation of an environmental impact assessment report.

Figure 4.1: Grenada EIA process



4.2.2.2 Waste Management Act, 2001

The Waste Management Act 2001 was created to provide for the management of waste in conformity with the best environmental practices and related matters. The Grenada Solid Waste Management Authority Act (1995) is not repealed by the 2001 Act, but rather supports it as it establishes a Solid Waste Management Authority. Arising from the Waste Management Act (2001) is the need to prepare a comprehensive National Waste Management Strategy (NWMS) for Grenada. The Strategy must contain:

- A summary of the National Waste Inventory.
- Mechanisms for establishing standards, requirements, procedures and monitoring for the management of wastes (generation, handling, storage, treatment, transport and disposal of all waste types).
- Standards and procedures for reducing, recycling, recovering, reclaiming, and reusing wastes and the use of recycled materials.

The Grenada NWMS is dated April 2003[1].

The Act also requires that an Environmental Impact Assessment be prepared before any waste management facility is established, the issuance of licenses for commissioning any waste facility (including waste haulage permits) and the monitoring/enforcement of published waste management standards and established waste (management or disposal) facilities. This Act does not make provisions for individual Contractors to apply for permits for the haulage or storage of construction wastes.

[1] Grenada Solid Waste Management Authority. National Waste Management Strategy, 2003. Available at: http://www.gswma.com/strategy.htm. Accessed in June 2023.

4.2.2.3 Environmental Levy Act, 1997

This Act provides for the imposition and collection of an environmental levy on the persons, goods and services specified in the Second Schedule. The Minister may by Order exempt a person, or a Department of Government, from any or all the levies imposed by this Act or another enactment. The Act also concerns refund of levy on beverage containers and other products as listed in the First Schedule.

4.2.2.4 Abatement of Litter Act, 1990

The Abatement of Litter Act, 1990 was established to control and punish the depositing of litter. It outlines summary of convictions for those who are in breach of the Act. It also gives the Sanitary Authority (established under the Public Health Act) power to give notice to those found guilty of littering, as well as permission to enter a premises at all reasonable hours (with timely notice and warrants) to remove litter from such premises.

4.2.3 Biodiversity

4.2.3.1 Grenada National Biodiversity Strategy and Action Plan (NBSAP) (2016-2020)

Through assistance from Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP), the Government of Grenada prepared a National Biodiversity Strategy and Action Plan in accordance with Article 6 of the Convention (General Measures for Conservation and Sustainable Use), and Article 7 (Identification and Monitoring). This document is the principal instrument for implementing the Convention on Biodiversity at the national level. Objectives address:

- Promoting biodiversity conservation
- Sharing of benefits arising from the use of genetic resources
- Implement plans for environmental restoration in a range of areas including nature reserves
- Promoting research on changes in environmental cycles and natural resources in the light of climate change and climate variability
- Promoting environmental restoration of agricultural biodiversity for major export crops

The NBSAP was prepared in parallel with Grenada Fifth National Report (Spencer, 2016) and therefore the strategies included emanate from the status of Grenada's biodiversity. The NBSAP sets out two strategic priorities. Strategy 1 is for the Enhanced National Capacity for Biodiversity Conservation and Sustainable Use. Strategy 2 is for Key National Ecosystems Restored and Sustainably Managed. Focus areas and priority actions have been formulated for each strategy and the lead agency identified. The focus areas for Strategy 2 include: forest biodiversity, agricultural biodiversity, fresh water biodiversity and coastal and marine biodiversity. This Plan has not been updated.

4.2.3.2 Forest, Soil and Water Conservation Act, 1984

The Act sets out the aims of the forestry policy of Grenada, which includes the protection of forests, soil and water resources and protection of areas of natural and undisturbed habitat for indigenous flora and fauna.

The Act makes provision for the conservation of forest, soil, water and other natural resources in Granada. The Act requires that a Forestry Department be established and maintained, and for the purposes of planting, maintaining and using land, a Forest Policy be developed and implemented. The specific aims of the forest policy include, but are not limited to:

- Effecting the permanent preservation of tree cover so as to prevent soil erosion, flooding and protection of water supplies

- Setting aside land as forest reserves to ensure a continuous supply of forest products
- Maintaining forest growing stock by ensuring that sound practises are employed
- Protecting areas required for the provision of natural and undisturbed habitat for indigenous flora and fauna
- Encouraging and assisting the owners and managers of forests, woodland and plantations on private and Crown land

The Act also gives the Governor General, the power to declare any area of Crown land to be a forest reserve, for (in his/her opinion) the following purposes: protection against storms, floods, landslides; prevention of soil erosion, landslips, formation of ravines/torrents and/or deposition of mud, stones or sand on agricultural land; prevention of wastage of resources; securing the proper management of land; maintenance of water supplies and protection of infrastructure (roads, bridges, etc.).

To date, the Grand Etang Forest Reserve and the Annandale Forest Reserve have been officially designated as protected. Mount St. Catherine has been proposed but has not yet been officially designated. The Mount St. Catherine proposed protected area lies very close to Site F (Plaisance Estate). Under the International Finance Corporation Guidance Note 6 – any area which is proposed as a protected area, should be treated as if it were a designated area.

4.2.3.3 National Forest Policy, 1999

The National Forest Policy contains two specific subsections: forest tenure and financial issues. The major objectives of the forest policy are:

- Conserve species, ecosystems and genetic diversity;
- To maintain, enhance and restore the ability of forests to provide goods and services on a sustainable basis;
- Optimise the contribution of forest resources to social and economic development
- Maintain a positive relationship between the people and their forest environment.

A number of important directions have been identified, to guide the implementation of the objectives in a number of sub-sectors: Biodiversity, Mangroves, Non-Timber Forest Products, Recreation and Eco-Tourism, Timber Production, Tree Planting, Watershed Management and Wildlife Management. Details of the applicable directions are as follows:

- Biodiversity
  - Maintain representative samples of all forest ecosystems
  - Protect all species which are important because of their endemicity, rarity or value
  - Establish and maintain a base of knowledge on Grenada's biodiversity
  - Build awareness and appreciation of biodiversity and its importance
  - Promote the sustainable use of genetic resources for social, spiritual and economic benefits
  - Build the capacity of Grenadian institutions to participate in the conservation and management of the country's biodiversity
  - Create incentives and other mechanisms to encourage the conservation of privately owned forests
  - Encourage the participation of government and community stakeholders in programmes for biodiversity conservation
  - Minimise conversion of natural forest into plantations, particularly in upland areas
  - Minimised and control all burning and wildfires in forest areas
- Recreation and Eco-Tourism

  - Provide opportunities for forest based recreation
  - Enhance and diversify the nations tourism product
  - Bring social and economic benefits to communities located near forest areas
  - Minimise negative impacts of recreational and touristic uses on the forest
  - Involve communities in the development and management of ecotourism sites
  - Review institutional arrangements for the management of protected forest areas to ensure that it is integrated, effective and efficient
- Tree Planting
  - Encourage tree planting to reduce soil erosion, improve soil fertility, beautify and enhance the environment, provide timber and other products and maintain biodiversity
  - Develop programmes to encourage stakeholders (e.g. schools and other community groups/organisations) in tree planting in urban and rural areas
  - Create incentives for tree planting on private lands
- Watershed Management
  - Adopt an integrated approach to watershed management, with appropriate institutional arrangements
  - Conserve all ground and surface water resources and protect from pollution and depletion
  - Maximise soil cover and prevent deforestation, as far as possible in all watershed areas
  - Minimise soil erosion and sedimentation, particularly for the benefit of aquatic species and ecosystems (both freshwater and marine)
  - Control infrastructural development and improve farming practices in catchment areas
  - Developing incentives for proper watershed management practices
  - Identify and recommend alternatives for activities detrimental to watersheds
- Wildlife Management
  - Conserve wildlife for the benefit of public education, hunting, recreation and biodiversity
  - Limit the negative impacts of wildlife on agriculture
  - Conduct research on population dynamics of important wildlife species
  - Develop effective systems to control hunting and the sale of wild meat

4.2.3.4 Plan and Policy for a System of National Parks and Protected Areas in Grenada and Carricou, 1988

The Plan and Policy document applies definitions to threatened species within Grenada, as well as specifying their habitat requirements and which National Parks and Protected Areas they are found in. The threatened species definitions are as follows:

- Endangered: taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating
- Vulnerable: taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating
- Rare: taxa with small country populations that are not at present endangered or vulnerable, but are at risk
- Status uncertain: taxa that are suspected of belonging to one of the first three categories, but for which insufficient information is currently available

Four amphibian species, 18 reptiles, 53 birds, four mammals and three types of freshwater fish fauna are listed as threatened in this document.

4.2.3.5 National Parks and Protected Areas Act, 1991

The National Parks and Protected Areas Act grants authority for the Governor-General to proclaim government land, leased or purchased land or donated land, as a national park.

The National Parks and Protected Areas Act was created to provide for the designation and maintenance of national parks and protected areas and connected matters. Under this Act, the Governor General has the power to declare any government land to be a National Park, or he may add to an existing National Park by using any government land or any land leased to the Crown. The Act further places restrictions on any land so to designated as a National Park, prohibiting the grant or sale of any such land, as well as preventing any person from settling or occupying the land. The Minister has power to make regulations to assist in implementing the Act including subjects that may require further legislation such as the preservation of flora and fauna and regulations relating to the prohibition of hunting, shooting and fishing.

The Act also makes provision for the establishment of a National Parks Advisory Council, under which its main function is to advise the Minister on matters that relate to administration, management and control of the National Parks system and any other related matters.

4.2.3.6 Grand Etang Forest Reserve Act, 1906

This Act reserves and sets apart land for the public purpose of forest conservation. These lands form part of Government land and are known as Grand Etang Forest Reserve. Protection of forest growth in Grand Etang is of vital importance for the conservation and promotion of the rainfall and water supply of the island.

4.2.3.7 Birds and Other Wildlife Act, 1957

This act provides legal protection for wild birds, fish, lobster, oyster and turtle.

It is an offence to kill, wound or take any wild birds, eggs or nest of any wild birds specified under the First Schedule. Based on the First Schedule, all birds in Grenada are protected, including those listed in the Second Schedule, which can only be hunted during a specified season. In addition to the birds listed in this Second Schedule, there is also a closed season for hunting lobsters, turtles and oysters. It is an offence to hunt these species outside the following seasons:

- Wild birds, 1st March and 31st August;
- Oyster, 1st May to 30th September
- Turtle, 1st June to 30th September
- Lobster, 1st May to 30th September

It is also an offence to export any animals listed under this Act.

With respect to fish, Section 10 of the Act speaks to the method of fishing employed, indicating that poisoning, stupefying or intoxicating fish or destroying fish is an offence

4.2.3.8 Wild Animals and Birds Sanctuary Ordinance, 1964

This Ordinance establishes the Grand Etang Forest Reserve as a sanctuary for wild animals and birds of the colony and provide special protection for the agouti *Dasyprocta leporina albida*, nine-banded armadillo *Dasypus novemcinctus hoplites* and seven species of snake specified under the schedule. Under this Ordinance is it an offence to; kill, wound or take, or attempt to kill, wound or take any wild animal or bird; or set any snare or trap to the capture of any wild animal or bird; or carry any firearms within the Forest Reserve.

4.2.3.9 Grenada National Trust Ordinance, 1967

The Trust here established as a body corporate shall manage and conserve natural and cultural beauty and wealth of Grenada. In order to achieve this objective, it shall in particular: conserve, acquire and hold land; locate and conserve areas of beauty including marine areas and conserve the natural live existing therein; list flora and fauna for purposes of conservation; etc. Powers of the Trust are set out in sections 6 and 7. The Trust shall be managed by a Council.

4.2.3.10 National Sustainable Development Plan 2020-2035

Grenada's National Sustainable Development Plan 2020-2035 sets out the vision for the country's sustainable development and long-term transformation. To achieve each outcome, the Plan sets out a total of 217 strategic actions that are spread across the eight outcomes and three goals. Each National Outcome is linked to relevant Sustainable Development Goals (SDGs). The Plan includes two goals relevant to SDG 15: Life on Land and these are:

- Expand the production of flowers, revive flower gardens, and create a new botanical garden.
- Implement an annual trees-planting programme across the Tri-island State.

This is an overarching plan and there are existing sector strategies such as the National Biodiversity Strategy and Action Plan described in section 4.2.3.1.

4.2.4 Water

4.2.4.1 Grenada National Water Policy 2020

The National Water Policy is based on the understanding that:

- water is a socially vital, economic good; and,
- water's contribution to economic and social development must take into account the importance of balancing competing water uses with the requirements of its many interrelationships with the ecosystem.

The goal of Grenada's National Water Policy is to provide sustainable management of the country's water resources, through stakeholder participation and contribution to economic, social and environmental development in an efficient and equitable manner. To accelerate progress towards the achievement of the Policy Goal, the National Water Policy has defined 13 Policy objectives as follows:

- Improve the policy, legal, regulatory and institutional frameworks for the water sector.
- Build national human capacity for the design and implementation of water-related climate adaptation projects.
- Increase public awareness of integrated water resources management.
- Ensure that present and future generations have access to water of sufficient quality and quantity for their various uses and an acceptable standard of sanitation.
- Promote the sustainable use of alternative water sources, such as rainwater harvesting and water recycling and reuse, to ensure water availability under a changing climate.
- Secure water for ecosystem services, recreation and aesthetics in order to ensure that vital ecosystems are maintained, restored and enhanced.
- Promote sound stormwater management, as a measure which can contribute to the enhancement of limited available resources.
- Promote the reduction of pollution of fresh and adjacent coastal waters through implementation of the obligations of the Cartagena Convention's LBS Protocol on Bio-safety.
- Improve water infrastructure to build climate resilience.

- Ensure water is used as efficiently as possible, including promotion of wise use and conservation, while recognizing the important role of women in household water management.
- Promote 'climate smart' agriculture.
- Improve hydrometeorological monitoring, emergency planning and decision making.
- Minimize water-related climate change risks by adopting ecosystem-based adaptation solutions.

In implementing the Water Policy, the goals and objectives outlined above shall apply equally to:

- management of the water resource;
- provision of water and sewerage services and sanitation;
- irrigation, storm-water and drought emergency management;
- water recycling and reuse; and,
- maintaining health of ecosystems.

4.2.4.2 Water Quality Act, 2005

Water quality is protected by regulations under the Water Quality Act, 2005. Water intended for human consumption must be regularly monitored, to ensure that water quality parameters meet the guideline limits stipulated in Schedule 1 of the Act.

4.2.4.3 National Water and Sewerage Authority Act, 1990

The protection and management of water resources is governed by the National Water and Sewerage Authority Act 1990 (as amended). This establishes the National Water and Sewerage Authority (NAWASA) with administrative powers, and requires that a national policy for water and sewerage be promoted with respect to:

- the provision of water supplies;
- the conservation, augmentation, distribution and proper use of water resources (including the preservation and protection of catchment areas); and,
- the treatment and disposal of sewage and other effluents.

Section 12 of the National Water and Sewerage Authority Act states *"The right to the use of every body of water is vested in the Authority and no person shall divert, abstract, obstruct or use water from a body of water otherwise than under or by virtue of the provisions of this Act."*

The sinking of boreholes, for the abstraction or disposal of water, fall under Part VIII Section 44 of the Act, which requires written authority from NAWASA for any associated activity. The plugging of boreholes may be required under Section 47 of the Act.

Whilst legislation supports water abstraction licensing, there is no licensing system currently in place. However, once the National Water Policy 2020 has been implemented (through the Water Resources Management and Regulation Bill[2]), abstraction licences and discharge permits will be required.

There are no provisions in the Act which delineate specific limits of development near watercourses.

Subsidiary legislation under this Act, comprising the National Water and Sewerage Authority Sewerage Regulations 1993, requires that:

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[2] https://climatefinance.gov.gd/2023/01/27/water-resources-management-and-regulation-bill/. Accessed in July 2023

- all premises within a defined district shall connect all sources of wastes within the premises (excluding rain or surface water) to a public sewer; and
- no person shall discharge sewage or industrial waste to any natural outlet, the ocean or the land.

All domestic and commercial properties are entitled to a sewerage connection and the disposal of wastewater to surface waters is not permitted.

4.2.5 Land management

4.2.5.1 Land Settlement Act, 1969

This Act gives the Minister and/or the Land Settlement Development Board authorization to purchase, take or lease land by agreement with the owner the purpose of providing small holdings. If the Minister or the Board is unable to acquire by agreement, and on reasonable terms, suitable land for the purpose of providing small holdings, the Governor-General may for that purpose acquire land compulsorily in accordance with the provisions of the Land Acquisition Act (see section 4.2.5.2), or any other Act which may hereafter be passed dealing with the compulsory acquisition of land by the Government and, for that purpose, the establishment and location of small holdings shall be deemed to be a public purpose.

4.2.5.2 Land Transfer Valuation Act, 1992

This Act provides for a better system of valuating land or other immovable property being transferred where such transfer attracts a tax. Specifically, whenever land is transferred in circumstances attracting any tax whatsoever, the taxing authority shall be entitled to require the Valuation Division of the Inland Revenue Department of the Ministry of Finance to determine the prevailing market value of such land for the purpose of its use.

4.2.5.3 Land Acquisition Act, 1998

The Land Acquisition Act, 1998 gives the Government of Grenada, through the Governor-General, authority to acquire land for public purposes in accordance with the procedures set out therein for public interest, with due compensation paid to the seller.

4.2.5.4 Grenada National Land Policy, 2019

The Grenada National Land Policy seeks to support the establishment of a comprehensive Natural Resource Information System to support and facilitate climate change hazard mapping, and the building of climate change resilience within ecosystems and in vulnerable communities. The objective of the policy is to achieve and maintain, over the next five years, the following measurable policy and strategic planning goals/outcomes for sustainable land management to support social and economic development:

- Establishment of the policy, legal and institutional framework necessary for the maintenance of the distinct natural resource uses that constitutes Grenada, including the following measures:
  - All natural resources defined and recorded on a national inventory
  - All threats and hazards to natural resources identified and mapped
  - All lands suitable for agricultural production identified and mapped
  - All State lands available for housing in urban areas identified and mapped for possible inclusion in the Grenada Land Bank
  - Community-based management plans developed for vulnerable land and natural resources and available in geo-spatial format to inform decision –making on physical and resource use

  - All vulnerable land and natural resources managed in a manner that conserves their ability to support social and economic benefit for present and future generations
  - Land, natural resources and coastal areas managed to preserve ecosystem resilience and biodiversity and support ecosystems-based livelihood and tourism activities
- Establishment and effective operation of a natural resource management agency to coordinate the pro-active management of all natural resources so as to conserve biodiversity, reduce pollution from land and marine based sources, and support sustainable and environmentally sound social and economic opportunities
- Establishment of the enabling framework to support first time home ownership by young Grenadians while promoting medium-density housing development to reduce stress on available land and also facilitating the computerization of the National Land Registry and land title search process to support inter-generation transfer of land
- Restructuring of the Ministry responsible for land, environment and natural resources so as to ensure it possesses the resources (human, technical, financial, legal) to oversee and coordinate the effective and timely implementation of this Policy

4.2.6 Labour

4.2.6.1 Employment Act, 1999

Table 4.2 summarises the key Employment Act requirements applicable to the project.

Table 4.2: Grenada's employment act 1999 requirements

Labor topic	Requirement
Wage & compensation	
Contract types	Three permissible forms of contract: • for an unspecified period of time – can be terminated by either party • for a specified period of time – automatically terminates on its date • for a specific task – automatically terminates on completion of task
Probation	Not more than one month in the case of less-skilled workers. Three months in the case of other workers, but which period may be extended by a collective agreement. During probationary period, the contract may be terminated without notice.
Contracts	Each employee to receive a written statement[3] covering: • the names of the employee and of the employer • the date of commencement of the contract • the rate of remuneration and the method of calculating remuneration • the intervals at which remuneration is paid • the nature of the work to be performed • normal hours of work • any provisions for the termination other than those in the Act • any disciplinary rules applicable to the employee.
Minimum wage	Minimum wage orders set by the Wages Advisory Committee must be paid.
Frequency of payment	Not less often than every fortnight for those with hour, daily or weekly wages and not less than every month for those with monthly or yearly wages.

[3] Note that international standards require some additional details. As well the Grenadian Act indicates that the statement is not necessary for someone who is employed for a fixed term of less than twelve weeks or a fixed task to be performed within twelve weeks; or who is a member of the immediate family. In comparison, international standards will require that all employees have a contract in place prior to being allowed on a project site.

Labor topic	Requirement
Pay statement	Each employee to receive a pay statement[4] including: • the employee's gross and net wages due at the end of that pay period • the amount of every deduction and its purpose
Hours / Overtime	
Normal working hours	8 hours a day, but 12 hours for a security guard or shift worker No person under 18 to be allowed to work from 9:00 pm to 6:00am
Meal intervals	No employer to require an employee to work for more than five hours continuously without a meal interval of not less than one hour or any period agreed upon. No work to be performed during the meal interval without the consent of that employee. An agreement can be made to shorten the meal interval to not less than thirty minutes, but the agreement will not be enforced until it has been shared with the Labour Commissioner.
Overtime hours	Any hours over the normal working hours are entitled to an overtime premium of not less than one and a half of the wage for one hour of overtime worked, or twice the wage for one hour of overtime worked on a Sunday or public holiday.
Annual leave / holidays / rest	
Annual leave requirements	Every construction and industrial worker is allowed two weeks for the first year of employment and three weeks thereafter. Leave to be granted not later than six months after the end of the year.
Public holiday pay	A worker who is paid on a daily basis and who works on the working day before and the working day after a public holiday will be paid for the public holiday.
Rest entitlement	No employer can require an employee to work for more than six consecutive days without a period of rest comprising at least twenty-four consecutive hours to be taken on a customary day of rest or on a day agreed between the parties.
Discipline and termination	
Disciplinary action	Includes a verbal warning, a written warning, suspension, demotion, and dismissal. No employer may impose a fine or other monetary penalty on an employee.
Grievance mechanism[5]	A complaint that disciplinary action is unreasonable may be made to the Labour Commissioner.
Justification for dismissal	There must be a valid reason for termination connected with the employee's capacity or conduct or based on the operational requirements of the enterprise, or breach of contract of employment or disciplinary rules. The following reasons do not constitute valid reasons for dismissal or disciplinary action: • an employee's race, colour, national extraction, social origin, religion, political opinion, sex, marital status, family responsibilities or disability • a female employee's pregnancy or a reason connected with her pregnancy • an employee's exercise of any of the labour rights in the Labour Relations Act, 1999 • an employee's temporary absence from work because of sickness or injury • an employee's exercise or proposed exercise of the right to remove himself or herself from a work situation which is reasonably believed to present an imminent or serious danger to life or health • an employee's participation, or proposed participation in industrial action which takes place in conformity with the Labour Relations Act, 1999 • an employee's refusal to do any work normally done by an employee who is engaged in industrial action • the filing of a complaint or the participation in proceedings against an employer involving alleged violations of any enactment
Notice of termination	Notice in writing of termination to be given: • 1 working day where employee was employed for less than 1 month • 1 week where employee was employed for 1 month or more, but less than three months • 2 weeks where employee was employed 3 months to 1 year

[4] International good practice requires pay slips to also show regular hours and overtime hours paid, and any bonuses as a lumpsum rather than as hours.

[5] Good international industry practice will require there to be a labour grievance mechanism at the project level.

Labor topic	Requirement
	• 1 month where employee was employed for 1 to 5 years. In lieu of providing notice of termination, the employer can pay a sum equal to wages, other remuneration and benefits due for the required period of notice. Where the employee terminates the contract without notice, the employee will be paid wages, remuneration and benefits accrued at the date of termination.
Certificate of termination	On termination, an employee can request a certificate indicating: • the name, address, nature of business of the employer • the length of continuous employment • the capacity in which the employee was employed • the wages and other remuneration payable at termination • where the employee requests, reasons for the termination The certificate need not contain any evaluation of the employee's work unless this is requested by the employee.
Family responsibilities	
Maternity leave[6]	Female employees are entitled to three months maternity leave paid at a sum of not less that forty percent of two months' pay for monthly paid employees.
Family leave	Any employee may take leave for reasons of family responsibilities with the consent of the employer for an agreed duration. An employer cannot unreasonably refuse to give the consent. "Family responsibilities" may include sickness or death of a spouse, close relative or dependent person.
Fair treatment	
Discrimination	No discrimination based on the grounds of race, colour, national extraction, social origin, religion, political opinion, sex, marital status, family responsibilities, age or disability, in respect of recruitment, training, promotion, terms and conditions, termination, or matters of the employment relationship.
Equal pay for equal work	Male and female employees to receive equal remuneration for work of equal value.
Forced & child labour	
Child labour	Prohibition of any person under sixteen years being employed or allowed to work in any public or private industrial undertaking. Every employer to keep a register of all employed persons under eighteen years and their birth dates.
Forced labor	Forced labour is prohibited
Others	
Duty to inspect	Officers of the Department of Labour can inspect places of work as often and as thoroughly as necessary to ensure effective application of the Act.

Source: Prepared by Ecoengineering and Mott MacDonald in 2023 based on several sources

4.2.7 Human rights

4.2.7.1 Constitution of Grenada, Part I: Protection of fundamental rights and freedoms, adopted in 1973, reinstated in 1991, and amended in subsequent years

The Constitution of Grenada, adopted in 1973 and amended in subsequent years, provides protection for various human rights and fundamental freedoms. These rights are enshrined in different sections of the constitution. Below we present key provisions related to human rights in Grenada's constitution:

- Right to life, liberty, security of the person, and the protection of the law.
- Protection of individuals from torture, inhuman or degrading punishment or treatment.
- Safeguarding the right to personal privacy and the privacy of the home.
- Guaranteeing the right to freedom of conscience, expression, assembly, and association.

[6] There are additional requirements related to maternity leave under the Employment Act.

- Ensuring the right to equality before the law and prohibits discrimination on various grounds, including race, sex, religion, and political opinion.
- Protection of the right to freedom of movement within Grenada and the right to leave and enter Grenada.
- Safeguarding the right to protection of property from arbitrary deprivation.
- Providing various protections to individuals accused of a crime, such as the right to a fair trial, the presumption of innocence, and protection against double jeopardy.

4.2.8 Emergency preparedness

4.2.8.1 Disaster (Emergency Powers) Act, 1984

Grenada's main governing piece of legislation for emergency preparedness is the Disaster (Emergency Powers) Act, 1984. An Act to make provision for the maintenance of supplies and services essential to the life of the community on the occurrence of a national disaster, and for connected matters. Under this Act, the Prime Minister is endowed with the powers to declare an event a national disaster.

The National Disaster Management Agency (NaDMA) formerly NERO was established in 1985 under a Pan-Caribbean Disaster Preparedness and Prevention Project. NaDMA is the body charged with the responsibility of coordinating all disaster-related activities in Grenada. In addition, there is the National Disaster Management Advisory Council, which is a multi-sectoral advisory body responsible for guiding the Prime Minister of policy issues relating to disaster management.

Apart from these National Bodies, the following pieces of legislation plays a critical role in disaster management:

- Fire Brigades Act – which establishes and empowers fire fighting services;
- The Public Health Act – which provides for sanitation and prevention and spread of infectious diseases and
- The District Councils Act – which sets up local government structure that supports fire preventions, road maintenance and the management of local public infrastructure.

4.2.8.2 National Disaster Plan, 2005

The National Disaster Plan outlines the structure, functions and roles of disaster organisations at the national, district and community levels. The aim and function of the Plan is to set out operating procedures for addressing all aspect of disaster management and to ensure that management is executed in a coordinated and collaborative manner. Specifically, the Plan provides for the following:

- The carrying out of preparedness exercises
- Implementation of a national public awareness program
- The development of a comprehensive disaster preparedness training program in all levels of disaster management
- The monitoring of relief supplies
- Detailing of evacuation plans, identification of emergency shelters and personnel
- Full examination of relevant laws
- The redevelopment of district organizations
- The establishment of management committee (public information and education, damage assessment, emergency works and transport, supplies management, emergency communications, national response oil spill team)

4.2.9 Cultural heritage

4.2.9.1 National Trust Act, 1967

The National Trust Act, 1967 is the main piece of applicable legislation for protecting the cultural heritage within the limits of the study area. This Act requires the establishment of a committee – The Grenada National Trust, a body, with limited liability, interested in the preservation of places of historic and architectural interest or national beauty and having as its objects:

- Prehistoric, historic and architectural interest
- Places of natural beauty with their animal or plant life
- Compilation of photographic and architectural records of the foregoing
- Preservation of chattels of prehistoric, historic or artistic interest and the establishment of museums
- Making the public aware of the value and beauty of Grenada's heritage
- The pursuance of a policy of preservation, and acting in an advisory capacity
- Acquiring property for the benefit of the people of Grenada
- Promoting and preserving for the benefit and enjoyment of the people of Grenada submarine areas of beauty or natural or historic interest, and the preservation (as far as possible) of their natural aspect, features and animal, plant and marine life
- Attracting funds by means of subscriptions, donations, requests and grants for the effective carrying out of those objects

4.3 International Standards and guidelines

4.3.1 IFC Performance Standards 2012

The IFC is a member of the World Bank Group and is recognised as an international leader in environmental and social sustainability policy. As a part of the 'positive development outcomes' outlined in the IFC's Policy on Social and Environmental Sustainability, the corporation applies a comprehensive set of social and environmental Performance Standards in its project review process. The IFC Performance Standards are an international benchmark for identifying and managing environmental and social risk. The revised IFC Policy and Performance Standards (PS) on Social and Environmental Sustainability came into force in January 2012. There are eight IFC PS which are outlined in Table 4.3.

Table 4.3: IFC Performance Standards

Performance Standard	Description
PS1 – Assessment and Management of Environmental and Social Risks and Impacts	PS1 establishes the importance of: (i) integrated assessment to identify the environmental and social 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 client's management of social and environmental performance throughout the life of the project.
PS2 – Labour and Working Conditions	PS2 recognises the need for economic development to be balanced with workers' rights. PS2 aims to: establish, maintain and improve the worker-management relationship; promote the equal opportunity of workers, and compliance with national labour and employment laws; protect the workforce by addressing child labour and forced labour; protect vulnerable workers; and, promote safe and healthy working conditions and the health of workers.
PS3 – Resource Efficiency and Pollution Prevention	PS3 recognises that economic activity and urbanisation often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment

Performance Standard	Description
	at the local, regional, and global levels. PS3 aims to: avoid or minimise adverse impacts on human health and the environment by avoiding or minimising pollution from project activities; promote more sustainable use of resources including energy and water; and reduce project-related emissions.
PS4 – Community Health, Safety and Security	PS4 recognises that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. PS4 aims to: anticipate and avoid adverse impacts on the health and safety of the affected community during the project life cycle; and ensure that the safeguarding of personnel and property avoids or minimises risks to the community's safety and security.
PS5 – Land Acquisition and Involuntary Resettlement	PS5 recognises that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons who use this land. PS5 aims to: avoid or at least minimise involuntary resettlement wherever feasible by exploring alternative project designs; mitigate adverse social and economic impacts from land acquisition by (i) providing compensation for loss of assets and (ii) ensuring that resettlement activities are implemented with appropriate consultation and disclosure; and improve or at least restore the livelihoods, standards of living and living conditions of displaced persons.
PS6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources	PS6 encourages sustainable development while recognising that the protection and conservation of biodiversity and sustainably managing living natural resources are fundamental to sustainable development. PS6 aims to: protect and conserve biodiversity; maintain the benefits from ecosystem services; and promote the sustainable management and use of natural resources through practices that integrate conservation and development.
PS7 – Indigenous Peoples	PS7 aims to: ensure that the development process fosters full respect for Indigenous Peoples; anticipate and avoid, minimise or compensate adverse impacts of projects on Indigenous Peoples and provide opportunities for development benefits; establish and maintain an ongoing relationship with affected Indigenous Peoples throughout the life of the project; ensure free, prior and informed consent of Indigenous Peoples; and respect and preserve their culture, knowledge and practices.
PS8 – Cultural Heritage	PS8 recognises the importance of cultural heritage for current and future generations. PS8 aims to: protect cultural heritage from the adverse impacts of project activities; support its preservation; and promote equitable sharing of benefits from cultural heritage.

Source: IFC

4.3.2 The World Bank General Environmental, Health, and Safety (EHS) Guidelines

IFC Performance Standard 3 specifies the use of the World Bank Group Environmental, Health, and Safety Guidelines (known as the "EHS Guidelines").

The revised IFC/WB EHS Guidelines are a set of general and industry specific examples of international good practice. The EHS General Guidelines contain information on crosscutting issues applicable to projects in all industry sectors. They provide guidance on performance levels and measurements considered to be achievable at reasonable cost by new or existing projects with the use of existing technologies and practices. Projects are expected to comply with the levels and measures identified in the EHS Guidelines where host country requirements are less stringent.

- The EHS General Guidelines cover four areas of international good practice, these are:
- Environmental;
- Occupational Health & Safety (OHS);
- Community Health & Safety (CHS); and

- Construction and Decommissioning.

The general guidelines are supported by a series of sector specific guidelines. The EHS Guidelines for Geothermal Power Generation are relevant to this Project.

4.3.3 EHS Guidelines for Geothermal Power Generation

The World Bank's Environmental, Health, and Safety Guidelines for Geothermal Power Generation is a guidance document focused on the impacts and recommendations for management of EHS issues relating to geothermal power development and generation.

4.3.4 World Bank Environmental and Social Framework

The World Bank environmental and social framework (ESF) provides a broad and systematic coverage of environmental and social risks. As of 1 October 2018, they apply to all new World Bank investment project financing. The ESF includes ten environmental and social standards, which are:

- Environmental and Social Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Environmental and Social Standard 2: Labor and Working Conditions
- Environmental and Social Standard 3: Resource Efficiency and Pollution Prevention and Management
- Environmental and Social Standard 4: Community Health and Safety
- Environmental and Social Standard 5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
- Environmental and Social Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Environmental and Social Standard 7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities
- Environmental and Social Standard 8: Cultural Heritage
- Environmental and Social Standard 9: Financial Intermediaries
- Environmental and Social Standard 10: Stakeholder Engagement and Information Disclosure

4.3.5 International Treaties, Conventions, and Agreements

The ILO Declaration on Fundamental Principles and Rights at Work and its follow-up (1998) makes it clear that these rights are universal, and that they apply to all people in all States - regardless of the level of economic development and regardless whether or not the States have ratified the applicable conventions. It particularly mentions groups with special needs, including the unemployed and migrant workers.

Grenada has made progress in ratifying international conventions on labour standards, with a total of 9 out of 11 fundamental conventions ratified and 2 out of the 4 governance (priority) conventions ratified[7] (Table 4.4).

[7] Conventions (or Protocols) are legally binding international treaties that may be ratified by member states. Fundamental conventions cover subjects that are considered by the ILO to be fundamental principles and rights at work. Governance (priority) conventions are considered by the ILO of importance for the functioning of the international labour standards system and the member States are encouraged to ratify them. Source: https://www.ilo.org/global/standards/introduction-to-international-labour-standards/conventions-and-recommendations/lang--en/index.htm. Accessed in July 2023.

Table 4.4: Status of ILO conventions ratifications in Grenada

Convention	Status in Grenada
Fundamental Conventions	
Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87)	In force
Right to Organise and Collective Bargaining Convention, 1949 (No. 98)	In force
Forced Labour Convention, 1930 (No. 29) (and its 2014 Protocol)	In force
Abolition of Forced Labour Convention, 1957 (No. 105)	In force
Minimum Age Convention, 1973 (No. 138)	In force
Worst Forms of Child Labour Convention, 1999 (No. 182)	In force
Equal Remuneration Convention, 1951 (No. 100)	In force
Discrimination (Employment and Occupation) Convention, 1958 (No. 111)	In force
Occupational Safety and Health Convention, 1981 (No. 155)	In force
Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187)	Not in force
Governance (priority) Conventions	
Labour Inspection Convention, 1947 (No. 81)	In force
Employment Policy Convention, 1964 (No. 122)	Not in force
Labour Inspection (Agriculture) Convention, 1969 (No. 129)	Not in force
Tripartite Consultation (International Labour Standards) Convention, 1976 (No. 144)	In force

Source: Prepared by Mott MacDonald based on information available at the ILO website in July 2023.

Grenada has signed and ratified several international conventions and treaties for the protection and conservation of the environment. Those relevant to this Project are listed in Table 4.5.

Table 4.5: International Treaties, Conventions, and Agreements

International Treaty, Convention, or Agreement	Status in Grenada
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Acceded in 1999
The Paris Agreement	Ratified in 2016
United Nations Environment Programme (UNEP) convention on biological diversity (CBD) Secretariat	Ratified in 1994
United Nations framework convention on climate change (UNFCCC)	Ratified in 2016
Kyoto protocol to the framework convention on climate change	Ratified in 2002
Ramsar international convention on wetlands of international importance, especially as waterfowl habitats	Ratified in 2012
Convention Concerning the Protection of the World’s Cultural and Natural Heritage (UNESCO)	Ratified in 1998
International plant protection convention (Rome)	Ratified in 2017

Source: Mott MacDonald

Relevant to note that the Government of Grenada signed the CBD in December 1992 and ratified the Convention in August 1994. CBD defines biodiversity as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". As a signatory country, Grenada has a responsibility to:

- Safeguard its biodiversity
- Introduce procedures requiring EIA for projects likely to have significant impacts on biological diversity
- Introduce legislative provisions that ensure environmental policies and procedures are duly considered

As a Contracting Party of the Ramsar Convention, Grenada has committed to work towards the wise use of all their wetlands; to designate suitable wetlands for the list of Wetlands of International Importance (the "Ramsar List") and ensure their effective management; and to cooperate internationally on transboundary wetlands, shared wetland systems and shared species. The wise use concept applies to all wetlands and water resources within Grenada and its territory, and includes matters such as: national wetland inventories, integrated river-basin and/or coastal-zone management, restoration of degraded wetlands, and the need for the impacts of key economic sectors on wetlands to be more sustainably managed. Grenada currently has one Ramsar site designated in the country. This is Levera wetland in St Patrick parish, a 518ha site with valuable tropical marine ecosystems in the northeast of the island.

As a member country of CITES since 1999, Grenada is part of an international agreement between governments that aims to ensure that international trade in species of wild animals and plants does not threaten their survival. CITES Appendix I includes species threatened with extinction and prohibits international trade of these species except when the purpose of the import is not commercial i.e. for scientific research. Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. Appendix II species may be authorized by the granting of an export permit or re-export certificate. Appendix III species need the cooperation of other countries to prevent unsustainable or illegal exploitation. International trade in specimens of species listed in this Appendix is allowed only on presentation of the appropriate permits or certificates.

However, trade of CITES species with Grenada has been suspended since March 2016 as Grenada had failed to provide its annual reports for three consecutive years. No reports have been provided since this decision.

The International Plant Protection Convention (IPPC) is an international treaty that aims to secure coordinated, effective action to prevent and to control the introduction and spread of pests of plants and plant products. The Convention extends to the protection of natural flora and plant products.

4.4 Subject matter standards and guidelines

In addition to the national laws and applicable international standards discussed above, the following standards are considered to subject matters as good international industry practice (GIIP).

4.4.1 Human rights

In general, international human rights treaties do not impose direct legal obligations on business enterprises. It is the duty of States to translate their international human rights law obligations into domestic law and to enforce those laws. States include various protections against human rights abuse by business in their laws and constitutions, including labour laws, non-discrimination laws, health and safety laws, environmental laws and similar[8].

However, national laws may not address all internationally recognised human rights, they may be weak, they may not apply to all people, and they may not be enforced by governments and the courts. The United Nations Guiding Principles on Business and Human Rights (UNGPs) make clear that where national laws fall below the standard of internationally recognised human rights, companies should respect the higher standard; and where national laws conflict with those standards, companies should seek ways to still honour the principles of those standards within the bounds of national law.

Internationally recognised human rights are, therefore, relevant for business beyond mere compliance with the law. The actions of business enterprises can affect people's enjoyment of their human rights either positively or negatively. Enterprises can and do infringe human rights where they are not paying sufficient attention to this risk. The purpose of this HRIA is to analyse the project's actual and potential human rights impacts to avoid this scenario from arising.

4.4.1.1 United Nations Guiding Principles on Business and Human Rights

The UNGPs are a set of guidelines for States and companies to prevent, address and remedy human rights abuses committed in business operations. They were devised by Professor John Ruggie (hence sometimes called the Ruggie Principles) and were endorsed by the United Nations (UN) Human Rights Council in June 2011. The UNGPs require businesses to respect human rights through a process of human rights due diligence, which identifies, prevents, mitigates and accounts for how they address human rights impacts with which they are involved. Human rights impact assessment is a key component of human rights due diligence.

The UNGPs state that when a business is assessing its human rights impacts it should[9]:

- Draw on internal and/or independent human rights expertise
- Undertake meaningful consultation with potentially affected rights-holders and other relevant parties
- Be gender-sensitive and pay particular attention to any human rights impacts on individuals from groups that may be at heightened risk of vulnerability or marginalisation
- Assess impacts from the perspective of risk to people rather than risk to business
- Repeat its risk and impact identification and assessment at regular intervals (i.e. before entering into a new activity, prior to significant decisions about changes in activities, and periodically throughout the project-cycle)

According to the UNGPs, the minimum reference point for 'internationally recognised human rights' is made up of the International Bill of Human Rights and the eight core conventions of the International Labor Organisation (ILO) (those relating to freedom of association and the right to collective bargaining; the elimination of compulsory labour; the abolition of child labour; and the elimination of discrimination in respect of employment and occupation). In addition, the UNGPs state that depending on circumstances, business enterprises may need to consider further standards. For example, businesses should respect the human rights of individuals belonging to specific groups or populations that require particular attention, where they may have adverse human rights impacts on them. Several UN core human rights treaties have elaborated further on the rights of indigenous peoples; women; national or ethnic, religious and linguistic

[8] The UN Guiding Principles on Business and Human Rights. Available at. https://www.ungpreporting.org/resources/the-ungps/. Accessed in June 2023.

[9] As highlighted in HRIA guidance and toolbox, Danish Institute for Human Rights, 2016. Available at: https://www.humanrights.dk/tools/human-rights-impact-assessment-guidance-toolbox. Accessed in June 2023

minorities; children; persons with disabilities; and migrant workers and their families. These treaties are discussed further below.

This human rights assessment will refer to the internationally recognised human rights elaborated on below, recognising that some aspects of Malawian law may not meet, or may even conflict with the international framework. The project company will respect internationally recognised human rights under all circumstances, including where State laws to protect human rights are absent, weak or unenforced. The remainder of this section discusses the meaning of human rights in the international context and the international requirements placed on the project regarding human rights.

4.4.1.2 International Bill of Human Rights

The International Bill of Human Rights, which underscores all 30+ human rights and fundamental freedoms, is comprised of several international covenants and declarations. The term ‘human rights’ refers to all of the rights listed in this Bill and some are more applicable to the project than others. The ‘International Bill of Human Rights’ is the informal name given to the UN main provisions on human rights and is comprised of the following:

- Universal Declaration of Human Rights (UDHR)
- International Covenant on Economic, Social and Cultural Rights (ICESR)
- International Covenant on Civil and Political Rights (ICCPR)
- Optional Protocol to the International Covenant on Civil and Political Rights
- Second Optional Protocol to the International Covenant on Civil and Political Rights (focussed on the abolition of the death penalty)

The UDHR contains 30 articles setting forth the human rights and fundamental freedoms to which all people are entitled without discrimination, all over the world. The first article sets out the declaration’s philosophy, as follows:

‘All human beings are born free and equal in dignity and rights. They are endowed with reason and conscience and should act towards one another in a spirit of brotherhood.’

The second article sets out the principle of equality and non-discrimination as regards the enjoyment of human rights. Article three is a pre-requisite for enjoyment of other rights; it proclaims the right to life, liberty and security and introduces articles four to 21 which set out other civil and political rights such as freedom from slavery and the right to own property. Article 22 introduces articles 23 to 27 which identify economic, social and cultural rights such as the right to work, rest and leisure. The final articles, 28-30, recognise that everyone is entitled to social and international order in which their other human rights may be realised.

The ICESR and ICCPR provide for many of the same human rights as the UDHR, with a few key additions, including regarding the rights of minorities.

4.4.2 Ambient air quality

This section provides an overview of the applicable air quality standards for the project.

IFC Performance Standard 3: Resource Efficiency, Pollution Prevention and Control aims to: “Prevent or minimize adverse impacts on human health and the environment by preventing or minimizing pollution from project activities.”

To meet this objective, the IFC provides both industry-specific and general guidance on Good International Industry Practice in relation to ambient air quality and emissions to air. The Project will be required to meet the IFC Performance Standards, and the standards set out in the IFC General EHS Guidelines. The IFC General EHS Guidelines state that “relevant standards” for ambient air quality are national standards mandated by law or, in their absence, existing World Health Organization (WHO) Air Quality Guidelines (AQGs) for Europe, 2nd Edition 2000, ("the WHO guidelines") or other internationally recognized sources. Grenada does not currently have its own mandated ambient air quality standards or emission requirements and therefore standards from the neighbouring CARICOM[10] country of Trinidad and Tobago needs to be adopted for the assessment.

The use of these standards is considered appropriate given the ambient standards broadly align numerically with those set out in other international jurisdictions, such as those used in the European Union. The standards also broadly align with those set out within the World Health Organization's (WHO) Ambient Air Quality Guidelines, Global Update, 2005.

As noted above, the construction (site clearance and preparation) and operation (drilling and testing) phases of the Project could potentially lead to emissions of a range of combustion related pollutants including NOx, particulates and SO_2. During the initial well testing phase, and in the unlikely event of fugitive emissions or a well blowout, hydrogen sulphide (H_2S) may also be released. The Project will be designed to comply with the relevant Trinidad and Tobago standards and for the case of H_2S, which is the main pollutant of concern, additional guidelines from the WHO.

4.4.2.1 Trinidad and Tobago air pollution rules (APR), 2014

The Air Pollution Rules, 2014 define an air pollutant as any parameter listed in the First or Second Schedule of the rules which is emitted into the air. Table 4.6Table 4.6: 7 and Table 4.8Table 4.8: provide the maximum permissible concentrations in ambient air and the maximum permissible emission limit for stack releases of applicable pollutants to the project.

Table 4.6: 7Ambient air pollutants

Compound	Short term maximum permissible level		Long term maximum permissible level	
	Maximum permissible level (µg/m³)	**Averaging time**	**Maximum permissible level (µg/m³)**	**Averaging time**
		Particulates		
Total suspended particulates (TSS)	150	24 hour		
Particulate matter (PM_{10})	75	24 hour	50	1 year
Particulate matter (PM2.5)	65	24 hour	15	1 year
		Non-metallic inorganic substances		
Nitrogen dioxide (NO_2)	200	1 hour	40	1 year
Carbon monoxide (CO)	200	1 hour		
	100,000	15 minute		
	60,000	30 minute		
	30,000	1 hour		
	10,000	8 hours		

[10] The Caribbean Community and Common Market (CARICOM) was established by the Treaty of Chaguaramas, which was signed by Barbados, Jamaica, Guyana and Trinidad & Tobago and came into effect on August 1, 1973.

Compound	Short term maximum permissible level		Long term maximum permissible level	
	Maximum permissible level ($\mu g/m^3$)	Averaging time	Maximum permissible level ($\mu g/m^3$)	Averaging time
Hydrogen Sulphide (H_2S)	30	30 minutes		

Source: Environmental Management Authority 2014

Table 4.8: Stack release limits

Parameter	Maximum permissible limit ($\mu g/m^3$)
Particulate matter	100mg of particulate matter in each normal cubic meter of residual gases (adjusted to a basis of 12% CO_2 for air emissions from fuel burning equipment, if required by the specified test method)
Oxides of nitrogen (NOx)	500 as NO_2
Cabon monoxide	1000
Hydrogen sulphide	15

Source: Environmental Management Authority 2014

4.4.2.2 WHO ambient air quality guidelines

The WHO guidelines, from which the guidelines for H_2S is sourced and draws heavily on international data, acknowledges that when States use the guidelines for setting legally binding standards, considerations such as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, and social, economic and cultural conditions should be taken into account.

The WHO defines a guideline as "…any kind of recommendation or guidance on the protection of human beings or receptors in the environment from adverse effects of air pollutants". This assessment has interpreted the application of the WHO standard as being relevant to those locations only where receptors can reasonably be expected to be exposed for the specified averaging period. This is in accordance with the application of the EU Air Quality Directive (2008/50/EC) where application of ambient air quality objectives excludes areas of non fixed habitation (i.e., residential areas), work and industrial locations and within roads. In the case of H_2S, the averaging period is 24 hours and therefore this guideline has only been applied to locations where receptors can reasonably be expected to be located for this duration, i.e., residential locations. This approach is consistent with international interpretation of air quality standards such as those in Europe.

Project workers and nearby agriculture workers exposure to H_2S is a key air quality risk to the Project. The United Kingdom's Health and Safety Executive has set a workplace exposure limit for H2S of 5ppm for a time weighted average of 8hrs which is equivalent to 7,000$\mu g/m^3$. This standard has been considered when assessing potential occupational air quality impacts from the Project.

Some studies of the potential impacts of H_2S on vegetation have been undertaken in the US and Canada which has included studies on plants in the biosphere as well as in laboratory experiments. In general, studies have found that negative effects on vegetation occur only with prolonged exposure to H_2S, and that lower levels can stimulate growth in certain types of plants. No formal guidelines have been set for the impacts of H_2S on vegetation, but a report published by Alberta Environment (Assessment Report on Reduced Sulphur Compounds, 2004) recommended a limit of 140$\mu g/m^3$ as a no observable effect concentration, for long-term exposure (long-term exposure usually being interpreted, for example within the EU, as annual average periods). Therefore, in the present assessment, this limit has been adopted as an annual mean to assess the potential effects of H_2S on vegetated areas.

The WHO H_2S guideline is presented in Table 4.9. Although covered by the standards adopted for the assessment, these only provide a standard for a 30 minute average whereas the WHO guidelines is based on a 24hr averaging period and has considered a wide range of epidemiology studies to derive this guideline.

Table 4.9: WHO Ambient Air Quality Guidelines

Pollutant	Averaging Period	Value (µg/m^3)
Hydrogen Sulphide	24 Hour	150 (guideline)

Source: The WHO guidelines (WHO, 2000)

4.4.2.3 IFC EHS guidelines for geothermal projects

The IFC EHS Guidelines for geothermal projects provide recommendations on how to manage environmental, health, and safety risks, including air quality concerns, throughout the lifecycle of a project. The guidelines aim to minimize air emissions and prevent adverse impacts on the environment, worker health, and nearby communities. When it comes to air quality, the IFC EHS Guidelines for geothermal projects address the following key aspects:

- Emission control: The guidelines recommend the use of best available technologies and practices to reduce emissions of pollutants such as PM_{10}, $PM_{2.5}$, NOx, SO_2 and volatile organic compounds (VOCs).
- Air dispersion modelling: To assess the potential impact of emissions on local air quality, the guidelines advise conducting air dispersion modelling to predict pollutant concentrations and evaluate compliance with applicable ambient air quality standards.
- Monitoring and reporting: Regular monitoring of emissions and air quality is advised to ensure compliance with relevant emission limits and standards. The guidelines also recommend reporting the monitoring results to relevant authorities and stakeholders.
- Emergency preparedness: The guidelines suggest developing and implementing emergency response plans to address potential accidental releases of air pollutants, ensuring the safety of workers and local communities.

4.4.3 Noise

The Grenada Noise Control Act 2006 mostly applies to amplified music and a small section of this Act covers construction noise but does not include assessment criteria or noise limit values. In the absence of specific noise guidelines, limits listed in Trinidad and Tobago's Noise Pollution Rules, 2001, as well as World Bank Guidelines are used.

4.4.3.1 Grenada Noise Control Act, 2006

The Noise Control Act 2006 outlines procedures, expectations and conditions in applying for and operating loudspeakers or amplified musical instruments. It indicates that written permission must be obtained by persons desirous of operating loudspeaker and/or amplified musical instruments, where it is reasonably likely to cause disturbance or nuisance to persons. The Act also makes provision for controlling noise on construction sites, including the erection, construction, alteration, repair or maintenance of buildings, structures or roads, and any works of engineering construction. The Act also gives the Minister power to designate an area as a 'Noise Abatement Zone'. There are no Noise Abatement Zones within the immediate vicinity of the proposed drill sites.

4.4.3.2 Trinidad and Tobago's Noise Pollution Rules, 2001 as amended 2022

Under the Environmental Management Act, 2000, the Environmental Management Authority has issued Noise Pollution Control Rules 2001 as amended 2022, which are in effect. These rules recognize the following noise zones:

- Zone I - Industrial Areas,
- Zone II - Environmentally Sensitive Areas, and
- Zone III - General Area.

Under Section 2 of the Noise Pollution Rules 2001, Zone I (Industrial Areas) is defined as areas 'expressly approved for industry by a competent governmental entity'. Zone II, Environmentally Sensitive Areas means a portion of the environment so designated as having flora and fauna of biological importance and Zone III (General Area) means all of Trinidad and Tobago except Environmentally Sensitive Areas and Industrial Areas. To determine compliance, the Rules state that sound pressure levels (SPLs) be measured at the property line of the person affected by the sound or the property where the source of the sound is located.

For the purposes of this Project, Site C (Tricolar) can be listed as a General Area, while Site F (Plaisance Estate) can be used as both General Area and Environmentally Sensitive Area. The Rules include daytime and night-time limits for the applicable zones as shown in Table 4.10.

Table 4.10: Trinidad and Tobago noise standards

Zone	Period	Limit	
		Equivalent sound pressure level (L_{eq})	**Peak sound pressure level (L_{pk})**
Zone II - Environmentally Sensitive Areas	Daytime: 08:00 to 20:00	No more than a 3 dB(A) increase above ambient sound pressure levels and not greater than 60 dB(A)	Instantaneous unweighted peak not to exceed 120 dB
	Night-time: 20:00 to 08:00	No more than 3 dB(A) above background sound pressure level and not greater than 60 dB(A)	Instantaneous unweighted peak not to exceed 115 dB
Zone III - General Areas	Daytime: 08:00 to 20:00	No more than a 5 dB(A) increase above ambient levels and not greater than 80 dB(A)	Instantaneous unweighted peak not to exceed 120 dB
	Night-time 20:00 to 08:00	No more than a 5 dB(A) increase above ambient levels and not greater than 65 dB(A)	Instantaneous unweighted peak not to exceed 115 dB

Source: Trinidad and Tobago's Noise Pollution Rules, 2001 as amended 2022

4.4.3.3 IFC and World Bank Group – Environmental, Health and Safety (EHS) Guidelines – Environmental Noise Management

The EHS guidelines for geothermal power generation state that noise associated with geothermal facilities include well drilling, steam flashing and venting, as well as the operation of equipment relating to pumping facilities and turbines. The EHS guidelines for environmental noise management require the noise impacts should not exceed the levels presented inTable 4.11, or result in a maximum increase in background levels of 3 dB at the nearest sensitive receptor location off site.

Table 4.11: World Bank Group noise level guidelines

Area	Period	Noise level $L_{eq,1\ hour}$ dB(A) free field
Residential, educational or institutional	Daytime: 07:00 to 22:00	55
	Night-time: 22:00 to 07:00	45
Industrial or Commercial	Daytime: 07:00 to 22:00	70
	Night-time: 22:00 to 07:00	70

Source: World Bank, 2007

4.4.4 Water

In the absence of appropriate local ambient water quality standards, international and regional standards water are used to place the water quality test results in context. In this case, the following guidelines have been selected, due to their similar climates to the study area:

- Trinidad and Tobago (T&T) Water Pollution Rules, 2019;
- Department of Environment and Natural Resources (DENR) of the Philippines - Water Quality Guidelines (WQG) and General Effluent Standards (GES) of 2016, updated in 2021 (DENR Administrative Order No. 2021-19).

Both sets of standards categorise inland water into similar classes. The streams and rivers within the study are considered to fall into the following classes:

- Protection of Aquatic Life and Aquatic Ecosystems (T&T) / Class C - Fishery Water, including Agriculture, Irrigation and Livestock Rearing (DENR); and,
- Recreational Use (T&T) / Class B - Recreational Water Class I, for bathing and swimming (DENR).

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Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

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Contents

5 Information disclosure, consultation and participation

5.1 Overview

This chapter outlines the stakeholder engagement (consultation, participation and disclosure) process including activities that have been undertaken as part of the ESIA. A stakeholder engagement plan (SEP) has been developed as part of the ESIA process to serve as a 'live' management tool to guide stakeholder engagement for the Project lifecycle, including the exploratory ESIA phase. The Grenada SEP is appended in Volume IV to this ESIA. The SEP outlines ongoing stakeholder engagement and implementation of the grievance mechanism throughout the construction, operation and decommissioning phases. The SEP will be a live document which the Government of Grenada (GoG) will update throughout the Project's lifecycle.

After a summary of the guiding principles for engagement, this chapter describes the ESIA engagement activities.

5.2 Principles of stakeholder engagement

Stakeholder engagement during the ESIA phase will be conducted on the principles of respectful and meaningful dialogue outlined in the SEP (refer to Volume IV). The consultation and disclosure activities used to inform affected communities about the Project and to inform the assessment in this ESIA will be underpinned by the principles that community engagement should be free from external manipulation, interference, coercion, and intimidation and conducted on the basis of timely, relevant, understandable and accessible information.

The ESIA phase engagement activities seek stakeholder opinions on impacts, mitigation and enhancement measures. For the ESIA phase, emphasis has been placed on:

- Informing stakeholders about the proposed Project and discussing the ESIA
- Providing engagement opportunities to confirm that the benefits of the Project are maximised and that no potential major impacts have been overlooked
- Obtaining local knowledge to inform the ESIA process
- Reducing conflict through identifications of contentious issues and finding acceptable solutions
- Creating a sense of Project ownership or involvement in the minds of stakeholders
- Identifying issues of concern to stakeholders so these can be addressed appropriately within the ESIA process
- Managing expectations and misconceptions regarding the Project
- Verifying the significance of environmental, social and health impacts identified
- Informing the process of developing appropriate mitigation measures
- Providing an opportunity for those otherwise unrepresented to present their views and values, therefore allowing more sensitive consideration of mitigation measures and trade-offs

All stakeholder engagement activities will be undertaken in compliance with Grenada's environmental law and related requirements as well as the requirements for stakeholder engagement in WB PS1[1].

5.3 Stakeholder identification and analysis

Act No. 25 of 2002 and IFC PS 1 were also used as reference guides in the identification of the Project stakeholders. Throughout the Project to date, a database of stakeholders has been revised to include additional organizations and individuals identified which have an interest in the Project or knowledge that would provide insight into Project issues. Key stakeholders were identified through a desktop stakeholder mapping exercise undertaken as part of the scoping phase (2019) and the associated public consultation event held in July 2019.The list of affected communities including the disadvantaged and vulnerable groups has been further validated and expanded during the ongoing focus group discussions (FGDs), key informant interviews (KII) and data gathering since 2019. Relevant interested and affected parties for consultation have also been identified through referrals.

5.4 ESIA stakeholder engagement

The following is the stakeholder engagement process that has been carried out by the GoG, Mott MacDonald and EcoEngineering (Mott MacDonald's local partner) from 2019 to 2022, which include the scoping phase consultations, the information disclosure and consultation during ESIA preparation, and main issues raised by stakeholders.

5.4.1 Scoping phase consultations (2019)

Scoping consultation individual meetings and focus groups discussions (FGD) were conducted by the ESIA Consultant in March 2019, and a public consultation event was organised on 24 July 2019 to gather opinions on key issues, the terms of reference for the detailed ESIA and the proposed assessment methodologies. During this phase the main stakeholders were governmental, NGO and local community members.

Table 5.1 below presents preliminary meetings held with stakeholders during the ESIA scoping phase from March to September 2019, the project information disclosed, and main topics discussed. Copies of meeting records from the scoping phase are included in Appendix A[2] where applicable.

Table 5.1: Stakeholder engagement activities during the ESIA scoping phase (2019)

Date	Location	Stakeholders met	Topics discussed
21 March 2019	Ministry conference room	Government ministry representatives: Chief Information Officer, Ministry of Tourism; Senior Programme Officer, Division of Gender and Family Affairs; Senior Planning Officer, Physical Planning Department; chief environmental health officer in Ministry of Health; Planning officer, Ministry of Planning, Housing and Development; Head of Department Environmental Division, Ministry of Climate Resilience; Member of the statutory notice team dealing with land; Permanent Secretary, Social Development; Gender Analyst	Information provided to stakeholders: • Mott MacDonald shared an introductory handout and presented a power point to provide background to the project. Issues raised by stakeholders: • Public awareness of the project • Cultural heritage • Social safeguards • Removal of equipment and waste from site

[1] The legal and regulatory framework in Chapter 3 of the Grenada SEP describes the information disclosure, consultation and participation requirements.

[2] Stakeholders´ names have been omitted for privacy.

Date	Location	Stakeholders met	Topics discussed
			• Local employment, managing expectations, speak to training institutes • Gender (job opportunities for women, women's land rights to be considered) • Biodiversity (birds, trees) • Water • Data sources (maps, LIDAR, census, meteorological) • Grenadian environmental and permitting regulations
21 March 2019 and 22 March 2019	Ministry conference room	Permanent Secretary for Public Utilities and Energy Permanent Secretary for Environment and Climate Resilience Permanent Secretary for Social Development	Information provided to stakeholders: • Overview of the ESIA, team members, deliverables, duration. Issues raised by stakeholders: • Need to brief line minister and cabinet • Bridge capacity for deliveries • Collaboration and assistance offered • Suggested meeting with Permanent Secretaries for Labour, Health and Education • Noise, water, health
22 March 2019	NAWASA offices	National Water and Sewerage Authority (NAWASA)	Information provided to stakeholders: • Overview of the ESIA, team members, deliverables, duration Issues raised by stakeholders: • Fire fighting • Bushfires • Water resources
22 March 2019	St George's	Non-governmental organisations (NGOs): Grenada Tourism Authority, President of GDA National Trust, Grenada Fund for Conservation, GDA National, Watershed Management (Forestry), SPID, Agency for Rural Transformation	Information provided to stakeholders: • Summary of technical aspects of the project – features, locations, duration of drilling phase, project timeline. Issues raised by stakeholders: • Concern that it is similar to fracking • Water – abstraction of safe amounts • Heritage • Use indigenous knowledge • Community consultation • Biodiversity • Tourism • Value for money
09 and 22 July 2019	Site F	Potential landowners	Information provided to stakeholders: • To formally introduce the project, the officers involved and get initial feedback.

Date	Location	Stakeholders met	Topics discussed
			Issue raised by stakeholders: ● Request for the participation of the lawyers to understand the legal scope
10 July 2019	Site C	Potential landowner	To formally introduce the project and get initial feedback.
15 and 30 July, 21 August 2019	Site C	Land users	To formally introduce the project, work on the ESIA land use questionnaire, introduce the CLO and meet the land users (famers). The 21 August was a follow up meeting to complete the exploratory drilling phase and the land use questionnaire.
14 July 2019	St George's	Member of Parliament for St. John, Alvin DaBreo and Member of Parliament for St. Patrick West, Anthony Boatswain	To formally introduce the project and the carried out ESIA in Florida and Tricolar.
17 July 2019	St George's	Government Officials from Land Use Planning	To formally introduce the project and the beginning of the exploratory drilling.
16 and 18 July 2019	Site F	Focus Groups Meetings with Mt. Rich Women, Florida Women and Gouyave Business Community.	Activities conducted as part of the exploratory drilling to formally introduce the project to stakeholders.
24 July 2019	Port Highway, St George's	ESIA draft Scoping Report Consultation	To get input on the draft scoping report for the ESIA.
15 and 21 August 2019	Site C	Potential landowners	To meet the landowner, Introduce the CLO and the Geothermal project.
31 August 2019	Email	Resident at Site C	Formal withdrawal from engagement with the project.

Source: Scoping Report for ESIA prepared by Mott MacDonald

An ESIA scoping phase public consultation meeting was held in the Public Workers Union Building, Port Highway, St George's on 24 July 2019. The event was advertised in The Grenada Informer newspaper on 19 July 2019. The Draft Scoping Report and a non-technical summary was published on the Government of Grenada website. Posters were also used to advertise the consultation meeting, and invitations were also sent by the ministry with responsibility for energy.

The meeting was attended by the GoG project manager, the ESIA project manager from Mott MacDonald, EcoEngineering Ltd (Mott MacDonald's subconsultant) and the technical consultants (Jacobs). There were 24 attendees excluding the project team, of whom six were women. Presentations on the Project, and the findings of the ESIA scoping event were given, followed by a Q&A discussion. Attendees were provided with opportunities to raise questions during the meeting, to participate in the next round of public consultation and/or write to CLO email.

5.4.2 Information disclosure and consultation during ESIA preparation (2020 to date)

Following the scoping stage, further technical engineering analysis by Jacobs resulted in the refinement of the proposed well pad location at Site C. Further baseline studies and environmental and social data collection was therefore required to ensure a robust dataset for the ESIA. In addition, the global COVID-19 pandemic from 2020 to 2022 restricted access to the site and also prevented international travel for a prolonged period.

During the detailed ESIA, key informant interviews (KII) and FGDs were conducted by Government of Grenada (GoG) and Ecoengineering with stakeholders and are summarised in Table 5.2. Copies of meeting records from the ESIA preparation phase are included in Appendix B, where applicable.

Table 5.2: Stakeholder engagement (2020 to date)

Date	Location	Stakeholders met
March 2020	Site C	Landowners and a farmer (five people)
	Site F	Landowner: Raphael Purcell
	Mt. Rich	Meeting with Mt. Rich Sports & Cultural Club
	Gouyave and Sauteurs	Fishermen
	Sauteurs	The tetere farmers at Beauseree
	Florida	Florida Neighbourhood: Plaisance Rd, Corbeau Town, Barbay and Gap
	Gouyave	Meeting with Lion's Club of Gouyave
December 2020	Pleasant and Gouyave	Students and teachers at St. John's Secondary School and St. Rose Modern Secondary School.
April 2021	Florida	Residents of "The Hole", "Dig" and Florida Junction (all Florida)
May 2021	Online	Meeting with friends of the Earth - Grenada
July - August 2021	Mt. Rich	Residents of Mt. Rich Main Road (south of the playing field) and residents of Top Hill and "The Cocoa"
August 2021	Mt. Reuill	Residents of Mt. Reuill Estate and Central Mt. Reuil
February 2022	Mt. Rich	Group at Era's Snackette, and at Mt. Rich Bridge.
March - April 2022	Within vicinity of local shops	Group at Jahi's Shop, Sheen's Snackette, at Deslyn's Shop, at Garbay Shop and at Lakay's Shop.
August 2022	Upper Mt. Rich	Group with residents from the junction back to Mt. Rose and before descent on to Hermitage.
March 2023	Site C	Landowners and land users (five participants)
March 2023	Mr. Reuil / Mt. Rich Pre School	Group with women from Mt. Reuill and local small business.
June 2023	Glenelg Spring Water Inc. (St Georges')	Meeting with Richard Dixon (managing Director) and Sterlisha Fletcher-Hinds (Operations Manager)

Source: Information provide by GoG and Ecoengineering (2020-2023).

5.4.3 Summary of issues raised by stakeholders during scoping phase public hearing

Table 5.3 below outlines key issues raised during the scoping phase public hearing and indicates how they are addressed in the ESIA.

Table 5.3: Summary of issues raised during the scoping phase public hearing, and how issues raised are addressed in the ESIA

Topics of the issues raised	Issues raised during scoping phase public hearing	How issue addressed in the ESIA
Stakeholder engagement	Request for user-friendly communication of technical information and provision of baseline data including water source studies to community residents. Additionally, improvements to project communication, such us more informal communication methods.	The non-technical summary (Volume I) presents the ESIA findings in a simple manner to help the general public to understand the Project. The stakeholder engagement information disclosure, consultation and participation chapter (chapter 5 of Volume II) presents outline process and activities that have been undertaken as part of the ESIA. The SEP (Volume IV) is the management tool to guide

Topics of the issues raised	Issues raised during scoping phase public hearing	How issue addressed in the ESIA
		stakeholder engagement for the Project lifecycle, including the exploratory ESIA phase.
Tourism	Queries about potential impacts on tourism from exploratory drilling, including land and visual impacts on the natural beauty of the area.	Impacts on tourism are addressed in the tourism and recreation section as part of the socioeconomic baseline (chapter seven Volume II). The management measures are presented in ESMP (Volume VI).
Displacement	Physical and economic displacement and impacts on livelihoods and compensation, loss of agricultural land, contamination of farmland	The Livelihood Restoration Framework (LRF) presents the guide to land acquisition and resettlement activities associated to the Project (Volume V). The LRF details the eligibility and entitlement of identified Project affected persons (PAPs) and incorporates livelihood monitoring of Project affected households. The SEP commits to ongoing consultation with local stakeholders including PAPs.
Biodiversity	Potential impacts on the forest reserve and watershed, potential impacts on ecosystem services, impacts on bees and other wildlife from noise and operation of equipment, soil contamination.	Impacts to biodiversity and management measures are addressed in the biodiversity chapter (Chapter 8 Volume II) and in the ESMP (Volume VI).
Water	Impacts from disposal of contaminated drilling fluids, local standards for water quality, contamination of drinking water or the springs supplying Glenelg Mineral Water bottling plant at Mt. Rich, wider concerns about climate change, drought and irreversible effects on surface water, groundwater and watershed functions	Impacts to water resources receptors and on the Glenelg springs, as well as management measures are addressed in the water resources and quality chapter (Chapter 9, Volume II). Management plans are presented in Chapter 9, Volume II and the ESMP (Volume VI).
Noise, Air quality	Air quality, noise and vibration impacts on local people and standards to be used in the ESIA	The methodology and criteria used for the assessment of potential noise impacts during construction and operation, presented in Chapter 10, is based on a qualitative assessment of noise impacts due to the project received at sensitive receptors and the expected compliance with the Noise Level Guidelines of the IFC/World Bank Group General EHS Guidelines or National standards, whichever is more stringent. Impacts to air quality and management measures are addressed in the air quality chapter (Chapter 11 Volume II) and in the ESMP (Volume VI).
Land stability	Impacts on land and slope stability	Impacts to land and slope stability are addressed in the geology and soil chapter 15 (Volume II) and in the ESMP (Volume VI).
Traffic	Questions in construction transport routes and possible impacts arising from road blocks causing delays to residents and tourists.	Impacts to transport and road users are addressed in the traffic and transport, chapter 13 (Volume II), in the social impacts and risks, chapter 7 (Volume II) and in the ESMP (Volume VI).
Waste	Concerns in the drilling mud final location	Impacts arising from hazardous and non-hazardous waste material and wastewater including appropriate management and mitigation measures are addressed in the waste and materials management chapter 14 (Volume II) and in the ESMP (Volume VI).
Decommissioning	Concerns in the management options post-closure of the wells, including the casings.	The current plan for decommissioning phase is presented in the project description chapter 2 (Volume II). In addition, each specialist chapter of the ESIA (chapters 7 to 16) contains an impact assessment for the decommissioning phase.

Source: Scoping Report for ESIA prepared by Mott MacDonald

The Grenada Energy Division Facebook page[3] will be used to provide new project information of relevance to stakeholders. The Project is also in the process of developing additional online and social media assets for sharing information.

5.5 Draft ESIA stakeholder engagement

The draft ESIA documentation will be published online on the Government's website. Hard copies of the draft ESIA, NTS and a project brochure in English will be disclosed in the direct Area of Influence (AoI). A hard copy of the NTS will be available at a school or other public facility in each community, together with forms to be completed in case community members have any comments or question about the Project. The forms will be placed in a suggestion box and the team will collect them to answer any questions presented and incorporate the information in the final version of the ESIA. People may also comment by contacting the following email address: clogrenadageothermal@gmail.com.

Public consultation meetings on the draft ESIA report will be organised in 2023 (expected in October 2023 as part of the process to finalise the draft ESIA). Announcements will be made using culturally appropriate means including local newspapers, the Project website and consultation with key stakeholders and communities and will provide at least two weeks' notice with location and timing details. Letters will also be sent to notify selected stakeholders. A suitable location will be chosen to facilitate attendance from governmental and non-governmental stakeholders can attend as well as affected communities. Further measures to encourage participation of women and vulnerable groups are outlined in the SEP Volume IV of the ESIA. Comments received on the draft ESIA will be considered by the ESIA consultants and reported in the final ESIA report.

The above approach is aligned with good international industry practice (GIIP). Regarding national requirements, once the GoG has applied for the necessary planning/development permit, the Physical Development Authority will define any additional public disclosure and public participation required.

[3] https://www.facebook.com/profile.php?id=100063804170425

Appendices

A. Meeting records – ESIA scoping phase

B. Meeting records – ESIA phase

MOTT MACDONALD

Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Volume II - ESIA
Chapter 6 - ESIA process and methodology

September 2023

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6 ESIA process and methodology

6.1 Introduction

This section describes the scope and methodology of the ESIA. This impact assessment has been completed in line with both the national and international requirements. Key steps during the main ESIA phase are to characterise the baseline environmental and social conditions, evaluate the significance of the likely impacts and to identify mitigation and enhancement measures. The approach to these is discussed below.

6.2 Baseline data collection

Baseline data collection to inform the impact assessment has been generated through a combination of approaches for all specialist areas and include primary and secondary source information.

- Primary source information: generated specifically for the assessment was gathered directly through interviews, site visits, field surveys, meetings, focus groups, and visual observation.
- Secondary source information: includes a desk based review of laws, policies, reports from the relevant governmental and non-governmental institutions and existing national and international publicly available information data from websites and national EIA

Examples of data sources include but are not limited to: project documentation, government policies, legislation, press releases and media coverage. Relevant secondary sources used to support the assessment process are referenced in the relevant specialist sections (Chapters 7 to 15). The whole baseline data collection approach is underpinned by stakeholder consultation consisting of public meetings with affected communities and interviews with key informants such as representatives from local authorities and from the local community. The outcomes of these meetings are summarised in Chapter 5.

This baseline assessment considers the project infrastructure known for the exploration phase.

6.3 Impact assessment

This exercise is intended to give an analysis of possible impacts of the project. In this document we have made an evaluation of potential impacts associated with the construction and operation of the project. Our analysis is based on site surveys, available secondary information, professional knowledge and judgment drawn from similar projects. The methodology applied in this ESIA to assess impacts is as follows:

- Each receptor is analysed to understand how sensitive it is to a change in its external environment (see 6.3.1).
- Each potential change which will be caused by the project is analysed to understand the extent to which it might impact the receptors in the project area (see 6.3.2).
- The two factors (sensitivity of a receptor and change parameter) are combined to estimate the significance of each impact to each receptor (see 6.3.3).

The method used is described in the following text.

6.3.1 Sensitivity of a receptor

We have estimated the sensitivity of each group of receptors based on our understanding of their potential status, using the criteria and scoring system set out in Table 6.1. It is important to note that the way in which sensitivity is assessed varies from receptor to receptor so the criteria in Table 6.1 is used as a guide only. Specific criteria for receptor sensitivity is given in each topic chapter.

Table 6.1: Criteria and scoring system for determining sensitivity of a receptor

Category	Score	Description
Negligible	1	Receptor with good capacity to absorb proposed changes or good opportunities for mitigation.
Low	2	Receptor with some capacity to absorb proposed changes or moderate opportunities for mitigation.
Medium	3	Receptor with little capacity to absorb proposed changes or limited opportunities for mitigation.
High	4	Receptor (human, physical or biological) with little or no capacity to absorb proposed changes or minimal opportunities for mitigation.

Source: Mott MacDonald

6.3.2 Change parameter

For each potential change we have described various parameters of the change and considered how each change could affect each receptor applying a scoring system. To describe the change, we used the parameters set out in Table 6.2.

Table 6.2: Change parameters

Parameter	Score	Description
Nature	Positive Negative (scoring system not applicable)	The nature of the change that is being considered may be positive, neutral or negative. For example, a gain in available habitat area for a key species would be classed as positive, whereas a habitat loss would be considered negative.
Magnitude	1 Negligible 2 Minor 3 Moderate 4 Major	The magnitude of change is a measure of the degree of change that will be incurred as a result of the proposed development. The categorisation of magnitude is based on a set of criteria that is specific to the discipline area being considered. For example, in the case of surface water, the magnitude may be defined as the extent to which the water quality (for example, suspended solids) exceeds the adopted national criteria.
Duration	1 Short term (0-5 years) 2 Medium term (5-15 years) 3 Long term (+16 years) 4 Permanent	The duration of change refers to the length of time over which an environmental impact may occur.
Scale	1 Local 2 Regional 3 National 4 International	The change may happen at a local, regional, national or international level
Probability	1 Low (unlikely) 2 Medium (as likely as not) 3 High (likely) 4 Certain	How likely is it that the change will happen.

Source: Mott MacDonald

6.3.3 Significance of impact

Having assessed the sensitivity of a receptor and change parameters set out above (see Table 6.1 and Table 6.2), we estimate the significance of the change by combining the parameters of change with the sensitivity of the receptor, using the following formula:

SP (Significance points) = (Magnitude + Duration + Scale + Probability) x Sensitivity

Based on the result of the calculation (the significance point), the relative significance of the impact is classified as set out in Table 6.3.

Table 6.3: Assessing the significance of impact

Significance points	Significance	Description
48-64	Major	The degree of impact that the project may have upon the environment and/or the community(s) is unacceptably high. It is unlikely that an impact of this magnitude can be satisfactorily mitigated. If this impact cannot be avoided, the project is unlikely to be permitted for development.
32-48	Moderate	The degree of impact that the project may have upon the environment and/or the community(s) is high. The project may be compromised if this impact cannot be avoided or mitigated (i.e. to reduce the significance of the impact).
16-32	Minor	The degree of impact that the project may have upon the environment and/or the community(s) is relatively low. Opportunities to avoid or mitigate the impact should be considered; however, this should not compromise the viability of the project.
<16	Negligible	No noticeable impact on the environment and/or the community(s). No mitigation is required.

Source: Mott MacDonald

Whilst reporting the levels of significance (major, moderate, minor, negligible) is considered good practice[1][2][3], there is no universally accepted measure of significance; different methodologies can be found in the impact assessment literature.

The methodology chosen for this ESIA aims to provide a reasoned determination of significance, where we demonstrate in a transparent manner how we have assessed whether a significant effect will occur, allowing others to see the score applied to different parameters so that they can understand the rationale for the assessment based not only on the magnitude of the change, but also the duration, scale and probability.

This method recognises the inherent subjectivity of the assessment of significance and therefore a scoring system is used to show how each change is considered to impact environment and social aspects.

It is important to note that some stakeholder groups might consider an impact significant, whilst others might not. For example, if an adverse effect is classified in this ESIA as of minor significance, in this methodology it means that a majority of people would not consider the effect to be significant; however, it is possible that a smaller group may disagree and consider the effect to be significant.

The specialist sections (Chapters 7 through 15) describe how the significance criteria for individual topics have been derived based on assessment of receptor sensitivity and change

[1] European Commission, Directorate-General for Environment, McGuinn, J., Lukacova, Z., McNeill, A., et al., Environmental impact assessment of projects : guidance on the preparation of the environmental impact assessment report (Directive 2011/92/EU as amended by 2014/52/EU), Publications Office, 2017, https://data.europa.eu/doi/10.2779/41362. Accessed in June 2023

[2] Vanclay, F., Esteves, A.M., Aucamp, I. & Franks, D. 2015. Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Projects. Fargo ND: International Association for Impact Assessment. https://www.iaia.org/uploads/pdf/SIA_Guidance_Document_IAIA.pdf. Accessed in June 2023

[3] Sida. 1998. Guidelines for Environmental Impact Assessments in International Development Cooperation. https://ec.europa.eu/echo/files/evaluation/watsan2005/annex_files/SIDA/SIDA%201%20-%20Environmental%20impact%20assessments.pdf. Accessed in June 2023

parameters. Impacts identified as having major or moderate significance based on the above approach are classified as significant impacts.

For each environmental and social aspect, the significance of impacts will be discussed before mitigation. Once the application of mitigation and management measures has been defined, the significance of impacts will be re-assessed (i.e. residual impact, see section 6.5).

6.4 Mitigation and enhancement measures

Mitigation measures are identified through the ESIA process in order to reduce the level of adverse impact upon a receptor.

The following hierarchy of mitigation measures is applied:

- Avoid and reduce impacts through design (embedded mitigation)
- Abate impacts at source or at receptor
- Repair, restore or reinstate to address temporary construction impacts
- Compensation for loss or damage

In addition to the above, community engagement and disclosure activities have played a key role in managing the extent of impacts and consideration has also been given to the identification of enhancement measures. Enhancement measures are actions and processes that:

- Create new positive impacts or benefits
- Increase the reach or number of positive impacts or benefits
- Distribute positive impacts or benefits more equitably

Each specialist section identifies relevant mitigation and enhancement measures. All the mitigation, management and monitoring measures to address likely impacts are reported in the ESMP.

6.5 Residual impacts

Residual impacts are those that remain after the application of mitigation and enhancement measures. As discussed above, once the application of mitigation and management measures has been defined, the residual significance is determined. Impacts considered ‘Major’ or ‘Moderate’ after application of mitigation and enhancement measures, are presented as significant residual impacts. These will be identified as part of this ESIA.

6.6 ESIA Study area / Area of influence

The project Area of Influence (AOI) is the area over which the impacts of the project are likely to be felt including all its related facilities such as the water pipelines, access roads, as well as any reasonably foreseen unplanned developments induced by the project or cumulative impacts.

The project AOI is comprised of areas of direct impacts and indirect impacts which will inform the impact assessment.

- Direct area of influence: considers the physical footprint of the project such as the construction sites, work staging area and area affected during project works
- Indirect area of influence: includes the area which may experience project related changes in combination with activities not under the direct control of the project.

The project direct AOI often varies depending on the specific environmental or social aspect considered based on the extent an impact may be affected and can be influenced on a spatial and temporal level. To address this, we have defined a general AOI with sub-definitions for key E&S topics to inform the boundaries of the impact assessment work.

The temporal influence of the project has been assessed by comparing the existing baseline conditions (social, biodiversity, hydrological and other) with the change expected over time as a result of the project activities as listed below:

- Site establishment
- Exploratory drilling works
- Site closure

The baseline conditions are those assumed to be prevailing immediately prior to the start of site establishment.

Stakeholder consultation during the baseline data collection process helped to inform the definition of the AOI.

The AOI for the E&S topics scoped in this ESIA is defined in each specialist chapter.

6.7 Data limitations and uncertainty

Any uncertainties associated with impact prediction or the sensitivity of receptors due to the absence of data or other limitations are explicitly stated in the relevant specialist sections (Chapters 7 to 15). Where applicable, the ESIA makes recommendations concerning measures that should be put in place with monitoring or environmental or social management plans to deal with the uncertainty so that they may be addressed.

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7 Socio-economic and cultural

7.1 Overview

This chapter considers the potential socio-economic and cultural heritage impacts associated with the exploratory phase of the project.

Impacts have been considered and assessed for the site preparation (including access roads construction, and well pad and pump station set up), exploratory works, and, where relevant, decommissioning.

7.2 Study area and area of influence

The social impact assessment considers the direct and indirect area of influence (AoI) of the project as indicated in Figure 7.1 and Figure 7.2.

The direct AoI include:

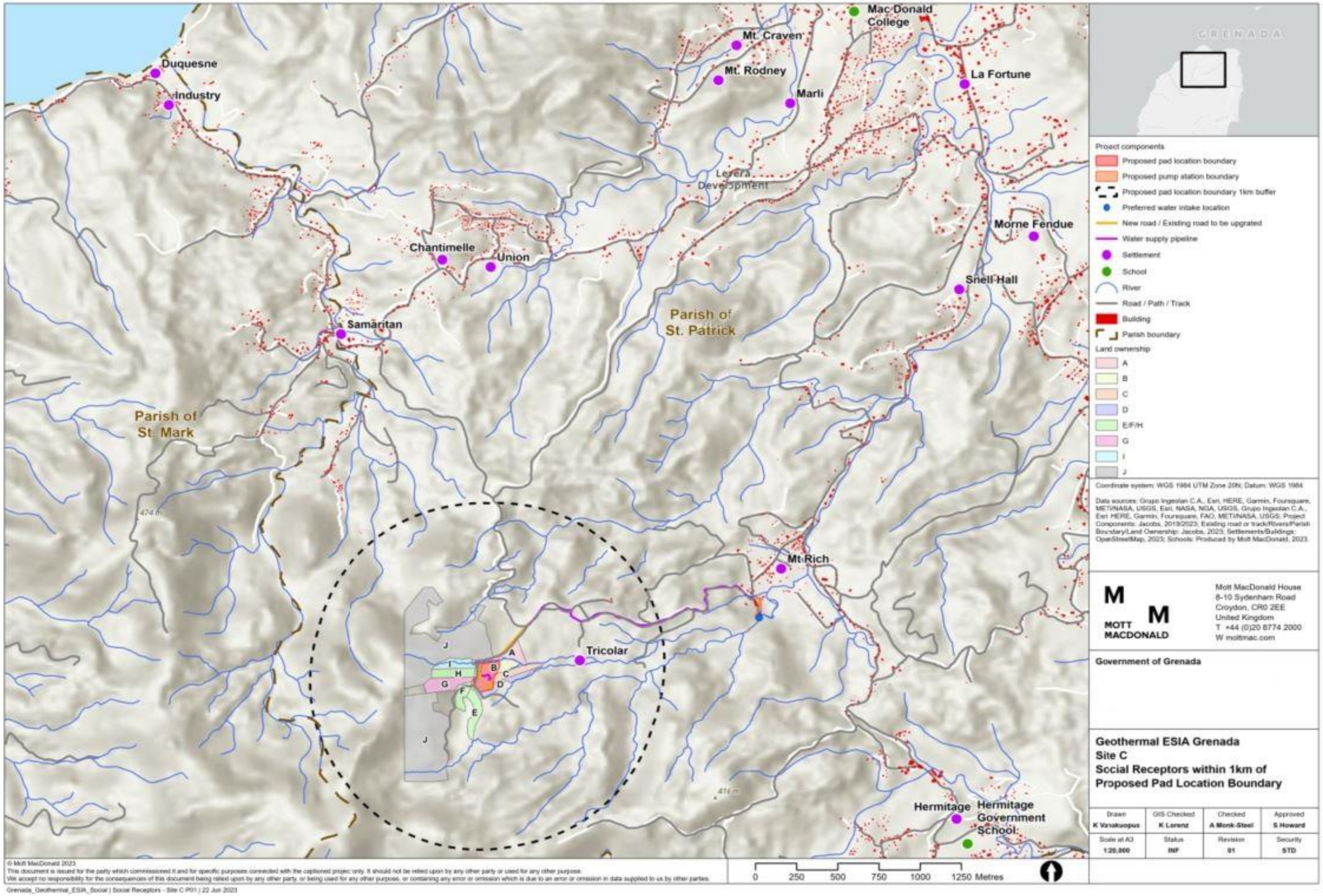
- The land plots needed for construction of the project infrastructure, and their landowners and land users including ecosystem service users.
- The residents and social infrastructure of the village of Florida, and the village of Mt Reuil/Mt Rich and the community of Tricolar, approx. 1 to 1.5km from Site F and Site C, respectively.
- The residents and social infrastructure of the town of Gouyave (7km approximately from Site F) and the town of Sauteurs (4km approximately from Site C).
- The roads to be used for project-related transportation (for transportation of workers, components, and supplies and construction materials),
- Residents of settlements through which access routes to the project site pass, and road users including:
  - Road users along the access road to well pad and pump station C, which will be reached via Grenville and to well pad and pump station F, which will be reached via Sauteurs and Gouyave
  - People travelling through the project AoI, including pedestrians and cyclists
- Archaeological sites located in the direct AoI.
- Tourist attractions and visitors to tourist attractions in the direct AoI.
- Project workers

The indirect AoI include:

- Road users from the port at St Georges to Grenville, Sauteurs and Gouyave.
- The remainder of the island of Grenada as less-skilled project workers could come from all over the island, and island residents can also be impacted by the effects of project-induced in-migration.

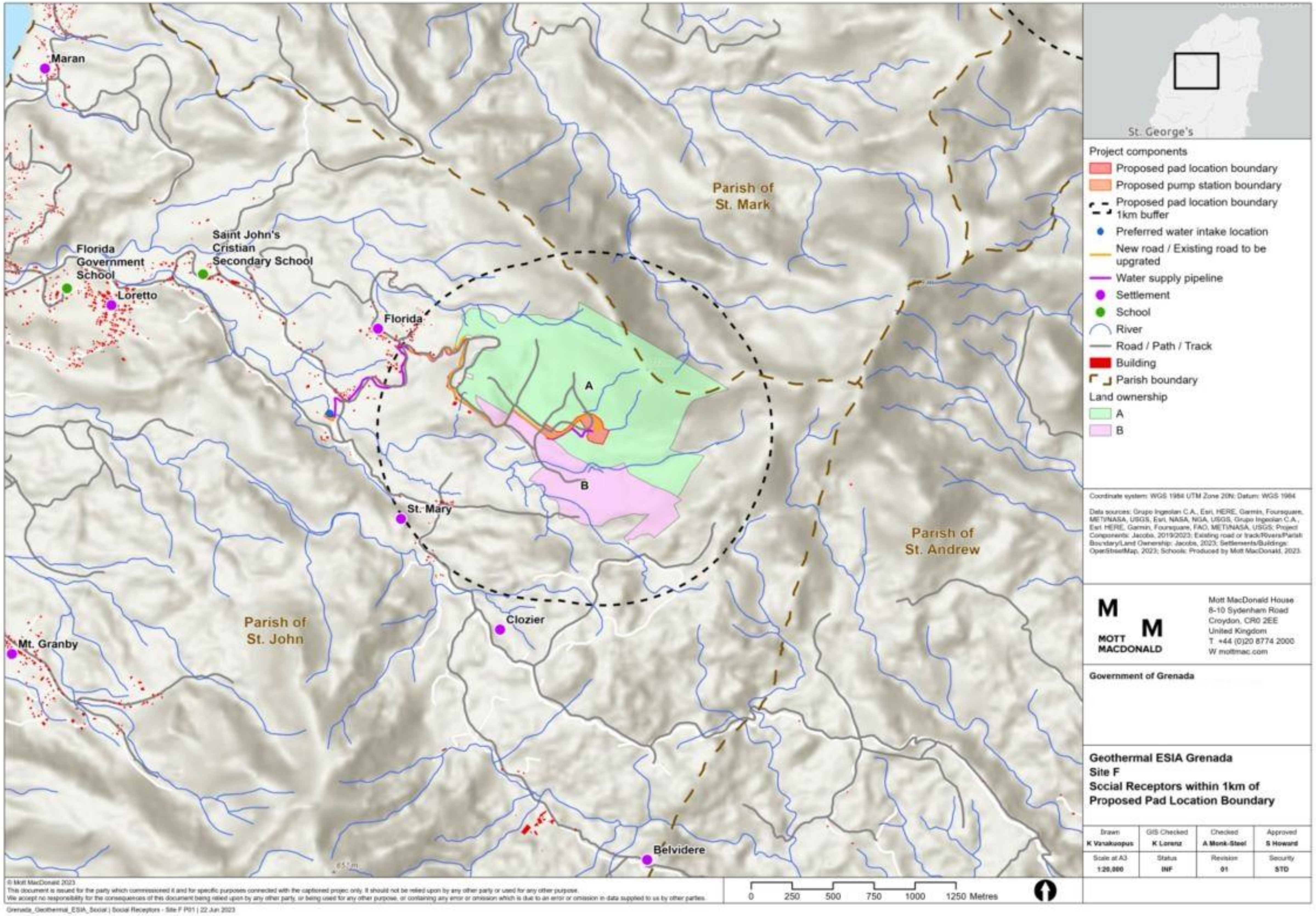
Other affected people and stakeholders may be identified during ongoing project consultation.

Figure 7.1: Socio-economic and cultural direct area of influence (Site C)



Source: Prepared by Mott MacDonald based on various sources

Figure 7.2: Socio-economic and cultural direct area of influence (Site F)



Source: Prepared by Mott MacDonald based on various sources

7.3 Methodology

The social impact assessment (SIA) considered the direct AoI and indirect AoI. Within these areas, impacts identified with the potential to change the socio-economic and cultural heritage baseline/context have been assigned significance using the overarching framework presented in Chapter 6 ESIA process and methodology.

7.3.1 Baseline data collection

Secondary and primary data was collected for the direct and indirect AoI during the ESIA scoping stage in 2019.

Following the ESIA scoping stage, further technical engineering analysis by Jacobs New Zealand resulted in a recommendation to relocate the proposed well pad at Site C, by approximately 500m to the north.

Therefore, primary data for the new Site C direct AoI was collected in 2023 – three focus group discussions (FGDs) were held with women only, landowners and small local businesses from the community of Tricolar.

Additionally, secondary data related to the Site F direct AoI and for the overall socio-economic and cultural indirect AoI were also updated in 2023, where available.

Primary and secondary data was collected in 2023 using the same data collection methodology used in 2019, which allows for consistency.

Primary data used for socio-economic baseline were collected mainly through:

- ESIA scoping site visit with observations and 14 stakeholder meetings with key governmental and community representatives in March 2019
- FGDs for each site covering landowners and land users, small businesses and women in March 2019 (Site F and Site C) and April 2023 (Site C).
- Outcomes from the ESIA scoping public hearing held in July 2019
- 10 key informant interviews (KIIs) with Ministries and NAWASA (March 2019).

Secondary baseline data was collected from a range of published sources including websites and reports from local authorities, government departments and organisations, civil society organisations, non-governmental organisations (NGOs), local media, and business groups. Examples of data sources include but are not limited to project documentation and previous social studies, most recent census reports, government socio-economic policies and legislation, press releases and media coverage, and civil society and business organisation reports. Information has been drawn from a number of published sources and project documents, principally from the World Bank Group (WBG), Pan American Health Organization (PAHO), Government of Grenada documents, United Nations Development Programme (UNDP), German Agency for International Cooperation (GIZ in English), World Health Organization (WHO), United Nations Children’s Fund (UNICEF), among others. All references are listed in Chapter 18 of this volume.

7.3.2 Sensitivity of social groups and resources[1]

The sensitivity of social groups and resources has been determined through consideration of their vulnerability to social impacts. This is measured by their capacity to cope with impacts that affect their access to or control over additional or alternative social resources of a similar nature, ultimately affecting their wellbeing. Sensitive or vulnerable people are generally considered to have less means to absorb adverse changes or shocks than less-sensitive or less-vulnerable people. Similarly, they may be less able to maximise and build on beneficial changes to their resource bases. The guideline criteria used to determine the sensitivity of social groups and resources[2] to the changes which the project will cause is defined in Table 7.1.

Table 7.1: Criteria for determining social groups and resources sensitivity

Sensitivity	Criteria
High	People who are already vulnerable with very little capacity and means to absorb proposed changes or with very little access to alternative similar resources, sites or services.
Medium	People who are already vulnerable with limited capacity and means to absorb proposed changes or with some access to alternative similar resources, sites or services.
Low	People who are not vulnerable with some capacity and means to absorb proposed changes and with some access to alternative similar resources, sites or services.
Negligible	People who are not vulnerable with plentiful capacity and means to absorb proposed changes and with good access to alternative similar resources sites or services.

Source: Mott MacDonald

7.3.3 Magnitude of change

The magnitude of the social impacts has been determined by consideration of the extent to which social groups gain or lose access to or control over socio-economic resources, resulting in a beneficial or adverse effect on their individual and collective wellbeing. Wellbeing is considered as the financial, physical and emotional, environmental and cultural conditions and quality of life of people and communities.

For beneficial impacts, the extent to which local wellbeing is likely to be enhanced has been considered. This is in accordance with the international movement in SIA practice towards an increased focus on enhancing long-term development benefits for local communities' sustainability, as opposed to only considering mitigation of adverse impacts. As such, the magnitude criteria include consideration of the extent to which benefits are shared with and or realised by local people and communities. The guideline criteria used to determine the magnitude of the changes which will be created by the project is defined in Table 7.2

[1] In the context of this ESIA, social groups are individuals, households, businesses, social groups, economic or sociocultural networks, and communities, whereas social resources are communal assets, amenities and services, businesses and opportunities. Social resources can be human and non-human. For example a rotating care organised by a network of mothers is a social resource, as is the church where it may be based. Social groups and resources are also called "social receptors", a common terminology used in ESIAs to describe whom or what is affected. For more on social receptors, see: Marielle Rowan (2009) Refining the attribution of significance in social impact assessment, Impact Assessment and Project Appraisal, 27:3, 185-191, DOI: 10.3152/146155109X467588.

Table 7.2: Criteria for determining impact magnitude

Magnitude (positive or adverse)	Description (considers duration of the impact, spatial extent, reversibility and ability to comply with legislation)
Major	A highly likely impact that would have implications beyond the project life affecting the wellbeing of many people across a broad cross-section of the population and affecting various elements of the local communities' and/or workers' resilience.
Moderate	A likely impact that continues over a number of years throughout the project life and affects the wellbeing of specific groups of people and affecting specific elements of the local communities' and/or workers' resilience.
Minor	A potential impact that occurs periodically or over the short term throughout the life of the project affecting the wellbeing of a small number of people and with little effect on the local communities' and/or workers' resilience.
Negligible	A potential impact that is very short in duration so that the socio-economic baseline remains largely consistent and there is no detectable effect on the wellbeing of people or the local communities' and/or workers' resilience.

Source: Mott MacDonald

The magnitude of social impacts is, to an extent, subjective. The determination of the magnitude will therefore be based upon professional judgement taking into account the perceived sensitivity of the receiving social groups and resources.

7.3.4 Human rights impact assessment

The human rights impact assessment (HRIA) AoI and methodology are described in sections 7.3.1 and 7.3.2. The rights-holders[3] within the assessment, and the assessment of the potential and actual human rights impacts with an evaluation of their severity are presented in section 7.5.6.

7.3.4.1 Area of influence

The human rights AoI includes:

- Social AoI (section 7.2).
- Workers including contracted workers
- Workers from main supply chain companies

7.3.4.2 Methodology

The assessment involved establishing a baseline understanding of the nature of the project context, as well as an assessment of impacts based on primary and secondary data collected and our technical expertise on similar projects. Actual and potential human rights impacts arising as a result of project activities have been identified and their severity assessed (see section 7.3). The methodology for assigning impact severity for the HRIA is different from the methodology described in Chapter 6 of this ESIA and used on the SIA (see section 7.3) and is discussed below.

Assigning severity

In accordance with the UNGPs, Principle 14, human rights impacts have been assessed according to their severity which is determined by considering the scale, scope and irremediability of the impact.

[3] From a human rights perspective, individuals (sometimes groups) are rights-holders that can make legitimate claims, and States and other actors such as business are duty-bearers that are responsible and can be held accountable for their acts or omissions.

Identifying severity helps to define the priority in which human rights impacts and risks should be addressed. The key difference between severity and significance – the concept used in environmental and social impact assessment – is that severity does not consider probability, rather it focuses on the potential severity of the consequences of the impact on human rights. This HRIA addresses all human rights impacts, both actual and potential. Actual impacts must be remedied as a matter of urgency and potential impacts must be mitigated.

According to the UNGPs:

- All human rights impacts need to be addressed.
- Where it is not possible to address all impacts simultaneously, the impacts should be addressed in order of their severity.
- Severity is determined by the scope (number of people affected), scale (seriousness of the impact[4]) and irremediability (any limits to restore the individual impacted to at least the same as, or equivalent to, her or his situation before the adverse impact occurred).
- While it is not necessary for an impact to have more than one of these characteristics to be considered 'severe', it is often the case that the greater the scale or the scope of an impact, the less it is 'remediable'.

Table 7.3 shows the parameters for evaluating human rights impacts used in this HRIA.

Table 7.3: Parameters for evaluating actual and potential impact severity

Factor		Description	Score
Vulnerability of affected people		Very limited capacity to absorb change	High
		Limited capacity to absorb change	Medium
		Some capacity to absorb change	Low
Severity of impact	Scale	Life- or long-term health threatening	A
		Non-life or health threatening, but tangible infringement of access to basic life necessities or freedoms including education, livelihood, etc	B
		All other impacts	C
	Scope	>50% of identifiable group	A
		11-50% of identifiable group	B
		<10% of identifiable group	C
	Irremediability	High – complex technical requirements, little acceptance of remediation by the identified group, low capacity of implementation partner, no viable	A

[4] The scale element also includes consideration of vulnerability of the rights holders because a person or group's circumstances including their capacity to absorb or respond to change may influence how serious the impact may be for them

Factor	Description	Score
	replacement for loss caused by impacts	
	Moderate – simpler technical requirements, acceptance by the identified group, implementation partner can deliver with some capacity development	B
	Low - simple technical requirements, acceptance by the identified group, implementation partner has capacity to deliver	C

Source: Danish Institute of Human Rights and Community Insights Group, based on UN Guiding Principles

Impacts will be scored A-C for scale, scope and irremediability as identified in Table 7.3 above. An impact that scores mostly A for scale, scope and irremediability which affects individuals or groups with a high level of vulnerability will be given an overall severity assessment score of 5, for 'high severity', as shown in Table 7.4 below. Impacts scoring mostly Cs for scale, scope and irremediability affecting individuals or groups which are not vulnerable will receive a severity score of 1, for 'not severe'. Professional judgement is also used when considering and determining overall assessment ratings.

Table 7.4: Overall impact severity classification criteria

	Scale, scope and irremediability scores		
Vulnerability	**Mostly As**	**Mostly Bs**	**Mostly Cs**
High	5 - high	4 - moderate to high	3 - moderate
Medium	4 - moderate to high	3 - moderate	2 - low
Low	3 - moderate	2 - low	1 - not severe

Source: Adapted from the Danish Institute for Human Rights (2016) Human Rights Impact Assessment: Guidance and Toolbox

Assigning priority

Where it is challenging to address all identified human rights impacts at once, the most severe, the most likely and the most imminent impacts must be prioritised and addressed first. As the project is new, planning to prevent human rights impacts can occur simultaneously and therefore priority has not been assigned to individual mitigation measures.

7.3.5 Limitations and assumptions

For the socioeconomic baseline secondary and primary data was used as described in section 7.3.1.

Secondary data, while valuable for the socioeconomic baselined purposes, presents two major limitations. The first one is related to outdated information. For example, the latest Grenada demographic census publicly available is from 2011, and a census was conducted in 2022/23, but the results have not yet been published[5]. The last labour survey dates from 2015 and the digital and virtualised cadastre of land ownership is from 2014. Another significant limitation is

[5] It is anticipated that the new census results will be available in the coming years. URL: https://nowgrenada.com/2023/03/census-period-extended-to-30-april/, retrieved 11 April 2023

the lack of disaggregated data and most of the secondary data used for this baseline was only available at the national level. These limitations can lead to inaccuracies and can also mask important variations within local contexts.

Primary data was collected in connection with the project locations. In March 2019 data was collected for site F and for site C, and given the new location of the well pad site C, new primary data was collected for site C in April 2023. The same methodology was used in 2019 and 2023. With regards to data collected for site F direct AoI, which is dated 2019, we have assumed that no major changes have occurred between 2019 and 2023 due to the site F characteristics (sparsely populated, limited economic activities and slow pace of development). Hence, the use of primary data collected for site F in 2019 is not understood as a limitation.

Based on the socio-economic and cultural heritage baseline (as described on this Chapter 7), we do not consider the outdated data have a major impact on our analysis. Finally, our analysis is also based on experience of similar projects and knowledge of the likely impacts. Professional judgement has been used to reduce the level of subjectivity within these assumptions as far as possible and explanation for assumptions provided.

7.4 Baseline – description of pre project conditions

This section presents a summary of the socio-economic and cultural baseline characterisation of the project's direct and indirect AoI.

7.4.1 Administrative divisions

Grenada is divided into six parishes, and each parish encompasses several villages and towns (see Table 7.5). Site F is located in the Saint John Parish and Site C is located in the Saint Patrick Parish. The Parishes where the sites are located, and villages and towns included in the direct AoI are highlighted in bold in Table 7.5. The closest villages to Site F are Gouyave and Florida, in parish Saint John. The closest villages to Site C are Tricolar and Sauteurs, in parish Saint Patrick.

Table 7.5: Parishes and main villages and towns

Grenada´s Parishes	Main villages and towns
Saint John (site F)	**Gouyave*, Florida**, Brothers, Clozier, Gouyave Estate, Grand Roy, Concord
Saint Patrick (site C)	**Sauteurs***, **Mt Reuil/ Mt Rich, Tricolar**, Hermitage, Snell Hall
Saint Andrew	Grenville, Tivoli, Birch Grove, La Poterie
Saint David	La Tante, Windsor Forest, Belle Isle, Corinth
Saint George	St. George's, Grand Anse, Woburn, Calliste
Saint Mark	Victoria, Waltham, Duquesne, Samaritan

Source: Government of Grenada: https://www.gov.gd/

Note: villages highlighted in bold are located in the direct AoI. Gouyave and Sauteurs are the main towns of their parish.

7.4.2 Demographics

Grenada is a small island nation comprising the main island of Grenada and several additional smaller islands[6], of which only Carriacou and Petite Martinique are populated.

Despite being one of the smallest nations in the world, Grenada has a sizeable population of 124,610[7] and a high population density of 364 people per square kilometre of land area[8]. Figure 7.3 and Figure 7.4 below shows Grenada's population pyramid[9] as of 2000 and 2023, respectively which illustrate an aging population.

On average women live longer than men, with a life expectancy of 77.5 years compared to 72.2 years[10]. By 2015, the national population had become stationary (i.e., with zero growth) for those younger than 30 years[11]. Similar to many other small island nations, net migration in Grenada is negative, at -2.8 people per 1,000.

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[6] Includes Carriacou Island, Petite Martinique, Ronde Island, Caille Island, Diamond Island, Large Island, Saline Island, and Frigate Island

[7] Estimated number for 2021, Pan American Health Organization (PAHO), https://hia.paho.org/en/countries-22/grenada-country-profile, retrieved 11 April 2023

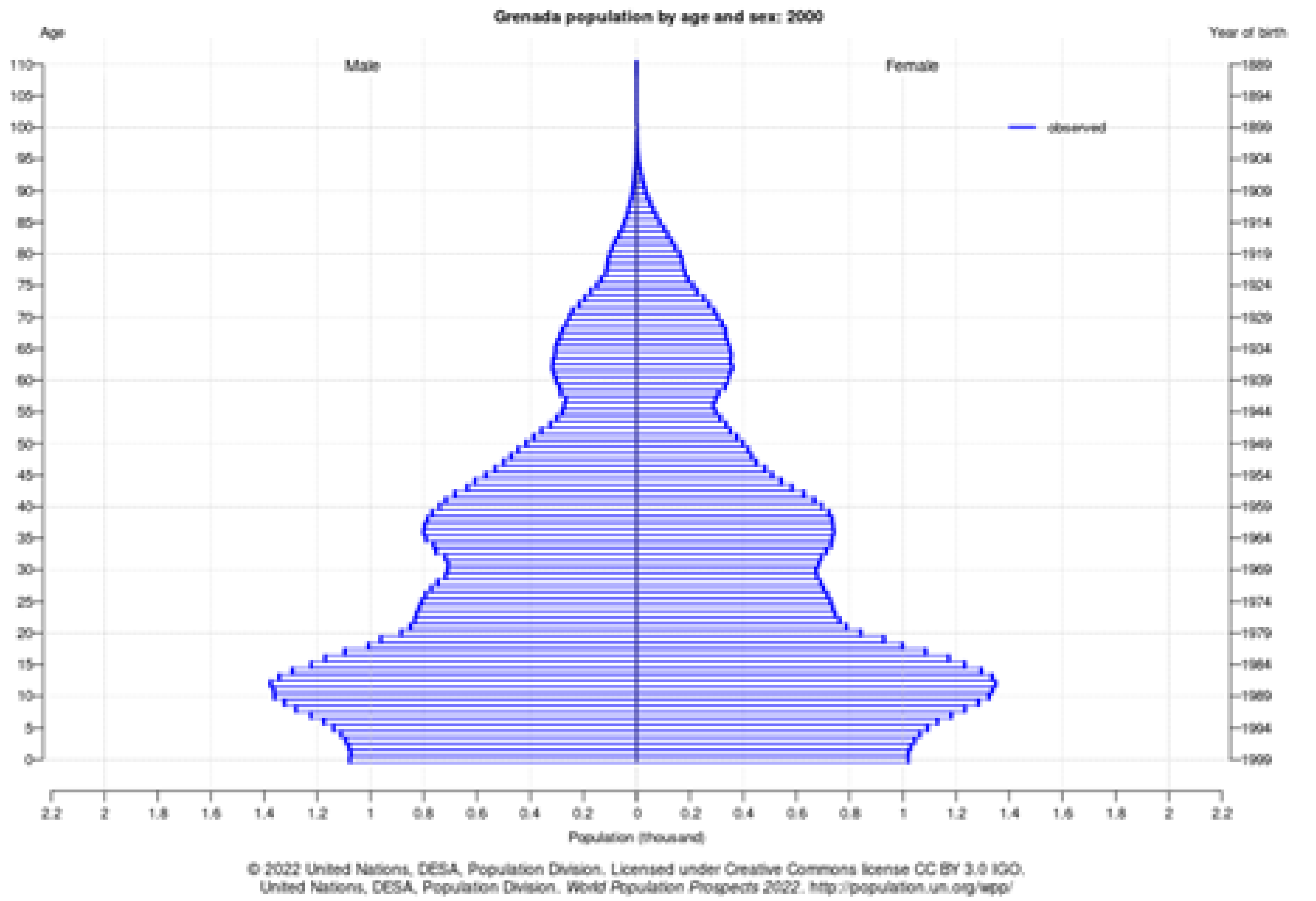
[8] World Bank, https://data.worldbank.org/indicator/EN.POP.DNST?locations=GD, retrieved 11 April 2023

[9] United Nations, Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022: Data Sources. Graphs/Profiles. Grenada. Available at: https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/308. Accessed in July 2023.

[10] Estimated number for 2021, PAHO, https://hia.paho.org/en/countries-22/grenada-country-profile, retrieved 11 April 2023

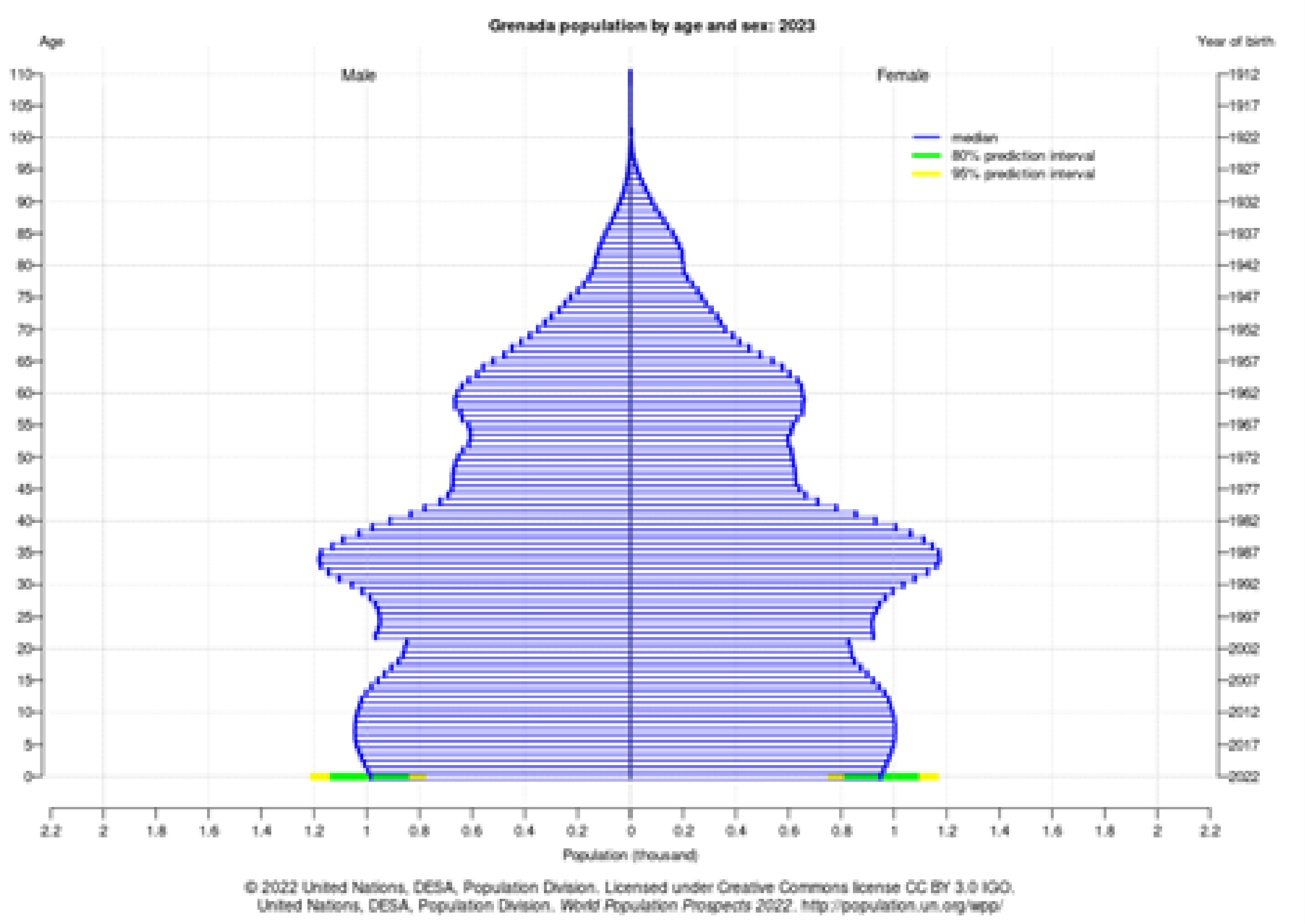
[11] PAHO, https://www.paho.org/salud-en-las-americas-2017/?page_id=125, retrieved 12 April 2019

Figure 7.3: Population pyramid for Grenada, 2000



Source: United Nations

Figure 7.4: Population pyramid for Grenada, 2023



Source: United Nations

Table 7.6 below shows the breakdown of Grenada's population by parish according to the 2011 census. The largest parish is St George, which is home to the island's capital, St George, in the south of Grenada. St Patrick (Site C) has the larger population of the two main parishes to where exploration is proposed. Both St Patrick and St John parishes are considered some of the smallest in population in Grenada. It is likely to continue to be small parishes, as the direction of internal migration is to the bigger towns of the island.

Table 7.6: Population of Grenada by Parish

Parish	Population 2011
Rest of St George	35,118
Town of St George's	3,133
St John (Site F)	8,466
St Mark	4,406
St Patrick (Site C)	10,503
St Andrew	26,503
St David	12,877
Carriacou and Petite Martinique	5,661
Total	106,667

Source: Grenada's national census, 2011

As of 2021, approximately 37% of the population lived in urban areas[12]. This has not changed significantly over the past 20 years with 35.7% of people living in urban areas in 2000. In 2010 6% of the total population were living in urban areas regarded as 'slums'[13]. The draft land policy[14] indicates that land acquisition by foreign investors has resulted in increases to land prices which in turn has contributed to a shortage of affordable land available for people moving to towns and increased the development/growth of slum areas (or informal settlements) close to areas of urban development.

7.4.3 Ethnicity and language

Most people in Grenada are of African descent (82.4%), 13.3% are of mixed descent, 2.2% are East Indian, with a further 1.3% identified as 'other' and 0.9% of unspecified ethnic origin[15]. Stakeholder consultation in 2019 and 2023 with government officials, landowners and community members did not identify indigenous peoples in the project's direct AoI, either Kalinago (Carib) or Taino (Arawak)[16], as per IFC PS7 definition. This ESIA concludes that there are no indigenous peoples likely to be affected by the project that require specific consideration as defined under IFC PS 7.

The official language is English.

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[12] World Bank, https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=GD, retrieved 1 June 2023

[13] Urban population living in slums (%) – Proportion of urban population living in slum households, defined as a group of individuals living under the same roof lacking one or more of the following conditions: access to improved water; access to improved sanitation; sufficient-living area; durability of housing. This definition used by UNFPA is proposed by UNHABITAT.

UNFPA, https://www.unfpa.org/sites/default/files/resource-pdf/FINAL_Grenada.pdf, retrieved 1 June 2023

[14] Please refer to 'Chapter 4. Policy, legal and institutional framework' for further information.

[15] Commonwealth Local Government Forum, http://www.clgf.org.uk/default/assets/File/Country_profiles/Grenada.pdf, retrieved 11 April 2019

[16] Refworld, https://www.refworld.org/type,COUNTRYPROF,,GRD,4954ce10c,0.html, retrieved 12 April 2019

7.4.4 Economy, employment and livelihoods

Grenada is classified by the World Bank as an upper middle-income country and its gross domestic product (GDP) per capita is approximately $9,010.6[17].

Based on preliminary data from the labour force survey in 2015[18], the working age population in 2015 was estimated as of almost 83,800, two-thirds of the population. The unemployment rate was 17% in the second quarter of 2021[19]. As a reference, the unemployment rate for Latin America & Caribbean in 2021 (9.2%[20])[21].

Data from the 2011 census indicates that a greater percentage of males participate in the labour force than females. Although the numbers mask the fact that women's reproductive work in the home, and informal economy are not quantified as work in the statistic, there is also the fact that women are more likely than men to work for no or low wages[22]. This disparity in labour force participation increases female dependency on males.

As of 2021, a large portion of the Grenadian economy is centred on services (80.2%), followed by industry (14.5%) and then agriculture, forestry, and fishing (5.3%)[23]. Main country-wide industries include food and beverages, textiles, light assembly operations, tourism, construction, education, and call-centre operations. Main types of agriculture include crops such as bananas, cocoa, nutmeg, sugar cane, mace, soursop, citrus, avocados, root crops, corn, vegetables, as well as fishing. Key exports include nutmeg, cocoa, fruit and vegetables, clothing, mace, chocolate, and fish. Grenada was formerly second in the world for nutmeg production but the effects of Hurricane Ivan in 2004 have lowered exports to around $10m, ranking Grenada eighth globally[24]. In the surrounding areas of the exploratory sites C and F agricultural estates[25] and key industrial employers have been identified, as described below.

Site F well pad will be located within a large privately owned land parcel known as Plaisance Estate owned by one landowner. The estate is a large scale commercial farm employing approximately 37 people of which 12 are women. A resident estate manager oversees the property and its operations on behalf of the owner. A small portion of the total land parcel is being actively farmed at any one time. Current active farming areas are located away from where the potential well pad would be located. The following crops are grown: banana, plantains, cocoa, clove, nutmeg, spice (cinnamon), dasheen, sweet potato, tannia, pepper, cucumbers, watermelon, citrus (grapefruit, lime, lemon, oranges), breadfruit and legumes. In Florida, which is the closest village to Site F, some employment comes from agricultural and small commercial activities and part of the households' incomes comes from remittances.

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[17] Estimated number for 2021, World Bank, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=GD, retrieved 11 April 2023

[18] Labour Force Survey 2013-2015. Analysis and Indicators, Grenada CSO and World Bank, https://www.finance.gd/images/LabourForceSurvey.pdf

[19] International Monetary Fund (IMF), https://www.imf.org/en/News/Articles/2022/05/10/pr22147-grenada-imf-executive-board-concludes-2022-article-iv-consultation-with-grenada, retrieved 12 April 2023

[20] World Bank, https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?locations=ZJ, retrieved 15 June 2023

[21] Data on unemployment rate may not be comparable due to differences on the methodologies. Website consulted do not provide detail.

[22] Gender Equality Policy and Action Plan, GoG 2014-2024.

[23] World Bank, https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=GD, retrieved 12 April 2023

[24] The Observatory for Economic Complexity, https://atlas.media.mit.edu/en/profile/hs92/0908/, retrieved 24 May 2019

[25] During the colonial period, in the 1600s, coffee, cocoa and sugarcane plantation were established

In the town of Gouyave, which is the closest larger town to Site F, the main economic activities are commerce, fishing and tourism.

The well pad at Site C will be located mainly within four land plots. During the 2023 FGDs, we were informed that these lands are being exploited by workers on behalf of the owner. Crops include cabbage, tomatoes, greens, sweet potatoes, carrots, bananas, pineapple and nutmeg trees. No plants were reported to be used for medicinal purposes.

Near Site C, there are private farms producing food crops and rearing livestock. Other private and public source of employment for residents at Sauteurs and Tricolar include the Tricolar agricultural estate, also known as the Mt Reuil Agricultural Estate, and is approximately 1.75 km from the proposed well pad location at Site C. Mt. Reuil Estate is owned by the government with the employees contracted by the Ministry of Agriculture a total of 28 employees, which 13 females and 15 males. The Glenelg Spring Water bottling plant employs 50 permanent staff (35 females/15 males) and about 20 casual staff at their bottling plant. The NAWASA (National Water and Sewage Authority) employs about 40 people (see Figure 7.7). The Belmont Estate (a popular eco-tourism destination based on chocolate production) employs around 78 people and tourism opportunities related to the petroglyph sites, and the hot springs and trail from Hermitage to Mt St. Catherine and Mt. Kublal provide livelihoods to a small, unknown number of local people.

Figure 7.5: Cocoa is an export product and source of income for farmers

Source: Mott MacDonald ESIA scoping site visit, March 2019

Figure 7.6: Banana trees are common

Source: Mott MacDonald ESIA site visit, June 2023

Agricultural work is generally manual labour with little automation. According to the female focus groups held in the villages of Florida (site F) and Mt Reuil/Mt Rich (site C) in July 2019 and April 2023, more men than women are involved in agriculture, with about 70% of agricultural workers being male. Men are also involved in livestock. Both men and women use cutlasses to cut grass and prune trees for land clearing. Depending on the kinds of crops, it is harvested by men or women. Women mainly dry cloves and nutmeg, as well as harvesting nutmeg. Men are usually responsible for harvesting cocoa. In May 2023, during the Mt Reuil/Mt Rich FGDs, participants indicated that most teachers, nurses and administrators are female.

Despite being classified as a middle-income country, a significant proportion of people are living below the poverty line. In 2016, the World Bank stated that 38% of people in Grenada were living in poverty[26] and 2% were indigent[27]. UNICEF notes that “Grenada has the highest poverty rate among countries in the Eastern Caribbean; significantly higher than the average of 23% for the region[28]. Almost half the households in Grenada (47%) are female-headed. Of these, more than 20% in the rural areas are poor according to the (Core Welfare Indicator), as compared to only 13% of male-headed households[29]. In relation to young people and childhood, 1 in 2 or 51% of children ages 0-17 and 18% of adolescents ages 10-19 were living in poverty, which is higher than the poverty rate for adults age 18+ years (30%). The poverty rate for young people ages 10-24 is not available because it has yet to be calculated. Grenada child and adolescent poverty rates are higher than the averages for the Eastern Caribbean (33% and 34% respectively)[30].

7.4.5 Land tenure and use

The draft land policy recognises changing land use pattern with the island’s economy shifting in the past two decades from agricultural dominant to services dominant. In an estimation made by the Food and Agriculture Organization (FAO), agriculture occupied 52%[31] of the land and 23.5% of forest for 2019[32]. Despite the change in land use patterns in most parts of the Island, land for agriculture use remains the main use at project sites C and F.

Property rights legislation in Grenada are based on a pre-1925 system of the United Kingdom. Real estate property is either owned by the state (Crown land) or by individuals or entities of the private sector (private land). The draft land policy indicates that 90% of land in Grenada is privately owned, with most of the remaining land considered to be Crown land[33]. Lack of statistical information on land tenure in Grenada has made it difficult to identify the current land tenure situation although supporting information from secondary data sources are used as proxies to ascertain the situation.

During the last decade, the GoG had made some modernization efforts to digitalize the land registry. This is an ongoing project using a dedicated database to “re-register” the Entry Books. Deeds and other relevant documentation are being scanned with cross references for easy search. There has been no formal proposal for much needed modernization and expansion of the Cadastre. This has been a discussion item for many years but has been hampered by lack of financial support to progress.

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[26] People don't have enough to meet their basic needs. World Bank: https://www.worldbank.org/en/news/video/2017/04/14/what-are-poverty-lines#:~:text=People%20living%20below%20a%20poverty,line%20of%20%241.90%20per%20day.

[27] Indigence entails living in a level of poverty in which real hardship and deprivation are suffered and comforts of life are wholly lacking.

[28] https://www.unicef.org/easterncaribbean/media/2961/file/GenU%20Grenada%20fact%20sheet.pdf

[29] Grenada UPR: Joint Submission from the United Nations Subregional Team for Barbados and the OECS. Annex 3: https://uprdoc.ohchr.org/uprweb/downloadfile.aspx?filename=1482&file=Annexe3

[30] https://www.unicef.org/easterncaribbean/media/2961/file/GenU%20Grenada%20fact%20sheet.pdf Retrieved June 2023.

[31] Grenada National Land Policy 2019 (draft). Retrieved 12 April 2023. https://climatefinance.gov.gd/wp-content/uploads/2019/10/DRAFT-National-Land-Policy.pdf. This policy is still under construction

[32] UNDP, Voluntary National Review Grenada 2022. Retrieved 12 April 2023. https://hlpf.un.org/sites/default/files/vnrs/2022/VNR%202022%20Grenada%20Report.pdf

[33] According to the Government Information Service of Grenada (GIS), the national land policy convened by the Ministry of Agriculture, Lands, Forestry and Fisheries was still under discussion as of December 2022. 20 April 2022 | Progress with Grenada's National Land Policy from the Government Information Service. https://www.youtube.com/watch?v=egWWqLZCk-w. Retrieved 12 April 2023.

For the exploration phase, land at sites C and F will be leased on a temporary basis, and for road widening there will be land acquisition. The Ministry of Agriculture and Lands will undertake the land lease and acquisition process. As per the information provided by the GoG, for the well pads, road widening and pump station, a total of 67,892 m^2 (6.8 ha) are required from which 4,358 m^2 (0.4 ha) are State land and 63,534 m^2 (6.4 ha) are privately owned. From the FGDs in 2023 for Site C, land plots in the area are usually worked by farmers who lease the land from the owners. Participants in the focus group discussions (2019 and 2023) indicated that mainly men own the land, which was traditionally passed on to sons (a practice which is said to be slowly changing). Site F well pad will be located within a large privately owned land parcel known as Plaisance Estate owned by one landowner.

A total of 18 landowners, including the State, have been identified at the well pad areas, road widening and new access, as well as pump stations. Some of the State land is being farmed by individuals or entities that are pending identification. Most of the landowners have been identified and arrangements are in progress for negotiations with landowners for acquisition or leasing.

The Land Acquisition Act describes the process by which land will be acquired/leased. The GoG is aiming to achieve negotiated settlements with all landowners; however, the GoG has the legal authority to acquire lands for a public purpose.

Table 7.7 and Table 7.8 and Figure 7.7 and Figure 7.8 below provide a summary of landowners and plots identified at site C and site F.

Table 7.7: Summary of lands required at Site C

Land plot #	Land purpose (access road/ water supply / well pad)	Ownership	Total area required (sq ft)
1	Pump station / access road	State land	21,872
2	Road widening	State land	388
3	Road widening	State land	6,242
4	Road widening	State land	10,226
5	Road widening	State land	8,180
6	Road widening	Not yet determined	4,413
7	Road widening	Not yet determined	13,778
8	Well pad	Privately owned – owner identified	35,102
9	Well pad	Privately owned – owner identified	75,466
10	Well pad	Privately owned – owner identified	110,049
11	Well pad	Privately owned – owner identified	5,102
Total			290,818

Source: GoG

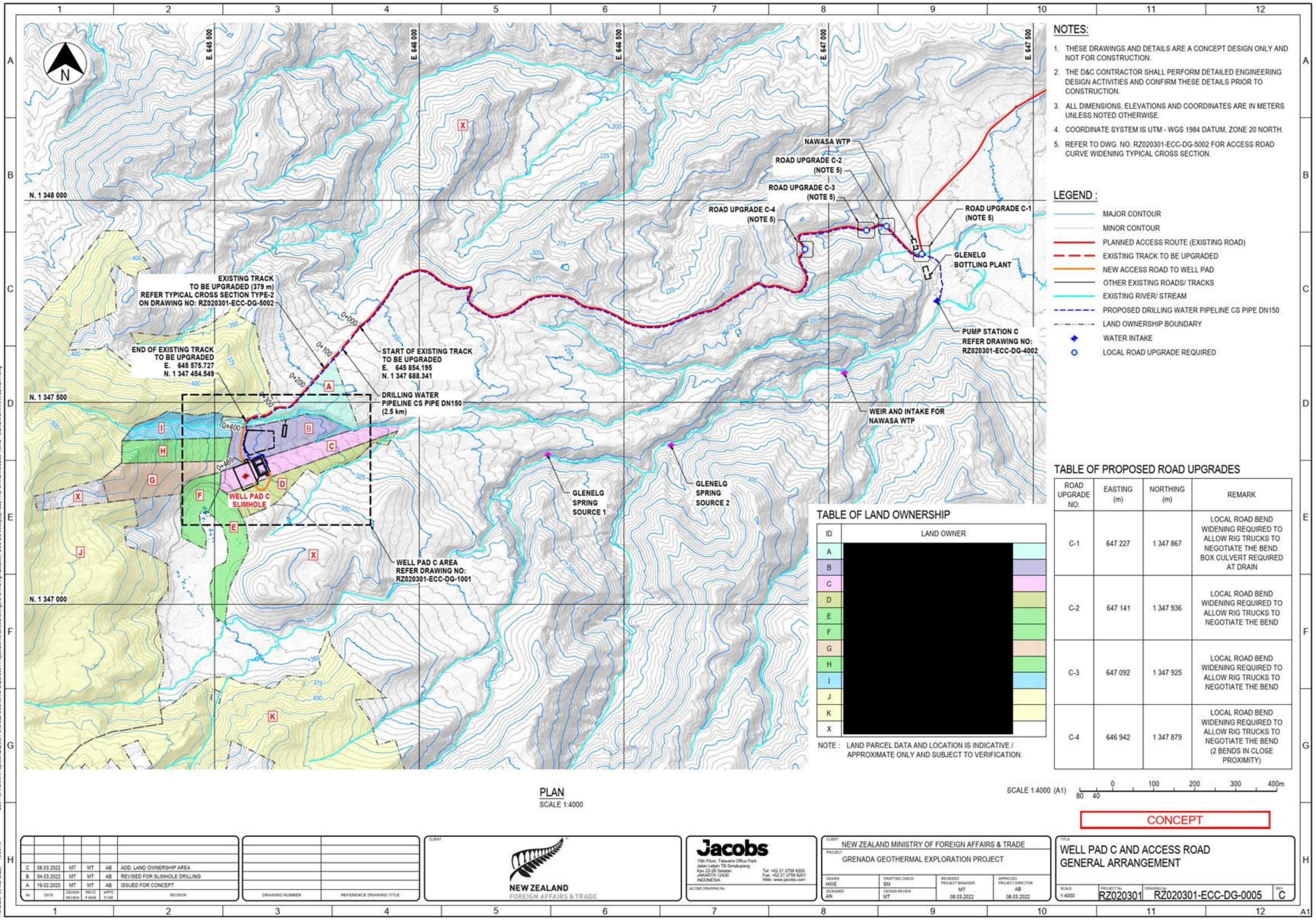
Table 7.8: Summary of lands required at Site F

Land plot #	Land purpose (access road/ water supply / well pad)	Ownership	Total area required (sq ft)
1	Road widening	Privately owned – owner and a caretaker identified	1,506
2	Road widening	Privately owned – owner identified	3,928
3	Road widening	Privately owned – owner identified	7,566
4	Water supply / pump station	Privately owned – owner identified	17,523

Land plot #	Land purpose (access road/ water supply / well pad)	Ownership	Total area required (sq ft)
5	Road widening	Privately owned – owner identified	1,098
6	Road widening	Privately owned – owner identified	2,594
7	Road widening	Privately owned – owner deceased and potential heirs out of State	366
8	Well pad / road widening / new access road	Privately owned – owner identified	435,909
Total			**439,967**

Source: GoG

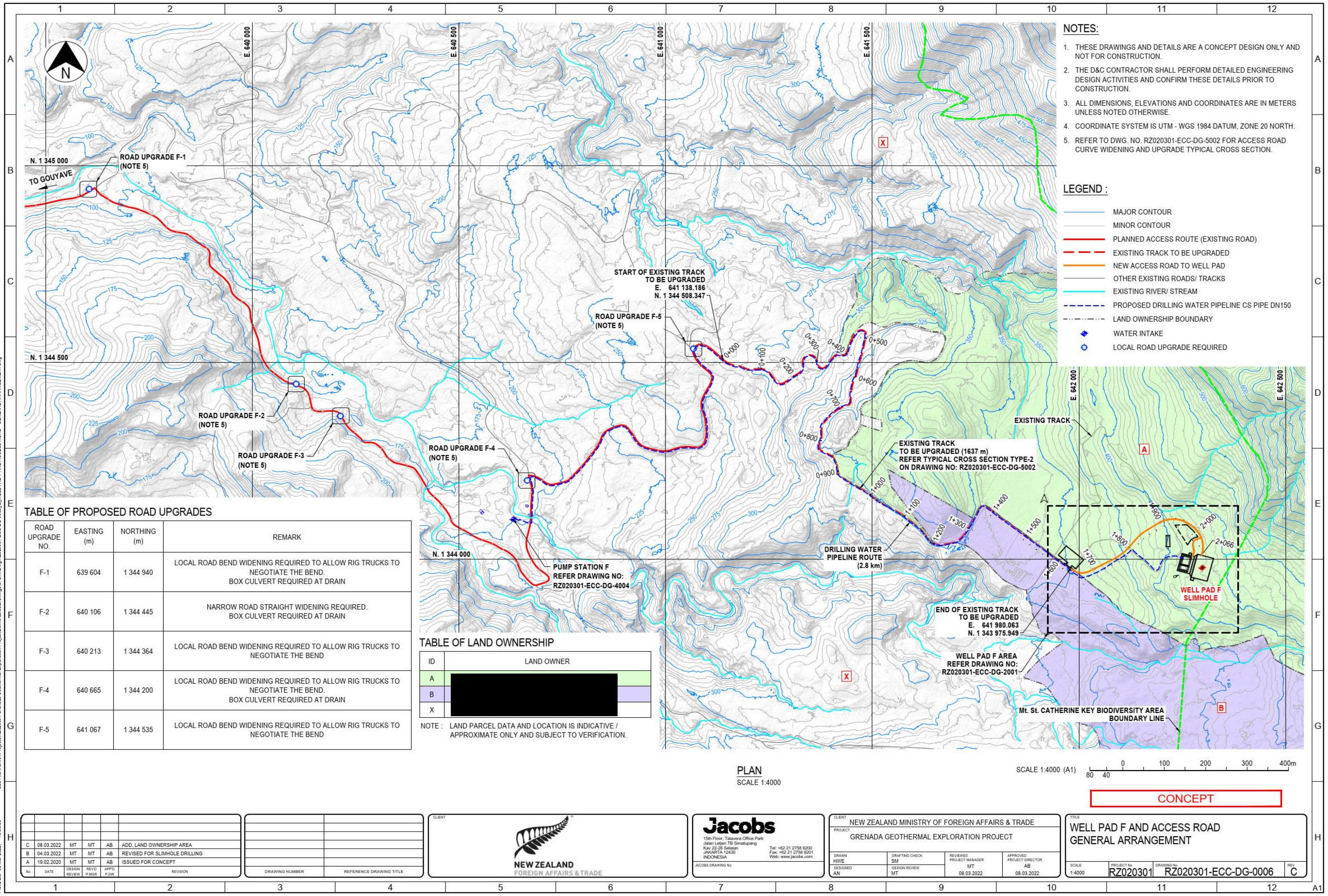
Figure 7.7: Land plots identified at Site C



Source: Jacobs. Well pad C and access road general arrangement. Rev C. 08 March 2022.

Note: Landowner names omitted for data privacy

Figure 7.8: Land plots identified at Site F



Source: Jacobs. Well pad F and access road general arrangement. Rev C. 08 March 2022.

Note: Landowner names omitted for data privacy.

The closest buildings located to Site C are two small day huts both less than 50m from project components. These huts are not residential dwellings but are used by farmers as a resting area. The first day hut is approximately 20m south of the proposed well pad (Figure 7.9). The second day hut is approximately 10m north-west from the proposed well pad and 20m south-west from the proposed spoil disposal (Figure 7.10). There are also a number of residential dwellings located from approximately 200m of the pump station, with the exception of one structure that is located approximately 70m away.

The closest structures to Site F are approximately 700m from the well pad. There is a structure approximately 70m west of the pump station.

Figure 7.9: Farmer's hut (20m south) in Site C

Source: Ecoengineering

Figure 7.10: Farmer's hut (20m south-west) Site C

Source: Ecoengineering

7.4.6 Informal land users

Across the country most informal settlements are located within State land, which corresponds to 10% of land ownership in the Island and is not considered a priority in Grenada's draft national land policy[34].

Some small incidences of the use of State lands required for the project has been identified. Especially farming activities along the right of way of public roads and a small road-side stall on privately-owned land along the proposed access route to well pad F – located within F1 on Figure 7.11 (grid reference C2) The stall is likely to be affected by corner widening, but the structure is dilapidated and unoccupied. Further information is being collated by the GoG to ascertain the number of informal land users who are located on lands required for the project. In these cases, occupancy is unlikely to be legal. Prescriptive rights to land are included in the legislation although there are some rights that can be conferred to illegal occupants that are

[34] Grenada National Land Policy (2019) – Draft: https://climatefinance.gov.gd/wp-content/uploads/2019/10/DRAFT-National-Land-Policy.pdf

able to meet a number of criteria including proof of a minimum number of years of uninterrupted unchallenged occupancy[35].

Figure 7.11: Small road side stall from Gouyave to Well pad - Site F

Source: GoG, 2023.

7.4.7 Ecosystem services

Ecosystem services are considered to be the benefits that people derive from ecosystems. There are four types of ecosystem services defined: (i) provisioning, (ii) regulating, (iii) supporting and (iv) cultural services[36]. In the direct AoI only provisioning and regulating services are present. Observations and information from the baseline data collection were used to help identify the types of ecosystem services utilised within the AoI. Information on ecosystem services at Site C and Site F is provided in Appendix A. Evidence of supporting services has not been found at either site.

Provisioning services used by local communities which occurs within the project AoI are considered to be the following:

- Agriculture
- Animal fodder
- Fishing (personal consumption)

[35] 12 years for occupation of Private Land, 30 years for Crown Land.

[36] Ecosystem services are conceptualised following the Millennium Ecosystem Assessment (MEA, 2005) definition consisting of four categories of ecosystem services: 1) Provisioning services: the goods or products obtained from ecosystems such as food, freshwater, timber, and fibre. 2) Regulating services: the benefits obtained from an ecosystem's control of natural processes such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards; 3) Cultural services: the nonmaterial benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment. 4) Supporting services: the natural processes such as nutrient cycling and primary production that maintain the other services.

- Hunting
- Irrigation
- Washing and laundry
- Jewellery
- Medicinal

Regulating services used by local communities which occurs within the project AoI are considered to be the following:

- Trees planted as windbreaks and shade
- Plants used as nitrogen fixing

Chapter 9 on Water Resources assesses impacts on water resources, including the provision of freshwater from the two nearby streams at Site C. The Mt St. Catherine Draft Environmental Baseline Assessment (2018) concluded that no timber production occurred within the proposed reserve area at the time the assessment was made. The assessment indicated that while nutmeg and mixed-woody agriculture (including cocoa, cinnamon and other tree crops) located at Site F did not guarantee against erosion and flooding they were more stabilising than less permanent crops.

As part of the ESIA data collection on biodiversity, ecosystem services information was obtained for Site F (March 2019) and Site C (April 2023). These results are presented on Appendix A which provide information on different species, their uses and indicate that the project sites provide food, materials and income for local people through agriculture but also other means. In addition, an identification of the medicinal plants existing in Site C and Site F (see Appendix A), which can be used by the inhabitants. The focus groups confirmed that the agricultural activities are seasonal. In addition to the above provisions at the site, there is small fishing in the local rivers for household consumption. At bridge locations, people use the river water for washing, some laundering, and some limited irrigation of crops.

Animals such as armadillos and possums (known locally as tatou and manicou), mona monkeys and the green iguana are hunted and consumed as wild meat. The Mt St. Catherine Draft Environmental Baseline Assessment (2018) identifies that hunting in the potential reserve areas and its surrounding area is widespread, even though hunting is prohibited from January to September. The importance of hunting as a livelihood and/or food source for households is not well understood but assumed to form a small supplementary contribution to some residents' livelihoods strategies. Hunting does not seem to hold any cultural or spiritual significance to local residents.

Sacred trees, rocks or water and cultural ecosystem services have not been identified in the direct area of influence.

7.4.8 Social infrastructure and services

This section considers education levels and schools, health, health services and medical facilities, utility service provision, traffic and road transportation, and recreation.

7.4.8.1 Education

The literacy rate amongst Grenadian citizens over the age of 15 is high, at 98.6%, and there is no disparity between men and women (in 2014)[37]. Most of the economically inactive population[38] between 25 and 64 years of age have not completed primary education[39].

For Tricolar (Site C), there are no schools in the immediate vicinity. The main primary school is located in Hermitage village (Hermitage Government School) which is approximately 4 km away from Tricolar. Most children attend to Sauteurs town (MacDonald College) for secondary school education which is approximately 5 km away.

Florida (Site F) is in the same situation as Tricolar, there are no schools in the immediate vicinity. There is an informal communal day care in Florida where a local resident takes care of several children. The nearest schools are Florida Government Primary School located in Loretto village 4 km away from Florida and St John's Christian Secondary School in Brothers Estate 2 km away from Florida.

In both villages, the students and other community members use the main roads that project vehicles would potentially use to access the well pads.

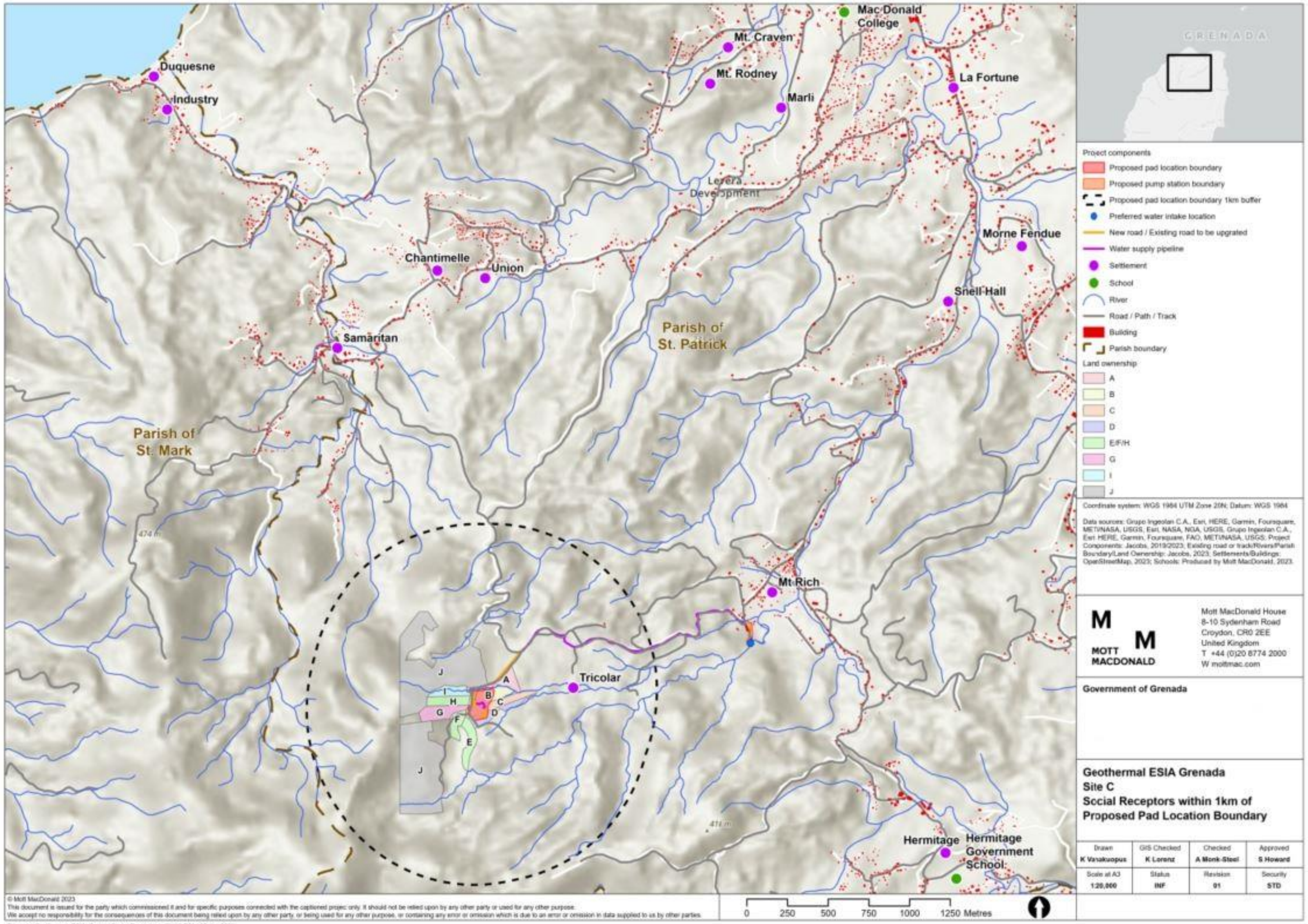
Figure 7.12 and Figure 7.13 show a map of schools in the vicinity of the proposed sites and along the proposed transportation routes.

[37] World Bank: https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=GD. Retrieved 9 May 2023.

[38] Economically inactive population refers to people who are of working age but are not working or not available to work or not actively seeking employment (eg students, certain disabilities or long-term sick, carers, retired people etc.)

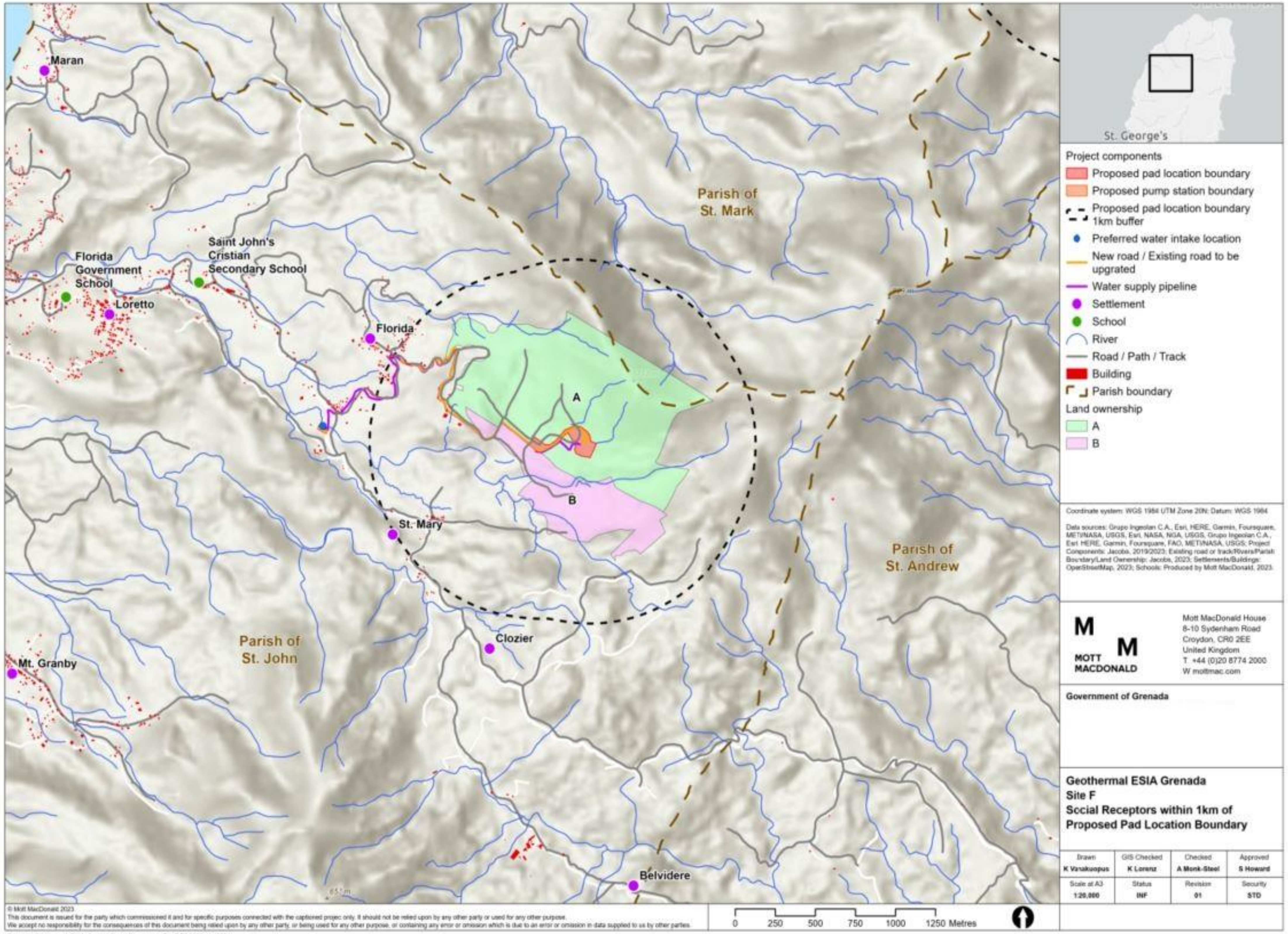
[39] Labour Force Survey 2013-2015 Analysis and Indicators, Grenada CSO and World Bank. Retrieved May 9, 2023.

Figure 7.12: The nearest schools to Tricolar (Site C)



Source: Mott MacDonald

Figure 7.13: The nearest schools to Florida (Site F)



Source: Mott MacDonald

7.4.8.2 Health, health services and medical facilities

In 2019, 83% of deaths in Grenada were due to non-communicable diseases[40], such as cancers, cardiovascular disease, diabetes and chronic lung illnesses. As per PAHO, main communicable diseases are tuberculosis (TB) (0,9 new cases per 100,000 people in 2020) and human immunodeficiency virus (HIV) infection (24,2 new cases per 100,000 people in 2018). We note that, from 2000 to 2019, the HIV infection indicator reduced by 61.6%.

Vector borne diseases such as dengue and chikungunya have in the past been responsible for epidemics in the country. Between 2010–2020 the total number of dengue cases in the wet seasons (June to December) and dry seasons (January to May) were 1741 and 458 respectively, indicating higher prevalence of the disease in wet periods[41]. The patterns in 2013, 2018 and 2020 show, while these were the driest years, the number of cases were higher than in other years. Two factors may explain high number of cases in the drier years: i) frequent sporadic heavy rainfall and ii) poor water storage practices in dry season[42].

The WHO recommends a minimum of 2.5 community health workers per 1,000 people. When looking at the ratios in Grenada (Table 7.9) of different health workers to the general population the country is sufficiently well staffed for nurse and midwives but lacks an adequate number of community health workers and to a lesser extent doctors. Where the physicians and nurses/ midwives are included, of the numbers in Grenada are well below the WHO recommendations with a ratio of 0.4 community health workers to 1,000 people overall in 2003[43].

Table 7.9: Ratio of health workers to general population

Service	Number (per 1,000 people)
Community health workers	0.4 (year 2003)
Hospital beds	3.6 (year 2017)
Physicians	1.4 (year 2018)
Nurses and midwives	3.1 (year 2018)

Source: World Bank

The Ministry of Health provides health services including two hospitals in Grenada and one on Carriacou as well as community health services. Community health services comprise a network of six district health centres and thirty medical stations, spread throughout the country[44]. The Table 7.10 presents the proximate distances between the closest two hospitals and Site C and Site F.

Table 7.10: Proximate distances between the closest two hospitals and Site C and Site F

Hospitals	Site C		Site F	
	Well pad	Pump station	Well pad	Pump station
St. George's General Hospital	34.5 km (60 min on road)	32.5 km (50 min on road)	25.4 km (54 min on road)	23 km (40 min on road)
Princess Alice Hospital	16 km	14 km	12 km	9.5 km

[40] World Bank: https://data.worldbank.org/indicator/SH.DTH.NCOM.ZS?locations=GD. Retrieved 9 May 2023.

[41] Francis K, Edwards O, Telesford L (2023) Climate and dengue transmission in Grenada for the period 2010–2020: Should we be concerned? PLOS Clim 2(6): e0000122. https://doi.org/10.1371/journal.pclm.0000122

[42] Ibid.

[43] World Bank: https://databank.worldbank.org/metadataglossary/all/series. Retrieved 11 May 2023.

[44] United Nations Development Programme. (2016). Grenada Health Sector Strategic Plan 2016-2015 Approved. Retrieved from https://info.undp.org/docs/pdc/Documents/BRB/GRENADA%20Health%20Sector%20Strategic%20Plan%202016-2015%20Approved.pdf Retrieved 9 May 2023.

Hospitals	Site C		Site F	
	Well pad	Pump station	Well pad	Pump station
	(30 minutes on road).	(20 min on road)	(30 min on road)	(20 min on road)

Source: Mott MacDonald, 2023.

In Florida village (Site F) there is a medical station that is not currently staffed, and there is a health centre in the town of Gouyave. Gouyave town also has a police station, fire service and ambulance services. The Hermitage Health Facility (Site C) provides primary health care, vaccinations, dressing of wounds, treatment of small injuries, and pregnancy check-up. A doctor visits the health facility weekly. The health post worker in Hermitage reported that they treat a variety of minor health concerns, but not a lot of respiratory issues. Each parish has its own ambulance.

7.4.8.3 Utility facilities

In Grenada by 2020, 93.6% had access to electricity[45], 99% to mobile telephone service[46] and 57% to internet[47]. Garbage is collected at least twice a week and generally people do not dump garbage in springs or rivers.

Grenada is divided into 3 police divisions and one 1 police district. The towns of Gouyave (close to Site F) and Sauteurs (close to Site C) has a police station[48]. The Fire Department is an arm of the Royal Grenada Police Force (RGPF) and they count with four fire stations, one in the town of Sauteurs (close to site F) and other one in Grenville (close to site C)[49]. The ambulance in Sauteurs services the St. Patrick parish.

People generally cook with liquified petroleum gas (LPG); some use wood that they have collected, and charcoal is also used but mainly for recreational cooking/barbecue purposes.

Figure 7.14: Houses in Florida, the community closest to Site F, are provided with electricity and water services

Source: Mott MacDonald ESIA scoping site visit (March 2019)

Figure 7.15: Water source for Site F is used downstream in the Florida settlement by some people to wash and do laundry

Source: Mott MacDonald ESIA scoping site visit (March 2019)

45 World Bank, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=GD Retrieved 11 May 2023
46 World Bank, https://data.worldbank.org/indicator/IT.CEL.SETS.P2?locations=GD Retrieved 11 May 2023
47 World Bank, https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=GD Retrieved 11 May 2023
48 Royal Grenada Police Force: https://www.rgpf.gd/index.php/divisions-and-departments Last time updated 2023
49 Ibid.

In 2017, 89.9.1% of people in Grenada were using safely-managed drinking water services, 5.7% had access to basic drinking water,3.2% used surface water and 1.1% used water with limited safety[50]. Estimates for 2015 indicate that 96.4% of the population in St. John parish and 98.7% of the population in St. Patrick parish have access to drinking water[51].

A study on gender and water in Grenada[52] identified an unequal division of labour in the household with women shouldering a large burden related to use and management of water. Women use more water since they cook, clean and launder. There can be water supply outages or bad water quality that requires management.

Sanitation facilities data indicates that 63% had access to a septic system, 30% to latrines and 7% had access to a sewer system in 2017[53].

According to women focus groups held in 2019, housing conditions in Florida and Mt Rich/Mt Reuil are generally good with regards to water and sanitation. Florida has electricity and telephone services which generally function. Plaisance Estate has fewer amenities: people live in barracks using communal toilets or latrines, and there is no electricity.

Near Site C, free water is accessible from Glenelg and the springs and rivers are an open access resource. They are not owned by anyone, and everyone is free to use it, with women and men having equal access to this natural resource. Focus group participants said in 2019 that many people use river and spring water for washing and drinking and there can be a preference to use these free sources as opposed to NAWASA pipe-borne water supply.

7.4.8.4 Traffic and road transportation

Grenada has two main coastal highways which travel from the Capital St George's in the southwest, heading along the west coast up to Gouyave, and on the east coast towards St Patrick. Driving is on the left of the road. Public transport is generally limited to small. Privately-owned buses which run on a hail-and-stop basis along main roads or other predetermined routes. No railways exists in Grenada.

Identified receptors include motorist, pedestrians, cyclist and livestock. In general, traffic on road that will be used to access sites C and F is generally low.

The west coast route would be used to transport equipment from the port to site F, which takes approximately 60 minutes in a car. The road is generally of reasonable quality between the port and Gouyave. The road becomes more rural after passing through Gouyave and gradually steeper as the altitude increases.

The east coast road route would be used to transport equipment to site C (Tricolar), around a 90-minute journey from the port. The road is of a reasonable condition, but it becomes more difficult to navigate after passing through Grenville, once the road begins to ascend into the hillier areas towards the site towards Tricolar. The road is of a better surface quality and width than that at site F.

7.4.8.5 Recreation

Recreational facilities in Tricolar include the Mt Rich Playing Field and Community Centre; there are efforts by a local committee to seek funding to renovate it. Florida has a playing field and

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[50] Data retrieved from WHO and UNICEF JMO platform 'WASH'. https://washdata.org/data/household#!/ . Retrieved 9 May 2023.

[51] Labour Force Survey 2013-2015 Analysis and Indicators, Grenada CSO and World Bank

[52] Gender Assessment and Action Plan for a funding proposal to the Green Climate Fund, by GIZ, 2017.

[53] UNICEF: https://www.unicef.org/media/55276/file/Progress. Retrieved 9 May 2023.

community centre. There are no indoor games at the centre which is used primarily for the annual Christmas party and other small social events.

7.4.9 Cultural heritage and archaeology

There are two types of cultural heritage: tangible and intangible. The term "tangible cultural heritage" refers to the physical artefacts that are created, preserved, and passed down between generations. It includes structures, historic sites, monuments, and artefacts, artistic creations, built heritage such as buildings and monuments, and other tangible products of human creativity endowed with cultural significance in a society. Intangible heritage includes nonmaterial intellectual wealth, such as folklore, customs, beliefs, traditions, knowledge, and language. United Nations Educational, Scientific and Cultural Organization (UNESCO) considers a practice, representation, expression, body of knowledge, or skill to be part of a location's intangible cultural heritage.

Grenada does not have any UNESCO World Heritage Sites, however it has three sites (St George Historic District, St George Fortified System, and Grenadines Island Group) on the tentative list[54] none of which are within vicinity of the project's direct AoI for either site.

According to national legal legislation, only two sites have official recognition: the Amerindian Site at the Pearls Airport and the Louis la Grenada Mausoleum at Morne Jaloux (none of them are within direct AoI)[55].

Grenada's system for managing and protecting the country's heritage involves multiple government ministries and organizations, leading to some overlapping responsibilities: the Physical Planning and Development Control Act of 2001 is responsible for both natural and cultural heritage. The Grenada National Trust Act of 1967 grants the Trust the responsibility of establishing museums but does not include the present Grenada National Museum in its purview[56]. Grenada does not have an official inventory of heritage sites, which may limit its ability to protect and promote historical and archaeological sites.

No areas of cultural significance were identified during the ESIA scoping site visit (2019) and the ESIA site visit (2023).

On the main island of Grenada, there are several sites where petroglyphs (rock carvings) are found. One of the main sites is located at Mount Rich, which is approximately 4-5km away from the Site C well pad where there is also the Carib Stone Interpretation Centre, a visitor centre run by Mycedo[57]. The Mount Rich petroglyphs are visible in a deep ravine (refer to Figure 7.16). These petroglyphs are located on the other side of the Mount Rich village approximately 500m from the Site C pump station and over 1 km from the well pad location. The other locations of petroglyphs are in coastal areas. Mount Rich is the only known inland petroglyph site. There is also an ´Amerindian Work Stone´ in the river approximately 125 m downstream of the Site C pumping station location. There are no other known petroglyphs or other aspect of cultural heritage interest located at either of the two well pad sites.

Grenada is one the few Caribbean islands where people have family cemeteries and have ancestors' graves on their private land (refer to Figure 7.17). No private familial burial grounds

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[54] A Tentative List is an inventory of those properties which each State Party intends to consider for nomination.

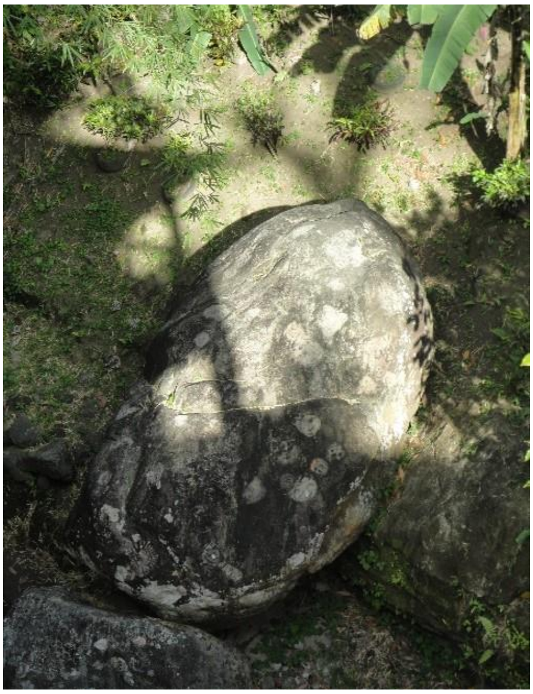
[55] https://oas.org/dsd/IABIN/Component1/ReefFix/Grenada%20Feb25-26.09/Jessamy%20Overview%20of%20Grenada.pdf. Retrieved 10 July 2023.

[56] Ibid.

[57] Mycedo is an Non-Governmental Organization (NGO) interested in development of youth, and organises community clean-ups, after school programs, environmental awareness.

or general cemeteries are located on the well pad Sites or any other land needed for the project[58].

Figure 7.16: Mt Rich petroglyphs



Source: Mott MacDonald, March 2019

Figure 7.17: Ancestral grave on private land

Source: Mott MacDonald, March 2019

7.4.10 Gender, vulnerable groups and human rights

The most vulnerable sectors of the population include people living below the poverty line, women, female-headed households, the elderly, and young people and children. The vulnerable, marginalised, and disadvantaged groups may be differentially impacted by the project or be less able to cope with project impacts than typical community members.

Women and groups considered to have specific vulnerability characteristics are identified in the Table 7.11 below.

Table 7.11: Women and vulnerable groups

Group vulnerabilities	Identification
People living below the poverty line	In 2016, 38% of people in Grenada were living in poverty[59] and 2% were indigent[60]. Grenada has the highest poverty rate among countries in the Eastern Caribbean; significantly higher than the average of 23% for the region[61]. The groups most likely

[58] Grenada Heritage: Cemeteries: https://grenadanationalarchives.wordpress.com/2008/03/01/grenada-cemeteries/. Retrieved 11 May 2023.

[59] People don't have enough to meet their basic needs. World Bank: https://www.worldbank.org/en/news/video/2017/04/14/what-are-poverty-lines#:~:text=People%20living%20below%20a%20poverty,line%20of%20%241.90%20per%20day. Retrieved 11 May 2023

[60] Indigence entails living in a level of poverty in which real hardship and deprivation are suffered and comforts of life are wholly lacking. Retrieved 11 May 2023

[61] Generation Unlimited: the Well-being of Young People in Grenada FACT SHEET. July 2021. https://www.unicef.org/easterncaribbean/media/2961/file/GenU%20Grenada%20fact%20sheet.pdf Retrieved 11 May 2023

Group vulnerabilities	Identification
	to be poor are women, young people and children, older persons, persons with disabilities, and farmers. Economic marginalisation may make individuals and households particularly vulnerable to negative impacts and less empowered to participate in consultation and access project benefits
Women	According to the World Bank collection of development indicators, the CPIA gender equality rating (1=low to 6=high) in Grenada was reported at 3.5 in 2021[62]. Women face multiple and intersecting forms of discrimination such us poverty, gaps on labour and educational opportunities, different kinds of violence, rurality, or areas geographically inaccessible, etc.
Female-headed households	Almost half the households in Grenada (47%) are female-headed. Of these, more than 20% in the rural areas are poor according to the (Core Welfare Indicator), as compared to only 13% of male-headed households. Over half the female heads (56%) are unemployed compared with the male heads where a quarter has no work. Female-headed households tend to be poor due to lower wages and have less access to assets and productive resources compared to men owing to gender bias against women[63].
Elderly	The elderly population were found to be particularly vulnerable with 22.5% characterised as poor[64]. The difficulty of access to stable income and dependence on other family members (mostly women) is what makes this population the main pillars of their vulnerability. In addition, because they do not have a stable income, they are one of the populations most likely to take advantage of ecosystem services and to use subsistence farming systems. Therefore, the possible impact on land access could increase their vulnerability[65].
Young people and children	1 in 2 or 51% of children ages 0-17 and 18% of adolescents ages 10-19 were living in poverty, which is higher than the poverty rate for adults age 18+ years (30%). The poverty rate for young people ages 10-24 is not available because it has yet to be calculated. Grenada child and adolescent poverty rates are higher than the averages for the Eastern Caribbean (33% and 34% respectively)[66]. The Gender Equality Observatory for Latin America and the Caribbean (2021) data shows a decreasing percentage on adolescent women aged 15-19 who are mothers, from 16.1% in 1981 and to 6.6% in 2021[67]. There is no data available on the rate of child pregnancies (i.e., girls aged 10–14 years)[68].

Source: Mott MacDonald (2023)

Poverty of female-headed households in Grenada exceeds the poverty of male-headed households. Gender-based violence is a recognised problem in Grenada and there is gender inequality in terms of income, poverty, family, unemployment, and political participation which hinder national development[69].

[62] World Bank: https://data.worldbank.org/indicator/IQ.CPA.GNDR.XQ Retrieved 11 May 2023

[63] Grenada UPR: Joint Submission from the United Nations Subregional Team for Barbados and the OECS. Annex 3: https://uprdoc.ohchr.org/uprweb/downloadfile.aspx?filename=1482&file=Annexe3 Retrieved 30 May 2023.

[64] Social policies in Grenada (2010): Social Policies in Grenada (ethz.ch) Retrieved 11 July 2023.

[65] Oxford Poverty & Human Development Initiative (OPHI) (2015): OPHIWP092_typosYD Retrieved 11 July 2023.

[66] UNICEF: https://www.unicef.org/easterncaribbean/media/2961/file/GenU%20Grenada%20fact%20sheet.pdf Retrieved 30 May 2023.

[67] Gender Equality Observatory for Latin America and the Caribbean (ECLAC): https://oig.cepal.org/en/countries/72/profile. Retrieved 30 May 2023.

[68] WHO: https://www.who.int/news-room/fact-sheets/detail/adolescent-pregnancy. Retrieved 30 May 2023.

[69] Government of Grenada, https://www.cepal.org/sites/default/files/events/files/grenada_report_-_xii_crm.pdf, retrieved 26 April 2019

According to Grenada Women's Health and Life Experiences Study report[70], a significant number of Grenadian women have experienced different forms of violence. One in every four women in Grenada has suffered physical violence in their lifetime, while nearly one in every ten women has experienced sexual violence. Emotional abuse is the most common form of intimate partner violence, experienced by around three in every ten women. More than two-thirds of women who have suffered physical violence from their partner have endured severe abuse, such as hitting, kicking, burning, or threatening with a weapon.

The abuse often continues during pregnancy, with 5.3% of ever-pregnant women reporting being beaten during at least one pregnancy. Non-partner sexual violence also affects a significant proportion of Grenadian women, with almost one in every four women experiencing at least one form of non-partner sexual violence over their lifetime[71]. Over the past decade, GoG has developed programs to combat gender-based violence including sensitizing youth, increasing the number of services to victims of gender-based violence and rehabilitation programmes for convicted perpetrators.

However, participants of the Mt. Reuil women's focus group held in 2023 considered the abuse to women one of the stresses in the communities, along with lack of parent support, unemployment and children staying home alone after school with no parental care or after-school activities.

Grenada's Gender Equality Policy and Action Plan (GEPAP) (2014-2024) supports the GoG's aim to ensure that men and women benefit equitably for all that society has to offer. Among other items, the GEPAP provides a framework for the full and equal participation of women and men in the development process. The GEPAP guides and informs the gender-responsive policies and plans for both public entities and private sector endeavours.

GEPAP priorities for St. John (Site F) include:

- Need for job creation to address male and female unemployment
- Need to address child abuse

GEPAP priorities for St. Patrick (Site C) are:

- Improve educational opportunities, especially for men
- Need for job creation
- Address gender-based and wider forms of violence

The GEPAP identifies St. Patrick as the parish with the highest poverty headcount (57%), the second highest poverty gap (16%) and second highest poverty severity (7%). in the same year, St. John presented lower numbers with highest poverty headcount 37%, with poverty gap 9% and poverty severity 3%.

The 2022 annual country report on human rights practices in Grenada did not identify significant violations or allegations of human rights although notes that prison conditions are harsh due to overcrowding and the presence of laws criminalizing consensual sexual conduct between men although notes that the law was not enforced[72]. Table 7.12 summarises the findings of the

[70] UN Women (2018) Grenada Women's Health and Life Experiences Study report, https://caribbean.unwomen.org/sites/default/files/Field%20Office%20Caribbean/Attachments/Publications/2021/20210209%20Grenada%20Life%20Experience%20Report%2018%20for%20digital.pdf. Retrieved 12 May 2023.

[71] Ibid.

[72] Grenada - United States Department of State, viewed 10 July 2023

annual report on human rights in Grenada. The Grenada social compact (undated)[73] recognises the rights of every citizen and resident as member of the human family as the foundation of freedom, justice and peace in accordance with the Universal Declaration of Human Rights and other core human rights instruments to which Grenada is a State Party. Social partners are expected to work together to create conditions for sustainable prosperity, including the protection of incomes of working people and the protection of the aged and vulnerable.

Table 7.12: Human rights practices of Grenada

Issue	Description as of 2022
Respect for the Integrity of the Person	No reports on government or its agents committed • Arbitrary or unlawful killings • Disappearances • Torture and other cruel, inhuman, or degrading treatment or punishment, and other related abuses • Arbitrary arrest and detention No political prisoners or detainees were reported
Respect for civil rights	No negative report on government restriction on: • Freedom of expression, including for members of the press and other media • Freedoms of peaceful assembly and association • Freedom of religion • Freedom of movement and the right to leave the country • Protection of refugees
Freedom to Participate in the Political Process	Elections and Political Participation • Recent Elections • Participation of Women and Members of Minority Groups
Corruption and Lack of Transparency in Government	-
Governmental Posture Towards International and Nongovernmental Investigation of Alleged Abuses of Human Rights	Government Human Rights Bodies
Discrimination and Societal Abuses	Women • Rape and Domestic Violence • Sexual Harassment • Reproductive Rights • Discrimination Systemic Racial or Ethnic Violence and Discrimination Children • Birth Registration • Child Abuse • Child, Early, and Forced Marriage • Sexual Exploitation of Children Antisemitism Trafficking in Persons Acts of Violence, Criminalization, and Other Abuses Based on Sexual Orientation, Gender Identity or Expression, or Sex Characteristics • Criminalization

[73] Grenada social compact: https://extranet.who.int/countryplanningcycles/sites/default/files/planning_cycle_repository/grenada/social_compact.pdf retrieved 26 April 2019

Issue	Description as of 2022
	● Violence against LGBTQI+ Persons ● Discrimination ● Availability of Legal Gender Recognition ● Involuntary or Coercive Medical or Psychological Practices Specifically Targeting LGBTQI+ Individuals ● Restrictions of Freedom of Expression, Association, or Peaceful Assembly ● Persons with Disabilities
Worker Rights	Freedom of Association and the Right to Collective Bargaining Prohibition of Forced or Compulsory Labor Prohibition of Child Labor and Minimum Age for Employment Discrimination with Respect to Employment and Occupation Acceptable Conditions of Work ● Wage and Hour Laws ● Occupational Safety and Health ● Wage, Hour, and OSH Enforcement ● Informal Sector

Source: 2022 Country Reports on Human Rights Practices: Grenada[74]

7.4.11 Tourism

Tourism in Grenada is dominated by coastal attractions (such as beaches, sailing, diving and cruises) although there are also limited tourist attractions inland including hiking, agricultural lands (cocoa and nutmeg) and factories (rum distillery). The tourism operators usually offer day trips inland returning to hotels along the beaches.

According to data published by the UNWTO, there were 112 hotels and similar accommodation establishments of this type in Grenada in 2020, mostly located in the southern part of the island in the parishes of St. George and St. David[75]. Grenada's room occupancy rate in hotels dropped to less than 30% in 2020, after staying above 60% the previous two years[76]. This is mostly to be due to travel restrictions imposed by the COVID-19 pandemic.

Although recent data on tourism facilities was not available, in 2018[77] in St. Patrick's parish (Site C) there were four lodgings with a total of 52 beds: one hotel in Sauteurs and three guest houses (one each in Mt Rodney, La Fortune and Sauteurs); and one cottage in Sauteurs. In St. John's Parish (Site F) a total of 10 beds were recorded: one guest house at Mt. Nesbit and an apartment. Rooms cost between $USD 35 and $75 per night.

In the direct AoI there are limited opportunities for tourism and few visitors compared to the rest of the Island. Currently there is more potential for developing tourism around Tricolar and Mt. Rich/Mt. Reuil (the villages closest to Site C), owing to the presence of more tourist attractions and accommodation facilities than in Florida (village closest to Site F). In the vicinity of Tricolar (Site C) there are two tourist attractions: Mt. Rich petroglyphs (800m from the pump station and 2.60km from the well pad, approximately) and the Myristic Mountain nature park (700m from the pump station and 900m from the well pad, approximately). The Mt. Rich Petroglyphs are a series of pre-Columbian petroglyphs, located along the St. Patrick River. The site consists of several boulders carved by ancient Amerindians. They are not included in United Nations Educational, Scientific and Cultural Organization (UNESCO) list of heritage sites but recognized by the Ministry of Tourism. The site is managed by the Mt. Rich Youth Culture and

[74] Country Reports on Human Rights Practices: Grenada - United States Department of State (2022). Retrieved 15 May, 2023.

[75] Statista: https://www.statista.com/statistics/1182781/grenada-number-hotels/. Retrieved 11 May 2023

[76] Statista: https://www.statista.com/statistics/1182789/grenada-room-occupancy-rate/. Retrieved 11 May 2023

[77] Government of Grenada. December 2018 list of accommodation.

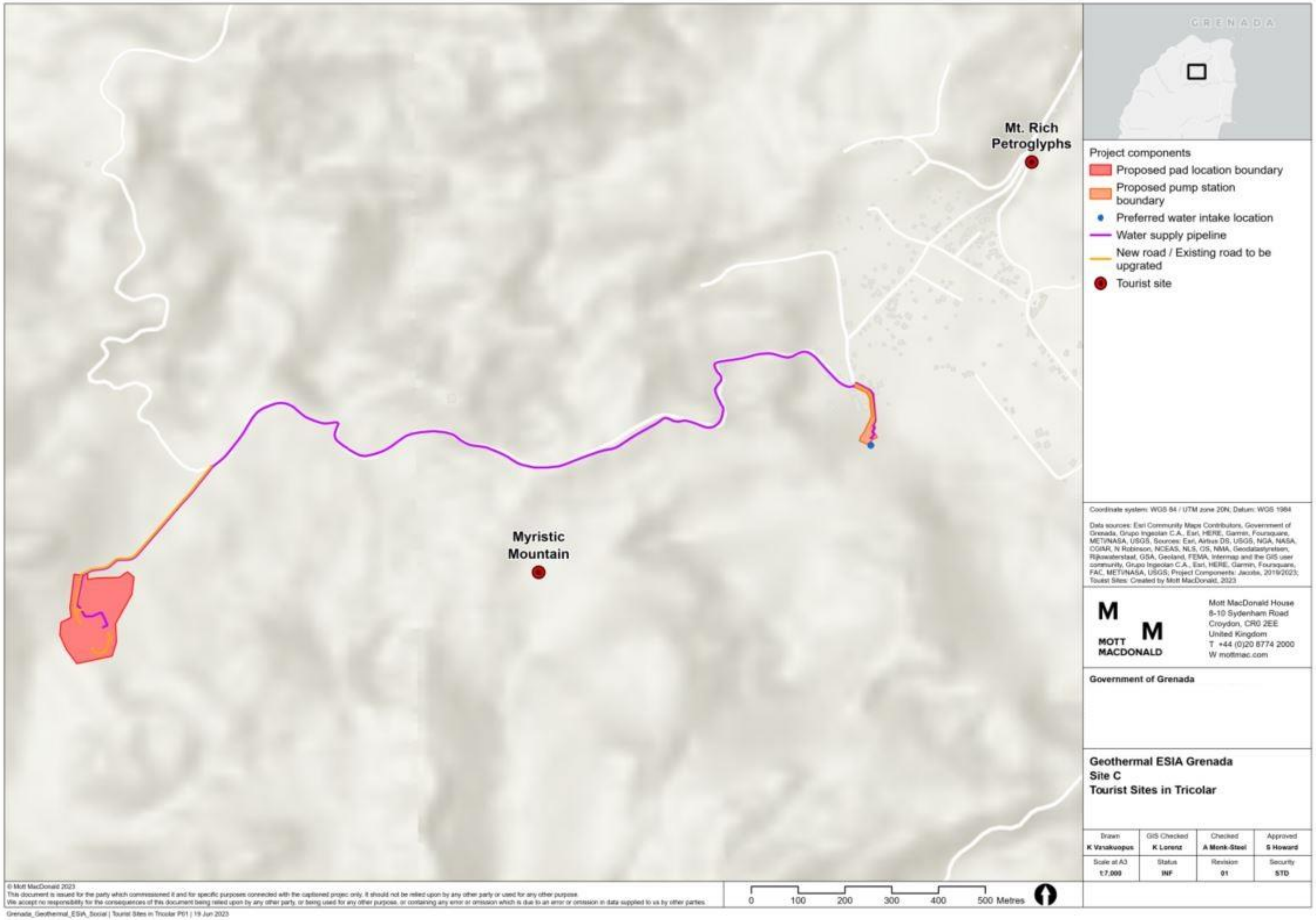
Environmental Development Organization, with an Interpretation Centre and guided tours to visitors. Myristic mountain has hiking trails and hosts a volunteer program on a farm at the foot of the mountains[78]. There are limited options for accommodation nearby, one hotel in Sauteurs, and three guest houses, one each in Mt Rodney, La Fortune and Sauteurs, with a total of 36 beds.

There are no tourism attractions in the village of Florida (Site F) but there are three hiking trails to the summit of Mt. St. Catherine Tufton Hall Waterfalls (1.26km from the well pad, approximately), Hapsack Region (1.43km from the well pad, approximately) and Rainbow falls (2.30km from the well pad, approximately) that could be accessed nearby. Participants in the women's only FGD (2019) informed that there were no tourist facilities available in Florida for tourists in the area and most people accessed the hiking trails from a nearby village (Clozier). There are limited options for accommodations nearby, in the parish of St. John, there is one guest house at Mt. Nesbit and an apartment with a total of 10 beds.

Sites C and F are located in remote areas away from main roads and tourism or archaeological sites of interest (Figure 7.18 and Figure 7.19).

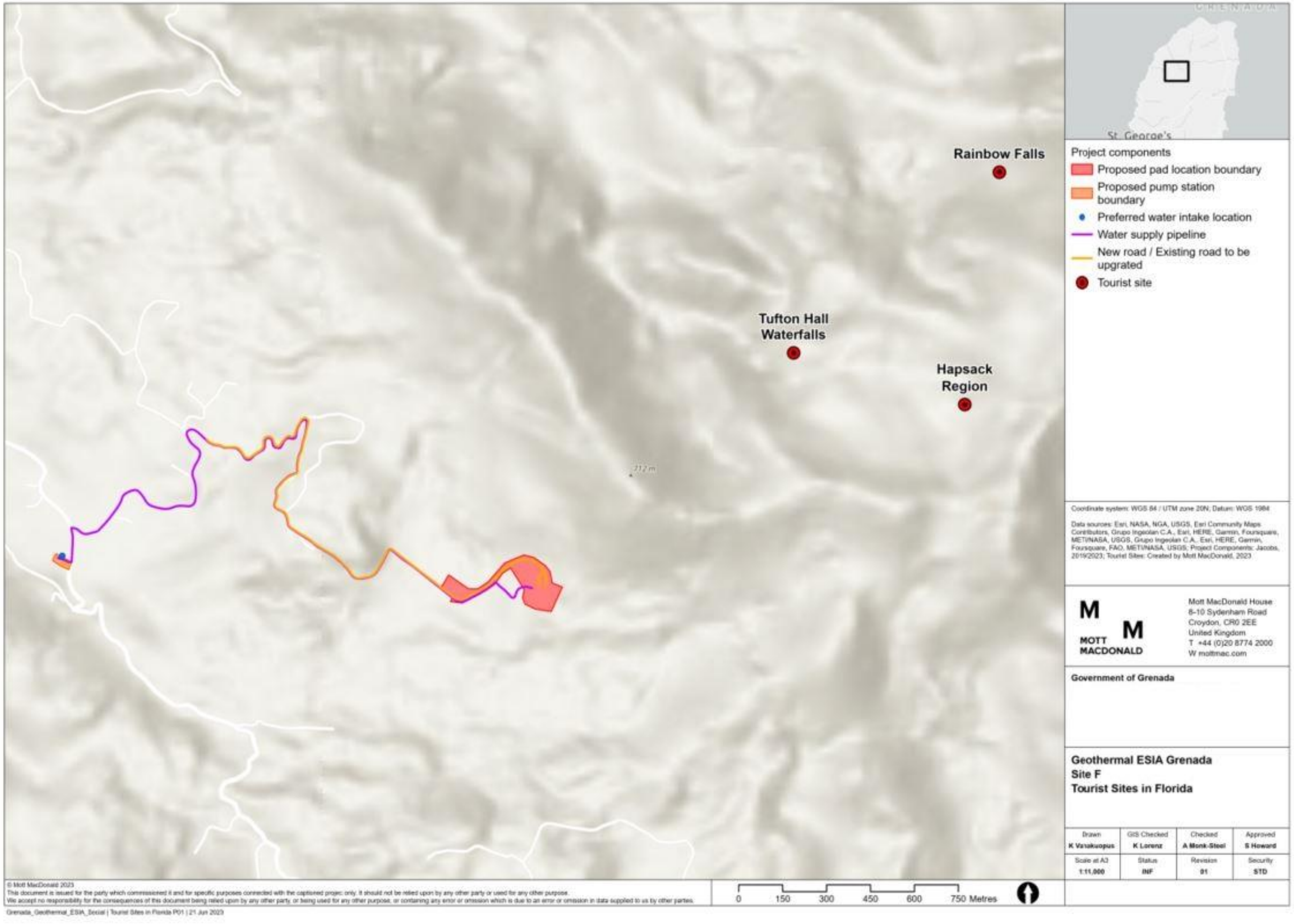
[78] Pure Grenada: https://www.puregrenada.com/voluntourism/myristic-mountain/. Retrieved 11 May 2023

Figure 7.18: The nearest tourism site to Tricolar (Site C)



Source: Mott MacDonald

Figure 7.19: The nearest tourism site to Florida (Site F)



Source: Mott MacDonald

7.5 Assessment of impacts and risks

This section presents the identification and assessment of the following anticipated beneficial and adverse significant social impacts of the project in the planning, construction, operational and decommissioning phases:

- Employment generation and economic development
- Economic displacement and loss of access to ecosystem services
- Damage to known and unknown archaeological sites
- Effects on tourism
- Project induced in-migration
- Improved access due to improvements to road network
- Health, safety and security risks (occupational and community)

A human rights impact assessment is provided in section 7.5.6.

These impacts are discussed in this section, which also identifies mitigation measures for each impact. Section 7.6 provides descriptions of each mitigation measure and section 7.7 outlines monitoring requirements. Section 7.8 describes any residual impacts post-mitigation.

7.5.1 Identification of social groups and resources, and analysis of sensitivity

The total timeframe for the project will be approximately nine months in duration with well pad construction expected to take four months, well drilling and testing for three months and site temporary closure / remediation lasting one month. During that time the project will restrict access to agricultural land resulting in potentially adverse impacts to local livelihoods. Modifications to the existing road network including creation of new access roads will result in improvements for road users while also potentially opening up previously less-accessible areas. The project will provide temporary employment and business opportunities. These impacts are described below for the construction, operational and decommissioning phases. Potentially affected social groups and resources within the study area are described in Table 7.13.

Table 7.13: Social groups and resources, and sensitivity

Social groups and resources	Brief description	Analysis of sensitivity	Sensitivity
Legal landowners and legal tenants	People who own land which will be required for the project or have legal rights to farm on land required for the project permanently or temporarily.	Landowners and tenants with legal titles/ rights to land and/or agricultural land-required for the project are considered to be of medium sensitivity. While they may be reliant on their land and/or farming as a means of livelihood no portion of land will be required entirely and have legitimately recognised rights to compensation.	Medium
Informal landowners and/or land users	Illegal occupants of land required for project components including along the rights of way of roads that will be widened as part of the access route upgrade and includes both farmers and roadside petty traders.	Informal (illegal) occupants are considered to be of high sensitivity as they are likely to rely on farming activities or petty trading (as in the case of one identified roadside stall) as part of their household incomes. Given the high levels of poverty and low levels of education reported in the affected parishes compared to the national average farmers/ petty traders are considered less able to adjust to household livelihoods or find alternatives.	High
Ecosystem services users	People who utilise ecosystem services located on land that is required for construction and operation of project components, such as for medicinal herbs, fishing, clothes washing or bathing and who may have access to those ecosystem services impeded are also considered under economic displacement impacts.	Ecosystem services users are considered of high sensitively as they are likely to have fewer resources to adjust to changes and fewer opportunities to utilise alternative options.	High
Businesses: • Plaisance estate • Glenelg water bottling company[79]	Businesses located within the direct AoI near sites C and F who may be directly or indirectly impacted by construction of access roads, nuisance from construction activities.	These two businesses identified within the direct AoI are considered of low sensitivity as they are either government owned or large scale.	Low

[79] Impacts related to water resources and quality that may affect the Glenelg water bottling company are discussed in Chapter 9 of this ESIA.

Social groups and resources	Brief description	Analysis of sensitivity	Sensitivity
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	Residents, local businesses and social infrastructure in the villages and towns located closest to the project sites	Residents, local businesses and social infrastructure are considered to be of high sensitivity because there is a high level of local unemployment, poverty and dependence on agriculture. It is assumed that the social infrastructure especially health facilities in these villages and towns have limited existing capacity and as such are less able to adjust to increased demands to services attributable to the Project.	High
Residents living along the access routes	Residents of dwellings along access routes that will be used by the project for transport of workers, project components and supplies.	People who live along the access routes are considered to be of high sensitivity as they have low capacity to mitigate the impact (caused by increase of traffic and transport of large project components and workers) or adapt to the changes caused.	High
Road users - local	Local road users along the access road to well pad and pump station C, which will be reached via Gouyave. Local road users along the access road to well pad and pump station F, which will be reached via Sauteurs. People travelling through the project AoI, including pedestrians and cyclists.	Motorists, pedestrians/ cyclists /livestock are considered to be of high sensitivity to changes on the road network as existing volumes of road traffic are low and where no access road exists.	High
Road users – regional	Road users from the port at St Georges to Gouyave and Sauteurs.	The existing roads are of good quality and as such any changes to the road network are not expected to be significant.	High
Archaeological sites – known and unknown	There are no known archaeological sites located within 500m of the footprints of the project.	Potential damage to unknown archaeological sites is considered irreparable.	High
Tourist attractions and visitors to tourist attractions in the direct AoI	There are no known tourist attractions located within the footprints of the project. The closest site (Mount Rich, petroglyphs) is approximately 500m from the pump	Potential damage to known archaeological sites would be considered irreparable whereas damage to other sites such as	High (tourist attractions)

Social groups and resources	Brief description	Analysis of sensitivity	Sensitivity
	station and more than 1km from Site C well pad.	hiking trails are considered remediable with alternatives options available.	
	Visitors travelling to the sites located near to Tricolar and Mt. Rich/Mt. Reuil (Site C), or Florida (Site F).	Visitors are mostly likely to be international tourists who are travelling for day trips.	Low (visitors)
Non-local skilled professionals, regional and national businesses, and citizens of Grenada	Non-local skilled professionals that will be employed by the project, national businesses, and highly skilled citizens of Grenada	Better able to access the limited opportunities for skilled employment and larger more established professional providers.	Low
Project workers	People who work on the project.	Skilled workers will be educated professionals who will be better able to ensure adequate labour rights and working conditions and experienced in working to required standards associated with health and safety.	Low
		Unskilled workers (mostly expected to be manual labourers) are less likely to have experience of working to required international safety standards and are more at risk of occupational H&S accidents and injuries. They are also less likely to be educated and able to assert their labour rights and adequate working conditions	High

Source: Mott MacDonald

7.5.2 Summary of changes, impacts, and social groups and resources

This section presents the identification and assessment of the following effects of the Project during construction, operation and decommissioning along with the key receptors associated with each activity, summarised in Table 7.14.

Table 7.14: Potential impacts and affected social groups and resources

Potential change	Phase	Key issues / impacts and potential effects	Social groups and resources which will be affected by the change
Temporary employment generation	Construction	Of the job opportunities, a small number are expected to be unskilled position with fewer skilled technical and managerial roles. Unskilled jobs will include labourers and the provision of services for workers such as food and refreshments, providing workers accommodation etc. A key social effect will be the provision of an income source for workers and their families contributing to their well-being and enhancing their quality of life. The labour pool for unskilled job opportunities will likely come from the direct AoI. Indirect or induced employment generation will create income generating opportunities for businesses in the project supply chain and supporting industries in the wider AoI through providing construction materials and equipment such as gravel/sand, cement, and personal protective equipment (PPE) as well as services to workers (eg groceries, restaurants, transportation).	Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) Non-local professionals, national businesses, and citizens of Grenada
	Operation	The operational phase is expected to generate fewer direct employment opportunities with very few unskilled positions available that could be taken up by local residents.	As for construction
	Decommissioning	The activities of the various site restoration works are deemed to be similar to the ones from the site establishment phase.	As for construction
Economic development	Construction	The procurement opportunities available for businesses is expected to be limited in Grenada. Sand and gravel are expected to be to sources from outside the country. Local community enterprises and start-ups are expected to face challenges in being able to compete with larger and more established professional providers to access the limited in-country higher value services and supplies. The impacts on local tourism are expected to be negligible given the distance of the project from tourism sites within the direct AoI. Benefits to the wider economy (ie Grenada) will not be very perceptible but are expected to include increased income for workers and businesses from the provision of specialists' services and materials (eg quarry material, cement, personal protective equipment (PPE).	Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) Non-local professionals, national businesses, and citizens of Grenada
	Operation	Similar to construction impacts although fewer opportunities are expected during this phase.	As for construction
	Decommissioning	Similar to construction impacts.	As for construction

Potential change	Phase	Key issues / impacts and potential effects	Social groups and resources which will be affected by the change
Land acquisition and economic displacement	Construction	No residential structures have been identified near to the drill pad locations as such no physical displacement is expected. The project is expected to result in temporary loss of land and access to land for landowners and farmers on the drill pads and permanent land loss for land required for the new access roads for the duration of the project. Individuals who are currently using government land along the right of way of roads will experience permanent loss of access to land and potentially loss of existing crops. There may be some informal land uses who have no recognised title. This is most evident along the roads. In total, the following categories of potentially economically displaced Project Affected Person (PAPs) have been identified: 1. Legal landowners and legal tenants 2. Informal land landowners and informal land users 3. Ecosystem services users	Legal landowners and legal tenants Informal landowners and/or land users Ecosystem services users
	Operation	Further impacts on land acquisition and economic displacement are not expected during operations	Not applicable
	Decommissioning	Once the project has been decommissioned it is expected that most land required for the drill sites will be rehabilitated and can return to existing land uses. The land required for the upgraded roads and new access roads will not be rehabilitated and so the land loss will be permanent.	Not applicable
Damage to known and unknown archaeological sites	Construction	There are no known archaeological sites located within 500m of the footprints of the project but the presence of as yet unidentified artifacts or sites of archaeological and/or historical importance cannot be ruled out that could be accidentally damaged during construction activities.	Archaeological sites – known and unknown
	Operation	Since no further disturbance of land is expected during operations the risk of accidentally uncovering archaeological artefacts or sites of importance is expected to be negligible	Not applicable
	Decommissioning	There is a small possibility that during the decommissioning activities hitherto undiscovered artefacts or sites may be discovered although the likelihood of this is low given that no new areas of land disturbance are expected.	Archaeological sites – known and unknown
Changes to tourism and tourism potential in the direct AoI	Construction	There are limited tourism activities occurring in the direct AoI and the potential is underdeveloped. Construction activities that would generate nuisance (such as noise or dust) or landscape/visual impacts are located far away enough not to have a direct effect on sites. Construction traffic could utilise the same roads that visitors use but the expected volume of traffic is not considered to be sufficient to result in inconvenience or increase risk of accidents and/or incidents to visitors.	Tourist attractions and visitors to tourist attractions in the direct AoI

Potential change	Phase	Key issues / impacts and potential effects	Social groups and resources which will be affected by the change
	Operation	The potential impacts during the operations phase are expected to be less noticeable such as fewer project vehicles on the road. Nuisance effects from noise or air pollution are not expected to impact the known tourist sites/attractions.	Tourist attractions and visitors to tourist attractions in the direct AoI
	Decommissioning	Similar impacts associated with the construction phase although it is over a shorter duration (one month only) and with fewer vehicles expected on the roads.	Tourist attractions and visitors to tourist attractions in the direct AoI
Health, safety and security risks: Risks to workers	Construction	The key OHS risks for the construction phase, include: • Exposure to physical hazards from use of heavy equipment • Trip and fall hazards • Exposure to dust, noise and vibrations • Falling objects • Exposure to hazardous materials; and exposure to electrical hazards from the use of tools and machinery • Environmental hazards adverse weather conditions, such as working in extreme heat, storms, strong winds, or heavy rainfall • Psychological hazards including high-stress work environments or fatigue • Risks specific to the project location include exposure to extreme heat and hazards associated with working on or near roads. Workers involved in vegetation clearance are at greater risk of snake bites.	Project workers
	Operation	Similar risks to workers during the construction phase with additional risks associated with geothermal exploration drilling include blowouts, gas and vapor leakage (geothermal brine), fuel spills or leaks, sewage spills, and agricultural fires and burns.	Project workers
	Decommissioning	Similar risks to those associated with construction phase.	Project workers

Potential change	Phase	Key issues / impacts and potential effects	Social groups and resources which will be affected by the change
Health, safety and security risks: Risks to communities	Construction	While it is not predicted that the Project will result in accidents and transmission of disease among community members, the Project does create potential risk for their occurrence. These risks and associated hazards require management measures. During construction, if not mitigated the following activities could cause disturbance or impact the health safety and security of land users, neighbouring villages and local community members: ● Project truck and vehicle movements will increase existing traffic volumes. See Chapter 13: Traffic and Transportation for details. ● Nuisance impacts from increased noise, vibration and dust related to construction activities. See Chapters 10: Noise and 11: Air Quality for more details. ● Construction site storage and use of hazardous materials. See Chapter 14: Waste and Materials Management for details. ● Potential diseases and infections passed from workers to local community, in particular HIV/AIDS and other sexually transmitted infections as a result of the presence of a migrant construction labour force population. ● Harm caused through use of inadequately trained security personnel.	Legal landowners and legal tenants Informal landowners and/or land users Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) Residents living along the access route Road users – local Road users – regional
	Operation	Similar risks to those associated with construction phase as well as specific risks associated with geothermal exploration drilling include blowouts, gas and vapor leakage (geothermal brine), fuel spills or leaks, sewage spills, and agricultural fires and burns	Legal landowners and legal tenants Informal landowners and/or land users Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) Residents living along the access route Road users - local Road users – regional
	Decommissioning	Similar risks to those associated with construction phase	Legal landowners and legal tenants Informal landowners and/or land users Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) Residents living along the access route Road users - local Road users - regional

Potential change	Phase	Key issues / impacts and potential effects	Social groups and resources which will be affected by the change
Project induced in-migration	Construction	The small size and nature of this project makes it less likely that opportunistic economic migrants will be attracted to the area looking for employment opportunities with this project The project will result in a barely perceptible temporary increase in the direct AoI population and is not expected to result in increased pressure on local services or markets for local goods and services although it could contribute to perceptions that local people are not sufficiently benefiting from employment opportunities and create conflict between the local community and non-local workers. The demands on electricity, water supply and solid waste collection will not increase significantly as the project is expected to supply its own requirements.	Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)
	Operation	As for construction	As for construction
	Decommissioning	As for construction	As for construction
Improved access due to upgrades to existing road network	Construction	Potential impacts on local road users and local people due to increased project traffic and upgrades to the road network are already assessed in chapter 13 Traffic of this ESIA.	Not applicable
	Operation	Improvements to the existing road network through upgrades to existing roads and creation of new roads to the pads will improve access for local people particular local farmers to their land plots. This could be considered as both a positive and adverse effect through improved journey times but could present risks of theft and increased access to illegal hunting and logging activities.	Legal landowners and legal tenants Informal landowners and/or land users Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) Residents living along the access route Road users - local Road users – regional
	Decommissioning	Not applicable as roads will not be decommissioned	Not applicable
Tourism	Construction	The direct AoI supports limited tourism activities. The well pads at sites C and F are located sufficiently far away enough to not impact on the landscape characteristics or noise that could affect future tourism potential. During the ESIA consultation local residents in the direct AoI identified concerns regarding potential project impacts on tourism (discussed in Chapter 5) which will need to be addressed through direct engagement.	Tourist attractions and visitors to tourist attractions in the direct AoI
	Operation	the impact of the project during construction will be negotiable. It is expected that once operational the well pads will remain of negligible impact to the closest sites located near to Tricolar and Mt. Rich/Mt. Reuil (Site C), or Florida (Site F).	Tourist attractions and visitors to tourist attractions in the direct AoI
	Decommissioning	Same as for operations	Tourist attractions and visitors to tourist attractions in the direct AoI

Potential change	Phase	Key issues / impacts and potential effects	Social groups and resources which will be affected by the change
Human rights risks	Construction	Potential and actual impacts on workers' and local people's rights are summarised in Table 7.15 to Table 7.19	All social groups and resources listed in Table 7.13 and Table 7.14
	Operation	Potential and actual impacts on workers' and local people's rights are summarised in Table 7.20 and Table 7.22	All social groups and resources listed in Table 7.13 and Table 7.14
	Decommissioning	Potential and actual impacts on workers' and local people's rights are summarised in Table 7.23	All social groups and resources listed in Table 7.13 and Table 7.14

7.5.3 Analysis of construction impacts

7.5.3.1 Employment generation and economic development

The project duration is expected to be nine months and will employ approximately 65 - 75 workers including foreign and national workers for the duration of the project. The construction workforce is expected to require 30-40 workers over a three-month period. Approximately 50% of these positions are expected to be skilled. The remaining 50% are expected to be unskilled positions. Unskilled jobs are expected to include manual work (i.e.: pushing wheelbarrows, lifting and laying pipework).

Indirect or induced employment generation will create income generating opportunities for businesses in the project supply chain and supporting industries in the wider AoI through providing construction materials and equipment such as gravel/sand, cement, and PPE as well as services to workers (eg groceries, restaurants, transportation).

Opportunities for unskilled workers during the project are expected to be small and temporary. Based on data presented in the socio-economic and cultural baseline, the people living in the direct AoI lack skills that could be easily applied to technical drilling positions. Direct employment benefits are expected to be negligible compared to the total working age population in the direct AoI, without vocational training. It is however possible that the skills and experience gained during construction phase will benefit future job prospects where workers develop new skills or enhance existing skills.

Given existing cultural attitudes, it is less likely that women will apply for employment opportunities that involve work considered to be manual labour. Therefore, local employment opportunities are even less likely to be offered to female applicants. In addition to possible gender bias, during the recruitment process, there is the potential for female workers to experience sexual harassment within the work environment.

Impact of local employment

It is expected that the project’s construction phase positive impact on local employment will be of negligible magnitude, because of the small number of unskilled, temporary jobs to be created over three months that would be available to local people (approximately 15 to 20 positions). The sensitivity of local people who are employed is considered high given that most residents may lack skills and experience to capture skilled and higher paid employment opportunities. Combining the expected characteristics of the impact of local employment with the sensitivity of the receptor creates a minor impact, which is not considered significant.

Impact on local economy (opportunities for in-country procurement and local businesses service providers)

The procurement opportunities available for businesses is expected to be limited in Grenada. Sand and gravel are expected to be sourced from outside the country. Local community enterprises and start-ups are expected to face challenges in being able to compete with larger and more established professional providers to access the limited in-country higher value services and supplies. The impacts on local tourism are expected to be negligible given the distance of the project from tourism sites within the direct AoI. As such the indirect economic impact on local people reliant on tourism as a livelihood activity is expected to be negligible. It is expected that the project ’s impact on the local economy will be of negligible magnitude, due to limited contracts available and local businesses being limited in their ability to access higher value contracts and the small number of employed local workers. The sensitivity of the receptors (i.e. local communities and businesses) are considered as high. Combining the expected characteristics of the impact on local economy with the sensitivity of the receptor creates a negligible impact, which is not considered significant.

National economy development

Benefits to the wider economy (ie Grenada) will not be very perceptible but are expected to include increased income for workers and businesses from the provision of specialists' services and materials (eg quarry material, cement, PPE. Recipients of skilled employment are expected to be local and non-local professionals who already have the prerequisite skills and experience needed for the specific technical positions that are available. The sensitivity of these receptors (ie workers and regional businesses) is considered low. It is expected that the project's impact on the national economy will be of negligible magnitude due to the small size of the project's procurement needs and short project duration. Combining the expected characteristics of the impact on national economy with the sensitivity of the receptor creates a negligible impact, which is not considered significant.

Table 7.15: Analysis of impacts of change on specific social groups and resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	During the construction phase it is expected that 30-40 people will be employed with approx..50% skilled positions. Local employment will provide a source of income for households on a temporary basis. Provision of an income source for any local workers and their families will contribute to their well-being and enhancing their quality of life. Opportunities for local employment are expected to be very limited Opportunities for women to be engaged are considered to be further limited.	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: high Significance of impact: minor	SE2 SE3 SE4 SE7	Preferential hiring from the project affected areas will maximise local employment opportunities	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: high Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should enhance the probability of change from medium to high. However, magnitude remains negligible and significance remains minor.
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	There will be limited opportunities for in-country procurement and local businesses service providers are expected to face challenges in being able to compete with larger and more established professional providers to higher value services and supplies. Some local opportunities such as provision of accommodation, local transport and groceries/meals are expected to be available.	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible	SE2 SE3 SE4 SE7 SE-E1	Provision of local content support measures will maximise opportunities for local businesses to capture economic opportunities from the project Development and distribution of a tourism brochure to promote existing tourist sites as well as hotels and restaurants in the area for workers and visitors to the project site	Parameter judgement Nature: positive Magnitude: minor Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should enhance the magnitude of change and

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
					significance from negligible to minor.
Non-local professionals, national businesses, and citizens of Grenada	Benefits to wider economy in the indirect AoI will be limited as main materials procured will be sources from outside Grenada. Some benefits will accrue from increased income for workers and businesses from employment and procurement opportunities.	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: national Probability: medium Sensitivity of the social group or resource: low Significance of impact: negligible	SE2 SE3 SE4 SE7	May including requirements for national procurement where feasible so that national economic benefits can be maximised to the extent this is possible	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: national Probability: high Sensitivity of the social group or resource: low Significance of impact: negligible The implementation of the proposed mitigation measures is not expected to change the significance of the impact which will remain negligible.

7.5.3.2 Economic displacement and loss of access to ecosystem services

Prior to commencing construction, it is expected that activities will comprise mainly those associated with project planning and permit application for the project sites including negotiating and securing access to land required for access roads. During the construction phase site preparation activities including construction of the well pads and pump stations at sites C and F are expected to result in temporary economic displacement arising from temporary land clearance and/or restrictions in accessing livelihood resources which are not expected to extend beyond the duration of the project. A small portion land is expected to be required permanently for the construction of new access roads to the well pads and the widening of public roads to accommodate construction vehicles.

Based on site reconnaissance and data collection, no residential structures were identified on any areas that would be required for construction of project components. . There are residential dwellings close to the public road, in particular when passing through Tricolar down to Tivoli. At Site F, there are several buildings located near to the access track (which would be upgraded) leading from the public road to the well pad location – most of these are the Plaisance estate buildings. Houses and schools are located near the access road from the site to Gouyave. These residential and other properties may experience nuisance impacts from dust and noise, but this will not be sufficient to require their relocation. These nuisance effects are assessed in the respective air quality chapter (Chapter 11) and noise and vibration chapter (Chapter 10). Physical displacement is therefore not expected.

Within 50 m of the well pad at Site C there are two day-huts used by farmers which will need to be compensated and removed. These are not residential dwellings.

The project will require 67,892 m^2 (6.8 ha) land for the well pads, road widening and pump station of which 4,358 m^2 (0.4 ha) are State land and 63,534 m^2 (6.4 ha) are privately owned[80]. Land required for the creation of the well pads and pump station will be leased. Land take for the roads will be permanent and as such land acquisition will be required: approximately 4,016 m^2 for Site C and 1,584 m^2 for Site F.

To date, the GoG has identified 18 owners, including the State, and four owners not yet identified. All owners at Site F have been identified. Land lease agreements are the preferred means for acquiring land access although expropriation is an instrument available to the project should it be required. Private land use is mostly small-scale commercial agriculture (eg. cabbage, potatoes, carrots) and commercial harvesting of nutmeg, pineapple and bananas. No animal husbandry was observed during the site reconnaissance. Based on FGD results in 2019 and 2023, women comprise the majority of farmers around the vicinity of the well pads. From FGDs held in 2023, most farmers are lessees who pay owners to use land plots. Individuals who are currently using government land along the right of way of roads will experience permanent loss of access to land and potentially the loss of existing crops.

One business structure (a road side stall) has been identified within the right of way along the side road off the main road to Gouyave which will be widened to facilitate access to Site F. This stall will need to be relocated.

The project is expected to result in the temporary loss of 62,292 m^2 land access for landowners and farmers on the drill pads, pump station and other supporting components (such as temporary laydown areas during construction).

There may be some informal land users who have no recognised title. This is most evident along the roads where it is likely that an as yet unknown number of people are engaging in farming activities with one petty trading stall also identified at the road junction from the amin

[80] Includes land whose ownership has not yet been determined but assumed to be privately owned.

road to well pad F. Under Grenadian laws these users may be illegal with no provision for compensation although some recognition of illegal occupancy is provided under the national tenure systems. This is further described in the Livelihood Restoration Framework (LRF) in Volume IV of this ESIA report.

The following categories of economically displaced Project Affected Persons (PAPs) have been identified on this project as follows:

- legal landowners and legal tenants
- informal landowners and/or land users
- ecosystem services users

The State is not considered as an economically displaced entity in this assessment as it is assumed that sufficient mechanisms already exist to deal with acquisition of government owned land for the purpose of this project.

Economic displacement – legal landowners and legal tenants

The number of legal landowners and legal tenants is still being determined by the GoG. The GoG has gathered evidence of ownership for most of the private land owners and only three plots remain unknown at this time (July 2023).

Under the existing national tenure system those with formal rights to land (as owners or users) will be in a stronger position to negotiate for compensation under existing compensation processes. At this time, it is assumed that all formal landowners will be compensated through land lease agreements to be negotiated although if negotiations fail the landowners could be subject to expropriation procedures.

Two caretakers have been identified at two land plots at site F. A legal review by the GoG is required to determine if under national law these individuals would be entitled to a degree of protection and/or compensation should they lose their employment, although this is considered unlikely as no whole plot is required for the project.

Tenants with legally recognised rights are expected to afford a degree of compensation regarding any loss of livelihoods. The sensitivity of legal owners and tenants is considered to be medium. As although they may be reliant on their land and/or farming as a means of livelihood, no portion of land will be required entirely, and these PAPs have legitimately recognised rights to compensation. The level of compensation available will need to be determined against the IFC PS5 requirements for full replacement costs. This is discussed further in the LRF (Volume IV). The impact magnitude for economically displaced legal landowners and tenants is estimated to be minor as, based on available information, there are likely to be a small number of affected people and at this time it is not expected that any landowner will lose access to their whole land parcel. The loss of income from farming activities will be of short-term as the land is expected to be returned to near baseline conditions with the exception of the land required for access road improvements and road creation which is expected to be permanent. The impact of the Project on the livelihoods of legal landowners and tenants is considered of minor significance.

Economic displacement – informal landowners and/or land users

Informal occupants of state-owned or private land (especially along the rights of way for roads) are less likely to be entitled to receive compensation under existing national requirements. Identification of informal land users at the two well pad sites, at the pump station locations and at the road upgrade locations is in progress.

A case in point is one local shop that has been identified along the road to be widened to facilitate access to Site F. The shop is located in the right of way (RoW) on land owned by the GoG where land will be required for road widening. This stall owner is considered for this assessment to be an informal occupant of the land. If informal owners or users are identified and viable alternative land is not easily available, farmers they may experience loss of livelihoods if they are unable to continue with their activities for the duration of the project, and the normal arrangements under local law and practice would need to be made in such cases.

At site C, three government land plots are being farmed by individuals or entities that are yet to be confirmed and no information has been gathered on land use of two other government plots. Similarly, no information is yet available for the three land plots whose ownership remains unknown. In summary, there is pending information to be collected on informal landowners and/or users who will be affected by the project's activities.

The sensitivity of informal landowners and/or land users who will be economically displaced by the drilling activities or road access activities is considered to be high because they have fewer rights under existing tenure system. It is assumed that they have fewer economic resources to adapt to changes and are more likely to be reliant on the land for food security and livelihood. The loss of income from farming activities will largely be temporary as the land is expected to be returned to near baseline conditions with the exception of users who are located on land that is or would be required permanently for the project (ie: at road widening locations). Potential loss of income for the stall owner could be permanent if an alternative location cannot be identified and assistance provided to relocate. Although the numbers of potentially displaced informal landowners and land users are not yet known it is conservatively estimated to be higher than legal owners and tenants and as such the magnitude is determined to be moderate. The impact of the Project on the livelihoods of informal landowners and tenants is considered of moderate significance and therefore a significant impact.

Loss of access to ecosystem services

In addition to the provisioning of ecosystem services discussed above (agricultural services), other services are utilised by local residents including medicinal plants, firewood, fishing and use of water sources for bathing and laundry. The sensitivity of people utilising ecosystem services is considered to be high. The construction of the project components may result in loss of some of these services (eg medicinal plants firewood) but there are likely to be alternative locations for gathering. Destruction of trees is to be avoided to the extent possible and as such impacts are expected to be minimal. The project impacts on local rivers that people use for fishing, washing and bathing (discussed in Chapter 9 Water resources and quality) are also expected to be minimal. The magnitude of impacts on ecosystem services is considered to be negligible. The impact of the Project on ecosystem, service users is considered minor and therefore not significant.

Table 7.16: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Legal landowners and farmers legal tenants	Landowners will lose access to land required for the construction of the project including temporary and permanent land requirements. Landowners will be engaged in negotiations for land lease agreements although the GoG is able to expropriate land should it be required. Land users from villages and settlements in the direct AoI (Gouyave and Florida towns, Site F, and Grenville and Tricolar, Site C) with recognised rights on the land (eg., tenant farmers) will temporarily lose access to land and may lose crops if unable to harvest before land clearance.	Parameter judgement Nature: negative Magnitude: minor Duration: short-term Scale: local Probability: certain Sensitivity of the social group or resource: medium Significance of impact: minor	SE4 SE6	A LALRP developed to set out how to improve or at least restore local project affected people's (PAPs) livelihoods to pre-project levels and cover all categories of PAPs so that they will be compensated in accordance with IFC PS5 and no PAPs will be economically disadvantaged by the project. The LALRF is being developed to establish principles and procedures to make sure that the interests and needs of PAPs are incorporated and addressed.	Parameter judgement Nature: negative Magnitude: minor Duration: short-term Scale: local Probability: low Sensitivity of the social group or resource: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce probability from certain to low and the significance of the impact from minor to negligible.
Informal land owners and users	Land users without recognised rights (eg. informal farming activity or petty trading along road rights of way) will permanently lose access to land, business or may lose crops if unable to harvest before land clearance. Shop will need to be moved. It is unlikely that the shop has permission in that location and as such is unlikely to be entitled to	Parameter judgement Nature: negative Magnitude: moderate Duration: permanent Scale: local Probability: certain Sensitivity of the social group or resource: high Significance of impact: moderate	SE4 SE6	LALRP developed to set out how to improve or at least restore local PAPs livelihoods to pre-project levels and cover all categories of PAPs so that they will be compensated in accordance with IFC PS5 and no PAPs will be economically disadvantaged by the project. The LALRF is being developed to establish principles and procedures to make sure that the	Parameter judgement Nature: negative Magnitude: minor Duration: short-term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce magnitude from

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
	compensation under national requirements.			interests and needs of PAPs are incorporated and addressed.	moderate to minor, duration from permanent to short-term and probability from certain to low. This would reduce significance from moderate to minor.
Ecosystem services users	The project is expected to have negligible impacts on priority ecosystem services used by local residents	Parameter judgement Nature: negative Magnitude: negligible Duration: short-term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible	Measures outlined in Chapter 8 Biodiversity and Chapter 9 water resources and quality SE6 SE7	With the implementation of measures outlined in relevant chapters the expected impacts on ecosystem services will be negligible	Parameter judgement Nature: negative Magnitude: negligible Duration: short-term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible Significance would remain negligible. .

7.5.3.3 Damage to known and unknown archaeological sites

There is an "Amerindian work stone" in the river, approximately 125 metres downstream of Site C pump station. There are no other known archaeological sites located within 500m of the footprints of the project but the presence of as-yet unidentified artifacts or sites of archaeological and/or historical importance cannot be ruled out. There is potential that construction activities particularly on and near the well pads could reveal and possibly accidentally damage unknown artefacts or sites.

The magnitude of the project's impact on known archaeological artefacts and sites is considered negligible given the distance of construction activities at the well pads to the sites. The magnitude on unknown archaeological artefacts and sites can't be known. Given the absence of known sites nearby and the agricultural activities in the footprint it is not considered likely that there are archaeological artefacts however damage to an artefact could be irreparable and of national significance so the magnitude is cautionary estimated as major. Sensitivity of known and unknown artefacts is cautiously considered to be high. The impact of the Project on known archaeological sites is considered to be negligible during construction and therefore not significant. The impact on unknown archaeological artefacts is considered minor and therefore not significant.

Table 7.17: Analysis of impact of change on specific social groups and resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Damage to known archaeological sites	The location of the project to the nearest site is considered sufficiently far away to not impact on any known archaeological sites	Parameter judgement Nature: negative Magnitude: negligible Duration: permanent Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: minor	SE13 SE7	Inclusion of cultural heritage as part of site induction training to all workers to minimise risks associated with accidental damage to known archaeological sites. Communication of grievance mechanism to report any concerns regarding potential/ or actual damage.	Parameter judgement Nature: negative Magnitude: negligible Duration: permanent Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: minor Although the implementation of the proposed mitigation measures should mitigate the impact, significance would remain minor given the high sensitivity of cultural heritage.
Damage to unknown archaeological sites	Construction activities may accidentally damage unknown archaeological artefacts	Parameter judgement Nature: negative Magnitude: major Duration: permanent Scale: national Probability: low Sensitivity of the social group or resource: high Significance of impact: moderate	SE13 SE7	Implementation of a chance finds procedure including adequate training to workers will minimise likelihood of damage to unknown archaeological artefacts. Communication of grievance mechanism to report any concerns regarding potential/ or actual damage.	Parameter judgement Nature: negative Magnitude: minor Duration: permanent Scale: national Probability: low Sensitivity of the social group or resource: high Significance of impact: moderate Although the implementation of the proposed mitigation measures should reduce magnitude from major to minor, significance would remain

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
					moderate given the high sensitivity of cultural heritage.

7.5.3.4 Effects on tourism

During the ESIA consultation, local residents in the direct AoI identified concerns regarding project impacts on tourism potential. Nevertheless, the direct AoI supports limited tourism activities and tourism within the direct AoI is considered underdeveloped. Additionally, construction activities are not located close to any known tourist destinations with the closest site (the Mount Rich petroglyphs) located 1km from Site C well pad and 500m from the pump station but located on the other side of the Tricolar community and unlikely to be seen by visitors. The hiking trails near to Site F are accessed via the town of Clozier and are not located near to the closest village of the direct AoI – Florida - which has no known attractions. The well pads and pump stations at Sites C and F are located sufficiently far away to not impact on the landscape characteristics or noise that could affect existing tourism facilities.

While the accommodation of non-local workers may remove potential accommodation stock, this would be temporary, and the owners of the guest houses/ lodges/ houses used by workers would directly benefit from rental income. As such, this is not considered to be an adverse impact on local tourism. Economic benefits are already discussed in section 7.5.3.1 and not covered in this section to avoid double counting.

Concerns from local residents who are engaged in tourism or hope to capitalise on tourism potential in the direct AoI should be further understood as part of the ongoing stakeholder engagement being undertaken by the GoG.

The magnitude of the project's impact on local tourism and tourism potential in the direct AoI are considered negligible given the distance of construction activities at the well pads to the tourism attractions. There is the possibility of visitors encountering construction vehicles on the main roads but any increase in road traffic attributable to the project will be of short duration. The sensitivity of visitors is considered low. The economic impact on local residents is considered in section 7.5.3.1. The probability of impacts occurring is considered low. The impact of the project on tourism and tourism potential is considered to be negligible during construction.

Table 7.18: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Visitors to tourist attractions in the direct AoI	The location of the project to the nearest tourist attractions is considered sufficiently distant to not impact on the current or future potential of these sites. However, concerns of local residents relying on visitors to these sites or who wish to develop tourism potential needs to be carefully managed through ongoing stakeholder engagement.	Parameter judgement Nature: negative Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: low Significance of impact: negligible	SE6 SE-E1	Engaging with residents and local workers to alleviate concerns regarding adverse impacts on tourism potential and visitors to the area	Parameter judgement Nature: negative Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: low Significance of impact: negligible Significance would remain negligible.

7.5.3.5 Project induced in-migration risks

When project-induced in-migration occurs it can increase project risks and costs through the creation of new migrant stakeholder groups; unmet promises of local participation, benefit and development; and deterioration in the socioeconomic context in which a project is operating. Adverse impacts of an influx workforce may include increased demand and competition for:

a. local social and health services, as well as
b. for local goods and services, which can lead to price hikes and crowding out of local consumers,
c. increased volume of traffic and higher risk of accidents,
d. increased demands on the ecosystem and natural resources,
e. social conflicts within and between communities,
f. increased risk of spread of communicable diseases, and
g. increased rates of illicit behaviour and crime.

Such adverse impacts are usually amplified by local-level low capacity to manage and absorb the incoming labour force, and specifically when civil works are carried out in, or near, vulnerable communities and in other high-risk situations[81].

In this section, we discuss impacts b and d above. Community, health and safety impacts (impacts a, c, e, f and g above) are discussed below in section 7.5.3.6. Ecosystem services are discussed in section 7.5.3.2.

The estimated number of workers to be engaged during the construction phase is approximately 30-40 workers most of which are expected to be non-local skilled. The small size and nature of this project makes it less likely that opportunistic economic migrants will be attracted to the area looking for employment opportunities with this project. The project will result in a barely perceptible temporary increase in the direct AoI population and is not expected to result in increased pressure on local services or markets for local goods and services although it could contribute to perceptions that local people are not sufficiently benefiting from employment opportunities and create conflict between the local community and non-local workers. As discussed in section 7.5.3.1, economic benefits could be felt by local businesses who are able to provide accommodation, goods and services to the project and/or the workforce.

The demands on electricity, water supply and solid waste collection will not increase significantly as the project is expected to supply its own requirements.

The magnitude of the project inducted in-migration impacts to the direct AoI residents and businesses is considered negligible given the small number of workers employed by the project and the less likely scenario that opportunistic economic migrants will be attracted to the area. Any increase in population will be of short duration. The sensitivity of local residents is considered high given the levels of poverty and unemployment and limited public services. The probability of project induced in-migration impacts occurring is considered low.

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[81] World Bank Environmental and Social Safeguards Advisory Team (2016). Managing The Risks of Adverse Impacts on Communities from Temporary Project Induced Labour Influx, World Bank Group, Washington. Available at: https://thedocs.worldbank.org/en/doc/497851495202591233-0290022017/original/ManagingRiskofAdverseimpactfromprojectlaborinflux.pdf. Accessed in July 2023.

Table 7.19: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F) (residents, local businesses and social infrastructure in the villages and towns located closest to the project sites)	There is the potential for project workers in-migration to result in demographic change and increased demand for goods, services in the direct AoI (Gouyave and Florida towns, Site F, and Grenville and Tricolar, Site C). Opportunistic in-flux is considered unlikely.	Parameter judgement Nature: negative Magnitude: negligible Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible	SE3 SE7	Guidance provided so that workers are housed in communities which are best able to absorb the small increase. Maximizing local employment through recruitment procedure. Information on local employment to be communicated to local residents and leaders in the direct AoI. Managing local communities' expectation of job opportunities and providing community grievance mechanism to raise concerns.	Parameter judgement Nature: negative Magnitude: negligible Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible Significance would remain negligible.

7.5.3.6 Health, safety and security risks (occupational and community)

This section identifies and discusses the occupational and community health, safety and security risks to which workers, site visitors and nearby residents may be exposed during the construction phase. Risks have been identified based on professional judgment and knowledge of similar projects.

The items covered here are considered to be risks (that are generally typical of projects of this nature and are not expected or considered likely to happen) as opposed to impacts (things that are expected or considered likely to happen and which can be positive as well as adverse). For this reason, significance has not been assessed, however appropriate management and mitigation measures are described in section 7.6. The control measures identified for the construction phase could also be applicable to risks associated with the operational and decommissioning phase.

Changes in environmental factors that could influence public health, such as water pollution, air quality and noise are considered within the respective assessment chapters of this volume to avoid double-counting of impacts.

Occupational health and safety (OHS) and security risks

The main project activities that represent risks to the health and safety of workers, local residents and the general public during construction are:

- Upgrading access roads and widening of main roads
- Site clearance
- Construction activities (well pads, water intake and pump stations, temporary water pipeline to supply well pads)
- Transportation of drilling rigs and associated equipment

Risks associated with OHS are based on assumptions of activities identified in Chapter 2 (Project Description) and which include only daytime working (07:00 to 19:00). The key OHS risks for the construction phase, include:

- Exposure to physical hazards from use of heavy equipment
- Trip and fall hazards
- Exposure to dust, noise and vibrations
- Falling objects
- Exposure to hazardous materials; and exposure to electrical hazards from the use of tools and machinery
- Environmental hazards adverse weather conditions, such as working in extreme heat, storms, strong winds, or heavy rainfall
- Psychological hazards including high-stress work environments or fatigue

Risks specific to the project location include exposure to extreme heat and hazards associated with working on or near roads. Workers involved in vegetation clearance are at greater risk of snake bites.

The use of temporary workers' accommodation is expected to be through rental of properties although the locations are not yet determined. Potential risks to the health, safety, security and therefore wellbeing of construction workers from temporarily rented accommodation if not selected or managed appropriately include those relating to sanitation, disease, fire, sleeping space, quality and quantity of food, personal safety and security, temperature control and recreation.

The employment of local people who may be unfamiliar with working on a construction site of this nature increases risks of accidents and injuries since the local workforce may be unfamiliar with processes, materials, technology and the working culture. It must be assumed that the local workforce has no existing knowledge of hazards, protection, working with others using harnesses and duty of care.

Community health, safety, and security risks

There are a number of activities in the construction phase that could cause risks to local communities. For example, project truck and passenger vehicle movements will increase existing traffic volumes and may result in road safety risks, especially in areas where there are pedestrians and cyclists on the road. For further discussion of traffic impacts see Chapter 13 (Traffic and Transport) of this ESIA. Noise and air quality impacts are discussed in Chapters 10 and 11.

There could be health and safety risks to the local community posed by the existence of construction sites and possible presence of security guards. Access to construction sites by community members presents health and safety risks similar to those described for workers.

Disease related risks which might arise during the construction phase of the project include outbreaks and increase in the incidence of communicable diseases due to the presence of the construction workforce living in a limited geographic area. The in-migration of workers carries potential risks to community health from communicable diseases, particularly tuberculosis (TB), COVID-19 and HIV/AIDS infections. Having to treat communicable diseases increases pressure on existing health services. Treating communicable diseases can increase pressure on existing health services. However, with a small workforce, the risk to the local area is low.

On other construction projects, respiratory illnesses have been an issue, eg an increase in TB or COVID-19 occurring. Ensuring good accommodation conditions and nutritional status of the workers will be instrumental.

Increased population from influx is not considered likely (discussed in section 7.5.3.5) although the arrival of workers during the construction phase could lead to an increase in communicable disease in local communities where workers are housed. Ensuring good housing conditions and nutritional status of the workers are preventive measures.

The presence of construction workforce and construction activities can increase HIV/AIDS in surrounding communities. An increase in HIV/AIDs can have significant social, economic and biophysical impacts such as reduced school attendance, loss of income, and groundwater pollution from waste disposal (UNEP, 2002). There may be an increased risk of workers’ sexual abuse and exploitation of local people in the community. The project workforce is not considered to be large, relatively short project duration (nine months), small size of the island (meaning that workers are not separated from families for long periods of time) and lack of presence of sex workers in the direct AoI are all factors that reduce the risks of spread of STIs.

New migrant groups may result in social tension or possibly conflict between migrant workers and local host communities due to competition for scarce social resources and opportunities and cultural differences. For example, the migrant workforce that is away from their families is likely to increase demand for the sex industry, which also poses increased risk of gender-based violence and health risks from STIs to young vulnerable women and the local communities. Few unskilled jobs are expected to be available although all are expected to go to local people. The majority of construction vacancies are expected to be filled by skilled migrant workers. Anti-social behaviour (behaviour nor customarily accepted in society) can be instigated by increases in wages, for instance substance abuse that causes accidents and injuries, prostitution or domestic violence.

The project's existence may present security risks to local stakeholders/residents by the presence of security personnel and a risk of harm causes through use of inadequately trained security personnel or disproportional use of force by public law enforcement. A small security presence is expected. Erecting public warning signage and theft deterrents (such as fencing) for project components, worksites and equipment will minimise risks of theft.

Early engagement and consultation with landowners, land users and affected communities near to the well pad and along the roads, and regular information dissemination and safety awareness campaigns will help foster a good understanding of the project activities and the measures in place for public safety. A programme of engagement and information disclosure will be set out in the SEP.

Given the expected small presence of site security mitigation and management measures will be adequately included in the ESMP. Assessment of risks to land users, local residents and the public will be prepared as part of a site security protocols to be developed. The risk assessment will consider potential interactions between workers, vehicles and local people as well as how the project will establish and enforce safety zones. The community grievance mechanisms and contact details will be posted on signage. The security protocols will make specific commitments to international and national security and human rights laws and statutes, regulations, conventions, standards, and GIIP.

Measures to avoid the risks identified regarding community health and safety and worker in-migration will be set out in a worker code of conduct and the worker accommodation guidance (in the ESMP) which will include expectations for behaviour that are reasonable and non-discriminatory. The worker accommodation guidelines will cover the lifetime of the project and will cover any project provided worker accommodation in line with international standards presented in the IFC guidance note on Worker's Accommodation: Processes and Standards (2009) to the extent possible.

7.5.4 Analysis of operation phase impacts (drilling and testing)

7.5.4.1 Employment generation and economic development

The operations phase is expected to last for up to 107 days. It is not clear whether workers engaged in the construction phase will be retained during the operations phase given the technical activities involved. Approximately 23 workers are expected for this phase and will include foreign highly skilled workers (approximately 9% of total workforce, two positions) and national workers. Unskilled positions that would be available to local residents without relevant experience are expected to be limited. As described in section 7.5.3.1, similar negligible indirect or induced employment generation and local business benefits are expected. Minor indirect socio-economic benefits will result from workers' earnings being spent on local goods and services and local businesses capturing limited procurement opportunities.

It is expected that the project's operations phase impact on local employment will be of negligible magnitude, because of the small number of unskilled, temporary jobs to be created over three and half months. The sensitivity of local people who are employed is considered high given that most residents may lack skills and experience to capture skilled and higher paid employment opportunities. The impact of local employment generation is considered to be negligible during construction.

Wider benefits to the local economy may be experienced but would also be expected to be of negligible magnitude given the number of local employment opportunities provided. The provision of an income source for any local workers and their families will contribute to their well-being and enhancing their quality of life. Migrant workers will tend to send remittances to their families thereby injecting money into other localities whereas local jobs will contribute to poverty reduction in the direct AoI. Indirect socioeconomic benefits will result from local workers earnings being spent on local goods and services.

With the distribution of a local tourism brochure as a project enhancement measure to be implemented in the construction phase to workers a small increase in visitors to local tourist sites is possible. Wider benefits to the local economy are expected to be of negligible magnitude given the number of local employment opportunities provided.

The procurement opportunities in the direct AoI during the operations phase are expected to be fewer than those experienced during construction phase. The sensitivity of the receptors (i.e.: residents, local businesses and social infrastructure in the villages and towns located closest to the project sites) is considered as high. As such, the impact on the local economy is considered to be negligible during operations.

Benefits to the wider economy (ie Grenada) will not be very perceptible and are likely to be fewer than those available in construction. The sensitivity of skilled non-local workers and regional and national businesses are considered low. It is expected that the project's impact on the regional economy will be of negligible magnitude due to the small size of the project's procurement needs and short project duration. As such, the impact is expected to be negligible during operation.

Table 7.20: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	During the operations phase it is expected that 23 people will be employed, mainly skilled positions. Local employment will provide a source of income for households on a temporary basis. Provision of an income source for any local workers and their families will contribute to their well-being and enhancing their quality of life. Opportunities for local employment are expected to be very limited ~ fewer than 23 positions. Opportunities for women to be engaged are considered to be further limited.	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible	SE2 SE3 SE4 SE7	Preferential hiring from the project affected areas will maximise local employment opportunities	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should enhance the probability of change from low to medium and significance from negligible to minor.
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	There will be limited opportunities for in-country procurement and local businesses service providers are expected to face challenges in being able to compete with larger and more established professional providers to higher value services and supplies. Some local opportunities such as provision of accommodation, local	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible	SE2 SE3 SE4 SE7 SE-E1	Provision of local content support measures will maximise opportunities for local businesses to capture economic opportunities from the project	Parameter judgement Nature: positive Magnitude: minor Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should enhance the

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
	transport and groceries/meals are expected to be available.				magnitude of change from negligible to minor and significance from negligible to minor.
Non-local professionals, national businesses, and citizens of Grenada	Benefits to wider economy in the indirect AoI will be limited as main materials procured will be sources from outside Grenada. Some benefits will accrue from increased inform for workers and businesses from employment and procurement	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: national Probability: medium Sensitivity of the social group or resource: low Significance of impact: negligible	SE2 SE3 SE4 SE7	May include requirements for national procurement where feasible so that national economic benefits can be maximised to the extent this is possible.	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: national Probability: medium Sensitivity of the social group or resource: low Significance of impact: negligible The implementation of the proposed mitigation measures is not expected to change the significance of the impact which will remain negligible.

7.5.4.2 Improved roads and access

The project will upgrade sections of the current roads for use during construction and operations to facilitate access to the well pads where currently no access exists. This change will allow vehicles into areas that were previously difficult to access which has benefits to landowners and farmers. Hunting does take place in the direct AoI presumably as part of subsistence/ food security strategies for local residents even though these activities are illegal for part of the year. Opening access to these areas could result in increased hunting, poaching and logging activities. Chapter 8 Biodiversity assesses the impact of opening up new access roads on flora and fauna. species and habitat degradation from improved access through new / upgraded roads and includes mitigation measures to ban hunting by construction staff as well as community awareness raising and education to minimise hunting however the successful of any public campaign will be dependent on the needs of local people. Additionally, the traffic and transport chapter (Chapter 13) assesses the impact of project traffic on road users regarding inconvenience during construction and risks associated with increased traffic, and nuisance experience by residents who live along the access routes. Therefore, this section does not duplicate these other assessments but rather considers the effects of improved access on local people's livelihoods.

Improving access for landowners and land users (legal and illegal/informal) will have a positive impact on increasing accessibility to land they own and/or use for livelihood activities. The magnitude of the improved roads and access benefits to all landowners and all users who continue to access the same land plots / or land close to the areas required for the project footprint is considered moderate as although improvements will affect a small number of people the improvement are likely to be noticeable to those households. The probability is considered certain. The sensitively of legal landowners and tenants is medium and for informal land lands and users is high. The impact is considered to be moderate and therefore significant to legal land owners and tenants. For informal land owners and users whose sensitively is high the impact is also considered to be of moderate and therefore significant.

Improvements to the local roads and upgrading of access tracks are likely to result in improved accessibility for local residents of the villages closest to the well pads. Improving accessibility to hard-to-reach areas may also make it easier for local residents to engage in hunting activities. The magnitude of the improved roads and access benefits to local residents is considered minor as the improvements are not likely to benefit every resident and the probability is considered low. The sensitively of residents in the village of Mt Reuil/Mt Rich, the community of Tricolar and Sauteurs town (Site C), and Florida village and Gouyave town (Site F) is high. The impact is therefore considered to be minor and not significant to residents within the direct AoI.

In addition to obvious benefits to landowners and users through increased accessibility, there is the potential that with this comes increased opportunities for localised criminal behaviour – namely theft of agricultural crops or illegal hunting activity. The magnitude of livelihoods of land owners and users (both legal and informal/illegal) adversely affected by increased criminal activity considered minor as the area is not known for high levels of criminality. The probability of this impact occurring is considered low. The sensitively of legal landowners and tenants is medium and for informal land lands and users is high. The impact is considered to be minor and therefore not significant to legal landowners and tenants. For informal landowners and users whose sensitively is high the impact is also considered to be minor and therefore not significant. For local residents within the directly AoI the magnitude is considered minor and the probability is low. The sensitivity of local residents is considered high therefore the impact is minor and not significant.

Table 7.21: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Legal landowners and farmers legal tenants/	Creation of access roads will improve their accessibility to the area but may (b) increase risk of theft or damage to land and/or farms from unauthorised access	Parameter judgement Nature: positive and adverse Magnitude: moderate (access improvements), low (risk of theft) Duration: permanent Scale: local Probability: certain (access improvements), low (risk of theft) Sensitivity of receptor: medium Significance of impact: moderate (positive) – minor (adverse)	SE7 SE5	Engage in public and community awareness Security measures.	Parameter judgement Nature: positive and- adverse Magnitude: moderate (access improvements), negligible (risk of theft) Duration: permanent Scale: local Probability: certain (access improvements), low (risk of theft) Sensitivity of receptor: medium Significance of impact: moderate (positive) – minor (adverse) For access improvements the implementation of the proposed mitigation measures is not expected to change the significance of the impact which will remain positive moderate. Risk of theft with the implementation of mitigation measures should reduce magnitude from low to negligible but the significance of the impact remain minor adverse
Informal landowners and/or land users	Creation of access roads will improve their accessibility to the area but may increase risk of theft from unauthorised access	Parameter judgement Nature: positive and adverse Magnitude: moderate (access improvements), low (risk of theft) Duration: permanent Scale: local	SE7 SE5	Engage in public and community awareness Security measures	Parameter judgement Nature: positive and- adverse Magnitude: moderate (access improvements), negligible (risk of theft) Duration: permanent

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
		Probability: certain (access improvements), low (risk of theft) Sensitivity of receptor: high Significance of impact: moderate (positive) – minor (adverse)			Scale: local Probability: certain (access improvements), low (risk of theft) Sensitivity of receptor: high Significance of impact: moderate (positive) – minor (adverse) For access improvements the implementation of the proposed mitigation measures is not expected to change the significance of the impact which will remain positive moderate. Risk of theft with the implementation of mitigation measures should reduce magnitude from low to negligible but the significance of the impact remain minor adverse
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	Local residents who use the roads within the direct AoI may experience some improvements to accessibility through the road upgrades for the project. The improved accessibility could indirectly lead to an increase in hunting which while illegal could have a shot-term benefit to food security for the most vulnerable households. Longer term overhunting and risk of criminalisation could lead to longer term adverse effects on households.	Parameter judgement Nature: positive and adverse Magnitude: minor (access improvements), low (risk of theft) Duration: permanent Scale: local Probability: low (access improvements), low (risk of theft) Sensitivity of receptor: high Significance of impact: minor (positive) – minor (adverse)	SE7 SE5	Public and community awareness Security measures	Parameter judgement Nature: positive and adverse Magnitude: minor (access improvements), negligible (risk of theft) Duration: long term Scale: local Probability: high (positive), low (adverse) Sensitivity of receptor: medium Significance of impact: moderate (positive) – minor (adverse) For access improvements the implementation of the proposed

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
					mitigation measures is not expected to change the significance of the impact which will remain positive moderate. Risk of theft with the implementation of mitigation measures should reduce magnitude from low to negligible but the significance of the impact remain minor adverse

7.5.4.3 Damage to known and unknown archaeological sites

As discussed in section 7.5.3.3 the impact of the Project on known archaeological sites during construction will be negligible and on unknown archaeological artefacts will be of minor. It is expected that once operational the activities taking place at the well pads will not result in any changes to the potential impacts on archaeology. The impact of the Project on known archaeological sites is considered to remain negligible during construction and on unknown archaeological artefacts to remain minor.

7.5.4.4 Effects on tourism

The effects of the Project during operations are expected to be similar to those already described during construction (see section 7.5.3.4. Once operational the well pads and supporting infrastructure are not expected to directly impact on the closest tourist sites located near to Tricolar and Mt. Rich/Mt. Reuil (Site C), or Florida (Site F).

The magnitude of the project’s impact on local tourism and tourism potential in the direct AoI are considered negligible given the distance of operations activities to the tourism attractions. There is the possibility of visitors encountering operations vehicles on the main roads but any small increase in road traffic attributable to the Project will be of short duration. The sensitivity of visitors is considered low. The probability of impacts occurring is considered low. The impact of the Project on tourism is considered to be negligible during operations.

The magnitude of the Project’s impact on local tourism and tourism potential in the direct AoI during operations is considered negligible. The long-term benefits that could be realised could be of up to long term duration. The sensitivity of visitors is considered low. The probability of impacts occurring is considered low. The impact of the Project on tourism is considered to be of negligible significance during operation without enhancement measures.

The economic impact on local residents is considered in section 7.5.4.1

Table 7.22: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Visitors to tourist attractions in the direct AoI	Project will not adversely affect the closest tourist attractions to the project sites. Improves to access roads may result in improved accessibility to tourist attractions.	Parameter judgement Nature: adverse Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: low Significance of impact: negligible	SE6 SE-E1	Engaging with residents and local workers to alleviate concerns regarding adverse impacts on tourism potential and visitors to the area.	Parameter judgement Nature: negative Magnitude: negligible Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: low Significance of impact: negligible Significance would remain negligible.

7.5.4.5 Project induced in-migration risks

The risks to local residents and the general public from operations activities are expected to be similar to those identified during the construction phase (section 7.5.3.5) although it is noted that the control measures identified for the construction phase would also be applicable to risks associated with the operational phase (outlined in section 7.6.1).

7.5.4.6 Health, safety and security risks (occupational and community)

This section identifies and discusses the occupational and community health, safety and security risks to which workers, site visitors and nearby residents may be exposed during the operations phase. Risks have been identified based on professional judgment and knowledge of similar projects.

As outlined above under section 7.5.3.6, this section covers risks rather than impacts and as such has not assessed significance. Changes in environmental factors that could influence public health, such as water pollution, air quality and noise are considered within the respective assessment chapters of this volume to avoid double-counting of impacts

Occupational health, safety and security risks

The main project activities that represent risks to the health and safety of workers, local residents and the general public during operations are:

- Exploratory drilling works
- Pumping of water / drilling muds
- Drilling rig and ancillary equipment maintenance
- Geological sampling and analysis
- Well testing

The key OHS risks for the operations phase are similar to those identified during construction (section 7.5.3.6). Specific risks associated with geothermal exploration drilling include blowouts, gas and vapor leakage (geothermal brine), fuel spills or leaks, sewage spills, and agricultural fires and burns.

Well drilling and well testing activities are expected to be conducted 24 hours a day and as such night working will be required.

The risks associated with temporary housing are expected to be the same during the operations phase as those identified during construction (section 7.5.3.6) although fewer workers are expected to be housed at this time (up to maximum of 23 workers, compared to 30-40 during construction).

Community health, safety, and security risks

The risks to local residents and the general public from on-site operations activities will include. The control measures identified for the construction phase could also be applicable to risks associated with the operational phase (outlined in section 7.6.1).

7.5.5 Analysis of decommissioning phase impacts

Decommissioning phase impacts will have some similarities to other project phases although the short timeframe (duration of one month) and the small number of workers expected (12 workers) will reduce the overall probability and/or magnitude of some impacts occurring. As the roads will remain in place the impacts are expected to be the same as for the operations phase and no health and safety risks are expected associated with constructing on and/or near roads.

7.5.5.1 Employment generation and economic development

The decommissioning phase of the project is expected to be one month and will employ approximately 12 workers including foreign and national workers. The decommissioning workforce is expected to comprise around 75% skilled positions with the remaining 25% (four positions) expected to be available to local residents without relevant experience. Opportunities for unskilled workers are considered to be negligible during this phase of the Project including opportunities for women.

Impact of local employment generation

As noted for the construction and operations phase there will be indirect or induced employment generation which are expected to be of negligible magnitude during the decommissioning phase.

The sensitivity of local people who are employed is considered high given that most residents may lack skills and experience to capture skilled and higher paid employment opportunities. The impact of local employment generation is considered to be of negligible significance during decommissioning.

Impact on local economy (opportunities for in-country procurement and local businesses service providers)

The procurement opportunities available for businesses will remain limited during decommissioning.

The impacts on local tourism are expected to remain negligible given the distance of the project from tourism sites within the direct AoI. It is expected that the project's impact on the local economy will be of negligible magnitude, due to limited contracts available and local businesses being limited in their ability to access higher value contracts and the small number of employed local workers. The sensitivity of the receptors (ie local communities and businesses) is considered as high. As such, the impact on the local economy is considered to be negligible during decommissioning.

National economy development

Benefits to the wider economy (ie Grenada) will remain imperceptible but are expected to include increased income for workers and businesses from the provision of specialists' services and materials (eg PPE). Recipients of skilled employment are expected to be local and non-local workers who already have the prerequisite skills and experience needed for technical positions. The sensitivity of these receptors (ie workers and regional businesses) is considered low. It is expected that the project's impact on the regional economy will be of negligible magnitude due to the small size of the project 's procurement needs and short project duration. As such, the impact is expected to be negligible during decommissioning.

Table 7.23: Analysis of impact of change on specific social groups or resources

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	During the decommissioning phase it is expected that 12 people will be employed, with four unskilled positions available. Local employment will provide a source of income for households on a temporary basis. Provision of an income source for any local workers and their families will contribute to their well-being and enhancing their quality of life. Opportunities for local employment are expected to be very limited Opportunities for women to be engaged are considered to be further limited.	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: high Significance of impact: minor	SE2 SE3 SE4 SE7	Preferential hiring from the project affected areas will maximise local employment opportunities	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: high Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should enhance the probability of change from medium to high. However, magnitude remains negligible and significance remains minor.
Village of Mt Reuil/Mt Rich, community of Tricolar and Sauteurs town (Site C) Florida village and Gouyave town (Site F)	There will be limited opportunities for in-country procurement and local businesses service providers are expected to face challenges in being able to compete with larger and more established professional providers to higher value services and supplies. Some local opportunities such as provision of accommodation, local transport and	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: low Sensitivity of the social group or resource: high Significance of impact: negligible	SE2 SE3 SE4 SE7 SE-E1	Provision of local content support measures will maximise opportunities for local businesses to capture economic opportunities from the project	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: local Probability: medium Sensitivity of the social group or resource: high Significance of impact: minor The implementation of the proposed mitigation measures should enhance the

Social groups or resources	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied	Analysis of change to impact post mitigation	Summary of residual impact (post-mitigation)
	groceries/meals are expected to be available.				probability of the change from low to medium and significance from negligible to minor.
Non-local professionals, national businesses, and citizens of Grenada	Benefits to wider economy in the indirect AoI will be limited as main materials procured will be sources from outside Grenada. Some benefits will accrue from increased income for workers and businesses from employment and procurement	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: national Probability: medium Sensitivity of the social group or resource: low Significance of impact: negligible	SE2 SE3 SE4 SE7	May including requirements for national procurement where feasible national economic benefits can be maximised to the extent this is possible	Parameter judgement Nature: positive Magnitude: negligible Duration: short term Scale: national Probability: high Sensitivity of the social group or resource: low Significance of impact: negligible The implementation of the proposed mitigation measures should enhance the probability of the change from medium to high; however, significance would remain negligible.

7.5.5.2 Improved roads and access

During the decommissioning phase the improvements made to the road network and creation of new access roads will remain in place ie the new roads will not be decommissioned. Therefore, the assessment of potential positive and adverse impacts during the operations phase remains applicable for this phase. No further impacts, beyond those described for the operations phase (section 7.5.4.2), are expected on landowners, farmers, residents located along the access roads or within the direct AoI.

7.5.5.3 Damage to known and unknown archaeological sites

As discussed in section 7.5.4.3 the impact of the Project on known archaeological sites during operation will remain negligible and on unknown archaeological artefacts will remain minor. The decommissioning phase is not expected to encompass any activities that would pose further risks of impacts on known or unknown archaeological sites and artefacts. Therefore, the impact of the Project on known archaeological sites is considered to remain negligible during decommissioning and on unknown archaeological artefacts to remain minor.

7.5.5.4 Effects on tourism

During the decommissioning phase potential adverse effects on tourism activities within the direct and indirect AoI are expected to be the similar to those outlined during construction although with fewer vehicles on the roads that could potentially cause inconvenience to visitors travelling to sites (Section 7.5.4.3). The duration of the decommissioning activities is only one month. The distance of the well pads from the closest sites located near to Tricolar and Mt. Rich/Mt. Reuil (Site C), or Florida (Site F) is sufficient that potential impacts from decommissioning activities are expected to remain negligible (the economic impact on local residents is considered in section 7.5.5.1).

The impact of the project on tourism and tourism potential is considered to be negligible during decommissioning.

7.5.5.5 Project induced in-migration risks

The risks to local residents and the general public from decommissioning activities are expected to be similar to those identified during the construction phase (section 7.5.3.5) and operations phase (Section 7.5.4.5). The control measures identified for the construction phase (outlined in section 7.6.1) would also be applicable to risks associated with the decommissioning phase.

7.5.5.6 Health, safety and security risks (occupational and community)

This section identifies and discusses the occupational and community health, safety and security risks to which workers, site visitors and nearby residents may be exposed during the decommissioning phase. Risks have been identified based on professional judgment and knowledge of similar projects.

As outlined above under section 7.5.3.6, this section covers risks rather than impacts and as such has not assessed significance. Changes in environmental factors that could influence public health, such as water pollution, air quality and noise are considered within the respective assessment chapters of this volume to avoid double-counting of impacts.

Occupational health, safety and security risks

The main project activities that represent risks to the health and safety of workers, local residents and the general public during decommissioning are:

- Removal of drilling equipment

- Restoration of temporary work sites

The key OHS risks for the decommissioning phase are similar to those identified during construction (section 7.5.3.6) and will include exposure to physical hazards from use of heavy equipment, trip and fall hazards, exposure to dust, noise and vibrations, falling objects and exposure to hazardous materials; and exposure to electrical hazards from the use of tools and machinery during dismantling and removal of equipment. The environmental hazards associated with adverse weather conditions are expected to be similar and would include working in extreme heat, storms, strong winds, or heavy rainfall. Psychological hazards could include high-stress work environments or fatigue although activities are expected to occur only during normal working hours (7am to 7pm).

Risks associated with working on or near roads are not expected during the decommissioning phase as the roads will not be rehabilitated. Workers working remoted in dense vegetation are at greater risk of snake bites.

The risks associated with temporary housing are expected to be the similar during the decommissioning phase as those identified during construction (section 7.5.3.6) although fewer workers are expected to be housed at this time (up to maximum of 12 workers, compared to 30-40 during construction).

Community health, safety, and security risks

The risks to local residents and the general public from decommissioning activities are expected to be similar to those identified during the construction phase (section 7.5.3.6) with the exception of risks associated with working on or near roads. The control measures identified for the construction phase could also be applicable to risks associated with the decommissioning phase (outlined in section 7.6.1).

7.5.6 Human rights assessment

This chapter predicts human rights impacts which may occur as a result of the construction, operation and decommissioning phases of the project. A separate baseline section has not been drawn up in relation to human rights, please refer instead to the socio-economic baseline in section 7.4 which contains all the relevant information. The methodology and AoI for the human rights impact assessment are described in section 7.3 Table 7.24 identifies the relevant human rights that the project is required to respect as outlined in the UNGPs and categorises them according to topic.

Table 7.24: Human rights topic areas

Topic area and section number	Most relevant human rights
Labour rights	Right not to be subjected to slavery, servitude or forced labor UDHR 4; ICCPR 8; ILO No.29; ILO No.105
	Right to equality before the law, equal protection of the law, non-discrimination UDHR 7; ICCPR 26; ILO No. 100; ILO No.111 and International Convention on the Elimination of All Forms of Racial Discrimination
	Right to access to effective remedies UDHR 8; ICCPR 2
	Right to life UDHR 3; ICCPR6
	Right to freedom of movement UDHR 13; ICCPR 12
	Right to freedom of association UDHR 20; ICCPR 22; ILO No.87
	Right to social security, including social insurance UDHR 22; ICESCR 9
	Right to work UDHR 23; ICESCR 6
	Right to enjoy just and favourable conditions of work (including rest and leisure) UDHR 23 and 24; ICESCR 7
	Right to form trade unions and join the trade unions, and the right to strike UDHR 23; ICESCR 8; ILO No.98
	Right of protection for the child UDHR 25; ICCPR 24; ILO No. 138; ILO No.182 and Convention on the Rights of the Child
	Right to health UDHR 25; ICESCR 12
	Right to freedom of thought, conscience and religion UDHR 18; ICCPR 18
	Right to privacy UDHR 12; ICCPR 17
	International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families
	Convention on the Elimination of All Forms of Discrimination against Women
	Convention on the Rights of Persons with Disabilities
Resettlement	Right to own property (UDHR 17; ICESCR 15)
Livelihoods	Right to an adequate standard of living (housing, food, water & sanitation) UDHR 25; ICESCR 11
	Right to life UDHR 3; ICCPR6

Topic area and section number	Most relevant human rights
Community health and safety	Right to health UDHR 25; ICESCR 12
	Right to an adequate standard of living (housing, food, water & sanitation) UDHR 25; ICESCR 11
Participation	Right to freedom of opinion, information and expression UDHR 19; ICCPR 19
	Right to freedom of assembly UDHR 20; ICCPR 21
	Convention on the Elimination of All Forms of Discrimination against Women
	The Convention on the Rights of Persons with Disabilities
Access to remedy	Right to access to effective remedies UDHR 8; ICCPR 2
Security	Right to liberty and security (including freedom from arbitrary arrest, detention or exile) UDHR 3 and 9; ICCPR 9
	Right not to be subjected to torture, cruel, inhuman and/or degrading treatment or punishment UDHR 5; ICCPR 7 and Convention against Torture and Other Cruel, Inhuman or Degrading Treatment or Punishment
Privacy and data security	Right to privacy UDHR 12; ICCPR 17
Noise, vibrations, visual impacts	Right to privacy UDHR 12; ICCPR 17
Supply chain	All rights listed above

Source: Mott MacDonald

In addition to the categorisations listed above, the Convention on the Rights of the Child and the Convention on the Elimination of All Forms of Discrimination against Women are considered to cut across most if not all potential areas of impact. Particular attention has been paid to impacts to women and children where applicable. The other core UN human rights treaty of potential relevance to the project is the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families, consideration of which has been incorporated into the identification and mitigation of workers' rights issues.

The human rights assessment has been undertaken in alignment with requirements of the United Nations Guiding Principles on Business and Human Rights (UNGP), the International Bill of Human Rights, the four core labour standards and other key conventions of the ILO, other core UN human rights treaties. The human rights AoI includes all physical components of the project, affected communities and people. A general consideration of supply chain/supplier risks has been included in this assessment although suppliers are not yet known including where sand would be imported from (sand mining is not allowed in Grenada).

7.5.6.1 Identification of rights-holders

The key rights-holders[82] whose rights may be affected by the project are:

- Project workers including the project company's employees and contracted/sub-contracted workers

[82] From a human rights perspective, individuals (sometimes groups) are rights-holders that can make legitimate claims, and States and other actors such as business are duty-bearers that are responsible and can be held accountable for their acts or omissions.

- Landowners and land users affected by land acquisition
- Communities living in the project's area of influence who may be affected by movement of vehicles, temporary worker accommodation, emergencies and people who need to use the roads
- Jobseekers and stakeholders who may be affected by discrimination with regard to employment, participation or access to remedy
- Supply chain workers and affected communities in the supply chain (for example in sand mining communities)

Within each of these groups, there may be people who are affected more severely than others including migrants, women and children.

7.5.6.2 Project impacts

As a large number of the human rights impacts identified cross-over with other sections of the ESIA, this section has been presented in summary form.

Table 7.25: Human rights impact assessment

Project activity	Impact (potential or actual)	Affected rights-holders	Vulnerability of rights-holders	Scale	Scope	Irremediability	Severity
Construction and pre-construction impacts							
Employment and management of workers	**Potential** infringements on workers' rights including the relevant conventions of the ILO (child labour, forced labour, right to organize and bargain collectively, non-discrimination and equal opportunity, reasonable terms and conditions including wages, rest, leave, hours of work), migrant workers' rights	Project workers Job seekers Children	High	C	C	C	3
	Potential impact to access to remedy	Project workers Job seekers	High (although skilled and experienced workers are considered less vulnerable)	C	C	C	3
	Potential impact on the right to work (if contracts are terminated without warning or protections)	Project workers	Medium	B	A	C	4
	Potential impact on occupational health and safety	Project workers	Medium	A	C	A	4
	Potential impact on the right privacy and data security	Project workers	High	B	A	C	4
Land clearance for construction	**Actual** economic displacement affecting people's right to own property and adequate standard of living	Landowners Shop owner	High (although landowners not utilising their land are less vulnerable)	B	A	B	4
	Actual impact to people's right to an adequate standard of living through loss of access to natural resources/ecosystem services (loss of crops)	Landowners and farmers	High (although landowners not utilising their land are less vulnerable)	B	A	B	4
	Actual impacts on the right to freedom of movement	Landowners and farmers Other affected communities along roadside	High (although landowners not utilising their land are less vulnerable)	C	A	B	3

Project activity	Impact (potential or actual)	Affected rights-holders	Vulnerability of rights-holders	Scale	Scope	Irremediability	Severity
Influx of project workforce	**Potential** impact on right to health relating to spread of communicable disease (HIV/AIDS or other STIs, COVID-19)	Affected communities Project workers	High	A	C	A	5
	Potential impact on women (workers or communities) in the form of GBVH from project workforce	Women in affected communities Female project workers	High	B	C	B	4
Presence of a construction site	**Potential** impact on the rights to health and life if non-workers access the construction site	Affected communities	High	A	C	A	5
Data management	**Potential** impact on the right to privacy and data security	All stakeholders Landowners	High	C	B	C	3
Operational impacts							
Employment and management of workers	**Potential** infringements on workers' rights including the relevant conventions of the ILO (child labour, forced labour, right to organize and bargain collectively, non-discrimination and equal opportunity, reasonable terms and conditions including wages, rest, leave, hours of work), migrant workers' rights	Project workers Job seekers Children	High	C	C	C	3
	Potential impact to access to remedy	Project workers Job seekers	High (although skilled and experienced workers are considered less vulnerable)	C	C	C	3
	Potential impact on the right to work (if contracts are terminated without warning or protections)	Project workers	Medium	B	A	C	4
	Potential impact on occupational health and safety	Project workers	Medium	A	C	A	4
	Potential impact on the right privacy and data security	Project workers	High	B	A	C	4

Project activity	Impact (potential or actual)	Affected rights-holders	Vulnerability of rights-holders	Scale	Scope	Irremediability	Severity
Stakeholder engagement program	**Potential** impact on freedom of expression	All stakeholders	Medium	C	A	C	3
	Potential impact on the rights to non-discrimination (especially of women, children and people with disabilities)	Vulnerable groups	High	C	A	C	3
	Potential impact on the right to access to remedy	All stakeholders	High (although large businesses owners less vulnerable)	C	A	C	3
Transportation of equipment, materials, hazardous materials and spoil	**Potential** impact on increased traffic and heavy vehicles on roads used for the project potentially affecting individual's rights to health and life in the event of a serious accident or relating to wear and tear caused by project traffic causing an accident.	Affected communities Project workers	High – non-motorized road users (pedestrians and cyclists)	A	C	A	5
Potential mismanagement of hazardous materials including chemicals	**Potential** impacts to the rights to health and life of project workers and community members including the relevant conventions of the ILO (occupational safety and health)	Affected communities Project workers	High	A	C	A	5
Upgrade of road to be used by heavy vehicles during construction	**Potential** impact on the right to privacy and the right to own property. Vibrations could cause damage to properties and the widening on the road so that it is closer to properties could also cause damage, noise and nuisance to residents living close to the project roads.	Affected communities	High	C	C	B	3
Operation of exploratory drilling equipment	**Potential** impacts to the rights to health and life of project workers and community members including the relevant conventions of the ILO (occupational safety and health)	Affected communities Project workers	High	A	C	A	5
	Potential impact on occupational health and safety including the relevant conventions of the ILO (occupational safety and health)	Project workers	Medium	A	C	A	4

Project activity	Impact (potential or actual)	Affected rights-holders	Vulnerability of rights-holders	Scale	Scope	Irremediability	Severity
Use of project security forces	**Potential** impacts on the right to liberty and security, right not to be subjected to torture, cruel, inhuman and/or degrading treatment and punishment; right to access to effective remedies; right to freedom of opinion, information and expression; right to freedom of assembly; and right of detained persons to humane treatment	Affected communities Project workers	High	B	C	A	4
Upgrade of project roads	**Potential** impacts on the rights to health and life and the right to an adequate standard of living brought about by influx of people from outside of the local area looking for work. Generation of an informal economy including proliferation of sex work and STIs, increase in alcoholism.	Affected communities	High	A	C	A	4
Decommissioning impacts							
Employment and management of workers	**Potential** infringements on workers' rights including relevant conventions of the ILO (child labour, forced labour, right to organize and bargain collectively, non-discrimination and equal opportunity, reasonable terms and conditions including wages, rest, leave, hours of work), migrant workers' rights	Project workers Job seekers Children	High	C	C	C	3
	Potential impact to access to remedy	Project workers Job seekers	High (although skilled and experienced workers are considered less vulnerable)	C	C	C	3
	Potential impact on the right to work (if contracts are terminated without warning or protections)	Project workers	Medium	B	A	C	4
	Potential impact on occupational health and safety including the relevant conventions of the ILO (occupational safety and health)	Project workers	Medium	A	C	A	4
	Potential impact on the right privacy and data security	Project workers	High	B	A	C	4
	Potential impact on freedom of expression	All stakeholders	Medium	C	A	C	3

Project activity	Impact (potential or actual)	Affected rights-holders	Vulnerability of rights-holders	Scale	Scope	Irremediability	Severity
Stakeholder engagement program	**Potential** impact on the rights to non-discrimination (especially of women, children and people with disabilities)	Vulnerable groups	High	C	A	C	3
	Potential impact on the right to access to remedy	All stakeholders	High (although large businesses owners less vulnerable)	C	A	C	3
Transportation of equipment, materials, hazardous materials and spoil	**Potential** impact on increased traffic and heavy vehicles on roads used for the project potentially affecting individual's rights to health and life in the event of a serious accident or relating to wear and tear caused by project traffic causing an accident.	Affected communities Project workers	High – non-motorized road users (pedestrians and cyclists)	A	C	A	5
Dismantling of drilling equipment and restoration of temporary site	**Potential** impacts to the rights to health and life of project workers and community members	Affected communities Project workers	High	A	C	A	5
	Potential impact on occupational health and safety including the relevant conventions of the ILO (occupational safety and health)	Project workers	Medium	A	C	A	4
Use of project security forces	**Potential** impacts on the right to liberty and security, right not to be subjected to torture, cruel, inhuman and/or degrading treatment and punishment; right to access to effective remedies; right to freedom of opinion, information and expression; right to freedom of assembly; and right of detained persons to humane treatment	Affected communities Project workers	High	B	C	A	4
Upgrade of project roads	**Potential** impacts on the rights to health and life and the right to an adequate standard of living brought about by influx of people from outside of the local area looking for work. Generation of an informal economy including proliferation of sex work and STIs, increase in alcoholism.	Affected communities	High	A	C	A	4

7.6 Mitigation and enhancement measures

Table 7.26 and Table 7.27 presents the mitigation and benefit enhancement measures that will be used to avoid, mitigate, manage and improve the potential socioeconomic, cultural heritage and human rights risks and impacts identified.

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7.6.1 Socio-economic, community and cultural heritage mitigation and enhancement measures

Table 7.26: Socio-economic, community and cultural heritage mitigation and enhancement measures

Reference	Impact topic	Details of mitigation/enhancement measure	Implementation timing	Implementation method	Responsibility
	Embedded mitigation / design measures				
SE1	Signage and theft deterrents for project components, worksites and equipment	Design and establish signage and theft deterrents	Planning prior to construction, implementation throughout.	Security management measures in the security management plan	• Contractors
	Mitigation of risks and impacts				
SE2	Fair labour management and working conditions	• Develop and implement a project company human resource policy and procedures which include the following – project commitment to uphold labour rights and to prevent use of child and forced labour (that project contractors will be required to adhere to through contract clauses) – require that all workers have a contract detailing working terms and conditions – implement recruitment based on non-discrimination and equal opportunity principles • Develop and implement a workers' Code of Conduct • Develop and implement a construction labour monitoring procedure • Develop and implement measures to increase women's participation within the workforce during construction and operations, and to protect women working within the project • Use gender neutral terms in official communications (including reporting of person hour time use) • Develop and implement a workers' grievance procedure, which includes specific measures for	Planning prior to construction, implementation throughout.	Labour management system with policies, plans, procedures, code of conduct and monitoring Supply chain analysis	• Project company • Contractors

Reference	Impact topic	Details of mitigation/enhancement measure	Implementation timing	Implementation method	Responsibility
		addressing grievances related to gender-based violence and sexual harassment • Undertake a supply chain analysis to identify any risks related to use of child or forced labour and unacceptable OHS conditions			
SE3	Local employment and procurement benefits	• Establish roles and responsibilities for recruitment and staff development • Identify the recruitment procedure including justification, job description, advertising, selection (shortlisting, interviewing, skills assessment, reference), appointment, feedback • Develop recruitment and local content plan including: – Disclosing required positions and skills/experience within local communities in advance through appropriate mechanisms (for instance CLO and community representatives) – Prohibiting “at-the-gate” hiring	Planning prior to construction, implementation throughout. Plans updated for operations	Local employment and procurement plan	• Project company • Contractors
SE4	Gender mainstreaming	• Implement a gender mainstreaming component in project related plans and programs, especially the livelihood restoration plan (LRP) (see SE6 below) • Gender components of the livelihood restoration activities should include: – Offer and promote option for compensation to be paid to women rather than the male head of household only especially where the compensation is regarding female farmed crops	Planning prior to construction, implementation throughout.	ESMP LRP	• Project company • Contractors
SE5	Safeguarding personnel, property and the risks from presence of a security force	• Develop a security management plan (based on a risk assessment and human rights impact assessment) that detail measures to secure and safeguard personnel and property for security providers (public and private), as well as protect communities from security risks posed by the presence of a security force	Planning prior to construction, implementation throughout.	Security management plan	• Project company in collaboration as deemed relevant with a security service provider and

Reference	Impact topic	Details of mitigation/enhancement measure	Implementation timing	Implementation method	Responsibility
					drilling contractor
SE6	Land acquisition and displacement	• Develop a LRP for planning and implementation of locations and activities not addressed in the LRF developed as part of this ESIA [83], including: – Compensation and livelihood restoration measures for livelihoods which currently include commercial and subsistence agriculture, moving one roadside shop – Informed consultation and participation of project affected persons – Grievance resolution – Monitoring, evaluation and close out audit of LRP	Implementation of LRF, and LRP as per timeframes to be stipulated in LRP and commencing prior to construction	Livelihood restoration framework Land acquisition and livelihood restoration plan	• Project company
SE7	Meaningful stakeholder engagement	• Implement a regularly update the stakeholder engagement plan (SEP)[84] to manage stakeholder and community relations, expectations and grievances through consultation and disclosure mechanisms based on principles of respectful and meaningful dialogue, and including identified roles and responsibilities for information disclosure, communication strategies, informed consultation and participation, and achieving broad community support • Implement community grievance mechanism (part of the SEP) including recording and tracking of grievances received	Updated SEP and community grievance mechanism prior to construction Implementation prior to construction, during construction and operations	SEP Community grievance mechanism	• Project company
SE8	Worker accommodation	• Develop guidance for worker rental accommodation in alignment with the IFC/EBRD guidance note on workers' accommodation[85].	Prior to construction and/or use of the accommodation, implementation during use	Guidance included in the ESMP	• Project company • Contractors

[83] Included in Volume IV.
[84] Included in Volume III.
[85] Workers' Accommodation: Processes and Standards, September 2009

Reference	Impact topic	Details of mitigation/enhancement measure	Implementation timing	Implementation method	Responsibility
SE9	Emergency preparedness and response	• Develop and implement a regularly updated emergency preparedness and response plan (EPRP) so that project company, project employers and their staff, and relevant third parties (local authorities and emergency services) are prepared to respond to accidental and emergency situations in a manner that prevents and mitigates harm to people and the environment. The EPRP will: – Identify accidents and emergency situations and the communities and individuals that may potentially be impacted. – Identify response procedures, provision of equipment and resources, designation of responsibilities, communication systems and channels and periodic response training. – Install telecommunication systems with emergency personnel in place prior to civil works commencing and emergency communication protocol	Prior to construction and operations commencing, updated regularly and, as necessary, by location	EPRP	Project company • Contractors
SE10	Occupational health and safety	• Undertake risk assessment to identify potential hazards to workers, including physical, chemical, biological, and radiological • Provision of medical insurance for the workforce • Develop and implement plan and procedures to address: – Hazard analysis, mitigation, and training – PPE usage – Roles and responsibilities – First aid provisions, staff resources including first responder training for relevant personnel – Pest and vector control, especially snakes and vector borne diseases associated with working in remote areas such as dengue fever – Documenting and reporting occupational accidents, diseases, and incidents	Prior to construction Implementation throughout	OHS plan	• Project company • Contractors

Reference	Impact topic	Details of mitigation/enhancement measure	Implementation timing	Implementation method	Responsibility
SE11	Community health and safety	• Develop and implement community health and safety procedures including: – Road safety: road safety awareness campaign will be designed and implemented in consultation and participation with communities. Traffic management measures to be developed and implemented by the drilling contractor – Communicable diseases: community health and safety awareness campaign will be designed and implemented in consultation with affected communities and local health care services and will involve information disclosure to raise awareness and educate communities about health risks and health determinants (genetics, lifestyle, environment, and others). Focus will be on site-specific diseases such as HIV, malaria, diarrhoeal disease, and tuberculosis.,. • Drill pad site safety: – Establish safety exclusion zones with markings and signage – Undertake community meetings on safety zones and access restrictions – Periodically inspect sites	All phases of the project	Community health and safety management measures in the ESMP, TMP and other relevant plans SEP.	Project company Contractors
SE12	Improve accessibility to the project area and road network	• Refer to measures proposed for stakeholder engagement (above) and measures in chapter 13 Traffic and transport	During construction and operations	SEP Community grievance mechanism Traffic management plan	• Project company • Contractors
SE13	Manage chance finds	• Develop and implement a chance finds procedure for groundwork, vegetation clearance and excavations, in consultation with GoG antiquities department. If any unexpected tangible cultural heritage or archaeological finds are encountered, the following will be employed: • Work will be immediately stopped in the area	Construction Decommissioning	Chance Finds Procedure Induction training for all workers	• Project company • Contractors

Reference	Impact topic	Details of mitigation/enhancement measure	Implementation timing	Implementation method	Responsibility
		• Any finds will be demarked and protected via fencing/blocking off and the site manager and cultural heritage focal point will be contacted • The antiquities department will be informed and consulted to seek guidance and specialist advice for management of the find(s) and how best to proceed, given its nature and extent • All finds will be recorded (including but not limited to): – date, time, location of the discovery – Description of the estimated weight and dimensions with photo; description of temporary protection for implementation (if any).			
	Enhancement measures				
SE-E1	Tourism	– Production of a tourism strategy and brochure for construction workers and project visitors	Prior to construction	Brochure	• Project company/GoG

7.6.2 Human rights mitigation measures

Many of the mitigation and management measures align with other E&S aspects but are summarized here for completeness.

Table 7.27: Human rights mitigation measures

Reference	Risk topic	Details of mitigation	Implementation timing	Implementation method	Responsibility
	Embedded mitigation / design measures				
	None				
	Mitigation of risks and impacts				
HR1	Human rights policy	• Develop and implement a human rights policy to drive human rights compliance	All phases	Human rights policy	• Project company

Reference	Risk topic	Details of mitigation	Implementation timing	Implementation method	Responsibility
HR2	Stakeholder engagement carried out in an inclusive way, providing access to remedy	• Prepare and implement stakeholder engagement plan allowing freedom of expression for interested and affected parties • Ensure consultation is non-discriminatory, enabling access for vulnerable groups through careful consideration of venues, timing and potential for environments intimidating certain stakeholders • Prepare and implement a project performance grievance mechanism to provide access to remedy in the case that human rights are infringed	All phases	SEP	• Project company and its E&S consultants
HR3	Training	• Train managers and key staff in anticipated interactions between the project and human rights issues to embed the project's commitments on delivering on human rights policies and procedures	All phases	ESMP	• Project company
HR4	Gender-based violence and harassment (GBVH)	• Incorporate GBVH considerations into the worker's code of conduct • Incorporate GBVH aspects into grievance mechanisms, providing training for those handling grievances • Include GBVH issues and expectations on workers in induction training	Construction phase	Workers' code of conduct Grievance mechanism Induction training	• Project company • Contractors
HR5	Data security policy	• Prepare and implement a data security policy to ensure secure handling of personal data by the project	All phases	Data security policy	• Project company

7.7 Monitoring

Social monitoring requirements are presented in Table 7.28. Procedures for social monitoring identified in Table 7.28 will be described in project specific policies plans and procedures related to labour and working conditions, livelihood restoration, stakeholder engagement, OHS, CHS (including security) and traffic.

External monitoring of the LRP and evaluation of the return of economically displaced households to pre-existing or improved livelihood restoration will be required. A LRP closeout report verified by an independent third party will need to be produced. The LRP will include details on the requirements of a close out report.

Monitoring will be undertaken to determine the effectiveness of mitigation measures in terms of potential or actual human rights impacts. Many of the relevant monitoring measures are included under social, so monitoring that is specific only to the human rights impact assessment is outlined in Table 7.28.

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7.7.1 Socio-economic, community and cultural heritage monitoring

Table 7.28: Monitoring requirement

Monitoring topic	Responsibility	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
OHS risks and incidents	Contractors Project company	• Number of accidents/injuries/diseases/OHS incidents • Number of first aid cases and serious injuries/fatalities • Number of near misses • OHS training • Ratio of OHS staff to workers • Fire safety drills and incidents • Number of inspections • First aid equipment	All worksites	Daily	During construction and operations
Covid-19 management (if required)	Contractors Project company	• Number of cases among workers • Degree of close contact in worker accommodation and site locations • Community cases or country incident rate • Activities modified because of Covid-19	All worksites	Monthly	During pandemic
Emergency preparedness and response	Contractors Project company	• Training drills, including lessons learned • Emergency preparedness and response equipment (fire extinguishers, spill kits, medical emergency equipment, etc) and facilities • Community preparedness and response engagement activities (numbers and type) • Emergency service providers preparedness and response times	All worksites	Quarterly	During construction and operations
Worker accommodation	Project company Contractors	Pre-accommodation check based on guidelines to be developed but likely to include: • Number of rooms and beds, workers accommodated • Worker and community grievances • Disease type / incident, lost time impacts	Accommodation	Pre-accommodation check: One-off inspection • Ongoing monitoring: Monthly	During construction and operations

Monitoring topic	Responsibility	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
		• Facility, including water and food quality and hygiene inspections • Ablution facility ratios per user • Waste segregation and appropriate disposal • Ongoing monitoring: • Adherence to code of conduct for accommodated workers • Facility maintenance and upkeep			
Security	Project company	• Number of security guards • Vetting of security guards • Training of security guards • Memorandum of understandings (MoUs) with public security forces – if relevant • Use of force or other security related grievances • Incidents (onsite – threats, theft and robbery, roadblocks, manifestations, damage; off site – community conflicts, protests, other) • Security engagement – meetings with public security entities, meetings about security with other stakeholders,	Project worksites	Monthly	During construction and operations
Labour monitoring	Project company Drilling contractor	• Adherence to project labour commitment, code of conduct, contract clauses related to labour rights and working conditions • Worker profile (gender, origin, permanent/temporary) • Worker contracts, working hours, overtime hours, timely worker payments • Worker grievances • Notifications prior to termination of contracts, dismissals, disciplinary cases • Provision of training (types, duration, certification, outcomes) and training records • Benefits, leave	Project worksites	Daily to quarterly	During construction and operations

Monitoring topic	Responsibility	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
		• Inspections of forced labour and child labour • Presence and activities of workers' organizations • Access to H&S provisions and PPE • Local employment and content • Worker health prevention measures and incident rates			
Labour rights	Contractors	• Supply chain reviews completed and findings	Primary supply chain	Annually	Prior to operations, annually thereafter
Gender management	Contractors Project company	• Women included in programs/initiatives	Neighbouring communities and project workforce	Monthly	During all phases
Chance finds	Contractors	• Training records • Number and types of chance finds • Remedial activities	Project worksites	Monthly	Construction
Livelihoods restoration	Project company	• LRP	Economically displaced households	Monthly	As per LALRP
Community investment	Project company	• Community investment initiative activities, beneficiaries, outcomes • Budget allocated • Budget spent	Neighbouring communities	Monthly	During construction and operations
Stakeholder engagement	Project company	• Information disclosed • Meetings held (participant numbers, gender representation, topics covered, satisfaction with resolutions) • Grievances received • Grievances open • Grievances closed • Timeframe for closing grievances	All stakeholders	Monthly	During construction and operations
Community health and safety	Project company	• Health risk awareness campaigns (participant numbers, gender representation, topics covered, outcomes) • GBVH complaints	Neighbouring communities	Monthly	During construction and operations

Monitoring topic	Responsibility	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
		• Disease incidence • Anti-social behaviour incidence			

Source: Mott MacDonald

7.7.2 Human rights monitoring

Table 7.29: Monitoring requirement

Monitoring topic	Responsibility	Monitoring parameters	Monitoring area	Monitoring frequency	Monitoring timing / duration
Consultation and information disclosure	Project company	• Accessibility of engagement activities for vulnerable groups including women and people with disabilities • Meaningful two-way consultation opportunities provided in timely manner	Affected communities	Quarterly	Throughout project lifecycle
Public grievances	Project company	• Numbers of grievances • Types of grievances • Number of grievances related to GBVH • Appropriate close-out measures and actions to prevent recurrence • Grievances closed out within timeframes	Affected communities	Quarterly	Throughout project lifecycle
Training	Project company	• Numbers of staff trained on human rights topics, dates of courses and refreshers • Inclusion of human rights issues in induction training • Understanding of human rights topics (such as GBVH) among workers	Project staff on site	Quarterly	Throughout project lifecycle
Human rights policy	Project company	• Senior level commitment to human rights policy • Contract clauses for contractors to adhere to human rights policy	Project managers on site	One-off	Once at the start of construction and once at the start of operations

Monitoring topic	Responsibility	Monitoring parameters	Monitoring area	Monitoring frequency	Monitoring timing / duration
GBVH measures	Project company contractor	• Numbers of signed workers' codes of conducts as a % of project workers • Review grievance mechanisms for GBVH complaints and satisfactory close-out	Project managers and staff on site	Quarterly	Throughout project lifecycle
Access to remedy strategy	Project company Contractors	• Number of times access to remedy strategy has been used • Number of successful remedies provided for human rights infringements (how many people affected, signed statements to say that they are satisfied with the outcomes) • Contract clauses for contractors to adhere to access to remedy strategy	Project managers on site	Quarterly	Throughout project lifecycle
Data security	Project company contractor	• Number of personal data breaches • Contract clauses for contractors to adhere to data security policy	Project managers on site	Quarterly	Throughout project lifecycle

7.8 Residual impacts

The residual impacts for socio-economic and cultural are presented in section 7.5. Refer Table 7.15 to Table 7.19 for construction phase, refer Table 7.20 to Table 7.22 for operation phase and refer to Table 7.23 for decommissioning phase.

Appendices

A. Ecosystem services

B. Medicinal species

Table B.1: Medicinal species recorded at Site F

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				F1	F2	F3	F4		National	International	
ACANTHACEAE	Mini Root / Bluebell / Snapdragon Root	*Ruellia tuberosa*	Herb		✓		✓		Not Listed	Not Listed	Tea from shoots, flowers and tubers is used to treat cold, fevers and hypertension.
	Rock Balsam	*Blechum pyramidatum*	Herb	✓			✓		Not Listed	Not Listed	Used as a poultice for wounds.
	St John's Bush	*Justicia secunda*	Shrub	✓	✓		✓		Not Listed	Not Listed	Tea from leaves used to start menstruation and to treat 'red eye' (i.e. viral conjunctivitis).
	Mango	*Mangifera indica*	Tree	✓	✓		✓		Not Listed	Data Deficient (IUCN)	Cultivated for its edible fruit. Extracts from the leaves and bark can be used to relieve toothaches and sore gums.
ARECACEAE	Railway Daisy / Creeping Daisy	*Wedelia trilobata*	Herb				✓		Not Listed	Not Listed	Used to treat coughs and colds.
	Shepard's Needles	*Bidens pilosa*	Herb	✓	✓	✓	✓			Not Listed	Used in other places to treat colds, earaches, inflamed eyes and difficulty in urination.
	Shaving Bush	*Emilia sonchifolia*	Herb	✓			✓		Not Listed	Not Listed	Used in other places to treat eye inflammation, cuts, earaches, tooth decay, bowel issues and diarrhoea.
	Shaving Bush	*Emilia sonchifolia*	Herb	✓			✓		Not Listed	Not Listed	Used in other places to treat eye inflammation, cuts, earaches, tooth decay, bowel issues and diarrhoea.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
	Goatweed	*Ageratum conyzoides*	Herb					✓	Not Listed	Least Concern (IUCN)	Used in other places top treat fevers, headaches, colic and rheumatism.
ASTERACEAE	Cinderella Weed	*Synedrella nodiflora*	Herb					✓	Not Listed	Not Listed	Used in other places to treat rheumatism and arthritis and as a laxative.
	Cat's Claw	*Macfadyena unguis-cati*	Vine	✓		✓			Not Listed	Not Listed	Used to treat Manchineel (*Hippomane mancinella*) 'burns.'
	Wild Breadnut / Cacao Sauvage	*Pachira insignis*	Tree	✓	✓				Not Listed	Not Listed	Bark is used as bait for cocoa beetles and as a fever treatment. Edible seeds can be eaten raw or roasted.
	Canna Lily	*Canna indica*	Herb				✓		Not Listed	Not Listed	Used for stomach-aches.
	Pawpaw	*Carica papaya*	Tree					✓	Not Listed	Data Deficient (IUCN)	Cultivated for its fruit. Sap contains papain which is used to tenderize meat and coagulate milk. Young shoots and seeds are edible. Extract from leaves is used to treat burns and fever and 'ague' associated with Dengue and Chikungunya. Leaves may be smoked to relieve asthma.
	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	Tree	✓	✓	✓	✓		Not Listed	Not Listed	Young buds are edible. Tea is used for cold and hypertension.
	Galba	*Calophyllum calaba*	Tree	✓	✓				Not Listed	Not Listed	Hardwood, often planted as a wind-break, used to make furniture and huts. Bark has medicinal value.
	Caner Grass	*Commelina elegans*	Herb	✓	✓		✓		Not Listed	Not Listed	Used as a 'cooling' infusion and for animal fodder.
	Caner Grass	*Commelina diffusa*	Herb	✓			✓		Not Listed	Least Concern (IUCN)	Used as a 'cooling' infusion and for animal fodder.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
BOMBACACEAE	Wild Ginger	*Costus speciosus*	Herb	✓		✓			Not Listed	Not Listed	Ornamental species. Used elsewhere to treat cough, asthma, dysmenorrhea, skin issues and intestinal parasites.
	Wild Ginger	*Costus scaber*	Herb		✓	✓			Not Listed	Least Concern (IUCN)	Ornamental species. Used as part of a remedy to treat snakebites in other places.
CARICACEAE	-	*Cyperus kyllingia*	Sedge	✓	✓	✓	✓		Not Listed	Not Listed	Used in other places as animal fodder and to treat fever, ulcers, sore throat, diarrhoea and skin problems. Used as a diuretic and abortifacient.
CECROPIACEAE	Nut Grass	*Cyperus rotundus*	Sedge	✓	✓	✓	✓		Not Listed	Not Listed	Used in other places to treat diarrhoea, diabetes, fever, inflammation, stomach issues and malaria.
CLUSIACEAE	Water Vine	*Doliocarpus sp.*	Vine	✓		✓			Not Listed	Not Listed	Used as a source of water by persons (e.g. hikers) in the forest. In the other places, this sap is used as an anti-inflammatory.
COMMELINACEAE	Yam / Kush Kush	*Dioscorea alata*	Vine	✓	✓	✓	✓		Not Listed	Not Listed	Important root crop. Has pharmaceutical applications elsewhere; contains a natural 'steroid precursor' used in the manufacturing of certain steroids and corticosteroids.
COSTACEAE	Sand Box Tree / Monkey's Dinner Bell	*Hura crepitans*	Tree	✓			✓		Not Listed	Not Listed	Segments of the seed-case used to make jewellery. Seeds may be used as a purgative.
CYPERACEAE	Cinnamon Tree	*Cinnamomum verum*	Tree				✓		Not Listed	Not Listed	Important export spice used as flavouring and fragrance. Medicinal uses include tonics, child-birth sedative, breath freshener and for guts and respiratory ailments.
DIOSCOREACEAE	Sweethearts / Coeur de Valeur	*Desmodium incanum*	Herb	✓	✓		✓		Not Listed	Not Threatened	Treatment for diarrhoea in children.

Family	Common Name	Scientific Name	Form	Transect F1	F2	F3	F4	Opp.	Status National	International	Notes
										(Catalogue of Life)	
DRYOPTERIDACEAE	Sensitive Plant	*Mimosa pudica*	Shrublet	✓	✓	✓	✓		Not Listed	Least Concern (IUCN)	Used to treat colds, coughs, venereal diseases, toothache and to induce vomiting and urination.
EUPHORBIACEAE	Quick Stick / Glorisita	*Gliricidia sepium*	Tree				✓		Not Listed	Not Threatened (Catalogue of Life)	Used as live fencing, windbreaks and as a shade tree. Wood is durable. Leaves are used for fodder. Leaves are used to treat skin ulcers and sores.
	Cow Itch	*Mucuna pruriens*	Vine	✓	✓	✓			Not Listed	Not Threatened (Catalogue of Life)	Used to treat worms.
LEGUMINOSAE	Wire Weed / Sweet Broom	*Sida acuta*	Shrublet	✓	✓	✓	✓		Not Listed	Not Listed	Stems and roots used as poultice on sprains and strains.
	Kak Mel	*Clidemia hirta*	Shrub	✓	✓	✓			Not Listed	Not Listed	Leaves are crushed with lard and applied to treat hernias. Can also be used for healthy skin.
	Breadfruit / Breadnut	*Artocarpus altilis*	Tree	✓			✓		Not Listed	Not Listed	Cultivated for its edible fruit. Breadfruit is the main ingredient in Grenada's national dish (i.e. Oil Down). Leaves used to treat diabetes and hypertension.
	Figuier	*Ficus guianensis*	Tree	✓	✓				Not Listed	Not Listed	Used as a shade plant. Latex is applied to decaying tooth to relieve pain and results in tooth falling out 1-2 days later.
	Strangler Fig	*Ficus citrifolia*	Tree	✓		✓			Not Listed	Least Concern (IUCN)	Used in other Caribbean countries to treat cancer, constipation, heart ailments, skin problems and toothaches.
LINDSAEACEAE	Nutmeg	*Myristica fragrans*	Tree	✓	✓		✓		Not Listed	Data Deficient (IUCN)	Grenada's most important commercial export. Mace is used in flavouring and fragrances. Seed is used as an insecticide and as a remedy for colds, flu and fever; also used as natural ground

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
											covering in gardens. Oil is used as a rub for muscular pains.
MARANTACEAE	Cloves	*Syzygium aromaticum*	Tree				✓		Not Listed	Not Listed	This spice is exported and is used for flavouring and fragrance. Clove oil is used to treat toothaches.
MORACEAE	Wall Cress / Shining Bush	*Peperomia pellucida*	Herb		✓	✓			Not Listed	Not Listed	Used to treat asthma and diarrhoea.
MUSACEAE	Bamboo	*Bambusa vulgaris*	Grass	✓	✓	✓	✓		Not Listed	Not Listed	Used for construction, water pipes and in basket-making. Leaves are used to relive fever and reduce blood sugar. Used to increase sex-drive in both animals and humans. Shoots are edible.
MYRISTICACEAE	Gully Bead / Buck Bead	*Coix lachryma-jobi*	Grass	✓	✓	✓	✓		Not Listed	Not Listed	Seeds are edible; can be boiled like rice or milled into flour. Used as a ‘cooling’ herb to reduce fever, inflammation, pain and to treat rheumatoid arthritis and to lower blood sugar. Seeds are used to make jewellery and decorations.
MYRTACEAE	Guinea Grass / Animal Grass	*Panicum maximum*	Grass	✓	✓	✓	✓		Not Listed	Not Listed	Used as animal fodder. Used elsewhere in other places to treat heartburn.
POACEAE	Cabbage Palm Fern	*Phlebodium aureum*	Fern	✓	✓	✓			Not Listed	Not Listed	Is an ornamental species. Used in other places to treat coughs, fevers, skin aliments and rheumatoid arthritis.
	Broadleaf Maidenhair	*Adiantum latifolium*	Fern	✓	✓	✓	✓		Not Listed	Not Listed	Potentially an ornamental species. Used in other places to calm anxiety, reduce pain and inflammation.
	Rough-skin Lemon	*Citrus* x *jambhiri*	Tree					✓	Not Listed	Not Listed	Used to balance the body’s pH, promotes healthy digestive and

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
											urinary systems and reduced inflammation.
PTERIDACEAE	Bread and Cheese	*Paullinia pinnata*	Vine	✓		✓			Not Listed	Not Listed	Used as a tonic or aphrodisiac. Roots are chewed for coughs. Stems can be used like twine.
RUBIACEAE	Maruba / Birdfood	*Simarouba amara*	Tree	✓			✓		Not Listed	Not Listed	Light weight wood is used to make shingles and cabinet. Fruit is edible. In other places the bark is used to treat malaria and dysentery.
RUTACEAE	Nettle Tree	*Urera baccifera*	Tree	✓	✓				Not Listed	Not Listed	Used as a diuretic and for pain relief.
SAPOTACEAE	Ven-ven / Vervain	*Stachytarpheta jamaicensis*	Herb	✓	✓				Not Listed	Not Listed	Leaves are used in a 'cooling' herbal tea for nursing women, for fevers and in poultices for wounds.
	Ven-ven / Vervain	*Stachytarpheta urticifolia*	Herb	✓					Not Listed	Not Listed	Leaves are used in a 'cooling' herbal tea for nursing women.
	Lantana	*Lantana camara*	Shrublet	✓	✓				Not Listed	Not Listed	Flowers and buds are used in a tea to treat flu and chills.

Source: Hawthorne, 2004 and IUCN, 2019

Table B.2: Medicinal species recorded at Site C

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				Q1	Q2	Q3	Q4		NATIONAL	INTERNATIONAL	
MORACEAE	Breadnut	*Artocarpus camansi*	Tree	✓		✓			Not Listed	Not Listed	Cultivated for its edible fruit. Breadfruit is the main ingredient in Grenada's national dish (i.e. Oil Down). Leaves used to treat diabetes and hypertension.
MYRISTICACEAE	Nutmeg	*Myristica fragrans Houtt.*	Tree	✓	✓	✓	✓		Not Listed	Data Deficient (IUCN)	Grenada's most important commercial export. Mace is used in flavouring and fragrances. Seed is used as an insecticide and as a remedy for colds, flu and fever; also used as natural ground

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				Q1	Q2	Q3	Q4		NATIONAL	INTERNATIONAL	
											covering in gardens. Oil is used as a rub for muscular pains.
ASTERACEAE	Beggar Ticks	*Bidens cynapiifolia*		✓	✓				Not Listed	Not Listed	Herbal remedies for irritation, inflammation, pain, and bleeding of the urinary tract, among other things
MYRTACEAE	Clove	*Syzygium aromaticum*	Tree		✓				Not Listed	Not Listed	Most valuable spices that has been used for centuries as food preservative and for many medicinal purposes.
	Pomme Rose	*Syzygium jambos*	Tree	✓					Not Listed	Not Listed	Rich in Vitamin C, the fruit can be eaten raw or cooked in various regional recipes.
FABACEAE	Sweethearts	*Desmodium adscendens*	Plant						Not Listed	Not Listed	It is especially valued as a treatment for asthma and allergies. It is generally harvested from the wild and is often traded.

Source: Hawthrone, 2004, Grenada's National Red List of Threatened Species, 2014 and IUCN, 2019

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8 Biodiversity

8.1 Overview

This chapter presents a summary of survey methodologies and baseline characterisation of the Project area's biodiversity to enable comparison of the current situation with changes anticipated to biodiversity receptors as a result of the Project. It includes legally protected and internationally recognised areas, habitats, flora and fauna species, gathered through primary and secondary sources. A critical habitat screening was undertaken to understand if the Project is potentially located in Critical Habitat.

The methodology used to assess the potential impacts and to identify where significant effects are expected to arise have been presented. Impacts have been considered and assessed for the site preparation (including access road upgrade construction and well pad set up), exploratory drilling works and where relevant decommissioning/ site closure. Mitigation, enhancements, further studies and monitoring requirements are also presented in this chapter.

8.2 Study Area and Area of Influence

A Biodiversity Study Area (BSA) has been defined for the desktop study that informs this ESIA. The BSA generally follows the Grenada coastline 1km inland, except for the southern boundary. The southernmost boundary of the BSA coincides with the southernmost boundary of Grand Etang National Park. The BSA excludes protected areas and habitats associated with coastal and marine habitats as these will not be affected by the development.

The Biodiversity AoI has been defined as:

Terrestrial and aquatic habitats, flora, mammals, herpetofauna: 500m buffer around each Project component.

Birds: 2km buffer around each Project component.

The BSA is presented in (Figure A.1), the Biodiversity AoI for Site C is shown in Figure A.2 and for Site F in Figure A.3 in Appendix A.

8.3 Methodology

The assessment involved establishing a baseline understanding of habitats and associated biodiversity present within the BSA. This was undertaken through a desk study of secondary data sources (as described in Section 8.3.1) and using primary data within the AoI, collected following the site reconnaissance during the scoping site visit, 2019 field surveys (Appendix B) and 2023 field surveys (Appendix C).

An assessment of impacts was made based on information provided by the Sponsor and technical consultants. Possible impact arising as a result of the changes created by the Project, have been identified and their significance assessed.

8.3.1 Desk based review methodology

A desk-based review of available information from national and international sources was undertaken. This included:

- Convention on Biological Diversity website (http://www.cbd.int/)
- UNESCO database on World Heritage Sites (http://whc.unesco.org/en/interactive-map/)
- The Ramsar Convention on Wetlands of International Importance (https://www.ramsar.org)

- Critical Ecosystem Partnership Fund (https://www.cepf.net/our-work/biodiversity-hotspots)
- Protected Planet (https://protectedplanet.net/country/GD)
- Integrated Biodiversity Assessment Tool (https://ibat-alliance.org/)
- IUCN Red List of Threatened Species (http://www.iucnredlist.org)
- National Red List (http://www.nationalredlist.org/files/2015/09/Grenada-Species-for-IUCN-listing-2014.pdf)
- Species protected by the Wild Animals and Birds (Sanctuary) Ordinance (https://leap.unep.org/countries/gd/national-legislation/wild-animals-and-birds-sanctuary-act-cap-339)
- BirdLife International Data Zone (http://www.birdlife.org/datazone/home).
- Catalogue of Life (http://www.catalogueoflife.org/)
- The Reptile Database (http://reptile-database.reptarium.cz/)
- The Amphibia Web (http://amphibiaweb.org/)
- World Flora Online (http://www.worldfloraonline.org/)

Information on the following nature conservation areas and other protected areas (existing or proposed) within the BSA has also been collected and reviewed:

- Ramsar sites
- Key Biodiversity Areas (KBA)
- Important Bird and Biodiversity Areas (IBA)
- World Heritage Sites (WHS)
- Biosphere Reserves
- National Protected Areas of Grenada:
  - National Park
  - Forest Reserve
  - Local Area Planning

Previous reports undertaken as part of the Grenada Geothermal Project have been reviewed and included:

- Ecoengineering Consultants Limited (ECL) (2019). Grenada Geothermal Project: Biodiversity Baseline Survey Report (Site F only).

In addition, stakeholder consultation was undertaken in 2019, 2020, 2021 and 2022, Outcomes of the consultation are presented in Chapter 5.

8.3.2 Biodiversity survey methodology

Biodiversity surveys were undertaken from 8 – 12 April (dry season) and 19 – 22 July (wet season) 2019, and 19 – 30 March 2023 by Ecoengineering to inform this ESIA. This section describes the methods used to carry out following biodiversity surveys:

- Habitats and flora
- Mammals
- Birds
- Herpetofauna (reptiles and amphibians)
- Aquatic species

8.3.2.1 2019 and 2023 Dry (March / April) and Wet (July) Season Biodiversity Surveys

In addition to field surveys that are discussed in the following sections, interviews with local farmers, landowners and workers were conducted on 11 April 2019 at Site F, and on 24 – 27 March 2023 at Site C.

The objective of the farmer interviews was to determine the use and functions of local plant species. Therefore, an Ecosystem Sheet was used in each interview to assess the importance of each flora species for each use, by asking farmers to score plant use from 1 to 3, based on livelihood.

Local people were interviewed regarding the occurrence of fauna within the area. Questions concerned the different species present in the Project area and the average number of individuals per species. Information on hunting patterns was also collected, including times of year and frequency data.

Full details of the 2019 and 2023 surveys are presented in Appendix X and X respectively.

Habitat and Flora Survey Methodology

Habitat and flora surveys were conducted as per the following programme:

- 2019 Dry season
  - Site F: 11 April 2019
- 2019 Wet season
  - Site F: 21 – 22 July 2019
- 2023 Dry season
  - Site C: 21 March 2023

Prior to both the 2019 and 2023 site surveys, Google Images and the World Bank Land Use Map for Grenada (World Bank, 2019) were used to determine transects within the Project area.

In 2019, four transects (of 140 – 500m) were established in site F, within a 500m radius of the centre point of each proposed drill pad. Their respective lengths are displayed in Table 8.1 below. Quadrats (sized 10x10m) were set up along each transect, with their locations varying according to local vegetation size and homogeneity. A total of 18 quadrats were created at Site F. Any flora within the quadrats was rated using the DAFOR scale (D=Dominant, A=Abundant, F=Frequent, O=Occasional, R=Rare), and the percentage cover of each species was also recorded. Ground truthing was undertaken along the transects as well. This took place initially in the dry season, with the wet season being used to verify species presence and note any significant changes. This comprised the identification and recording of all plant species within 5m either side of the transect line.

Table 8.1: Habitat and Flora Transect Lengths and Directions

Site	Transect	Length (m)	Direction
F	1	300	North
	2	400	East
	3	140 (after which it became a wandering transect along a watercourse)	South
	4	500	West

Source: Ecoengineering 2019

In 2023, four transects (of 100 – 500m) were established in site C, within a 500m radius of the centre point of the proposed drill pad. The lengths of each transect are displayed in Table 8.2 and Table 8.1 below. Quadrats (sized 10x10m) were set up along each transect, with their locations varying according to local vegetation size and homogeneity. The position of the quadrats along each transect are also within Table 8.2Table 8.1 below. A total of ten quadrats were created at Site C. Any flora within the quadrats was rated using the DAFOR scale (D=Dominant, A=Abundant, F=Frequent, O=Occasional, R=Rare). Ground truthing was undertaken along the transects as well. This comprised the identification and recording of all plant species within 5m either side of the transect line.

Table 8.2: Habitat and Flora Transect Lengths, Directions, and Quadrat Positions (Site C)

Transect	Length (m)	Direction	Quadrat distance along transect (m)
1	500	East	100
			200
			300
			400
			500
2	160	West	100
			160
3	160	North	100
			160
4	100	South	100

Source: Ecoengineering, 2023

Mammal Survey Methodology

During the 2019 surveys, the transects and quadrats established during the habitat and flora surveys were used to survey mammal presence within the Project area. The drilling site (F) was also surveyed to a radius of 500m. Any observations of mammals, including direct sightings, footprints, nests, faecal matter, signs of feeding, hair or calls were recorded and (where possible) photographed. Surveys were conducted during the day and at least once during the night, using spotlights.

During the dry season surveys, camera traps were also used to survey mammals. Two camera trap locations were established at the Site F drill site (based on habitat types present), with the cameras installed for two periods during March and April 2019. The traps were secured to trees, and positioned in such a way as to capture terrestrial fauna on the ground. The cameras were present for three consecutive nights in March, and in April, they were set up for four nights.

The 2023 surveys also utilised the transects and quadrats established within Site C during the 2023 habitat and flora surveys for mammalian surveys. Any incidental observations of mammals, including direct sightings, footprints, nests, faecal matter, signs of feeding, hair or calls were recorded and (where possible) photographed. Surveys were conducted during the day and at least once during the night, using spotlights.

Bird Survey Methodology

Birds were surveyed via fixed point bird counts in both survey years.

In 2019, the locations of the fixed points corresponded to the major habitats present within each site (agroforestry, grassland, and secondary forest), with two points being established per site. Any bird species observed within a 25m radius of each point over a ten-minute window were recorded, as per Hutto et al.'s 1986 method. Each fixed point was monitored once in the dry season, and twice in the wet season using 8x42 binoculars and call recognition. Counts were conducted either between 07:00 – 09:00 in the morning, or between 16:00 – 18:00 in the afternoon, as bird activity peaks during these hours. Opportunistic bird sightings were also recorded and photographed along the flora transects and within 500m of the proposed well sites.

In 2023, the locations of the fixed points also corresponded to the major habitats present, with five points being set up within Site C. Bird surveys took place on the morning of 21 and 23 March 2023. Any bird species observed within a 25m radius of each point over a ten-minute window were recorded, as per Hutto et al.'s 1986 method, and where possible the number of individuals present was also recorded. Each fixed point was monitored twice in the morning using 8x42 binoculars and call recognition. Counts were conducted either between 06:00 – 09:00 in the morning as bird activity peaks during these hours. Opportunistic bird sightings were also recorded and photographed during afternoon and night walks and along the flora transects and within 500m of the proposed well sites.

Herpetofauna and Invertebrate Survey Methodology

In both the 2019 and 2023 surveys, the transects and quadrats established during the habitat and flora surveys were used to survey for herpetofauna within the Project area. Any flora species encountered along or within the transects and quadrats that are known habitats for amphibians (such as ferns and bromeliads) were surveyed for a five-minute period.

Amphibian surveys were also carried out from 17:30 – 18:30 in the evening during dusk in 2019 and from 19:00 on 22 March 2023. This involved call recognition and spotlighting in areas near streams and rivers and in damp areas.

In addition to the above survey methods, dry pitfall traps were used to capture herpetofauna and invertebrates. These were installed according to the habitat types present, in areas where herpetofauna species were considered likely to occur. The traps consisted of 1-litre plastic containers that were sunk into the ground until the mouth of the container was level with the soil's surface (Cogger 1986). In 2019, a total of three pitfall traps were placed in the Project area during the dry season, and seven during the wet season. The difference in trap numbers was due to time constraints during the dry season, and due to an endeavour to increase sampling efforts in the wet season as a result of the low number of species encountered during the dry season. During the dry season, the traps were present in each location for three days, and were inspected every other day. Throughout the wet season, the traps were in each position for four to five hours in total. In 2023, two pitfall traps were established within Site C, and kept in position for one day (23 March 2023). These traps were checked once during the day prior to removal.

Aquatic Survey Methodology

Surveys for aquatic fauna within the Project area were conducted in both the wet and dry seasons in 2019, and in Site C during the 2023 dry season surveys on 24 March 2023. Rivers within Sites C and F were surveyed at their closest accessible point to the transect lines established during the habitat and flora surveys. At each point, the surveyors walked alongside the river for approximately 100m, in order to observe any aquatic species present, including fish and macroinvertebrates. When species were detected, a dip-net was used to capture them. Where possible, any aquatic species observed were identified, photographed, and recorded in the field.

8.3.3 Critical habitat screening

A high-level screening was undertaken to identify if the Project has the potential be located in Critical Habitat as defined by IFC PS6 Guidance Note 6 (IFC, 2019). A full Critical Habitat Assessment (CHA) has not been undertaken as part of this ESIA, however, species and habitats that could meet the Critical Habitat criteria and therefore trigger additional requirements under IFC PS6 have been identified.

The criteria and the quantitative thresholds for Critical Habitat for Criteria 1-4 are described in Table 8.3 below. Species included in the screening were identified using their IUCN geographic ranges (IBAT, 2023) which overlapped with the BSA and those that were confirmed during the 2019 and 2023 field surveys. Habitats that were included in the screening were identified following the desk study, review of satellite data and land cover from British Geological Survey (BGS) and field survey data from 2019 and 2023.

The screening identified IUCN Critically Endangered (CR) and Endangered (EN) species, restricted-range and migratory/ congregatory species within the BSA. Likelihood of occurrence within the AoI was evaluated based on land cover mapping, habitat preferences of the species and consultation with local biodiversity specialists.

Species and habitats that meet the criteria, will need to be assessed against the quantitative threshold as part of a full CHA that will specify if the Project is located within Critical Habitat. The BSA was used for this screening. An Ecologically Appropriate Area of Analysis (EAAA) will need to be confirmed as part of the full CHA. Refer to Section 8.5 for the results of the screening.

Table 8.3: Quantitative Thresholds for Critical Habitat for Criteria 1, 2, 3 and 4

Criteria	Quantitative Thresholds
1. Critically Endangered (CR) / Endangered (EN) Species	a. Areas that support globally important concentrations of an IUCN Red-listed EN or CR species (≥ 0.5% of the global population AND ≥ 5 reproductive units of a CR or EN species). b. Areas that support globally important concentrations of an IUCN Red-listed Vulnerable (VU) species, the loss of which would result in the change of the IUCN Red List status to EN or CR and meet the thresholds in GN72(a). c. As appropriate, areas containing important concentrations of a nationally or regionally listed EN or CR species. Areas supporting species listed in Annex IV of the EU Habitats Directive.
2. Endemic / Restricted-range Species[1]	a. Areas that regularly hold ≥10% of the global population size AND ≥10 reproductive units of a species.
3. Migratory / Congregatory Species	a. Areas known to sustain, on a cyclical or otherwise regular basis, ≥ 1 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle. b. Areas that predictably support ≥10 percent of the global population of a species during periods of environmental stress.
4. Highly Threatened / Unique Ecosystems	a. Areas representing ≥5% of the global extent of an ecosystem type meeting the criteria for IUCN status of CR or EN. b. Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or national systematic conservation planning.

Source: IFC, 2019

Criterion 1-3: Species Biodiversity Values

This screening included:

- All species with IUCN geographic ranges that overlap with the projects BSA (IBAT, 2023); and
- All species that were confirmed in the AoI during the 2019 and 2023 field surveys.

[1] For terrestrial vertebrates and plants, restricted-range species are defined as those species that have an extent of occurrence (EOO) less than 50,000 km^2

For coastal, riverine, and other aquatic species in habitats that do not exceed 200 km width at any point (for example, rivers), restricted range is defined as having a global range of less than or equal to 500km linear geographic span (i.e., the distance between occupied locations furthest apart).

- IUCN geographic ranges were obtained through IBAT in 2023. Species that meet the criteria listed in Table 8.3 have been highlighted and require further assessment against quantitative thresholds within an EAAA to see if they trigger critical habitat requirements under IFC PS6.

Criterion 4: Highly Threatened / Unique Ecosystems

For this screening, a desk study was undertaken to identify if a formal IUCN Red List of Ecosystems assessment has been performed in or adjacent to the BSA. Where no formal IUCN assessment has been undertaken, a search for national/regional level assessments which use systematic methods should be undertaken within an EAAA as part of a full CHA.

Criterion 5: Key Evolutionary Processes

The structural attributes of a region, such as its topography, geology, soil, temperature, and vegetation, and combinations of these variables, can influence the evolutionary processes that give rise to regional configurations of species and ecological properties such as genetically unique populations or subpopulations of plant and animal species. Maintaining these key evolutionary processes inherent in a landscape as well as the resulting species (or subpopulations of species) is important for the conservation of genetic diversity. By conserving species diversity within a landscape, the processes that drive speciation, as well as the genetic diversity within species, ensures the evolutionary flexibility in a system.

The determination of critical habitat for Key Evolutionary Processes is determined qualitatively on a case-by-case basis and heavily reliant on scientific knowledge (IFC, 2019) therefore, a literature review would need to be undertaken as part of a full CHA to assess if the EAAA includes sites where key evolutionary processes occur for biodiversity values.

8.3.4 Sensitivity of receptors

The criteria used to determine the sensitivity of receptors to the changes which the Project will cause is defined in Table 8.4.

Table 8.4: Criteria for determining receptor sensitivity

Sensitivity	Detail	Species criteria	Habitat or site criteria
High	Very high or high conservation concern and rarity. International scale or national/ regional scale with limited potential for substitution.	Species that trigger (or have potential to trigger) Critical Habitat requirements in accordance with IFC PS6. IUCN Critically Endangered and Endangered species, and IUCN Vulnerable species that trigger Critical Habitat. Restricted range species (IUCN classification). Nationally threatened/protected species (that trigger Critical Habitat). Migratory species likely to trigger Critical Habitat (>1% of the global population).	All areas of potential Critical Habitat (IFC PS6 definition). Internationally recognised areas (IFC PS6 definition) and nationally designated sites in IUCN categories I and II. Habitats of significant international ecological importance, Natural Habitats that are globally threatened and/or of international and/or national conservation concern and/or high biodiversity, with limited potential for substitution.
Medium	Medium conservation concern and rarity, regional scale with good potential for substitution.	Vulnerable species listed by IUCN that do not trigger Critical Habitat. Nationally protected or rare species (that do not trigger Critical Habitat).	Nationally designated sites in IUCN categories III-VI or with no equivalent IUCN category. Regionally important natural habitats.

Sensitivity	Detail	Species criteria	Habitat or site criteria
		Endemic species. Migratory species that do not trigger Critical Habitat (<1% of the global population).	Natural habitats which do not qualify as Critical Habitat. Endemic Bird Areas (EBAs).
Low	Very low or low conservation concern and local scale.	IUCN Near Threatened /Least Concern. IUCN Data Deficient species. Species of no national importance (threat and/or protection).	Sites designated at local level (no IUCN category). Undesignated sites and natural habitats of some local biodiversity and cultural heritage interest. Modified habitats with limited biodiversity value. Artificial and converted habitats (e.g., artificial water bodies, plantations, agricultural crops).
Negligible	Very limited ecological importance.	Invasive species. Species of no international or national value.	Highly modified habitats of no biodiversity value (e.g., hardstanding, bare ground and buildings).

8.3.5 Magnitude of change

The magnitude of impact is defined by taking into account the degree of change to the biodiversity baseline in terms of how permanent or reversible the impact is likely to be, its spatial scale (local, regional, national, international) and the ease with which mitigation measures can be put in place to return it to the baseline state.

The criteria used to determine the magnitude of the changes which will be created by the Project is defined in Table 8.5.

Table 8.5: Criteria for determining impact magnitude

Magnitude (positive or adverse)	Description (considers duration of the impact, spatial extent, reversibility and ability to comply with legislation)
Major	Fundamental change to critical habitat (natural/ modified) and/or natural habitats and associated species, resulting in long term or permanent change, typically widespread in nature (regional, national and international). Would require significant intervention to return to baseline.
Moderate	Detectable change to the habitats and associated species, resulting in non-fundamental temporary or permanent change typically affecting the local area.
Minor	Detectable but minor change to habitats and associated species that is temporary in nature, with high capacity to return to the baseline conditions.
Negligible	No perceptible change to habitats and associated fauna.

The magnitude of biodiversity impacts is, to an extent, subjective. The determination of the magnitude will therefore be based upon professional judgement taking into account the perceived sensitivity of the receiving environment.

8.3.6 Limitations and assumptions

Biodiversity surveys are limited by factors such as time of year which affect the ability to detect plants and animals. Although the surveys have been undertaken during both the wet season and dry season, the surveys may have not produced a complete list of plants and animals and the absence of evidence of any species should not be taken as conclusive proof that the species is not present or that it will not be present in the future.

During the 2023 dry season surveys at Site C, land access was the predominant limitation to the surveys being conducted. Roads were present in the northern and western areas, and a deep ravine was present to the south of the proposed well head. These barriers prevented access to the entirety of the 500m radius around the drilling pad centres, as the land beyond the roads and ravine belongs to other landowners.

Despite the above limitations it is considered that the data collected, including IBAT data and satellite data and landcover mapping acquired by the BGS in combination with field data from the 2019 and 2023 surveys, was sufficient to inform this ESIA.

8.4 Baseline – description of pre project conditions

8.4.1 Biodiversity importance of Grenada

Grenada comprises three main islands: Grenada, Carriacou and Petit Martinique which are located within The Caribbean Islands biodiversity hotspot. This archipelago sustains an array of ecosystems ranging from montane cloud forests to cactus scrublands and hosts a number of highly threatened species (CEPF, 2023). Grenada is located within the Windward Islands Moist Forests ecoregion, which is characterised by rugged mountains, lush tropical vegetation and high annual rainfall levels (Schipper 2023a). Grenada is also located in the Lesser Antillean Dry Forests ecoregion, characterised by moderate relief and rainfall. In accordance with the lower elevations and reduced rainfall, the forests here include littoral, thorn, deciduous, and semi-evergreen woodland (Schipper 2023b). The status of both ecoregions is Critical/Endangered (Armstrong 2018; Armstrong 2019).

Grenada has one Ramsar site, six IBAs, nine KBAs, and eight nationally designated areas. Land use categories from a land use census conducted in 1995 indicated that approximately 75% of the total land area is under some form of agriculture. Forested areas represent 20.8% of the land area. Much of the forest in Grenada is secondary re-growth due to the impacts of hurricanes.

There are two endemic species of plants in Grenada, the Grand Etang Fern *Danaea* sp. and the Cabbage Palm *Roystonea oleracea* (*Oreodoxa oleracea)*, and one endemic tree species *Monteverdia grenadensis (Maytenus grenadensis)*. There is a general lack of information in regard to the statuses and trends of Grenada's forests (CBD, 2014).

Grenada's terrestrial wildlife consists of 4 amphibian species, 8 species of lizard and 5 species of snake, 150 species of birds (18 of which are globally threatened), 4 native species of terrestrial mammals and 11 native species of bats (CBD, 2014; CBD Secretariat, 2023).

Freshwater ecosystems on mainland Grenada include surface water streams, small springs, three volcanic crater lakes (Lake Antoine, Grand Etang Lake and Levera Lake) and a man-made lake (Palmiste Lake). In terms of biodiversity, there are 17 freshwater fish species within mainland Grenada, and a wide variety of invertebrates including shrimps, snails and insects are also present (CBD, 2014).

The main threats to terrestrial biodiversity in Grenada are habitat destruction as a result of land use changes and unsustainable extraction and hunting practices. Natural disasters (in particular hurricanes) also threaten habitats and species within Grenada. The lack of adequate legislation, education, enforcement and monitoring contributes to the pressures on biodiversity (CBD Secretariat, 2023).

Freshwater biodiversity in Grenada is predominately threatened by forest clearcutting, heavy pesticide and fertiliser use, and soil erosion. Riparian habitat encroachment, illegal river damming, invasive species (tipalia fish) introduction, high levels of water abstraction, and solid waste disposal can all also drive change within Grenada's freshwater ecosystems, resulting in reduced water supplies and degraded aquatic habitats which negatively impacts dependent species (Canari 2020).

8.4.2 Internationally recognised areas

Within the BSA, there are two internationally recognized areas: Mount Saint Catherine Key Biodiversity Area (KBA) and Grand Etang Important Bird and Biodiversity Area (IBA) and KBA (see sFigure A.4 in Appendix A).

KBAs are sites that contribute to the global persistence of biodiversity, including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems. An IBA is an area identified using an internationally agreed set of criteria as being globally important for the conservation of bird populations. Since birds have been shown to be effective indicators of wider biodiversity, many (but not all) IBAs are also KBAs for other animal and plant species.

The BSA is also located within Lesser Antilles Endemic Bird Area (EBA). EBA's are not considered internationally recognised areas under IFC PS6, however they are areas of land identified by BirdLife International as being important for habitat-based bird conservation because they contain the habitats of restricted-range bird species, which are thereby endemic to them. Descriptions of the IBA's, KBA's and EBA's within the AoI are presented below.

8.4.2.1 Mount Saint Catherine KBA

Mount Saint Catherine KBA is located 1.3km away from Site C, and 14.2m away from Site F. The KBA covers 573 ha in the northern mountains of central Grenada. This area does not meet the criteria for an IBA. The KBA encompasses the principal peak of the Mount Saint Catherine massif 840masl (the highest point in Grenada). Cloud forest, montane and lower montane forests are represented within this KBA. This KBA partially overlaps with Mount Saint Catherine National Park and Forest Reserve which is described in Section 8.4.3.1 below.

This KBA has been identified as such based on the presence of significant populations of globally threatened species and significant populations of endemic species known only to be found in a limited area. *Pristimantis euphronides* is a restricted-range, globally Critically Endangered species of amphibian known to occur within Mount Saint Catherine KBA (IBAT, 2023a; Amphibiaweb, 2023) (See Section 8.4.8 for details).

This internationally recognised area is within Lesser Antilles EBA (described in Section 8.4.2.3 below). Five Lesser Antilles EBA restricted-range birds occur within this KBA. These species are: Green-throated carib *Eulampis holosericeus*, Antillean crested hummingbird *Orthorhyncus cristatus*, Grenada flycatcher *Myiarchus nugator*, Lesser Antillean tanager *Tangara cucullata* and Lesser Antillean bullfinch *Loxigilla noctis* (See Section 8.4.7).

8.4.2.2 Grand Etang IBA/ KBA

Grand Etang IBA/ KBA is situated 7km away from Site C, and 1.9km from Site F. It has an area of 1,739ha and is located within the southern mountains of central Grenada. Rainforests, lower montane rainforests and elfin woodlands characterise the steeper slopes throughout the high region. At lower altitudes, the trees are smaller and more thickly covered by epiphytes (ferns and mosses). The IBA represents a major portion of Grenada's remaining high altitude forests that are important for the restricted-range birds.

This IBA/ KBA has been identified as such based on the presence of significant populations of globally threatened species and significant populations of endemic species known only to be found in a limited area. *Pristimantis euphronides*, also present within Mount Saint Catherine KBA, is present within this IBA/KBA (described in Section 8.4.8 below). This internationally recognised area is within Lesser Antilles EBA (described in Section 8.4.2.3 below). Six Lesser Antilles EBA restricted-range birds occur within this IBA. These species are: Green-throated carib, Antillean crested hummingbird, Grenada flycatcher, Lesser Antillean tanager, Lesser

Antillean bullfinch, and Caribbean elaenia *Elaenia martinica*. Five of these species are also present within Mount Saint Catherine KBA. All species are described in Section 8.4.7 below.

Other endemic species present within this IBA/ KBA include *Anolis aeneus* and *A. richardii* (described in Section 8.4.8). Endemic plants include Grand Etang Fern *Danaea* sp., the Cabbage Palm *Oxeodoxa oleracea*, *Maythenus grenadensis*, *Hytidophyllum caribaeum* and *Lonchcarpus broadwayi* (described in Section 0). The Mona monkey *Cercopithecus mona*, introduced from West Africa, is found in the upper montane forest of this IBA.

Grand Etang IBA, KBA, National Park and Forest Reserve all have contiguous boundaries. Grand Etang National Park and Forest Reserve are described in Section 8.4.3.2 below. Due to the distance between this IBA/KBA and the two sites, it will not be considered further in this assessment.

8.4.2.3 Lesser Antilles EBA

Lesser Antilles EBA is 630,000 ha and comprises those islands of the Lesser Antilles which includes Grenada (BirdLife, 2023a). This EBA has a particularly distinct avifauna, including seven endemic genera - *Catharopeza, Cichlherminia, Cinclocerthia, Cyanophaia, Leucopeza, Melanospiza* and *Ramphocinclus.* Most restricted-range species occur over a wide altitudinal range and in many habitats including dry and rain forest, and, less frequently, montane thickets and elfin forest of the uplands. The IUCN Critically Endangered Grenada dove *Leptotila wellsi* and IUCN Endangered White-breasted Thrasher *Ramphocinclus brachyurus* have a more specific requirement and is confined to the dry forest of the lowlands, and The IUCN Critically Endangered Semper's warbler *Leucopeza semperi* and IUCN Endangered Whistling Warbler *Catharopeza bishopi* occur in montane habitats only. In addition to its restricted-range birds, this EBA is important for many North American migrants and for seabirds.

8.4.3 Nationally protected areas

Within the BSA, there are two Nationally Protected Areas: Mount Saint Catherine National Park and Forest Reserve and Grand Etang National Park and Forest Reserve (see sFigure A.4 in Appendix A). These are described in the sections below.

8.4.3.1 Mount Saint Catherine National Park and Forest Reserve

The Mount Saint Catherine National Park is an IUCN Category II Protected Area (IBAT, 2023). This protected area is situated 424m from Site C and 167m from Site F. It was designated as such in 1990. The Forest Reserve, which has identical boundaries to the National Park, is designated under the Forest Soil and Water Conservation Act 1984. 34% of the Mount Saint Catherine National Park and Forest Reserve overlaps with the Mount Saint Catherine KBA (see sFigure A.4 in Appendix A).

This National Park and Forest Reserve is the second largest declared terrestrial protected area in Grenada after the Grand Etang and Annandale Forest Reserves. It comprises 934 ha of lowland rainforest and lower montane cloud forest. The vegetation transitions from secondary forest surrounding lower supporting ridges and around the periphery of the reserve to Elfin/ Sierra palm to ferns, mosses and other epiphytes at higher exposed elevations. Nutmeg *Myristica fragrans* and other mixed-woody agriculture (including cacao, cinnamon, and other tree crops) cover an estimated 13% of the forest reserve (Aucoin, 2018).

An Environmental Baseline Assessment was conducted by Green Park's Consultancy prior to the preparation of the Mount Saint Catherine Forest Reserve Land Management Plan (Aucoin, 2018). However, no comprehensive inventory of the vegetation or fauna in the Mount Saint Catherine Forest Reserve has been conducted. Species present within Mount Saint Catherine

National Park and Forest Reserve are listed under Mount Saint Catherine KBA (Section 8.4.2.1 above).

8.4.3.2 Grand Etang National Park and Forest Reserve

Grand Etang Forest Reserve is located 6.9km from Site C and 1.9km from Site F. The Reserve was designated as such by the Government of Grenada under the Grand Etang Forest Reserve Act, 1906. It was then designated as a National Park in 1910 which is an IUCN Category II Protected Area (Protected Planet, 2023) and is currently protected under the National Parks and Protected Areas Act, 1991. This area was also established as a nationally protected sanctuary under the Wild Animals and Bird (Sanctuary) Ordinance, 1928. Its boundaries are contiguous with Grand Etang IBA and KBA (Section 8.4.2.2 above).

Grand Etang Forest Reserve is contiguous with Annandale Forest Reserve to the south and together encompass the largest declared protected areas in Grenada. The Grand Etang and Annandale Forest Reserves are therefore managed together. The Management Plan was published in 2007 and includes the vision, goals and key actions for the Forest Reserves. According to this management plan, The Forestry and National Parks Department does not have an approved zoning policy to apply to its protected areas managed lands. The management plan includes a list of threatened species and their status within the Forest Reserves which are described under their relevant sections below. Some species present within Grand Etang National Park and Forest Reserve are listed in Section 8.4.2.2 under Grand Etang IBA/ KBA. Specific inventories, species lists and wildlife habitat needs were not assessed as part of the management plan (Turner, 2007).

Due to the distance between this National Park and the two sites, it will not be considered further in this assessment.

8.4.4 Terrestrial Habitats

8.4.4.1 Habitats within the Biodiversity Study Area

The literature review conducted as part of this report identified the following natural habitat types present within the BSA (CBD, 2014):

- Cloud-forest (including elfin woodlands, palm brake and montane thickets);
- Rainforests and lower montane rainforest;
- Evergreen and semi-evergreen seasonal forest; and
- Deciduous forest and dry woodlands.

Like many Caribbean islands, Grenada was cleared of most of its forests to make way for agriculture. In 1728, nutmeg was introduced to Grenada, and thrived in the island's ideal soils (BirdLife, 2019). Approximately 24% of the land in Grenada in 2016 was used for agricultural purposes (World Bank, 2016). The habitat types present within the BSA were identified using satellite data and landcover mapping acquired by the British Geological Survey (BGS). A map of habitats within the BSA are presented in Figure A.5 in Appendix A.

8.4.4.2 Habitats within the Biodiversity AoI

The habitat types present within the biodiversity AoI of the Project were identified using satellite data and landcover mapping acquired by BGS in combination with field data from the 2019 and 2023 surveys. Site C is located 360m above sea level, and Site F is 420m above sea level. The habitats are as follows:

Agriculture:

- Nutmeg and mixed woody agriculture (e.g. cacao, coconut, banana)

  - Including nutmeg plantations and tree crops such as cacao and citrus (interspersed bamboo *Bambusa vulgaris* and bois canot *Cecropia schreberiana*)
- Pastures, cultivated land and herbaceous agriculture
  - Including grasses (Guinea grass *Panicum maximum*, para grass *Brachiaria mutica*, Bamboo grass *Arthrostylidium excelsum* and palm grass *Setaria palmifolia*) used for livestock grazing (cows and donkeys), overgrown areas, and agricultural crops

Forest:

- Drought deciduous open woodland
- Deciduous, coastal evergreen and mixed forest or shrubland
  - Including secondary forests with sparse mature trees, woody shrubs, and thicker understories
- Semi-deciduous forest
- Evergreen and seasonal Evergreen forest
  - Including secondary forests with dense mature trees and high canopies
- Elfin and Sierra Palm tall cloud forest

Water

- Springs, rivers and streams with rocky substrate. Waterbodies include waterfalls over rock faces and slow flowing deeper pools.

Urban

- Bare ground (e.g. sand, rock)
- Buildings
- Roads and other built-up surfaces (e.g. concrete, asphalt)
- Quarry

The habitat types present within 500m of the Site C and Site F, their natural/ modified classification and the areas (ha) and proportion (%) of the AoI are presented in Table 8.6 and Table 8.7. Habitat maps for the AoI of Site C (Figure A.6) and Site F (Figure A.7) are presented in Appendix A.

Table 8.6: Habitat types and areas within 500m buffer zone of Site C

Habitat Type	Natural/ modified classification	Area (ha)	Proportion (%)
Agriculture			
Nutmeg and mixed woody agriculture	Modified	1,845,852	60.13
Pastures, cultivated land and herbaceous agriculture	Modified	140,540	4.58
Forest			
Deciduous, coastal evergreen and mixed forest or shrubland	Natural	90,819	2.96
Semi-deciduous forest	Natural	331,464	10.80
Evergreen and seasonal evergreen forest	Natural	581,247	18.93
Elfin and Sierra Palm tall cloud forest	Natural	15,781	0.51

Water			
Rivers, lakes, ponds	Natural	1,692	0.06
Urban			
Bare ground	Modified	1,136	0.04
Buildings	Modified	16,270	0.53
Roads and other built-up surfaces	Modified	44,975	1.47
Total		**3,069,776**	**100.0**

Source: Mott MacDonald 2023

Table 8.7: Habitat types and areas within 500m buffer zone of Site F

Habitat Type	Natural/ modified classification	Area (ha)	Proportion (%)
Agriculture			
Nutmeg and mixed woody agriculture	Modified	1,011,385	31.49
Pastures, cultivated land and herbaceous agriculture	Modified	34,237	1.07
Forest			
Deciduous, coastal evergreen and mixed forest or shrubland	Natural	43,960	1.37
Semi-deciduous forest	Natural	156,825	4.88
Evergreen and seasonal evergreen forest	Natural	1,700,581	52.94
Elfin and Sierra Palm tall cloud forest	Natural	239,654	7.46
Water			
Rivers, lakes, ponds	Natural	8	0.00
Urban			
Bare ground	Modified	3,684	0.11
Buildings	Modified	17,740	0.55
Roads and other built-up surfaces	Modified	4,165	0.13
Total		**3,212,239**	**100.00**

Source: Mott MacDonald 2023

8.4.5 Flora

During the desk study, six species of flora were identified as globally/ nationally threatened or restricted range within the BSA. These species are presented in Table 8.8. Two records of globally threatened flora were returned from the IBAT search (IBAT, 2023), Spanish Cedar *Cedrela odorata* (IUCN Vulnerable) and Lansan *Protium attenuatum* (IUCN Endangered). Turk's Cap *Melocactus broadwayi* is listed on the National Red List as Endangered. Three species, hummingbird-pollinated shrub *Charianthus grenadensis*, Tree fern *Cyathea elliottii* and *Rhytidophyllum caribaeum* are endemic to Grenada and recorded within Mount Saint Catherine KBA (Aucoin, 2018).

The 2019 flora surveys recorded 154 plant species at Site F. Of these plants, one has national protection status: Mountain Cabbage *Euterpe dominicana* (Endangered). Four species are listed as endemic: Mountian Cabbage (Near Endemic to Grenada (see below)), *Lobelia cirsifolia* (Endemic to the Lesser Antilles), Siguine Batard *Asplundia insignis* (Endemic to the Lesser Antilles), and Monkey Paws Vine *Marcgravia umbellata* (Endemic to the Lesser Antilles). No plants identified during the surveys were listed as Vulnerable, Endangered, or Critically Endangered on the IUCN Red List.

Two invasive plant species were observed during the 2019 surveys. These were: bamboo *Bambusa vulgaris* and Bois Canot *Cecropia schreberiana*. These species are both invasive to Grenada, and are generally found within disturbed areas.

The 2023 surveys recorded 59 plant species at Site C. of these species, none were reported to be restricted range or nationally protected, and no plants were listed as Vulnerable, Endangered, or Critically Endangered on the IUCN Red List. The invasive species bamboo and Bois Canot were also recorded in large numbers during the 2023 surveys.

Spanish Cedar

Spanish Cedar is a large Neotropical species of tree with a large range from Mexico to northern Argentina, as well as in the Caribbean. It occurs in humid or dry lowland forest, preferring well-drained soils. It is highly light demanding and is a fast-growing pioneer species in secondary forest. Deforestation data across its full range indicate that the range has decreased by 28.8% in the last 100 years. The main threat to this species is unsustainable harvest of the timber. It is listed under Appendix III of CITES to avoid trade and over-utilisation. Deforestation and the associated habitat loss also threaten the species (Mark & Rivers, 2017). Spanish Cedar was not recorded during the 2019 surveys within Site C or Site F. This species is unlikely to be present within the AoI due to the habitat types present, it will therefore not be considered further.

Lansan

Lansan is endemic to the upper semi-evergreen and lower evergreen forests of the Lesser Antilles, with all known localities being on volcanic soils. It is a pioneer species that readily colonises forest clearings, though it is highly susceptible to insects and decay. The area of occupancy for this species has decreased by 60% since the 1940s. Unsustainable resin extraction is a significant threat to this species, alongside habitat loss (Daltry and Prospere 2021). No lansan individuals were recorded within either Site C or Site F during the 2019 surveys. Evergreen forests are present within the Project AoI, therefore this species' presence here cannot be ruled out.

Turk's Cap

This species is present in the coastal regions of Grenada, Tobago and St. Vincent, inhabiting areas of coastal volcanic rock. Population size and trends are unknown for this species, though it is thought to be relatively abundant on Grenada's southern coast. The largest threat to Turk's cap is tourist development. No individuals of this species were recorded within Site C or within Site F during the 2019 flora surveys. This species is unlikely to be present within the AoI due to the habitat types present, it will therefore not be considered further.

The hummingbird-pollinated shrub

This species is endemic to the elfin forests of Grenada, and is found between 550 – 800m. Individual plants are evergreen shrubs or trees, growing up to 10m in height (Penneys et al. 2004). Elfin forests are present within the Project AoI, however both sites are at lower elevations than this species' range therefore it is unlikely that this species is present here.

Tree fern

This species is Endemic to Grenada. This species has been poorly described. The genus *Cyathea* is the largest group of tree ferns, commonly referred to as scaly or rough tree ferns. They can grow to 2.7 – 4m in size and are usually found in warm, tropical climates. The biggest threat to tree ferns is human overharvesting for their trunks and for cultivation (San Diego Zoo Wildlife Alliance 2023). It is possible that this species could be present within the Project AoI, although no individuals were encountered during the 2019 surveys.

Rhytidophyllum caribaeum

This species is Endemic to Grenada, and grows in the wet tropical biome (Kew 2023d). It is a woody plant with capsule fruit (Encyclopaedia of Life 2023). It is possible that this species could be present within the Project AoI, although no individuals were encountered during the 2019 surveys.

Mountain Cabbage

This species is listed as being Near Endemic to Grenada on the national red list. It is found on the mountains of Grenada, Dominca and St. Vincent, and there is one recorded individual on Guadelope as well. Therefore, this species is not restricted-range. Mountain Cabbage has value as an ornamental species, and as an edible plant. The palm heart (‘cabbage’) which consists of young shoots and leaves is eaten, which results in the death of the plant. This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Lobelia cirsifolia

This species is Endemic to the Lesser Antilles (Grenada, St. Kitts, Dominica, St. Lucia and St. Vincent). It is a perennial subshrub that grows primarily in the wet tropical biome (Kew 2023a). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Siguine Batard

This species is Endemic to the Lesser Antilles; from St Kitts to Grenada. The leaves of this plant may be used locally to line baskets and pots. It is a subshrub that grows primarily in the wet tropical biome (Kew 2023b). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Monkey Paws Vine

This species is Endemic to the Lesser Antilles. It grows primarily in the wet tropical biome (Kew 2023c). The flowers of this plant are adapted for hummingbird and bat pollination, and it is found in lower montane to montane rain-forests, at heights of 300– 1000 m. It grows on several volcanically derived soil types, and requires high humidity levels (Dressler 1997). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Endemic plants in Grenada include Grand Etang Fern *Danaea* sp., the Cabbage Palm *Oxeodoxa oleracea*, *Monteverdia grenadensis (Maytenus grenadensis), Hytidophyllum caribaeum* and *Lonchcarpus broadwayi.* None of these species were recorded within the AoI during the 2019 surveys.

Table 8.8: Flora of conservation concern within the BSA and AoI

Common Name	Species name	Restricted Range / Endemic Status	IUCN treat category (IUCN, 2023)	National Status (Jessamy, 2014)	Present in BSA and/ or AoI?	Source
Spanish Cedar	*Cedrela odorata*	No	VU	N/A	No	IBAT, 2023
Lansan	*Protium attenuatum*	No	EN	N/A	No	IBAT, 2023
Turk's cap	*Melocactus broadwayi*	No	NT	EN	No	IBAT, 2023
The hummingbird-pollinated shrub	*Cheiranthus grenadensis*	Restricted range	Not Evaluated	N/A	No	Aucoin, 2018
Tree fern	*Cyathea elliottii*	Endemic to the Windward Islands	Not Evaluated	N/A	No	Aucoin, 2018
-	*Rhytidophyllum caribaeum*	Restricted range	Not Evaluated	N/A	No	Aucoin, 2018
Mountain Cabbage	*Euterpe dominicana*	Almost Endemic to Grenada	Not Evaluated	Endangered	Yes	2019 surveys
-	*Lobelia cirsifolia*	Endemic to the Lesser Antilles	Not Evaluated	N/A	Yes	2019 surveys
Siguine Batard	*Asplundia insignis*	Endemic to the Lesser Antilles	Not Evaluated	N/A	Yes	2019 surveys
Monkey Paws Vine	*Marcgravia umbellata*	Endemic to the Lesser Antilles	Not Evaluated	N/A	Yes	2019 surveys

Source: Compiled by Mott MacDonald, 2023. EN= Endangered, VU = Vulnerable, NT= Near Threatened

8.4.6 Mammals

The list of species received from IBAT included one Critically Endangered / Endangered / Vulnerable species, within the AoI of the Project (IBAT, 2023). The bat species, *Myotis nyctor* is listed as Vulnerable under the IUCN Red List (IUCN, 2023). One species is listed on the National Red List, and two others are protected under national legislation. These species are described below and within Table 8.9.

During the 2019 surveys, four mammal species were recorded in Site F, alongside some unidentified bat species. The four species were: nine-banded armadillo *Dasypus novemcinctus*, Common Opossum *Didelphis marsupialis*, Robinson's Mouse Opossum *Marmosa robinsoni* and Small Indian Mongoose *Herpestes auropunctatus*. All species are listed as IUCN Least Concern. The nine-banded armadillo is nationally protected, and the Robinson's Mouse Opossum is listed on the National Red List. These species are described below.

During the 2023 surveys, two mammal species were recorded in Site C. these were: the leaf-nosed bat (*Phyllostomidae sp.,* not identified to species level) and the Small Indian mongoose. Both species are locally common, and neither are restricted-range, nationally protected, or threatened on the IUCN Red List.

One mammal species encountered in the 2019 and 2023 surveys, is invasive to Grenada. This is the Small Indian Mongoose, which local farmers have reported as being regularly responsible for the destruction of the majority of crops present within the Biodiversity AoI. Mongoose are also responsible for the decline of some local reptile species (see Section 8.4.8.1 below), however the Project activities are unlikely to spread mongoose within the area, therefore they will not be considered within the impact section below.

8.4.6.1 Bats

Myotis nyctor

Myotis nyctor is poorly known and only found in Barbados and Grenada. It is insectivorous and can be found near caves, gullies and rocky outcrops, rivers and freshwater pools with densely packed trees and also near cliffs with rock crevices. The current population is unknown. Hurricanes and severe weather are the main threats to island populations. At a smaller scale, changes in cover land use might affect this and other insectivorous species by changing or reducing availability of prey (Larsen, 2016). There are no caves present within the Project AoI, however there is bare ground (which may be a rocky outcrop) and small cliff faces, therefore this species' presence here cannot be ruled out.

8.4.6.2 Terrestrial mammals

Robinson's Mouse Opossum

One mammal species, the Robinson's Mouse Opossum *Marmosa robinsoni chopmoni* is listed as nationally Endangered under the National Red list. This is a subspecies is *Marmosa robinsoni* which is least concern globally (IUCN, 2023). This species is also listed as a threatened species within Forest Reserves and is present within Grand Etang Forest Reserve (Turner, 2007). *Marmosa robinsoni* occupies a variety of habitats including lowland and montane moist forests, lowland dry forests, savannas, and xeric shrublands. No major threats are known to this species and they are found in many protected areas throughout its range (Pérez-Hernandez, 2016). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Agouti and Nine-Banded Armadillo

The agouti *Dasyprocta leporina albida*, nine-banded armadillo *Dasypus novemcinctus hoplites* are nationally protected under the Wild Animals and Birds Sanctuary Ordinance, 1964 within Grand Etang National Park (refer to the ESIA chapter 4 for further details regarding legislation).

Dasyprocta leporina albida is a subspecies of the red-rumped agouti *Dasyprocta leporina* which is least concern globally (IUCN, 2023). It can occur in all available vegetation types but found primarily in open forest, usually distant from both water and dense vegetation. Greater numbers are found in fragmented patches than continuous forest; it can also be found in degraded secondary forest (Emmons & Reid, 2016). Many forest types are present within the Project AoI, therefore it is likely that this species will be present here.

Dasypus novemcinctus hoplites is a subspecies of *Dasypus novemcinctus* which is least concern globally (IUCN, 2023). It has a wide range across Southern United States through Mexico and South America. It is also present in the Lesser Antilles, on Grenada and Trinidad and Tobago. This armadillo is very adaptable and is present in a variety of habitats including forest, grassland, shrubland and savanna (Loughry et al, 2014). There are no major threats to this species however, it is hunted throughout its range. The species occurs in many protected areas including Grand Etang National Park where it is illegal to hunt this animal. This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Table 8.9: Mammals of conservation concern within the BSA and AoI

Common name	Species name	Restricted Range / Endemic Status	IUCN treat category (IUCN, 2023)	Nationally Protected (Wild Animals and Birds Sanctuary Ordinance, 1964)	National Status (Jessamy, 2014; Turner 2007)	Present in BSA and/ or AoI?	Source
Bats							
-	*Myotis nyctor*	Restricted range	VU	No	Not listed	No	IBAT, 2023
Terrestrial Mammals							
Robinson's Mouse Opossum	*Marmosa robinsoni chapmoni*	No	LC	No	EN, Rare	Yes	Turner, 2007, 2019 surveys
Nine-banded armadillo	*Dasypus novemcinctus*	No	LC	Yes	Rare	Yes	Turner, 2007, 2019 surveys
Agouti	*Dasyprocta leporina*	No	LC	Yes	EN, possibly extinct	No	Turner, 2007

Source: Compiled by Mott MacDonald, 2023. EN= Endangered, VU = Vulnerable, LC = Least Concern. Rare taxa are those with small country populations that are not currently endangered or vulnerable, but are at risk.

8.4.7 Birds

During the desk study, eight species of birds were identified as globally/ nationally threatened within Grenada. These species are described below and presented in Table 8.10. Two species were included in the list received from IBAT; Grenada dove *Leptotila wellsi* (IUCN Critically Endangered) and black swift *Cypseloides niger* (IUNC Vulnerable). Two species were listed on the National Red List as nationally Endangered; Grenada dove and Grenada hook -billed kite *Chondrohierax uncinatus murus.* Five species which are least concern globally (IUCN, 2023) were listed as Vulnerable within the Grand Etang Management Plan (Turner, 2007); bat falcon *Falco rufigularis*, blue-ground dove *Claravis pretiosa*, blue-hooded euphonia *Euphonia musica*, garnet throated hummingbird *Eulampis jugularis* and Grey Kingbird *Tyrannus dominicensis*.

The Americas flyways connects North American breeding grounds with wintering grounds in the Caribbean and Central and South America (BirdLife, 2023). The Atlantic Americas flyway entirely overlaps with the island of Grenada, and therefore with the Project AoI. It is possible that the Project AoI could support globally significant populations of migratory species.

A total of 19 bird species were observed in Site F during the 2019 surveys. One species is listed as Nationally Endangered, the Grenada hook -billed kite, one as Nationally Vulnerable, Grey Kingbird*,* and one is restricted-range, the Lesser Antillean tanager *Tangara cucullata*. No IUCN Critically Endangered, Endangered or Vulnerable species were recorded during the 2019 surveys. Five species encountered are migratory: Grey Kingbird*,* Tropical Kingbird *Tyrannus melancholicus,* Cattle Egret *Bubulcus ibis,* Broad Winged Hawk *Buteo platypterus,* and Little Blue Heron *Egretta caerulea*. These species are discussed below and displayed in Table 8.10.

During the 2023 surveys, 21 birds from 16 families were observed at Site C. All of the observed bird species are categorised as Least Concern on the IUCN Red List. One, the Grey Kingbird, is listed as a nationally Vulnerable species. Two species encountered are restricted range: the Lesser Antillean tanager and the Grenada flycatcher *Myiarchus nugato*. Seven species encountered are migratory: Grey Kingbird, Broad Winged Hawk, Mangrove Cuckoo *Coccyzus minor,* Eared Dove *Zenaida auriculata*, House Wren *Troglodytes aedon*, Black Whiskered Vireo *Vireo altiloquus*, and Night Hawk *Chordeiles minor*. These species are discussed below and displayed in Table 8.10.

8.4.7.1 Kites, hawks and eagles (Accipitridae)

Grenada hook -billed kite

The Grenada hook-billed kite has an extremely large range. Although the population is declining, it is not at a rate to justify this species being classified as Vulnerable by the IUCN. The forest within this species' range has declined by 7% over three generations, which may be responsible for the decline of the species itself. Subtropical and tropical moist lowland forests are of major importance to this species, though dry and moist montane forests are also suitable, as are dry shrublands and plantations. Threats to this species include deforestation which is reducing the availability of tree snail prey, and local persecution by farmers who mistakenly believe the kite preys on chickens (Birdlife International 2020a). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Broad Winged Hawk

This species has an extremely large range, and its population size appears to be increasing by 14.9% a decade (which is statistically significant). Forest habitats are of particular importance to this species: mostly subtropical and tropical moist lowland forests, though dry forests and moist montane forests are also suitable. This species can also tolerate plantations (Birdlife International 2016b). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.2 Pigeons and doves (Columbidae)

Grenada Dove

The Grenada dove is restricted range and endemic to Grenada. It inhabits a successional stage of dry, coastal scrub-woodland in the south-west, which comprises a closed canopy of leguminous trees and shrubs, a sparse understorey of shrubs and saplings, sparse to absent ground-cover and much exposed soil. On the west coast, its habitat includes some mixed deciduous/evergreen vegetation. It is therefore unlikely to be present within the AoI (Birdlife International 2021a).

Blue-ground dove

The blue ground dove is classified as Vulnerable within the Grand Etang Forest Reserve (Turner 2007). This species has an extremely large range, and a large population size too. The population has declined moderately since 1970 however, because of deforestation reducing forest habitat. Subtropical and tropical moist lowland forests are of high importance to this species, though it is also present in moist savannas and heavily degraded former forests (Birdlife International 2020b). There are moist forest habitats within the AoI, therefore the presence of this species cannot be ruled out.

Eared dove

This species is common and migratory. Populations are increasing as habitat degradation creates new habitats. It resides in forests, shrublands, savannas, arable land, pastureland, rural gardens, urban areas and degraded forests (BirdLife 2016c). This species was encountered during the 2023 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.3 Swifts (Apodidae)

Black swift

This species is undergoing a rapid decline, thought to be as a result of climate change and pesticide use. The population declined by 94% from 1970 to 2014, leading to an IUCN classification of Vulnerable. The species prefers montane evergreen and secondary forests, though it can also tolerate a variety of open habitats. It nests on ledges or caves in steep rock faces, near to waterfalls, and is mainly present at 1,000 – 3,000m above sea level (Birdlife International 2021b). This is a higher elevation than either of the sites, although there are evergreen and secondary forests within the AoI. Therefore, this species is unlikely to be present here.

8.4.7.4 Hummingbirds (Trochilidae)

Garnet throated hummingbird

The garnet throated hummingbird is classified as Vulnerable within the Grand Etang Forest Reserve (Turner 2007). Although the global population size of this species is unknown, it is described as common within its range in the Caribbean islands. Subtropical and tropical moist lowland forests are of major importance to this species, but it can also tolerate heavily degraded former forest habitats (Birdlife International 2016a). There are moist forest habitats within the AoI, therefore the presence of this species cannot be ruled out.

8.4.7.5 Finches and euphonias (Fringilidae)

Blue-hooded euphonia

The blue-hooded euphonia is classified as Vulnerable within the Grand Etang Forest Reserve (Turner 2007). This species has a large range and a stable population trend. It has been recorded in several Caribbean islands, including Hispaniola and Gonâve, the Dominican Republic and Haiti. Blue-hooded euphonias inhabit forests, shrublands and plantations (Birdlife International 2017a). There are forest, shrubland and plantation habitats within the AoI, therefore the presence of this species cannot be ruled out.

8.4.7.6 Caracaras and falcons (Falconidae)

Bat falcon

The bat falcon is classified as Vulnerable within the Grand Etang Forest Reserve (Turner 2007). This species has both an extremely large range and a very large population size. Bat falcons are undergoing a moderate decline however, due to habitat loss and degradation. The species can inhabit forest, savanna, and urban habitats, with tropical moist lowland forests being the most important habitat for this species (Birdlife International 2020c). There are moist forest habitats within the AoI, therefore the presence of this species cannot be ruled out.

8.4.7.7 Tyrant flycatchers and calyptura (Tyrannidae)

Gray kingbird

Gray kingbirds are classified as Vulnerable within the Grand Etang Forest Reserve (Turner 2007). The global population of this species is thought to be stable, despite anthropogenic processes affecting it both negatively and positively. This species is tolerant of a range of different habitat types: subtropical and tropical dry forests, mangrove forests, moist savannas, shrublands, grasslands, arable land, pastureland, urban areas, and heavily degraded former forests. There are no major threats to this species (Birdlife International 2021c). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Tropical Kingbird

The population of tropical kingbirds is thought to be 200 million. They thrive within open, degraded and converted habitats, and are therefore increasing in number as deforestation opens up new areas of suitable habitat. They can tolerate the following habitat types: mangroves, shrubland, wetlands including rivers and marshes, arable land, pastureland, urban areas, and heavily degraded former forest (Birdlife International 2022). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Grenada Flycatcher

This species is restricted-range, with an estimated extent of occurrence of 3,300km^2. The species is fairly common throughout its range, though populations are declining due to habitat destruction. Habitats that the Grenada fluycatcher can tolerate include dry and moist lowland forests and heavily degraded former forests (BirdLife International 2016d). This species was encountered during the 2023 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.8 Herons and bitterns (Ardeidae)

Cattle Egret

Cattle egrets are currently increasing in number overall, although some populations may be decreasing or stable. Most cattle egret populations are either partially or fully migratory, and all are colonially breeding (in groups sized from a few dozen to several thousand). Feeding also occurs in flocks and is commonly associated with native grazing mammals or domesticated livestock. Cattle egrets also sometimes follow farm machinery to capture disturbed prey. As a result of these feeding habits, this species commonly inhabits open grassy areas, and is rarely found in marine habitats or forested areas. Its prey comprises invertebrates, small vertebrates and vegetable matter. Cattle egrets can have an adverse effect on trees and bushes used for nesting, which can result in colony abandonment if this goes unmanaged. Threats to the species include their perception as a public nuisance which can lead to persecution, wetland degradation and destruction, and pesticide poisoning. In some parts of its range (such as Nigeria), it is hunted and traded as traditional medicine as well (Birdlife International 2019b). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Little Blue Heron

This species has an extremely large range, and although the population is globally decreasing, it is not at a sufficient rate for this species to be classified as Vulnerable by the IUCN. Inland wetlands such as bogs, marshes, swamps, fens and peatlands are of major importance to this species. Other suitable habitats include marine intertidal zones such as salt marshes, and mangrove forests above high tide level (Birdlife International 2017b). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.9 Tanagers and allies (Thraupidae)

Lesser Antillean Tanager

This species has a stable population trend, despite having an extent of occurrence estimated at only 370km^2. The species is described as fairly common within Grenada, and resides predominantly within subtropical and tropical moist lowland forests. It can also tolerate moist montane forests, degraded forests, dry and moist shrubland, plantations, and rural gardens (Birdlife International 2017). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.10 Cuckoos (Cuculidae)

Mangrove Cuckoo

There are estimated to be 200,000 mature individuals of mangrove cuckoo globally. They are undergoing a moderate decline due to habitat loss. The species is a migrant that can inhabit forests, mangroves, and degraded former forests (BirdLife International 2020d). This species was encountered during the 2023 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.11 Wrens (Troglodytidae)

House Wren

This migratory species has undergone a small increase in the last 40 years. They can tolerate a wide variety of habitats, including forests, savannas, shrubland, and artificial habitats such as agriculture and urban areas (BirdLife International 2017d). This species was encountered during the 2023 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.12 Vireos, Greenlets, Shrike-babblers (Vireonidae)

Black Whiskered Vireo

There are estimated to be 6.2million mature individuals of this species, though the population trend is difficult to ascertain due to uncertainty over habitat modification and cowbird parasitism impacts. The species can inhabit forests, shrubland, plantations, gardens and former forests (BirdLife International 2021d). This species was encountered during the 2023 surveys, and is therefore confirmed to be present in the Project AoI.

8.4.7.13 Nightjars (Caprimulgidae)

Night Hawk

The global population numbers 23 million mature individuals, however the species has been undergoing a large, significant decline of 1.8% per year from 1970 – 2017. The species can tolerate forests, savannas, grassland, wetlands, marine habitats such as sandy and shingle beaches, agricultural land and urban areas (BirdLife International 2021e). This species was encountered during the 2023 surveys, and is therefore confirmed to be present in the Project AoI.

Table 8.10: Birds of conservation concern within the BSA and AoI

Common name	Species name	Restricted Range / Endemic Status	Migratory Species	IUCN treat category (IUCN, 2023)	Nationally Protected (Wild Animals and Birds Sanctuary Ordinance, 1964)	National Status (Turner 2007 and/or Jessamy, 2014)	Recorded in BSA and/ or AoI?	Source
Kites, hawks and eagles (Accipitridae)								
Grenada hook -billed kite	*Chondrohierax uncinatus murus*	Endemic	No	LC	Yes	EN	Yes	Aucoin, 2018, 2019 surveys
Broad Winged Hawk	*Buteo platypterus*	No	Yes	LC	Yes	N/A	Yes	2019 surveys, 2023 surveys
Pigeons and doves (Columbidae)								
Grenada dove	*Leptotila wellsi*	Yes	No	CR	Yes	EN	No	IBAT, 2023
Blue-ground dove	*Claravis pretiosa*	No	No	LC	Yes	VU	No	Turner, 2007

Common name	Species name	Restricted Range / Endemic Status	Migratory Species	IUCN treat category (IUCN, 2023)	Nationally Protected (Wild Animals and Birds Sanctuary Ordinance, 1964)	National Status (Turner 2007 and/or Jessamy, 2014)	Recorded in BSA and/ or AoI?	Source
Eared Dove	*Zenaida auriculata*	No	Yes	LC	Yes	N/A	Yes	2023 surveys
Swifts (Apodidae)								
Black swift	*Cypseloides niger*	No	Yes	VU	Yes	N/A	No	IBAT, 2023
Hummingbirds (Trochilidae)								
Garnet throated hummingbird	*Eulampis jugularis*	No	No	LC	Yes	VU	No	Turner, 2007
Finches and euphonias (Fringilidae)								
Blue-hooded euphonia	*Euphonia musica*	No	No	LC	Yes	VU	No	Turner, 2007
Caracaras and falcons (Falconidae)								
Bat falcon	*Falco rufigularis*	No	No	LC	Yes	VU	No	Turner, 2007
Tyrant flycatchers and calyptura (Tyrannidae)								
Gray kingbird	*Tyrannus dominicensis*	No	Yes	LC	Yes	VU	Yes	Turner, 2007, 2019 surveys, 2023 surveys
Tropical Kingbird	*Tyrannus melancholicus*	No	Yes	LC	Yes	N/A	Yes	2019 surveys
Grenada Flycatcher	*Myiarchus nugato*	Yes	No	LC	Yes	N/A	Yes	2023 surveys
Herons and bitterns (Ardeidae)								
Cattle Egret	*Bubulcus ibis*	No	Yes	LC	Yes	N/A	Yes	2019 surveys
Little Blue Heron	*Egretta caerulea*	No	Yes	LC	Yes	N/A	Yes	2019 surveys
Tanagers and allies (Thraupidae)								
Lesser Antillean tanager	*Tangara cucullata*	Restricted range	No	LC	Yes	N/A	Yes	2019 surveys, 2023 surveys
Cuckoos (Cuculidae)								
Mangrove Cuckoo	*Coccyzus minor*	No	Yes	LC	Yes	N/A	Yes	2023 surveys
Wrens (Troglodytidae)								
House Wren	*Troglodytes aedon*	No	Yes	LC	Yes	N/A	Yes	2023 surveys

Common name	Species name	Restricted Range / Endemic Status	Migratory Species	IUCN treat category (IUCN, 2023)	Nationally Protected (Wild Animals and Birds Sanctuary Ordinance, 1964)	National Status (Turner 2007 and/or Jessamy, 2014)	Recorded in BSA and/ or AoI?	Source
Vireos, Greenlets, Shrike-babblers (Vireonidae)								
Black Whiskered Vireo	*Vireo altiloquus*	No	Yes	LC	Yes	N/A	Yes	2023 surveys
Nightjars (Caprimulgidae)								
Night Hawk	*Chordeiles minor*	No	Yes	LC	Yes	N/A	Yes	2023 surveys

Source: Compiled by Mott MacDonald, 2023. CR, Critically Endangered, EN= Endangered, VU = Vulnerable, NT= Near Threatened

8.4.8 Herpetofauna

During the desk study, thirteen herpetofauna species were identified as being of conservation concern within Grenada. These species are presented in Table 8.11. Two species were listed as globally threatened: Grenada frog *Pristimantis euphronides* (IUCN Critically Endangered), and lesser windward skink *Marisora aurulae* (IUCN Vulnerable). Three species are listed as definitely being restricted range (lesser windward skink, green tree anole *Anolis richardii*, Grenada frog), with two others are listed as possibly restricted range (Barbour's tropical racer *Mastigodryas bruesi* and Grenada bush anole *Anolis aeneus*). Ten species are either nationally protected or listed on the national red list (for further details see Table 8.11).

A total of three herpetofauna species (one reptile and two amphibians) were encountered during the 2019 Site F surveys: Grenada tree anole *Anolis richardii*, Lesser Antillean frog *Eleutherodactylus johnstonei*, Windward Islands ditch frog *Leptodactylus validus*. These were recorded during both the wet and dry seasons. One unidentified snake species was also recorded via camera trap surveys. The Grenada tree anole is a restricted range species, but the two amphibians are not of conservation concern. The Lesser Antillean frog is listed as restricted range on the IUCN, however as it is an introduced species in Grenada, it is not considered to be restricted range for the purposes of this assessment (IUCN SSC Amphibian Specialist Group 2021a). All herpetofauna species of conservation concern are listed in Table 8.11 below.

During the 2023 surveys two herpetofauna species were encountered in Site C (one reptile and one amphibian). The reptile was a Grenada tree anole. The amphibian was the piping frog *Eleutherodactylus syristes*. Both species are locally common, and neither are nationally protected or listed as threatened on the IUCN Red List.

8.4.8.1 Reptiles

Neuwied's moonsnake

This species is listed as nationally endangered, possibly extinct, within the Grand Etang Forest Reserve according to Turner (2007). It is a nocturnal snake that inhabits leaf litter in dry, moist and wet forests, and can also be present within open areas, plantations, gardens, and disturbed forests. It is a widespread and common species, with no major threats to the population (Ibáñez et al. 2019). All of these habitats are recorded within the AoI, therefore this species is likely to be present here.

Mussurana

Turner (2007) states that the national status of this species is uncertain within the Grand Etang Forest Reserve, however it is listed as Critically Endangered in Jessamy (2014). It is a widely distributed, common species with few known threats, although it is not known whether it is still present within Grenada. It was last collected here in 1962 and has not been recorded since. This snake inhabits dry and humid lowland forests, and occurs marginally within premontane humid forests. It can tolerate disturbed areas such as plantations and pastureland, provided they are situated near forests. The species is generally nocturnal, but can also be active in the day. Urban expansion is considered a threat to this species in Argentina (Gutiérrez-Cárdenas 2019). Plantations, pasturelands and dry woodlands are habitats in the AoI, making it possible that this species could be present here, if a population remains on Grenada.

Shaw's dark ground snake

Shaw’s dark ground snake is listed as an Endangered, possibly extinct species within the Grand Etang Forest Reserve (Turner 2007). This is an abundant species with a large distribution, and the ability to persist in disturbed habitats. One specimen was encountered in Grenada in 1880. No specimens have been recorded here since, therefore the presence of this snake on Grenada is under question. Inland wetlands are of major importance to Shaw’s dark ground snake, but it has also been found in secondary growth forests and agricultural areas and is considered to be a habitat generalist. The habitats this snake requires are habitats in the AoI, making it possible that this species could be present here, if a population remains on Grenada.

Lesser Windward Skink

This species is restricted range, with an extent of occurrence below 20,000km^2. The population is severely fragmented and is currently declining due to predation by invasive mammals like the mongoose. No specimens have been recorded outside of Trinidad and Tobago since 1960, although no targeted searches have taken place. Lesser windward skinks have been reported in a variety of habitats, including agriculture, coastal resorts, towns, forests, coconut trash, woody underbrush, and on and amongst cacti (Hedges et al. 2016). Some of these habitats exist in the AoI, making it possible that this species could be present here, if a population remains on Grenada.

Tree boa

The tree boa is listed as a threatened species within the Grand Etang Forest Reserve, designated as ‘status uncertain’ (Turner 2007). This species is naturally rare, though it is well-adapted to human-modified habitats, particularly residential areas. Illegal trade has been reported in recent years, though the extent of this practice is unknown. Other habitats that this species resides in include: forests, arable land, pastureland, plantations, and rural gardens. Tree boa presence appears to be positively correlated with human activity levels (Henderson and Powell 2021). All of these habitats are in the AoI, making it likely that this species is present here.

Morocoy tortoise

The Morocoy tortoise is classified as threatened, possibly extinct within the Grand Etang Forest Reserve (Turner 2007). It is typically found within tropical rainforests with high humidity and dim lighting levels. The species is omnivorous. The major threat to this species is hunting by humans for their meat (King 2011). Humid forests are present in the AoI, making it possible that this species could be present here, if a population remains on Grenada.

Green tree anole

This species is common and widespread throughout its range. It adapts well to disturbance, and is not subject to any major threats. It is present in Grenada, Grenada Bank, the Grenadines and

Tobago, from sea level to 870m above sea level, decreasing in abundance as elevation increases. The population of green tree anoles appears to be stable. It can tolerate xeric to mesic habitats, where it is associated with trees or shrubs, and has also been observed on buildings due to its ability to adapt well to human disturbance (Powell et al. 2020a). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Barbour's Tropical Racer

This species is widespread throughout its range in areas where invasive mongooses do not occur. This includes islands that are mongoose-free as well as areas of Grenada and St. Vincent where mongoose are absent (such as anthropogenic areas). This snake typically inhabits mesic habitats, though can also tolerate xeric areas (Henderson and Powell 2016), making it likely that the species could be present in the AoI.

Grenada bush anole

This species is widespread in its native range, and is not subject to any major threats. Species density in Grenada ranges from 1,125 – 9,360 individuals per hectare. It can tolerate xerophilic and mesophilic habitats, including scrub, rainforest, mangroves, gardens, cacao groves, fences and buildings (Powell et al. 2020b). All of these habitats are in the AoI, making it likely that this species is present here.

8.4.8.2 Amphibians

Grenada Frog

The globally Endangered *Pristimantis euphronides* is listed as Nationally Endangered under the National Red List and is Endemic and restricted range within Grenada. The species is confined to just 59km^2 of Grenadian montane forest at elevations >300 m, including within Grand Etang Forest Reserve IBA/ KBA and Mount Saint Catherine KBA (IBAT, 2023a; 2023b). The area and quality of habitat suitable for the Grenada frog is continuously declining, thought to be due to both habitat fragmentation and pathogens. Suitable habitats include rainforests and montane meadows (IUCN SASG 2021b). Neither of these habitats are present within the AoI, so it is therefore unlikely to be present within the AoI.

Cane Toad

The cane toad is listed as nationally rare within the Grand Etang Forest Reserve (Turner 2007). This species has a wide distribution, large population and is tolerant of a wide range of habitats. It is also unlikely to be declining as its range is increasing. This toad inhabits humid areas with adequate cover, including fields, savannah, open forest, and gardens. It thrives in degraded and manmade habitats, preferring open and disturbed areas near human settlements to pristine or densely vegetated environments. Threats include skins being used for bags and drum skins, and animals being sold as souvenirs or for traditional medicinal uses. The highly invasive nature of this species means no conservation measures are deemed to be necessary (Solis et al. 2009). This species' wide habitat tolerance means it may be present within the Project AoI.

Lesser Antillean Whistling Frog/ Piping frog

The Lesser Antillean whistling frog is listed as a threatened species within the Grand Etang Forest Reserve, designated as 'status uncertain' (Turner 2007). This frog is highly adaptable, therefore despite its restricted distribution the population is abundant and stable, and its range is increasing. The species was introduced to Grenada from Barbados in 1885. The species is tolerant of disturbed habitats including fields, gardens, towns, houses and plantations (IUCN SASG 2021c). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Giant Woodland Frog

The giant woodland frog is listed as a threatened species within the Grand Etang Forest Reserve, designated as 'status uncertain' (Turner 2007). The current population estimate for this species is 132 individuals, leading to its current classification by the IUCN of Critically Endangered. Further population declines are predicted because of ongoing threats. These threats include human consumption as well as disease in the form of chytridiomycosis. Illegal hunting and habitat loss are ongoing threats as well, and in certain parts of its range lava flows also impact the frogs. The species inhabits dense secondary vegetation and sometimes plantations. They are associated with certain soil types which facilitate nest digging (IUCN SSCASG 2017). Both of these habitats are in the AoI, making it possible that this species is present here.

Table 8.11: Reptiles and Amphibians of conservation concern within the BSA and AoI

Common name	Species name	Restricted Range / Endemic Status	IUCN treat category (IUCN, 2023)	Nationally Protected Wild Animals and Birds (Sanctuary) Ordinance	National Status (Jessamy, 2014; Turner 2007)	Recorded in BSA and/ or AoI?	Source
Reptiles							
Neuwied's moonsnake	*Pseudoboa neuwiedii*	No	Not Evaluated	Yes	EN, Possibly Extinct	No	Turner, 2007
Mussurana	*Clelia clelia*	No	LC	Yes	CR	No	Turner, 2007, IBAT 2023
Shaw's dark ground snake	*Erythrolamprus melanotus*	No	LC	Yes	EN, Possibly Extinct	No	Turner, 2007
Lesser Windward Skink	*Marisora aurulae*	Restricted range	VU	No	Not listed	No	IBAT, 2023
Tree boa	*Corallus cookii*	No	Not Evaluated	No	Status uncertain	No	Turner, 2007
Morocoy tortoise	*Geochelone carbonaria*	No	Not Evaluated	No	Threatened, possibly extinct	No	Turner, 2007
Green tree anole	*Anolis richardii*	Restricted range	LC	No	Not listed	Yes	2019 surveys, 2023 surveys, IBAT 2023
Barbour's Tropical Racer	*Mastigodryas bruesi*	Possibly	LC	No	EN	No	IBAT, 2023
Grenada bush anole	*Anolis aeneus*	Possibly	LC	No	LC	No	IBAT 2023
Amphibians							
Grenada Frog	*Pristimantis euphronides*	Restricted range	CR	No	EN	No	IBAT, 2023; Turner, 2007
Cane Toad	*Rhinella marina*	No	LC	No	Rare	No	Turner, 2007
Lesser Antillean Whistling Frog/ Piping frog	*Eleutherodactylus johnstonei*	No	LC	No	Status uncertain	Yes	Turner, 2007; 2019 surveys

Common name	Species name	Restricted Range / Endemic Status	IUCN treat category (IUCN, 2023)	Nationally Protected Wild Animals and Birds (Sanctuary) Ordinance	National Status (Jessamy, 2014; Turner 2007)	Recorded in BSA and/ or AoI?	Source
Giant Woodland Frog	*Leptodactylus fallax*	No	CR	No	Status uncertain	No	Turner, 2007

Source: Compiled by Mott MacDonald, 2023. CR, Critically Endangered, EN= Endangered, VU = Vulnerable, LC = Least Concern. Rare taxa are those with small country populations that are not currently endangered or vulnerable but are at risk.

8.4.9 Terrestrial invertebrates

The IBAT screening identified seven insect species and five gastropods as being potentially present within the Project AoI. One species is migratory: the painted lady butterfly *Vanessa cardui.* Therefore this species is of conservation concern (see Table 8.12).

The 2019 Site F surveys identified 44 invertebrate species during the wet and dry season surveys. Of these 44, three were gastropods, three were millipedes, four were spiders, and 34 were insects. One of these is endemic to Grenada, the damselfly *Argia telesfordi*. This species are listed in Table 8.12 below.

During the 2023 surveys, 20 invertebrate species were identified within Site C: one spider and 19 insects. None of the species recorded were restricted-range, migratory, congregatory, nationally protected, or listed as threatened on the IUCN Red List.

Painted lady

The painted lady is the most widespread butterfly globally, and is reported to be common throughout its range. No specific threats to this species are known, though habitat conversion and degradation, climate change and agricultural intensification are all likely to impact butterflies. Painted ladies are not habitat specialists, and can occur in many habitats, including: gardens, marshes, forests, shrubland, grasslands, deserts, mountains, fields, and coastal areas (Walker and Coetzer 2020). Many of these habitats are present in the AoI, therefore this species' presence here is a possibility, although it was not recorded during the 2019 surveys.

Damselfly Argia telesfordi

The damselfly, *Argia telesfordi* is listed as Data Deficient species according to IUCN. It has an extent of occurrence of 2,900km^2, and therefore qualifies as a restricted range species. It is considered to be a rare species, for which future research is required. This species is endemic to Grenada, St. Vincent and the Grenadines, occurring from 120 – 450m. It inhabits the slower areas of fast flowing mountain streams, and can be found near stagnant water sources too. Adults reside on exposed rocks, in open or forested areas (González-Soriano and Guzmán 2021). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Table 8.12: Invertebrates of conservation concern within the BSA and AoI

Common name	Species name	Restricted Range / Endemic Status	Migratory / congregatory Species	IUCN treat category (IUCN, 2023)	Nationally Protected Wild Animals and Birds (Sanctuary) Ordinance	National Status (Jessamy, 2014; Turner 2007)	Recorded in BSA and/ or AoI?	Source
Damselfly	*Argia telesfordi*	Restricted range	No	DD	No	No	Yes	2019 surveys
Painted lady	*Vanessa cardui*	No	Migratory	LC	No	No	No	IBAT 2023

Source: Compiled by Mott MacDonald, 2023. CR, Critically Endangered, EN= Endangered, VU = Vulnerable, LC = Least Concern

8.4.10 Fish and aquatic-macroinvertebrates

The IBAT screening identified six decapod species, two bivalves and one fish species as potentially present within the Project AoI. Of these species, four decapods are migratory. They are: *Macrobrachium faustinum, Atya innocous, Atya scabra* and *Macrobrachium crenulatum*. Because these four species are migratory, they are all of conservation concern, and therefore are displayed in Table 8.13 below.

The 2019 Site F surveys recorded nine aquatic species during the wet and dry season surveys. Of these nine species, one was a fish, one a crustacean, and seven were insects. All Antillean freshwater fish fauna are nationally listed as endangered in Grenada, therefore the fish species encountered is of conservation concern: the jumping guabine *Anablepsoides hartii*.

The crustacean recorded during the 2019 surveys is not globally threatened, migratory or restricted range. None of the aquatic invertebrate species were identified to species level, therefore it is unknown if they are of conservation concern.

During the 2023 surveys, one aquatic species was recorded in Site C: the manicou crab *Rodriguezus garmanii*. This species is not restricted-range, migratory, congregatory, nationally protected, or listed as threatened on the IUCN Red List.

8.4.10.1 Freshwater Decapods

Macrobrachium faustinum

This species has a wide distribution and inhabits lowland rivers and streams. There are no known major threats to this species (De Grave 2013a). These habitats are present within the AoI, therefore it is possible that this species could inhabit this area.

Atya innocous

This species has a wide distribution across Mesoamerica and the Caribbean islands. It can occur in small streams and large river systems up to 925m above sea level. The species displays ecological plasticity and is thought to be abundant. Adults migrate downstream and enter brackish waters in order to reproduce (De Grave et al. 2013a). Streams are present within the AoI, therefore it is possible that this species could inhabit this area.

Atya scabra

This species has a wide amphi-Atlantic distribution and has no known threats. It is locally abundant in some parts of its range. It inhabits streams and rivers from coastal areas to considerable altitude (De Grave et al. 2013b). Streams and rivers are present within the AoI, therefore it is possible that this species could inhabit this area.

Macrobrachium crenulatum

This is a widespread species with no known major threats. The species inhabits lowland rivers and streams (De Grave 2013b). Streams and rivers are present within the AoI, therefore it is possible that this species could inhabit this area.

8.4.10.2 Freshwater Fish

Jumping guabine

All Antillean freshwater fish are listed as Endangered within the Grand Etang Forest Reserve (Turner 2007). The jumping guabine is broadly distributed throughout freshwater drainages and coastal brackish habitat in the Lesser Antilles. The species faces several locally pervasive threats (such as elevated concentrations of industrial pollutants) and its habitat quality is continuously declining, however there is no evidence yet of major range-wide population decline. The species occurs across a broad range of habitat types, including headwater streams, drainage ditches, swamps and weakly brackish water. The species can also tolerate low dissolved oxygen conditions, exposure to moist air, and it has the ability to move short distances over land (Lyons 2021). This species was encountered during the 2019 surveys, and is therefore confirmed to be present in the Project AoI.

Table 8.13: Aquatic species of conservation concern within the BSA and AoI

Common name	Species name	Restricted Range / Endemic Status	Migratory / congregatory Species	IUCN treat category (IUCN, 2023)	Nationally Protected Wild Animals and Birds (Sanctuary) Ordinance	National Status (Jessamy, 2014; Turner 2007)	Recorded in BSA and/ or AoI?	Source
-	*Macrobrachium faustinum*	No	Migratory	LC	No	No	No	IBAT 2023
-	*Atya innocous*	No	Migratory	LC	No	No	No	IBAT 2023
-	*Atya scabra*	No	Migratory	LC	No	No	No	IBAT 2023
-	*Macrobrachium crenulatum*	No	Migratory	LC	No	No	No	IBAT 2023
Jumping guabine	*Anablepsoides hartii*	No	No	LC	No	EN	Yes	2019 surveys

Source: Compiled by Mott MacDonald, 2023. CR, Critically Endangered, EN= Endangered, VU = Vulnerable, LC = Least Concern

8.5 Critical habitat screening

8.5.1 Criteria 1-3: Species Biodiversity Values

In total, 313 species were screened against the relevant criteria and thresholds in Section 8.3.3 to determine if the Project has the potential to be located in Critical Habitat. All 313 species are presented in Appendix D. Forty species meet Critical Habitat criteria 1-3 listed in Table 8.3 (18 meet Criterion 1 (C1), 14 meet Criterion 2 (C2), and 16 meet Criterion 3 (C3)). They would need to undergo a full CHA against the quantitative thresholds also listed in Table 8.3 in order to confirm if the Project is located in Critical Habitat. The results of the screening are displayed in

Table 8.14 below. Eight species were listed as Data Deficient by the IUCN. One of these is thought to be restricted range, and hence should be assessed against C2 (the damselfly *Argia telesfordi*), though it would be recommended that all Data Deficient species be investigated further as part of a full CHA. To date, the Project has consulted with the IUCN Species

Specialist Groups (SSGs) on bats and snakes to understand whether they are likely to be restricted range and present within the Project AoI.

Table 8.14: Critical Habitat screening

Common name	Scientific name	IUCN Red List Category	National Status (Jessamy 2014; Turner 2007)	Restricted Range	Migratory / Congregatory	C1	C2	C3	Likelihood of meeting Critical Habitat thresholds*	Source
Flora										
Spanish cedar	Cedrela odorata	VU	N/A	No	N/A	C1(b)			Unlikely	IBAT, 2023
Mountain cabbage	Euterpe dominicana	N/A	EN	Yes	N/A	C1(c)	C2(a)		Unlikely	2019 surveys
Turk's cap	Melocactus broadwayi	NT	EN	No	N/A	C1(c)			Unlikely	IBAT, 2023
Lansan	Protium attenuatum	EN	N/A	No	N/A	C1(a)			Unlikely	IBAT, 2023
The hummingbird-pollinated shrub	Cheiranthus grenadensis	N/A	N/A	Yes	N/A		C2(a)		Unlikely	Aucoin, 2018
-	Rhytidophyllum caribaeum	N/A	N/A	Yes	N/A		C2(a)		Unlikely	Aucoin, 2018
Mammals										
Agouti	Dasyprocta leporina	LC	EN	No	No	C1(c)			Likely	Turner, 2007
Robinson's mouse opossum	Marmosa robinsoni	LC	EN	No	No	C1(c)			Likely	Turner, 2007; 2019 surveys
Barbados myotis	Myotis nyctor	VU	N/A	Yes	No	C1(b)	C2(a)		Unlikely	IBAT, 2023
Birds										
Grenada Flycatcher	Myiarchus nugato	LC	N/A	Yes	No		C2(a)		Likely	2023 surveys
Mangrove Cuckoo	Coccyzus minor	LC	N/A	No	Migratory			C3(a)	Possible	2023 surveys
Eared Dove	Zenaida auriculata	LC	N/A	No	Migratory			C3(a)	Possible	2023 surveys
House Wren	Troglodytes aedon	LC	N/A	No	Migratory			C3(a)	Unlikely	2023 surveys
Black Whiskered Vireo	Vireo altiloquus	LC	N/A	No	Migratory			C3(a)	Unlikely	2023 surveys
Night Hawk	Chordeiles minor	LC	N/A	No	Migratory			C3(a)	Possible	2023 surveys
Cattle egret	Bubulcus ibis	LC	N/A	No	Migratory			C3(a)	Possible	2019 surveys
Broad winged hawk	Buteo platypterus	LC	N/A	No	Migratory			C3(a)	Possible	2019 surveys;

Common name	Scientific name	IUCN Red List Category	National Status (Jessamy 2014; Turner 2007)	Restricted Range	Migratory / Congregatory	C1	C2	C3	Likelihood of meeting Critical Habitat thresholds*	Source
										2023 surveys
Grenada hook-billed kite	Chondrohierax uncinatus mirus	LC	EN	Endemic	No	C1(c)	C2(a)		Likely	Aucoin 2018; 2019 surveys
Black swift	Cypseloides niger	VU	N/A	No	Migratory	C1(b)		C3(a)	Unlikely	IBAT, 2023
Little blue heron	Egretta caerulea	LC	N/A	No	Migratory			C3(a)	Possible	2019 surveys
Grenada dove	Leptotila wellsi	CR	EN	Yes	No	C1(a), C1(c)	C2(a)		Possible	IBAT, 2023
Lesser Antillean tanager	Tangara cucullate	LC	N/A	Yes	No		C2(a)		Possible	2019 surveys; 2023 surveys
Gray kingbird	Tyrannus dominicensis	LC	VU	No	Migratory			C3(a)	Likely	Turner 2007; 2019 surveys; 2023 surveys
Tropical kingbird	Tyrannus melancholicus	LC	N/A	No	Migratory			C3(a)	Possible	2019 surveys
Reptiles										
Grenada bush anole	Anolis aeneus	LC	N/A	Possibly	No		C2(a)		Possible	IBAT, 2023
Grenada tree anole	Anolis richardii	LC	N/A	Possibly	No		C2(a)		Possible	2019 surveys; IBAT, 2023
Mussurana	Clelia clelia	LC	CR	No	No	C1(c)			Possible	Turner 2007; IBAT, 2023
Shaw's dark ground snake	Erythrolamprus melanotus	LC	EN	No	No	C1(c)			Possible	Turner 2007
Lesser windward skink	Marisora aurulae	VU	N/A	Yes	No	C1(b)	C2(a)		Unlikely	IBAT, 2023
Barbour's tropical racer	Mastigodryas bruesi	LC	EN	Possibly	No	C1(c)	C2(a)		Possible	IBAT, 2023
Neuwied's moonsnake	Pseudoboa neuwiedii	N/A	EN	No	No	C1(c)			Possible	Turner 2007

Common name	Scientific name	IUCN Red List Category	National Status (Jessamy 2014; Turner 2007)	Restricted Range	Migratory / Congregatory	C1	C2	C3	Likelihood of meeting Critical Habitat thresholds*	Source
Amphibians										
Giant woodland frog	Leptodactylus fallax	CR	Status uncertain	No	No	C1(a)			Likely	Turner 2007
Grenada frog	Pristimantis euphronides	CR	EN	Yes	No	C1(a), C1(c)	C2(a)		Unlikely	Turner 2007; IBAT, 2023
Fish										
Jumping guabine	Anablepsoides hartii	LC	EN	No	No	C1(c)			Possible	2019 surveys
Insects										
Damselfly	Argia telesfordi	DD	N/A	Yes	No		C2(a)		Likely	2019 surveys
Painted lady	Vanessa cardui	LC	N/A	No	Migratory			C3(a)	Unlikely	IBAT, 2023
Crustaceans										
-	Atya innocous	LC	N/A	No	Migratory			C3(a)	Possible	IBAT, 2023
-	Atya scabra	LC	N/A	No	Migratory			C3(a)	Possible	IBAT, 2023
-	Macrobrachium crenulatum	LC	N/A	No	Migratory			C3(a)	Possible	IBAT, 2023
-	Macrobrachium faustinum	LC	N/A	No	Migratory			C3(a)	Possible	IBAT, 2023

8.5.2 Criterion 4: Highly Threatened / Unique Ecosystems

The Project is not located within an area where a formal IUCN assessment has been performed as part of the Red List of Ecosystems (IUCN, 2020). The Biodiversity AoI overlaps with two ecoregions: the Windward Islands Moist Forests and the Lesser Antillean Dry Forests. Both of these ecoregions are considered to be Critical / Endangered (Armstrong 2018; Armstrong 2019). The area of the Windward Islands Moist Forests ecoregion is 203,000ha, and the Lesser Antillean Dry Forests ecoregion is 64,000ha (Schipper 2023a; Schipper 2023b). Given that the Biodiversity AoI is approximately 16,000ha, it is possible that the Biodiversity AoI may overlap with a significant proportion of these ecoregions. It is therefore feasible that the Biodiversity AoI may meet Criterion 4 to qualify as Critical Habitat for Highly Threatened or Unique Ecosystems, though a full CHA would be required to confirm this. In addition to this, Ocean Viewer data suggests that the Biodiversity AoI overlaps predominantly with habitat that is classified as 'likely' to be critical habitat (UNEP WCMC, 2021).

8.5.3 Criterion 5: Key Evolutionary Processes

The Project area is located within the Caribbean Islands biodiversity hotspot. This hotspot consists of three island groups: the Bahamas, the Lesser Antilles, and the Greater Antilles. The hotspot spans over 4,000,000km^2 in the ocean, and 230,000km^2 on land. High levels of amphibian speciation and endemism within the hotspot render it very important for global amphibian conservation activities. High levels of flora, bird and reptile endemism are also present here (CEPF 2023). Although the dominant habitat type within the Biodiversity AoI is modified (agriculture), the natural forest habitat is the second commonest habitat type here. It is therefore possible that the area may qualify as Critical Habitat for Key Evolutionary Processes, though a full CHA is needed to confirm this.

8.5.4 Critical habitat high level screening conclusion

Given the presence of species and habitats that meet the criteria of C1, C2, C3 and C4, a full CHA is required according to IFC PS6, in order to accurately identify Project requirements. A project located in Critical Habitat must achieve Biodiversity Net Gain (BNG) for all Critical Habitat features, whilst a project situated in natural habitat must achieve No Net Loss (NNL) of biodiversity.

It is recommended that a CHA be undertaken at the exploratory drilling phase, with pre-construction surveys (wet season) prior to any disturbance to the site occurring. This will ensure an accurate understanding of the potential of any critical habitat features regularly occurring within the Project area.

8.6 Assessment of impacts

8.6.1 Identification of receptors and analysis of sensitivity

The Project could lead to impacts to habitats, flora and fauna that are present within or use the Project AoI. These impacts are described below for both the construction and operational phases. Table 8.15 shows the biodiversity related receptors and an analysis of their sensitivity. Further assessment is required to identify if the Project is located within Critical Habitat, therefore a precautionary approach has been taken at this stage and the species that have potential trigger Critical Habitat have been assigned a high sensitivity. These may be reduced to medium sensitivity following the full Critical Habitat Assessment (see Section 8.6).

To reduce repetition, similar receptors at the two sites are analysed together.

Table 8.15: Biodiversity receptors and sensitivity

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
Mount Saint Catherine NP Mount Saint Catherine KBA	Mount Saint Catherine NP is nationally protected in Grenada. Mount Saint Catherine KBA is an internationally recognised area for biodiversity.	These areas are nationally protected or internationally recognised for biodiversity value.	High
Habitats of high sensitivity: Forest habitats	– Drought, deciduous open woodland – Deciduous, coastal evergreen and mixed forest or shrubland – Semi-deciduous forest – Evergreen and seasonal evergreen forest – Elfin and Sierra Palm tall cloud forest	Both forest ecoregions that overlap with the Project are listed by the WWF as Critical/Endangered and have the potential to trigger critical habitat requirements.	High
Habitats of medium sensitivity (natural habitats): Water	– Rivers and riparian habitats	Rivers are natural and are of importance to the aquatic species that inhabit them.	Medium
Habitats of low sensitivity: Agricultural habitats	– Nutmeg and mixed woody agriculture (e.g. cacao, coconut, banana) – Pastures, cultivated land and herbaceous agriculture	Agricultural plantations and pastures are the dominant habitat type within the Project AoI. These habitats are modified, with limited ecological and biodiversity value.	Low
Flora of high sensitivity	– Lansan Protium attenuatum (EN) – Rhytidophyllum caribaeum (NE) – Mountain cabbage Euterpe dominicana (nationally EN)	Lansan is IUCN Endangered, and mountain cabbage is nationally Endangered. *Rhytidophyllum caribaeum* is	High

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
		restricted range. These species have the potential to trigger critical habitat requirements.	
Flora of medium sensitivity	Four plant species are listed as endemic to the Lesser Antilles or Windward Islands: – Tree fern Cyathea elliottii – Lobelia cirsifolia – Siguine batard Asplundia insignis – Monkey paws vine Marcgravia umbellata	These four flora species are all relatively rare, given that they are endemic to the Windward Isles / Lesser Antilles. None are restricted range, classified by the IUCN, or under national protection, therefore they are classed as being of medium sensitivity.	Medium
Flora of low sensitivity	All other terrestrial and aquatic flora species that are present or have the potential to be present within the Project AoI.	IUCN Near Threatened /Least Concern. Species of local national importance.	Low
Mammals (bats) of high sensitivity	The Barbados myotis *Myotis nyctor* (VU) has the potential to be present within the Project area.	This bat species is IUCN Vulnerable and range restricted.	High
Terrestrial mammals of high sensitivity	– Robinson's Mouse Opossum *Marmosa robinsoni* (nationally EN) – Agouti *Dasyprocta leporina* (nationally EN)	Both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat requirements.	High
Terrestrial mammals of medium sensitivity	– Nine-banded armadillo *Dasypus novemcinctus* (nationally rare)	This species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size	Medium
Mammals of low sensitivity	All other terrestrial mammals and bats that are present or have the potential to be present within the Project area.	IUCN Near Threatened, Least Concern, and Data Deficient species.	Low
Birds of high sensitivity	One bird species which is globally threatened according to the IUCN has the potential to be present in the Project AoI: – Black Swift Cypseloides niger (VU) One nationally Endangered species has been recorded in the Project area: – Hook-billed kite *Chondrohierax unicatus mirus* (nationally EN, RR) One restricted range species has been recorded in the Project area: – Lesser Antillean tanager *Tangara cucllata* (RR) – Grenada Flycatcher *Myiarchus nugato (*RR)	These species have the potential to trigger critical habitat requirements (C1, C2, and C3).	High

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
	Eleven migratory bird species have been recorded in the Project area: – Cattle egret *Bubulcus ibis* (migratory) – Broad winged hawk *Buteo platypterus* (migratory) – Little blue heron *Egretta caerulea* (migratory) – Grey kingbird *Tyrannus dominicensis* (migratory) Tropical kingbird *Tyrannus melancholicus* (migratory) – Mangrove Cuckoo *Coccyzus minor* – Eared Dove *Zenaida auriculata* – House Wren *Troglodytes aedon* – Black Whiskered Vireo *Vireo altiloquus* – Night Hawk *Chordeiles minor*		
Birds of medium sensitivity	All other wild bird species that are present or have the potential to be present within the Project AoI.	All wild bird species are protected within Grenada under the Birds and Other Wildlife Act, 1957	Medium
Amphibians of high sensitivity	Giant Woodland Frog *Leptodactylus fallax* (CR)	This amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements.	High
Amphibians of medium sensitivity	– Cane toad *Rhinella marina* (nationally rare) – Lesser Antillean Whistling Frog *Eleutherodactylus johnstonei* (national status uncertain)	The cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as ‘status uncertain”, but the Project site is unlikely to include a significant population size of either species	Medium
Amphibians of low sensitivity	All other amphibian species that are present or have the potential to be present within the Project area.	IUCN Near Threatened, Least Concern, and Data Deficient species.	Low
Reptiles of high sensitivity	– Lesser Windward Skink *Marisora aurulae* (VU) – Mussurana *Clelia clelia* (nationally CR) – Barbour's Tropical Racer *Mastigodryas bruesi* (nationally EN) – Grenada Tree Anole *Anolis richardii* (RR) – Grenada Bush Anole *Anolis aeneus* (RR) – Shaw’s dark ground snake *Erythrolamprus melanotus* (nationally EN)	These species have the potential to trigger critical habitat requirements (C1 and C2).	High

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
	– Neuwied's moonsnake *Pseudoboa neuwiedii* (nationally EN)		
Reptiles of medium sensitivity	– Morocoy tortoise *Geochelone carbonaria* (nationally threatened) – Tree boa *Corallus cookii* (National status uncertain)	The Morocoy tortoise is nationally listed as threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species	Medium
Reptiles of low sensitivity	All other reptile species that are present or have the potential to be present within the Project area.	IUCN Near Threatened, Least Concern, and Data Deficient species.	Low
Invertebrates of high sensitivity	– Painted lady butterfly *Vanessa cardui* – Damselfly *Argia telesfordi*	The painted lady is a migratory species and the damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements.	High
Invertebrates of low sensitivity	All other invertebrate species that are present or have the potential to be present within the Project area.	IUCN Near Threatened, Least Concern, and Data Deficient species	Low
Fish and macroinvertebrates of high sensitivity	Fish species: – Jumping guabine Anablepsoides hartii Freshwater macroinvertebrate species: – Macrobrachium faustinum – Atya innocous – Atya scabra – Macrobrachium crenulatum	The jumping guabine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements.	High
Fish and macroinvertebrates of medium sensitivity	All Antillean freshwater fish species that are present or have the potential to be present within the project area.	All Antillean freshwater fish species are listed as nationally Endangered within Grenada.	Medium
Fish and macroinvertebrates of low sensitivity	All other fish and macroinvertebrates that are present or have the potential to be present within the Project area that are not listed above.	IUCN Near Threatened, Least Concern, and Data Deficient species	Low

8.6.2 Summary of changes, impacts and receptors

Table 8.16 shows the changes caused by construction activities, the potential receptors and the potential impact of the change. For further information on the site-specific mitigation measures referred to in the table below, see Section 8.7.

Table 8.16: Changes, receptors and potential impacts

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Vegetation removal	Construction	Habitat loss and degradation	Habitats listed in Table 8.19
		Disturbance and displacement of species	Flora of high, medium and low sensitivity
		This change will lead to permanent and temporary habitat and flora loss. It may also lead to habitat fragmentation and degradation. Terrestrial habitats will be permanently lost under the footprint of the new and upgraded access roads, well pads and water intake and pump stations. Terrestrial habitat will also be lost temporarily under the footprint of the storage and laydown areas and construction of the temporary water supply pipeline.	Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, associated with the habitats that are lost and within the AoI.
		Riparian and freshwater habitats may become degraded due to the construction of the water intake, pump stations and temporary pipelines.	
		This change can also lead to the disturbance and displacement of terrestrial fauna species that are present within the Project area.	
		Site-specific mitigation measures in line with international best practice will be adopted and implemented (see Section 8.7).	
		Additional information is included in Table 8.17 and Table 8.18 to present the habitats under the footprint of Site C and Site F.	
	Operation	Habitat degradation	Habitats and flora adjacent to the Project components
		Disturbance and displacement of species	Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, associated with the habitats within the AoI.
		No additional habitat should be lost during the operation phase of this Project. However, terrestrial habitat adjacent to the Project could become degraded during operational activities such as drilling rig and ancillary equipment maintenance.	
		Riparian and freshwater habitats could become degraded as large volumes of water are required during drilling and testing of the boreholes.	
	Decommissioning	No additional habitat should be lost during site closure.	Habitats and flora adjacent to the Project components
			Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, associated with the habitats within the AoI.

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Excavation/ drilling and the movement and management of excavated/drilling material	Construction	Accidental introduction of invasive species Movements of soil through excavation activities could result in the accidental introduction of invasive plant species. Bamboo and Bois Canot are already present in large numbers within the Project area (see Section 8.4.5) and could be spread through Project activities. These two invasive species are also frequently found within disturbed areas, which excavation works will generate. However, site-specific mitigation measures in line with international best practice will be adopted and implemented. Killing or injury of species through Project activities Excavations of areas for mud pond and water storage and the movement and management of excavated materials will impact terrestrial and freshwater habitats, flora and fauna. This change could result in the accidental introduction of invasive species and/or injury/ death of terrestrial fauna trapped in excavations/ excavated materials. There is potential for terrestrial and freshwater habitats and species to be impacted by run-off of excavated materials into watercourses particularly if heavy rainfall occurs. Changes in turbidity, increased sedimentation, silting, and riverbed scouring through excavations or drilling can all impact freshwater species. However, site-specific mitigation measures in line with international best practice will be adopted and implemented.	Flora of high, medium and low sensitivity Small terrestrial mammals of high, medium and low sensitivity Herpetofauna of high, medium and low sensitivity.
	Operation	Killing or injury of species through Project activities There is potential for injury/ death of terrestrial fauna through individuals becoming trapped in the mud pond/ water storage areas during drilling. A significant activity in the drilling phase is the management of the drilling mud. The settling pond will contain any discarded mud during the operations. Site-specific mitigation measures in line with international best practice will be adopted and implemented to minimise injury/ death of terrestrial fauna due to drilling.	Flora of high, medium and low sensitivity Small terrestrial mammals of high, medium and low sensitivity Herpetofauna of high, medium and low sensitivity.
	Decommissioning	Movement of excavated materials will be undertaken during site closure; therefore impacts are considered to be similar to Construction phase detailed above.	As for construction.

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Use of chemicals (such as cement, petroleum, drilling fluid)	Construction	This change will introduce emissions from vehicles and pollution from vehicle run-offs into the AoI. Human operating error or equipment failure could lead to chemical spills e.g. diesel fuel (hydrocarbon) spills during fuel storage facility recharge from fuel tanker trucks. These spillage events can also adversely impact terrestrial and aquatic habitats and species (including freshwater species located downstream from the Project area). However, site-specific mitigation measures in line with international best practice will be adopted and implemented. Refer to Chapter 9 - water chapter for more detail.	Habitats of high, medium and low sensitivity Flora of high, medium and low sensitivity Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Operation	Habitat degradation Killing or injury of species through Project activities Pollution of deeper groundwater may occur due to potential release of contaminants, drilling fluids or geothermal fluids during drilling. Drilling mud and drilling cuttings from geothermal drilling (using air/aerated fluid or water-based substances), are typically not classified as hazardous waste. However, sampling and laboratory testing of drill mud and drilling cuttings will be undertaken as a precautionary measure. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Habitats of high, medium and low sensitivity Flora of high, medium and low sensitivity Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Decommissioning	No chemicals will be used during site closure.	As for Construction
Presence of people, noise, artificial light, vibration and air emissions (including dust)	Construction	Disturbance and displacement of species Presence of people, noise, artificial light, vibration and air emissions (including dust) will impact terrestrial mammals, birds and some herpetofauna species during construction through disturbance and displacement. This change can disrupt fauna populations by interfering with their movements and/or breeding activities. Vibration may also lead to habitat avoidance by freshwater fish, resulting in displacement from their preferred feeding and spawning areas. Dust particles generated by vehicle movements on dirt roads may adhere to leaves, impeding photosynthesis and plant growth. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Habitats of high, medium and low sensitivity Flora of high, medium and low sensitivity Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Operation	Disturbance and displacement of species Drilling operations will be 24 hours a day and cause disturbance and displacement of fauna species due to noise and vibration. Slimhole continuous coring and drilling technology will be used. The drilling activities are undertaken using progressively smaller drill bits as the sections become deeper. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Habitats of high, medium and low sensitivity Flora of high, medium and low sensitivity Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
	Decommissioning	During site closure, the impacts are likely to be similar to construction.	As for Construction.
Vehicle operation (movement and transportation of drilling rig and associated equipment)	Construction	Habitat degradation Killing or injury of species through Project activities Off-road vehicle movement can cause degradation of terrestrial habitats. There is also potential for injury/ death of terrestrial fauna due to collisions with vehicles. Emissions from vehicles and pollution from operational vehicle run-offs. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Habitats of high, medium and low sensitivity Flora of high, medium and low sensitivity Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Operation	Habitat degradation Killing or injury of species through Project activities Off-road vehicle movement can cause degradation of terrestrial habitats. There may also be habitat degradation caused by pollution (including dust), storage of materials and equipment, and trampling. There is also potential for injury/ death of terrestrial fauna due to collisions with vehicles. There is potential for injury/ death of terrestrial fauna through collisions with vehicle. Emissions from vehicles and pollution from operational vehicle run-offs. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Habitats of high, medium and low sensitivity Flora of high, medium and low sensitivity Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Decommissioning	Off-road vehicle movement can cause degradation of terrestrial habitats.	As for Construction
Increased water intake	Construction	Aquatic habitat degradation and reduced water availability for aquatic species Some water may be required during construction but the volumes are unlikely to be significant. This change could impact aquatic habitats and species. Site-specific mitigation measures in line with international best practice will be adopted and implemented. Refer to Chapter 9 – water resources chapter for more detail.	Aquatic habitats Fish and aquatic macroinvertebrates Amphibians

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
	Operation	Aquatic habitat degradation and reduced water availability for aquatic species Killing or injury of species through Project activities For slimhole drilling, a maximum rate of 12.5 litres/second continuous water flow are required. This change could impact aquatic habitats and species. Baseline flow data for the two intake locations is limited, however the minimum environmental flow for Site C is set to be 5.1l/s, and 4.4l/s at Site F (see Chapter 9 – water resources). Fish species moving though the main river channel may be caught or entrained at the intake infrastructure during operation, resulting in fish mortality. Site-specific mitigation measures in line with international best practice will be adopted and implemented. Refer to Chapter 9 - water resources for more detail.	Aquatic habitats Fish and aquatic macroinvertebrates Amphibians
	Decommissioning	As for construction	As for Construction
Improved access through new / upgraded roads	Construction	Killing or injury of species through Project activities This change will improve access which can result in hunting and poaching of wildlife in the area. Site-specific mitigation measures in line with international best practice will be adopted and implemented. Habitat degradation This change will improve access which can result in increased or new illegal tree logging in the area. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Operation	Killing or injury of species through Project activities This change will improve access which can result in hunting and poaching of wildlife in the area. Site-specific mitigation measures in line with international best practice will be adopted and implemented. Habitat degradation This change will improve access which can result in increased or new illegal tree logging in the area. Site-specific mitigation measures in line with international best practice will be adopted and implemented.	Mammals, birds, herpetofauna, terrestrial invertebrates, fish and aquatic invertebrates, present within the AoI.
	Decommissioning	As the roads will remain open following site closure, the impacts will be similar to the Construction and operation phases.	As for Construction

8.6.3 Analysis of construction impacts

8.6.3.1 Habitat loss and degradation

The magnitude of the habitat loss and degradation is considered minor for all forest habitats and species present within them because 1.63ha of forest habitat will be lost during the construction phase which will impact forest flora and fauna. The magnitude is considered moderate for medium and low sensitivity habitats and the respective species here because 4.12ha of agricultural land will be lost. At water extraction points, intake pipe shall be fully submerged in the river. The magnitude is minor for protected areas, because no direct habitat loss is expected to occur within their boundaries. At present, it is assumed that all habitat loss will be short term (three months). The details of any temporary components are not known at this stage. Table 8.17 presents permanent habitat loss under Site C, Table 8.18 presents habitat loss under Site F, and Table 8.19 displays the total habitats under the two sites combined. Vegetation removal will occur during site clearance in the construction phase, but the duration of the loss is considered short term (three months). The vegetation removal will occur under the footprint of the Project components, so the scale is considered local. The probability of vegetation removal occurring is considered certain because site clearance is required to upgrade roads and build Project components.

Upgrading of access tracks leading up to each of the sites will be approximately 400m at site C and 1600m at site F. New roads within the sites will be approximately 500m at Site C and 400m at Site F to provide access to well pads from the access track. This will lead to permanent habitat loss of approximately 0.87 ha. The new roads are situated closer to the Mount Saint Catherine KBA and Mount Saint Catherine National Park than the pre-existing roads (at the road's nearest point there is a distance of approximately 70m between the road and the KBA). This could result in induced impacts on the protected areas and sensitive biodiversity features within them, through increased access.

Table 8.17: Site C habitat loss

Habitat type	Habitats under the Project footprint (m^2, except river in m)						
	Pad location	Spoil disposal	New water pond	Pump station	Water intake	New road (with 1.5m buffer)	Total habitat loss
Nutmeg and mixed woody agriculture	3773.37	3278.80	304.54	386.36	-	589.12	8332.19
Pastures, cultivated land and herbaceous agriculture	468.71	289.19	-	-	13.69	245.89	1017.47

Habitat type	**Habitats under the Project footprint (m^2, except river in m)**						
Deciduous, coastal evergreen and mixed forest or shrubland	8.00	-	-	-	-	38.35	46.35
Semi-deciduous forest	-	-	-	-	-	3.90	3.90
Evergreen and seasonal evergreen forest	-	-	-	-	-	-	-
Elfin and Sierra Palm tall cloud forest	23.93	-	0.36	-	-	-	24.29
Rivers	-	-	-	-	3.24	-	3.24
Buildings	-	-	-	-	-	-	-
Roads and other built-up surfaces	-	-	-	43.97	-	79.75	123.72
Total land take per component (m^2)	**4724.00**	**3567.99**	**304.90**	**430.33**	**13.69**	**957.02**	**9547.93**

Source: Mott MacDonald

Table 8.18: Site F habitat loss

Habitat type	**Habitats under the Project footprint (m^2, except river in m)**							
	Pad location	**Pad laydown**	**Spoil disposal**	**Sediment pond**	**Pump station**	**Water intake**	**New road (with 1.5m buffer)**	**Total habitat loss**
Nutmeg and mixed woody agriculture	1163.75	861.06	477.48	5.71	348.34	10.36	606.53	3473.23
Pastures, cultivated land and herbaceous agriculture	8.00	29.92	3.75	-	24.00	-	-	65.67
Deciduous, coastal evergreen and mixed forest or shrubland	-	20.68	-	-	-	-	3.14	23.83
Semi-deciduous forest	198.12	108.89	71.04	7.80	9.45	0.06	59.13	454.47

Habitat type	Habitats under the Project footprint (m^2, except river in m)							
Evergreen and seasonal evergreen forest	2799.27	523.56	367.33	291.39	-	0.24	720.63	4702.42
Elfin and Sierra Palm tall cloud forest	28.00	175.68	413.81	-	18.24	-	150.92	786.65
Rivers	-	-	-	-	-	2.99	-	2.99
Bare ground	-	-	-	-	-	-	-	-
Buildings	-	27.44	-	-	-	-	22.67	50.11
Roads and other built-up surfaces	-	-	-	-	-	-	6.55	6.55
Total land take per component (m^2)	**4197.13**	**1747.24**	**1333.40**	**304.90**	**400.03**	**10.65**	**1569.58**	**9562.93**

Source: Mott MacDonald

Table 8.19: Habitats under the footprint across both sites

Habitat type	Habitats under the Project footprint (m^2, except river in m)							
	Pad location	**Pad laydown**	**Spoil disposal**	**Sediment pond / new water pond**	**Pump station**	**Water intake**	**New road (with 1.5m buffer)**	**Total habitat loss (m^2 or m)**
Nutmeg and mixed woody agriculture	4937.11	861.06	3756.28	310.25	734.70	10.36	1195.65	11805.42
Pastures, cultivated land and herbaceous agriculture	476.71	29.92	292.94	-	24.00	13.69	245.89	1083.15
Deciduous, coastal evergreen and mixed forest or shrubland	8.00	20.68	-	-	-	-	41.50	70.18
Semi-deciduous forest	198.12	108.89	71.04	7.80	9.45	0.06	63.03	458.37

Habitat type	Habitats under the Project footprint (m^2, except river in m)							
Evergreen and seasonal evergreen forest	2799.27	523.56	367.33	291.39	-	0.24	720.63	4702.42
Elfin and Sierra Palm tall cloud forest	51.93	175.68	414.17	-	18.24	21.51	150.92	810.94
Rivers	-	-	-	-	-	6.23	-	6.23
Bare ground	-	-	-	-	-	-	-	-
Buildings	-	27.44	-	-	-	3.37	22.67	50.11
Roads and other built-up surfaces	-	-	-	-	43.97	-	86.30	130.27
Total land take per component (m^2)	**8471.13**	**1747.24**	**4901.40**	**609.80**	**830.35**	**24.34**	**2526.59**	**19110.86**

Source: Mott MacDonald, 2023

Table 8.20: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
Mount Saint Catherine NP Mount Saint Catherine KBA	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to have high biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B1 B4 B5 B8 B10
Habitats of high sensitivity: Forest habitats	As defined in Table 8.15, the sensitivity of forest habitats are considered high because both forest ecoregions that overlap with the Project are listed by the WWF as Critical/Endangered and have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term Scale: local Probability: certain	B1 B4 B5 B8

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
		Sensitivity of receptor: high Significance of impact: minor	
Habitats of medium sensitivity (natural habitats): Rivers and riparian habitats	As defined in Table 8.15, the sensitivity of natural habitats are considered medium because Rivers and riparian habitats are natural and are of importance to the aquatic species that inhabit them. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is considered not significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B1 B4 B5 B8 B10
Habitats of low sensitivity: Agricultural habitats	As defined in Table 8.15, the sensitivity of agricultural habitats are considered low because agricultural plantations and pastures are the dominant habitat type within the Project area. These habitats are modified, with limited biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8
Flora of high sensitivity	As defined in Table 8.15, the sensitivity of lansan, *Rhytidophyllum caribaeum*, and mountain cabbage are considered high because Lansan is IUCN Endangered and mountain cabbage is nationally Endangered. *Rhytidophyllum caribaeum* is restricted range. These species have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter: Judgement Nature: Negative Magnitude: major Duration: short term Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8
Flora of medium sensitivity	As defined in Table 8.15, the sensitivity of tree fern, *Lobelia cirsifolia*, siguine batard and monkey paws vine are considered medium because these four flora species are all relatively rare, given that they are endemic to the Windward Isles / Lesser Antilles. None are restricted range, classified by the IUCN, or under national protection, therefore they are classed as being of medium sensitivity. Combining the expected characteristics of the predicted change with the	Parameter Judgement Nature: Negative Magnitude: major Duration: short term Scale: local	B1 B4 B5 B8

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
	sensitivity of the receptor creates a minor impact, which is considered not significant.	Probability: certain Sensitivity of receptor: medium Significance of impact: minor	
Flora of low sensitivity	As defined in Table 8.15, the sensitivity of all other flora present on site are considered low because they are categorised as IUCN Near Threatened /Least Concern and are species of local national importance. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8
Mammals (bats) of high sensitivity	As defined in Table 8.15, the sensitivity of the *Barbados myotis* is considered high because this bat species is IUCN Vulnerable and range restricted. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8
Terrestrial mammals of high sensitivity	As defined in Table 8.15, the sensitivity of Robinson’s mouse opossum and agouti are considered high because both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8
Terrestrial mammals of medium sensitivity	As defined in Table 8.15, the sensitivity of the nine banded armadillo is considered medium because this species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size. Combining	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months)	B1 B4 B5 B8

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
	the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	
Mammals of low sensitivity	As defined in Table 8.15, the sensitivity of all other mammals present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8
Birds of high sensitivity	As defined in Table 8.15, the sensitivity of globally and nationally threatened, restricted range and migratory birds are considered high because these species have the potential to trigger critical habitat requirements (C1, C2, and C3). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8
Birds of medium sensitivity	As defined in Table 8.15, the sensitivity of all other bird species present on site are considered medium because all wild bird species are protected within Grenada under the Birds and Other Wildlife Act, 1957. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B1 B4 B5 B8
Amphibians of high sensitivity	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements.	Parameter Judgement Nature: Negative Magnitude: moderate	B1 B4 B5

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
	Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B8 B10
Amphibians of medium sensitivity	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B1 B4 B5 B8 B10
Amphibians of low sensitivity	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8 B10
Reptiles of high sensitivity	As defined in Table 8.15, the sensitivity of globally threatened, nationally endangered and restricted-range reptiles are considered high because these species have the potential to trigger critical habitat requirements (C1 and C2). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8
Reptiles of medium sensitivity	As defined in Table 8.15, the sensitivity of Morocoy tortoises and tree boas is considered medium because the Morocoy tortoise is nationally listed as	Parameter Judgement Nature: Negative	B1 B4

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
	threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B5 B8
Reptiles of low sensitivity	As defined in Table 8.15, the sensitivity of all other reptile species present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8
Invertebrates of high sensitivity	As defined in Table 8.15, the sensitivity of painted lady butterflies and damselflies is considered high because the painted lady is a migratory species, and the damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8
Invertebrates of low sensitivity	As defined in Table 8.15, the sensitivity of all other invertebrates present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8

Receptor	Analysis of impact (without-mitigation)	Pre mitigation impact	Mitigation to be applied
Fish and macroinvertebrates of high sensitivity	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B4 B5 B8 B10
Fish and macroinvertebrates of medium sensitivity	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B1 B4 B5 B8 B10 B18
Fish and macroinvertebrates of low sensitivity	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B1 B4 B5 B8 B10 B18

8.6.3.2 Accidental introduction and spread of invasive species

The magnitude of the accidental introduction and spread of invasive species is considered minor for internationally recognised and legally protected areas, and moderate for habitats and flora within the Project footprint because there are two invasive plant species in the area which are already widespread within the AoI. The duration of the accidental introduction and spread of invasive species is considered long-term because these species will remain on site and around it for many years. The accidental introduction of invasive species will happen within the Project footprint so the scale is considered local. The probability of accidental introduction of invasive species occurring is considered high / medium / low depending on the receptor (refer to Table 8.21 below for more information), because Project activities include excavation/drilling and the movement and management of excavated/drilling material.

Table 8.21: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Mount Saint Catherine NP Mount Saint Catherine KBA	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to have biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B9
Habitats (high sensitivity): Forest habitats	As defined in the Table 8.15, the sensitivity of forest habitats are considered high because both forest ecoregions that overlap with the Project are listed by the WWF as Critical/Endangered and have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: long term Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: moderate	B9
Natural Habitats (medium sensitivity): Rivers and riparian habitats	As defined in Table 8.15, the sensitivity of natural habitats are considered medium because rivers and riparian habitats are natural and are of importance to the aquatic species that inhabit them. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: long term Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor	B9
Habitats (low sensitivity):	As defined in Table 8.15, the sensitivity of agricultural habitats are considered low because agricultural plantations and pastures are the dominant habitat type	Parameter Judgement	B9

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Agricultural habitats	within the Project area. These habitats are modified, with limited ecological and biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: Negative Magnitude: moderate Duration: long term Scale: local Probability: high Sensitivity of receptor: low Significance of impact: minor	
Flora (high sensitivity)	As defined in Table 8.15, the sensitivity of lansan, *Rhytidophyllum caribaeum*, and mountain cabbage are considered high because Lansan is IUCN Endangered and mountain cabbage is nationally Endangered. *Rhytidophyllum caribaeum* is restricted range. These species have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: long term Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: moderate	B9
Flora (medium sensitivity)	As defined in Table 8.15, the sensitivity of tree fern, *Lobelia cirsifolia*, siguine batard and monkey paws vine are considered medium because these four flora species are all relatively rare, given that they are endemic to the Windward Isles / Lesser Antilles. None are restricted range, classified by the IUCN, or under national protection, therefore they are classed as being of medium sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: long term Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B9
Flora (low sensitivity)	As defined in Table 8.15, chapter the sensitivity of all other flora present on site are considered low because they are categorised as IUCN Near Threatened /Least Concern and are species of local national importance. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: long term Scale: local Probability: high Sensitivity of receptor: low Significance of impact: minor	B9

8.6.3.3 Killing or injury of species through Project activities

The magnitude of the killing or injury of species through Project activities is considered minor for internationally recognised and legally protected areas and bats, and moderate for all other species groups because 90 species have been recorded as present within the Project area. The majority of these are terrestrial species: four are mammals, 21 are birds, three are herpetofauna, 52 are invertebrates and 10 are aquatic species. The killing or injury of species through Project activities is considered short term (three months). The killing or injury of species through Project activities will happen within the Project footprint, so the scale is considered local. The probability of killing or injury of species through Project activities occurring is considered low / medium / high depending on the receptor (refer to Table 8.22 below for more information) because Project activities include excavation/drilling and the movement and management of excavated/drilling material, the use of chemicals (such as cement, petroleum, drilling fluid), vehicle operation (movement and transportation of drilling rig and associated equipment), and improved access through new / upgraded roads.

Table 8.22: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Mount Saint Catherine NP Mount Saint Catherine KBA	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to have biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B7 B8 B12 B15 B16
Mammals (bats) (high sensitivity)	As defined in Table 8.15, the sensitivity of the Barbados myotis is considered high because this bat species is IUCN Vulnerable and range restricted. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B7 B8 B12 B16
Terrestrial mammals (high sensitivity)	As defined in Table 8.15, the sensitivity of Robinson's mouse opossum and agouti are considered high because both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat	Parameter Judgement Nature: Negative Magnitude: moderate	B7 B8 B12

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B15 B16
Terrestrial mammals (medium sensitivity)	As defined in Table 8.15, the sensitivity of the nine banded armadillo is considered medium because this species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B7 B8 B12 B15 B16
Mammals (low sensitivity)	As defined in Table 8.15, the sensitivity of all other mammals present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B7 B8 B12 B15 B16
Birds (high sensitivity)	As defined in Table 8.15, the sensitivity of globally and nationally threatened, restricted range and migratory birds are considered high because these species have the potential to trigger critical habitat requirements (C1, C2, and C3). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B7 B8 B12 B16
Birds (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other bird species present on site are considered medium because all wild bird species are protected within	Parameter Judgement Nature: Negative	B7 B8

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	Grenada under the Birds and Other Wildlife Act, 1957. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor	B12 B15 B16
Amphibians (high sensitivity)	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: high Significance of impact: minor	B7 B8 B12 B15 B16
Amphibians (medium sensitivity)	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as 'status uncertain", but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor	B7 B8 B12 B15 B16
Amphibians (low sensitivity)	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: low Significance of impact: negligible	B7 B8 B12 B15 B16

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Reptiles (high sensitivity)	As defined in Table 8.15, the sensitivity of globally threatened, nationally endangered and restricted-range reptiles are considered high because these species have the potential to trigger critical habitat requirements (C1 and C2). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B7 B8 B12 B15 B16
Reptiles (medium sensitivity)	As defined in Table 8.15, the sensitivity of Morocoy tortoises and tree boas is considered medium because the Morocoy tortoise is nationally listed as threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B7 B8 B12 B15 B16
Reptiles (low sensitivity)	As defined in Table 8.15, the sensitivity of all other reptile species present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B7 B8 B12 B15 B16
Invertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of painted lady butterflies and damselflies is considered high because the painted lady is a migratory species, and the damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium	B7 B8 B12 B16

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Sensitivity of receptor: high Significance of impact: minor	
Invertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other invertebrates present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B7 B8 B12 B16
Fish and macroinvertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	B3 B7 B8 B12
Fish and macroinvertebrates (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B3 B7 B8 B12
Fish and macroinvertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months)	B3 B7 B8 B12

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Scale: regional Probability: medium Sensitivity of receptor: low Significance of impact: negligible	

8.6.3.4 Disturbance and displacement of species

The magnitude of the disturbance and displacement of species is considered minor for internationally recognised and legally protected areas, moderate for fish and macroinvertebrates, and major for all other species groups because 80 terrestrial species have been recorded as present within the Project area. The majority of these are terrestrial invertebrates: four are mammals, 21 are birds, three are herpetofauna and 52 are invertebrates. Ten aquatic species have also been recorded. The disturbance and displacement of species is considered short term (three months). The disturbance and displacement of species will happen within the Project footprint, so the scale is considered local. The probability of disturbance and displacement of species occurring is considered low / medium / certain depending on the receptor (refer to Table 8.23 below for more information) because Project activities include vegetation removal, presence of people, noise, artificial light, vibration, and air emissions (including dust).

Table 8.23: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Mount Saint Catherine NP Mount Saint Catherine KBA	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to have biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B2 B6 B13
Mammals (bats) (high sensitivity)	As defined in Table 8.15, the sensitivity of the Barbados myotis is considered high because this bat species is IUCN Vulnerable and range restricted. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain	B2 B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Sensitivity of receptor: high Significance of impact: moderate	
Terrestrial mammals (high sensitivity)	As defined in Table 8.15, the sensitivity of Robinson's mouse opossum and agouti are considered high because both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Terrestrial mammals (medium sensitivity)	As defined in Table 8.15, the sensitivity of the nine banded armadillo is considered medium because this species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6
Mammals (low sensitivity)	As defined in Table 8.15, the sensitivity of all other mammals present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B2 B6
Birds (high sensitivity)	As defined in Table 8.15, the sensitivity of globally and nationally threatened, restricted range and migratory birds are considered high because these species have the potential to trigger critical habitat requirements (C1, C2, and C3). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local	B2 B6 B14

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Probability: certain Sensitivity of receptor: high Significance of impact: moderate	
Birds (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other bird species present on site are considered medium because all wild bird species are protected within Grenada under the Birds and Other Wildlife Act, 1957. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6 B14
Amphibians (high sensitivity)	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Amphibians (medium sensitivity)	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as 'status uncertain", but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6
Amphibians (low sensitivity)	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of	Parameter Judgement Nature: Negative Magnitude: major	B2 B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	
Reptiles (high sensitivity)	As defined in Table 8.15, the sensitivity of globally threatened, nationally endangered and restricted-range reptiles are considered high because these species have the potential to trigger critical habitat requirements (C1 and C2). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Reptiles (medium sensitivity)	As defined in Table 8.15, the sensitivity of Morocoy tortoises and tree boas is considered medium because the Morocoy tortoise is nationally listed as threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6
Reptiles (low sensitivity)	As defined in Table 8.15, the sensitivity of all other reptile species present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B2 B6
Invertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of painted lady butterflies and damselflies is considered high because the painted lady is a migratory species, and the	Parameter Judgement	B2

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B6
Invertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other invertebrates present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B2 B6
Fish and macroinvertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B6 B10
Fish and macroinvertebrates (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B6 B10

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Fish and macroinvertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B6 B10

8.6.3.5 Aquatic habitat degradation and reduced water availability for aquatic species

The magnitude of the aquatic habitat degradation and reduced water availability for aquatic species is considered minor because water is unlikely to be used in significant quantities during construction. The aquatic habitat degradation and reduced water availability for aquatic species duration is considered short term (three months). The aquatic habitat degradation and reduced water availability for aquatic species will happen within the Project AoI, so the scale is considered local. The probability of aquatic habitat degradation and reduced water availability for aquatic species occurring is considered medium because Project activities include increased water intake.

Table 8.24: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Natural Habitats (medium sensitivity): Rivers and riparian habitats	As defined in Table 8.15, the sensitivity of natural habitats are considered medium because water habitats are natural and are of importance to the aquatic species that inhabit them. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B10 B18
Amphibians (high sensitivity)	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months)	B10 B18

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	sensitivity of the receptor creates a minor impact, which is not considered significant.	Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	
Amphibians (medium sensitivity)	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as ‘status uncertain", but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B10 B18
Amphibians (low sensitivity)	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B10 B18
Fish and macroinvertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B10 B18
Fish and macroinvertebrates (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada.	Parameter Judgement Nature: Negative Magnitude: minor	B10 B18

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	
Fish and macroinvertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B10 B18

8.6.4 Analysis of operation phase impacts (drilling and testing)

8.6.4.1 Habitat loss and degradation

The magnitude of the habitat loss and degradation is considered minor for terrestrial habitats because no additional habitat is expected to be lost during the operation phase, however habitat degradation may still occur. For the habitat loss under each component during the construction phase, see Table 8.19 in Section 8.6.3.1 above. Habitat degradation will occur throughout the operations phase, so the duration is considered short term (three months). The degradation will occur under the footprint of the Project components, so the scale is considered local. The magnitude of the habitat loss and degradation is considered moderate for aquatic habitats. The probability of habitat degradation occurring is considered medium for terrestrial habitats and respective species because they could become degraded during equipment maintenance, and high for aquatic habitats and species because they could become degraded due to the large volumes of water required for this phase. Deep groundwater could also be polluted through the use of chemicals during operations.

Table 8.25: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
Mount Saint Catherine NP	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to	Parameter Judgement Nature: Negative	B1

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
Mount Saint Catherine KBA	have biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	
Habitats of high sensitivity: Forest habitats	As defined in Table 8.15, the sensitivity of forest habitats are considered high because both forest ecoregions that overlap with the Project are listed by the WWF as Critical/Endangered and have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B1 B7
Habitats of medium sensitivity (natural habitats): Rivers and riparian habitats	As defined in Table 8.15, the sensitivity of natural habitats are considered medium because rivers and riparian habitats are natural and are of importance to the aquatic species that inhabit them. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: Major Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor	B1 B7 B10
Habitats of low sensitivity: Agricultural habitats	As defined in Table 8.15, the sensitivity of agricultural habitats are considered low because agricultural plantations and pastures are the dominant habitat type within the Project area. These habitats are modified, with limited ecological and biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B1 B7

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
Flora of high sensitivity	As defined in Table 8.15, the sensitivity of lansan, *Rhytidophyllum caribaeum*, and mountain cabbage are considered high because Lansan is IUCN Endangered and mountain cabbage is nationally Endangered. *Rhytidophyllum caribaeum* is restricted range. These species have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B1 B7
Flora of medium sensitivity	As defined in Table 8.15, the sensitivity of tree fern, *Lobelia cirsifolia*, siguine batard and monkey paws vine are considered medium because these four flora species are all relatively rare, given that they are endemic to the Windward Isles / Lesser Antilles. None are restricted range, classified by the IUCN, or under national protection, therefore they are classed as being of medium sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B1 B7
Flora of low sensitivity	As defined in Table 8.15, the sensitivity of all other flora present on site are considered low because they are categorised as IUCN Near Threatened /Least Concern and are species of local national importance. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B1 B7
Mammals (bats) of high sensitivity	As defined in Table 8.15, the sensitivity of the *Barbados myotis* is considered high because this bat species is IUCN Vulnerable and range restricted. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high	B1 B7

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
		Significance of impact: minor	
Terrestrial mammals of high sensitivity	As defined in Table 8.15, the sensitivity of Robinson's mouse opossum and agouti are considered high because both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B1 B7
Terrestrial mammals of medium sensitivity	As defined in Table 8.15, the sensitivity of the nine banded armadillo is considered medium because this species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B1 B7
Mammals of low sensitivity	As defined in Table 8.15, the sensitivity of all other mammals present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B1 B7
Birds of high sensitivity	As defined in Table 8.15, the sensitivity of globally and nationally threatened, restricted range and migratory birds are considered high because these species have the potential to trigger critical habitat requirements (C1, C2, and C3). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium	B1 B7

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
		Sensitivity of receptor: high Significance of impact: minor	
Birds of medium sensitivity	As defined in Table 8.15, the sensitivity of all other bird species present on site are considered medium because all wild bird species are protected within Grenada under the Birds and Other Wildlife Act, 1957. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B1 B7
Amphibians of high sensitivity	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B1 B7
Amphibians of medium sensitivity	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B1 B7
Amphibians of low sensitivity	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local	B1 B7

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
		Probability: medium Sensitivity of receptor: low Significance of impact: negligible	
Reptiles of high sensitivity	As defined in Table 8.15, the sensitivity of globally threatened, nationally endangered and restricted-range reptiles are considered high because these species have the potential to trigger critical habitat requirements (C1 and C2). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B1 B7
Reptiles of medium sensitivity	As defined in Table 8.15, the sensitivity of Morocoy tortoises and tree boas is considered medium because the Morocoy tortoise is nationally listed as threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B1 B7
Reptiles of low sensitivity	As defined in Table 8.15, the sensitivity of all other reptile species present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B1 B7
Invertebrates of high sensitivity	As defined in Table 8.15, the sensitivity of painted lady butterflies and damselflies is considered high because the painted lady is a migratory species, and the damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements. Combining the expected characteristics of	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months)	B1 B7

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
	the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	
Invertebrates of low sensitivity	As defined in Table 8.15, the sensitivity of all other invertebrates present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B1 B7
Fish and macroinvertebrates of high sensitivity	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: moderate	B1 B7 B10
Fish and macroinvertebrates of medium sensitivity	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: regional Probability: high Sensitivity of receptor: medium Significance of impact: minor	B1 B7 B10
Fish and macroinvertebrates of low sensitivity	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining	Parameter Judgement Nature: Negative	B1 B7

Receptor	Analysis of impact (without-mitigation)	Analysis of impact without mitigation	Mitigation to be applied
	the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Magnitude: minor Duration: short term (3 months) Scale: regional Probability: high Sensitivity of receptor: low Significance of impact: negligible	B10

8.6.4.2 Killing or injury of species through Project activities

The magnitude of the killing or injury of species through Project activities during operation is considered minor for internationally recognised and legally protected areas and bats, and moderate for all other species groups because 90 species have been recorded as present within the Project area. The majority of these are terrestrial species: four are mammals, 21 are birds, three are herpetofauna, 52 are invertebrates and 10 are aquatic species. The killing or injury of species through Project activities duration is considered short term (three months). The killing or injury of species through Project activities will happen within the Project footprint, so the scale is considered local. The probability of killing or injury of species through Project activities occurring is considered low / medium / high depending on the receptor (refer to Table 8.22 below for more information) because Project activities include excavation/drilling and the movement and management of excavated/drilling material, the use of chemicals (such as cement, petroleum, drilling fluid), vehicle operation (movement and transportation of drilling rig and associated equipment), and improved access through new / upgraded roads.

Table 8.26: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Mount Saint Catherine NP Mount Saint Catherine KBA	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to have biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	B12 B15 B16
Mammals (bats) (high sensitivity)	As defined in Table 8.15, the sensitivity of the Barbados myotis is considered high because this bat species is IUCN Vulnerable and range restricted. Combining the expected characteristics of the predicted change with the	Parameter Judgement Nature: Negative Magnitude: minor	B12 B16

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	sensitivity of the receptor creates a minor impact, which is not considered significant.	Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	
Terrestrial mammals (high sensitivity)	As defined in Table 8.15, the sensitivity of Robinson's mouse opossum and agouti are considered high because both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B12 B15 B16
Terrestrial mammals (medium sensitivity)	As defined in Table 8.15, the sensitivity of the nine banded armadillo is considered medium because this species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B12 B15 B16
Mammals (low sensitivity)	As defined in Table 8.15, the sensitivity of all other mammals present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B12 B15 B16
Birds (high sensitivity)	As defined in Table 8.15, the sensitivity of globally and nationally threatened, restricted range and migratory birds are considered high because these	Parameter Judgement Nature: Negative	B12 B16

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	species have the potential to trigger critical habitat requirements (C1, C2, and C3). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	
Birds (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other bird species present on site are considered medium because all wild bird species are protected within Grenada under the Birds and Other Wildlife Act, 1957. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B12 B15 B16
Amphibians (high sensitivity)	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: high Significance of impact: minor	B12 B15 B16
Amphibians (medium sensitivity)	As defined in the baseline chapter the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as ‘status uncertain”, but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor	B12 B15 B16

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Amphibians (low sensitivity)	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: low Significance of impact: negligible	B12 B15 B16
Reptiles (high sensitivity)	As defined in Table 8.15, the sensitivity of globally threatened, nationally endangered and restricted-range reptiles are considered high because these species have the potential to trigger critical habitat requirements (C1 and C2). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B12 B15 B16
Reptiles (medium sensitivity)	As defined in Table 8.15, the sensitivity of Morocoy tortoises and tree boas is considered medium because the Morocoy tortoise is nationally listed as threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B12 B15 B16
Reptiles (low sensitivity)	As defined in Table 8.15, the sensitivity of all other reptile species present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium	B12 B15 B16

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Sensitivity of receptor: low Significance of impact: negligible	
Invertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of painted lady butterflies and damselflies is considered high because the painted lady is a migratory species, and the damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	B12
Invertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other invertebrates present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B12
Fish and macroinvertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	B3 B11 B12
Fish and macroinvertebrates (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months)	B3 B11 B12

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	sensitivity of the receptor creates a minor impact, which is not considered significant.	Scale: regional Probability: medium Sensitivity of receptor: medium Significance of impact: minor	
Fish and macroinvertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Regional Probability: medium Sensitivity of receptor: low Significance of impact: minor	B3 B11 B12

8.6.4.3 Disturbance and displacement of species

The magnitude of the disturbance and displacement of species during operation is considered minor for internationally recognised and legally protected areas, moderate for fish and macroinvertebrates, and major for all other species groups because 80 terrestrial species have been recorded as present within the Project area. The majority of these are terrestrial: four are mammals, 21 are birds, three are herpetofauna and 52 are invertebrates. Ten aquatic species have also been recorded. The disturbance and displacement of species duration is considered short term (three months). The disturbance and displacement of species will happen within the Project footprint, so the scale is considered local. The probability of disturbance and displacement of species occurring is considered low / medium / certain depending on the receptor (refer to Table 8.23 below for more information) because Project activities include presence of people, noise, artificial light, vibration, and air emissions (including dust).

Table 8.27: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Mount Saint Catherine NP Mount Saint Catherine KBA	As defined in Table 8.15, the sensitivity of internationally recognised and legally protected areas are considered high because these areas are acknowledged to have biodiversity value. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months)	B2 B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor	
Mammals (bats) (high sensitivity)	As defined in Table 8.15, the sensitivity of the Barbados myotis is considered high because this bat species is IUCN Vulnerable and range restricted. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Terrestrial mammals (high sensitivity)	As defined in Table 8.15, the sensitivity of Robinson's mouse opossum and agouti are considered high because both of these species are listed as being nationally Endangered. They both have the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Terrestrial mammals (medium sensitivity)	As defined in Table 8.15, the sensitivity of the nine banded armadillo is considered medium because this species is nationally listed as rare in Grenada but the Project site is unlikely to include a significant population size. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6
Mammals (low sensitivity)	As defined in Table 8.15, the sensitivity of all other mammals present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of	Parameter Judgement Nature: Negative Magnitude: major	B2 B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	
Birds (high sensitivity)	As defined in Table 8.15, the sensitivity of globally and nationally threatened, restricted range and migratory birds are considered high because these species have the potential to trigger critical habitat requirements (C1, C2, and C3). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Birds (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other bird species present on site are considered medium because all wild bird species are protected within Grenada under the Birds and Other Wildlife Act, 1957. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6
Amphibians (high sensitivity)	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Amphibians (medium sensitivity)	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed	Parameter Judgement Nature: Negative	B2 B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	as rare in Grenada, and the Lesser Antillean whistling frog is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	
Amphibians (low sensitivity)	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B2 B6
Reptiles (high sensitivity)	As defined in Table 8.15, the sensitivity of globally threatened, nationally endangered and restricted-range reptiles are considered high because these species have the potential to trigger critical habitat requirements (C1 and C2). Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Reptiles (medium sensitivity)	As defined in Table 8.15, the sensitivity of Morocoy tortoises and tree boas is considered medium because the Morocoy tortoise is nationally listed as threatened in Grenada, and the tree boa is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor	B2 B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Reptiles (low sensitivity)	As defined in Table 8.15, the sensitivity of all other reptile species present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B2 B6
Invertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of painted lady butterflies and damselflies is considered high because the painted lady is a migratory species, and the damselfly is a restricted range species. Both of these could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	B2 B6
Invertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other invertebrates present on site is considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor	B2 B6
Fish and macroinvertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium	B6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Sensitivity of receptor: high Significance of impact: minor	
Fish and macroinvertebrates (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B6
Fish and macroinvertebrates (low sensitivity)	As defined in Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible	B6

8.6.4.4 Aquatic habitat degradation and reduced water availability for aquatic species

The magnitude of the aquatic habitat degradation and reduced water availability for aquatic species is considered moderate because a maximum flow rate of 12.5 litres/second of water or more are required continuously throughout operation. Baseline flow data for the two intake locations is limited, however the Mean Annual Low Flow (MALF) for each site is 7.3l/s for Site C, and 6.3l/s for Site F (using the lowest estimates available - see Chapter 9 – water resources). The Minimum Environmental Flow (MEF) at each site will be set by the regulator at the appropriate value to protect aquatic life. Modifications in flow velocity and sediment fluxes may disrupt species food webs, disturb migratory routes, displace populations from feeding and spawning grounds, and alter the dilution of pollutants in the waterbody. The aquatic habitat degradation and reduced water availability for aquatic species will occur over three months so it is considered short term. The aquatic habitat degradation and reduced water availability for aquatic species will happen within the Project AoI, so the scale is considered regional. The probability of aquatic habitat degradation and reduced water availability for aquatic species occurring is considered medium because Project activities include increased water intake.

Table 8.28: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Natural Habitats (medium sensitivity): Rivers and riparian habitats	As defined in Table 8.15, the sensitivity of natural habitats are considered medium because water habitats are natural and are of importance to the aquatic species that inhabit them. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B10
Amphibians (high sensitivity)	As defined in Table 8.15, the sensitivity of giant woodland frogs are considered high because this amphibian species is listed as Critically Endangered by the IUCN, and hence has the potential to trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	B10
Amphibians (medium sensitivity)	As defined in Table 8.15, the sensitivity of cane toads and lesser Antillean whistling frogs are considered medium because the cane toad is nationally listed as rare in Grenada, and the Lesser Antillean whistling frog is listed as 'status uncertain'', but the Project site is unlikely to include a significant population size of either species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional Probability: medium Sensitivity of receptor: medium Significance of impact: minor	B10
Amphibians (low sensitivity)	As defined in Table 8.15, the sensitivity of all other amphibians present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: regional	B10

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Probability: medium Sensitivity of receptor: low Significance of impact: negligible	
Fish and macroinvertebrates (high sensitivity)	As defined in Table 8.15, the sensitivity of nationally endangered fish and migratory crustaceans is considered high because the jumping guanine is nationally Endangered, and all four macroinvertebrates are migratory. All of these species could potentially trigger critical habitat requirements. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: moderate	B10
Fish and macroinvertebrates (medium sensitivity)	As defined in Table 8.15, the sensitivity of all other Antillean freshwater fish species present on site are considered medium because all Antillean freshwater fish species are listed as nationally Endangered within Grenada. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: regional Probability: high Sensitivity of receptor: medium Significance of impact: minor	B10
Fish and macroinvertebrates (low sensitivity)	As defined Table 8.15, the sensitivity of all other fish and macroinvertebrate species present on site are considered low because they are categorised as IUCN Near Threatened, Least Concern and Data Deficient species. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: regional Probability: high Sensitivity of receptor: low Significance of impact: minor	B10

8.6.5 Analysis of decommissioning phase impacts

Decommissioning phase impacts will be similar as construction phase impacts, to avoid duplication we have not repeated the analysis here, please refer to Section 8.6.3 for details.

8.7 Mitigation and enhancement measures

The measures in this section have been identified to ensure the implementation of the mitigation hierarchy i.e., avoid, reduce (minimise), remedy (restore) and compensate or offset biodiversity. This will allow for the careful management of risk and the best possible outcomes for the Project and local communities, without compromising the health, function and integrity of the ecological systems.

These practical measures should minimise any additional pressures on habitats and fauna from land clearance activities and exploratory drilling.

Table 8.29 provides a summary of mitigation and enhancement measures for impacts identified in this chapter. They are discussed in more detail in the following sub-sections.

Offsets are required when a Project i) results in significant residual impacts and ii) is required to achieve net gain. This ESIA assumes that the construction and operation (this is exploratory drilling) are short term and it may be possible to restore the habitats impacted to the original state. However, this depends on the outcome of the exploratory drilling, i.e., that is whether they are successful or not and whether the well pads will be used for production. The need for biodiversity offsets will be assessed in the ESIA for the subsequent phases of the Project.

Table 8.29: Biodiversity mitigation and enhancement measures

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
Embedded mitigation / design measures					
B1	Avoid and minimise terrestrial habitat loss and degradation through Project siting and design	• Site all Project components will be located outside of all legally / nationally protected and internationally recognised area boundaries • Limit construction in size as much as possible • Prioritise upgrading existing roads over the construction of new ones. In addition, when construction of new roads is unavoidable, disturbed areas (e.g., old and/or unused agricultural lands) will be prioritised over ecologically intact areas • Design the layout of the Project site to reduce working widths within sensitive habitats to avoid or minimise loss of habitat that is of significance to species of conservation significance, where possible • Assign areas for stockpiles of materials and excavated waste away from sensitive habitats	• Design phase – no Project components are located within protected areas	Design	• GoG and designers
B2	Minimise disturbance of wildlife within protected areas through Project siting and design	• Site construction camp (if required) to be situated as far as possible from area boundaries. Natural land features (dips/hills) to be used to maximise screening between the camp and the areas and to avoid noise impacts	Design phase	• Design	• GoG and designers
B3	Avoid and minimise killing or injury of aquatic species through design	• Design options that reduce fish mortality / injury within the intake pipe (such as inclusion of mesh screens between 30-75mm) • Design a weir to maintain river water level	Design phase	• Design	• Designer

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
Mitigation of impacts and risks					
B4	Avoid and minimise temporary and permanent habitat loss, degradation and fragmentation under Project footprint through management of construction activities	• Work within defined construction working areas, prohibiting off-road driving • Keep clearings associated with construction in as small a footprint as possible to reduce habitat loss and degradation • Areas to be cleared will be pre-identified to avoid accidental or excessive removal of vegetation and avoid or reduce impacts on other plants • Prepare and implement a Construction Ecological Management Plan (CEMP) and a Habitat Removal and Restoration Plan (HRRP) • Identify location and abundance of high sensitivity flora and avoid removal where possible. Minimise impacts through translocation or planting (restoration).	Implemented throughout construction	• Ecological Management Plan • Habitat removal and restoration plan	• GoG to appoint NGO or consultant to prepare CEMP and implement it • Contractor to prepare and implement HRRP on behalf of GoG; independent consultant to review / monitor
B5	Restore on-site temporary habitat loss	• Include habitat rehabilitation and restoration on all well pads that are unsuccessful and will not be used for production, as well as the sites affected temporarily by construction. This will allow species to safely navigate around the Project. The nature and areas of habitats to be restored on these sites will be determined following stakeholder consultation led by GoG • Where restoration of Natural Habitat is not possible on site (e.g. under the footprint of the permanent structures), similar habitat will be created off-site • Replanting of any lost aquatic or riparian vegetation with appropriate native species (or	Implement immediately after construction	• Habitat removal and restoration plan	• Led by GoG with contractor implementation support

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
		translocation of removed vegetation) to ensure any losses are temporary			
B6	Avoid and minimise disturbance and displacement of species through management of artificial lighting, noise and presence of people	• Select equipment with low noise emissions will be procured and blasting restricted to daylight hours • Avoid noise from site camps (if required) by implementing a noise policy • Keep the workforce within defined site boundaries and agreed access routes where possible to avoid disturbance to wildlife • Minimise extraneous noise sources and use adequate noise attenuation on engines • Reduce exterior lighting to minimum levels necessary for safe operation and implement strategies to reduce spill light. Use non-UV lights where possible, as light emitted at one wavelength has low levels of attraction to insects. This will reduce the likelihood of attracting insects and their predators • Develop a “dark skies” policy to minimise light pollution at night. Lighting to be directed onto site infrastructure only during operation • Water or dust control agents will be used in working areas and roads will be sprayed for dust suppression on a regular basis in designated susceptible areas during heavy usage • Require mandatory environmental induction for all construction and operation staff members to address specific issues such as the potential of fire e.g., only smoking in designated areas, no open cooking fires etc.	Construction	• Ecological Management Plan • Noise Management Plan • Accommodation Code of Conduct	• Contractor
			Operation	• Operational Ecological Management Plan • Lighting strategy	• GoG

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
B7	Avoid and minimise environmental pollution	• Correct storing and handling of chemicals to avoid water pollution incidents • Make spill kits available to ensure that any fuel or oil spills are cleaned up and discarded correctly. Chemical spill clean-up kits must be stationed at all sites where spills are probable. Several staff should be trained in the chemical clean-up procedure and at least one member of this unit must be on duty at all times • Divert surface water flows • Undertake river rehabilitation following spill incident. If extensive spills have occurred, the area must be rehabilitated appropriately. This will require consultation with an ecologist specialised in the rehabilitation of polluted habitats • Establish appropriate stockpiling arrangements • Conduct machinery and vehicle service off-site away from watercourses / drainage lines • Undertake mechanical or manual clearing of vegetation. The use of herbicides to clear vegetation will be avoided where possible, to minimise environmental pollution impacts • Optimize the flow regime and sediment dynamic • Use drip trays and oil absorbents in areas where construction equipment is parked, hydrocarbon collection and separation systems according to industry best practice will be installed at required areas, and accidental hydrocarbon spills will be cleaned rapidly. • A drainage system should be incorporated into site design to collect surface runoff. Polluted runoff from construction sites and excavation of	Construction	• Ecological Management Plan • Spill Management Plan • Water Resources Management Plan • Waste Management Plan	• Contractor

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
		tunnels should then be treated before entering into the river			
B8	Avoid and minimise secondary additional habitat loss (from encroachment and logging/fuelwood) and hunting due to increased access through managing influx	• Provide security in and around the Project site, to prevent the use of access roads for the exploitation of natural resources • Install barriers to control any new access created by the Project • Install signage illustrating the hunting ban on any species throughout the Project-controlled areas • Feed construction staff adequately to avoid poaching • Include support to prepare and/or implement land use management plan • Closely work with government authorities and local communities to ensure efficiency of influx management strategies and implement catchment-based land use management plan • Implement awareness raising and education for local communities through educational programmes	Construction	• Ecological Management Plan	• Contractor • GoG to sponsor and coordinate with local NGOs
B9	Avoid, minimise and reduce the introduction or spread of non-native invasive species through management plan	• Prevent the introduction of non-native and invasive species by using phytosanitary measures on arrival and departure of vehicles and personnel onto site – including all earth movement equipment, trucks, vehicles and equipment to be imported to be cleaned, disinfected and accompanied by a certificate that this has been done • Implementation of measures to control invasive species that are present within the Project area	Construction	• Ecological Management Plan • Operational Ecological Management Plan • Invasive species management plan	• Contractor • GoG to appoint local botanist to monitor invasive species

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
		prior to construction (e.g. bamboo). This could involve cutting / mowing • Implementation of measures to eradicate alien species from Natural Habitats over which the GoG has management control. This could involve regular cutting/ mowing of the invasive plants (especially before flowering) or excavation and disposal (offsite) or burial (on-site) • Raise awareness through staff inductions. • Biosecurity measures to ensure appropriate removal and or management control of invasive species at the source		•	
		• Include actions within the invasive species management plan to include monitoring for invasive species and methods such as weed eradication and control measures for invasive species: • Control regrowth of bamboo and bois canot around the Project components through means such as: – Regular mowing – Application of herbicides based on an integrated pest management approach	Operation	• Invasive species management plan	GoG to appoint local botanist to monitor invasive species
B10	Avoid and minimise impacts in flow and water level	• Maintain streamflow around weirs	Construction	• Habitat removal and restoration plan	• Contractor
		• Monitoring upstream and downstream of the weir, identifying fish migration, presence and abundance.	Operation	• Operational Ecological Management Plan	• GoG

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
B11	Minimise loss of fish populations	• Undertake well managed native restocking with monitoring and expert oversight to minimise fish population fluctuations. Undertake appropriate management to avoid risk of accidental translocation of invasive fish and other aquatic species	Operation	• Biodiversity Action Plan (if required)	• GoG
B12	Avoid and minimise hunting and poaching of wildlife by construction/ operation workers through Workers Code of Conduct.	• Include hunting and poaching prohibition in the Workers Code of Conduct: Ban hunting, fishing and poaching by construction and operation staff to reduce pressure on threatened and protected species in the Project areas and surroundings • Raise awareness through staff training • Install signage illustrating the hunting ban on any species throughout the Project areas • Install security barriers on the new or upgraded roads required for this Project • Company policies and contractor agreements to have meaningful penalties for violations to these policies • Include any breaches in the hunting ban in the regular reporting.	Construction	• Ecological Management Plan • Worker's code of conduct	• Contractor
			Operation	• Operational Ecological Management Plan • Worker's code of conduct	• GoG
B13	Avoid and minimise disturbance of wildlife within protected areas through management of construction activities	• Ensure construction does not encroach into protected areas • Follow GIIP, including sensitive working methods to reduce noise and light disturbance to these areas. Restrict blasting to daylight hours	Throughout construction	• Ecological Management Plan	• Contractor
B14	Avoid and minimise disturbance to breeding birds during construction activities	• Undertake vegetation clearance outside of the main bird breeding period if possible (the main breeding season is March to August in Grenada)	Prior to and during construction (within 48h of clearance of each site)	• Ecological Management Plan	GoG Contractor

Reference	Mitigation or enhancement measure	Details of mitigation / enhancement measure	Implementation timing	Implementation method	Responsibility
		• Where this is not possible, check areas for breeding birds prior to the clearance and if nesting birds are found, appropriate mitigation measures will be implemented. This may involve avoiding construction within 50m of the active nest until the chicks have fledged.			
B15	Avoid and minimise trapping of wildlife in deep excavations	• Protect excavations and trenches • Monitor for any trapped wildlife	Throughout construction and operation During habitat reinstatement on site	• Ecological Management Plan • Habitat Removal and Restoration Plan	• GoG • Contractor
B16	Avoid and minimise increased road kills	• Install road signs to highlight the risk of collision with animals • Introduce and enforce speed limits on all roads	Throughout construction and operation During habitat reinstatement on site	• Ecological Management Plan • Habitat Removal and Restoration Plan • Worker's code of conduct	• GoG • Contractor

Source: Mott MacDonald 2023

8.8 Monitoring

The biodiversity monitoring measures prior to and during construction and operation are summarised in the following sections. The purpose of the monitoring is to detect changes in key biodiversity features to assess Project impacts and effectiveness of on-going mitigation. Should set thresholds be found to be exceeded, an adaptive management response will be triggered with mitigation and site management plans reviewed and amended as necessary.

The restored habitats will be monitored to measure the success of habitat establishment, including the habitat condition and the health and mortality of planted trees. The monitoring will start six months after the completion of habitat restoration or creation at each site and will be maintained twice per year (February and June) for the first five years and once per year between years six and ten. The biannual monitoring reports will include monitoring indicators, monitoring action-triggers, recommendations for any remediation measures needed, for example replacement of dead tree saplings, watering of tree saplings in the dry season, weed control, pest protection, etc.

During site establishment and exploratory drilling, checks will be undertaken for the accidental introduction or spread of alien invasive species, especially plant species which may be brought into the areas on vehicles, or in any imported materials. Measures to remove/eradicate any species introduced, if found, will be put in place. The monitoring will include the invasive species already known in the Project AoI (bamboo and Bois Canot).

An adaptive management program will be implemented. This will be in place to ensure that if significant impacts are detected during construction and operation stages these will be addressed. Data will need to be analysed and if significant changes in the ecological receptors are reported further mitigation measures will need to be put in place.

Table 8.30 summarises the biodiversity monitoring to be implemented.

8.8.1 Terrestrial biodiversity monitoring

Monitoring of certain terrestrial biodiversity features will be undertaken prior to and during construction and operation. The following biodiversity features will be monitored:

- Terrestrial habitats
- Terrestrial species of high and medium conservation concern (distribution and abundance)
- Quantity of vegetation clearance and avoidance/minimization of natural habitats (forests and wetlands)
- Alien invasive species
- Habitat cover, habitat condition and land use change in Project-affected areas

8.8.2 Aquatic biodiversity monitoring

The following aquatic biodiversity features will be monitored during construction and operation to inform changes to the mitigation measures:

- Presence and abundance of aquatic vegetation / macrophytes
- Presence and abundance of alien invasive species
- Freshwater macroinvertebrate community metrics
- Presence and abundance of fish species of high and medium conservation concern

Table 8.30: Biodiversity monitoring to be implemented by the Project

Monitoring topic	Responsibility	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing (phase)	Potential response in case of exceedance
Staff awareness	Government of Grenada	• Number of biodiversity training / awareness raising sessions attended by Project staff and local communities and number of attendees at each session	Project-affected areas (including restored areas after decommissioning)	Once pre-construction, then every month, throughout Project construction and operation	Pre-construction, during construction and post construction	Implement adaptive management
Terrestrial habitats	Government of Grenada	• Habitat area/cover/condition and land use change • Cleanliness of construction site • Degradation of habitats outside construction areas • Deforestation and /or logging rates outside construction areas • Quantity and quality of vegetation clearing • Quality of landscaping at restored sites (planted species)	All habitats of high and medium sensitivity in Project-affected areas (including restored areas after decommissioning)	Pre-construction and during operation: weekly inspections Post operation (restored habitats): biannually for 5 years then annually for 5 years	Pre-construction and post-construction	Implement adaptive management
Species of conservation concern or critical habitat species	Government of Grenada	• Number of species with increased IUCN or national threat status from VU/EN/CR	Project-affected areas (including restored areas after decommissioning)	Pre-construction and during operation	Construction and Operation	Implement adaptive management
Road wildlife mortality	Government of Grenada with implementation support from contractor	• Identification of species of conservation concern that have been killed by road strike; and, • Logbook system of road mortalities with review as part of monthly reporting.	All roads on Project site	Ongoing during construction and operation	Construction and Operation	Implement adaptive management

Monitoring topic	Responsibility	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing (phase)	Potential response in case of exceedance
Invasive species	Government of Grenada with implementation support from contractor	• Identification of invasive species	Working areas of Project and habitat adjacent including access roads	Every month	Construction	Implement adaptive management
Terrestrial wildlife species of conservation concern	Government of Grenada	• Presence and abundance of terrestrial species of high and medium sensitivity identified in baseline assessment.	Project-affected areas, and the AoI. Locations and species to be defined in CEMP and Operation Ecological Management Plan (OEMP).	Construction and Operation: Monitoring frequency to be defined in CEMP and OEMP.	Pre-construction, during construction and post-construction	Implement adaptive management
Fish	Government of Grenada	• Presence and abundance of fish species of conservation concern • Fish community metrics • Fishing activity by local people • Invasive fish species abundance • •	All waterbodies / courses impacted by the Project	Pre-construction: twice per year (dry/wet seasons) Construction and operation: monthly	Pre-construction, during construction and post construction	Implement adaptive management
Macroinvertebrates	Government of Grenada	• Macroinvertebrate community metrics	All waterbodies / courses to be impacted by the Project	Pre-construction and construction: twice per year (wet/dry season) Operation: monthly	Pre-construction, during construction and post construction	Adaptive management plan implemented

Source: Mott MacDonald 2023

8.9 Residual impacts

The section presents qualitative assessment of predicted residual biodiversity impact expected to occur post mitigation.

8.9.1 Analysis of residual construction impacts

8.9.1.1 Habitat loss and degradation

Table 8.31 presents a summary of residual impacts (post-mitigation) related to habitat loss and degradation. Magnitude of three impacts would be reduced from moderate to minor. However, for three impacts magnitude would be reduced from major to moderate after mitigation measures are applied. For eight impacts, significance would be reduced from moderate to minor and for five impacts significance would be reduced from minor to negligible.

Table 8.31: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term Scale: Local Probability: low Sensitivity of receptor: high Significance of impact: minor The design of the project avoids direct habitat loss within these areas, however secondary habitat degradation may still occur, therefore the magnitude cannot be reduced to negligible. This results in no change in the significance.
Habitats of high sensitivity: Forest habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the amount of degradation, however habitat degradation may still occur, therefore the magnitude cannot be reduced to negligible. This results in no change in the significance.
Habitats of medium sensitivity (natural habitats): Rivers and riparian habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term Scale: Local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor because aquatic habitat fragmentation will be minimised through the construction of diversionary channels, and any habitat loss will be restored following construction. This results in no change in the significance.

Receptor	Summary of residual impact (post-mitigation)
Habitats of low sensitivity: Agricultural habitats	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term Scale: Local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the long-term habitat loss and degradation, however habitat loss and degradation will still occur, therefore the magnitude and probability will not change. This results in no change in the significance.
Flora of high sensitivity	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate and the probability from certain to medium, as the Project can try to site components in areas where these species are not present. This results in a minor impact which is considered not significant.
Flora of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate and the probability from certain to medium, as the Project can try to site components in areas where these species are not present. This results in no change in the significance.
Flora of low sensitivity	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate as the Project can try to site components in areas where flora species are not present and can restore areas that are lost temporarily. This results in no change in the significance.
Mammals (bats) of high sensitivity	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term

Receptor	Summary of residual impact (post-mitigation)
	Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results a minor impact which is considered not significant.
Terrestrial mammals of high sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results a minor impact which is considered not significant.
Terrestrial mammals of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in no change in the significance.
Mammals of low sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from minor to negligible.
Birds of high sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor

Receptor	Summary of residual impact (post-mitigation)
	The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from moderate to minor.
Birds of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in no change in the significance.
Amphibians of high sensitivity	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from moderate to minor.
Amphibians of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in no change in the significance.
Amphibians of low sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to

Receptor	Summary of residual impact (post-mitigation)
	reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from minor to negligible.
Reptiles of high sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from moderate to minor.
Reptiles of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in no change in the significance.
Reptiles of low sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: long term (life of project) Scale: Local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from minor to negligible.
Invertebrates of high sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from moderate to minor.

Receptor	Summary of residual impact (post-mitigation)
Invertebrates of low sensitivity	Parameter Judgement Nature: Negative Magnitude: major Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from certain to medium because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. This results in a change in the significance from minor to negligible.
Fish and macroinvertebrates of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: high Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from certain to high because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. Also, diversionary channels will help maintain streamflow for aquatic species. This results in a change in the significance from moderate to minor.
Fish and macroinvertebrates of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: high Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from certain to high because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. Also, diversionary channels will help maintain streamflow for aquatic species. This results in no change in the significance.
Fish and macroinvertebrates of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: high Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from certain to high because habitats will be restored where possible and efforts will be made to reduce secondary habitat loss, minimise degradation and to site the Project away from important habitats. Also, diversionary channels

Receptor	Summary of residual impact (post-mitigation)
	will help maintain streamflow for aquatic species. This results in a change in the significance from minor to negligible.

8.9.1.2 Accidental introduction and spread of invasive species

Table 8.32 presents a summary of residual impacts (post-mitigation) related to accidental introduction and spread of invasive species. Magnitude of six impacts would be reduced from moderate to minor after mitigation measures are applied. However, for two impacts, significance would be reduced be from moderate to minor and for two impacts significance would be reduced from minor to negligible.

Table 8.32: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of introducing invasive species, however this may still occur, therefore the probability and magnitude cannot be moved to negligible. This results in no change in the significance.
Habitats (high sensitivity): Forest habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from medium to low because it will reduce the likelihood of introducing invasive species, and control the invasive species that are currently present already. This results in a change in the significance from moderate to minor.
Natural Habitats (medium sensitivity): Rivers and riparian habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from medium to low because it will reduce the likelihood of introducing invasive species, and control the invasive species that are currently present already. This results in a change in the significance from moderate to minor.
Habitats (low sensitivity): Agricultural habitats	Parameter Judgement Nature: Negative Magnitude: minor

Receptor	Summary of residual impact (post-mitigation)
	Duration: long term Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from high to low because it will reduce the likelihood of introducing invasive species, and control the invasive species that are currently present already. This results in a change in the significance from minor to negligible.
Flora (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from medium to low because it will reduce the likelihood of introducing invasive species, and control the invasive species that are currently present already. This results in a change in the significance from moderate to minor.
Flora (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from medium to low because it will reduce the likelihood of introducing invasive species, and control the invasive species that are currently present already. This results in no change in the significance.
Flora (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: long term Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the probability from high to low because it will reduce the likelihood of introducing invasive species, and control the invasive species that are currently present already. This results in a change in the significance from minor to negligible.

8.9.1.3 Killing or injury of species through Project activities

Table 8.33 presents a summary of residual impacts (post-mitigation) related to killing or injury of species through Project activities. Magnitude of 16 impacts would be reduced from moderate to minor after mitigation measures are applied. However, for four impacts significance would be reduced from minor to negligible.

Table 8.33: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of killing or injury of species, however this may still occur, therefore the probability and magnitude cannot be moved to negligible. This results in no change in the significance.
Mammals (bats) (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of killing or injury of species, however this may still occur, therefore the probability and magnitude cannot be moved to negligible. This results in no change in the significance.
Terrestrial mammals (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Terrestrial mammals (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in a change in the significance from minor to negligible.
Mammals (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor

Receptor	Summary of residual impact (post-mitigation)
	Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Birds (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned and speed limits installed. This results in no change in the significance.
Birds (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned and speed limits installed. This results in a change in the significance from minor to negligible.
Amphibians (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from high to medium and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Amphibians (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium

Receptor	Summary of residual impact (post-mitigation)
	Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from high to medium and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Amphibians (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from high to medium and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Reptiles (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Reptiles (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in a change in the significance from minor to negligible.
Reptiles (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: low Significance of impact: negligible

Receptor	Summary of residual impact (post-mitigation)
	The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, excavations checked and speed limits installed. This results in no change in the significance.
Invertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, and speed limits installed. This results in no change in the significance.
Invertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low and the magnitude from moderate to minor because environmental pollution will be minimised, hunting banned, and speed limits installed. This results in no change in the significance.
Fish and macroinvertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the scale from regional to local, the probability from medium to low and the magnitude from moderate to minor because the intake pipe will be meshed, environmental pollution will be minimised, and fishing banned. This results in no change in the significance.
Fish and macroinvertebrates (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the scale from regional to local, the probability from medium to low and the magnitude from moderate to

Receptor	Summary of residual impact (post-mitigation)
	minor because the intake pipe will be meshed, environmental pollution will be minimised, and fishing banned. This results in a change in the significance from minor to negligible
Fish and macroinvertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the scale from regional to local, the probability from medium to low and the magnitude from moderate to minor because the intake pipe will be meshed, environmental pollution will be minimised, and fishing banned. This results in no change in the significance.

8.9.1.4 Disturbance and displacement of species

Table 8.34 presents a summary of residual impacts (post-mitigation) related to disturbance and displacement of species. Magnitude of three impacts would be reduced from moderate to minor. However, for 14 impacts magnitude would be reduced from major to moderate after mitigation measures are applied. For one impact, significance would be reduced from moderate to minor.

Table 8.34: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of species disturbance within protected areas, however disturbance and displacement may still occur, therefore the magnitude cannot be moved to negligible. This results in no change in the significance.
Mammals (bats) (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Terrestrial mammals (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months)

Receptor	Summary of residual impact (post-mitigation)
	Scale: Local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Terrestrial mammals (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Mammals (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Birds (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. Works will also aim to avoid breeding bird season. This results in no change in the significance.
Birds (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: medium Significance of impact: minor

Receptor	Summary of residual impact (post-mitigation)
	The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. Works will also aim to avoid breeding bird season. This results in no change in the significance.
Amphibians (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Amphibians (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Amphibians (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Reptiles (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Reptiles (medium sensitivity)	Parameter Judgement Nature: Negative

Receptor	Summary of residual impact (post-mitigation)
	Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Reptiles (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Invertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate because lighting, noise and human presence will all be managed and reduced where possible. This results in no change in the significance.
Invertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: Local Probability: certain Sensitivity of receptor: low Significance of impact: minor
Fish and macroinvertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor because lighting, noise and human presence will all be managed and reduced where possible, and aquatic habitat fragmentation will be minimised. This results in no change in the significance.

Receptor	Summary of residual impact (post-mitigation)
Fish and macroinvertebrates (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor because lighting, noise and human presence will all be managed and reduced where possible, and aquatic habitat fragmentation will be minimised. This results in no change in the significance.
Fish and macroinvertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: Local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor because lighting, noise and human presence will all be managed and reduced where possible, and aquatic habitat fragmentation will be minimised. This results in no change in the significance.

8.9.1.5 Aquatic habitat degradation and reduced water availability for aquatic species

Table 8.35 presents a summary of residual impacts (post-mitigation) related to aquatic habitat degradation and reduced water availability for aquatic species. Magnitude of al impacts would remain same after mitigation measures are applied. Also, significance for all the impacts would remain same.

Table 8.35: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Natural Habitats (medium sensitivity): Rivers and riparian habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.
Amphibians (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium

Receptor	Summary of residual impact (post-mitigation)
	Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.
Amphibians (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.
Amphibians (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.
Fish and macroinvertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.
Fish and macroinvertebrates (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.

Receptor	Summary of residual impact (post-mitigation)
Fish and macroinvertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude of the impacts, however, not enough to classify it as negligible. This results in no change in the significance.

8.9.2 Analysis of residual operation phase impacts (drilling and testing)

8.9.2.1 Habitat loss and degradation

Table 8.36 presents a summary of residual impacts (post-mitigation) related to habitat loss and degradation. Magnitude of two impacts would be reduced from moderate to minor. However, for one impact magnitude would be reduced from major to moderate after mitigation measures are applied. For five impacts, significance would be reduced from minor to negligible and for two impacts significance would be reduced from moderate to minor.

Table 8.36: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will be sited away from protected areas. This results in no change in the significance.
Habitats of high sensitivity: Forest habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats will be restored. This results in no change in the significance.
Habitats of medium sensitivity (natural habitats): Rivers and riparian habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local

Receptor	Summary of residual impact (post-mitigation)
	Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from high to medium because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in no change in the significance.
Habitats of low sensitivity: Agricultural habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures will not reduce the probability or magnitude because the Project will prioritise disturbed habitats such as agriculture over intact ones. This results in no change in the significance.
Flora of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Flora of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in a change in the significance from minor to negligible.
Flora of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible

Receptor	Summary of residual impact (post-mitigation)
	The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Mammals (bats) of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Terrestrial mammals of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Terrestrial mammals of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in a change in the significance from minor to negligible.
Mammals of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any

Receptor	Summary of residual impact (post-mitigation)
	lost forest habitats and respective flora will be restored. This results in no change in the significance.
Birds of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Birds of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in a change in the significance from minor to negligible.
Amphibians of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in a change in the significance from moderate to minor.
Amphibians of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in a change in the significance from minor to negligible.

Receptor	Summary of residual impact (post-mitigation)
Amphibians of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Reptiles of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Reptiles of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in a change in the significance from minor to negligible.
Reptiles of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Invertebrates of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor

Receptor	Summary of residual impact (post-mitigation)
	Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Invertebrates of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because the Project will prioritise disturbed habitats over intact ones, and any lost forest habitats and respective flora will be restored. This results in no change in the significance.
Fish and macroinvertebrates of high sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the scale from regional to local, the probability from high to medium because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in a change in the significance from moderate to minor.
Fish and macroinvertebrates of medium sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the scale from regional to local, the probability from high to medium because the Project will minimise aquatic habitat disturbance through monitoring maintenance of the weir. This results in no change in the significance.
Fish and macroinvertebrates of low sensitivity	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium

Receptor	Summary of residual impact (post-mitigation)
	Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the scale from regional to local, the probability from high to medium because the Project will minimise aquatic habitat disturbance through monitoring maintenance of the weir. This results in no change in the significance.

8.9.2.2 Killing or injury of species through Project activities

Table 8.37 presents a summary of residual impacts (post-mitigation) related to killing or injury of species through Project activities. Magnitude of three impacts would be reduced from moderate to minor after mitigation measures are applied. For two impacts, significance would be reduced be from minor to negligible

Table 8.37: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of killing / injury of species within protected areas, however these activities may still occur, therefore the magnitude and probability cannot be moved to negligible. This results in no change in the significance.
Mammals (bats) (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of killing / injury of bat species, however these activities may still occur, therefore the magnitude and probability cannot be moved to negligible. This results in no change in the significance.
Terrestrial mammals (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.

Receptor	Summary of residual impact (post-mitigation)
Terrestrial mammals (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Mammals (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Birds (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Birds (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Amphibians (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months)

Receptor	Summary of residual impact (post-mitigation)
	Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from high to medium because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Amphibians (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from high to medium because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Amphibians (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from high to medium because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Reptiles (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Reptiles (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium

Receptor	Summary of residual impact (post-mitigation)
	Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Reptiles (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Invertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Invertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low because hunting bans will deter targeted killings, and checking excavations and installing speed limits will reduce accidental killings / injuries. This results in no change in the significance.
Fish and macroinvertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor

Receptor	Summary of residual impact (post-mitigation)
	The implementation of the proposed mitigation measures should reduce the scale from regional to local, the magnitude from moderate to minor and the probability from medium to low because fishing bans will deter targeted killings, fish will be restocked, and pipes will be designed to reduce mortality and injury. This results in no change in the significance.
Fish and macroinvertebrates (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the scale from regional to local, the magnitude from moderate to minor and the probability from medium to low because fishing bans will deter targeted killings, fish will be restocked, and pipes will be designed to reduce mortality and injury. This results in a change in the significance from minor to negligible.
Fish and macroinvertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the scale from regional to local, the magnitude from moderate to minor and the probability from medium to low because fishing bans will deter targeted killings, fish will be restocked, and pipes will be designed to reduce mortality and injury. This results in a change in the significance from minor to negligible.

8.9.2.3 Disturbance and displacement of species

Table 8.38 presents a summary of residual impacts (post-mitigation) related to disturbance and displacement of species. Magnitude of four impacts would be reduced from moderate to minor. However, for 13 impacts magnitude would be reduced from major to moderate. For all the impacts significance would remain same after mitigation measures are applied.

Table 8.38: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Mount Saint Catherine NP Mount Saint Catherine KBA	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the likelihood of disturbance or displacement of species within protected areas, however these activities may still occur, therefore the magnitude and probability cannot be moved to negligible. This results in no change in the significance.

Receptor	Summary of residual impact (post-mitigation)
Mammals (bats) (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Terrestrial mammals (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Terrestrial mammals (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Mammals (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Birds (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain

Receptor	Summary of residual impact (post-mitigation)
	Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Birds (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Amphibians (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Amphibians (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Amphibians (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.

Receptor	Summary of residual impact (post-mitigation)
Reptiles (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Reptiles (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Reptiles (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Invertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Invertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: certain

Receptor	Summary of residual impact (post-mitigation)
	Sensitivity of receptor: low Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Fish and macroinvertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Fish and macroinvertebrates (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.
Fish and macroinvertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor, because lighting, noise and human presence during operations will all be managed and minimised where possible. This results in no change in the significance.

8.9.2.4 Aquatic habitat degradation and reduced water availability for aquatic species

Table 8.39 presents a summary of residual impacts (post-mitigation) related to aquatic habitat degradation and reduced water availability for aquatic species. Magnitude of four impacts would be reduced from moderate to minor. However, for two impacts magnitude would be reduced from major to moderate. For one impact, significance would be reduced from moderate to minor and for one impact significance would be reduced from minor to negligible.

Table 8.39: Analysis of residual impacts of change on specific receptors

Receptor	Summary of impact post-mitigation
Natural Habitats (medium sensitivity): Rivers and riparian habitats	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in no change in the significance.
Amphibians (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in no change in the significance.
Amphibians (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in no change in the significance.
Amphibians (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: minor Duration: short term (3 months) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in no change in the significance

Receptor	Summary of impact post-mitigation
Fish and macroinvertebrates (high sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in a change in the significance from moderate to minor.
Fish and macroinvertebrates (medium sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in no change in the significance.
Fish and macroinvertebrates (low sensitivity)	Parameter Judgement Nature: Negative Magnitude: moderate Duration: short term (3 months) Scale: local Probability: high Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from major to moderate and the scale from regional to local because the Project will minimise aquatic habitat disturbance through maintenance of the weir. This results in a change in the significance from minor to negligible.

8.9.3 Analysis of residual decommissioning phase impacts

Residual decommissioning phase impacts will be similar as construction phase impacts, to avoid duplication, please refer to Section 8.9.1.

8.9.4 Discussion regarding residual significant impacts

During both the construction and operation phases, disturbance and displacement of species is considered to have a moderately significant impact on high sensitivity terrestrial fauna (including bats, terrestrial mammals, birds, reptiles, amphibians, and invertebrates). This impact will be short-term (three months), however during this time it will be of moderate significance.

Assuming that the exploratory results are not favourable, then decommissioning and abandonment of the site will occur (see Chapter 2). This will involve the removal of pipelines, fencing and temporary infrastructure, and the covering of the well pad area with topsoil. Site earthworks and access roads will remain. Therefore, the aquatic habitats will be able to regenerate naturally, and the majority of terrestrial habitats will be restored. Hence, no significant residual impacts are anticipated at the decommissioning stage of the Project.

Should the exploratory results be found to be favourable and the Project continue, residual impacts would need to be re-assessed as part of the ESIA for the Geothermal Power Plant.

8.10 Further studies and additional plans

8.10.1.1 Further studies

Pre-Construction Surveys

To complement the existing biodiversity baseline surveys undertaken in the dry season at Site C in 2023, it is recommended that pre-construction surveys are undertaken later in 2023 during the wet season. These additional surveys should cover the same species groups and site and use the same methodologies as those deployed in the March 2023 surveys. The surveys should include a focus on river and riparian habitats to determine their sensitivity at the local level.

Critical Habitat Assessment

Based on the results of the high-level Critical Habitat screening in Section 8.5, a full Critical Habitat Assessment (CHA) will be required at the exploratory drilling phase to determine whether or not this Project is located within critical habitat. A CHA is a separate assessment to an ESIA which identifies areas of the highest biodiversity value to assist Projects in setting long-term biodiversity objectives. In line with IFC PS6, Projects located in critical habitat must achieve net gain for critical habitat features whereas Projects located in natural habitat, must achieve no net loss of natural habitats. Therefore, the identification of critical habitat is recommended at the early stages of a Project.

A CHA is a desk based assessment that utilises primary data previously collected with the Project's AoI and additional secondary data sources to quantitatively justify if species/habitats meet the thresholds set out in IFC PS6. The species listed as "possible" or "likely" critical habitat triggers in

Table 8.14 will need to be assessed as part of the full CHA. It is recommended that the CHA is undertaken prior to the development of the Ecological Management Plans to set biodiversity objectives for the Project and to incorporate relevant mitigation measures. The estimated fee for a CHA for this Project is presented in section 6.2 of the ESMP.

If the Project is located within Critical Habitat, a Biodiversity Action Plan (BAP) will be required if the Project progresses to full implementation (see below).

8.10.1.2 Additional plans

Environmental and Social Management Plans (ESMP) and sub-plans

Mitigation and enhancement responsibilities will be managed by the Ministry of Infrastructure Development, Public Utilities, Energy, Transport and Implementation, a branch of the Government of Grenada (GoG) and the construction company. Within the framework of the Environmental and Social Management Plan (ESMP), the contractor EHS officer will be responsible for Project compliance with the relevant measures identified in the ESMP. They will also be responsible for the production and implementation of a Construction Ecological Management Plan (CEMP). The CEMP will include the following sub-plans to manage biodiversity during the construction phase:

- Habitat Removal and Restoration plan
- Wildlife Rescue and Relocation Plan
- Invasive Species Management plan

Other relevant sub-plans to be included in the ESMP are:

- Waste management plan
- Traffic management plan
- Water management plan
- Noise management plan

Operational Ecological Management Plan (OEMP)

A OEMP will be required to manage operational impacts to biodiversity and monitoring during the operational phase.

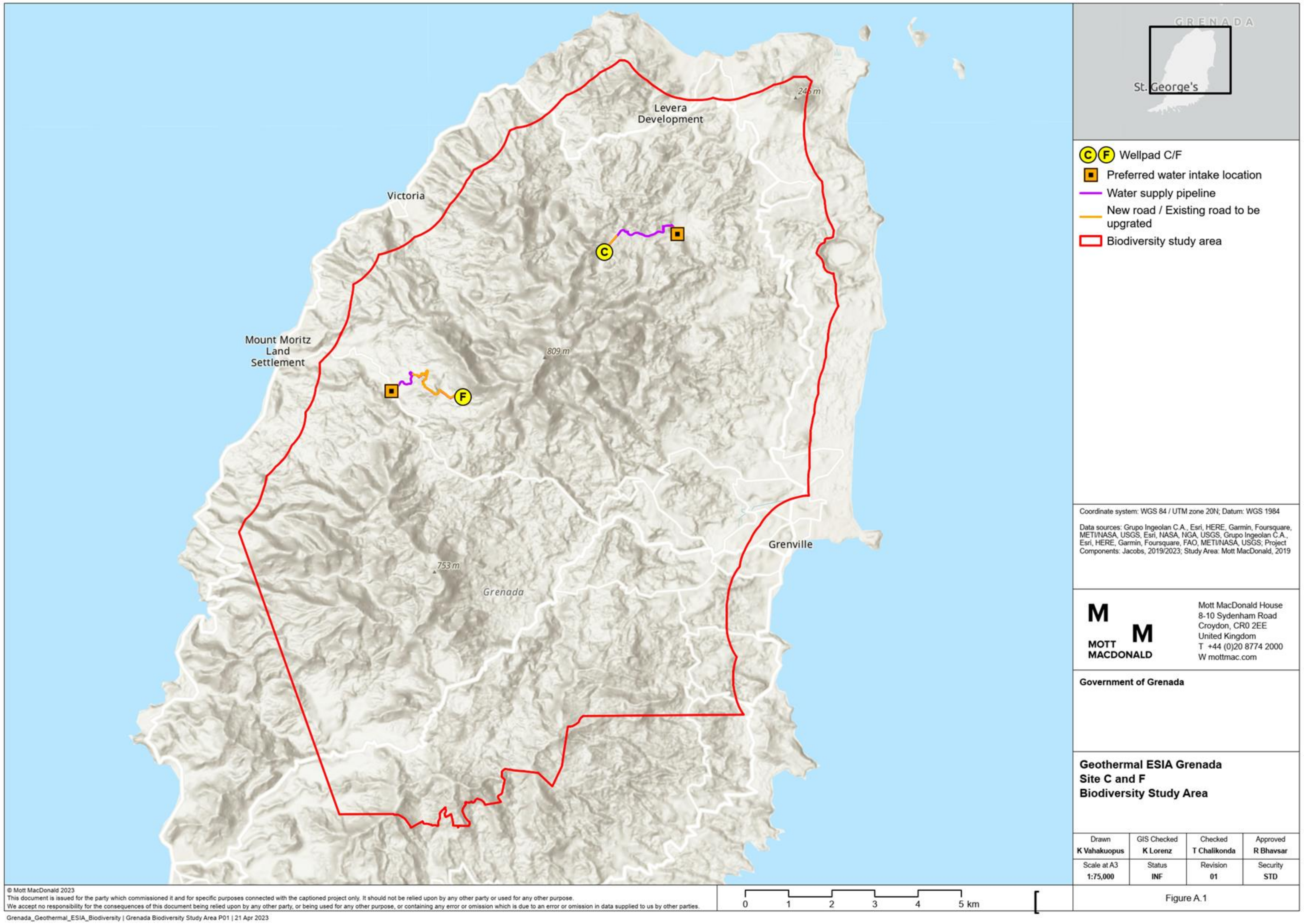
Biodiversity Action Plan

A BAP is required under IFC PS6 for projects located in Critical Habitat and is recommended for high-risk projects in Natural Habitats. A BAP would only be required if the Project progresses to the next phase. A BAP assists the Project in demonstrating No Net Loss of Natural Habitats and Net Gain for the biodiversity values for which Critical Habitat is designated. The GoG would be responsible for the implementation of the BAP. The BAP must include a long-term Biodiversity Monitoring and Evaluation Plan (BMEP). The BMEP would present the Project's adaptive management approach so that the implementation of mitigation and management measures are responsive to changing conditions and the results of monitoring throughout the project's lifecycle.

Appendices

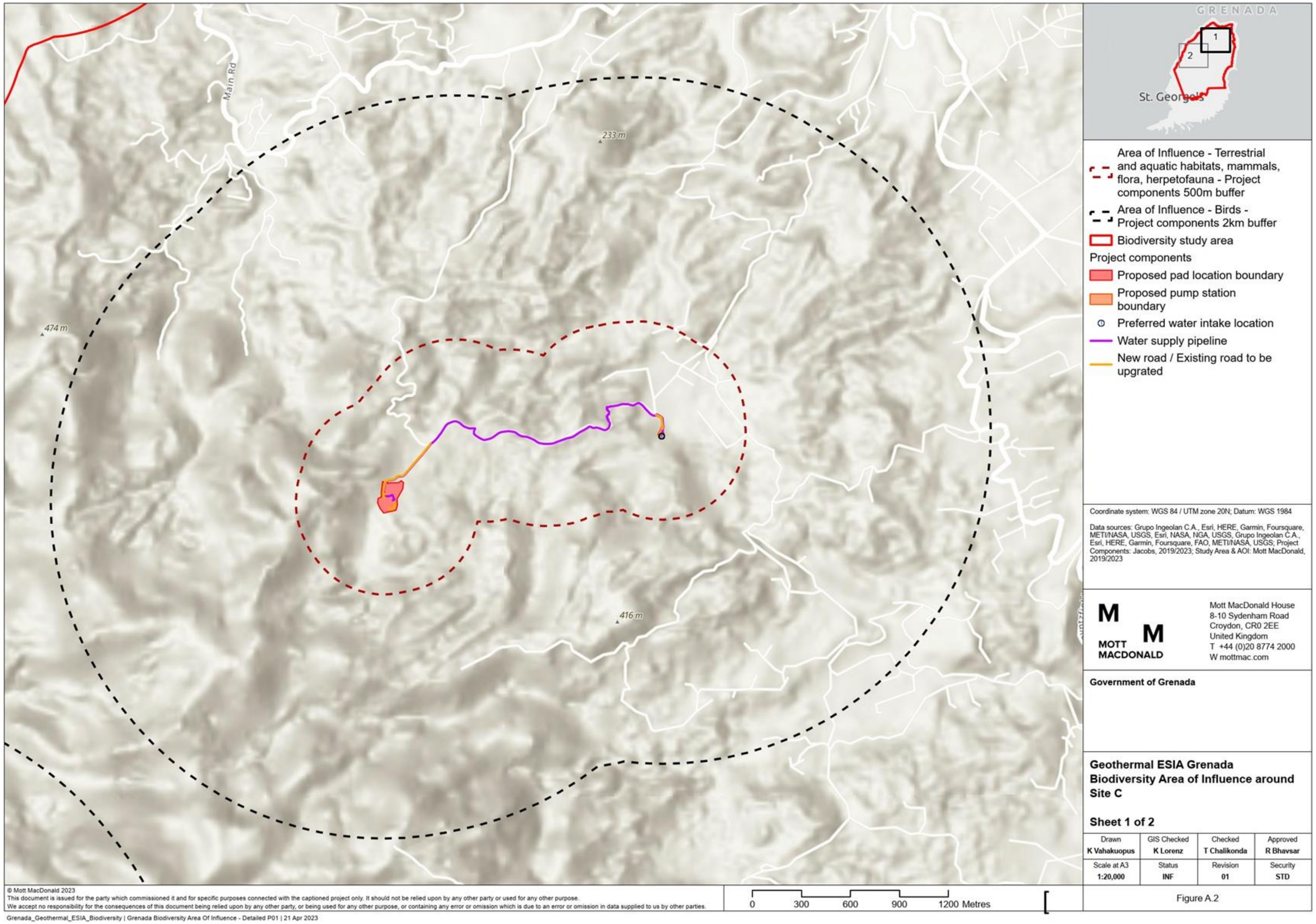
A. Figures

Figure A.1: Biodiversity Study Area



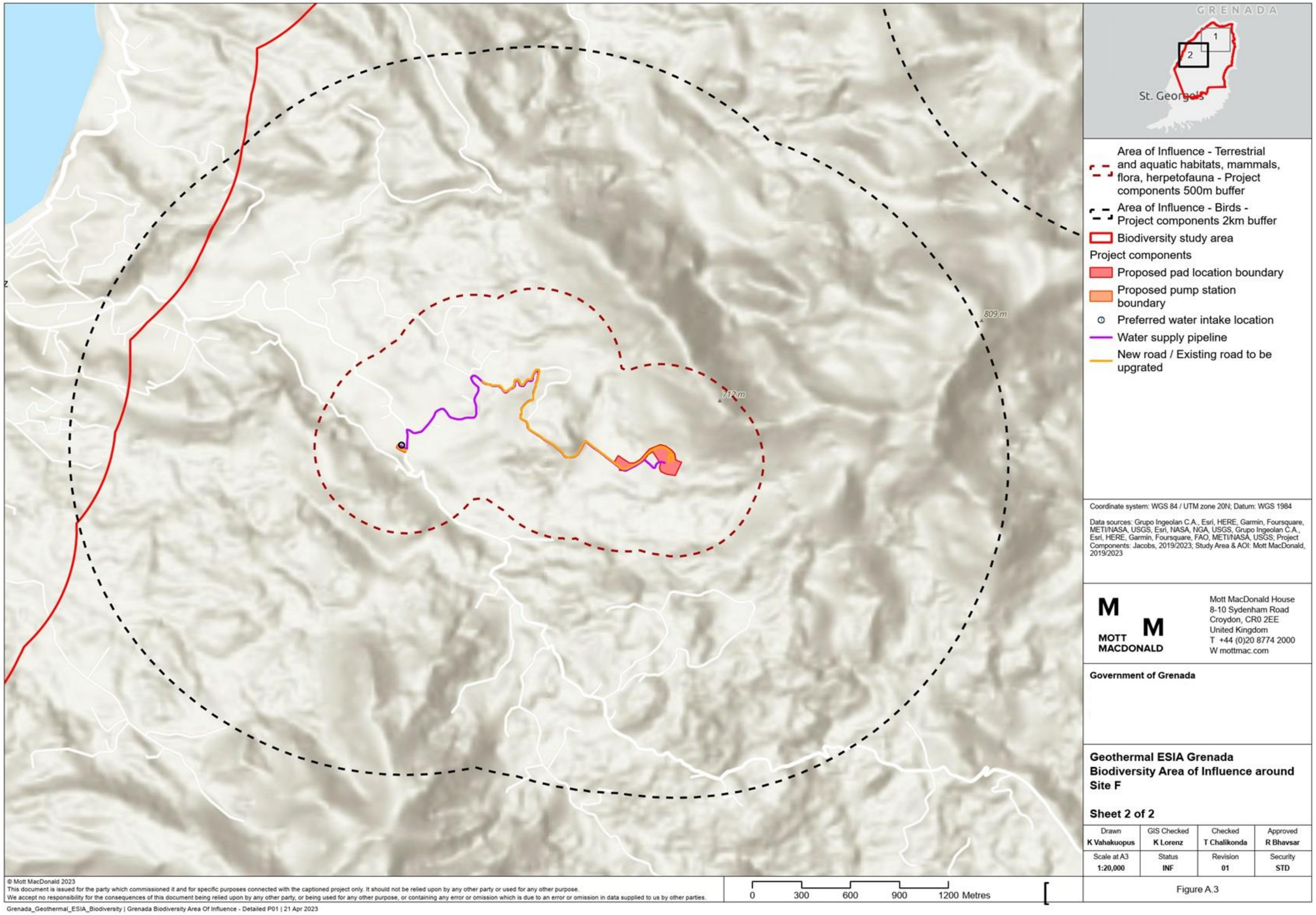
Source: Mott MacDonald, 2023

Figure A.2: Biodiversity Area of Influence around Site C



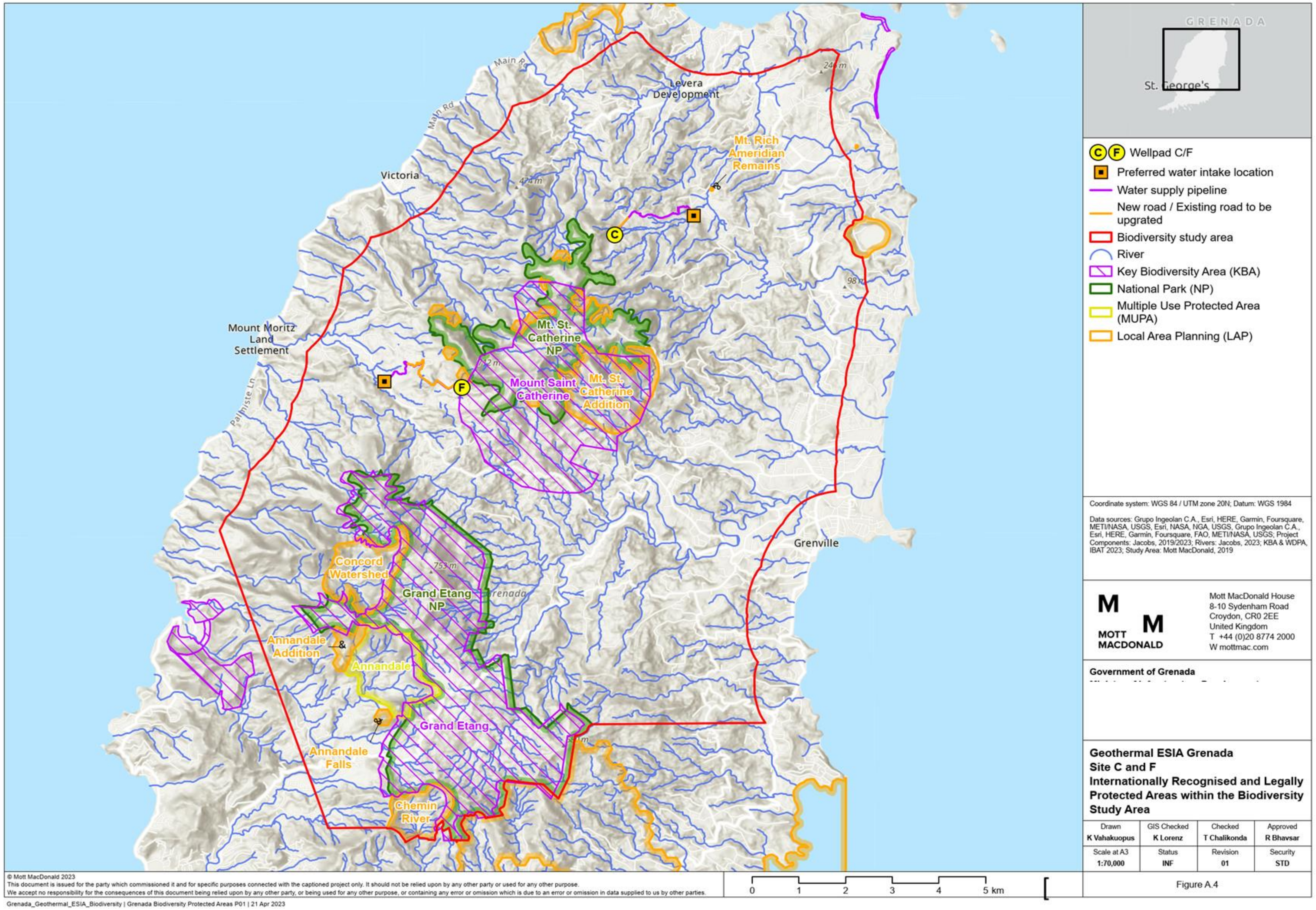
Source: Mott MacDonald, 2023

Figure A.3: Biodiversity Area of Influence around Site F



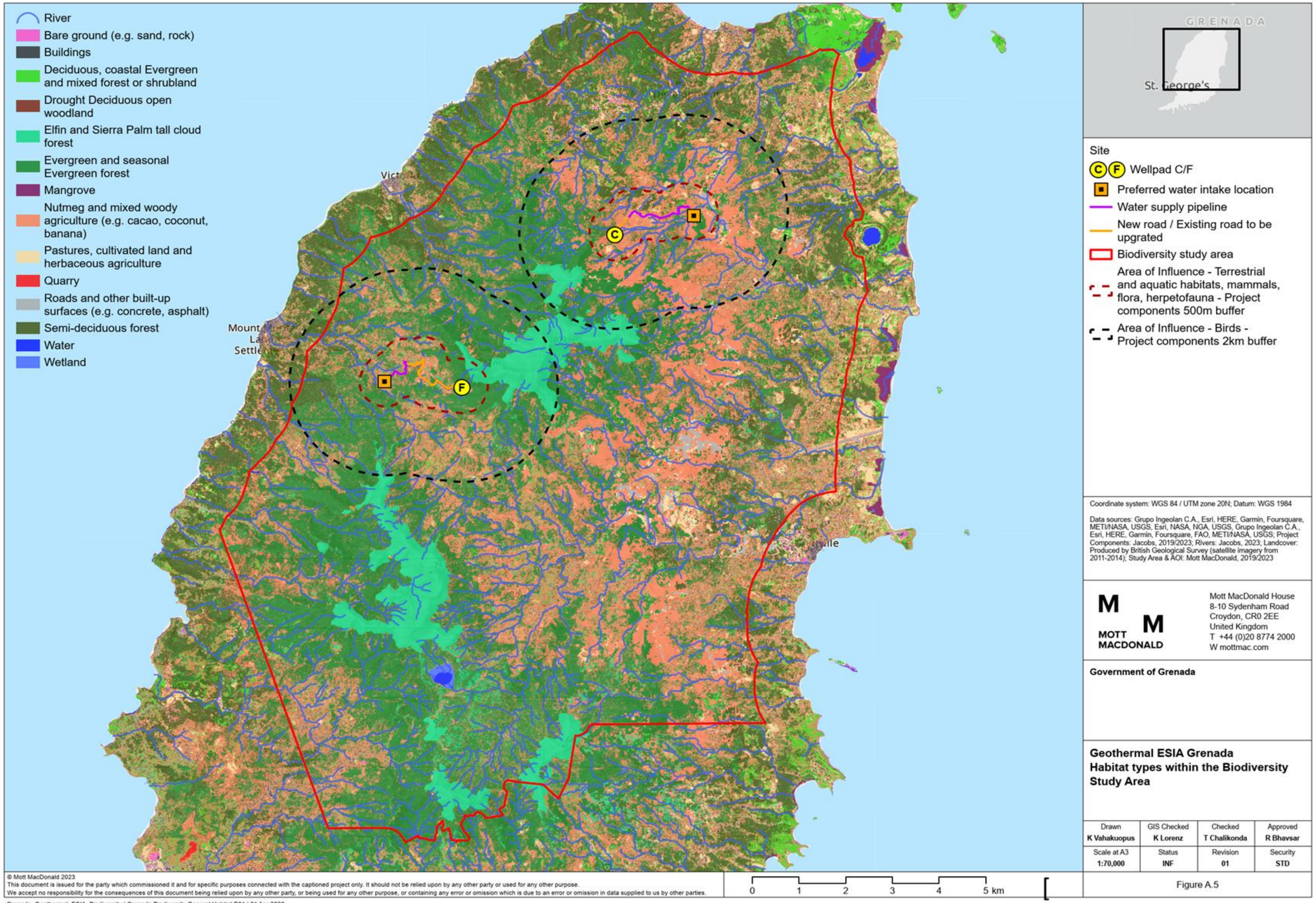
Source: Mott MacDonald, 2023

sFigure A.4: Internationally Recognised and Legally Protected Areas within the Biodiversity Study Area



Source: Mott MacDonald, 2023

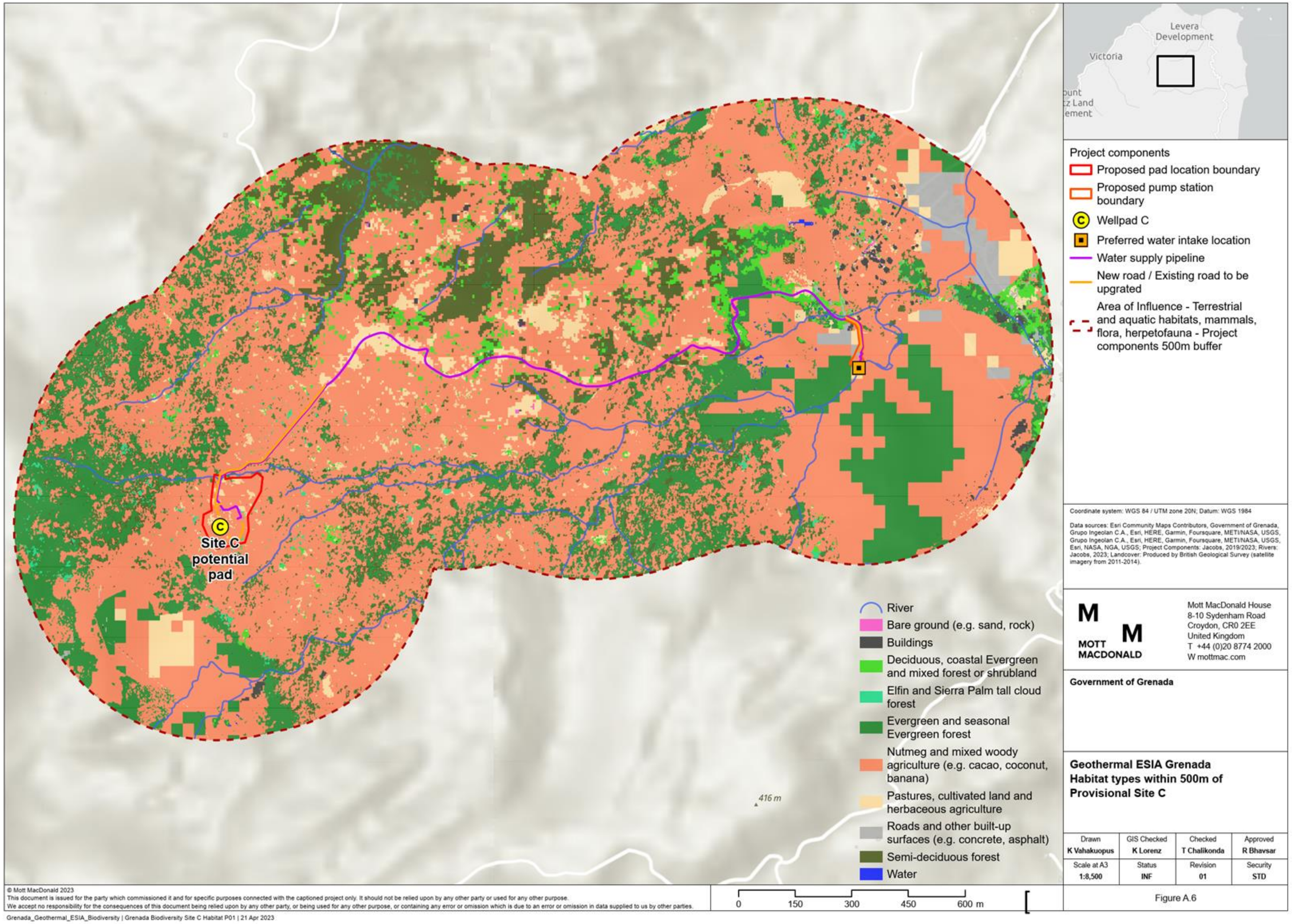
Figure A.5: Habitat types within the Biodiversity Study Area



Grenada_Geothermal_ESIA_Biodiversity | Grenada Biodiversity General Habitat P01 | 21 Apr 2023

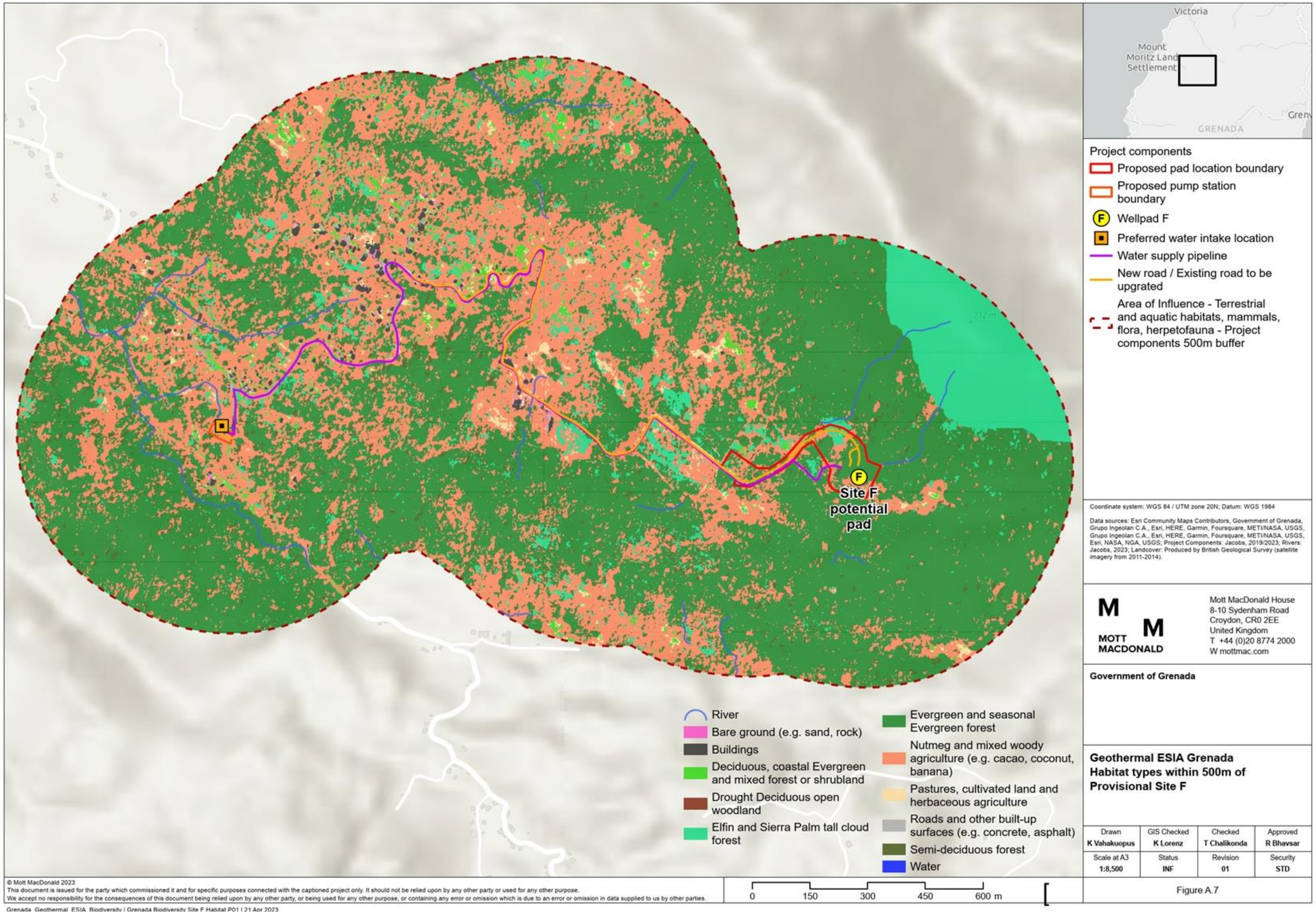
Source: Mott MacDonald, 2023

Figure A.6: Habitat types within 500m of Site C



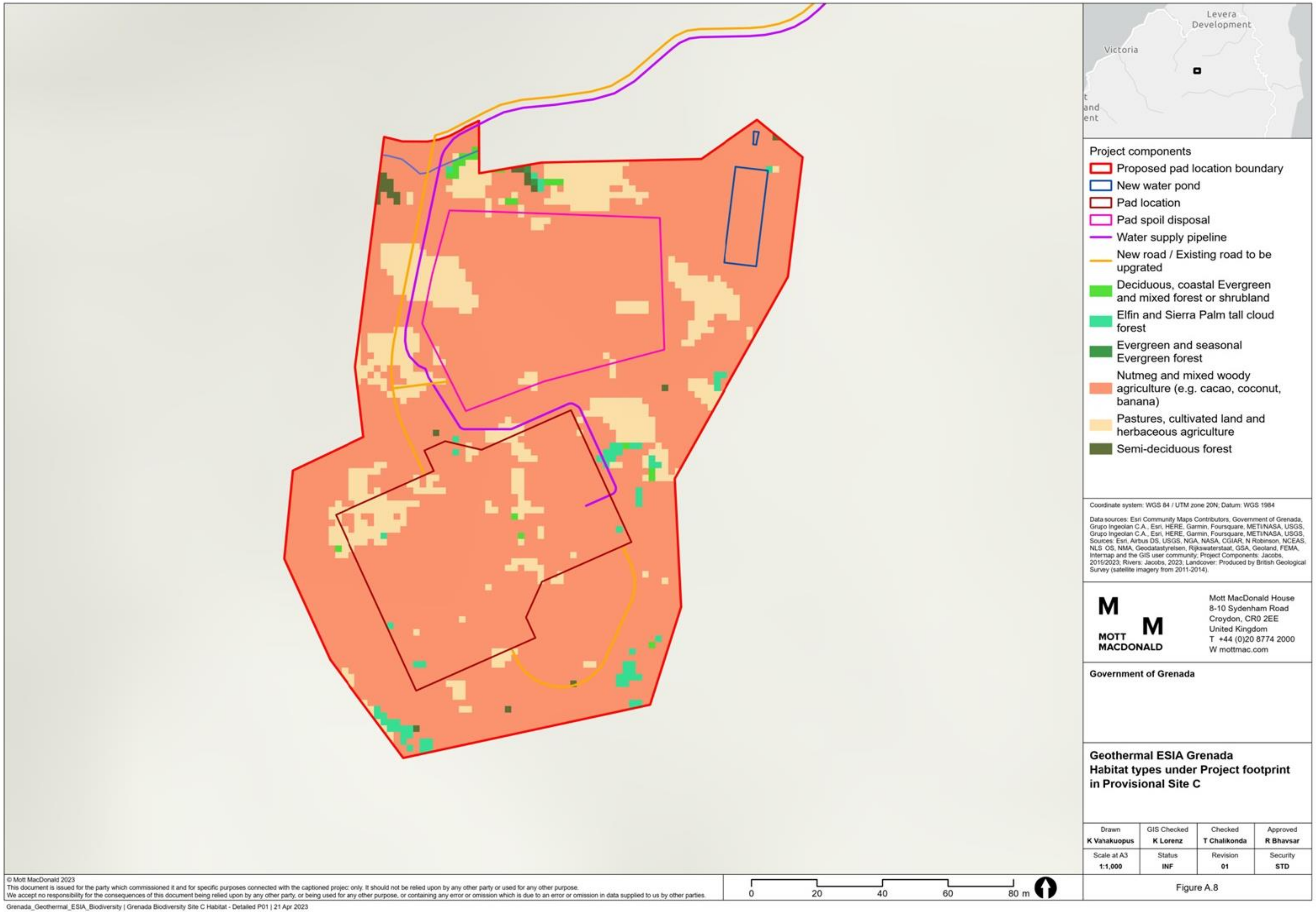
Source: Mott MacDonald, 2023

Figure A.7: Habitat types within 500m of Site F



Source: Mott MacDonald, 2023

Figure A.8: Habitat types under Project footprint in Site C



Source: Mott MacDonald, 2023

Figure A.9: Habitat types under Project footprint in Site F

Source: Mott MacDonald, 2023

B. 2019 Survey Results

Grenada Geothermal Project

Biodiversity Baseline Survey Report

Prepared by Ecoengineering Consultants Limited

(Final – September 20, 2019)

1. Introduction

This report presents the results of the Dry and Wet Seasons Biodiversity Surveys undertaken by Ecoengineering Consultants Limited between April 8-12 and July 19-22, respectively, in the area of influence (AoI) of the Grenada Geothermal Project. These surveys are required to inform the Environmental and Social Impact Assessment (ESIA) for this project. All tables and figures are listed in Appendix 1.

2. Methodology

2.1. Study Area and Survey Locations

The study area for the two proposed well sites are shown in Figure 2-1 in Appendix 1. Flora and fauna (avifauna, aquatic, mammalian, reptilian, amphibian and other fauna) surveys were undertaken within 500 m from the centre of the proposed exploratory drilling pads at Sites C and F (see Figures 2-2 and 2-3, respectively), using line transects, point counts, quadrats, camera traps and pitfall traps. The coordinates of each transect/quadrat at each site, as well as the sample dates are provided in Table 2-1 in Appendix 1.

2.2. Survey Methods

This section presents the methods employed for undertaking the biodiversity surveys according to the following subsections:

- Desktop Review;
- Field Surveys;
- Interviews with Local People; and
- Limitations

2.2.1. Desktop Review

A literature review of applicable studies and publications regarding the flora and fauna in Grenada was undertaken. The major local and regional studies, publications and documents reviewed are listed here, and a full listing of all resources used is presented at the end of this Report:

- Land Use Map from the World Bank Dataset (2014)
- Aucoin, S. (2018): Mount St. Catherine Forest Reserve Environmental Baseline Assessment – Implementing a Ridge-to–Reef approach to protecting biodiversity and ecosystem functions within and around protected areas in Grenada.
- Cooper, B., Mings, L., Lindsay, K. and Bacie, J.P. (2011): Environmental and Socio Economic Baseline Studies – Grenada Site Report for Grand Etang and Annandale Forest Reserves. Prepared by Island Resources Foundation for the OECS Protected Areas and Associated Livelihoods (OPAAL) Project.
- Government of Grenada (2014): Fifth National Report to the Convention on Biodiversity

The main objective of the desktop review was to identify the major land use type within the study area, which was then used to set up field exercises. In addition, any species of concern (having environmental or biological importance) that are known to occur in the area would be the focal point for the field exercises.

2.2.2. Field Surveys

To inform the ESIA for the Project, biodiversity field surveys were undertaken to identify habitats and key species which occur or have the potential to occur within the Project area of influence.
The two sites proposed for exploratory drilling sites were reconnoitred in March over three days, when camera traps were also used for a period of 4/5 days. Biodiversity surveys were conducted in the dry and wet seasons: for five days in April and four days in July 2019.

Biodiversity surveys were undertaken for habitats and the major taxonomic groups found or likely to be found in the project site and surrounding area: notably plants, mammals, birds, herpetofauna and fish. These were targeted on species of conservation importance which have the potential to be affected by the project. This includes those listed on the IUCN Red List (as near threatened, critically endangered, endangered and vulnerable), and species threatened and/or protected at the national level. Survey methodologies followed international best practice (after Hardner and Gullison, 2015) and took into consideration the accessibility of the study area to gather the maximum amount of data within the time allocated.

In addition to the field surveys described below, local people were interviewed regarding threatened, endemic/restricted-range or protected species. Information was collected regarding the presence, abundance, local distribution, breeding, threats (hunting, trade) of these species. The interviews included questions regarding the year/month when species were seen/captured, the distance from the village, how many individuals/quantities were captured and with what frequency these activities are carried out. If the area is visited by local people then these interviews may also provide useful information on paths and access routes across the Project area.

2.2.2.1 Habitats and Flora

The aims of the Floristic and Habitat survey were to:

- Identify and describe the structure and composition of the broad habitat types (with clear distinction between natural and modified habitats) and the floristic diversity of the study area, with focus on threatened, endemic, protected, and invasive plant species
- Ground truth, refine and update the draft habitat map prepared using satellite imagery (see below)
- Establish how local people use flora in the project area

The Dry Season botanical surveys were conducted on April 09 to 10, 2019 at Site C and on April 11, 2019 at Site F. The Wet Season surveys were conducted at Site C and Site F on July 19-20, 2019 and July 21-22, 2019, respectively. Using the latest Google Images and a World Bank Land Use Map for Grenada (World Bank, 2019), transects were established within a 500 m radius from the centre point of the proposed drill pad. A total of 4 line transects per site were established, ranging between 140 m to 500 m. These transects followed the four cardinal directions. During the Dry Season survey, ground truthing was undertaken along these transects, and plant species within 5 m of either side of the transect line were identified and recorded. In addition, 10 x 10m quadrats were established at approximately 100 m intervals along the transect line, or dependent on the size and homogeneity of the vegetation in the area. Within these quadrats all plant species were recorded using the DAFOR scoring system (D=dominant, A=abundant, F=frequent, O=occasional, R=rare). Species cover as a (%) was also recorded. In the interest of time, the DAFOR scoring system was used only within the Quadrats and not along the transects.

At Site C, 15 quadrats were established, while at Site F, 18 quadrats were established. Using a handheld GPS unit, GPS coordinates were recorded at each quadrat, and photographs were taken. The lengths of the transects and the GPS Coordinates of their start and end points, as well as GPS coordinates for the quadrats are presented in Table 2-1 (Appendix 1) and shown in Figures 2-2 and 2-3 (Appendix 1). During the Wet Season survey, the same transects and quadrats were re-visited to verify the occurrence of the species in the area, and to note any significant changes (if any) that may have undergone in the area. Additional, selected species of ferns were photographed and sent to STB Consultants Limited for identification.

The same quadrats and transects were used to make incidental records of fauna species, as described in the sections below.

2.2.2.2 *Avifauna*

Fixed point bird counts were undertaken in proximity to each of the proposed well site locations (see Table 2-1 for GPS coordinates and Figures 2-4 and 2-5). The bird count locations were chosen based on the major habitat types within each Site. Species observed within a 25 m radius of each sampling location during a 10 minute duration were recorded. Where practical, the number of individuals was also recorded. This is a standard method for estimating bird diversity, noting all the bird species present within a 25 m radius from a point (Hutto et al, 1986). At each Site, 2 bird count locations were selected (see Figures 2-4 and 2-5). Using an 8 x 42 binoculars and call recognition, each location was sampled once during the Dry Season surveys and twice during the Wet Season surveys in accordance with the following schedule:

SITE	BIRD COUNT LOCATION	DATE	
		DRY SEASON	WET SEASON
Site C	BC-C1	April 09, 2019 (morning period)	July 19, 2019 (morning period)
		-	July 20, 2019 (afternoon period)
	BC-C2	April 10, 2019 (morning period)	July 19, 2019 (morning period)
		-	July 20, 2019 (afternoon period)
Site F	BC-F1	April 11, 2019 (afternoon period)	July 21, 2019 (morning period)
		-	July 22, 2019 (afternoon period)
	BC-F2	April 12, 2019 (afternoon period)	July 21, 2019 (morning period)
		-	July 22, 2019 (afternoon period)

Counts were conducted once in the dry season due to constraints in time, and twice during the wet season as time permitted. Counts were conducted during either the morning period (7:00am – 9:00am) or the afternoon period (4:00pm – 6:00pm), when peak bird activity takes place. For the Wet Season surveys, the data collected during the bird counts were pooled by bird count locations since the number of individuals recorded during the individual counts were low. In addition, any opportunistic sighting of bird species along transects, within the quadrats and within 500 m of the proposed well site (see Figures 2-2 and 2-3) was recorded and photographed.

2.2.2.3 *Mammals*

Along the transect lines, at the quadrats and within 500 m of the drill sites (see Figures 2-2 and 2-3), incidental observations of mammalian presence (direct sightings, footprints, nests, faecal pellets, feeding signs, hair and calls) were recorded and photographed (where applicable). This was done during the daytime and at least once during the night time, using spotlights.

In addition, mammalian fauna were surveyed using camera traps in the Dry Season, targeted to capture species within the area. These traps were placed at two locations at each site, in March 2019 and again in April 2019. The locations of the camera traps were selected based on the habitat type. The traps were secured on trees and positioned to capture terrestrial fauna. Camera traps were left in place at Site C for 3 nights in March 2019 and 3 nights in April 2019. At Site F, camera traps were left in place for 3 nights in March 2019 and for 4 nights in April 2019. The GPS Coordinates for these camera traps are presented in Table 2-1 and the locations were shown in Figure 2-4 and 2-5.

2.2.2.4 Invertebrates, Amphibians and Reptiles

Amphibians and reptiles were surveyed using line transects and quadrats during both Dry and Wet Season surveys (see Figures 2-2 and 2-3). At each site, 4 transect lines were established, and a total of 15 and 18 quadrants were established at Sites C and F, respectively. Quadrats were 10 m x 10 m and the lengths of the transects are presented in Table 2-1 in Appendix 1. Along these transects and quadrats, any trees and plants in which amphibians are known to occur (such as ferns and bromeliads) were surveyed for a period of 5 minutes. In addition, amphibian surveys were conducted during dusk (5:30 pm to 6:30 pm) using call recognition and spotlighting. Areas near streams/rivers or damp areas were targeted for this survey.

In addition, at each Site, dry pitfall traps were established, based on habitat type, and in areas where amphibians and reptiles are generally known to occur (see Table 2-1 for GPS Coordinates and Figure 2-4 and 2-5). These were established to capture invertebrates, amphibians and reptiles. Plastic containers (of 1 litre volume), were sunk into the soil such that the mouth of the container was level with the surface of the soil (Cogger, 1986).

At Site C, three pitfall traps were established during the dry season, and 7 pitfall traps were established during the wet season. At Site F, three pitfall traps were established in the dry season and 8 pitfall traps were established during the wet season (see Table 2-1 for GPS Coordinates and Figure 2-4 and 2-5). The differences in the seasonal number of traps were due to:

- time constraints experienced during the dry season, and
- to increase sampling effort due to the low numbers of species observed during the dry season.

Dry season pitfall traps were left in place for 3 days, and checked/inspected every other day, while wet season pitfall traps were left in place between 4 and 5 hours.

2.2.2.5 Aquatic Surveys

Aquatic fauna surveys were conducted along the respective streams at Sites C and F during both the Dry and Wet Seasons (see Table 2-1 for GPS Coordinates and Figures 2-4 and 2-5 for locations). The rivers were surveyed at the closest accessible point to the transect line. At each Site, the team walked along the river (for approximately 100 m) and scouted the watercourse for aquatic species. Where riverine fauna were observed, a dip-net was used to capture these species. Where practical, species were identified on the field, photographed, and recorded.

2.2.3. Interviews with Local People

To determine the use and functions of plant species in the area, local farmers were interviewed using an Ecosystem Services Sheet. These interviews were held on April 09, 2019 at Site C and on April 11, 2019 at Site F. In addition, the importance of each species for each use was assessed using the following scale: 1=fair; 2=good; 3=excellent (based on livelihood). A copy of this Ecosystem Sheet is appended at the end of this report (Appendix 2).

In addition, local people were asked questions regarding the occurrence of faunal species in the area, including, but not limited to the different faunal species found within the area, the average number of individuals and the hunting pattern (including time of year for hunting, frequency of hunting, etc.).

3. Results

3.1. Results of Field Surveys

3.1.1 Habitats and Flora

Based on the World Bank Land Use Map (see Figures 2-2 and 2-3), 4 broad vegetation/habitat types were observed during the field surveys:

- Pastures, cultivated land and herbaceous agriculture – which included grasses (used for livestock grazing and fodder, overgrown areas and areas with agricultural crops)
- Nutmeg and Mixed Woody Agriculture – which included nutmeg plantations and tree crops such as cocoa, citrus, etc.)
- Evergreen and seasonal evergreen forest – included secondary forest (dense mature trees and high canopies)
- Deciduous, coastal Evergreen and mixed forest or shrubland – secondary forest with sparse mature trees, woody shrubs and thicker understories

At Site C, four transects and fifteen (15) quadrats were established (see Figure 2-2). Along these transects and quadrats, total of 127 plant species belonging to 53 Families were recorded. At Site F, four transects and eighteen (18) quadrats were established (see Figure 2-3). Along these transects and quadrats, total of 145 plant species belonging to 61 Families were recorded. A full listing of the species recorded at Sites C and F are presented in Tables 3-1 and 3-3 respectively, and results of the DAFOR assessment are presented in Tables 3-2 and 3-4 for Sites C and F respectively (see Appendix 1). Three habitats/vegetation communities were delineated and described within the 500 m radius of each of the proposed drill sites. At both sites, these comprised pasture/cultivated land; mixed agriculture (nutmeg/mixed woody agriculture) and secondary forest (seasonal evergreen forest/mixed forest/shrubland) (see Figures 2-2 and 2-3). Full details of the description of the vegetation in the area is provided in Appendix 3, mapped in Figure 2-2 and 2-3 (Appendix 1) and shown in Photographs 3-1 to 3-48 (Site C) and 3-49 to 3-98 (Site F) (Appendix 4).

There were no significant changes in the composition of plant species along the transects and at the quadrants during the wet season. The fundamental difference included a thicker understory.

3.1.2 Avifauna

At Site C, a combined total of 18 species belonging to 11 families were recorded for both seasons, while at Site F, a combined total of 19 species belonging to 11 families were recorded for both seasons. A full listing of the birds recorded and their numbers are presented in Tables 3-5 and 3-6, Appendix 1 and Photographs 3-99 to 3-113, Appendix 4). Excluding the opportunistic sightings, a summary of the abundance of bird species recorded on site are presented below.

Common Name	**Scientific Name**	**Site C**			**Site F**		
		DS	**WS**	**Total**	**DS**	**WS**	**Total**
Grey Kingbird	*Tyrannus dominicensis*	4	9	**13**		5	**5**
Tropical Kingbird	*Tyrannus melancholicus*					1	**1**
Orange Winged Parrot	*Amazona amazonica*				2	2	**4**
Cattle Egret	*Bubulcus ibis*		1	**1**	7	2	**9**
Hook-Billed Kite	*Chondrohierax uncinatus mirus*				1		**1**
Broad Winged Hawk	*Buteo platypterus*	3		**3**			
Rufous Breasted Hermit	*Glaucis hirsuta*		1	**1**			
Antillean Crested Hummingbird	*Orthorhyncus cristatus*	3	3	**6**	1	4	**5**
Spectacled Thrush	*Turdus nudigenis*		2	**2**	1	1	**2**
Tropical Mockingbird	*Mimus gilvus*	2	1	**3**	2	1	**3**
Bananaquit (Ce-Ce Bird)	*Coereba flaveola*	9	18	**27**	13	15	**28**
Lesser Antillean Tanager	*Tangara cucullata*	3	6	**9**	1	5	**6**
Lesser Antillean Bullfinch	*Loxigilla noctis*	5	17	**22**	22	6	**28**
Scaley-Naped Pigeon (Ramier)	*Columba squamosa*		1	**1**		2	**2**

COMMON NAME	SCIENTIFIC NAME	SITE C			SITE F		
		DS	WS	TOTAL	DS	WS	TOTAL
Common Ground Dove	*Columbina passerina*	1	8	**9**		8	**8**
Zenaida Dove	*Zenaida aurita*	**1**	2	**3**		1	**1**

Note: Does not include opportunistic sightings

Based on these results, the Bananaquit (*Coereba flaveola*) and the Lesser Antillean Bullfinch (*Loxigilla noctis*) were the most abundant species observed on both sites. Apart from the scheduled bird counts, these species were opportunistically observed throughout the day. All birds were commonly noted in the pasture/cultivated lands and areas of woody agriculture.

3.1.3 Mammals

At Site C, a total of three identified species belonging to two families, and at Site F, a combined total of four identified species belonging to three families were recorded for the Wet and Dry Seasons (see Tables 3-7 to 3-10, Appendix 1 and Photographs 3-114 to 3-121, Appendix 4). Unidentified bats were also observed during the night survey. Excluding opportunistic sightings, a summary of the abundance of mammals observed on site are presented below.

COMMON NAME	SCIENTIFIC NAME	SITE C			SITE F		
		DS	WS	TOTAL	DS	WS	TOTAL
Nine-banded Armadillo	*Dasypus novemcinctus*				1		
Common Opossum / Manicou	*Didelphis marsupialis*	1		**1**	1		
Robinson's Mouse Opossum	*Marmosa robinsoni*	1		**1**	1		
Small Indian Mongoose	*Herpestes auropunctatus*	1		**1**	1		
Unidentified Bat	-		3	**3**	1	2	**2**

Note: Does not include opportunistic sightings

3.1.4 Terrestrial Invertebrates

This section presents the results of the terrestrial invertebrates recorded at the two locations for both seasons. At Site C, the following invertebrates were recorded: three species of molluscs belonging to four families; one annelid species belonging to one family; two species of millipedes belonging to one family; five species of spiders belonging to four families and 31 species of insects (including butterflies, dragon flies, grasshoppers, ants and wasps) belonging to 18 families.

At Site F, the following invertebrates were recorded: three species of molluscs belonging to three families; three species of millipedes belonging to one family; four species of spiders belonging to four families and 31 species of insects (including butterflies, dragonflies, grasshoppers, ants and wasps) belonging to 18 families.

Tables 3-7 to 3-10 in Appendix 1 and Photographs 3-122 to 3-179 in Appendix 4, provide the detailed results of the survey methods employed. Excluding opportunistic sightings, a summary of the abundance of terrestrial invertebrates observed on site are presented below.

COMMON NAME	SCIENTIFIC NAME	SITE C			SITE F		
		DS	WS	TOTAL	DS	WS	TOTAL
Molluscs							
Helicinid Land Snail	*Helicina sp.*	8	7	**15**	18	3	**21**
Neocyclotid Land Snail	*Asperostoma sp.*	1	2	**3**	1	2	**3**
Giant South American Snail	*Megalobulimus oblongus*	14	15	**29**	36	10	**46**
Millipedes							
Yellow-banded Millipede	*Anadenobolus monilicornis*					1	**1**
Congaree / Round-backed Millipede	*Sp.1*	35	36	**71**	58	36	**94**
Congaree / Round-backed Millipede	*Sp.2*	1	2	**3**	1	1	**2**
Spiders							
Garden Orbweaver	*Argiope sp.*				2		**2**
Fishing Spider	*Ancylometes sp.*	1	3	**4**	2	1	**3**
Jumping Spider	-	2	2	**4**	3	3	**6**
Comb-footed Spider	*Sp.1*	3	3	**6**	5	2	**7**
Comb-footed Spider	*Sp.2*	2		**2**			
Insects							
Damselfly	*Argia telesfordi*	3	2	**5**	5	3	**8**
Rubyspot Damselfly	*Hetaerina sp.*		4	**4**			
Damselfly (Larva)	-				7	1	**8**
Red-faced Dragonlet	*Erythrodiplax fusca*	2	5	**7**	2	4	**6**
Dragonfly (Adult)	-				1		**1**
Dragonfly (Larva)	-					1	**1**
Cicada	-					1	**1**
Short-horned Grasshopper	-	49	45	**94**	47	57	**104**
True Cricket	-	1	3	**4**	2	3	**5**
Bush Cricket / Katydid	-	18	20	**38**	11		**11**
Cockroach	*Blatta sp.*		4	**4**			
Termite	-		>102	**>102**	>300	>301	**>601**
Mosquito (Larva)	-		>20	**>20**		>20	**>20**
Stick Insect	-					1	**1**
Beetle Larva	-				2		**2**
Ground Beetle	-				1	1	**2**
Weevil	-	1	2	**3**			
Passalid Beetle	-	1		**1**	2		**2**
Dug Beetle / Scarab Beetle	-	3	1	**4**	4	3	**7**
Chafer Beetle	-		1	**1**			
Leaf-footed Bug	-	18	28	**46**	22	21	**43**
Meadow Bug	-				3	1	**4**
Shield Bug / Stink	-		1	**1**			

Common Name	Scientific Name	Site C			Site F		
		DS	WS	Total	DS	WS	Total
Bug							
Assassin Bug	-	12	5	**17**			
Carpenter Ant	*Camponotus sp.*	>85	>92	**>177**	7	>85	**>92**
Cock-tail Ant	*Crematogaster sp.*	>83	>86	**>169**	>42	>42	**>84**
Fire Ant	*Solenopsis sp.*	>86	>97	**>183**	>89	>91	**>180**
Trap-jaw Ant	*Odontomachus sp.*	12	16	**28**	11	10	**21**
Maribone Wasp	*Polybia occidentalis*	>80	>80	**>160**	>80	>80	**>160**
Cohong / Armadillo Wasp	*Synoeca sp.*	>80	>80	**>160**	>80	>80	**>160**
Yellow Paper Wasp	*Polistes versicolor*		>80	**>80**			
Wollybear Moth	*Spilosoma sp.*	32	25	**57**	8	14	**22**
Lesser Whirlabout	*Polites dictynna*	26	18	**44**		2	**2**
Skipper	*Polites sp.*		2	**2**			
Orcus Checkered Skipper	*Pyrugus orcus*					5	**5**
Long-tail Skipper	*Chioides vintra*		2	**2**			
Flambeau	*Dryas iulia*		5	**5**	14	16	**30**
Scarlet Peacock	*Anartia amathea*	50	16	**66**	17	18	**35**
Stinky Leafwing / Orion Cecropian	*Historis odius*				1		**1**
White Crescent	*Janatella leucodesma*		5	**5**		3	**3**
White Peacock	*Anartia jatrophae*		8	**8**			

Note: This summary table does not include opportunistic sightings

3.1.5 Amphibians and Reptiles

At both Sites C and F, during both the Dry and Wet Season surveys, one species of lizard (Grenada Tree Anole [*Anolis richardii*]) and two species of frogs (Lesser Antillean Frog [*Eleutherodactylus johnsonei*] and Windward Island Ditch Frog [*Leptodactylus validus*]) were recorded (see Tables 3-7 to 3-10, Appendix 1 and Photographs 3-180 to 3-187, Appendix 4). One unidentified species of Snake was captured on the Camera Trap at Site F in April, 2019. The abundance of these species are as follows:

Common Name	Scientific Name	Site C			Site F		
		DS	WS	Total	DS	WS	Total
Reptiles							
Grenada Tree Anole / Giant Crown Anole	*Anolis richardii*	41	38	**79**	47	>52	**>99**
Unidentified Snake	-	1		**1**	1		
Amphibians							
Lesser Antillean Frog	*Eleutherodactylus johnsonei*	5	4	**9**	3	5	**8**
Windward Islands Ditch Frog	*Leptodactylus validus*	3	3	**6**	2	2	**4**

Note: This summary table does not include opportunistic sightings

3.1.6 Aquatic Species

At Site C, for the combined Wet and Dry Season surveys, one species of fish was recorded (Suckstone [*Sicydium sp.*)]) and three species of crustaceans (Atyid Shrimp [*Jonga serrei*], Crayfish [*Macrobrachium sp*.] and Manicou Crab [*Guinotia dentate*]) belonging to three families were observed. One species of mollusc, the Red-rimmed Melania (*Melanoides tuberculata*) and four species of insects belonging to four families were also observed.

At Site F, for the combined Wet and Dry Season surveys the following aquatic fauna were observed: one fish species (Jumping Guabine [*Anablepsoides hartii*]), one species of crustacean (Atyid Shrimp [*Jonga serrei*]) and 7 species of insects belonging to 7 families (see Section 3.1.4 above). The abundance of these species are summarized as follows:

Common Name	**Scientific Name**	**Site C**			**Site F**		
		DS	**WS**	**Total**	**DS**	**WS**	**Total**
Fish							
Suckstone / Titiri / Titi	*Sicydium sp.*	2	1	**3**			
Jumping Guabine / Rivulus	*Anablepsoides hartii*				1	2	**3**
Crustaceans							
Atyid Shrimp	*Jonga serrei*	9	11	**20**	2	1	**3**
Crayfish	*Macrobrachium sp.*	2	1	**3**			
Manicou Crab	*Guinotia dentata*	1	1	**2**			
Insects							
Water Strider	-	5	9	**14**	8	3	**11**
Smaller Water Strider	-	13	>20	**>33**	16	5	**21**
Whirligig Beetles	-		7	**7**	13	3	**16**
Stonefly (Larva)	-				3	2	**5**
Molluscs							
Red-rimmed Melania	*Melanoides tuberculata*	11	7	**18**			

Tables 3-7 to 3-10 in Appendix 1 and Photographs 3-188 to 3-203 in Appendix 4, provide the detailed results of the survey methods employed.

3.2. Results of Interviews with Local People

Based on interviews with persons Nutmeg, Cocoa and Coconut play an important role in farmers' livelihood. Several other species were listed as important, as they contribute to ensuring that the plantations are successful, these include trees that are used as windbreaks. The results of the Ecosystem Services interviews are presented in Tables 3-8 and 3-9 in Appendix 2.

With respect to faunal species, the Common Opossum and Armadillo are the most hunted species in the area. Hunting season usually runs from October to December, but some hunters tend to hunt during off season as well. Based on informal interviews with farmers at Site C, hunting was prevalent in Tricolar, however, in recent years, persons seldom hunt in the area, primarily due to the issue of trespassing on private lands. At Site F, hunting is prevalent in the area, throughout the year.

4. Discussion

4.1 Site C

4.1.1 Habitats and Flora

At Site C, the proposed drill pad (the area between 120 m x 90 m) supported agricultural land with crop species such as pepper, cabbage and pumpkin. The surrounding area is described as pasture/cultivated land, which included a variety of grasses (Guinea Grass [*Panicum maximum*]); Para Grass [*Brachiaria mutica*]; Bamboo Grass [*Arthrostylidium excelsum*] and Palm Grass [*Setaria palmifolia*]) (see Photographs 3-2 and 3-25, Appendix 4) of which several farmers use as fodder for livestock. During the site surveys, several cows and donkeys were noted grazing in the area. In addition, several farmers often cut these grasses and take to their animals outside of the study area. Extending away from the proposed drill pad, and within the 500 m radius, the vegetation can be described as mixed agriculture (herbaceous and woody crops), with Nutmeg being the major crop on the site (see Photograph 3-20). The trees were not fully mature. In some areas, the plots were well maintained, while in other areas, the plots were observed to be overgrown. Specifically, during the wet season, it was noted a thicker understory in some of the plots. This was attributed to increased rainfall (wet season), typically experienced by tropical Caribbean countries such as Grenada. Among the agricultural plots, a large number Bois Canot and Bamboo trees were interspersed. Bamboo (*Bambusa vulgaris*) and Bois Canot (*Cecropia schreberiana*) are known to be native invasive species, known to establish themselves in areas of disturbance. Based on discussions with some farmers in the area, the site was once a thriving nutmeg plantation, however, with the passage Hurricane Ivan in 2004, the entire plantation was severely hit, and over 90% of the nutmeg trees were lost. The establishment of the aforementioned invasive species, as well as the maturity of the Nutmeg trees are indicative of a previous large scale disturbance, and the present efforts to re-establish agroforestry in the area.

Of the plant species identified on the site, the Mountain Cabbage (*Euterpe dominicana*) and the herb *Lobelia cordifolia* are considered near Endemics to the Lesser Antilles (including Grenada) (Hawthorne, 2004) and Almost Endemic - Endangered (according to Grenada's National List of Threatened Species, 2014). Pigeon Pea (*Cajanus cajan*) is considered near threatened (IUCN, 2019). Ferns observed on site were identified down to the Lowest Possible Identifiable Level (lpil), and based on these; none had international or national conservation importance. All other plant species did not have any conservation statuses or were categorized as Least Concern under the IUCN Red List.

4.1.2 Avifauna

In total 18 avifauna species were recorded at Site C. The majority of species at were common year-round residents. According to Raffaele, *et. al.* (2003), the Lesser Antillean Tanager (*Tangara cucullata*), Yellow Crowned Night Heron (*Nyctanassa violacea*) and Little Blue Heron (*Egretta caerulea*), are listed as uncommon residents and the Barn Owl (*Tyto alba insularis*) is a rare resident in Grenada. The Tropical Kingbird (*Tyrannus melancholicus*) is a rare and irregular migrant to Grenada while the Orange-winged Parrot (*Amazona Amazonica*) [Sites C&F] is an introduced species. Generally, the species encountered were associated with one or more of the habitat types (*i.e.* Mixed Agriculture, Mixed Forest and Riverine vegetation) present in the study area. Exceptions to this were the Rufous Breasted Hermit (*Glaucis hirsuta*), Scaley-naped Pigeon (*Columba squamosa*) and the Zenaida Dove (*Zenaida aurita*) which inhabit forested areas and the Little Blue Heron and the Yellow Crowned Night Heron which are found in riverine and marshy habitats.

All birds observed at Site C were classified as 'Least Concern' based on the IUCN Red List. None of the birds listed on Grenada's List of Threatened Species (2014) were observed at Site C. In general, the same species were recorded for both the Wet and Dry Seasons with the exception of the Little Blue Heron and the Yellow Crowned Night Heron which were recorded only in the Dry Season and the Tropical Kingbird and the Spectacled Thrush (*Turdus nudigenis*) which were observed only in the Wet Season. The Little Blue Heron Yellow Crowned Night Heron and Spectacled Thrush are common year-round residents (Raffaele, *et. al.,* 2003) therefore their absence during a sampling period maybe due to these species not being present at the time of sampling as opposed to seasonal variations. Avifaunal activity, as indicated by number of individuals observed, was higher during the Wet Season sampling. This can be attributed to the occurrence of cool, overcast conditions (associated with the Wet Season) which are conducive to increased activity.

4.1.3 Mammals

Three species of mammals were recorded at Site C. With the exception of the Robinson's Mouse Opossum (*Marmosa robisoni*), which is locally uncommon to rare (University of the West Indies, 2018), all species were locally common (University of the West Indies, 2018). The Common Opossum (*Didelphis marsupiallis*) and the Small Indian Mongoose are habitat generalist, occurring in a range of habitats – pasture, mixed woody agriculture and secondary forest. In contrast, the Robinson's Mouse Opossum was observed in the forested areas of the site. The Small Indian

Mongoose is native to South Asia, and was introduced to the Caribbean Islands to help control rats and snakes (University of the West Indies, 2018). Overtime, they became invasive, and based on informal interviews with farmers on site, they destroy most of the crops on site. The differences in Dry and Wet Season abundances can be attributed to the sampling effort employed, as Camera Traps were used in the Dry Season which recorded all of the mammals on the respective sites.

All species with the exception of the introduced Small Indian Mongoose (*Herpestes auropunctatus*) are residents and are listed as 'Least Concern' on the IUCN Red List. The Robinson's Mouse Opossum is listed as endangered on Grenada's National List of Threatened Species (2014).

4.1.4 Terrestrial Invertebrates

In terms of terrestrial invertebrates, a total of 47 species belonging to 33 families were found at Site C. All species were resident to Grenada. The Damselfly (*Argia telesfordi*) was listed as an endemic species in Grenada (Meurgey, 2009) and was present at this site. There was no other information available concerning the national and international statuses of these invertebrates. The species recorded were habitat generalists and were generally observed in most of the habitats associated with the Site. Species abundance for Dry and Wet Seasons were generally comparable with the exception of some butterfly species that appeared to be more abundant in the Wet Season. The reason for this apparent increase in abundance has not been determined but can be attributed to seasonal changes at the sites such as availability of host plants *et cetera.*

4.1.5 Amphibians and Reptiles

One species of lizard and two species of frogs were recorded at Site C, all of which are locally common. With the exception of the introduced Lesser Antillean Frog (*Eleutherodactylus johnsonei*), the other herpetofauna species were resident species. The Windward Island Ditch Frog (*Leptodactylus validus*) is listed as 'Least Concern' on the IUCN Red List while the other species are not listed. The Grenada Tree Anole (*Anolis richardii*) did not exhibit a habitat preference and was found on trees while both species of frogs were found near to the watercourses. There were no significant seasonal differences in species abundance.

None of the amphibian and reptile species observed on site were listed on Grenada's National List of Threatened Species (2014).

4.1.6 Aquatic Fauna

Nine resident species of aquatic fauna including one fish species, three species of crustaceans, one species of molluscs and four insect species were recorded at Site C. All species were commonly associated with watercourses of Grenada. With the exception of the Atyid Shimp which is listed as 'Least Concern' on the IUCN Red List, there were no national or international conservation statuses available for the species observed. Generally, there were no seasonal differences in species abundance, the exception being Small Water Striders which were more prevalent in the Wet Season.

4.2 Site F

4.2.1 Habitats and Flora

A portion of the 500 m radius around Site F lies within a Key Biodiversity Area (see Figure 2-3). Within the 500 m radius surveyed, the western portion and south western portion can be described as agricultural, with crops such as citrus, cocoa and banana (see Photographs 3-56, 3-62, 3-79, 3-80, 3-83, 3-87, 3-97 and 3-98). Within the limits of the proposed drill pad, the vegetation can be described as modified, as indicative of abandoned woody agricultural trees, and overgrown grasses. Based on observations, the area was once under banana and citrus cultivation, but the trees are not maintained, and have now become overgrown. Along the southern transect, closer to the watercourse, several species of ferns were observed. This is considered typical to tropical regions, as ferns prefer moist habitats. None of the fern species identified on site had any international (IUCN) or local (Grenada List of Threatened Species) conservation status.

The northern, eastern and south eastern portions of the 500 m radius can be described as secondary forest, as indicative of taller, mature species (including several native and introduced hardwood species) (see Photographs 3-60, 3-64, 3-70, 3-84 to 3-86 and 3-88). None of the fern species identified on site had any international (IUCN) or local (Grenada List of Threatened Species) conservation status.

Of the plant species identified on the site, the Mountain Cabbage (*Euterpe dominicana*), the herb *Lobelia cordifolia,* Siguine Batard (*Asplundia insignis*), Monkey Paws Vines (*Marcgravia umbellate*) and *Psychotria muscosa* are considered near Endemics to the Lesser Antilles (including Grenada) (Hawthorne, 2004). There were no identified plant species recorded on site that had national conservation importance (were not listed on Grenada's National List of Threatened Species, 2014). All other plant species did not have any conservation statuses or were categorized as Least Concern under the IUCN Red List.

4.2.2 Avifauna

In total 19 avifauna species were recorded at Site F. The majority of species were common year-round residents. As mentioned previously, the Lesser Antillean Tanager (*Tangara cucullata*) and the Little Blue Heron (*Egretta caerulea*) are listed as uncommon residents and the Barn Owl (*Tyto alba insularis*) and Hook-billed Kite (*Chondrohierax uncinatus mirus*) are rare residents in Grenada (Raffaele, *et. al.,* 2003). The Tropical Kingbird (*Tyrannus melancholicus*) is a rare and irregular migrant to Grenada while the Orange-winged Parrot (*Amazon*) is an introduced species.

Similar to the species recorded at Site C, the majority of birds at Site F were habitat generalists that inhabited a variety of modified habitats. Exceptions to this included forest species such as the Rufous-breasted Hermit (*Glaucis hirsuta*) which was observed in forested areas and water-birds such as the Little Blue Heron which was observed in proximity to the watercourses. There was increased avifaunal activity during the wet season which was probably due to the prevalence of cool, overcasts conditions.

In general, the same species were recorded for both the Wet and Dry Seasons with the exception of the Little Blue Heron and the Broad Winged Hawk (*Buteo platypterus*) which were recorded only in the Dry Season and the Barn Owl and the Smooth Billed Ani (*Crotophaga ani*) which were observed only in the Wet Season. These four species are common year-round residents therefore, as discussed previously, their absence during a sampling period maybe due to these species not being present at the time of sampling as opposed to seasonal variations. Similarly to Site C, avifaunal activity was higher during the Wet Season sampling and was probably due to overcast conditions.

With the exception of the Hook-billed Kite (*Chondrohierax uncinatus mirus*), all birds observed at Site F were classified as 'Least Concern' based on the IUCN Red List. The Hook-billed Kite subspecies is not listed on the IUCN Red List, but it is endemic to Grenada (Hawthorne, 2004) and is considered to be endangered according to Grenada's National List of Threatened Species, 2014.

4.2.3 Mammals

Three four species of mammals were recorded at Site F. All species with the exception of the introduced Small Indian Mongoose (*Herpestes auropunctatus*) were residents and are listed as 'Least Concern' on the IUCN Redlist. With the exception of the Robinson's Mouse Opossum (*Marmosa robisoni*), which is locally uncommon to rare, all species were locally common. The Common Opossum (*Didelphis marsupiallis*) and the Small Indian Mongoose are habitat generalist while the Robinson's Mouse Opossum and the Nine-banded Armadillo were observed in the forested areas of the site. Differences in Dry and Wet Season abundances are as a result of

Camera traps only be used in the Dry Season. As mentioned previously, the Small Indian Mongoose is native to South Asia, and was introduced to the Caribbean Islands to help control rats and snakes (University of the West Indies, 2018). Overtime, they became invasive, and based on informal interviews with farmers on site, they destroy most of the crops on site.

Unidentified bats were also observed during the night surveys during both seasons. In addition, Nine-banded Armadillo (*Dasypus novemcinctus*) tracks (see Photograph 3-74) and nests, possibly belonging to Robinson's Mouse Opossum (*Marmosa robisoni*) (see Photograph 3-75), were observed at Site F (along Transect F1) during both Seasons. Apart from the camera traps, the Small Indian Mongoose (*Herpestes auropunctatus*), was observed opportunistically during both Dry and Wet Season Surveys. The Nine-banded Armadillo is locally common and is classified as 'Least Concern' on the IUCN Red List. It is not listed on Grenada's List of Threatened Species. This species is found mainly in forested area. Of the mammals observed on site, only the Robinson's Mouse Opossum was listed as Endangered on Grenada's National List of Threatened Species (2014).

4.2.4 Terrestrial Invertebrates

In term of terrestrial invertebrates, a total of 44 species belonging to 29 families were found at Site F; all of which were resident to Grenada. The Damselfly (*Argia telesfordi*) was listed as an endemic species in Grenada (Meurgey, 2009) and was present at Site F. As mentioned previously, there was no other information available concerning the national and international statuses of these invertebrates. The species recorded were habitat generalists and were generally observed in most of the habitats associated with the Site. Similar to Site C, species abundance for Dry and Wet Seasons were generally comparable with the exception of some butterfly species that appear to be more abundant in the Wet Season; the reason for this apparent increase in abundance has not been determined but maybe due to seasonal changes at the sites such as availability of host plants *et cetera.*

4.2.5 Amphibians and Reptiles

One species of lizard, two species of frogs and one unidentified snake were recorded at Site F, all of which are locally common. As discussed previously, with the exception of the introduced Lesser Antillean Frog (*Eleutherodactylus johnsonei*), the other herpetofauna were resident species. The Windward Island Ditch Frog (*Leptodactylus validus*) is listed as 'Least Concern' on the IUCN Red List while the other species are not listed. The Grenada Tree Anole (*Anolis richardii*) did not exhibit a habitat preference and was found on trees while both species of frogs were found near to the watercourses. There were no significant seasonal differences in species abundance.

None of the amphibian and reptile species observed on site were listed on Grenada's National List of Threatened Species (2014).

4.2.6 Aquatic Fauna

Nine resident species of aquatic fauna including one fish species, one species of crustacean and seven insect species were recorded at Site F. All species were commonly associated with watercourses of Grenada. As discussed previously, with the exception of the Atyid Shimp which is listed as 'Least Concern' on the IUCN Red List, there was no national (Grenada National List of Threatened Species) or international conservation statuses available for the species observed. Generally, there were no seasonal different in species abundance, the exceptions being Small Water Striders and Whirligig Beetles which were more prevalent in the Wet Season.

5. Recommendations

5.1. Mitigation

With respect to valuable/sensitive habitats, protected, threatened, endemic/restricted-range, migratory species, no specific mitigation measures are required.

The Mountain Cabbage Palm is listed as 'Almost Endemic – Endangered' according to Grenada's National List of Threatened Species. This Palm was observed at Sites C and F, but significantly away from the proposed drill pad. Therefore, they will not be removed to accommodate the proposed drilling activities. As such, no specific mitigation measures are recommended for this species. Notwithstanding, and based on discussions with Grenada's Forestry Division, it is recommended that consultations be held with the Forestry Division when trees are to be removed to facilitate the drilling works.

The Robinson's Mouse Opossum is listed as 'Endangered' according to Grenada's National List of Threatened Species, and was observed at both Sites C and F. These nocturnal species occur in forested areas. The proposed drill pad will be in an areas of pasture/mixed agriculture, and therefore, it is unlikely that the habitat of the Robinson Mouse Opossum will be removed or physically altered. However, these species can be affected by noise and light (if drilling is to occur during the night) associated with drilling activities. It is therefore recommended that noise control be implemented during the drilling phase. In addition, if night works is to occur, the following can be implemented:

- Use the minimum intensity of light that can be safely used for night work;
- Avoid the use of bare or upturned bulbs; and
- Orient light such that it focuses away from forested areas.

The Hook-Billed Kite is an endemic species to Grenada and listed as 'Endangered' on their National List of Threatened Species. The Hook-Billed Kite was observed feeding at Site F, in the agricultural areas (approximately 250 m west of the proposed drill pad). They are known to feed on snails in the area. They have a range of nesting areas (deciduous, evergreen and montane forests above 400 m) (Throrstrom and Mc. Queen, 2008). During the 2019 field surveys, no nests were observed. During the drilling phase of the project, it is likely that this species will be affected by noisy works. However, Site F is part of a larger forested estate and as such it is expected that the Hooked Bill Kite will be able to feed in similar contiguous areas and their functioning may only be impaired for a short period (during the drill phase) until they re-establish themselves in adjacent suitable areas. Other than implementing adequate noise controls during drilling, no further mitigation measures are recommended.

5.2. Further Surveys and Monitoring

No further surveys and monitoring are required as part of this study.

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7. Appendices

Appendix 1: Maps and Tables

Figure 2-1, 2-2, 2-3, 2-4 and 2-5

Species Tables and Lists

Table 2-1: GPS Coordinates of Transects, Quadrats and Faunal Survey Locations.

COMPONENT	LATITUDE	LONGITUDE	DESCRIPTOR
Vegetation			
Site C	12.181503	-61.663272	Centre of drilling pad
Transect C1 (Start)	12.181503	-61.663272	Length of transect: approximately 400 m heading north
Transect C1 (End)	12.185119	-61.663254	
Quadrat C1a	12.181503	-61.663272	
Quadrat C1b	12.183311	-61.663263	
Quadrat C1c	12.184364	-61.663219	
Quadrat C1d	12.185119	-61.663254	
Transect C3 (Start)	12.181503	-61.663272	Length of transect: approximately 500 m heading south
Transect C3 (End)	12.176982	-61.663295	
Quadrat C3a	12.181503	-61.663272	
Quadrat C3b	12.179694	-61.663281	
Quadrat C3c	12.178790	-61.663286	
Quadrat C3d	12.176982	-61.663295	
Transect C2 (Start)	12.181503	-61.663272	Length of transect: approximately 400 m heading east
Transect C2 (End)	12.181485	-61.659596	
Quadrat C2a	12.180962	-61.662484	
Quadrat C2b	12.180895	-61.661734	
Quadrat C2c	12.180943	-61.660386	
Quadrat C2d	12.181485	-61.659596	
Quadrat C4 (Start)	12.181503	-61.663272	Length of transect: approximately 400 m heading west
Quadrat C4 (End)	12.181525	-61.667867	
Quadrat C4a	12.181507	-61.664191	
Quadrat C4b	12.181516	-61.666029	
Quadrat C4c	12.181520	-61.666948	
Quadrat C4d	12.181525	-61.667867	
Site F	12.154310	-61.692281	Centre of drilling pad
Transect F1 (Start)	12.154310	-61.692281	Length of transect: approximately 300 m heading north
Transect F1 (End)	12.157023	-61.692267	
Quadrat F1a	12.154310	-61.692281	
Quadrat F1b	12.155251	-61.692274	
Quadrat F1c	12.156075	-61.692084	
Quadrat F1d	12.157008	-61.692262	
Transect F2 (Start)	12.154310	-61.692281	Length of transect: approximately 400 m heading east
Transect F2 (End)	12.154293	-61.688605	
Quadrat F2a	12.154300	-61.692036	
Quadrat F2b	12.154306	-61.691362	
Quadrat F2c	12.154283	-61.690574	

COMPONENT	LATITUDE	LONGITUDE	DESCRIPTOR
Quadrat F2d	12.154312	-61.689577	
Quadrat F2e	12.154299	-61.688613	
Transect F3 (Start)	12.154310	-61.692281	Length of transect: approximately 140 m heading south, after which it became a wandering transect along the watercourse
Transect F3 (End)	12.152172	-61.693482	
Quadrat F3a	12.154310	-61.692281	
Quadrat F3b	12.153477	-61.692297	
Quadrat F3c	12.152502	-61.692289	
Quadrat F3d	12.152463	-61.692815	
Transect F4 (Start)	12.154310	-61.692281	Length of transect: approximately 500 m heading west
Transect F4 (End)	12.154332	-61.696875	
Quadrat F4a	12.154315	-61.693199	
Quadrat F4b	12.154323	-61.695037	
Quadrat F4c	12.154328	-61.695956	
Quadrat F4e	12.154332	-61.696875	
Camera Traps			
Camera F1 (March)	12.154779	-61.691966	Secondary Forest
Camera F2 (March)	12.153867	-61.692292	Uphill site in secondary forest
Camera F1 (April)	12.153983	-61.689856	Uphill site in secondary forest
Camera F2 (April)	12.152532	-61.694754	Near a Stream. Surrounding Vegetation is Secondary Forest
Camera C1 (March)	12.180398	-61.662993	On a stream behind an old weir. Surrounding vegetation is nutmeg plantation and banana
Camera C2 (March)	12.181353	-61.662179	Secondary Forest
Camera C1 (April)	12.182813	-61.662320	Near wetland area, surrounding area is Nutmeg Plantation
Camera C2 (April)	12.179486	-61.663435	Uphill nutmeg plantation
Pitfall Traps			
Pitfall C1	12.179894	-61.663545	Near the watercourse - surrounding area is agroforestry, mostly nutmeg and christophene
Pitfall C2	12.182813	-61.662320	Secondary Forest
Pitfall C3	12.179486	-61.663435	Mixed Woody Agriculture - primarily nutmeg trees
Pitfall C4	12.181543°	-61.659948°	Mixed woody Agriculture
Pitfall C5	12.177208°	-61.663366°	Secondary Forest
Pitfall C6	12.181566°	-61.666679°	Cultivated Land
Pitfall C7	12.182171°	-61.663267°	Pasture Land
Pitfall F1	12.154188	-61.693295	Secondary Forest - mostly bamboo
Pitfall F2	12.153805	-61.690302	Edge of grassland and secondary forest
Pitfall F3	12.152532	-61.694754	Near the watercourse - surrounding area is secondary forest
Pitfall F4	12.152930°	-61.695629°	Along edge of Watercourse
Pitfall F5	12.151706°	-61.694464°	Along edge of Watercourse

COMPONENT	LATITUDE	LONGITUDE	DESCRIPTOR
Pitfall F6	12.154279°	-61.692203°	Mixed Woody Agriculture (abandoned)
Pitfall F7	12.156878°	-61.692275°	Secondary Forest
Pitfall F8	12.154322°	-61.695481°	Mixed woody agriculture)
Bird Counts (Fixed Point)			
BC-C1	12.181334	-61.663852	Along the roadway near the Farmer's hut - agroforestry and grassland
BC-C2	12.180282	-61.663168	Near the river, surrounding vegetation is agroforestry
BC-F1	12.153865	-61.694190	Agroforestry - primarily cocoa, citrus and banana
BC-F2	12.154193	-61.690105	Edge between grassland and secondary forest
Aquatic Surveys / Amphibian Surveys			
AS-C1 (Start)	12.179905	-61.663749	Along the watercourse
AS-C2 (End)	12.180282	-61.663168	
AS-F1 (Start)	12.152163	-61.693274	Along the watercourse
AS-F1 (End)	12.151582	-61.694619	

Table 3-1: Plant Species Recorded At Site C

Source: Hawthorne, 2004, Grenada's National Red List of Threatened Species, 2014 and IUCN, 2019

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL	
ACANTHACEAE	Mini Root / Bluebell / Snapdragon Root	*Ruellia tuberosa*	Herb					✔	Not Listed	Not Listed	Tea from shoots, flowers and tubers is used to treat cold, fevers and hypertension.
	Rock Balsam	*Blechum pyramidatum*	Herb				✔		Not Listed	Not Listed	Used as a poultice for wounds.
ANACARDIACEAE	Mango	*Mangifera indica*	Tree	✔					Not Listed	Not Listed	Cultivated for its edible fruit. Extracts from the leaves and bark can be used to relieve toothaches and sore gums.
	Pommecythere / Golden Apple	*Spondias cytherea*	Tree		✔	✔			Not Listed	Not Listed	Cultivated for edible fruit which is used in jams, juice, wine, chutney and pickles.
ANNONACEAE	Cherimoya	*Annona cherimola*	Tree				✔		Not Listed	Least Concern (IUCN)	Cultivated for fruit.
ARACEAE	Dasheen / Taro / Callaloo	*Colocasia esculenta*	Herb	✔	✔	✔	✔		Not Listed	Least Concern (IUCN)	Cultivated for export; edible leaves and corm.
	Tannia	*Xanthosoma sagittifolium*	Herb	✔	✔				Not Listed	Not Listed	Cultivated for export; edible leaves and corm.
	Tayo	*Xanthosoma sp.*	Herb	✔	✔				Not Listed	Not Listed	Cultivated mainly for edible corm.
	Swiss Cheese Plant	*Monstera adansonii*	Vine					✔	Not Listed	Not Listed	Has value as an ornamental. Ripe fruit is edible.
	Philodendron Vine	*Philodendron sp.1*	Vine			✔			Not Listed	Not Listed	Has value as an ornamental.
	Philodendron Vine	*Philodendron sp.2*	Vine			✔			Not Listed	Not Listed	Has value as an ornamental.
ARECACEAE	Coconut	*Cocos nucifera*	Palm	✔	✔		✔		Not Listed	Not Listed	Variety of uses including: consumption (coconut water, jelly, milk, copra, oil *etc.*); fibrous husks used for 'coir' mats and shredded for use in gardening; jewellery, shack-shacks (i.e. maracas) *etc.* from the

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				C1	C2	C3	C4		National	International	
											shells; leaflets made into mats, belts, cocoyea brooms *etc.*
	Royal Palm	*Roystonea oleracea*	Palm	✔		✔			Not Listed	Not Listed	Ornamental species. Other uses include thatch, timber and livestock feed. The palm heart is edible.
	Mountain Cabbage	*Euterpe dominicana*	Palm				✔		Near Endemic – found on the mountains of Grenada, Dominica and St Vincent. Almost Endangered	Not Listed	Has value as an ornamental. Palm heart / 'cabbage' (i.e. young shoots and leaves) are eaten; this results in the loss of the entire tree.
	Mountain Palm	*Prestoea acuminate* var. *montana*	Palm			✔			Not Listed	Not Listed	Shoots and young leaves are edible.
ASTERACEAE	Wild Marigold	*Wedelia calycina*	Shrub					✔	Not Listed	Not Listed	-
	Railway Daisy / Creeping Daisy	*Wedelia trilobata*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used to treat coughs and colds.
	Shepard's Needles	*Bidens pilosa*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used in other places to treat colds, earaches, inflamed eyes and difficulty in urination.
	West Indian Beggarticks	*Bidens cynapiifolia*	Herb	✔			✔		Not Listed	Not Listed	-
	Shaving Bush	*Emilia fosbergii*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used as fodder for small livestock.
	Shaving Bush	*Emilia sonchifolia*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used in other places to treat eye inflammation, cuts, earaches, tooth decay, bowel issues and diarrhoea.
	Iron Weed	*Vernonia sp.*	Herb					✔	Not Listed	Not Listed	-
	Dandelion / Wild Gerbera	*Gerbera sp.*	Herb					✔	Not Listed	Not Listed	-
	Goatweed	*Ageratum conyzoides*	Herb		✔				Not Listed	Least Concern	Used in other places top treat fevers, headaches, colic and rheumatism.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL (IUCN)	
	Cinderella Weed	*Synedrella nodiflora*	Herb					✔	Not Listed	Not Listed	Used in other places to treat rheumatism and arthritis and as a laxative.
BIXACEAE	Roucou / Annatto	*Bixa orellana*	Tree					✔	Not Listed	Not Listed	Used to colour oil-down in Grenada. Elsewhere it is a commercial source of Annatto. Has use as a natural insect repellent
BOMBACACEAE	Wild Breadnut / Cacao Sauvage	*Pachira insignis*	Tree					✔	Not Listed	Not Listed	Bark is used as bait for cocoa beetles and as a fever treatment. Edible seeds can be eaten raw or roasted.
	Bois Flot / Balsa	*Ochroma pyramidale*	Tree			✔			Not Listed	Not Listed	One of the lightest weight commercial woods.
BRASSICACEAE	Cabbage	*Brassica oleracea* var. capitata				✔	✔		Not Listed	Not Listed	Cultivated for edible leaves.
	Pak Choi / Bok Choy	*Brassica rapa* var. *chinensis*			✔				Not Listed	Not Listed	Cultivated for edible leaves.
BROMELIACEAE	Pineapple	*Ananas comosus*					✔		Not Listed	Not Listed	Cultivated for fruit.
CAMPANULACEAE	-	*Lobelia cordifolia*	Herb				✔		Endemic to the Lesser Antilles (Grenada, St. Kitts, Dominica, St. Lucia and St. Vincent).	Not Listed	
CANNABACEAE	Marijuana	*Cannabis sativa*	Shrublet		✔				Not Listed	Not Listed	Used to treat arthritis and asthma. Also, used to get rid of bedbugs.
CARICACEAE	Pawpaw	*Carica papaya*	Tree				✔		Not Listed	Data Deficient (IUCN)	Cultivated for its fruit. Sap contains papain which is used to tenderize meat and coagulate milk. Young shoots and seeds are edible.

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				C1	C2	C3	C4		National	International	
											Extract from leaves is used to treat burns and fever and 'ague' associated with Dengue and Chikungunya. Leaves may be smoked to relieve asthma.
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*		✔	✔	✔	✔		Not Listed	Not Listed	Young buds are edible. Tea is used for cold and hypertension.
CLEOMACEAE	Acaya / Masambay	*Cleome aculeata*	Herb				✔		Not Listed	Not Listed	-
CLUSIACEAE	Galba	*Calophyllum calaba*	Tree				✔		Not Listed	Not Listed	Hardwood, often planted as a wind-break, used to make furniture and huts. Bark has medicinal value.
COMMELINACEAE	Caner Grass	*Commelina elegans*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used as a 'cooling' infusion and for animal fodder.
	Caner Grass	*Commelina diffusa*	Herb		✔				Not Listed	Not Listed	Used as a 'cooling' infusion and for animal fodder.
CONCOLVULACEAE	Wild Potato Vine	*Ipomoea tiliacea*	Vine	✔	✔	✔	✔		Not Listed	Not Listed	Tubers are edible.
COSTACEAE	Wild Ginger	*Costus speciosus*	Herb	✔	✔				Not Listed	Not Listed	Ornamental species. Used elsewhere to treat cough, asthma, dysmenorrhea, skin issues and intestinal parasites.
	Wild Ginger	*Costus scaber*	Herb	✔	✔				Not Listed	Not Listed	Ornamental species. Used as part of a remedy to treat snakebites in other places.
CUCURBITACEAE	Pumpkin	*Cucurbita maxima*	Vine			✔			Not Listed	Not Listed	Cultivated for edible fruit.
	Cucumber	*Cucumis sativus*	Vine			✔			Not Listed	Not Listed	Cultivated for edible fruit.
	Christophene	*Sechium edule*	Vine				✔		Not Listed	Not Listed	Cultivated for edible fruit.
CYATHEACEAE	Tree Fern	*Cyathea tenera*	Fern			✔		✔	Not Listed	Not Listed	-
CYPERACEAE	-	*Cyperus kyllingia*	Sedge	✔	✔	✔	✔		Not Listed	Least Concern (Encyclopaedia of life)	Used in other places as animal fodder and to treat fever, ulcers, sore throat, diarrhoea and skin problems. Used as a diuretic and abortifacient.
	Nut Grass	*Cyperus rotundus*	Sedge	✔	✔	✔			Not Listed	Least	Used in other places to treat

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				C1	C2	C3	C4		National	International	
										Concern (IUCN)	diarrhoea, diabetes, fever, inflammation, stomach issues and malaria.
	Umbrella Flatsedge	*Cyperus alternifolius*	Sedge		✔				Not Listed	Least Concern (IUCN)	Has value as an ornamental species, especially in aquatic settings such as around ponds.
	Finger Flatsedge	*Cyperus digitatus*	Sedge		✔				Not Listed	Least Concern (IUCN)	In other places it is used to make mats and baskets, to treat colds and to make perfume.
DILLENIACEAE	Water Vine	*Doliocarpus sp.*	Vine			✔			Not Listed	Not Listed	Used as a source of water by persons (e.g. hikers) in the forest. In the other places, this sap is used as an anti-inflammatory.
DIOSCOREACEAE	Yam / Kush Kush	*Dioscorea alata*	Vine	✔			✔		Not Listed	Not Listed	Important root crop. Has pharmaceutical applications elsewhere; contains a natural 'steroid precursor' used in the manufacturing of certain steroids and corticosteroids.
DRACAENACEAE	Dragon Tree / Boundary Plant	*Dracaena sp.*	Shrub			✔			Not Listed	Not Listed	Used as boundary markers on estates.
DRYOPTERIDACEAE	Shield Fern	*Polybotrya sp.*	Fern		✔		✔		Not Listed	Not Listed	Potentially an ornamental species.
	Shield Fern	*Dryopteris sp.*	Fern		✔	✔	✔		Not Listed	Not Listed	Potentially an ornamental species.
EUPHORBIACEAE	Gripe Weed / Egg Woman / Seed-under-leaf	*Phyllanthus amarus*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	-
	Bois d'Amande / Tapana	*Hyeronima laxiflora*					✔		Not Listed	Not Listed	Commercial hardwood.
HELICONIACEAE	Balisier	*Heliconia caribaea*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Leaves used in other Caribbean countries as thatch, liners for basket and to cover bread during baking.
	Heliconia	*Heliconia psittacorum*	Herb		✔		✔		Not Listed	Not Listed	Is an ornamental species.
LAURACEAE	Laurier	*Ocotea sp.*	Tree		✔				Not Listed	Not Listed	Hardwood species used for timber.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL	
	Avocado Pear / Zaboca	*Persea americana*	Tree					✔	Not Listed	Least Concern (IUCN)	Cultivated for its popular edible fruit.
	Cinnamon Tree	*Cinnamomum verum*	Tree					✔	Not Listed	Not Listed	Important export spice used as flavouring and fragrance. Medicinal uses include tonics, child-birth sedative, breath freshener and for guts and respiratory ailments.
LEGUMINOSAE	Cacoley	*Inga laurina*	Tree	✔		✔	✔		Not Listed	Not Threatened (Catalogue of Life)	Fruit is edible; once sold in Grenadian markets.
	Immortelle	*Erythrina poeppigiana*	Tree	✔					Not Listed	Not Threatened (Catalogue of Life)	Used to shade cocoa and as boundary markers on estates.
	Sweethearts / Coeur de Valeur	*Desmodium incanum*	Herb	✔			✔		Not Listed	Not Threatened (Catalogue of Life)	Treatment for diarrhoea in children.
	Shack-shack	*Crotalaria incana*	Shrublet					✔	Not Listed	Not Threatened (Catalogue of Life)	Children use seeds to make 'shack-shacks' (noise makers).
	Crotalaria	*Crotalaria pallida*	Shrublet					✔	Not Listed	Not Threatened (Catalogue of Life)	Roasted seeds used to make a kind of coffee.
	Sensitive Plant	*Mimosa pudica*	Shrublet	✔	✔	✔	✔		Not Listed	Least Concern (IUCN)	Used to treat colds, coughs, venereal diseases, toothache and to induce vomiting and urination.
	Jamaican Horse Bean / Sword Bean	*Canavalia ensiformis*	Vine		✔		✔		Not Listed	Not Listed	Cultivated mainly for green manure and fodder. Also for human consumption.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL	
	Quick Stick / Glorisita	*Gliricidia sepium*	Tree		✔				Not Listed	Not Threatened (Catalogue of Life)	Used as live fencing, windbreaks and as a shade tree. Wood is durable. Leaves are used for fodder. Leaves are used to treat skin ulcers and sores.
	Bodi / Yardlong Bean	*Vigna unguiculata* var. *sesquipedalis*	Vine			✔	✔		Not Listed	Not Threatened (Catalogue of Life)	Cultivated for human consumption (young pods are eaten).
	Pigeon Pea	*Cajanus cajan*	Shrub					✔	Not Listed	Near Threatened (IUCN)	Cultivated for human consumption (seeds are eaten). Leaves are used to clean teeth.
	Cow Itch	*Mucuma pruriens*	Vine					✔	Not Listed	Not Listed	Used to treat worms.
	Kudzu	*Pueraria phaseoloides*	Vine	✔	✔	✔	✔		Not Listed	Not Threatened (Catalogue of Life)	In other places it is used as green manure and animal fodder.
MALVACEAE	Blue Mahoe	*Hibiscus elatus*	Tree	✔					Not Listed	Least Concern (IUCN)	Introduced for reforestation after Hurricane Janet in 1955. Used in woodwork.
	Wire Weed / Sweet Broom	*Sida acuta*	Shrublet	✔	✔	✔	✔		Not Listed	Not Listed	Stems and roots used as poultice on sprains and strains.
	Broom Weed	*Sida glabra*	Shrublet			✔	✔		Not Listed	Not Listed	-
MARANTACEAE	Arouma / Terite	*Ischnosiphon arouma*	Herb		✔				Not Listed	Not Listed	Used in other places to make baskets.
MELASTOMATACEAE	Kak Mel	*Clidemia hirta*	Shrub				✔		Not Listed	Not Listed	Leaves are crushed with lard and applied to treat hernias. Can also be used for healthy skin.
MORACEAE	Breadfruit / Breadnut	*Artocarpus altilis*	Tree		✔	✔			Not Listed	Not Listed	Cultivated for its edible fruit. Breadfruit is the main ingredient in Grenada's national dish (i.e. Oil Down). Leaves used to treat diabetes and hypertension.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL	
	Figuier	*Ficus guianensis*	Tree					✔	Not Listed	Not Listed	Used as a shade plant. Latex is applied to decaying tooth to relieve pain and results in tooth falling out 1-2 days later.
	White Fig	*Ficus americana*	Tree				✔		Not Listed	Least Concern (IUCN)	Has value as a slope stabilizing species.
MUSACEAE	Banana, Plantain	*Musa sp.*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Cultivated for fruit. Several varieties are present in Grenada. Plantains refer to 'hard' varieties which are cooked while bananas are 'soft' varieties which may be consumed raw.
MYRISTICACEAE	Nutmeg	*Myristica fragrans*	Tree	✔	✔	✔	✔		Not Listed	Data Deficient (IUCN)	Grenada's most important commercial export. Mace is used in flavouring and fragrances. Seed is used as an insecticide and as a remedy for colds, flu and fever; also used as natural ground covering in gardens. Oil is used as a rub for muscular pains.
MYRTACEAE	Allspice / Pimento	*Pimenta dioica*	Tree					✔	Not Listed	Not Listed	Cultivated for un-ripened fruit which are dried as used as a spice to flavour food and drinks.
	Guava	*Psidium guajava*	Tree		✔		✔		Not Listed	Least Concern (IUCN)	Cultivated for fruit which can be eaten raw and is also used to make jams, jelly and juice *et cetera.*
	Pomme Rose / Malabar Plum	*Syzygium jambos*	Tree				✔		Not Listed	Least Concern (IUCN)	Fruit was once used (eaten raw or used to make jam) but has declined in popularity. In other places, has been used in herbal medicine, as windbreaks, as firewood and for dye from its tannins.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL	
	Wax Apple	*Syzygium malaccense*	Tree					✔	Not Listed	Least Concern (IUCN)	Cultivated for edible fruit which is used to make drinks, wine and jams. It is also used in stews and pies.
ONAGRACEAE	Wild Clove	*Ludwigia sp.*	Herb					✔	Not Listed	Least Concern (IUCN)	-
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*	Shrub	✔	✔		✔		Not Listed	Not Listed	Leaves may be used as fodder.
	Wall Cress / Shining Bush	*Peperomia pellucida*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used to treat asthma and diarrhoea.
POACEAE	Bamboo	*Bambusa vulgaris*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	Used for construction, water pipes and in basket-making. Leaves are used to relive fever and reduce blood sugar. Used to increase sex-drive in both animals and humans. Shoots are edible.
	Gully Bead / Buck Bead	*Coix lacryma-jobi*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	Seeds are edible; can be boiled like rice or milled into flour. Used as a 'cooling' herb to reduce fever, inflammation, pain and to treat rheumatoid arthritis and to lower blood sugar. Seeds are used to make jewellery and decorations.
	Razor Grass	*Paspalum virgatum*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	-
	Guinea Grass / Animal Grass	*Panicum maximum*		✔	✔	✔	✔		Not Listed	Not Listed	Used as animal fodder. Used elsewhere in other places to treat heartburn.
	Bull Grass	*Paspalum fasciculatum*	Grass	✔	✔				Not Listed	Not Listed	Used as animal fodder.
	Para Grass / Animal Grass	*Brachiaria mutica*	Grass	✔	✔	✔			Not Listed	Least Concern (IUCN)	Used as animal fodder.
	Carpet Grass	*Axonopus compressus*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	Used as lawn grass.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				C1	C2	C3	C4		NATIONAL	INTERNATIONAL	
	Bamboo Grass	*Arthrostylidium excelsum*	Grass		✔				Not Listed	Not Listed	-
	-	*Chloris sp.*	Grass					✔	Not Listed	Not Listed	-
	Finger Grass / Crab Grass	*Digitaria ciliaris*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	-
	Fowl-foot Grass	*Eleusine indica*	Grass	✔	✔	✔	✔		Not Listed	Least Concern (IUCN)	Used as animal fodder.
	Iron Grass	*Sporobolus jacquemontii*	Grass					✔	Not Listed	Not Listed	-
	Palm Grass	*Setaria palmifolia*	Grass		✔		✔		Not Listed	Not Listed	Used as animal fodder.
	Sugarcane	*Saccharum officinarum*	Grass				✔		Not Listed	Not Listed	Cultivated for sugary sap which is used to make sugar, rum *et cetera.*
POLYGONACEAE	Coral Vine, Coralita	*Antigonon leptopus*	Vine		✔				Not Listed	Not Listed	Leaves used for poultices for swellings and boils. Tea used for hypertension, diabetes, flu and menstrual cramps.
PTERIDACEAE	Broadleaf Maidenhair	*Adiantum latifolium*	Fern			✔	✔		Not Listed	Not Listed	Potentially an ornamental species. Used in other places to calm anxiety, reduce pain and inflammation.
RHAMNACEAE	Chew-stick	*Gouania lupuloides*	Vine				✔		Not Listed	Not Listed	Chewed to clean teeth. Used to make a medicinal tea and used as a hops substitute in ginger-beer.
RUBIACEAE	Broom Weed	*Spermacoce latifolia*		✔	✔	✔	✔		Not Listed	Not Listed	-
RUTACEAE	Rough-skin Lemon	*Citrus* x *jambhiri*	Tree				✔		Not Listed	Not Listed	Used to balance the body's pH, promotes healthy digestive and urinary systems and reduced inflammation.
	Citrus	*Citrus sp.*	Tree					✔	Not Listed	Not Listed	-
SAPOTACEAE	Penny Piece	*Pouteria multiflora*	Tree				✔		Not Listed	Not Listed	Fruits is edible.
SELAGINELLACEAE	Spike Moss / Carpet Fern	*Selaginella sp.*	Herb	✔					Not Listed	Not Listed	-

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				C1	C2	C3	C4		National	International	
STERCULIACEAE	Cocoa	*Theobroma cacao*	Tree	✔	✔	✔			Not Listed	Not Listed	Commercially cultivated for fruit which is used to make chocolate and other cocoa products such as cocoa tea.
	Cola Nut / Bichy Tree	*Cola nitida*	Tree				✔		Not Listed	Least Concern (IUCN)	The seed has a simulant and is chewed for energy. It is also used to treat diarrhoea.
SOLANACEAE	-	*Solanum nudum*	Shrub		✔				Not Listed	Not Listed	-
	Scotch Bonnet Pepper	*Capsicum chinense*	Shrublet			✔	✔		Not Listed	Not Listed	Cultivated for edible fruit which is used as a seasoning and in condiments.
	Pimento Pepper / Seasoning Pepper	*Capsicum annuum*	Shrublet			✔	✔		Not Listed	Least Concern (IUCN)	Cultivated for edible fruit which is used primarily as a seasoning.
THELYPTERIDACEAE	Maiden Fern / Marsh Fern	*Thelypteris sp.1*	Fern		✔	✔			Not Listed	Not Listed	-
	Maiden Fern / Marsh Fern	*Thelypteris sp.2*	Fern			✔			Not Listed	Not Listed	-
URTICACEAE	Nettle Tree	*Urera baccifera*	Tree			✔			Not Listed	Not Listed	Used as a diuretic and for pain relief.
	Stinging Nettle	*Laportea aestuans*	Herb	✔		✔			Not Listed	Not Listed	Leaves can be boiled and eaten.
	-	*Pilea sp.*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Many species in this genus are cultivated as ornamentals.
	-	*Phenax sonneratii*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	-
VERBENACEAE	Ven-ven / Vervain	*Stachytarpheta jamaicensis*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Leaves are used in a 'cooling' herbal tea for nursing women, for fevers and in poultices for wounds.
	Ven-ven / Vervain	*Stachytarpheta urticifolia*	Herb	✔			✔		Not Listed	Not Listed	Leaves are used in a 'cooling' herbal tea for nursing women.
	Lantana	*Lantana camara*	Shrublet					✔	Not Listed	Not Listed	Flowers and buds are used in a tea to treat flu and chills.
VITACEAE	Pudding Bush / Snake Vine	*Cissus verticillata*	Vine	✔			✔		Not Listed	Not Listed	Stem is used as twine and skipping rope. Fruit used as dye. Leaves used as soap.

Table 3-2(a): DAFOR Scale for Plant Species in Quadrats Along Transect C1

Plant Species Found along Transect C1						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**C1a (Pasture, Cultivated Land, Herbaceous Agriculture)**	**C1b (Secondary Forest / Cultivated Land)**	**C1c (Nutmeg / mixed woody agriculture**	**C1d (Secondary Forest / Seasonal Evergreen Forest)**
ARACEAE	Tannia	*Xanthosoma sagittifolium*		**O**		
ARECACEAE	Coconut	*Cocos nucifera*	**R**			
	Royal Palm	*Roystonea oleracea*		**F**		
ASTERACEAE	Shepard's Needles	*Bidens pilosa*	**O**			
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	**R**			**O**
COMMELINACEAE	Caner Grass	*Commelina elegans*	**F**			
	Caner Grass	*Commelina diffusa*	**F**			
COSTACEAE	Wild Ginger	*Costus speciosus*		**A**		
	Wild Ginger	*Costus scaber*		**O**		
DIOSCOREACEAE	Yam / Kush Kush	*Dioscorea alata*	**O**			
HELICONIACEAE	Balisier	*Heliconia caribaea*				**F**
	Heliconia	*Heliconia psittacorum*				**F**
LEGUMINOSAE	Cacoley	*Inga laurina*		**R**		
	Immortelle	*Erythrina poeppigiana*		**R**		
MALVACEAE	Blue Mahoe	*Hibiscus elatus*		**A**		
MUSACEAE	Banana, Plantain	*Musa sp.*			**O**	
MYRISTICACEAE	Nutmeg	*Myristica fragrans*			**D**	
POACEAE	Bamboo	*Bambusa vulgaris*	**O**	**F**		**A**
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**F**			
	Razor Grass	*Paspalum virgatum*	**O**			

Plant Species Found along Transect C1						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**C1a (Pasture, Cultivated Land, Herbaceous Agriculture)**	**C1b (Secondary Forest / Cultivated Land)**	**C1c (Nutmeg / mixed woody agriculture**	**C1d (Secondary Forest / Seasonal Evergreen Forest)**
	Guinea Grass / Animal Grass	*Panicum maximum*	**F**			
STERCULIACEAE	Cocoa	*Theobroma cacao*			**A**	
SOLANACEAE	Scotch Bonnet Pepper	*Capsicum chinense*				
URTICACEAE	Nettle Tree	*Urera baccifera*				

Table 3-2(b): DAFOR Scale for Plant Species Along Transect C2

Plant Species Found along Transect C2						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**QUADRANT**			
			C2a (Pasture/Cultivated Land/Herbaceous Agriculture)	**C2b (Pasture/ Cultivated Land/Herbaceous Agriculture)**	**C2c (Mixed Forest / Shrubland)**	**C2d (Secondary Forest/Seasonal Evergreen Forest)**
ANACARDIACEAE	Pommecythere / Golden Apple	*Spondias cytherea*		**R**		
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	**O**		**R**	
COMMELINACEAE	Caner Grass	*Commelina elegans*	**F**			
	Caner Grass	*Commelina diffusa*	**F**			
CUCURBITACEAE	Pumpkin	*Cucurbita maxima*	**O**			
CYATHEACEAE	Tree Fern	*Cyathea tenera*				**R**
CYPERACEAE	Umbrella Flatsedge	*Cyperus alternifolius*		**F**		
	Finger Flatsedge	*Cyperus digitatus*		**O**		

Plant Species Found along Transect C2						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	COMMON NAME	SCIENTIFIC NAME	QUADRANT			
			C2a (Pasture/Cultivated Land/Herbaceous Agriculture)	C2b (Pasture/ Cultivated Land/Herbaceous Agriculture)	C2c (Mixed Forest / Shrubland)	C2d (Secondary Forest/Seasonal Evergreen Forest)
EUPHORBIACEAE	Bois d'Amande / Tapana	*Hyeronima laxiflora*				**R**
HELICONIACEAE	Balisier	*Heliconia caribaea*		**O**	**R**	
LAURACEAE	Laurier	*Ocotea sp.*			**R**	
MUSACEAE	Banana, Plantain	*Musa sp.*				**R**
MYRISTICACEAE	Nutmeg	*Myristica fragrans*		**R**		**O**
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*		**O**	**F**	
POACEAE	Bamboo	*Bambusa vulgaris*		**R**	**F**	**D**
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**A**			
	Razor Grass	*Paspalum virgatum*		**A**		
	Guinea Grass / Animal Grass	*Panicum maximum*	**F**			
STERCULIACEAE	Cocoa	*Theobroma cacao*			**O**	
URTICACEAE	Nettle Tree	*Urera baccifera*			**F**	

Table 3-2(c): DAFOR Scale for Plant Species Along Transect C3

Plant Species Found along Transect C3						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	COMMON NAME	SCIENTIFIC NAME	QUADRANT			
			C3a (Pasture/Cultivated Land/Herbaceous Agriculture)	C3b (Secondary Vegetation/Seasonal Evergreen Forest)	C3c (Nutmeg/Mixed Woody Agriculture)	C3d (Secondary Forest/Seasonal Evergreen Forest)
ARECACEAE	Royal Palm	*Roystonea oleracea*			**R**	
BOMBACACEAE	Bois Flot	*Ochroma pyramidale*		**R**	**O**	
BRASSICACEAE	Cabbage	*Brassica oleracea* var. capitata	**O**			

Plant Species Found along Transect C3						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**QUADRANT**			
			C3a (Pasture/Cultivated Land/Herbaceous Agriculture)	**C3b (Secondary Vegetation/Seasonal Evergreen Forest)**	**C3c (Nutmeg/Mixed Woody Agriculture)**	**C3d (Secondary Forest/Seasonal Evergreen Forest)**
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*			**F**	
CUCURBITACEAE	Pumpkin	*Cucurbita maxima*	**O**			
	Cucumber	*Cucumis sativus*	**O**			
	Christophene	*Sechium edule*	**O**			
CYATHEACEAE	Tree Fern	*Cyathea tenera*			**R**	
HELICONIACEAE	Balisier	*Heliconia caribaea*			**A**	
LEGUMINOSAE	Bodi / Yardlong Bean	*Vigna unguiculata* var. *sesquipedalis*		**R**		
MORACEAE	Breadfruit / Breadnut	*Artocarpus altilis*		**R**		
MUSACEAE	Banana, Plantain	*Musa sp.*	**O**			
MYRISTICACEAE	Nutmeg	*Myristica fragrans*			**R**	
POACEAE	Bamboo	*Bambusa vulgaris*		**D**	**D**	
	Guinea Grass / Animal Grass	*Panicum maximum*	**A**			
STERCULIACEAE	Cocoa	*Theobroma cacao*			**R**	
SOLANACEAE	Scotch Bonnet Pepper	*Capsicum chinense*	**O**			

Table 3-2(d): DAFOR Scale for Plant Species Along Transect C4

Plant Species Found along Transect C4						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**QUADRANT**			
			C4a (Pastrure/Cultivated Land/Herbaceous Agriculture)	**C4b (Pasture/Shrubland)**	**C4c (Herbaceous and Woody Agriculture)**	**C4d (Secondary Vegetation/Seasonal Evergreen Forest)**
ANNONACEAE	Cherimoya	*Annona cherimola*	**R**			
ARECACEAE	Coconut	*Cocos nucifera*			**R**	
	Mountain Cabbage	*Euterpe dominicana*				**R**
	Mountain Palm	*Prestoea acuminate* var. *montana*				**R**
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*			**R**	**R**
COMMELINACEAE	Caner Grass	*Commelina elegans*	**F**	**F**		
	Caner Grass	*Commelina diffusa*	**F**	**F**		
EUPHORBIACEAE	Bois d'Amande / Tapana	*Hyeronima laxiflora*				**R**
HELICONIACEAE	Balisier	*Heliconia caribaea*	**O**	**O**	**A**	**A**
	Heliconia	*Heliconia psittacorum*				**O**
LEGUMINOSAE	Cacoley	*Inga laurina*				**R**
MORACEAE	Figuier	*Ficus guianensis*				**R**
MUSACEAE	Banana, Plantain	*Musa sp.*	**R**	**F**		
MYRISTICACEAE	Nutmeg	*Myristica fragrans*	**R**	**R**		**R**
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*		**F**		**A**
POACEAE	Bamboo	*Bambusa vulgaris*			**A**	**O**
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**F**	**A**		
	Razor Grass	*Paspalum virgatum*	**O**	**A**		
	Guinea Grass / Animal Grass	*Panicum maximum*	**A**	**A**		
SAPOTACEAE	Penny Piece	*Pouteria multiflora*				**R**
STERCULIACEAE	Cocoa	*Theobroma cacao*	**R**			

Table 3-3: Plant Species Recorded At Site F

Source: Hawthorne, 2004 and ICUN, 2019

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
ACANTHACEAE	Mini Root / Bluebell / Snapdragon Root	*Ruellia tuberosa*	Herb		✔		✔		Not Listed	Not Listed	Tea from shoots, flowers and tubers is used to treat cold, fevers and hypertension.
	Rock Balsam	*Blechum pyramidatum*	Herb	✔			✔		Not Listed	Not Listed	Used as a poultice for wounds.
	St John's Bush	*Justicia secunda*	Shrub	✔	✔		✔		Not Listed	Not Listed	Tea from leaves used to start menstruation and to treat 'red eye' (i.e. viral conjunctivitis).
	Chandeliere	*Pachystachys spicata*	Shrub	✔	✔	✔			Not Listed	Not Listed	-
ANACARDIACEAE	Mango	*Mangifera indica*	Tree	✔	✔		✔		Not Listed	Data Deficient (IUCN)	Cultivated for its edible fruit. Extracts from the leaves and bark can be used to relieve toothaches and sore gums.
	Pommecythere / Golden Apple	*Spondias cytherea*	Tree				✔		Not Listed	Not Listed	Cultivated for edible fruit which is used in jams, juice, wine, chutney and pickles.
	Cashew	*Anacardium occidentale*	Tree		✔				Not Listed	Not Listed	Cultivated mainly for seeds which are used to make 'Cashew Nuts'. Fruit is edible and used to make wine, jams *etc.*
AQUIFOLIACEAE	Caca-Poule / Bois Citron	*Ilex sideroxyloides*	Tree	✔					Not Listed	Not Listed	-
ARACEAE	Dasheen / Taro / Callaloo	*Colocasia esculenta*	Herb	✔			✔		Not Listed	Least Concern (IUCN)	Cultivated for export; edible leaves and corm.
	Tannia	*Xanthosoma sagittifolium*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Cultivated for export; edible leaves and corm.
	Tayo	*Xanthosoma sp.*	Herb			✔			Not Listed	Not Listed	Cultivated mainly for edible corm.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
	Swiss Cheese Plant	*Monstera adansonii*	Vine	✔	✔	✔			Not Listed	Not Listed	Has value as an ornamental. Ripe fruit is edible.
	Philodendron Vine	*Philodendron sp.1*	Vine	✔	✔	✔	✔		Not Listed	Not Listed	Has value as an ornamental.
	Philodendron Vine	*Philodendron sp.2*	Vine	✔		✔			Not Listed	Not Listed	Has value as an ornamental.
	Philodendron Vine	*Philodendron sp.3*	Vine	✔	✔				Not Listed	Not Listed	Has value as an ornamental.
	-	*Anthurium acaule*	Epiphyte / Terrestrial	✔	✔	✔			Not Listed	Not Listed	-
ARECACEAE	Coconut	*Cocos nucifera*	Palm					✔	Not Listed	Not Listed	Variety of uses including: consumption (coconut water, jelly, milk, copra, oil *etc.*); fibrous husks used for 'coir' mats and shredded for use in gardening; jewellery, shack-shacks (i.e. maracas) *etc.* from the shells; leaflets made into mats, belts, cocoyea brooms *etc.*
	Royal Palm	*Roystonea oleracea*	Palm		✔	✔		✔	Not Listed	Not Listed	Ornamental species. Other uses include thatch, timber and livestock feed. The palm heart is edible.
	Mountain Cabbage	*Euterpe dominicana*	Palm	✔	✔	✔			Near Endemic – found on the mountains of Grenada, Dominica and St Vincent Almost Endangered	Not Listed	Has value as an ornamental. Palm heart / 'cabbage' (i.e. young shoots and leaves) are eaten; this results in the loss of the entire tree.
	Mountain Palm	*Prestoea acuminate* var. *montana*	Palm			✔			Not Listed	Not Listed	Shoots and young leaves are edible.
ASTERACEAE	Wild Marigold	*Wedelia calycina*	Shrub					✔	Not Listed	Not Listed	-
	Railway Daisy /	*Wedelia trilobata*	Herb				✔		Not Listed	Not Listed	Used to treat coughs and colds.

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				F1	F2	F3	F4		National	International	
	Creeping Daisy										
	Shepard's Needles	*Bidens pilosa*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used in other places to treat colds, earaches, inflamed eyes and difficulty in urination.
	West Indian Beggarticks	*Bidens cynapiifolia*	Herb		✔		✔		Not Listed	Not Listed	-
	Shaving Bush	*Emilia fosbergii*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Used as fodder for small livestock.
	Shaving Bush	*Emilia sonchifolia*	Herb	✔			✔		Not Listed	Not Listed	Used in other places to treat eye inflammation, cuts, earaches, tooth decay, bowel issues and diarrhoea.
	Iron Weed	*Vernonia sp.*	Herb		✔		✔		Not Listed	Not Listed	-
	Goatweed	*Ageratum conyzoides*	Herb					✔	Not Listed	Least Concern (IUCN)	Used in other places top treat fevers, headaches, colic and rheumatism.
	Cinderella Weed	*Synedrella nodiflora*	Herb					✔	Not Listed	Not Listed	Used in other places to treat rheumatism and arthritis and as a laxative.
BIGNONIACEAE	Cat's Claw	*Macfadyena unguis-cati*	Vine	✔		✔			Not Listed	Not Listed	Used to treat Manchineel (*Hippomane mancinella*) 'burns.'
BLECHNACEAE	Fern	*Blechnum sp.*	Fern			✔			Not Listed	Not Listed	Possibly used as an ornamental.
BOMBACACEAE	Wild Breadnut / Cacao Sauvage	*Pachira insignis*	Tree	✔	✔				Not Listed	Not Listed	Bark is used as bait for cocoa beetles and as a fever treatment. Edible seeds can be eaten raw or roasted.
	Bois Flot / Balsa	*Ochroma pyramidale*	Tree					✔	Not Listed	Not Listed	One of the lightest weight commercial woods.
	Swizzlestick Tree	*Quararibea turbinata*	Tree	✔	✔				Not Listed	Not Listed	Small whorls of branches are used to make swizzlesticks for mixing food and drinks.
BURSERACEAE	Mountain Gommier	*Dacryodes excelsa*	Tree	✔					Not Listed	Not Listed	Hardwood used for lumber, shingles and in boat building.
CAMPANULACEAE	-	*Lobelia cirsifolia*	Herb	✔		✔			Endemic to the Lesser Antilles	Not listed in the Catalogue of	Endemic to the Lesser Antilles (Grenada, St. Kitts, Dominica, St. Lucia and St. Vincent).

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
									(Grenada, St. Kitts, Dominica, St. Lucia and St. Vincent).	Life	
CANNACEAE	Canna Lily	*Canna indica*	Herb				✔		Not Listed	Not Listed	Used for stomach-aches.
CARICACEAE	Pawpaw	*Carica papaya*	Tree					✔	Not Listed	Data Deficient (IUCN)	Cultivated for its fruit. Sap contains papain which is used to tenderize meat and coagulate milk. Young shoots and seeds are edible. Extract from leaves is used to treat burns and fever and 'ague' associated with Dengue and Chikungunya. Leaves may be smoked to relieve asthma.
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	Tree	✔	✔	✔	✔		Not Listed	Not Listed	Young buds are edible. Tea is used for cold and hypertension.
CLUSIACEAE	Galba	*Calophyllum calaba*	Tree	✔	✔				Not Listed	Not Listed	Hardwood, often planted as a wind-break, used to make furniture and huts. Bark has medicinal value.
COMMELINACEAE	Caner Grass	*Commelina elegans*	Herb	✔	✔		✔		Not Listed	Not Listed	Used as a 'cooling' infusion and for animal fodder.
	Caner Grass	*Commelina diffusa*	Herb	✔			✔		Not Listed	Least Concern (IUCN)	Used as a 'cooling' infusion and for animal fodder.
CONCOLVULACEAE	Wild Potato Vine	*Ipomoea tiliacea*	Vine	✔	✔	✔			Not Listed	Not Listed	Tubers are edible.
	Whorled Clustervine	*Jacquemontia verticillata*	Vine		✔				Not Listed	Not Listed	-
COSTACEAE	Wild Ginger	*Costus speciosus*	Herb	✔		✔			Not Listed	Not Listed	Ornamental species. Used elsewhere to treat cough, asthma, dysmenorrhea, skin issues and intestinal parasites.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
	Wild Ginger	*Costus scaber*	Herb		✔	✔			Not Listed	Least Concern (IUCN)	Ornamental species. Used as part of a remedy to treat snakebites in other places.
CYATHEACEAE	Tree Fern	*Cyathea tenera*	Fern	✔					Not Listed	Not Listed	-
	Tree Fern	*Cyathea arborea*	Fern	✔					Not Listed	Not Listed	-
CYCLANTHACEAE	Siguine Batard	*Asplundia insignis*	Shrublet	✔	✔				Endemic to the Lesser Antilles; from St Kitts to Grenada.	No International Status	Leaves may be used for lining baskets and pots.
	Ailes a Mouche	*Asplundia rigida*	Vine	✔	✔				Not Listed	Not Listed	-
CYPERACEAE	-	*Cyperus kyllingia*	Sedge	✔	✔	✔	✔		Not Listed	Not Listed	Used in other places as animal fodder and to treat fever, ulcers, sore throat, diarrhoea and skin problems. Used as a diuretic and abortifacient.
	Nut Grass	*Cyperus rotundus*	Sedge	✔	✔	✔	✔		Not Listed	Not Listed	Used in other places to treat diarrhoea, diabetes, fever, inflammation, stomach issues and malaria.
DILLENIACEAE	Water Vine	*Doliocarpus sp.*	Vine	✔		✔			Not Listed	Not Listed	Used as a source of water by persons (e.g. hikers) in the forest. In the other places, this sap is used as an anti-inflammatory.
DIOSCOREACEAE	Yam / Kush Kush	*Dioscorea alata*	Vine	✔	✔	✔	✔		Not Listed	Not Listed	Important root crop. Has pharmaceutical applications elsewhere; contains a natural 'steroid precursor' used in the manufacturing of certain steroids and corticosteroids.
DRACAENACEAE	Dragon Tree / Boundary Plant	*Dracaena sp.*	Shrub					✔	Not Listed	Not Listed	Used as boundary markers on estates.
DRYOPTERIDACEAE	Shield Fern	*Polybotrya sp.*	Fern	✔	✔		✔		Not Listed	Not Listed	Potentially an ornamental species.
	Shield Fern	*Dryopteris sp.*	Fern	✔	✔	✔			Not Listed	Not Listed	Potentially an ornamental species.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
EUPHORBIACEAE	Gripe Weed / Egg Woman / Seed-under-leaf	*Phyllanthus amarus*	Herb	✔	✔		✔		Not Listed	Not Listed	-
	Sand Box Tree / Monkey's Dinner Bell	*Hura crepitans*	Tree	✔			✔		Not Listed	Not Listed	Segments of the seed-case used to make jewellery. Seeds may be used as a purgative.
GLEICHENIACEAE	Forked Fern	*Gleichenella pectinata*	Fern	✔					Not Listed	Not Listed	Potentially an ornamental species.
HELICONIACEAE	Balisier	*Heliconia caribaea*	Herb	✔	✔	✔			Not Listed	Not Listed	Leaves used in other Caribbean countries as thatch, liners for basket and to cover bread during baking.
	Heliconia	*Heliconia psittacorum*	Herb	✔	✔				Not Listed	Not Listed	Is an ornamental species.
LAURACEAE	Laurier	*Ocotea sp.*	Tree	✔	✔	✔	✔		Not Listed	Not Listed	Hardwood species used for timber.
	Cinnamon Tree	*Cinnamomum verum*	Tree				✔		Not Listed	Not Listed	Important export spice used as flavouring and fragrance. Medicinal uses include tonics, child-birth sedative, breath freshener and for guts and respiratory ailments.
LEGUMINOSAE	Cacoley	*Inga laurina*	Tree	✔	✔	✔	✔		Not Listed	Not Threatened (Catalogue of Life)	Fruit is edible; once sold in Grenadian markets.
	Immortelle	*Erythrina poeppigiana*	Tree		✔		✔		Not Listed	Not Threatened (Catalogue of Life)	Used to shade cocoa and as boundary markers on estates.
	Sweethearts / Coeur de Valeur	*Desmodium incanum*	Herb	✔	✔		✔		Not Listed	Not Threatened (Catalogue of Life)	Treatment for diarrhoea in children.
	Shack-shack	*Crotalaria incana*	Shrublet	✔	✔	✔	✔		Not Listed	Not Threatened (Catalogue	Children use seeds to make 'shack-shacks' (noise makers).

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
										of Life)	
	Crotalaria	*Crotalaria pallida*	Shrublet	✔			✔		Not Listed	Not Threatened (Catalogue of Life)	Roasted seeds used to make a kind of coffee.
	Sensitive Plant	*Mimosa pudica*	Shrublet	✔	✔	✔	✔		Not Listed	Least Concern (IUCN)	Used to treat colds, coughs, venereal diseases, toothache and to induce vomiting and urination.
	Quick Stick / Glorisita	*Gliricidia sepium*	Tree				✔		Not Listed	Not Threatened (Catalogue of Life)	Used as live fencing, windbreaks and as a shade tree. Wood is durable. Leaves are used for fodder. Leaves are used to treat skin ulcers and sores.
	Cow Itch	*Mucuna pruriens*	Vine	✔	✔	✔			Not Listed	Not Threatened (Catalogue of Life)	Used to treat worms.
	Kudzu	*Pueraria phaseoloides*	Vine	✔	✔		✔		Not Listed	Not Threatened (Catalogue of Life)	In other places it is used as green manure and animal fodder.
	Wild Hops	*Flemingia strobilifera*	Shrub			✔			Not Listed	Not Threatened (Catalogue of Life)	Used in dry floral arrangements.
	Stinking Toe / Locust	*Hymenaea coubaril*	Tree				✔		Not Listed	Least Concern (IUCN)	Produces a resin which may be used for varnish. Parts of the pod are edible.
	Monkey Vine / Money Ladder Vine	*Bauhinia sp.*	Vine	✔	✔	✔			Not Listed	Least Concern (IUCN)	-
LINDSAEACEAE	Woodland Necklace Fern	*Lindsaea lancea*	Fern	✔					Not Listed	Not Listed	Potentially used as an ornamental.
LOMARIOPSIDACE	Streamside Sword	*Nephrolepis rivularis*	Fern			✔			Not Listed	Not Listed	Potentially used as an ornamental.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
AE	Fern										
MALVACEAE	Wire Weed / Sweet Broom	*Sida acuta*	Shrublet	✔	✔	✔	✔		Not Listed	Not Listed	Stems and roots used as poultice on sprains and strains.
	Broom Weed	*Sida glabra*	Shrublet	✔	✔	✔	✔		Not Listed	Not Listed	-
MARANTACEAE	Arouma / Terite	*Ischnosiphon arouma*	Herb			✔			Not Listed	Not Listed	Used in other places to make baskets.
	Arrowroot	*Maranta arundinacea*	Herb			✔			Not Listed	Not Listed	Starch from this is used to thicken sauces and gravy.
MARATTIACEA	Danafern	*Danaea sp.*	Fern	✔	✔				Not Listed	Not Listed	Potentially used as an ornamental.
MARCGRAVIACEAE	Monkey Paws Vines	*Marcgravia umbellata*	Vine	✔	✔				Endemic to the Lesser Antilles.	Not Listed	
MELASTOMATACEAE	Kak Mel	*Clidemia hirta*	Shrub	✔	✔	✔			Not Listed	Not Listed	Leaves are crushed with lard and applied to treat hernias. Can also be used for healthy skin.
MORACEAE	Breadfruit / Breadnut	*Artocarpus altilis*	Tree	✔			✔		Not Listed	Not Listed	Cultivated for its edible fruit. Breadfruit is the main ingredient in Grenada's national dish (i.e. Oil Down). Leaves used to treat diabetes and hypertension.
	Figuier	*Ficus guianensis*	Tree	✔	✔				Not Listed	Not Listed	Used as a shade plant. Latex is applied to decaying tooth to relieve pain and results in tooth falling out 1-2 days later.
	Strangler Fig	*Ficus citrifolia*	Tree	✔		✔			Not Listed	Least Concern (IUCN)	Used in other Caribbean countries to treat cancer, constipation, heart ailments, skin problems and toothaches.
MUSACEAE	Banana, Plantain	*Musa sp.*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Cultivated for fruit. Several varieties are present in Grenada. Plantains refer to 'hard' varieties which are cooked while bananas are 'soft' varieties which may be consumed raw.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
MYRISTICACEAE	Nutmeg	*Myristica fragrans*	Tree	✔	✔		✔		Not Listed	Data Deficient (IUCN)	Grenada's most important commercial export. Mace is used in flavouring and fragrances. Seed is used as an insecticide and as a remedy for colds, flu and fever; also used as natural ground covering in gardens. Oil is used as a rub for muscular pains.
MYRTACEAE	Allspice / Pimento	*Pimenta dioica*	Tree					✔	Not Listed	Not Listed	Cultivated for un-ripened fruit which are dried as used as a spice to flavour food and drinks.
	Guava	*Psidium guajava*	Tree				✔		Not Listed	Least Concern (IUCN)	Cultivated for fruit which can be eaten raw and is also used to make jams, jelly and juice *et cetera.*
	Wax Apple	*Syzygium malaccense*	Tree					✔	Not Listed	Least Concern (IUCN)	Cultivated for edible fruit which is used to make drinks, wine and jams. It is also used in stews and pies.
	Cloves	*Syzygium aromaticum*	Tree				✔		Not Listed	Not Listed	This spice is exported and is used for flavouring and fragrance. Clove oil is used to treat toothaches.
ONAGRACEAE	Wild Clove	*Ludwigia sp.*	Herb				✔		Not Listed	Not Listed	-
ORCHIDACEAE	Monk Orchid / African Spotted Orchid	*Oeceoclades maculata*	Herb		✔	✔			Not Listed	Least Concern (IUCN)	Ornamental species.
PASSIFLORACEAE	Water Lemon	*Passiflora quadriglandulosa*	Vine	✔	✔	✔			Not Listed	Not Listed	Fruit is edible.
PHYTOLACCACEAE	Murette / Basket Whist Vine / Hoop Vine	*Trichostigma octandrum*	Vine	✔		✔			Not Listed	Not Listed	Used to make whist baskets.
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*	Shrub	✔	✔	✔			Not Listed	Not Listed	Leaves may be used as fodder.
	-	*Piper dussii*	Shrub	✔		✔			Not Listed	Not Listed	Leaves may be used as fodder.
	Wall Cress / Shining Bush	*Peperomia pellucida*	Herb		✔	✔			Not Listed	Not Listed	Used to treat asthma and diarrhoea.
POACEAE	Bamboo	*Bambusa vulgaris*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	Used for construction, water pipes and in basket-making. Leaves are

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
											used to relive fever and reduce blood sugar. Used to increase sex-drive in both animals and humans. Shoots are edible.
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	Seeds are edible; can be boiled like rice or milled into flour. Used as a 'cooling' herb to reduce fever, inflammation, pain and to treat rheumatoid arthritis and to lower blood sugar. Seeds are used to make jewellery and decorations.
	Razor Grass	*Paspalum virgatum*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	-
	Guinea Grass / Animal Grass	*Panicum maximum*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	Used as animal fodder. Used elsewhere in other places to treat heartburn.
	Para Grass / Animal Grass	*Brachiaria mutica*	Grass	✔	✔	✔	✔		Not Listed	Least Concern (IUCN)	Used as animal fodder.
	Carpet Grass	*Axonopus compressus*	Grass		✔		✔		Not Listed	Not Listed	Used as lawn grass.
	Bamboo Grass	*Arthrostylidium excelsum*	Grass	✔	✔	✔	✔		Not Listed	Not Listed	-
	-	*Chloris sp.*	Grass					✔	Not Listed	Not Listed	-
	Finger Grass / Crab Grass	*Digitaria ciliaris*	Grass		✔		✔		Not Listed	Not Listed	-
	Fowl-foot Grass	*Eleusine indica*	Grass	✔	✔		✔		Not Listed	Least Concern (IUCN)	Used as animal fodder.
	Iron Grass	*Sporobolus jacquemontii*	Grass					✔	Not Listed	Not Listed	-
	Palm Grass	*Setaria palmifolia*	Grass	✔	✔	✔			Not Listed	Not Listed	Used as animal fodder.
	Sugarcane	*Saccharum officinarum*	Grass					✔	Not Listed	Not Listed	Cultivated for sugary sap which is used to make sugar, rum *et cetera.*
POLYPODIACEAE	Cabbage Palm Fern	*Phlebodium aureum*	Fern	✔	✔	✔			Not Listed	Not Listed	Is an ornamental species. Used in

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
											other places to treat coughs, fevers, skin aliments and rheumatoid arthritis.
	Rabbit's Foot Fern	*Phlebodium sp.*	Fern		✔				Not Listed	Not Listed	Is an ornamental species
PTERIDACEAE	Broadleaf Maidenhair	*Adiantum latifolium*	Fern	✔	✔	✔	✔		Not Listed	Not Listed	Potentially an ornamental species. Used in other places to calm anxiety, reduce pain and inflammation.
	Fourleaf Maidenhair	*Adiantum tetraphyllum*	Fern		✔				Not Listed	Not Listed	Potentially an ornamental species.
	Maidenhair	*Adiantum sp.*	Fern		✔				Not Listed	Not Listed	Potentially an ornamental species.
	Silverback Fern	*Pityrogramma calomelanos*	Fern	✔	✔				Not Listed	Not Listed	Potentially an ornamental species.
RUBIACEAE	Broom Weed	*Spermacoce latifolia*	Herb	✔			✔		Not Listed	Not Listed	-
	False Buttonwood	*Spermacoce assurgens*	Herb	✔					Not Listed	Not Listed	-
	-	*Psychotria muscosa*	Shrub			✔			Endemic to Lesser Antilles.	Not Listed	
RUTACEAE	Rough-skin Lemon	*Citrus* x *jambhiri*	Tree					✔	Not Listed	Not Listed	Used to balance the body's pH, promotes healthy digestive and urinary systems and reduced inflammation.
	Grapefruit	*Citrus* x *paradisi*	Tree		✔				Not Listed	Not Listed	Cultivated for edible fruit which may be eaten raw or turned into a variety of products.
	Sweet Orange	*Citrus sinensis*	Tree				✔		Not Listed	Not Listed	Cultivated for edible fruit which may be eaten raw or turned into a variety of products.
	Lemon	*Citrus limon*	Tree				✔		Not Listed	Not Listed	Cultivated for edible fruit which is often used as a seasoning or turned into a variety of products.
	Tangerine / Mandarine	*Citrus reticulatum*	Tree				✔		Not Listed	Not Listed	Cultivated for edible fruit which may

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				F1	F2	F3	F4		National	International	
											be eaten raw or turned into a variety of products.
	Citrus	*Citrus sp.*	Tree		✔	✔	✔		Not Listed	Not Listed	-
SAPINDACEAE	Bread and Cheese	*Paullinia pinnata*	Vine	✔		✔			Not Listed	Not Listed	Used as a tonic or aphrodisiac. Roots are chewed for coughs. Stems can be used like twine.
SAPOTACEAE	Penny Piece	*Pouteria multiflora*	Tree	✔	✔	✔			Not Listed	Not Listed	Fruits is edible.
	Mammee Sapota	*Pouteria sapota*	Tree			✔	✔		Not Listed	Not Listed	Fruit is edible. Seed kernel used as a spice in baking.
	Balata / Bulletwood	*Manilkara bidentata*	Tree	✔					Not Listed	Not Listed	Fruit are edible and is a commercial timber species.
SELAGINELLACEAE	Spike Moss / Carpet Fern	*Selaginella sp.*	Herb	✔	✔				Not Listed	Not Listed	-
SIMAROUBACEAE	Maruba / Birdfood	*Simarouba amara*	Tree	✔			✔		Not Listed	Not Listed	Light weight wood is used to make shingles and cabinet. Fruit is edible. In other places the bark is used to treat malaria and dysentery.
STERCULIACEAE	Cocoa	*Theobroma cacao*	Tree	✔	✔	✔	✔		Not Listed	Not Listed	Commercially cultivated for fruit which is used to make chocolate and other cocoa products such as cocoa tea.
SOLANACEAE	-	*Solanum nudum*	Shrub	✔	✔				Not Listed	Not Listed	-
THELYPTERIDACEAE	Maiden Fern / Marsh Fern	*Thelypteris sp.1*	Fern	✔	✔	✔			Not Listed	Not Listed	-
	Maiden Fern / Marsh Fern	*Thelypteris sp.2*	Fern	✔		✔			Not Listed	Not Listed	-
URTICACEAE	Nettle Tree	*Urera baccifera*	Tree	✔	✔				Not Listed	Not Listed	Used as a diuretic and for pain relief.
	Stinging Nettle	*Laportea aestuans*	Herb	✔	✔				Not Listed	Not Listed	Leaves can be boiled and eaten.
	-	*Pilea sp.*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	Many species in this genus are cultivated as ornamentals.
	-	*Phenax sonneratii*	Herb	✔	✔	✔	✔		Not Listed	Not Listed	-
VERBENACEAE	Ven-ven / Vervain	*Stachytarpheta*	Herb	✔	✔				Not Listed	Not Listed	Leaves are used in a ‘cooling’

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				F1	F2	F3	F4		NATIONAL	INTERNATIONAL	
		jamaicensis									herbal tea for nursing women, for fevers and in poultices for wounds.
	Ven-ven / Vervain	*Stachytarpheta urticifolia*	Herb	✔					Not Listed	Not Listed	Leaves are used in a 'cooling' herbal tea for nursing women.
	Lantana	*Lantana camara*	Shrublet	✔	✔				Not Listed	Not Listed	Flowers and buds are used in a tea to treat flu and chills.
VITACEAE	Pudding Bush / Snake Vine	*Cissus verticillata*	Vine	✔	✔		✔		Not Listed	Not Listed	Stem is used as twine and skipping rope. Fruit used as dye. Leaves used as soap.

Table 3-4 (a): DAFOR Scale for Plant Species in Quadrats Along Transect F1

Plant Species Found Along Transect F1						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
Family	**Common Name**	**Scientific Name**	**Quadrant**			
			F1a (Pasture/Mixed Woody Agriculture)	**F1b (Secondary Forest/Mixed Woody Agriculture)**	**F1c (Secondary Forest/Seasonal Evergreen Forest)**	**F1d (Secondary Forest/Seasonal Evergreen Forest)**
ACANTHACEAE	St John's Bush	*Justicia secunda*		**O**		
ARACEAE	Tannia	*Xanthosoma sagittifolium*		**R**		
ARECACEAE	Mountain Palm	*Prestoea acuminate* var. *montana*			**R**	
	Mountain Cabbage	*Euterpe dominicana*				**R**
BOMBACACEAE	Wild Breadnut / Cacao Sauvage	*Pachira insignis*		**O**		
	Swizzlestick Tree	*Quararibea turbinate*			**O**	
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	**F**	**O**	**R**	**R**
CLUSIACEAE	Galba	*Calophyllum calaba*		**R**		

Plant Species Found Along Transect F1						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
Family	**Common Name**	**Scientific Name**	**Quadrant**			
			F1a (Pasture/Mixed Woody Agriculture)	**F1b (Secondary Forest/Mixed Woody Agriculture)**	**F1c (Secondary Forest/Seasonal Evergreen Forest)**	**F1d (Secondary Forest/Seasonal Evergreen Forest)**
COMMELINACEAE	Caner Grass	*Commelina elegans*		**O**		
	Caner Grass	*Commelina diffusa*		**O**		
CONCOLVULACEAE	Whorled Clustervine	*Jacquemontia verticillata*	**R**	**R**		
CYATHEACEAE	Tree Fern	*Cyathea tenera*		**R**	**R**	
CYCLANTHACEAE	Siguine Batard	*Asplundia insignis*				**O**
GLEICHENIACEAE	Forked Fern	*Gleichenella pectinata*			**R**	
HELICONIACEAE	Balisier	*Heliconia caribaea*			**O**	
	Heliconia	*Heliconia psittacorum*			**O**	
LAURACEAE	Laurier	*Ocotea sp.*			**R**	**D**
LEGUMINOSAE	Cacoley	*Inga laurina*	**O**		**O**	
MARATTIACEA	Danafern	*Danaea sp.*			**R**	**R**
MORACEAE	Figuier	*Ficus guianensis*	**R**			
MUSACEAE	Banana, Plantain	*Musa sp.*	**F**	**A**		
MYRISTICACEAE	Nutmeg	*Myristica fragrans*	**R**			
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*			**F**	
POACEAE	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**O**			
	Guinea Grass / Animal Grass	*Panicum maximum*	**A**	**O**		
	Bamboo Grass	*Arthrostylidium excelsum*	**O**	**A**		
	Palm Grass	*Setaria palmifolia*	**O**			
RUTACEAE	Citrus	*Citrus sp.*	**R**			
STERCULIACEAE	Cocoa	*Theobroma cacao*	**O**	**R**		
URTICACEAE	Nettle Tree	*Urera baccifera*		**F**		

Table 3-4 (b): DAFOR Scale for Plant Species in Quadrats Along Transect F2

Plant Species Found Along Transect F2							
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)							
Family	**Common Name**	**Scientific Name**	**Quadrant**				
			F2a (Woody Agriculture)	**F2b (Secondary Forest/Shrubland)**	**F2c (Secondary Forest/Seasonal Evergreen Forest)**	**F2d (Secondary Forest/Seasonal Evergreen Forest)**	**F2e (Secondary Forest/Seasonal Evergreen Forest)**
ACANTHACEAE	St John's Bush	*Justicia secunda*		**F**	**F**		
ARACEAE	Tannia	*Xanthosoma sagittifolium*	**R**				
ARECACEAE	Mountain Cabbage	*Euterpe dominicana*					**R**
BLECHNACEAE	Fern	*Blechnum sp.*				**R**	**R**
BOMBACACEAE	Wild Breadnut / Cacao Sauvage	*Pachira insignis*				**O**	
	Swizzlestick Tree	*Quararibea turbinate*				**A**	**O**
CLUSIACEAE	Galba	*Calophyllum calaba*				**R**	
CONCOLVULACEAE	Wild Potato Vine	*Ipomoea tiliacea*	**R**	**R**			
	Whorled Clustervine	*Jacquemontia verticillata*	**R**				
CYCLANTHACEAE	Siguine Batard	*Asplundia insignis*					**O**
DRYOPTERIDACEAE	Shield Fern	*Polybotrya sp.*		**R**			
	Shield Fern	*Dryopteris sp.*		**R**			
HELICONIACEAE	Heliconia	*Heliconia psittacorum*					**R**
LAURACEAE	Laurier	*Ocotea sp.*				**A**	**F**
LEGUMINOSAE	Cacoley	*Inga laurina*		**F**	**D**		
LINDSAEACEAE	Woodland Necklace Fern	*Lindsaea lancea*				**R**	
MUSACEAE	Banana, Plantain	*Musa sp.*	**F**	**A**			
MYRISTICACEAE	Nutmeg	*Myristica fragrans*	**R**				
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*		**O**	**O**		

Plant Species Found Along Transect F2							
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)							
Family	**Common Name**	**Scientific Name**	**Quadrant**				
			F2a (Woody Agriculture)	**F2b (Secondary Forest/Shrubland)**	**F2c (Secondary Forest/Seasonal Evergreen Forest)**	**F2d (Secondary Forest/Seasonal Evergreen Forest)**	**F2e (Secondary Forest/Seasonal Evergreen Forest)**
POACEAE	Bamboo	*Bambusa vulgaris*	**R**	**R**	**R**	**O**	
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**R**	**R**			
	Guinea Grass / Animal Grass	*Panicum maximum*	**D**	**O**	**R**		
	Para Grass / Animal Grass	*Brachiaria mutica*	**R**				
	Bamboo Grass	*Arthrostylidium excelsum*		**A**			
RUTACEAE	Citrus	*Citrus sp.*	**F**				
SAPOTACEAE	Penny Piece	*Pouteria multiflora*					**R**
URTICACEAE	Nettle Tree	*Urera baccifera*		**F**	**A**		
	-	*Pilea sp.*		**O**	**O**		

Table 3-4 (c): DAFOR Scale for Plant Species in Quadrats Along Transect F3

Plant Species Found Along Transect F3						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
Family	**Common Name**	**Scientific Name**	**Quadrat**			
			F3a (Woody Agriculture)	**F3b (Secondary Forest/Seasonal Evergreen Forest)**	**F3c (Secondary Forest/Seasonal Evergreen Forest)**	**F3d (Secondary Forest/Seasonal Evergreen Forest)**
ACANTHACEAE	St John's Bush	*Justicia secunda*			**O**	**F**
ARECACEAE	Royal Palm	*Roystonea oleracea*	**R**			
	Mountain Cabbage	*Euterpe dominicana*		**R**		

Plant Species Found Along Transect F3						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
Family	**Common Name**	**Scientific Name**	**Quadrat**			
			F3a (Woody Agriculture)	**F3b (Secondary Forest/Seasonal Evergreen Forest)**	**F3c (Secondary Forest/Seasonal Evergreen Forest)**	**F3d (Secondary Forest/Seasonal Evergreen Forest)**
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	**R**	**R**	**R**	
CONCOLVULACEAE	Whorled Clustervine	*Jacquemontia verticillata*	**O**			
COSTACEAE	Wild Ginger	*Costus speciosus*			**O**	**R**
	Wild Ginger	*Costus scaber*			**O**	**R**
DILLENIACEAE	Water Vine	*Doliocarpus sp.*		**O**	**O**	
HELICONIACEAE	Heliconia	*Heliconia psittacorum*				**O**
LAURACEAE	Laurier	*Ocotea sp.*		**D**		
LEGUMINOSAE	Cacoley	*Inga laurina*	**O**		**A**	
MUSACEAE	Banana, Plantain	*Musa sp.*	**A**			
PIPERACEAE	Malanbe / Melambe	*Piper dilatatum*			**O**	
POACEAE	Bamboo	*Bambusa vulgaris*			**F**	**A**
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**A**			
	Guinea Grass / Animal Grass	*Panicum maximum*	**F**			
	Bamboo Grass	*Arthrostylidium excelsum*	**O**			**O**
RUTACEAE	Citrus	*Citrus sp.*	**R**			
SAPOTACEAE	Penny Piece	*Pouteria multiflora*	**R**			
STERCULIACEAE	Cocoa	*Theobroma cacao*	**R**			

Table 3-4 (d): DAFOR Scale for Plant Species in Quadrats Along Transect F4

Plant Species Found Along Transect F4							
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)							
Family	**Common Name**	**Scientific Name**	**Quadrat**				
			F4a (Mixed Woody and Herbaceous Agriculture)	**F4b (Secondary Forest/Seasonal Evergreen Forest)**	**F4c (Pasture/Cultivated Land/Herbaceous Agriculture)**	**F4d (Herbaceous and Woody Agriculture)**	**F4e (Woody Agriculture)**
ANACARDIACEAE	Mango	*Mangifera indica*	**R**				
ARACEAE	Dasheen / Taro / Callaloo	*Colocasia esculenta*			**F**		
ARECACEAE	Royal Palm	*Roystonea oleracea*					**R**
CECROPIACEAE	Bois Canot / Trumpet Plant	*Cecropia schreberiana*	**R**	**R**			**R**
EUPHORBIACEAE	Sand Box Tree / Monkey's Dinner Bell	*Hura crepitans*					**R**
LAURACEAE	Laurier	*Ocotea sp.*	**R**	**O**			
	Cinnamon Tree	*Cinnamomum verum*					**R**
LEGUMINOSAE	Cacoley	*Inga laurina*	**R**	**R**			
	Immortelle	*Erythrina poeppigiana*		**R**			
	Quick Stick / Glorisita	*Gliricidia sepium*					**O**
	Stinking Toe / Locust	*Hymenaea coubaril*					**R**
MORACEAE	Breadfruit / Breadnut	*Artocarpus altilis*				**R**	
MUSACEAE	Banana, Plantain	*Musa sp.*	**R**	**O**	**F**	**F**	
MYRISTICACEAE	Nutmeg	*Myristica fragrans*				**R**	
MYRTACEAE	Cloves	*Syzygium aromaticum*		**R**			**R**
POACEAE	Bamboo	*Bambusa vulgaris*		**R**			**O**

Plant Species Found Along Transect F4							
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)							
Family	**Common Name**	**Scientific Name**	**Quadrat**				
			F4a (Mixed Woody and Herbaceous Agriculture)	**F4b (Secondary Forest/Seasonal Evergreen Forest)**	**F4c (Pasture/Cultivated Land/Herbaceous Agriculture)**	**F4d (Herbaceous and Woody Agriculture)**	**F4e (Woody Agriculture)**
	Gully Bead / Buck Bead	*Coix lachryma-jobi*	**O**	**A**	**A**	**A**	**A**
	Guinea Grass / Animal Grass	*Panicum maximum*	**A**				
	Bamboo Grass	*Arthrostylidium excelsum*		**O**		**O**	**F**
RUTACEAE	Sweet Orange	*Citrus sinensis*					**R**
	Lemon	*Citrus limon*					**R**
	Tangerine / Mandarine	*Citrus reticulatum*					**R**
	Citrus	*Citrus sp.*	**R**		**O**	**R**	
SIMAROUBACEAE	Maruba / Birdfood	*Simarouba amara*	**R**				
STERCULIACEAE	Cocoa	*Theobroma cacao*	**O**	**F**	**O**	**F**	**F**

Table 3-5: Avifauna Species Recorded at Sites C and F (Dry Season)

Source: IUCN Red List (2019) and Raffaele, et. al. (2003)

FAMILY	COMMON NAME	SCIENTIFIC NAME	BIRD COUNT LOCATIONS						STATUS		NOTES
			BC-C1	BC-C2	OPP	BC-F1	BC-F2	OPP.	NATIONAL	INTERNATIONAL	
TYRANNIDAE	Grey Kingbird	*Tyrannus dominicensis*	4		✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Tropical Kingbird	*Tyrannus melancholicus*						✔	Not Listed	Least Concern (IUCN)	Rare and irregular migrant to Grenada
PSITTACIDAE	Orange Winged Parrot	*Amazona amazonica*				2			Not Listed	Least Concern (IUCN)	Introduced
ARDEIDAE	Little Blue Heron	*Egretta caerulea*			✔			✔	Not Listed	Least Concern (IUCN)	Uncommon
	Cattle Egret	*Bubulcus ibis*			✔	7		✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Yellow Crowned Night Heron	*Nyctanassa violacea*			✔				Not Listed	Least Concern (IUCN)	Uncommon in Grenada
ACCIPITRIDAE	Hook-Billed Kite	*Chondrohierax uncinatus mirus*				1		✔	Sub-Species Endemic to Grenada	Not Listed	Rare in Grenada. A critically endangered year round resident in extreme southwest and northeast Grenada
	Broad Winged Hawk	*Buteo platypterus*	2	1				✔	Not Listed	Least Concern (IUCN)	Common resident
TYTONIDAE	Barn Owl	*Tyto alba insularis*			✔				Not Listed	Not Listed	Rare resident in Grenada
TROCHILIDAE	Rufous Breasted Hermit	*Glaucis hirsuta*			✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident in mountains above 450 m.
	Antillean Crested Hummingbird	*Orthorhyncus cristatus*	1	2	✔		1	✔	Not Listed	Least Concern (IUCN)	Common year round resident
CUCULIDAE	Smooth Billed Ani	*Crotophaga ani*			✔				Not Listed	Least Concern (IUCN)	Common year round resident
TURDIDAE	Spectacled Thrush	*Turdus nudigenis*				1		✔	Not Listed	Least Concern (IUCN)	Common year round resident
MIMIDAE	Tropical Mockingbird	*Mimus gilvus*	1	1	✔	1	1	✔	Not Listed	Least Concern (IUCN)	Common year round resident

FAMILY	COMMON NAME	SCIENTIFIC NAME	BIRD COUNT LOCATIONS						STATUS		NOTES
			BC-C1	BC-C2	OPP	BC-F1	BC-F2	OPP.	NATIONAL	INTERNATIONAL	
EMBERIZIDAE	Bananaquit (Ce-Ce Bird)	*Coereba flaveola*	6	3	✔	8	5	✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Lesser Antillean Tanager	*Tangara cucullata*	2	1	✔	1			Not Listed	Least Concern (IUCN)	Uncommon resident to Grenada
	Lesser Antillean Bullfinch	*Loxigilla noctis*	3	2	✔	5	17	✔	Not Listed	Least Concern (IUCN)	Common year round resident
COLUMBIDAE	Scaley-Naped Pigeon (Ramier)	*Columba squamosa*			✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Common Ground Dove	*Columbina passerina*		1	✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Zenaida Dove	*Zenaida aurita*	1		✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident

Table 3-6: Avifauna Species Recorded at Sites C and F (Wet Season)

Source: IUCN Red List (2019) and Raffaele, et. al. (2003)

FAMILY	COMMON NAME	SCIENTIFIC NAME	BIRD COUNT LOCATIONS						STATUS		NOTES
			BC-C1	BC-C2	OPP.	BC-F1	BC-F2	OPP.	NATIONAL	INTERNATIONAL	
TYRANNIDAE	Grey Kingbird	*Tyrannus dominicensis*	4	5	✔	5			Not Listed	Least Concern (IUCN)	Common year round resident
	Tropical Kingbird	*Tyrannus melancholicus*			✔	1			Not Listed	Least Concern (IUCN)	Rare and irregular migrant to Grenada
PSITTACIDAE	Orange Winged Parrot	*Amazona amazonica*					2	✔	Not Listed	Least Concern (IUCN)	Introduced
ARDEIDAE	Cattle Egret	*Bubulcus ibis*	1		✔	2		✔	Not Listed	Least Concern (IUCN)	Common year round resident
ACCIPITRIDAE	Hook-Billed Kite	*Chondrohierax uncinatus mirus*						✔	Sub-Species Endemic to Grenada	Not Listed	Rare in Grenada. A critically endangered year round resident in extreme southwest and northeast Grenada
	Broad Winged Hawk	*Buteo platypterus*			✔				Not Listed	Least Concern (IUCN)	Common resident

FAMILY	COMMON NAME	SCIENTIFIC NAME	BIRD COUNT LOCATIONS						STATUS		NOTES
			BC-C1	BC-C2	OPP.	BC-F1	BC-F2	OPP.	NATIONAL	INTERNATIONAL	
TYTONIDAE	Barn Owl	*Tyto alba insularis*			✔			✔	Not Listed		Rare resident in Grenada
TROCHILIDAE	Rufous Breasted Hermit	*Glaucis hirsuta*		1	✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident in mountains above 450 m.
	Antillean Crested Hummingbird	*Orthorhyncus cristatus*	2	1	✔	1	3	✔	Not Listed	Least Concern (IUCN)	Common year round resident
CUCULIDAE	Smooth Billed Ani	*Crotophaga ani*			✔			✔	Not Listed	Least Concern (IUCN)	Common year round resident
TURDIDAE	Spectacled Thrush	*Turdus nudigenis*	2			1		✔	Not Listed	Least Concern (IUCN)	Common year round resident
MIMIDAE	Tropical Mockingbird	*Mimus gilvus*		1	✔		1	✔	Not Listed	Least Concern (IUCN)	Common year round resident
EMBERIZIDAE	Bananaquit (Ce-Ce Bird)	*Coereba flaveola*	10	8	✔	9	6	✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Lesser Antillean Tanager	*Tangara cucullata*	2	4	✔	3	2	✔	Not Listed	Least Concern (IUCN)	Uncommon resident to Grenada
	Lesser Antillean Bullfinch	*Loxigilla noctis*	8	9	✔	4	2	✔	Not Listed	Least Concern (IUCN)	Common year round resident
COLUMBIDAE	Scaley-Naped Pigeon (Ramier)	*Columba squamosa*	1		✔	1	1	✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Common Ground Dove	*Columbina passerina*	3	5	✔	4	4	✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Zenaida Dove	*Zenaida aurita*		2	✔		1	✔	Not Listed	Least Concern (IUCN)	Common year round resident

Table 3-7: Other Fauna Species Recorded at Site C (Dry Season)

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
Mammals														
DIDELPHIDAE	Common Opossum / Manicou	*Didelphis marsupialis*	Locally Common	Least Concern	1									
	Robinson's Mouse Opossum	*Marmosa robinsoni*	Uncommon to Rare	Least Concern	1									
HERPESTIDAE	Small Indian Mongoose	*Herpestes auropunctatus*	Introduced, Locally Common	Least Concern	1									✔
ORDER CHIROPTERA	Unidentified Bat	-	-	-					1					
Reptiles														
DACTYLOIDAE	Grenada Tree Anole / Giant Crown Anole	*Anolis richardii*	Common	Not Listed						9	14	11	7	✔
Amphibians														
ELEUTHERODACTYLIDAE	Lesser Antillean Frog	*Eleutherodactylus johnsonei*	Introduced, Locally Common	Not Listed					5					
LEPTODACTYLIDAE	Windward Islands Ditch Frog	*Leptodactylus validus*	Locally Common	Least Concern					3					
Fish														
GOBIIDAE	Suckstone / Titiri / Titi	*Sicydium sp.*	-	-				2						
Crustaceans														
ATYIDAE	Atyid Shrimp	*Jonga serrei*	Not Listed	Least Concern				9						
PALAEMONIDAE	Crayfish	*Macrobrachium sp.*	-	-				2						
PSEUDOTHELPHUSIDAE	Manicou Crab	*Guinotia dentata*	Not Listed	Least Concern				1						
Molluscs														
THIARIDAE	Red-rimmed Melania	*Melanoides tuberculata*	Not Listed	Least Concern				11						
HELICINIDAE	Helicinid Land Snail	*Helicina sp.*	-	-						2	2	3	1	✔
NEOCYCLOTIDAE	Neocyclotid Land Snail	*Asperostoma sp.*	-	-							1			✔
STROPHOCHEILIDAE	Giant South American Snail	*Megalobulimus oblongus*	Not Listed	Not Listed						3	6	3	2	✔
Millipedes														
SPIROBOLIDAE	Congaree / Round-backed Millipede	*Sp.1*	-	-						9	7	8	11	✔
	Congaree / Round-backed Millipede	*Sp.2*	-	-		1								
Spiders														

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
ARANEIDAE	Garden Orbweaver	*Argiope sp.*	-	-										✔
CTENIDAE	Fishing Spider	*Ancylometes sp.*	-	-				1						
SALTICIDAE	Jumping Spider	-	-	-		1	1							✔
THERIDIIDAE	Comb-footed Spider	*Sp.1*	-	-		2	1							
	Comb-footed Spider	*Sp.2*	-	-								2		
Insects														
GERRIDAE	Water Strider	-	-	-				5						
VELIIDAE	Smaller Water Strider	-	-	-				13						
COENAGRIONIDAE	Damselfly	*Argia telesfordi*	Endemic	Not Listed				3						✔
LIBELLULIDAE	Red-faced Dragonlet	*Erythrodiplax fusca*	Not Listed	Least Concern				2						✔
CICADIDAE	Cicada	-	-	-										✔
ACRIDADAE	Short-horned Grasshopper	-	-	-						8	13	16	12	✔
GRYLLIDAE	True Cricket	-	-	-		1								
TETTIGONIIDAE	Bush Cricket / Katydid	-	-	-						5	7	3	3	✔
EPIFAMILY TERMITOIDAE	Termite	-	-	-										✔
CULICIDAE	Mosquito	-	-	-										✔
CARABIDAE	Ground Beetle	-	-	-										✔
CURCULIONIDAE	Weevil	-	-	-						1				
PASSALIDAE	Passalid Beetle	-	-	-							1			
SCARABAEIDAE	Dug Beetle / Scarab Beetle	-	-	-		2	1							
	Chafer Beetle	-	-	-										✔
	Rose Chafer Beetle	-	-	-										✔
COREIDAE	Leaf-footed Bug	-	-	-						6	3	2	7	✔
REDUVIIDAE	Assassin Bug	-	-	-						2	1	5	4	✔
FORMICIDAE	Carpenter Ant	*Camponotus sp.*	-	-		2	3			>20	>20	>20	>20	
	Cock-tail Ant	*Crematogaster sp.*	-	-		2	1			>20	>20	>20	>20	
	Fire Ant	*Solenopsis sp.*	-	-		4	2			>20	>20	>20	>20	✔
	Trap-jaw Ant	*Odontomachus sp.*	-	-		1	2			1	3	4	1	✔
VESPIDAE	Maribone Wasp	*Polybia occidentalis*	Not Listed	Not Listed						>20	>20	>20	>20	✔
	Cohong / Armadillo Wasp	*Synoeca sp.*	-	-						>20	>20	>20	>20	✔
EREBIDAE	Wollybear Moth	*Spilosoma sp.*	-	-						8	10	6	8	✔

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
HESPERIIDAE	Lesser Whirlabout	*Polites dictynna*	Not Listed	Not Listed						7	4	3	12	✔
	Skipper	*Polites sp.*	-	-										✔
	Long-tail Skipper	*Chioides vintra*	Not Listed	Not Listed										✔
NYMPHALIDAE	Scarlet Peacock	*Anartia amathea*	Not Listed	Not Listed						8	13	12	17	✔

CT - Camera Trap; PT - Pitfall Trap; AS - Aquatic Survey; NS - Night Survey; TR - Transect; OP – Opportunistic

Table 3-8: Other Fauna Species Recorded at Site C (Wet Season)

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS		SURVEY METHOD											
			NATIONAL	IUCN	PT 1	PT 2	PT 3	PT 5	PT 6	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
Mammals																
HERPESTIDAE	Small Indian Mongoose	*Herpestes auropunctatus*	Introduced, Locally Common	Least Concern												✔
ORDER CHIROPTERA	Unidentified Bat	-	-	-							3					
Reptiles																
DACTYLOIDAE	Grenada Tree Anole / Giant Crown Anole	*Anolis richardii*	Common	Not Listed								6	11	13	8	✔
Amphibians																
ELEUTHERODACTYLIDAE	Lesser Antillean Frog	*Eleutherodactylus johnsonei*	Introduced, Locally Common	Not Listed							4					✔
LEPTODACTYLIDAE	Windward Islands Ditch Frog	*Leptodactylus validus*	Locally Common	Least Concern							3					
Fish																
GOBIIDAE	Suckstone / Titiri / Titi	*Sicydium sp.*	-	-						1						✔
Crustaceans																
ATYIDAE	Atyid Shrimp	*Jonga serrei*	Not Listed	Least Concern						11						
PALAEMONIDAE	Crayfish	*Macrobrachium sp.*	-	-						1						

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS		SURVEY METHOD											
			NATIONAL	IUCN	PT 1	PT 2	PT 3	PT 5	PT 6	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
PSEUDOTHELPHUSIDAE	Manicou Crab	*Guinotia dentata*	Not Listed	Least Concern						1						✔
Molluscs																
THIARIDAE	Red-rimmed Melania	*Melanoides tuberculata*	Not Listed	Least Concern						7						
HELICINIDAE	Helicinid Land Snail	*Helicina sp.*	-	-								1	1	3	2	✔
NEOCYCLOTIDAE	Neocyclotid Land Snail	*Asperostoma sp.*	-	-								1		1		✔
STROPHOCHEILIDAE	Giant South American Snail	*Megalobulimus oblongus*	Not Listed	Not Listed								2	4	5	4	✔
VERONICELLIDAE	Leatherleaf Slug	-	-	-												✔
Annelids																
ORDER OPISTHOPORA	Earthworm	-	-	-												✔
Millipedes																
SPIROBOLIDAE	Congaree / Round-backed Millipede	*Sp.1*	-	-			1					7	10	6	13	✔
	Congaree / Round-backed Millipede	*Sp.2*	-	-	1			1								
Spiders																
ARANEIDAE	Garden Orbweaver	*Argiope sp.*	-	-												✔
CTENIDAE	Fishing Spider	*Ancylometes sp.*	-	-						3						
SALTICIDAE	Jumping Spider	-	-	-		1			1							✔
THERIDIIDAE	Comb-footed Spider	*Sp.1*	-	-	1	1			1							
Insects																
GERRIDAE	Water Strider	-	-	-						9						
VELIIDAE	Smaller Water Strider	-	-	-						>20						
GYRINIDAE	Whirligig Beetles	-	-	-						7						
COENAGRIONIDAE	Damselfly	*Argia telesfordi*	Endemic	Not Listed						2						✔
	Rubyspot Damselfly	*Hetaerina sp.*	-	-						4						

Family	Common Name	Scientific Name	Status		Survey Method											
			National	IUCN	PT 1	PT 2	PT 3	PT 5	PT 6	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
LIBELLULIDAE	Red-faced Dragonlet	*Erythrodiplax fusca*	Not Listed	Least Concern						5						✔
	Tawny Pennant Dragonfly	*Brachymesia herbida*	Not Listed	Data Deficient												✔
CICADIDAE	Cicada	-	-	-												✔
ACRIDADAE	Short-horned Grasshopper	-	-	-								6	12	19	8	✔
GRYLLIDAE	True Cricket	-	-	-		1	1	1								
TETTIGONIIDAE	Bush Cricket / Katydid	-	-	-								4	3	6	7	✔
BLATTIDAE	Cockroach	*Blatta sp.*	-	-								1	3			
EPIFAMILY TERMITOIDAE	Termite	-	-	-	2							>100				✔
CULICIDAE	Mosquito (Adult)	-	-	-												✔
	Mosquito (Larva)	-	-	-						>20						✔
CARABIDAE	Ground Beetle	-	-	-												✔
CURCULIONIDAE	Weevil	-	-	-								1			1	
PASSALIDAE	Passalid Beetle	-	-	-												✔
SCARABAEIDAE	Dug Beetle / Scarab Beetle	-	-	-		1										
	Chafer Beetle	-	-	-									1			✔
COREIDAE	Leaf-footed Bug	-	-	-								8	6	7	7	✔
PENTATOMIDAE	Shield Bug / Stink Bug	-	-	-										1		✔
REDUVIIDAE	Assassin Bug	-	-	-								2	1	1	1	✔
FORMICIDAE	Carpenter Ant	*Camponotus sp.*	-	-	1	4	3	3	1			>20	>20	>20	>20	
	Cock-tail Ant	*Crematogaster sp.*	-	-	3	1			2			>20	>20	>20	>20	
	Fire Ant	*Solenopsis sp.*	-	-	2	5	6	2	2			>20	>20	>20	>20	✔
	Trap-jaw Ant	*Odontomachus sp.*	-	-		1	1	1				3	5	1	2	✔
APIDAE	Honey Bee	*Apis mellifera*	Not Listed	Not Listed												✔
VESPIDAE	Maribone Wasp	*Polybia occidentalis*	Not Listed	Not Listed								>20	>20	>20	>20	✔
	Cohong / Armadillo Wasp	*Synoeca sp.*	-	-								>20	>20	>20	>20	✔

Family	Common Name	Scientific Name	Status		Survey Method											
			National	IUCN	PT 1	PT 2	PT 3	PT 5	PT 6	AS	NS	TR C1	TR C2	TR C3	TR C4	OP
	Yellow Paper Wasp	*Polistes versicolor*	Not Listed	Not Listed								>20	>20	>20	>20	✔
EREBIDAE	Wollybear Moth	*Spilosoma sp.*	-	-								3	8	9	5	✔
HESPERIIDAE	Lesser Whirlabout	*Polites dictynna*	Not Listed	Not Listed								2	2	5	9	✔
	Skipper	*Polites sp.*	-	-								1			1	✔
	Long-tail Skipper	*Chioides vintra*	Not Listed	Not Listed									2			✔
NYMPHALIDAE	Flambeau	*Dryas iulia*	Not Listed	Not Listed									3	2		✔
	Scarlet Peacock	*Anartia amathea*	Not Listed	Not Listed								5	3	2	6	✔
	White Crescent	*Janatella leucodesma*	Not Listed	Not Listed								1	2	1	1	✔
	White Peacock	*Anartia jatrophae*	Not Listed	Not Listed								1	1	4	2	✔

PT - Pitfall Trap; AS - Aquatic Survey; NS - Night Survey; TR - Transect; OP – Opportunistic

Table 3-9: Other Fauna Species Recorded at Site F (Dry Season)

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR F1	TR F2	TR F3	TR F4	OP **
Mammals														
DASYPODIDAE	Nine-banded Armadillo	*Dasypus novemcinctus*	Locally Common	Least Concern	1									✔
DIDELPHIDAE	Common Opossum / Manicou	*Didelphis marsupialis*	Locally Common	Least Concern	1									
	Robinson's Mouse Opossum	*Marmosa robinsoni*	Uncommon to Rare	Least Concern	1									
HERPESTIDAE	Small Indian Mongoose	*Herpestes auropunctatus*	Introduced, Locally Common	Least Concern	1									✔
ORDER CHIROPTERA	Unidentified Bat	-	**-**	-					1					
Reptiles														
DACTYLOIDAE	Grenada Tree Anole / Giant Crown Anole	*Anolis richardii*	Common	Not Listed						18	12	6	11	✔
-	Unidentified Snake	-	-	-	1									
Amphibians														
ELEUTHERODACTYLIDAE	Lesser Antillean Frog	*Eleutherodactylus johnsonei*	Introduced, Locally Common	Not Listed					3					

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR F1	TR F2	TR F3	TR F4	OP **
LEPTODACTYLIDAE	Windward Islands Ditch Frog	*Leptodactylus validus*	Locally Common	Least Concern					2					
Fish														
RIVULIDAE	Jumping Guabine / Rivulus	*Anablepsoides hartii*	Not Listed	Not Listed				1						
Crustaceans														
ATYIDAE	Atyid Shrimp	*Jonga serrei*	Not Listed	Least Concern				2						
Molluscs														
HELICINIDAE	Helicinid Land Snail	*Helicina sp.*	-	-						8	2	1	7	✔
NEOCYCLOTIDAE	Neocyclotid Land Snail	*Asperostoma sp.*	-	-									1	✔
STROPHOCHEILIDAE	Giant South American Snail	*Megalobulimus oblongus*	Not Listed	Not Listed						15	7	3	11	✔
Millipedes														
SPIROBOLIDAE	Congaree / Round-backed Millipede	*Sp.1*	-	-						20	13	10	15	✔
	Congaree / Round-backed Millipede	*Sp.2*	-	-			1							
Spiders														
ARANEIDAE	Garden Orbweaver	*Argiope sp.*	-	-						2				✔
CTENIDAE	Fishing Spider	*Ancylometes sp.*	-	-				2						
SALTICIDAE	Jumping Spider	-	-	-		2	1							✔
THERIDIIDAE	Comb-footed Spider	*Sp.1*	-	-		2	3							
Insects														
GERRIDAE	Water Strider	-	-	-				8						
VELIIDAE	Smaller Water Strider	-	-	-				16						
GYRINIDAE	Whirligig Beetles	-	-	-				13						
PERLIDAE	Stonefly (Larva)	-	-	-				3						
COENAGRIONIDAE	Damselfly	*Argia telesfordi*	Endemic	Not Listed				5						✔
	Damselfly (Larva)	-	-	-				7						
LIBELLULIDAE	Red-faced Dragonlet	*Erythrodiplax fusca*	*Argia telesfordi*	Least Concern				2						✔
	Dragonfly	-	-	-						1				
CICADIDAE	Cicada	-	-	-										✔
ACRIDADAE	Short-horned	-	-	-						15	12	3	17	✔

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR F1	TR F2	TR F3	TR F4	OP **
	Grasshopper													
GRYLLIDAE	True Cricket	-	-	-		1	1							✔
TETTIGONIIDAE	Bush Cricket / Katydid	-	-	-						6	3		2	✔
EPIFAMILY TERMITOIDAE	Termite	-	-	-						> 100	> 100		> 100	✔
CULICIDAE	Mosquito	-	-	-										✔
ORDER COLEOPTERA	Beetle Larva	-	-	-			2							
CARABIDAE	Ground Beetle	-	-	-		1								✔
ELATERIDAE	Click Beetle	-	-	-										✔
PASSALIDAE	Passalid Beetle	-	-	-						1			1	
SCARABAEIDAE	Dug Beetle / Scarab Beetle	-	-	-		3	1							
	Chafer Beetle	-	-	-										✔
COREIDAE	Leaf-footed Bug	-	-	-						8	12		2	✔
MIRIDAE	Meadow Bug	-	-	-						2			1	✔
FORMICIDAE	Carpenter Ant	*Camponotus sp.*	-	-		3	4							
	Cock-tail Ant	*Crematogaster sp.*	-	-		1	1			<10	<10	<10	<10	✔
	Fire Ant	*Solenopsis sp.*	-	-		2	7			>20	>20	>20	>20	✔
	Trap-jaw Ant	*Odontomachus sp.*	-	-		1	2			3	2	1	2	
VESPIDAE	Maribone Wasp	*Polybia occidentalis*	Not Listed	Not Listed						>20	>20	>20	>20	✔
	Cohong / Armadillo Wasp	*Synoeca sp.*	-	-						>20	>20	>20	>20	✔
EREBIDAE	Wollybear Moth	*Spilosoma sp.*	-	-						2	2	1	3	✔
HESPERIIDAE	Long-tail Skipper	*Chioides vintra*	Not Listed	Not Listed										✔
NYMPHALIDAE	Flambeau	*Dryas iulia*	Not Listed	Not Listed						7	2	1	4	✔
	Scarlet Peacock	*Anartia amathea*	Not Listed	Not Listed						6	4	2	5	✔
	Stinky Leafwing / Orion Cecropian	*Historis odius*	Not Listed	Not Listed						1				

CT - Camera Trap; PT - Pitfall Trap; AS - Aquatic Survey; NS - Night Survey; TR - Transect; OP – Opportunistic;

** Armadillo tracks were opportunistically observed.

Table 3-10: Other Fauna Species Recorded at Site F (Wet Season)

Family	Common Name	Scientific Name	Status		Survey Method										
			National	IUCN	PT 1	PT 3	PT 4	PT 6	AS	NS	TR F1	TR F2	TR F3	TR F4	OP
Mammals															
DASYPODIDAE	Nine-banded Armadillo	*Dasypus novemcinctus*	Locally Common	Least Concern											✔
HERPESTIDAE	Small Indian Mongoose	*Herpestes auropunctatus*	Introduced, Locally Common	Least Concern											✔
ORDER CHIROPTERA	Unidentified Bat	-	-	-						2					
Reptiles															
DACTYLOIDAE	Grenada Tree Anole / Giant Crown Anole	*Anolis richardii*	Common	Not Listed							>20	14	5	13	✔
Amphibians															
ELEUTHERODACTYLIDAE	Lesser Antillean Frog	*Eleutherodactylus johnsonei*	Introduced, Locally Common	Not Listed						5					✔
LEPTODACTYLIDAE	Windward Islands Ditch Frog	*Leptodactylus validus*	Locally Common	Least Concern						2					✔
Fish															
RIVULIDAE	Jumping Guabine / Rivulus	*Anablepsoides hartii*	Not Listed	Not Listed					2						
Crustaceans															
ATYIDAE	Atyid Shrimp	*Jonga serrei*	Not Listed	Least Concern					1						
Molluscs															
HELICINIDAE	Helicinid Land Snail	*Helicina sp.*	-	-							2		1		✔
NEOCYCLOTIDAE	Neocyclotid Land Snail	*Asperostoma sp.*	-	-								1		1	✔
STROPHOCHEILIDAE	Giant South American Snail	*Megalobulimus oblongus*	Not Listed	Not Listed							5	1	2	2	✔
Millipedes															
SPIROBOLIDAE	Yellow-banded Millipede	*Anadenobolus monilicornis*	Not Listed	Not Listed	1										✔
	Congaree / Round-backed Millipede	*Sp.1*	-	-		1					6	10	11	9	✔
	Congaree / Round-	*Sp.2*	-	-			1								

Family	Common Name	Scientific Name	Status		Survey Method										
			National	IUCN	PT 1	PT 3	PT 4	PT 6	AS	NS	TR F1	TR F2	TR F3	TR F4	OP
	backed Millipede														
Spiders															
ARANEIDAE	Garden Orbweaver	*Argiope sp.*	-	-											✔
CTENIDAE	Fishing Spider	*Ancylometes sp.*	-	-					1						
SALTICIDAE	Jumping Spider	-	-	-		1					1	1			✔
THERIDIIDAE	Comb-footed Spider	*Sp.1*	-	-		1	1								
Insects															
GERRIDAE	Water Strider	-	-	-					3						
VELIIDAE	Smaller Water Strider	-	-	-					5						
GYRINIDAE	Whirligig Beetles	-	-	-					3						
PERLIDAE	Stonefly (Larva)	-	-	-					2						
COENAGRIONIDAE	Damselfly	*Argia telesfordi*	Endemic	Not Listed					3		1				✔
	Damselfly (Larva)	-	-	-					1						
LIBELLULIDAE	Red-faced Dragonlet	*Erythrodiplax fusca*	Not Listed	Least Concern					4						✔
	Dragonfly (Larva)	-	-	-					1						
CICADIDAE	Cicada	-	-	-									1		
ACRIDADAE	Short-horned Grasshopper	-	-	-							14	16	11	16	✔
GRYLLIDAE	True Cricket	-	-	-		1	1	1							✔
TETTIGONIIDAE	Bush Cricket / Katydid	-	-	-											✔
EPIFAMILY TERMITOIDAE	Termite	-	-	-					1		>100	>100		>100	✔
CULICIDAE	Mosquito (Adult)	-	-	-											✔
	Mosquito (Larva)	-	-	-					>20						✔
ORDER PHASMATODEA	Stick Insect	-	-	-									1		
CARABIDAE	Ground Beetle	-	-	-		1									✔
SCARABAEIDAE	Dug Beetle / Scarab Beetle	-	-	-	1	1					1				✔
	Chafer Beetle	-	-	-											✔
	Rose Chafer Beetle	-	-	-											✔
COREIDAE	Leaf-footed Bug	-	-	-							3	14	1	3	✔
MIRIDAE	Meadow Bug	-	-	-								1			✔

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS		SURVEY METHOD										
			NATIONAL	IUCN	PT 1	PT 3	PT 4	PT 6	AS	NS	TR F1	TR F2	TR F3	TR F4	OP
FORMICIDAE	Carpenter Ant	*Camponotus sp.*	-	-	1	1	2	1			>20	>20	>20	>20	
	Cock-tail Ant	*Crematogaster sp.*	-	-	1			1			<10	<10	<10	<10	✔
	Fire Ant	*Solenopsis sp.*	-	-	2	4	3	2			>20	>20	>20	>20	✔
	Trap-jaw Ant	*Odontomachus sp.*	-	-			1				4	1	3	1	✔
VESPIDAE	Maribone Wasp	*Polybia occidentalis*	Not Listed	Not Listed							>20	>20	>20	>20	✔
	Cohong / Armadillo Wasp	*Synoeca sp.*	-	-							>20	>20	>20	>20	✔
EREBIDAE	Wollybear Moth	*Spilosoma sp.*	-	-							4	3	2	5	✔
HESPERIIDAE	Lesser Whirlabout	*Polites dictynna*	Not Listed	Not Listed							2				✔
	Orcus Checkered Skipper	*Pyrugus orcus*	Not Listed	Not Listed							1	1	1	2	✔
	Long-tail Skipper	*Chioides vintra*	Not Listed	Not Listed											✔
NYMPHALIDAE	Flambeau	*Dryas iulia*	Not Listed	Not Listed							5	6	2	3	✔
	Scarlet Peacock	*Anartia amathea*	Not Listed	Not Listed							5	8	1	4	✔
	White Crescent	*Janatella leucodesma*	Not Listed	Not Listed							1	1		1	✔

PT - Pitfall Trap; AS - Aquatic Survey; NS - Night Survey; TR - Transect; OP - Opportunistic

Note: Pitfall Traps PT2, PT5, PT7 and PT8 did not contain any fauna.

** Armadillo tracks were opportunistically observed.

Appendix 2: Ecosystem Services Sheet

TABLE 2-1: TREE AND GRASS IDENTIFICATION AT SITE C

Tree and Grass Identification																									
Species	**Food**		**Fodder**			**Wood**							**Services**							**Miscellaneous**				**Rating**	**Other Remarks**
	Fruits/pods/leaves	**Nuts/Seeds**	**Leaves**	**Fruits/pods/leaves**	**Shoots**	**Bee Forage**	**Fuel wood**	**Charcoal**	**Building/hut material**	**Implements furniture/tools**	**Pulp**	**Sawn timber**	**Windbreak/shelter**	**Live Fence**	**Soil Conservation**	**Dune Fixing**	**N2 fixing**	**Organic Manure**	**Soil Improvement**	**Oil tannins/dyes**	**Gums**	**Medicinal**	**Shade/Ornamental**		
Nutmeg (*Myristica fragrans*)	✔	✔																						**3**	Seeds are used extensively as a major spice on the island.
Dragon Blood / Dragon Tree (*Dracaena sp.)*													✔	✔										2	This tree is used as a windbreak and also as a boundary plant (demarking property boundaries)
Dandelion (*Gebera sp.*)																						✔		1	The leaves and roots of the dandelion plant is used medicinally to treat a number of ailments (bladder infections, used as a laxative, treat gas and indigestion, helps with inflammation)
Coconut (*Cocos nucifera*)		✔							✔											✔		✔		2	The water in the nut is a natural source of

Tree and Grass Identification

Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
																									electrolytes. Leaves are used as building material and used to make brooms. Coconut oil is also derived from the nut, which also has mild medicinal value
Bois Canot (*Cecropia schreberiana*)			✔																			✔		1	The leaves are used to feed cows, and are also used medicinally
Mountain Cabbage (*Euterpe dominicana*)	✔																							1	The heart of this palm plant is edible
Roucou (*Bixa orellana*)																				✔		✔		1	This is used as a mosquito repellent, and in the bright red colour is used as a dye.
Gully Bead / Buck Bead (*Coix lachryma-jobi*)																							✔	1	Seeds are used to make jewellery
Penny Piece (*Pouteria multiflora*)	✔								✔	✔														2	This tree is used as windbreak and is a good hardwood species.
Galba (*Calophyllum calaba)*													✔	✔								✔	✔	2	The seeds are used to make jewellery. The leaves are used

Tree and Grass Identification

Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
																									medicinally to treat bladder infections and the trees themselves are planted as windbreaks, to demarcate property boundaries and as shade for cocoa plantations.
Cacolay (*Inga laurina*)													✔										✔	2	This tree is used as windbreak and was used in the past as a shade tree in cocoa plantations.
Cabbage Palm Fern (*Phlebodium aureum*)																							✔	1	The leaves are used in floral arrangements and is a common ornamental plant
Cat's Claw (*Macfadenya unguis-cati)*																							✔	1	The vines are used in weaving baskets
Cola Nut (Cola nitida)																						✔		1	The nut is used as a mild stimulant. Once chewed, it gives short term relief from fatigue, depression and muscle

Tree and Grass Identification																									
Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
																									exhaustion

1(Fair)	2(Good)	3(Excellent)

TABLE 2-2: TREE AND GRASS IDENTIFICATION AT SITE F

Tree and Grass Identification																									
Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
Nutmeg (*Myristica fragrans*)	✔	✔																		✔		✔		3	Seeds are used extensively as a major

Tree and Grass Identification

Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
																									spice on the island. Nutmeg oil is also used medicinally
Clove (*Syzygium aromaticum*)		✔																		✔		✔		3	Seeds/pods are used extensively as a major spice on the island. Nutmeg oil is also used medicinally
Cocoa (*Theobroma cacao)*	✔																							3	Seeds/pods are used to make chocolate
Glorisita (*Gliricidia sepium)*			✔							✔				✔	✔									2	The trunk of this tree is used to construct piles/props for fencing around properties. The tree is also planted along property boundaries as a demarcation, as well as on hills to prevent erosion. The leaves are fed to animals.

Tree and Grass Identification																									
Species	**Food**		**Fodder**			**Wood**							**Services**							**Miscellaneous**				**Rating**	**Other Remarks**
	Fruits/pods/leaves	**Nuts/Seeds**	**Leaves**	**Fruits/pods/leaves**	**Shoots**	**Bee Forage**	**Fuel wood**	**Charcoal**	**Building/hut material**	**Implements furniture/tools**	**Pulp**	**Sawn timber**	**Windbreak/shelter**	**Live Fence**	**Soil Conservation**	**Dune Fixing**	**N2 fixing**	**Organic Manure**	**Soil Improvement**	**Oil tannins/dyes**	**Gums**	**Medicinal**	**Shade/Ornamental**		
Galba (*Calophyllum calaba)*													✔	✔								✔	✔	3	The seeds are used to make jewelry. The leaves are used medicinally to treat bladder infections and the trees themselves are planted as windbreaks, to demarcate property boundaries and as shade for cocoa plantations.
Immortelle (*Erythrina poeppigiana*)													✔				✔	✔	✔				✔	3	The trees themselves are planted as windbreaks, and as shade for cocoa plantations. The leaves and flowers are used as mulch and being a legume, it is a nitrogen fixing plant
Gommier (*Dacryodes excelsa*)																						✔		1	The bark of the tree is used as a laxative
Simarouba (*Simarouba amara)*									✔	✔												✔		2	The leaves and bark is used as a medicine to

Tree and Grass Identification

Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
																									treat diarrhoea. The wood is used to make light furniture such as chairs and window frames and tools.
Bois Canot (*Cecropia schreberiana*)			✔																			✔		1	The leaves are used to feed cows, and are also used medicinally
Cacolay (*Inga laurina*)							✔						✔										✔	2	This tree is used as windbreak and was used in the past as a shade tree in cocoa plantations. The wood is used for fireside cooking
Penny Piece (*Pouteria multiflora*)	✔						✔		✔	✔		✔												3	This tree is used as windbreak and is a good hardwood species. The wood is also used for making tools and furniture. The wood is also used for fireside cooking
Stinking Toe (*Hymenaea coubaril*)	✔																				✔	✔		1	The pods are edible. The leaves, sap, and

Tree and Grass Identification																									
Species	**Food**		**Fodder**			**Wood**							**Services**							**Miscellaneous**				**Rating**	**Other Remarks**
	Fruits/pods/leaves	**Nuts/Seeds**	**Leaves**	**Fruits/pods/leaves**	**Shoots**	**Bee Forage**	**Fuel wood**	**Charcoal**	**Building/hut material**	**Implements furniture/tools**	**Pulp**	**Sawn timber**	**Windbreak/shelter**	**Live Fence**	**Soil Conservation**	**Dune Fixing**	**N2 fixing**	**Organic Manure**	**Soil Improvement**	**Oil tannins/dyes**	**Gums**	**Medicinal**	**Shade/Ornamental**		
																									fruits have medicinal uses (coughs, bronchitis, anaemia).
Water Vine (*Dolio carpus sp)*																						✔		1	The water in the vines are known to have mild antibiotic properties

1(Fair)	*2(Good)*	*3(Excellent)*

Appendix 3: Detailed Results of Plant Species Identified Along Transects and Quadrats

<u>Habitats and Flora at Site C</u>

These descriptions are based on the field surveys conducted during April, 2019. At Site C, four transects and fifteen (15) quadrats were established (see Figure 2-2). Along these transects and quadrats, total of 127 species belonging to 53 Families were recorded. A full listing of the species recorded at Site C are presented in Tables 3-1 and 3-2. At a 10 m radius around the centre of the proposed drilling pad, (Quadrats C1a, C2a, C3a and C4a), the vegetation was described as modified (see Photographs 3-1 to 3-4). Grasses were the dominant vegetation, interspersed with various crops. Grasses were approximately 0.6 to 0.93 m in height. Agricultural crops within this radius included Cabbage (*Brassica oleracea* var. *capitata*), Pumpkin (*Cucurbita maxima*), Pepper (*Capsicum chinense*), Bodi (*Vigna unguiculata* var. *sesquipedalis*), Christophene (*Sechium edule*), Cucumber (*Cucumis sativus*), Coconut (*Cocos nucifera*) and Banana/Plantain (*Musa sp*.). The prevalent grasses were Caner Grass (*Commelina elegans* and *Commelina diffusa*), Guinea Grass (*Panicum maximum*), Gully Beads (*Coix lachryma-jobi*), Carpet Grass (*Axonopus compressus*) and Razor Grass (*Paspalum virgatum*).

Transect C1 was the northerly transect. From the Quadrat C1a, and moving north, there was a shift in vegetation from grasses to modified secondary forest, with species such as Blue Mahoe (*Hibiscus elatus*), Royal Palm (*Roystonea oleracea*) (see Photograph 3-5), Tayo (*Xanthosoma sp*.) (see Photograph 3-6), Dasheen (*Colocasia esculenta*), Tannia (*Xanthosoma sagittifolium*), Figuier (*Ficus guianensis*) and Cacolay (*Inga laurina*). Blue Mahoe was thick along this transect, and ranged from 4.6 to 7.6 m, while Royal Palms, which were interspersed in the area, towered more than 12.2 m high. Cacolay and Figuier, were also sparsely distributed and were approximately 9.1 m tall, while Tayo, Dasheen and Tannia were no more than 0.9 m tall. Further north, there was another shift from secondary forest to agroforestry, with the dominant species being Nutmeg (*Myristica fragrans*). These trees stood at about 3.0 to 5.5 m. Banana and Cocoa (*Theobroma cacao*) were interspersed among the nutmeg plantation, and were also in the height range of 1.8 to 3.7 m. There was no undergrowth in this area. Beyond the nutmeg plantation, there was a shift into mature secondary forest, with Bamboo being the dominant vegetation. Bois Canot was sparsely distributed in this area. Balisier (*Heliconia caribaea*) and Heliconia (*Heliconia psittacorum*) were the major understory here.

Transect C2 was the easterly transect. From quadrat C2a, and moving east, there was a shift from pasture/grassland to crops, the main ones being banana (ranging from 1.5 to 2.1 m) (see Photograph 3-7) and Patchoi (*Brassica rapa* var. *chinensis*). Interspersed in this plot were fruit trees such as Mango (*Mangifera indica*), Guava (*Psidium guayava*) and Breadfruit/Breadnut (*Artocarpus altilis*). These were well established trees ranging from 2.4 to 3.7 m in height.

Continuing eastward, an areas of pasture was encountered, with the dominant species being Bull Grass (*Paspalum fasciculatum*) of heights of 0.9 to 1.2 m. Within this pasture, there were patches of Flat Sedges (*Cyperus alternifolius* and *Cyperus digitatus*) (see Photographs 3-8 and 3-9), Balisier, Tannia and Bamboo (*Bambusa vulgaris*) (see Figure 3-10). The Flat Sedges towered approximately 1.8 m tall, while the Balisier and Tannia were between 1.2 and 2.4 m tall. The Bamboo was approximately 9.1 m tall. A few Nutmeg trees (approximately 1.8 to 2.4 m tall) were interspersed in the area. Further east, there was a shift in vegetation to shrubland, followed by thick, tall stands of Bamboo (more than 9.1 m tall) (see Photograph 3-11). The shrubs included Malanbe (*Piper dilatatum*), and Balisier (see Photograph 3-12) as the dominant species, and these were in the order of 1.2 m and 2.4 m respectively. A few tall Laurier (*Ocotea sp.*) (9.1 m), Bois Canot (*Cecropia schreberiana*) (8.5 m) and Cocoa trees (3.7 m) were also observed.

Transect C3 was the southerly transect. At quadrat C3a, there were mostly crops such as Cabbage, Pepper, Bodi and Banana (see Photograph 3-3), with a few Nutmeg trees. Continuing south, and immediately south of the river, the dominant vegetation was Bamboo (see Photograph 3-13). These were tall, thick, mature stands of bamboo with heights of approximately 9.1 to 12.2 m. Further south, a Nutmeg plantation was present, with trees of approximately 2.4 to 4.6 m tall. Banana and breadfruit were interspersed among this plantation (see Photograph 3-14). The undergrowth was sparsely distributed with Nettle and Bamboo grasses (both under 1 foot) (see Photograph 3-15). Continuing southward along the transect, there was shift to secondary forest, with the canopy species bieng Bois Flot (*Ochroma pyramidale*), Bois Canot and Bamboo as the dominant species. Other species included a few Tree Ferns, Nutmeg, Clove (*Syzygium aromaticum*) and Cocoa (see Photograph 3-16). Balisier and Wild Nettle were the dominant understory species.

Transect C4 was the westerly transect. At quadrat C4a, grasses were the dominant vegetation (see Photograph 3-4). Continuing west, grasses (between 0.6 and 1.2 m tall) remained the dominant vegetation (see Photograph 3-17 and 3-18), with the prevalent species being Guinea Grass, Gully Bead, Shield Ferns (*Polybotrya sp. Dryopteris sp.*) and Whorled Clustervine (*Jacquemontia verticillatavines*). Interspersed among this area were isolated, juvenile trees such Nutmeg and Cherimoya (*Annona cherimola*), (no more than 1.8 m in height). A few small patches of Heliconia were also present. Further west, grassland remained the main habita, but other isolated trees such as Guava, Banana and Sugarcane (*Saccharum officinarum*) were present. Those trees were no more than 2.4 m in height. Beyond this, a thick stand of Balisier (see Photograph 3-19), followed by mature thick stands of bamboo were encountered. Described as shrubland, the Balisier were between 2.4 to 3.0 m tall, while the Bamboo was in excess of 6.1 m. Immediately following this, a small Nutmeg Plantation (see Photograph 3-20) (of tree heights 6 to 3.0 m) and a large, well maintained agricultural plot was encountered (see Photograph 3-21). The plot included crops such as, Cabbage, Hot pepper (see Photograph 3-22), Pimento pepper, Coconut, Banana, Rough-Skin Lemon, Papaya, Pigeon Peas, Bodi, Dasheen and Sugarcane. Further west of the agricultural plot, was mature secondary forest, as evidenced by tall stands of Bamboo, Bois Canot, Tapana (*Hyeronima laxiflora*), Figuier, Mountain Cabbage (*Euterpe dominicana*), Cacolay and Penny Piece (see Photographs 3-23 and 3-24) . Nutmeg, Bamboo and Heliconia lined the edge of the forested area. The understory was sparsely distributed with few Shield Ferns and Bamboo Grass.

Habitats and Flora at Site F

At Site F, four transects and eighteen (18) quadrats were established (see Figure 3-2). Along these transects and quadrats, total of 145 species belonging to 61 Families were recorded. A full listing of the species recorded at Site F are presented in Tables 3-3 and 3-4. At a 10 m radius around the centre of the proposed drilling pad, (Quadrats F1a, F2a, F3a and F4a), the vegetation was described as modified (see Photographs 3-25 to 3-28). Grasses were the dominant undergrowth, occurring between 0.6 to 0.9 m. Species included: Gully Bead / Buck Bead (*Coix lachryma-jobi*); Guinea Grass (*Panicum maximum*); Para Grass (*Brachiaria mutica*); Bamboo Grass (*Arthrostylidium excelsum*) and Palm Grass (*Setaria palmifolia*). The Whorled Clustervine (*Jacquemontia verticillata*) was also prevalent in this area. Taller trees and crop species were interspersed among the grass area and included Cacolay and Bois Canot; and Banana, Nutmeg and a variety of Citrus, respectively. The taller trees were in the order of 7.6 to 9.1 m, while the crop species were between 1.8 and 2.4 m.

Transect F1 was the northerly transect. Immediately after quadrat F1a, modified mixed forest was encountered, with Bamboo being the dominant vegetation. The undergrowth included Heliconia, Balisier, St. John's Bush (*Justicia secunda*) and Malanbe. These stood between 0.6 to 1.2 m tall. Other species included Bois Canot, which was approximately 9.1 m tall; and Cocoa, which were approximately 3.7 m tall. Continuing north, Wild Breadnut/Chataigne *(Pachira insignis*), young Bois Canot, Tree Fern, Banana, and Cocoa were observed (see Photographs 3-29 and 3-30). The undergrowth included species such as Tannia, Nettle, Bamboo Grass and St. John's Bush (see Photograph 3-31). Immediately following this area was a Banana Plantation (see Photograph 3-32). Amidst this area were a few Laurier and Wild Breadnut/Chataigne Trees, which were approximately 9.1 m tall. The undergrowth was dominated by Guinea Grass and Para Grass (between 0.6 and 0.9 m tall). Moving northward along the transect, the area then transitioned into secondary forest, which included mature species such as Wild Breadnut/Chataingne, Laurier, and Cacolay, all over 10.7 m. The understory included numerous Laurier saplings, Whist Vines (*Trichostigma octandrum*) and various Ferns (*Blechnum sp.,Gleichenella pectinata*, and *Phlebodium aureum*) (see Photographs 3-33, 3-34 and 3-35, respectively). Further north, Bois Canot and Cacolay and Laurier remained the main tree species, but the undergrowth now also included Malanbe and Heliconia. In addition to the Laurier saplings, young Swizzlestick Trees (*Quararibea turbinate)* were prevalent. Moving further north, toward the end of the transect, Laurier remained the dominant species (see Photograph 3-36), with a few other species including Marouba (*Simarouba amara*), Immortelle (*Erythrina poeppigiana*), Quick Stick / Glorisita (Gliricidia sepium) and Stinking Toe / Locust (*Hymenaea coubaril*). These trees were more than 10.7 m tall. The understory was sparse, with Broadleaf Maidenhair (*Adiantum latifolium)* being the main species observed.

Transect F2 was the easterly transect. Beyond quadrat F2a, an agricultural plantation was present, with Banana and Cocoa being the prevalent species (see Photograph 3-37 and 3-38), and the understory being primarily St. John's Bush and Nettle (Photograph 3-39). There were also a few stands of Bamboo (approximately 6.1 m tall). Continuing easterly along the transect, there was a transition into secondary forest, with tree species such as Cacolay, Bois Canot, Swizzle Stick Tree, Mountain Palm, Laurier and Penny Piece (see Photograph 3-40). These trees were tall and mature, ranging from 9.1 to 12.2 m. The St. John's Bush and Nettle remained the dominant understory species, but Balisier and Heliconia (see Photograph 3-41), Guinea Grass, Malanbe and a few Ferns were also present. A small banana plantation was also noted. Further east, secondary forest remained the main habitat, with Laurier and Swizzlestick Tree saplings being dominant (see Photograph 3-42), in the understory in some areas. In other areas, ferns were the prevalent understory, but was sparsely distributed on the forest floor. Tree species included mature Laurier, Swizzle Stick Tree and Bois Canot (as the most prevalent) (see Photograph 3-43), while isolated Bamboo patches and Figuier, Penny Piece, Wild Breadnut/Chataigne, Mountain Cabbage (*Euterpe dominicana*) and Galba trees were present. These tree species were above 12.2 m tall. The understory was mostly sparse various species of ferns (see Photographs 3-44 and 3-45).

Transect F3 began as a southerly transect, however, due to the terrain, it became a wandering transect. Immediately south of the quadrat F3a was secondary forest, with Laurier and Mountain Cabbage (*Euterpe dominicana*) being the dominant species (see Photograph 3-46), and Penny Piece, Bamboo and Bois Canot being some of the other isolated species. Water Vine was hanging from the canopy. The undergrowth was sparse, with little to no grasses (see Photograph 3-47). Immediately following this, Bamboo became the dominant species, with some Laurier, Cacolay and Mountain Cabbage (see Photograph 3-48). Cacolay was approximately 15.2 m in height, while the other species were between 10.7 and 12.2 m. The undergrowth, was sparse, with Water Vine, and Juvenile Mountain Cabbage, Juvenile Tree Ferns and Wild Ginger (*Costus sp.*). Closer to the river, similar species were noted (see Photograph 3-50), but the understory now contained St. John's Bush, Wild Ginger and Malanbe as the dominant species (see Photograph 3-

51). Several species of ferns, including the Carpet Ferns were also present (see Photograph 3-52).

Transect F4 was the westerly transect. Immediately west of quadrat F4a, the vegetation transitioned from pasture to secondary forest. Species included Laurier, Mountain Cabbage, Bamboo and Cacolay, being more prevalent, while there were a few species of Bois Canot, Immortelle, Maruba, Banana and Citrus (see Photographs 3-53 and 3-54). The understory included Water Vine, with some ground ferns. Moving further west, agricultural crops became the dominant vegetation type, with species such Cocoa, Citrus and Banana (see Photograph 3-55) as the prevalent species. Other vegetation included were plantation of fruit trees such as mango, pommcythere and breadfruit, as well as ground provisions (root crops) such as dasheen (see Photograph 3-56). In some areas, the understory was clear (see Photograph 3-57), while in other areas, the understory included grasses such as Gully Beads, Guinea Grass and Bamboo Grass (see Photograph 3-58). Interspersed along the transect were Stinking Toe, Cinnamon, Clove, Sandbox, Bamboo, Royal Palm and Glory Sita. These ranged between 4.6 to 7.6 m tall.

Appendix 4: Site Photographs

FLORA

Site C Dry Season

Photograph 3-1: Quadrant C1a (facing North)

Photograph 3-2: Quadrant C2a (facing East)

Photograph 3-3: Quadrant C3a (facing South)

Photograph 3-4: Quadrant C4a (facing East)

Photograph 3-5: Blue Mahoe and Royal Palm along Transect C1

Photograph 3-6: Tayo along Transect C1

Photograph 3-7: Banana along Transect C2

Photograph 3-8: Umbrella Flat Sedge along Transect C2

Photograph 3-9: Finger Flat Sedge along Transect C2

Photograph 3-10: Bamboo and Balisier along Transect C2

Photograph 3-11: Bamboo near the end of Transect C2

Photograph 3-12: Malambe Shrubs at Transect C2

Photograph 3-13: Bamboo along Transect C3

Photograph 3-14: Nutmeg Plantation with Banana Interspersed along Transect C3

Photograph 3-15: Undergrowth at Nutmeg Plantation (Transect C3)

Photograph 3-16: Secondary Forest toward the end of Transect C3

Photographs 3-17 and 3-18: Grass dominated vegetation at the start of Transect C4


Photograph 3-19: Thick Stand of Balisier observed along Transect C4

Photograph 3-20: Nutmeg Plantation along Transect C4


Photograph 3-21: Agricultural Plot along Transect C4

Photograph 3-22: Hot Pepper at Agricultural Area along Transect C4


Photographs 3-23 and 3-24: Mature Secondary Forest toward the end of Transect C4

Site C Wet Season

	
Photograph 3-25: Center of Drill Pad (facing East)	Photograph 3-26 Nutmeg along Transect C1
	
Photograph 3-27: Cocoa along Transect C1	Photograph 3-28: Waterlogged area with Blue Mahoe and Royal Palms along Transect C1
	
Photograph 3-29: Dense undergrowth under Cocoa along Transect C1	Photograph 3-30: Bamboo with thick undergrowth along Transect C1

Photograph 3-31: Banana along Transect C2

Photograph 3-32: Tall Grasses and Ferns along Transect C2

Photograph 3-33: Sweet Potatoes along at Transect C2

Photograph 3-34: Dasheen along Transect C2

Photograph 3-35: Bamboo and Baliser along Transect C2

Photograph 3-36: Umbrella Flat Sedge along Transect C2

	
Photograph 3-37: Bamboo along Transect C3	Photograph 3-38: Nutmeg Plantation with Banana interspersed along Transect C3
	
Photograph 3-39: Undergrowth at Nutmeg Plantation (Transect C3)	Photograph 3-40: Secondary Forest toward the end of Transect C3
	
Photograph 3-41: Undergrowth towards the end of Transect C3	Photograph 3-42: Tree Fern close to the end of Transect C3


Photographs 3-43 & 3-44: Nutmeg along Transect C4

Photograph 3-45: Bamboo and Balisier along Transect C4

Photograph 3-46: Thick Grasses along Transect C4


Photographs 3-47 & 3-48: Agricultural Plots along Transect C4

Site F Dry Season

Photograph 3-49: Quadrant F1a (Facing North)

Photograph 3-50: Quadrant F2a (Facing East)

Photograph 3-51: Quadrant F3a (Facing South)

Photograph 3-52: Quadrant F4a (Facing West)

Photographs 3-53 and 3-54: Vegetation along Transect F1

Photograph 3-55: St. John's Bush

Photographs 3-56: Banana Plantation along Transect F1

Photographs 3-57: Laurier Saplings along Transect F1

Photographs 3-58: Whist Vine along Transect F1

Photographs 3-59: Fern along Transect F1

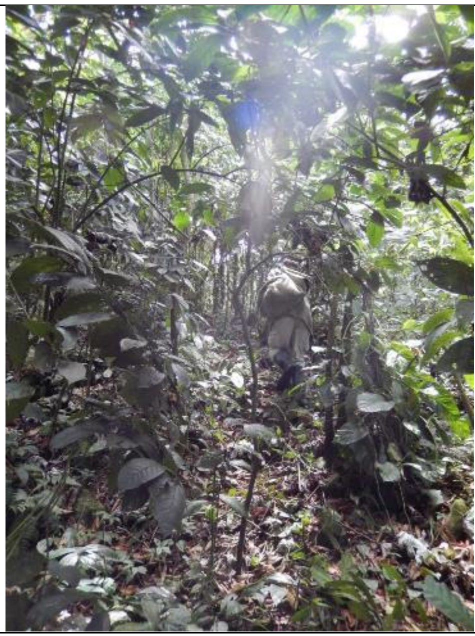
Photographs 3-60: Vegetation near the end of Transect F1

Photographs 3-61 and 3-62: Banana and Cocoa along Transect F2

Photograph 3-63: Nettle observed along Transect F2

Photograph 3-64: Secondary Vegetation along Transect F2

Photograph 3-65: Clump of Balisier along Transect F2



Photograph 3-66: Laurier and Swizzlestick Tree Saplings along Transect F2

Photograph 3-67: Laurier and Swizzlestick along Transect F2

Photograph 3-68: Ferns along Transect F2

Photograph 3-69: Ferns along Transect F2

Photograph 3-70: Laurier and Mountain Cabbage along Transect F3

Photograph 3-71: Sparse Undergrowth along Transect F3

Photograph 3-72: Bamboo observed along Transect F3

	
Photograph 3-73: Bamboo and Laurier observed along Transect F3	Photograph 3-74: Vegetation near the River along Transect F3
	
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Site F Wet Season

Photograph 3-83: Banana Plantation along Transect F1

Photograph 3-84: Bamboo and Forest Trees behind Banana Plantation along Transect F1

Photograph 3-85: Dense undergrowth in secondary forest along Transect F1

Photograph 3-86: Dense saplings and young trees along Transect F1

Photograph 3-87: Agricultural Field along Transect F2

Photograph 3-88: View inside of forested area along Transect F2

Photograph 3-89: Bamboo with dense undergrowth of Nettle along Transect F2

Photograph 3-90: Ferns in undergrowth of forested area along Transect F2

Photographs 3-91: Agricultural Field close to start of Transect F3

Photographs 3-92: View inside of Forest Area along Transect F3

Photograph 3-93: Palms along Transect F3

Photographs 3-94: Dense Undergrowth along Transect F3

Photograph 3-95: Bananas and Mixed Woody Agriculture along Transect F4

Photograph 3-96: Bamboo behind Bananas along Transect F4

Photographs 3-97 and 3-98: Mixed Agriculture with Grass dominated Undergrowth along Transect F4

AVIFAUNA

Site C Dry Season

	
Photograph 3-99: Smooth Billed Ani at Site C (Dry Season Survey)	Photograph 3-100: Cattle Egret at Site C (Dry Season Survey)
	
Photograph 3-101: Grey Kingbird at Site C (Dry Season Survey)	Photograph 3-102: Antillean Crested Hummingbird at Site C (Dry Season Survey)

Photograph 3-103: Yellow Crowned Night Heron Captured at Site C
(March 2019 Field Reconnaissance)

Photograph 3-104: Little Blue Heron Captured at Site C
(March 2019)

Site C Wet Season

	
Photograph 3-105: Bananaquit at Site C (Wet Season Survey)	Photograph 3-106: Grey Kingbird at Site C (Wet Season Survey)
	
Photograph 3-107: Rufous-breasted Hermit at Site C (Wet Season Survey)	Photograph 3-108: Lesser Antillean Tanager at Site C (Wet Season Survey)

Site F Dry Season

	
Photograph 3-109: Antillean Crested Hummingbird at Site F (Dry Season Survey)	Photograph 3-110: Tropical Kingbird at Site F (Dry Season Survey)

Photograph 3-111: Grenada Hook Billed Kite at Site F (Dry Season Survey)

Site F Wet Season

	
Photograph 3-112: Bananaquit Nest at Site F (Wet Season Survey)	Photograph 3-113: Grey Kingbird at Site F (Wet Season Survey)

MAMMALS

Site C Dry Season

Photograph 3-114: Common Opossum (Manicou) Captured at Site C
(March 2019 Field Reconnaissance)

Photograph 3-115: Mongoose Captured at Site C
(March 2019 Field Reconnaissance)

Photograph 3-116: Robinson’s Mouse Opossum Captured at Site C
(April 2019 Dry Season)

Site F Dry Season

Photograph 3-117: Nine Banded Armadillo at Site F
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Photograph 3-118: Mongoose at Site F
(March 2019 Field Reconnaissance)

Photograph 3-119: Common Opossum (Manicou) Captured at Site F
(April 2019 Dry Season Survey)

	
Photograph 3-120: Armadillo Tracks observed along Transect F (Dry Season Survey)	Photograph 3-121: Armadillo Nest observed along Transect F1 (Dry Season Survey)

INVERTEBRATES

Site C Dry Season

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Photograph 3-124: Neocyclotid Land Snail at Site C (Dry Season Survey)

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Photograph 3-126: Comb-footed Spider Species 1 at Site C (Dry Season Survey)

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Photograph 3-128: Garden Orbweaver at Site C (Dry Season Survey)

Photograph 3-129: Termite Colony at Site C (Dry Season Survey)

Photograph 3-130: Short-horned Grasshopper at Site C (Dry Season Survey)

Photograph 3-131: Bush Cricket at Site C (Dry Season Survey)

Photograph 3-132: Weevil at Site C (Dry Season Survey)

Photograph 3-133: Maribone Colony at Site C (Dry Season Survey)

	
Photograph 3-134: Trap-jaw Ant at Site C (Dry Season Survey)	Photograph 3-135: Carpenter Ant at Site C (Dry Season Survey)
	
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Site C Wet Season

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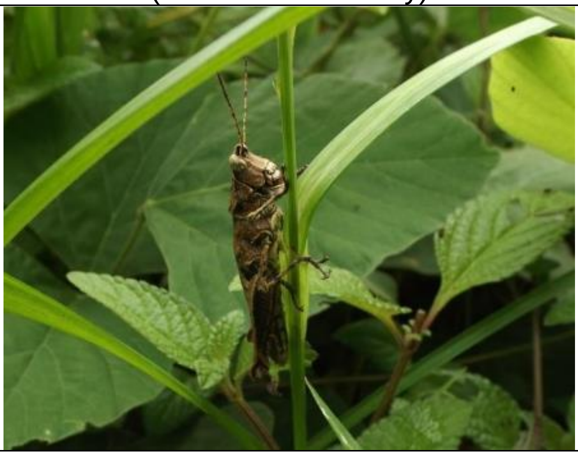

Photograph 3-146: Short-horned Grasshopper at Site C (Wet Season Survey)

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Site F Dry Season


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Photograph 3-163: Meadow Bug at Site F (Dry Season Survey)

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Site F Wet Season

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Photograph 3-176: Cicada Exoskeleton at Site F (Wet Season Survey)	Photograph 3-177: Maribone Wasp at Site F (Wet Season Survey)
	
Photograph 3-178: Short-horned Grasshopper at Site F (Wet Season Survey)	Photograph 3-179: Orcus Skipper at Site F (Wet Season Survey)

AMPHIBIANS AND REPTILES

Site C Dry Season

Photographs 3-180 & 3-181: Grenada Tree Anole at Site C (Dry Season Survey)

Site C Wet Season

Photograph 3-182: Grenada Tree Anole at Site C (Wet Season Survey)

Photograph 3-183: Lesser Antillean Frog at Site C (Wet Season Survey)

Site F Dry Season

 

Photographs 3-184 & 3-185: Grenada Tree Anole at Site F (Dry Season Survey)

Site F Wet Season

Photograph 3-186: Grenada Tree Anole at Site F (Wet Season Survey)

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AQUATIC FAUNA

Site C Dry Season

	
Photograph 3-188: Manicou Crab at Site C (Dry Season Survey)	Photograph 3-189: Atyid Shrimp at Site C (Dry Season Survey)
	
Photograph 3-190: Crayfish at Site C (Dry Season Survey)	Photographs 3-191: Red-rimmed melania at Site C (Dry Season Survey)
	
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Photographs 3-194 & 3-195: Damselfly (Endemic) at Site C (Dry Season Survey)

Site C Wet Season

Photograph 3-196: Manicou Crab at Site C (Wet Season Survey)

Photograph 3-197: Atyid Shrimp at Site C (Wet Season Survey)

Site F Dry Season

	
Photograph 3-198: Atyid Shrimp at Site F (Dry Season Survey)	Photograph 3-199: Whirligig Beetle at Site F (Dry Season Survey)
	
Photograph 3-200: Damselfly (Endemic) at Site F (Dry Season Survey)	Photographs 3-201: Damselfly (Larva) at Site F (Dry Season Survey)

Site F Wet Season

	
Photographs 3-202 & 3-203: Atyid Shrimp at Site F (Wet Season Survey)	

C. 2023 Survey Results

Grenada Geothermal Project

Biodiversity Baseline Survey Report

Prepared by Ecoengineering Consultants Limited

(Revision 1, June 02 2023)

1. Introduction

This report presents the results of the Dry Season Biodiversity Survey undertaken by Ecoengineering Consultants Limited between March 19-30 in the area of influence (AoI) specific to Site C of the Grenada Geothermal Project. These surveys are required to inform the Environmental and Social Impact Assessment (ESIA) for this project. All tables and figures are listed in Appendix 1.

2. Methodology

2.1. Study Area and Survey Locations

The study area for the proposed drilling pad location is shown in Figure 7-1, Appendix 1. Flora and fauna (avifauna, aquatic, mammalian, reptilian, amphibian and other fauna) surveys were undertaken within 500 m, where practical, from the centre of the proposed exploratory drilling pads at Site C (see Figures 7-2 and 7-3, Appendix 1), using line transects, point counts, quadrats and pitfall traps. The coordinates of each transect/quadrat at each site, as well as the sample dates are provided in Table 7-1, Appendix 1.

2.2. Survey Methods

This section presents the methods employed for undertaking the biodiversity surveys according to the following subsections:

- Desktop Review;
- Field Surveys;
- Interviews with Local People; and
- Limitations

2.2.1. Desktop Review

A literature review of applicable studies and publications regarding the flora and fauna in Grenada was undertaken. The major local and regional studies, publications and documents reviewed are listed here, and a full listing of all resources used is presented at the end of this Report:

- Land Use Map from the World Bank Dataset (2014)
- Aucoin, S. (2018): Mount St. Catherine Forest Reserve Environmental Baseline Assessment – Implementing a Ridge-to–Reef approach to protecting biodiversity and ecosystem functions within and around protected areas in Grenada.
- Cooper, B., Mings, L., Lindsay, K. and Bacie, J.P. (2011): Environmental and Socio Economic Baseline Studies – Grenada Site Report for Grand Etang and Annandale Forest Reserves. Prepared by Island Resources Foundation for the OECS Protected Areas and Associated Livelihoods (OPAAL) Project.
- Government of Grenada (2014): Fifth National Report to the Convention on Biodiversity

The main objective of the desktop review was to identify the major land use type within the study area, which was then used to set up field exercises. In addition, any species of concern (having environmental or biological importance) that are known to occur in the area would be the focal point for the field exercises.

2.2.2. Field Surveys

To inform the ESIA for the Project, biodiversity field surveys were undertaken to identify habitats and key species which occur or have the potential to occur within the Project area of influence. The site proposed for exploratory drilling sites was reconnoitred in March, 2023 over one day. A biodiversity survey was conducted in the dry season: for five days in March. Vegetation surveys (transects) were done on March 21, 2023, Bird Counts were done on March 23 and 23, 2023 between the hours of 6:00am and 8:00 am, Night Surveys were done on March 22, 2023 between the hours of 4:15pm and 9pm, and Aquatic Surveys were done on March 24, 2023. Additionally, pitfall traps were established on March 24, 2023 at 9am, checked at 12:30pm and removed at 2pm on the same day.

Biodiversity surveys were undertaken for habitats and the major taxonomic groups found or likely to be found in the project site and surrounding area: notably plants, mammals, birds, herpetofauna and fish. These were targeted on species of conservation importance which have the potential to be affected by the project. This includes those listed on the IUCN Red List (as near threatened, critically endangered, endangered and vulnerable), and species threatened and/or protected at the national level. Survey methodologies followed international best practice (after Hardner and Gullison, 2015) and took into consideration the accessibility of the study area to gather the maximum amount of data within the time allocated.

The weather conditions on each of the survey dates are provided below:

- March 21, 2023; Overcast And Wet
- March 22- Overcast/Windy
- March 23, 2023: Sunny
- March 24, 2023: Sunny

In addition to the field surveys described below, local people were interviewed regarding threatened, endemic/restricted-range or protected species. Information was collected regarding the presence, abundance, local distribution, breeding, threats (hunting, trade) of these species. The interviews included questions regarding the year/month when species were seen/captured, the distance from the village, how many individuals/quantities were captured and with what frequency these activities are carried out. If the area is visited by local people then these interviews may also provide useful information on paths and access routes across the Project area.

2.2.2.1 Habitats and Flora

The aims of the Floristic and Habitat survey were to:

- Identify and describe the structure and composition of the broad habitat types (with clear distinction between natural and modified habitats) and the floristic diversity of the study area, with focus on threatened, endemic, protected, and invasive plant species
- Ground truth, refine and update the draft habitat map prepared using satellite imagery (see below)
- Establish how local people use flora in the project area

The Dry Season botanical surveys were conducted on March 21, 2023 at Site C. Using the latest Google Images and a World Bank Land Use Map for Grenada (World Bank, 2019), transects were established within a 500 m radius, where practical, from the centre point of the proposed drill pad. A total of 4 line transects per site were established, ranging between 100 m to 500 m. These transects followed the four cardinal directions. During the Dry Season survey, ground truthing was undertaken along these transects, and plant species within 5 m of either side of the transect line were identified and recorded. In addition, 10 x 10m quadrats were established at approximately 100 m intervals along the transect line, or dependent on the size and homogeneity of the vegetation in the area. Within these quadrats all plant species were recorded using the DAFOR scoring system (D=dominant, A=abundant, F=frequent, O=occasional, R=rare). In the interest of time, the DAFOR scoring system was used only within the Quadrats and not along the transects.

At Site C, 10 quadrats were established. Using a handheld GPS unit, GPS coordinates were recorded at each quadrat, and photographs were taken. The lengths of the transects and the GPS Coordinates of their start and end points, as well as GPS coordinates for the quadrats are presented in Table 7-1 (Appendix 1) and shown in Figure 7-2 (Appendix 1).

The habitat type at each quadrat is given in the table below.

QUADRAT	HABITAT TYPE
T1 North 100m	• Pastures, Cultivated Land and Herbaceous Agriculture • Nutmeg and Woody Agriculture
T1 North 160 m	• Nutmeg and Woody Agriculture
T1 West 100 m	• Nutmeg and Woody Agriculture • Elfin and Sierra Palm Tall Cloud Forest
T1 West 160 m	• Nutmeg and Woody Agriculture • Evergreen and Seasonal Evergreen Forest
T1 East 100 m	• Nutmeg and Woody Agriculture
T1 East 200 m	
T1 East 300 m	
T1 East 400 m	• Nutmeg and Woody Agriculture • Elfin and Sierra Palm Tall Cloud Forest • Evergreen and Seasonal Evergreen Forest
T1 East 500 m	
T1 South 100 m	• Nutmeg and Woody Agriculture • Elfin and Sierra Palm Tall Cloud Forest • Evergreen and Seasonal Evergreen Forest

The same quadrats and transects were used to make incidental records of fauna species, as described in the sections below.

2.2.2.2 *Avifauna*

Fixed point bird counts were undertaken in proximity to the proposed well site location at site C (see Table 7-1 for GPS coordinates and Figure 7-3, Appendix 1). The bird count locations were chosen based on the major habitat types within each Site. Species observed within a 25 m radius of each sampling location during a 10-minute duration were recorded. Where practical, the number of individuals was also recorded. This is a standard method for estimating bird diversity, noting all the bird species present within a 25 m radius from a point (Hutto et al, 1986). Bird counts were taken at five locations during the morning period (6:00am – 9:00am), when peak bird activity takes place. (see Figure 7-3, Appendix 1). Using an 8 x 42 binoculars and call recognition, each location was sampled twice during the morning period. Additionally, incidental bird species were noted during the afternoon / night walk. The dates and times of each of the bird count surveys are listed below:

SITE	BIRD COUNT LOCATION	DATE	TIME
Site C	BC-1	March 21, 2023	6:22 am
		March 23, 2023	6:22 am
	BC-2	March 21, 2023	6:46 am
		March 23, 2023	6:36 am
	BC-3	March 21, 2023	7:05 am
		March 23, 2023	7:02 am
	BC-4	March 21, 2023	7:32 am
		March 23, 2023	6:48 am
	BC-5	March 21, 2023	8:00 am
		March 23, 2023	7:20 am

In addition, any opportunistic sighting of bird species along transects, within the quadrats and within 500 m of the proposed well site (see Figure 7-3, Appendix 1) were recorded and photographed.

2.2.2.3 *Mammals*

Along the transect lines, at the quadrats and within 500 m of the drill site (see Figure 7-1), incidental observations of mammalian presence (direct sightings, footprints, nests, faecal pellets, feeding signs, hair and calls) were recorded and photographed (where applicable). This was done during the daytime and at least once during the nighttime, using spotlights.

2.2.2.4 Invertebrates, Amphibians and Reptiles

Amphibians and reptiles were surveyed using line transects and quadrats during Dry Season surveys (see Figure 7-2). At each site, 4 transect lines were established, and a total of 9 quadrats were established along these transects. Quadrats were 10 m x 10 m and the lengths of the transects are presented in Table 7-1 in Appendix 1. Along these transects and quadrats, any trees and plants in which amphibians are known to occur (such as ferns and bromeliads) were surveyed for a period of 5 minutes. In addition, amphibian surveys were conducted during dusk (5:30 pm to 6:30 pm) using call recognition and spotlighting. Areas near streams/rivers or damp areas were targeted for this survey.

In addition, at the Site, dry pitfall traps were established, based on habitat type, and in areas where amphibians and reptiles are generally known to occur. These were established to capture invertebrates, amphibians and reptiles. Plastic containers (of 1 litre volume), were sunk into the soil such that the mouth of the container was level with the surface of the soil (Cogger, 1986).

At Site C, two pitfall traps were established (see Table 7-1 for GPS Coordinates and Figure 7-3). The traps were left in place for one day.

2.2.2.5 Aquatic Surveys

Aquatic fauna surveys were conducted along the respective streams at Site C (see Table 7-1 for GPS Coordinates and Figure 7-3 for locations). The rivers were surveyed at the closest accessible point to the transect line. At each Site, the team walked along the river (for approximately 100 m) and scouted the watercourse for aquatic species. Where riverine fauna were observed, a dip-net was used to capture these species. Where practical, species were identified on the field, photographed, and recorded.

2.2.3. Limitations

There were a few limitations encountered during the biodiversity survey. There were roads present to the north and west of the proposed well head. In addition, there was a deep ravine present to the south of the well head. The presence of these roads and the ravine hindered access to the full 500m radius for the transects. Surveys beyond these barriers would have encroached on other landowner's properties.

2.2.4. Interviews with Local People

To determine the use and functions of plant species in the area, local farmers were interviewed using an Ecosystem Services Sheet. These interviews were held on March 20-27, 2023. In addition, the importance of each species for each use was assessed using the following scale: 1=fair; 2=good;

3=excellent (based on livelihood). A copy of this Ecosystem Sheet is appended at the end of this report (Appendix 2).

In addition, local people were asked questions regarding the occurrence of faunal species in the area, including, but not limited to the different faunal species found within the area, the average number of individuals and the hunting pattern (including time of year for hunting, frequency of hunting, etc.).

3. Results

3.1. Results of Field Surveys

3.1.1 Habitats and Flora

Based on the Land Cover Map (see Figure 7-4), five (5) broad vegetation/habitat types were observed during the field surveys:

- Nutmeg and Mixed Woody Agriculture – which included nutmeg plantations and tree crops such as cocoa, citrus, etc.)
- Elfin and Sierra Palm Tall Cloud Forest
- Pastures, cultivated land and herbaceous agriculture – which included grasses (used for livestock grazing and fodder, overgrown areas and areas with agricultural crops)
- Deciduous, coastal Evergreen and mixed forest or shrubland – secondary forest with sparse mature trees, woody shrubs and thicker understories
- Semi-Deciduous Forest

At Site C, four transects and nine (9) quadrats were established (see Figure 7-2). Along these transects and quadrats, a total of 59 plant species belonging to 31 Families were recorded. A full listing of the species recorded at Site C is presented in Table 7-2, and results of the DAFOR assessment are presented in Tables 7-3(a) to 7-3(d) (see Appendix 1). Three habitats/vegetation communities were delineated and described within 500 m radius of the proposed drill site where possible. The site comprised of mixed agriculture (nutmeg/mixed woody agriculture), pasture/cultivated land and elfin and sierra palm tall cloud forest (see Figure 7-4). Full details of the description of the vegetation in the area is provided in Appendix 1 and shown in Photographs 7-1 to 7-11.

3.1.2 Avifauna

A combined total of 21 avifauna species belonging to 16 families were recorded (including opportunistic sightings). A full listing of the birds recorded, and their numbers are presented in Table 7-4, Appendix 1). Excluding the opportunistic sightings, a summary of the abundance of bird species recorded on site are presented below.

COMMON NAME	SCIENTIFIC NAME	TOTAL
Spectacled Thrush	*Turdus nudigenis*	32
Grey Kingbird	*Tyrannus dominicensis*	22
Grenada Flycatcher	*Myiarchus nugato*	9
Yellow Bellied Elaenia	Elaenia flavogaster	2
Mangrove Cuckoo	*Coccyzus minor*	4
Bananaquit (Ce-Ce Bird)	*Coereba flaveola*	47
Lesser Antillean Tanager	*Tangara cucullata*	7
Lesser Antillean Bullfinch	*Loxigilla noctis*	8
Amazon Parrot	*Amazona*	23
Antillean Crested Hummingbird	*Orthorhyncus cristatus*	38
Scaley-Naped Pigeon (Ramier)	*Columba squamosa*	3
Eared Dove	*Zenaida auriculata*	2
Black Faced Grassquit	Tiaris bicolor	9
Tropical Mockingbird	*Mimus gilvus*	4
Rufous Brested Hermit	*Glaucis hirsuta*	4
Broad Winged Hawk	*Buteo platypterus*	4
Magnificent Frigatebird	*Fregata magnificens*	4
House Wren	*Troglodytes aedon*	1
Black Whiskered Vireo	*Vireo altiloquus*	1

Note: Does not include opportunistic sightings

Based on these results, the Bananaquit (*Coereba flaveola*) and the Antillean Crested Hummingbird (*Orthorhyncus cristatus*) were the most abundant species observed. Apart from the scheduled bird counts, these species were also opportunistically observed during the afternoon / night surveys. All birds were commonly noted in the pasture/cultivated lands and areas of woody agriculture.

3.1.3 Mammals

A total of two identified species belonging to two families, including opportunistic sightings, were recorded (see Table 7-5, Appendix 1 and Photograph 7-13, Appendix 4). The Leaf Nosed Bat (Phyllostomidae) and Mongoose (*Herpestidae*) were the only two mammals observed on site, however, the Mongoose was recorded opportunistically.

3.1.4 Terrestrial Invertebrates

This section presents the results of the terrestrial invertebrates recorded. At Site C, the following invertebrates were recorded: one species of millipede belonging to one family; one species of spider belonging to one family and nineteen (19) species of insects (including hornets, dragon flies, grasshoppers, ants and wasps) belonging to eighteen (18) families.

Table 7-5, Appendix 1 provides the detailed results of the survey methods employed. Excluding opportunistic sightings, a summary of the terrestrial invertebrates observed on site are presented below.

COMMON NAME	SCIENTIFIC NAME
Mosquito	Culicidae
Horsefly	Tabanidae
Termite	Isoptera
Fruit Fly	Drosophila melanogaster
Dragonfly	Anisoptera
Hornets	Vespa
Wasp	Vespidae
Ants	Formicidae
Honeybee	Tribe Apini
Grasshoppers	Caelifera
Sandfly	Phlebotominae
Beetle	Coleoptera
Green Cricket	Tettigonia viridissima
Assassin Ants	Dasymutilla occidentalis
Moth	Lepidoptera
Cockroach	Blattodea

Note: This summary table does not include opportunistic sightings

3.1.5 Amphibians and Reptiles

At Site C, one species of Grenada Tree Anole (*Anolis richardii*) and one species of frog (Piping Frog [*Eleutherodactylus syristes*] were recorded (see Table 7-5). It must be noted that the piping frog was observed during the morning surveys as well as the night surveys.

3.1.6 Aquatic Species

One species of crustacean, Manicou Crab [*Rodriguezus garmanii*]) was observed at Site C. In addition, six (6) species of insects belonging to six families were also observed. Table 7-5 in Appendix 1 provides the detailed results of the survey methods employed. These species are summarized as follows:

COMMON NAME	SCIENTIFIC NAME
Manicou Crab	*Rodriguezus garmanii*
Mosquito	*Culicidae*
Fruit Fly	*Drosophila melanogaster*
Sandfly	*Phlebotominae*
Dragonfly Nymph	*Anisoptera*
Weever Beetle	*Lamia textor*
Water Strider	*Gerridae*

3.2. Results of Interviews with Local People

Based on interviews with persons, Nutmeg, Cocoa and Coconut play an important role in farmers' livelihood. Several other species were listed as important, as they contribute to ensuring that the plantations are successful, these include trees that are used as windbreaks. The results of the Ecosystem Services interviews are presented in Table 7-6 in Appendix 2.

With respect to faunal species, the Common Opossum and Armadillo are the most hunted species in the area. These species are hunted for food. Hunting season usually runs from October to December, but some hunters tend to hunt during off season as well. Based on informal interviews with farmers at Site C, hunting was prevalent in Tricolar, however, in recent years, persons seldom hunt in the area, primarily due to the issue of trespassing on private lands.

4. Discussion

4.1.1 Habitats and Flora

The proposed drill pad (the area between 120 m x 90 m) supported agricultural land with crop species such as Banana, Sugarcane and Breadfruit. The surrounding area is described as mixed woody agriculture, with Nutmeg being the most abundant crop observed. Extending away from the proposed drill pad, and within the 500 m radius, the vegetation can be described as deciduous, coastal evergreen and mixed forest or shrubland. Among the agricultural plots, a large number Bois Canot and Bamboo trees were interspersed. Bamboo (*Bambusa vulgaris*) and Bois Canot (*Cecropia schreberiana*) are known to be native invasive species, known to establish themselves in areas of disturbance. Based on discussions with some farmers in the area, the site was once a thriving nutmeg plantation, however, with the passage Hurricane Ivan in 2004, the entire plantation was severely hit, and over 90% of the nutmeg trees were lost. The establishment of the aforementioned invasive species, as well as the maturity of the Nutmeg trees are indicative of a previous large scale disturbance, and the present efforts to re-establish agroforestry in the area.

Of the plant species identified on the site, none were considered to be Endemic. Pigeon Pea (*Cajanus cajan*), identified at Transect 1 West, is considered near threatened (IUCN, 2019). All other plant species did not have any conservation statuses or were categorized as Least Concern under the IUCN Red List.

4.1.2 Avifauna

In total, 21 avifauna species were recorded at Site C. The majority of species were common year-round residents. According to Raffaele, *et. al.* (2003), the Lesser Antillean Tanager (*Tangara cucullata*) is listed as an uncommon resident, and the Barn Owl (*Tyto alba insularis*) is a rare resident in Grenada. The Amazon Parrot (*Amazona*) is an introduced species. Generally, the species encountered were associated with one or more of the habitat types (*i.e.* Mixed Woody Agriculture, Evergreen Forest and Pastures) present in the study area. Exceptions to this were the Rufous Breasted Hermit (*Glaucis hirsuta*), Scaley-naped Pigeon (*Columba squamosa*), which inhabit forested areas. All birds observed at Site C were classified as 'Least Concern' based on the IUCN Red List. None of the birds listed on Grenada's List of Threatened Species (2014) were observed at Site C.

4.1.3 Mammals

Two species of mammals were recorded at Site C. Both species were locally common (University of the West Indies, 2018). The Small Indian Mongoose are habitat generalist, occurring in a range of habitats – pasture, mixed woody agriculture and secondary forest. The Small Indian Mongoose is native to South Asia and was introduced to the Caribbean Islands to help control rats and snakes (University of the West Indies, 2018). Overtime, they became invasive, and based on informal interviews with farmers on site, they destroy most of the crops on site. The Small Indian Mongoose (*Herpestes auropunctatus*) was introduced to Grenada whilst the Leaf-Nosed Bat (Phyllostomidae) is a resident. Both species are listed as 'Least Concern' on the IUCN Red List.

4.1.4 Terrestrial Invertebrates

In terms of terrestrial invertebrates, a total of 21 species belonging to 20 families were found at Site C. All species were resident to Grenada. There was no other information available concerning the national and international statuses of these invertebrates. The species recorded were habitat generalists and were generally observed in most of the habitats associated with the Site.

4.1.5 Amphibians and Reptiles

One species of lizard and one species of frog were recorded at Site C, both of which are locally common. Neither species is listed on the IUCN Red List nor Grenada's National List of Threatened Species (2014).

4.1.6 Aquatic Fauna

One species of crustacean, Manicou Crab [*Rodriguezus garmanii*]) was observed at Site C. In addition, six (6) species of insects belonging to six families were also observed. All species were commonly associated with watercourses of Grenada. There were no national or international conservation statuses listed for the species observed.

5. Recommendations

5.1. Mitigation

With respect to valuable/sensitive habitats, protected, threatened, endemic/restricted-range, migratory species, no specific mitigation measures are required.

Based on discussions with Grenada's Forestry Division, it is recommended that consultations be held with the Forestry Division when trees are to be removed to facilitate the drilling works.

Although there were no Endangered Species observed at Site C, species within the forested areas/woody agriculture near the site can be affected by noise and light (if drilling is to occur during the night) associated with drilling activities. It is therefore recommended that noise control be implemented during the drilling phase. Noise control measures include the following:

- Use low-noise emitting equipment, to the extent practical; and
- Schedule noise-intense construction activities during the day, to the extent practical.

In addition, if night works are to occur, the following can be implemented:

- Use the minimum intensity of light that can be safely used for night work;
- Avoid the use of bare or upturned bulbs; and
- Orient light such that it focuses away from forested areas.

5.2. Further Surveys and Monitoring

No further surveys and monitoring are required as part of this study.

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Last Accessed, September 17, 2019

7. Appendices

Appendix 1: Maps and Tables

Figure 7-1: Location Map

Figure 7-2: Floral Transects

Figure 7-3: Faunal Survey Locations

Figure 7-4: Land Cover Map

Species Tables and Lists

Table 7-1: GPS Coordinates of Transects, Quadrats and Faunal Survey Locations and Survey Dates

COMPONENT	DATE SURVEYED	EASTINGS	NORTHINGS	DESCRIPTOR
Vegetation				
Site C		645575	1347317	Centre of drilling pad
T1 East 100m	March 21, 2023	645670	1347349	Length of transect: approximately 500 m heading east
T1 East 200m		645764	1347383	
T1 East 300m		645860	1347410	
T1 East 400m		645955	1347443	
T1 East 500m		646050	1347474	
T1 West 100m		645479	1347343	Length of transect: approximately 160 m heading west
T1 West 160m		645419	1347359	
T1 North 100m		645577	1347417	Length of transect: approximately 160 m heading north
T1 North 160m		645581	1347479	
T1 South 100m		645630	1347234	Length of transect: approximately 100 m heading south
Bird Counts (Fixed Point)				
BC-1	March 21, 2023 and March 23, 2023	645575.776	1347317.4	Bird Counts were done at each of the 5 locations on 2 days.
BC-2		645593	1347371	
BC-3		645614	1347424	
BC-4		645706	1347354	
BC-5		645538	1347398	
Pitfall Traps				
PF-1	March 23, 2023	645546	1347367	Pit fall traps were inspected on 23 March, 2023 at 12:30pm, and removed at 2pm.
PF-2		645563	1347373	
Aquatic Surveys				
AS-1	March 24, 2023			

Table 7-2: Plant Species Recorded at Site C

Source: Hawthorne, 2004, Grenada's National Red List of Threatened Species, 2014 and IUCN, 2019

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				Q1	Q2	Q3	Q4		National	International	
MORACEAE	Breadnut	*Artocarpus camansi*	Tree	✔		✔			Not Listed	Not Listed	Cultivated for its edible fruit. Breadfruit is the main ingredient in Grenada's national dish (i.e. Oil Down). Leaves used to treat diabetes and hypertension.
	Ficus/Fije	*Ficus americana*	Tree		✔	✔			Not Listed	Least Concern (IUCN)	They are native throughout the tropics with a few species extending into the semi-warm temperate zone.
MYRISTICACEAE	Nutmeg	*Myristica fragrans Houtt.*	Tree	✔	✔	✔	✔		Not Listed	Data Deficient (IUCN)	Grenada's most important commercial export. Mace is used in flavouring and fragrances. Seed is used as an insecticide and as a remedy for colds, flu and fever; also used as natural ground covering in gardens. Oil is used as a rub for muscular pains.
MUSACEAE	Banana	*Musa sp.*	Tree	✔	✔				Not Listed	Not Listed	Cultivated for fruit. Several varieties are present in Grenada. Plantains refer to 'hard' varieties which are cooked while bananas are 'soft' varieties which may be consumed raw.
	Musa Bloggoe	*Musa sp.*	Tree	✔	✔						
HELICONIACEAE	Lobster Claws	*Heliconia*	Shrub	✔	✔				Not Listed	Data Deficient (IUCN)	Native to the tropical Americas, many species of Heliconia are found in the tropical forests. They are widely cultivated as ornamentals, and a few are naturalized in Florida, Gambia, and Thailand
URTICACEAE	Bois Canot	*Cecropia peltata*	Tree	✔			✔		Not Listed	Not Listed	Fast-growing tree, normally reaching 15 metres (49 ft), but occasionally growing up to 25 metres (82 ft) tall.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				Q1	Q2	Q3	Q4		NATIONAL	INTERNATIONAL	
	Liverwort/Bryophytes	*Marchantiophyta*		✔					Not Listed	Not Listed	Division of non-vascular land plants. Their greatest impact is indirect, through the reduction of erosion along streambanks and their collection and retention of water in tropical forests
	Clearweed	*Pilea pumila*	Bush	✔					Not Listed	Not Listed	A herbaceous plant in the nettle family. It is native to Asia and eastern North America, where it is broadly distributed. This plant is most often found in rich loamy soil, usually in moist to wet areas.
MALVACEAE	Cocoa	*Theobroma cacao*	Tree	✔	✔				Not Listed	Not Listed	The seeds are the main ingredient of chocolate, while the pulp is used in some countries to prepare refreshing juice, smoothies, jelly, and cream.
CONVOLVULACEAE	Ipomea Sp. X 2	*Ipomoea tiliacea*	Shrub	✔					Not Listed	Least Concern (IUCN)	Most species have spectacular, colourful flowers, and are often grown as ornamentals, and a number of cultivars have been developed.
	Morning Glory	*Ipomoea*	Bush		✔				Not Listed	Not Listed	Most morning glory flowers unfurl into full bloom in the early morning. The flowers usually start to fade a few hours before the corolla begins to display visible curling. They prefer full solar exposure throughout the day, and mesic soils.
	Wild Morning Glory	*Ipomoea setifera*	Bush	✔					Not Listed	Not Listed	It is a liana, without tendril, climbing and creeping which extends on large surfaces
ASPARAGACEAE	Dracaena/Boundary plant	*Dracaena sp*	Tree	✔					Not Listed	Not Listed	A popular ornamental houseplant, grown both indoors and outdoors in subtropical climates
UMBELLIFERS	Shadow Beni	*Eryngium foetidum*	Bush	✔					Not Listed	Not Listed	It is made into a paste that's included as in ingredient in green seasoning. It can also be made into a sauce.

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				Q1	Q2	Q3	Q4		NATIONAL	INTERNATIONAL	
ASTERACEAE	Shaving Bush	*Emilia fosbergii*	Bush	✔					Not Listed	Not Listed	Species of plant in the sunflower family.
	Cupid's Shaving bush	*Emilia sonchifolia*	Bush						Not Listed	Not Listed	
	Wedelia	*Wedelia trilobata*	Bush		✔				Not Listed	Not Listed	They are one of the genera commonly called "creeping-oxeyes".
	Beggar Ticks	*Bidens cynapiifolia*		✔	✔				Not Listed	Not Listed	Herbal remedies for irritation, inflammation, pain, and bleeding of the urinary tract, among other things
	Cobblers Pegs	*Bidens pilosa*		✔	✔				Not Listed	Not Listed	It grows aggressively on disturbed land and often becomes weedy. The fruits are slightly curved, stiff, rough black rods, tetragonal in cross section, about 1 cm long, typically with two to three stiff, heavily barbed awns at their distal ends.
	Billygoat Weed	*Ageratum conyzoides*				✔			Not Listed	Not Listed	Native to Tropical America, especially Brazil, and is an invasive weed in many other regions.
BROMELIACEAE	Pineapple	*Ananas comosus*	Plant	✔	✔				Not Listed	Not Listed	The pineapple is a tropical plant with an edible fruit; it is the most economically significant plant that is indigenous to South America.
CYATHEACEAE	Tree Fern	*Cyathea tenera*	Plant	✔					Not Listed	Not Listed	Arborescent ferns that grow with a trunk elevating the fronds above ground level, making them trees.
ANNONACEAE	Soursop	*Annona muricata*	Tree	✔	✔				Not Listed	Least Concern (IUCN)	Fruit of Annona muricata, a broadleaf, flowering, evergreen tree. It is native to the tropical regions of the Americas and the Caribbean and is widely propagated
RUTACEAE	Orange	*Citrus sinensis*	Tree	✔					Not Listed	Not Listed	A fruit of various citrus species. Orange trees are widely grown in tropical and subtropical climates for their sweet fruit. The fruit of the orange

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				Q1	Q2	Q3	Q4		NATIONAL	INTERNATIONAL	
											tree can be eaten fresh, or processed for its juice or fragrant peel.
DRYOPTERIDACEAE	Ferns	*Polystichopsis muscosa*	Plant	✔	✔				Not Listed	Not Listed	Ferns are plants that do not have flowers. Ferns generally reproduce by producing spores. Similar to flowering plants, ferns have roots, stems and leaves
	Fern 1		Plant	✓							
ONAGRACEAE	Mexican Primrose-Willow	*Ludwigia Octovalvis*	Shrub	✔	✔				Not Listed	Least Concern (IUCN)	It is also cultivated as an aquatic plant. The plant is known for its anti-aging properties. The species is sometimes regarded as an invasive species.
POACEAE	Sugarcane	*Saccharum*	Grass		✔				Not Listed	Not Listed	A species of (often hybrid) tall, perennial grass that is used for sugar production. It is native to the warm temperate and tropical regions.
	Paspalum	*Paspalum sp*	Grasses						Not Listed	Not Listed	Most diverse in subtropical and tropical regions
	Para Grass	*Urochloa mutica*	Grasses						Not Listed	Not Listed	It has been intentionally introduced in some places as a "ponded pasture grass" due to its capability to establish on poorly drained (swampy or seasonally waterlogged) soils as well on free-draining soils in high rainfall environments.
	Bamboo	*Bambusa*	Grass	✔	✔	✔			Not Listed	Not Listed	Bamboo is versatile and has notable economic and cultural significance used for building materials, as a food source, and as a raw product, and depicted often in arts, such as in bamboo paintings and bamboo working.
	Khus Khus/Vetiver Grass	*Chrysopogon zizanioides*	Grass		✔	✔	✔		Not Listed	Not Listed	This is an edible plant and the oil obtain from the roots is used as a

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT Q1	Q2	Q3	Q4	OPP.	STATUS NATIONAL	INTERNATIONAL	NOTES
											flavouring in sherbets, syrup sweets, fruit drinks.
	Watergrass	*Commelina erectus*	Grass	✔					Not Listed	Not Listed	In the West Indies this grass is common in disturbed sites as well as in dry to moist woods from sea level up to 1300 meters.
CYPERACEAE	Tall Flatsedge	*Cyperus eragrostis*	Plant		✔				Not Listed	Not Listed	An herbaceous perennial growing from rhizomes.
	Razor Grass	*Scleria secans*	Grass	✔	✔				Not Listed	Not Listed	A Caribbean plant whose leaves and triangular stem are edged with minute sharp teeth.
RUTACEAE	Grapefruit	*Citrus × paradisi*	Tree		✔				Not Listed	Not Listed	A subtropical citrus tree known for its relatively large, sour to semi-sweet, somewhat bitter fruit. The interior flesh is segmented and varies in color from pale yellow to dark pink and originated in Barbados.
	Mandarin Orange	*Citrus reticulata*	Tree		✔				Not Listed	Not Listed	The mandarin orange, also known as mandarin or mandarine, is a small citrus tree fruit that is treated as a distinct species of orange.
	Citrus	*Citrus*	Tree	✔	✔				Not Listed	Not Listed	Plants in the genus produce citrus fruits, including important crops such as oranges, lemons, grapefruits, pomelos, and limes.
MYRTACEAE	Clove	*Syzygium aromaticum*	Tree		✔				Not Listed	Not Listed	Most valuable spices that has been used for centuries as food preservative and for many medicinal purposes.
	Pomme Rose	*Syzygium jambos*	Tree	✔					Not Listed	Not Listed	Rich in Vitamin C, the fruit can be eaten raw or cooked in various regional recipes.
CANNACEAE	Balisier	*Heliconia caribea*	Plant	✔	✔	✔			Not Listed	Not Listed	This plant is used as an ornamental plant in hot regions with a humid

Family	Common Name	Scientific Name	Form	Transect				Opp.	Status		Notes
				Q1	Q2	Q3	Q4		National	International	
											climate, and is typically pollinated by bats and hummingbirds.
ZINGIBERACEAE	Kakoli/ Pwa dou	*Inga ingoides*	Tree	✔	✔				Not Listed	Not Listed	Common tree of semi-evergreen seasonal forest, especially by rivers.
MELASTOMATACEAE	Kaka mel/Miconia crenata	*Clidemia hirta*	Shrub	✔	✔		✔		Not Listed	Not Listed	It is an invasive plant species in many tropical regions of the world, creating serious damage.
ANACARDIACEAE	Hog plum	*Spondias mombin*	Tree	✔					Not Listed	Least Concern (IUCN)	The fruit pulp is either eaten fresh or made into juice, concentrate, jellies, and sherbets.
	Golden Apple	*Spondias dulcis*	Tree			✔			Not Listed	Not Listed	A tropical tree, with edible fruit containing a fibrous pit.
	Mango	*Mangifera indica*	Tree		✔				Not Listed	Not Listed	An important herb in indigenous medical systems for over 4000 years.
CLUSIACEAE	Galba	*Calophyllum antillanum*	Plant	✔					Not Listed	Not Listed	It is prized for producing a very hard, durable wood. The wood of this tree is widely used in the tropics.
ARACEAE	Philodendron	*Philodendron lingulatum*	Plant	✔					Not Listed	Not Listed	Philodendron species can be found in many diverse habitats Most occur in humid tropical forests, but can also be found in swamps and on river banks, roadsides and rock outcrops. They are also found throughout the diverse range of elevations from sea level to over 2000 m above sea level. Species of this genus are often found clambering over other plants or climbing the trunks of trees with the aid of aerial roots.
	Dasheen	*Colocasia esculenta*	Plant		✔	✔			Not Listed	Not Listed	Most widely cultivated species of several plants in the family that are used as vegetables for their corms, leaves, stems and petiole.
	Unknown 1			✔							

FAMILY	COMMON NAME	SCIENTIFIC NAME	FORM	TRANSECT				OPP.	STATUS		NOTES
				Q1	Q2	Q3	Q4		NATIONAL	INTERNATIONAL	
DIOSCOREACEAE	Yam	*Dioscorea alata*	Plant	✔					Not Listed	Not Listed	Yams are also valued for the starch that can be processed from them.
SELAGINELLACEAE	Selaginella	*Selaginella flabellata*	Plant	✔		✔			Not Listed	Not Listed	Often used in traditional Indian systems of medicine for the prevention and cure of several disorders and for the treatment of patient
FABACEAE	Sweethearts	*Desmodium adscendens*	Plant						Not Listed	Not Listed	It is especially valued as a treatment for asthma and allergies. It is generally harvested from the wild and is often traded.
	Sweethearts	*Desmodium incanum*	Plant						Not Listed	Not Listed	Initially introduced as forage crop around the world, it has spread to many places although it is no longer an important fodder crop. It is considered a weed both within and outside its native range
	Calapo/Wild Ground Nut	*Calopogonium mucunoides*	Plant			✔			Not Listed	Not Listed	Introduced as a forage crop and a green manure to the tropics.
PIPERACEAE	Mal lestomak	*Piper dusii*		✔	✔				Not Listed	Not Listed	3m shrub, Leaf Stalk 5mm, Hairy, Blades 14-26cm. Not officially recorded for Grenada, but another specimen (*P. broadwayi*) is a synonym of *P. dussii*.
LAURACEAE	Avocado	*Persea americana*	Tree		✔				Not Listed	Least Concern (IUCN)	The avocado is a medium-sized, evergreen tree. It is native to the Americas. Then as now it was prized for its large and unusually oily fruit.
ARECACEAE	Roystonea	*Roystonea*	Tree		✔				Not Listed	Not Listed	The fruit is an important component of the diet of orange-winged amazon parrots and red-bellied macaws in Nariva Swamp, Trinidad and Tobago.

Table 7-3(a): DAFOR Scale for Plant Species in Quadrats Along Transect 1 South

Plant Species Found along Transect 1 South						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	COMMON NAME	SCIENTIFIC NAME	C1a (Pasture, Cultivated Land, Herbaceous Agriculture)	C1b (Secondary Forest / Cultivated Land)	C1c (Nutmeg / mixed woody agriculture	C1d (Secondary Forest / Seasonal Evergreen Forest)
MORACEAE	Breadnut	*Artocarpus camansi*	O			
MYRISTICACEAE	Nutmeg	*Myristica fragrans Houtt.*	D			
MUSACEAE	Banana	*Musa sp.*	F			
HELICONIACEAE	Lobster Claws	*Heliconia*	R			
URTICACEAE	Bois Canot	*Cecropia peltata*	R			
	Liverwort	*Marchantiophyta*	O			
MALVACEAE	Cocoa	*Theobroma cacao*	A			
CONVOLVULACEAE	Ipomea	*Ipomoea tiliacea*	r			

Table 7-3(b): DAFOR Scale for Plant Species Along Transect 1 North

Plant Species Found along Transect C2						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	COMMON NAME	SCIENTIFIC NAME	QUADRANT			
			C1a (Pasture/Cultivated Land/Herbaceous Agriculture)	C1b (Pasture/ Cultivated Land/Herbaceous Agriculture)	C1c (Mixed Forest / Shrubland)	C1d (Secondary Forest/Seasonal Evergreen Forest)
BIGNONIACEAE	Jacanda	*Jacaranda*	**B**			
UMBELLIFERS	Shadow Beni	*Eryngium foetidum*	**B**			
ASTERACEAE	Shaving Bush	*Emilia fosbergii*	**A**			
	Wedelia	*Wedelia trilobata*	**A**			
	Beggar Ticks	*Bidens cynapiifolia*	**A**			
POACEAE	Water Grass	*Commelina erectus*	**A**			
MUSACEAE	Banana	*Musa sp.*	**F**			
	Musa Bloogoe	*Musa sp.*		**O**		
MYRISTICACEAE	Nutmeg	*Myristica fragrans Houtt.*	**A**	**A**		
BROMELIACEAE	Pineapple	*Ananas comosus*	**R**	**R**		
CYATHEACEAE	Fern	*Cyathea tenera*	**O**			
	Ferns	*Cyathea tenera*	**A**	**A**		
RUTACEAE	Orange	*Citrus sinensis*	**R**			
ANNONACEAE	Soursop	*Annona muricata*	**F**	**A**		
URTICACEAE	Bois Canot	*Cecropia peltata*	**O**	**A**		
ONAGRACEAE	Mexican Primrose-Willow	*Ludwigia Octovalvis*	**O**	**O**		
POACEAE	Sugarcane	*Saccharum*			**F**	
RUTACEAE	Grapefruit	*Citrus × paradisi*			**R**	
	Mandarin Orange	*Citrus reticulata*			**A**	
CONVOLVULACEAE	Morning Glory	*Ipomoea*			**R**	
MYRTACEAE	Clove	*Syzygium aromaticum*			**O**	
MORACEAE	Ficus	*Ficus americana*			**O**	
CANNACEAE	Balisier	*Heliconia caribea*			**R**	

Table 7-3(c): DAFOR Scale for Plant Species Along Transect 1 East

Plant Species Found along Transect 1 East						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**QUADRAT**			
			C1a (Pasture/Cultivated Land/Herbaceous Agriculture)	**C1b (Secondary Vegetation/Seasonal Evergreen Forest)**	**C1c (Nutmeg/Mixed Woody Agriculture)**	**C1d (Secondary Forest/Seasonal Evergreen Forest)**
POACEAE	Bamboo	*Bambusa*	**D**	**A**	**R**	
CANNACEAE	Balisier	*Heliconia caribea*	**A**	**A**	**A**	
MALVACEAE	Cocoa	*Theobroma cacao*	**F**	**R**	**R**	
FABACEAE	Pois Doux/Ice Cream Bean	*Inga edulis*	**R**			
	Dandicayo	*Albizia niopoides var. niopoide*	**R**			
PIPERACEAE	Malik Stomacea/Mal Lestomak	*Piper dusii*	**R**	**A**		
HELICONIACEAE	Lobster Claws	*Heliconia*	**D**		**A**	
CLUSIACEAE	Galba	*Calophyllum antillanum*	**R**			
ARACEAE	Philodendron	*Philodendron lingulatum*	**R**			
	Unknown 1		**O**			
MYRTACEAE	Pomme Rose	*Syzygium jambos*	**R**			
LINDSAEACEAE	Woodland Necklace Fern	*Lindsaea lancea*	**R**			
DIOSCOREACEAE	Yam	*Dioscorea alata*	**R**			
SELAGINELLACEAE	Selaginella	*Selaginella flabellata*	**O**			
URTICACEAE	Clearweed	*Pilea pumila*	**D**			
	Unknown 2					
MORACEAE	Ficus	*Ficus americana*				
MYRISTICACEAE	Nutmeg	*Myristica fragrans Houtt.*				
URTICACEAE	Bois Canot	*Cecropia peltata*				
POACEAE	Water Grass	*Commelina erectus*				

Plant Species Found along Transect 1 East						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**QUADRAT**			
			C1a (Pasture/Cultivated Land/Herbaceous Agriculture)	**C1b (Secondary Vegetation/Seasonal Evergreen Forest)**	**C1c (Nutmeg/Mixed Woody Agriculture)**	**C1d (Secondary Forest/Seasonal Evergreen Forest)**
CYPERACEAE	Razor Grass	*Scleria secans*	**A**	**A**	**D**	**D**
LAURACEAE	Avocado	*Persea americana*	**R**	**R**		
CONVOLVULACEAE	Ipomea sp. X 2	*Ipomoea tiliacea*	**A**	**A**		
ARECACEAE	Roystonea	*Roystonea*	**R**	**R**	**R**	**R**
ANACARDIACEAE	Golden Apple	*Spondias dulcis*				
ARACEAE	Dasheen	*Colocasia esculenta*				
FABACEAE	Calapo	*Calopogonium mucunoides*				
MORACEAE	Breadnut	*Artocarpus camansi*	**R**			

Table 7-3(d): DAFOR Scale for Plant Species Along Transect 1 West

Plant Species Found along Transect 1 West						
D = dominant, (>75%) A = abundant (51-75%), F = frequent (26-50%), O = occasional (11-25%), R = rare (1-10%)						
FAMILY	**COMMON NAME**	**SCIENTIFIC NAME**	**QUADRANT**			
			C1a (Pastrure/Cultivated Land/Herbaceous Agriculture)	**C1b (Pasture/Shrubland)**	**C1c (Herbaceous and Woody Agriculture)**	**C1d (Secondary Vegetation/Seasonal Evergreen Forest)**
MYRISTICACEAE	Nutmeg	*Myristica fragrans Houtt.*	**F**	**F**		
RUTACEAE	Citrus	*Citrus*	**O**			
CYPERACEAE	Razor Grass	*Scleria secans*	**D**	**D**		
CYATHEACEAE	Fern	*Cyathea tenera*	**O**			
MUSACEAE	Banana	*Musa sp.*	**A**	**A**		
ARACEAE	Dasheen	*Colocasia esculenta*		**O**		
ANACARDIACEAE	Mango	*Mangifera indica*		**O**		
MALVACEAE	Cocoa	*Theobroma cacao*		**F**		
FABACEAE	Pigeon Peas	*Cajanus cajan*		**O**		
ANNONACEAE	Soursop	*Annona muricata*		**O**		

Table 7-4: Avifauna Species Recorded at Site C

Source: IUCN Red List (2019) and Raffaele, et. al. (2003)

FAMILY	COMMON NAME	SCIENTIFIC NAME	BIRD COUNT LOCATIONS						STATUS		NOTES
			BC-1	BC-2	BC-3	BC-4	BC-5	OPP.	NATIONAL	INTERNATIONAL	
TURDIDAE	Spectacled Thrush	*Turdus nudigenis*	6	7	9	9	1	✔	Not Listed	Least Concern (IUCN)	Common year round resident
TYRANNIDAE	Grey Kingbird	*Tyrannus dominicensis*	5	5	5	5		✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Grenada Flycatcher	*Myiarchus nugato*	3	4	2			✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Yellow Bellied Elaenia	*Elaenia flavogaster*	1		1				Not Listed	Least Concern (IUCN)	Common year round resident
CUCULIDAE	Mangrove Cuckoo	*Coccyzus minor*	1	1	1		1	✔	Not Listed	Least Concern (IUCN)	Common year round resident
EMBERIZIDAE	Bananaquit (Ce-Ce Bird)	*Coereba flaveola*	8	9	13	7	10	✔	Not Listed	Least Concern (IUCN)	Common year round resident
	Lesser Antillean Tanager	*Tangara cucullata*		5	6			✔	Not Listed	Not Listed	Uncommon resident to Grenada
	Lesser Antillean Bullfinch	*Loxigilla noctis*	2	4	2			✔	Not Listed	Least Concern (IUCN)	Common year round resident
PSITTACIDAE	Amazon Parrot	*Amazona*	3	4	1	5	10	✔	Not Listed	Not Listed	Introduced Species in Grenada
TROCHILIDAE	Antillean Crested Hummingbird	*Orthorhyncus cristatus*	5	5	8	10	10	✔	Not Listed	Least Concern (IUCN)	Common year round resident
COLUMBIDAE	Scaley-Naped Pigeon (Ramier)	*Columba squamosa*	1	1		1			Not Listed	Least Concern (IUCN)	Common year round resident
	Eared Dove	*Zenaida auriculata*		1	1				Not Listed	Least Concern (IUCN)	Common year round resident
THRAUPIDAE	Black Faced Grassquit	Tiaris bicolor	3	2	4			✔	Not Listed	Least Concern (IUCN)	Common year round resident
MIMIDAE	Tropical Mockingbird	*Mimus gilvus*	1		3			✔	Not Listed	Least Concern (IUCN)	Common year round resident
TROCHILIDAE	Rufous Brested Hermit	*Glaucis hirsuta*	1			2	1	✔	Not Listed	Least Concern (IUCN)	Common year round resident in mountains above 450 m.

FAMILY	COMMON NAME	SCIENTIFIC NAME	BIRD COUNT LOCATIONS						STATUS		NOTES
			BC-1	BC-2	BC-3	BC-4	BC-5	OPP.	NATIONAL	INTERNATIONAL	
ACCIPITRIDAE	Broad Winged Hawk	*Buteo platypterus*		1		1	2		Not Listed	Least Concern (IUCN)	Common year round resident
FREGATIDAE	Magnificent Frigatebird	*Fregata magnificens*		4					Not Listed	Least Concern (IUCN)	Common year round resident
TROGLODYTIDAE	House Wren	*Troglodytes aedon*			1				Not Listed	Least Concern (IUCN)	Common year round resident
VIREONIDAE	Black Whiskered Vireo	*Vireo altiloquus*			1				Not Listed	Least Concern (IUCN)	Common year round resident
TYTONIDAE	Barn Owl	*Tyto alba*						✔	Not Listed	Least Concern (IUCN)	Rare resident in Grenada
CAPRIMULGIDAE	Night Hawk	*Chordeiles minor*						✔	Not Listed	Least Concern (IUCN)	Common year round resident

Table 7-5: Other Fauna Species Recorded at Site C

Family	Common Name	Scientific Name	Status		Survey Method									
			National	IUCN	CT	PT 1	PT 2	AS	NS	TR 1E	TR 1W	TR 1S	TR 1N	OP
Mammals														
PHYLLOSTOMIDAE	Leaf-Nosed Bat	*Phyllostomidae*	Not Listed	Least Concern (IUCN)					✔	✔	✔	✔	✔	
HERPESTIDAE	Small Indian Mongoose	*Herpestes auropunctatus*	Not Listed	Least Concern (IUCN)										✔
Reptiles														
DACTYLOIDAE	Grenada Tree Anole	*Anolis richardii*	Not Listed	Least Concern (IUCN)						✔				
Amphibians														
ELEUTHERODACTYLIDAE	Piping Frog	*Eleutherodactylus syristes*	Not Listed	Least Concern (IUCN)					✔	✔	✔	✔	✔	
Crustaceans														
PSEUDOTHELPHUSIDAE	Manicou Crab	*Rodriguezus garmanii*		Not Listed				✔						
Millipedes														
SPIROBOLIDAE	Millipede	*Diplopoda*	Not Listed	Not Listed					✔	✔				
Spiders														
ARANEIDAE	Spider	*Araneae*	Not Listed	Not Listed					✔	✔	✔			
Insects														
CULICIDAE	Mosquito	*Culicidae*	Not Listed	Not Listed				✔	✔	✔	✔	✔		
TABANIDAE	Horsefly	*Tabanidae*	Not Listed	Not Listed						✔				
TERMITIDAE	Termite	*Isoptera*	Not Listed	Not Listed						✔				
DROSOPHILIDAE	Fruit Fly	*Drosophila melanogaster*	Not Listed	Not Listed				✔		✔				
LIBELLULIDAE	Dragonfly	*Anisoptera*	Not Listed	Not Listed						✔				
VESPIDAE		*Vespa*	Not Listed	Not Listed						✔				
	Wasp	*Vespidae*	Not Listed	Not Listed						✔				
FORMICIDAE	Ants	*Formicidae*	Not Listed	Not Listed					✔	✔	✔			
APIDAE	Honeybee	*Tribe Apini*	Not Listed	Not Listed						✔				
ACRIDIDAE	Grasshoppers	*Caelifera*	Not Listed	Not Listed						✔				
PSYCHODIDAE	Sandfly	*Phlebotominae*	Not Listed	Not Listed				✔		✔				
CARABIDAE	Beetle	*Coleoptera*	Not Listed	Not Listed						✔				

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS		SURVEY METHOD									
			NATIONAL	IUCN	CT	PT 1	PT 2	AS	NS	TR 1E	TR 1W	TR 1S	TR 1N	OP
TETTIGONIINAE	Green Cricket	*Tettigonia viridissima*	Not Listed	Not Listed					✔		✔	✔	✔	
MUTILLIDAE	Assassin Ants	*Dasymutilla occidentalis*	Not Listed	Not Listed		✔			✔					
SATURNIIDAE	Moth	*Lepidoptera*	Not Listed	Not Listed					✔		✔	✔	✔	
BLATTIDAE	Cockroach	*Blattodea*	Not Listed	Not Listed								✔		
CORDULEGASTRIDAE	Dragonfly Nymph	*Anisoptera*	Not Listed	Not Listed				✔						
CERAMBYCIDAE	Weever Beetle	*Lamia textor*	Not Listed	Not Listed				✔						
GERRIDAE	Water Strider	*Gerridae*	Not Listed	Not Listed				✔						
ATYIDAE	Cacando/Kakadoo Crayfish	*Atya sp.*	Not Listed	Not Listed				✔						

CT - Camera Trap; PT - Pitfall Trap; AS - Aquatic Survey; NS - Night Survey; TR - Transect; OP – Opportunistic

Appendix 2: Ecosystem Services Sheet

TABLE 7-6: TREE AND GRASS IDENTIFICATION AT SITE C

Tree and Grass Identification																								
Species	**Food**		**Fodder**			**Wood**							**Services**							**Miscellaneous**				**Rating**	**Other Remarks**
	Fruits/pods/leaves	**Nuts/Seeds**	**Leaves**	**Fruits/pods/leaves**	**Shoots**	**Bee Forage**	**Fuel wood**	**Charcoal**	**Building/hut material**	**Implements furniture/tools**	**Pulp**	**Sawn timber**	**Windbreak/shelter**	**Live Fence**	**Soil Conservation**	**Dune Fixing**	**N2 fixing**	**Organic Manure**	**Soil Improvement**	**Oil tannins/dyes**	**Gums**	**Medicinal**	**Shade/Ornamental**		
Nutmeg (*Myristica fragrans*)	✔	✔																						**3**	Seeds are used extensively as a major spice on the island.
Dragon Blood / Dragon Tree (*Dracaena sp.)*													✔	✔										2	This tree is used as a windbreak and also as a boundary plant (demarking property boundaries)
Coconut (*Cocos nucifera*)		✔							✔											✔		✔		2	The water in the nut is a natural source of electrolytes. Leaves are used as building material and used to make brooms. Coconut oil is also derived from the nut, which also has mild medicinal value
Bois Canot (*Cecropia schreberiana*)			✔																			✔		1	The leaves are used to feed cows, and are also used medicinally

Tree and Grass Identification																										
Species	**Food**		**Fodder**			**Wood**							**Services**							**Miscellaneous**				**Rating**	**Other Remarks**
	Fruits/pods/leaves	**Nuts/Seeds**	**Leaves**	**Fruits/pods/leaves**	**Shoots**	**Bee Forage**	**Fuel wood**	**Charcoal**	**Building/hut material**	**Implements furniture/tools**	**Pulp**	**Sawn timber**	**Windbreak/shelter**	**Live Fence**	**Soil Conservation**	**Dune Fixing**	**N2 fixing**	**Organic Manure**	**Soil Improvement**	**Oil tannins/dyes**	**Gums**	**Medicinal**	**Shade/Ornamental**		
Galba (*Calophyllum calaba)*													✔	✔								✔	✔	2	The seeds are used to make jewellery. The leaves are used medicinally to treat bladder infections and the trees themselves are planted as windbreaks, to demarcate property boundaries and as shade for cocoa plantations.
Breadnut (*Artocarpus camansi*)	✔																								Not only is it edible and sustaining, but it attracts game that can be hunted to provide meat.
Shadow Beni (*Eryngium foetidum*)	✔																								Shadow beni is a leafy herb native to the West Indies and Central America. It is often used in marinades and sauces, and the herb is also used as a garnish. and to dress various foods.

Tree and Grass Identification

Species	Food		Fodder			Wood							Services							Miscellaneous				Rating	Other Remarks
	Fruits/pods/leaves	Nuts/Seeds	Leaves	Fruits/pods/leaves	Shoots	Bee Forage	Fuel wood	Charcoal	Building/hut material	Implements furniture/tools	Pulp	Sawn timber	Windbreak/shelter	Live Fence	Soil Conservation	Dune Fixing	N2 fixing	Organic Manure	Soil Improvement	Oil tannins/dyes	Gums	Medicinal	Shade/Ornamental		
Banana (*Musa sp.*)	✔																								Used as a source of food.
Pineapple	✔																								Used as a source of food.
Soursop (*Annona muricata*)	✔																								Used as a source of food.
Hog Plum (*Spondias mombin*)			✔																						Used as a food source by animals
Avocado (*Persea americana*)	✔																								Used as a source of food.
Sugarcane (*Saccharum*)	✔																								Used as a source of food.
Yam (*Dioscorea alata*)	✔																								Used as a source of food.
Golden Apple (*Spondias dulcis*)	✔																								Used as a source of food.
Grapefruit (*Citrus x paradisi*)	✔																								Used as a source of food.
Vetiver Grass (*Chrysopogon zizanioides*)															✔										Used to stabilize soils.
Dasheen (*Colocasia escuelenta*)	✔																								Used as a source of food.
Mango (*Mangifera indica*)	✔																								Used as a source of food.

Tree and Grass Identification																									
Species	**Food**		**Fodder**			**Wood**							**Services**							**Miscellaneous**				**Rating**	**Other Remarks**
	Fruits/pods/leaves	**Nuts/Seeds**	**Leaves**	**Fruits/pods/leaves**	**Shoots**	**Bee Forage**	**Fuel wood**	**Charcoal**	**Building/hut material**	**Implements furniture/tools**	**Pulp**	**Sawn timber**	**Windbreak/shelter**	**Live Fence**	**Soil Conservation**	**Dune Fixing**	**N2 fixing**	**Organic Manure**	**Soil Improvement**	**Oil tannins/dyes**	**Gums**	**Medicinal**	**Shade/Ornamental**		
Royal Palm (*Roystonea regia*)																							✔		Planted as an ornamental. Leaves also used for thatching.
Bamboo (*Bambusa)*															✔										Found near watercourses and left to stabilize soils.

Appendix 3: Detailed Results of Plant Species Identified Along Transects and Quadrats

Habitats and Flora at Site C

These descriptions are based on the field surveys conducted during March, 2023. At Site C, four transects and nine (9) quadrats were established (see Figure 7-2). Along these transects and quadrats, total of 59 species belonging to 31 Families were recorded. A full listing of the species recorded at Site C are presented in Table 3-1. At a 100 m radius around the centre of the potential pad location, (Quadrat Q1), the vegetation was described as modified. There were agricultural crops present, interspersed with other ornamental plants. Agricultural crops within this radius included Breadnut (*Artocarpus camansi*), Nutmeg (*Myristica fragrans Houtt*.) (see Photograph 7-2) and Banana/Plantain (*Musa sp*.). Other ornamental plants included Lobster Claws (*Heliconia*), Bois Canot (*Cecropia peltate*) (see Photograph 7-4), Liverwort/Bryophytes (*Marchantiophyta*), Cocoa (*Theobroma cacao*) (see Photograph 7-9) and Morning Glory (*Ipomea*), to name a few.

Transect 1 North: From Quadrat Q1, moving north, there was a mixture of trees, bushes, grasses and other plants present. Species such as Shadow Beni (*Eryngium foetidu*m), Banana (*Musa sp.*), Nutmeg (*Myristica fragrans Houtt*.) and Sugarcane (*Saccharum*) (see Photographs 7-2 and 7-5). Further north, there was a shift to agroforestry, with the dominant species being Nutmeg (*Myristica fragrans*). In addition, Pineapple (*Ananas comosus*) (see Photograph 7-3), Soursop (*Annona muricata*), Grapefruit (*Citrus x paradisi*) were observed. Bois Canot was sparsely distributed in this area (see Photograph 7-4).

Transect 1 East: From Quadrat Q1, and moving east, there was a combination of pasture/grassland and crops. Interspersed in this plot were fruit trees such as Golden Apple (*Spondias dulcis*), Hog Plum (*Spondias mombin*) and Breadfruit/Breadnut (*Artocarpus altilis*). Continuing eastward, areas of Watergrass (Commelina erectus) and Vetiver Grass (Chrysopogon zizanioides) were encountered. Within this pasture, there were patches of Clear Weed (*Pilea pumila*), Balisier (Heliconia caribea) and Bamboo (*Bambusa*). A few Nutmeg and Bois Canot trees were interspersed in the area (see Photographs 7-2 and 7-4). Further east, a few Dasheen (*Colocasia escuelenta*), Calapo (*Calopogonium*) and Ficus (*Ficus americana*) were also observed.

Transect 1 South: At Quadrat Q1, there were mostly crops such as Breadnut, Nutmeg, Banana and Cocoa (see Photograph 7-9). Continuing south, Lobster Claws (Heliconia), and Morning Glory (*Ipomea*) were noted. Continuing southward along the transect, there was shift to secondary forest, with the canopy species being Bois Canot (*Cecropia peltata*). Other species included a few liverworts/bryophytes (*Marchantiophyta*).

Transect 1 West: At Quadrat Q1, trees were the dominant type of vegetation. Prevalent tree species observed were Nutmeg, Banana, Mango, Cocoa and Soursop. Interspersed among this area was razor grass (*Scleria secans*). A few small patches of Ferns were also present. Further west, trees remained the main habita, but other isolated plants such as Dasheen (*Colocasia escuelenta*) and Pigeon Peas (*Cajanus cajan*) were present (see Photographs 7-1 and 7-11)

Appendix 4: Site Photographs

FLORA

	
Photograph 7-1: Dasheen and Fern	Photograph 7-2: Nutmeg Plantation
	
Photograph 7-3: Pineapple	Photograph 7-4: Bois Canot
	
Photograph 7-5: Sugarcane	Photograph 7-6: Citrus

Photograph 7-7: Mango

Photograph 7-8: Coconut

Photograph 7-9: Cocoa

Photograph 7-10: Fern

Photograph 7-11: Pigeon Peas

AVIFAUNA

Photograph 7-12: Tropical Mockingbird

INVERTEBRATES

Photograph 7-13: Millepede

D. Species list (Critical Habitat Screening)

MOTT MACDONALD

Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Volume II - ESIA
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9 Water resources

9.1 Overview

This chapter discusses potential impacts on water resources which may occur as a result of the Project.

This chapter describes the methodology used to assess the magnitude and significance of effects, the Area of Influence (AOI), the water environment baseline conditions and the sensitive receptors present. The assessment of the potential impacts considers site establishment, including access road upgrade construction and well pad set up (the 'construction phase'); exploratory drilling and well testing (the 'operations phase'); and, where relevant, site closure (the 'decommissioning phase').

The assessment for water resources is supported by a Hydrogeological Study (Appendix B), examining the potential effects on the freshwater springs located close to Site C; and site survey reports, which describe the water quality and flow monitoring undertaken to inform the ESIA baseline.

A staged approach to the hydrogeological study has been adopted, whereby a preliminary (Phase 1) assessment been undertaken, using the available baseline data to inform the draft ESIA (this document). The Phase 1 hydrogeological study outlines a programme of additional data collection to support a more detailed interpretation of the hydrogeological regime at Site C, that will inform an updated assessment of the risks to groundwater and the freshwater springs located within the Site C study area. The Phase 2 study will be reported as an addendum update to the Final ESIA.

9.2 Study area and area of influence

The 'project area' refers to land where project activities will take place, i.e., the potential locations of well, pads, road improvements and pumping stations. The study area comprises the surface water and groundwater catchments where the Site C and Site F project areas are located. These are the St Patrick's and Gouyave watersheds (refer to Figure 9.2), for Sites C and F respectively. There is insufficient hydrogeological information to define groundwater catchment boundaries, but, since the surface water catchments cover a large area, it is reasonable to assume that they would include any aquifers that may be present.

Potential receptors have been identified in the area of influence (AOI) initially using a 500m search buffer around the project activities, as shown in Figure A.1 for Site C and Figure A.2 for Site F. Potential effects on more distant, downstream receptors are then considered using the industry standard source-pathway-receptor approach (see section 9.3.3 for further explanation).

9.3 Methodology

9.3.1 Identification of receptors and potential impacts

A baseline understanding of the existing surface water and groundwater environment has been established from a desk-based review of available published information, supplemented by site specific survey data.

A source-pathway-receptor model has been applied to determine potential effects of the scheme on potential receptors, i.e. all three components (source, pathway and receptor) must be present for a potential effect to occur. For example, a source could be generation of sediment laden runoff (during construction), a pathway could be overland flow, and a receptor could be a surface water body.

Receptors may be subject to direct or indirect impacts, dependent on the potential pathways available.

- Direct effects may occur to surface water or groundwater (present below ground, within permeable rocks known as aquifers).
- Indirect effects may occur to any dependent receptors, such as:
  - water supplies (including water treatment plants, commercial bottling plants, domestic supplies);
  - water dependent ecological and amenity sites; and,
  - populated areas and infrastructure that may be susceptible to flooding or erosion.

9.3.2 Sensitivity of receptors

The criteria used to determine the sensitivity of receptors potentially affected by the Project are defined in Table 9.1. Generic examples are provided but it is important to note that the sensitivity of a water receptor will depend on its particular circumstances.

Table 9.1: Criteria for determining receptor sensitivity

Sensitivity	Criteria	Examples
High	Has very limited or no capacity to accommodate physical or chemical changes; or, Is nationally or regionally important resource.	Surface water body of international or national environmental importance with little or no capacity to absorb proposed changes or minimal opportunities for mitigation. Boreholes, wells or surface water intakes that are regionally or nationally important for water supply Rivers, lakes and wetlands at high risk of flooding, drought and/or and increased siltation Groundwater located within a protection zone or close to a potable supply source
Medium	Has limited capacity to accommodate physical or chemical changes or influences. Is a locally important resource.	Surface water body of international or national environmental importance with limited capacity to absorb proposed changes. Boreholes, wells or surface water intakes that are locally important for water supply Water body important for fisheries Groundwater located close to a non-potable supply source (e.g. for livestock / irrigation)
Low	Has moderate capacity to accommodate physical or chemical changes. Is used intermittently or sparsely as a resource	Surface water body of regional environmental importance with moderate capacity to absorb proposed changes Boreholes, wells or surface water intakes used for used locally for supply to individual dwellings, or where alternative supplies are available Groundwater located within the total catchment area for, but not close to, a groundwater source Soil and agricultural land use which may be affected by flooding/change in hydrological conditions
Negligible	Is generally tolerant of physical or chemical changes. Is not used as a resource	Groundwater, springs, rivers and lakes not used for water supply and that are generally tolerant of physical or chemical changes Soil and agricultural land use not sensitive to some change in hydrological regime (e.g. grazing)

Source: Mott MacDonald

9.3.3 Change parameters

The degree of change to the hydrological baseline is assessed qualitatively, using the method described in Chapter 6, by taking into account different change parameters:

- the magnitude of change in comparison to normal variability seasonal fluctuations, or relevant standards;
- the duration of the change (between short-term and permanent);
- the spatial scale of the change (local, regional, national, international); and
- the likelihood that the change will occur.

The criteria used to determine the magnitude of changes are defined in Table 9.2.

Table 9.2: Criteria for determining magnitude of change

Magnitude (beneficial or adverse)	Description (considers duration of the impact, spatial extent, reversibility and ability to comply with legislation)
Major	Fundamental change in the integrity or quality of an attribute, or risk to a receptor (including total loss or creation of new attribute). Likely to be experienced over a very wide area, irrecoverable (if adverse) or permanent.
Moderate	Change in the integrity or quality of an attribute, or risk to a receptor, possibly affecting its purpose or exceeding national standards and limits. Likely to be experienced over a wide area, and recoverable (if adverse) or long-term.
Minor	Discernible but slight change in the integrity or quality of an attribute, or risk to the receptor, not affecting its purpose. Likely to be experienced at a short distance off-site or very short-lived or.
Negligible	No measurable change to integrity or quality of attribute, or risk to the receptor. Change within the normal bounds of variation. Likely to be confined to the development site

Source: Mott MacDonald

Specifically regarding magnitude and scale, as explained in section 9.3.1, for an impact to occur, there must be a viable pathway between the potential source of any impacts, and the receptor. The degree of change experienced by a receptor will be dependent on nature of both the receptor and, the pathway between it and the source of the impact.

The magnitude of change is affected by the length and nature of the pathway. For indirect receptors, the magnitude will typically decrease with distance (in the direction of flow) from the source of the impact on the direct receptor. For example, contaminants will usually be diluted as they travel downstream, and effects on groundwater or surface water level will dissipate as the proportion of total flow derived from the wider catchment increases and other, nearer influences predominate. To account of uncertainties in the conceptual understanding of the system (e.g. due to lack of data), magnitude has been assessed conservatively, assuming a realistic worst case scenario.

Because of the distance effects on magnitude, the scale of changes to the natural environment will typically be local. However, effects on receptors such as amenity areas or water supply sources may have wider consequences, dependent on the geographic area or number of people that they serve. For the purposes of this assessment, public water supply intakes are considered to have a regional footprint, whilst the Glenelg water supply springs have a national footprint, due to the widespread customer base of the company.

9.3.4 Impact significance

Impact significance has been assessed using the scoring approach described in Chapter 6 ESIA Methodology. Impact significance is summarised in Table 9.3.

Table 9.3: Summary of impact significance

Significance	Explanation
Major	Unacceptably high impact on the environment and/or the community(s). It is unlikely that an impact of this magnitude can be satisfactorily mitigated. If this impact cannot be avoided, the project is unlikely to be permitted for development.
Moderate	High impact on the environment and/or the community(s). The project may be compromised if this impact cannot be avoided or mitigated (i.e. to reduce the significance of the impact).
Minor	Relatively low impact on the environment and/or the community(s). Opportunities to avoid or mitigate the impact should be considered; however, this should not compromise the viability of the project.
Negligible	No noticeable impact on the environment and/or the community(s). No mitigation is required.

Source: Mott MacDonald

9.3.5 Surveys

Survey locations and water resources receptors are shown in Figure A.3 for Site C and Figure A.4 for Site F. The initial baseline survey, undertaken during July 2019, collected water samples and flow measurements from four locations, listed in Table 9.4. The survey targeted Site F and the original location of the Site C wellpad.

Table 9.4: 2019 survey locations (Sites C and F)

Location Ref.	Relevant Site	Location Description	Coordinates (UTM)	
			Longitude	Latitude
2019-01	C	Mt. Reuil Stream headwaters	645486	1346833
2019-02	C	Mt. Reuil Stream upstream of Mt. Reuil Dam water intake	647055	1347608
2019-03	F	Mt. Felix Stream downstream of Site F well pad	641936	1343812
2019-04	F	Mt. Felix Stream downstream of Mt. Felix Spring water intake	645486	1346833

Source: Mott MacDonald

A further baseline survey was undertaken in 2023 following the Covid-19 pandemic. This survey comprised three site visits, targeting the revised location of Site C and the potential effects that drilling at this location could have on springs supplying the Glenelg bottling plant. The first visit was completed during March 2023, to provide baseline information for the revised location of wellpad C and inform the Phase 1 Site C hydrogeology study (Appendix B). The remaining visits will inform the Phase 2 Site C hydrogeology study and ESIA update addendum report. Survey locations for the March 2023 site visit, are set out in Table 9.5.

Table 9.5: 2323 survey locations (Site C only)

Location Ref.	Location Description	Coordinates (UTM)	
		Longitude	Latitude
2023-01	Mt. Reuil Stream headwaters (downstream)	645490	1346884
2023-02	Mt. Reuil Stream headwaters (upstream)	645418	1346816
2023-03	Mt. Reuil Stream tributary (downstream)	646533	1347588
2023-04	Mt. Reuil Stream tributary (upstream)	646485	1347606

Location Ref.	Location Description	Coordinates (UTM)	
		Longitude	Latitude
2023-05	Mt. Reuil Stream at Mt. Rich	647222	1347658
2023-06	Irrigation spring south-west of well pad	645356	1346976
2023-07	Mt. Reuil Stream at Glenelg upstream spring	646324	1347371
2023-08	Mt. Reuil Stream at Glenelg downstream spring	646633	1347400

Source: Mott MacDonald

All survey locations are shown on the baseline survey Key Water Features plans given in Appendix A and indicated in Figure A.3.

9.3.6 Limitations and assumptions

This assessment is based on information available at the time of writing. No hydraulic modelling has been undertaken and geological information is limited, as ground investigations have not yet been undertaken at the proposed well pad and pumping station locations. The assessment of potential impacts on water quality and flood risk is therefore qualitative and based primarily on professional judgment.

9.4 Baseline – description of pre project conditions

This section presents a baseline characterisation of water resources and flood risk in the study area. Information has been drawn from: published sources, project documents, data provided by NAWASA and field surveys. Project documents include the Grenada Water Resource Study (Jacobs, 2018), which was undertaken to assess potential water supply sources for exploratory drilling.

9.4.1 Climate

Grenada is characterised by a humid tropical climate and is generally warm and humid all year round. Data measured by the meteorological office at the Maurice Bishop International Airport shows that[1] Grenada experienced a mean daily maximum temperature of 30.5 degrees Celsius and a mean daily minimum of 24.3 degrees Celsius, for the period 1986-2013. The mean annual temperatures have fluctuated within a very narrow range over the past two decades with the highest mean annual temperature at 31.2 degrees Celsius in 2005 and the lowest mean annual temperature at 24.1 degrees Celsius in 2012. The lowest mean monthly temperatures are experienced from January to March and the highest from September to October.

Relative humidity for the period 1990-2013 averages 81% and varies significantly throughout the year. The driest month is March with a low of about 77% relative humidity and the wettest month in November with a high of about 84% relative humidity.

Grenada has two distinct rainfall patterns, a dry season from January to May and a wet season from June to December[2]. As can be seen in Figure 9.1, mean annual rainfall varies from about 1000mm in the coastal zone to 4000mm in the interior, mountainous areas of the island.

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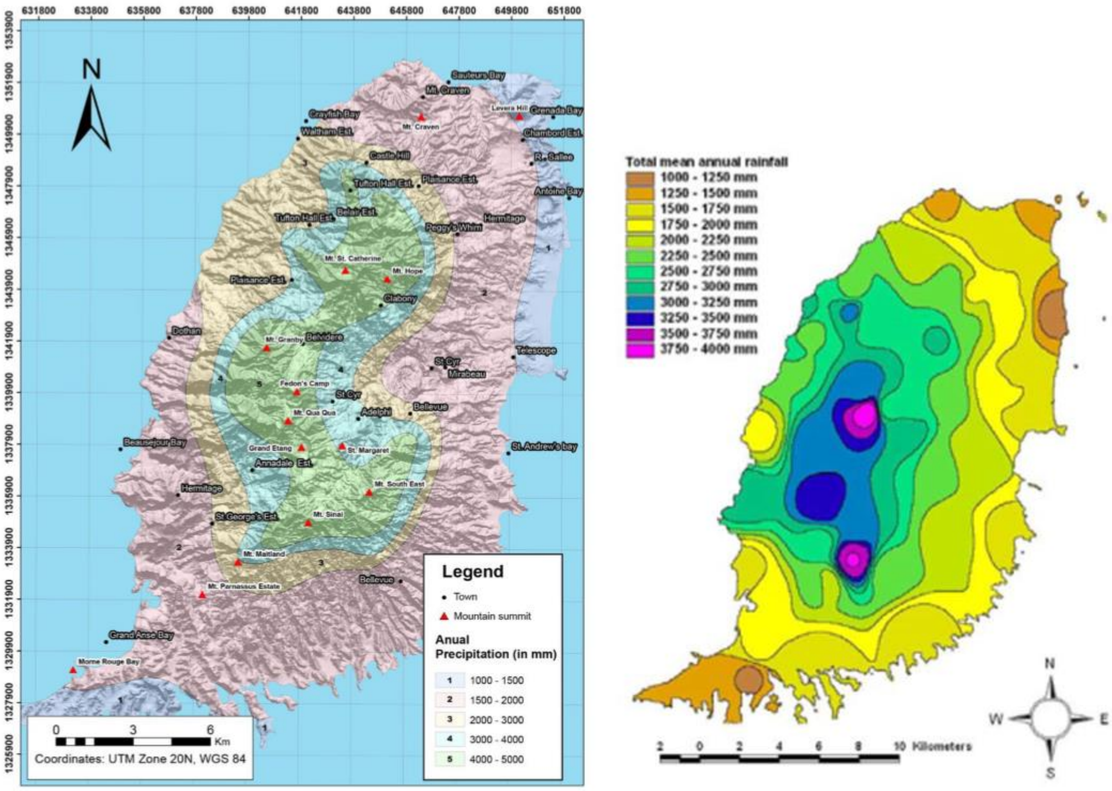
1 National Disaster Management Agency (NaDMA), Country document on Disaster Risk Reduction for Grenada, 2014. Available at: http://dipecholac.net/docs/files/871-documento-pais-grenada-web.pdf

2 C. McSweeney, M. New, and G. Lizcano, 2010. UNDP Climate Change Country Profiles. United Nations Development Programme: Grenada. Available at: https://www.geog.ox.ac.uk/research/climate/projects/undp-cp/UNDPCCCP_documentation.pdf [Accessed 23 April 2019].

In the dry season, the northeast trade winds blow steadily with a moderate intensity. However, the rainy season brings more irregular wind.

Figure 9.1: Mean annual rainfall on mainland Grenada

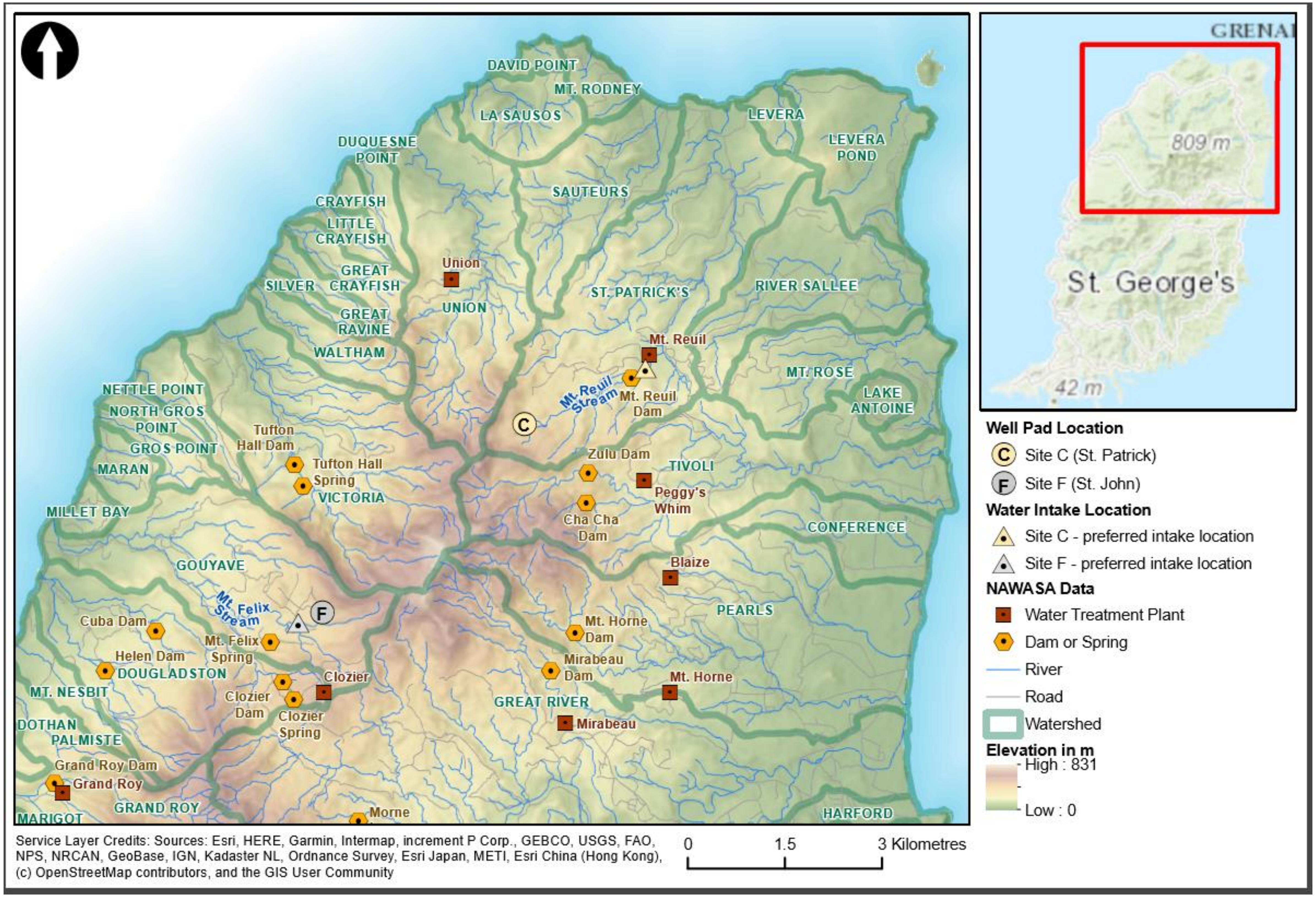


Source: Left - Grenada Water Resources Study, Jacobs 2018; Right - IWRM Water Resources Roadmap (Caribbean Environmental Health Institute, 2007)

9.4.2 Hydrology

The island is divided into 71 watersheds (catchments) in total. Watercourses, public water supply intakes and treatment plants in the study area, are shown on Figure 9.2.

Figure 9.2: Watersheds and key water infrastructure

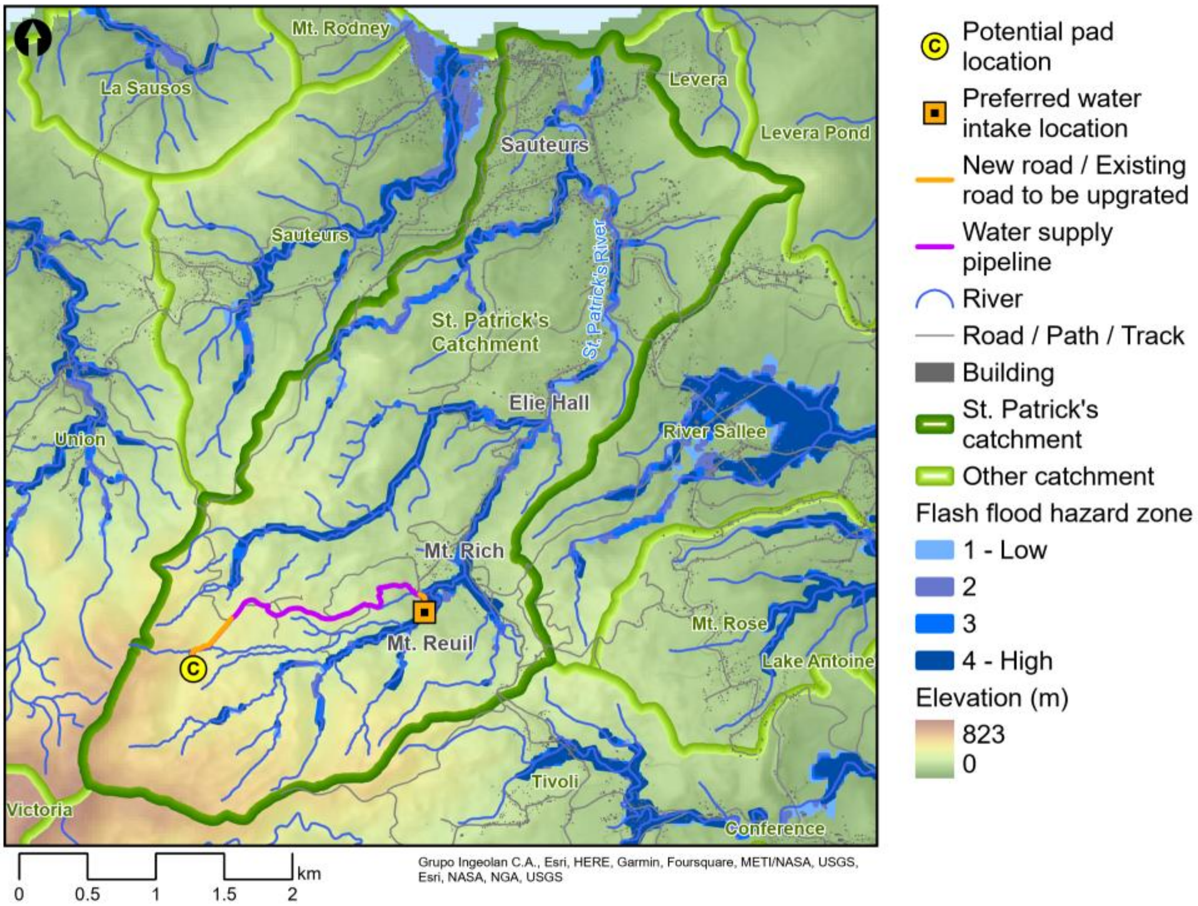


Source: Mott MacDonald

9.4.2.1 Site C hydrological setting

As shown on Figure A.3, Site C is situated on the north-east slopes of Mt. St. Catherine, within the St. Patrick's Watershed (1,253 ha), which drains northward to Irvine's Bay. The Mt. Reuil stream originates to the south of Site C and flows north-eastward through Mt. Rich, where it is joined by a tributary from the south. The river then flows north, through Elie Hall, where it is joined by a tributary from the west (see Figure 9.3). Known as the St. Patrick River, this watercourse flows through several small communities before reaching the sea in an unpopulated area to the east of Sauteurs.

Figure 9.3: St Patricks watershed map with flood hazard zones



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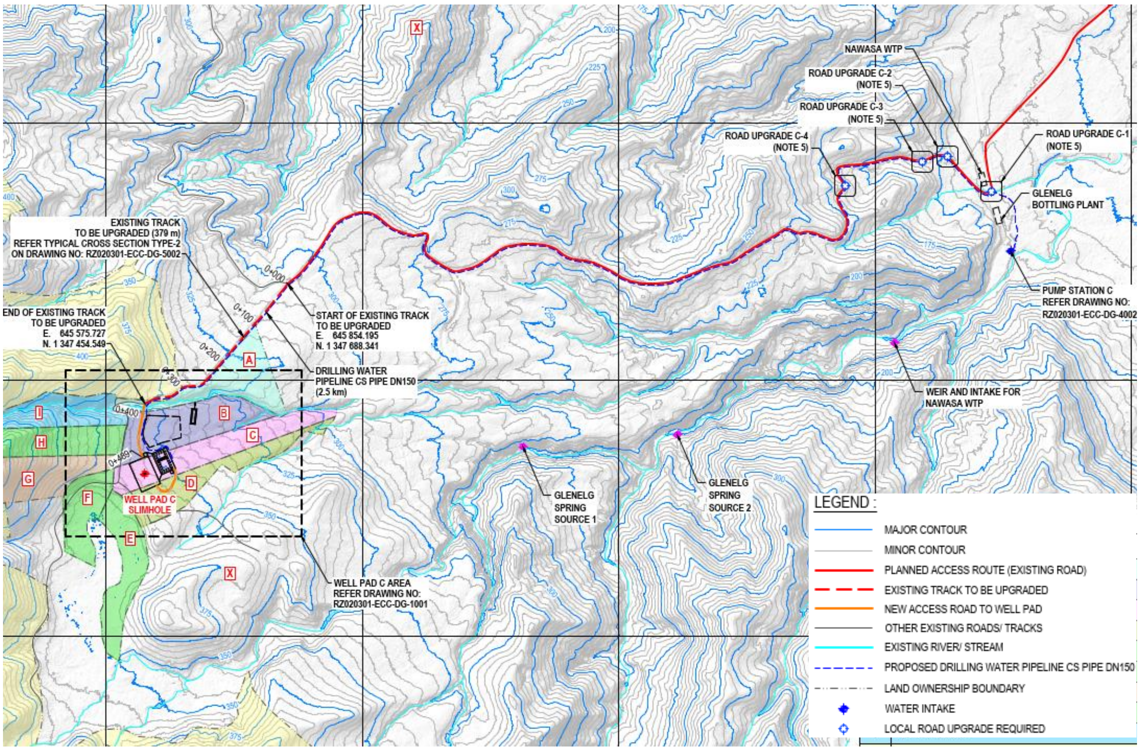
Source: Mott MacDonald. Flood hazard zones taken from the Caribbean Handbook on Risk Information Management, 2016

As shown on Figure 9.3, Site C is located between, and drains towards, two small streams, which converge to form a small tributary of the Mt. Reuil stream. The tributary joins the Mt. Reuil stream downstream of the NAWASA water supply intake at Mt. Reuil. The two streams may need to be diverted around the site dependant on final design.

Figure 9.4: Site C proposed infrastructure plan



Source: WELL PAD C AND ACCESS ROAD GENERAL ARRANGEMENT RZ020301-ECC-DG-0005 Rev.C

There is a wetland basin slightly down-slope and to the south-west of Site C. This is fed by a small spring used for irrigation, and drains southwards to the Mt. Reuil stream. The altitude of the wellpad is approximately 355 m above sea level (ASL). The proposed water intake for Site C is located approximately 2 km east at Tricolar, at approximately 136 m ASL. This is downstream of Mt. Reuil Dam, where the NAWASA intake for Mt. Reuil water treatment plant (WTP) is located.

Figure 9.5: Mt Reuil Stream looking upstream from culvert adjacent to the Glenelg bottling plant.

Source: Site Definition Report. Jacobs, 2018

9.4.2.2 Site F hydrological setting

As shown on Figure A.4, Site F is situated on the western flank of Mt. St. Catherine within the Gouyave / Florida watershed (834 ha), which drains westward through Gouyave to Milet Bay. The altitude of the wellpad is approximately 415 m ASL. As shown on Figure 9.4, the proposed water intake is situated approximately 1.8 km west of the wellpad, on the Mt. Felix stream, at approximately 200 m ASL (see Figure 9.6).

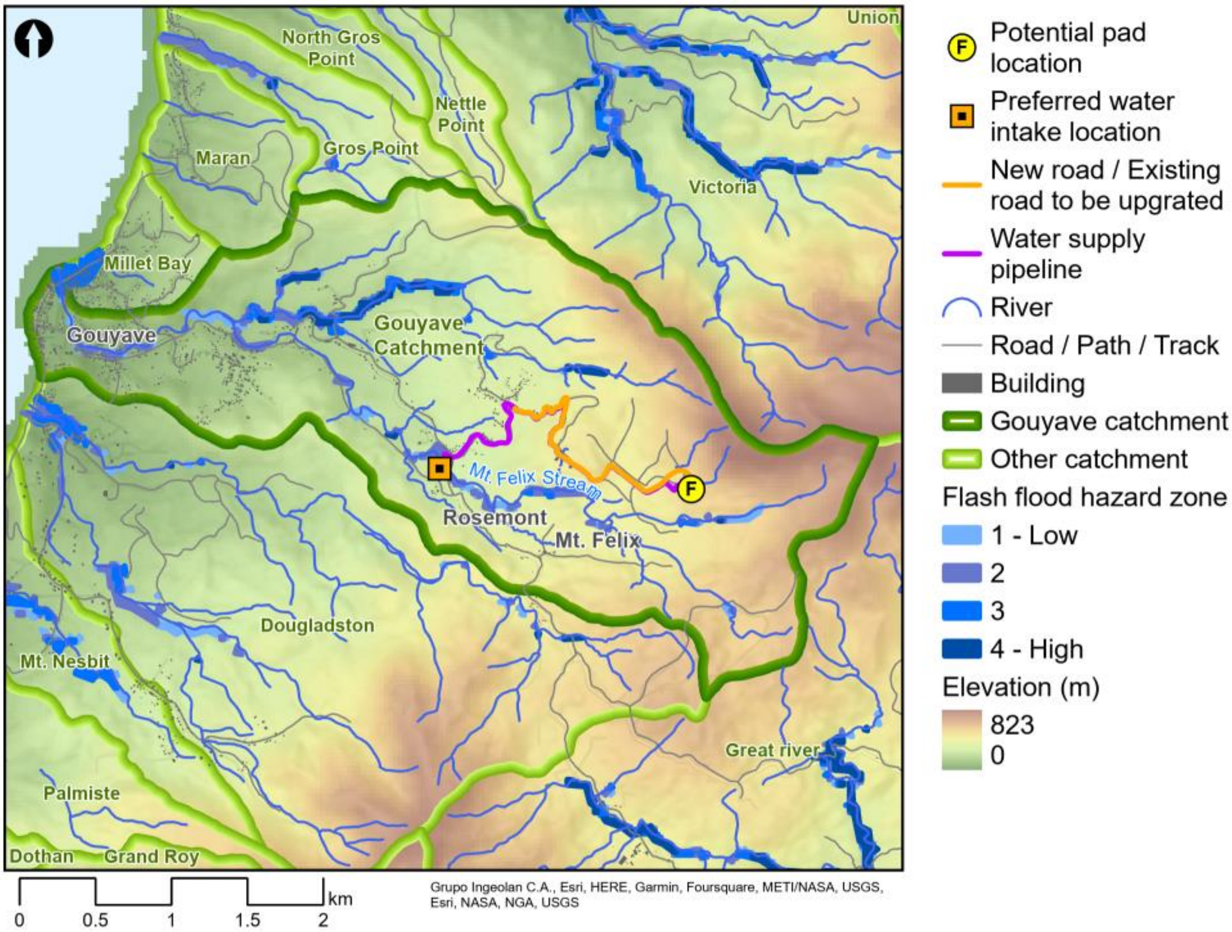
Figure 9.6: Site F water intake location, looking upstream

Source: Site Definition Report. Jacobs, 2018

A short distance downstream, this watercourse is joined by a tributary flowing from the Mt. Felix spring. There is a NAWASA public supply intake at the Mt. Felix spring, which is piped to Clozier WTP, situated in the neighbouring watershed to the south. Further downstream, the Mt

Felix Stream is joined by another watercourse originating to the north, before flowing to the sea at Gouyave.

Figure 9.7: Gouyave watershed map with flood hazard zones



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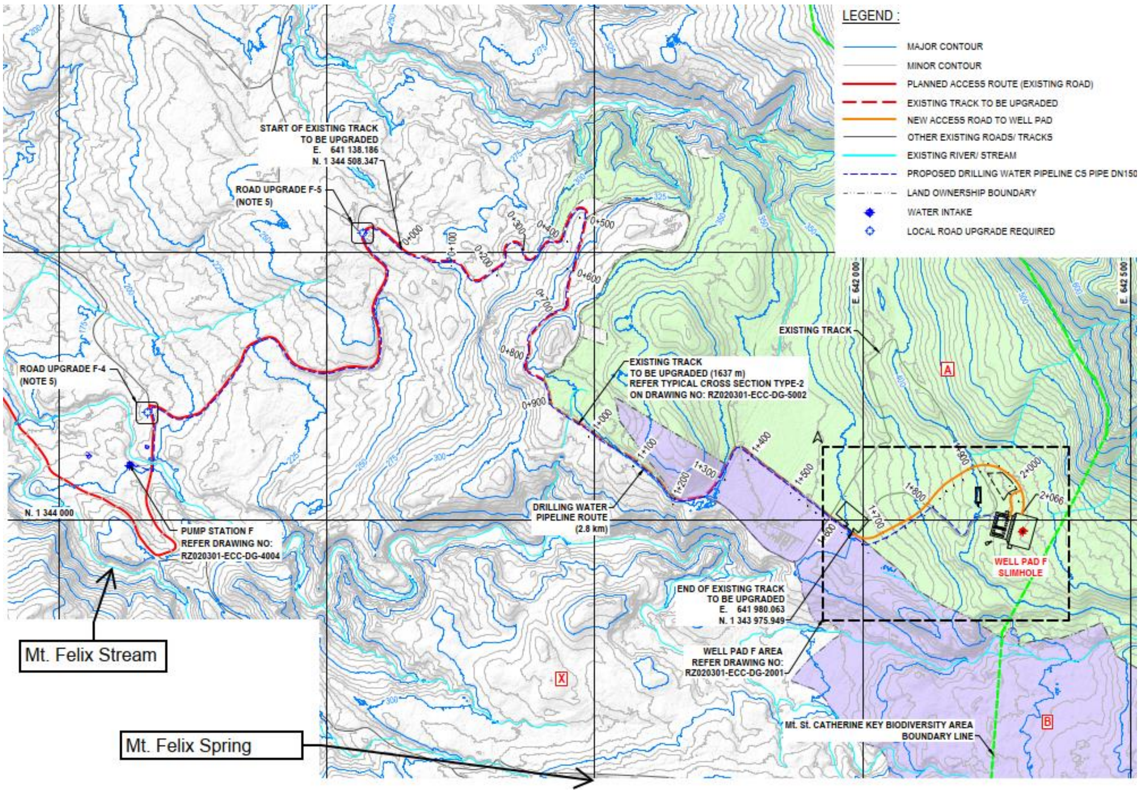
Source: Flood hazard zones taken from the Caribbean Handbook on Risk Information Management, 2016

Figure 9.8: Site F proposed infrastructure plan

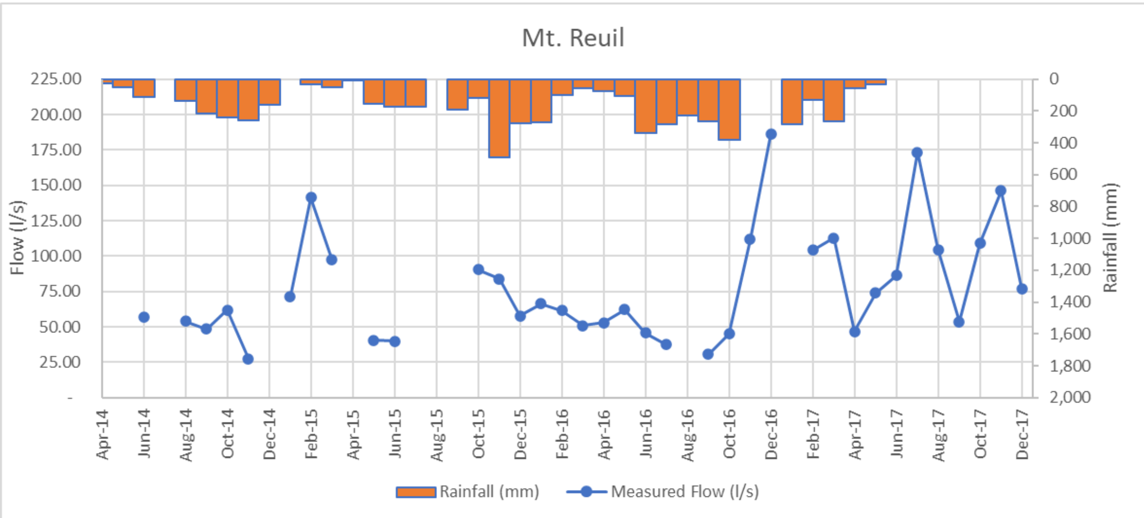


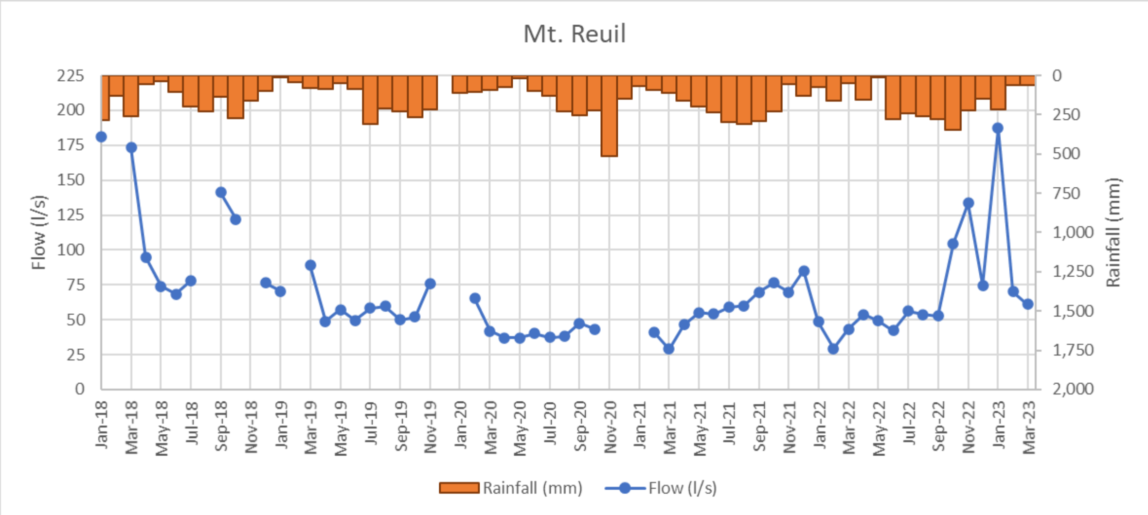
Source: WELL PAD F AND ACCESS ROAD GENERAL ARRANGEMENT RZ020301-ECC-DG-0006 Rev. C

9.4.2.3 Rainfall and river flow

Of the two relevant catchments, measured flow and rainfall records are only available for St Patrick's, and were collected at the Mt Reuil monitoring station. Monthly totals are presented in Figure 9.9. Note that there are gaps in both datasets.

Figure 9.9: Instantaneous flow and total monthly rainfall for Mt. Reuil monitoring station





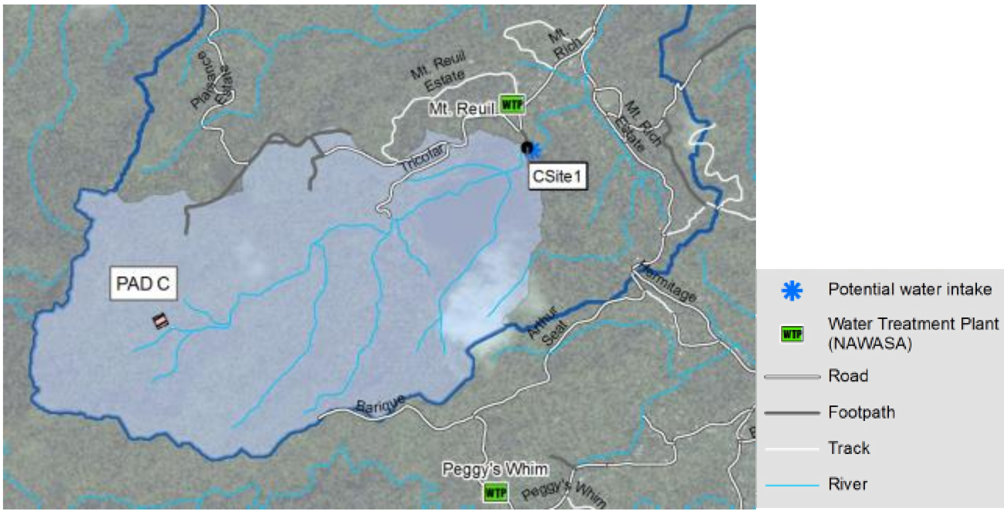
Source: NAWASA

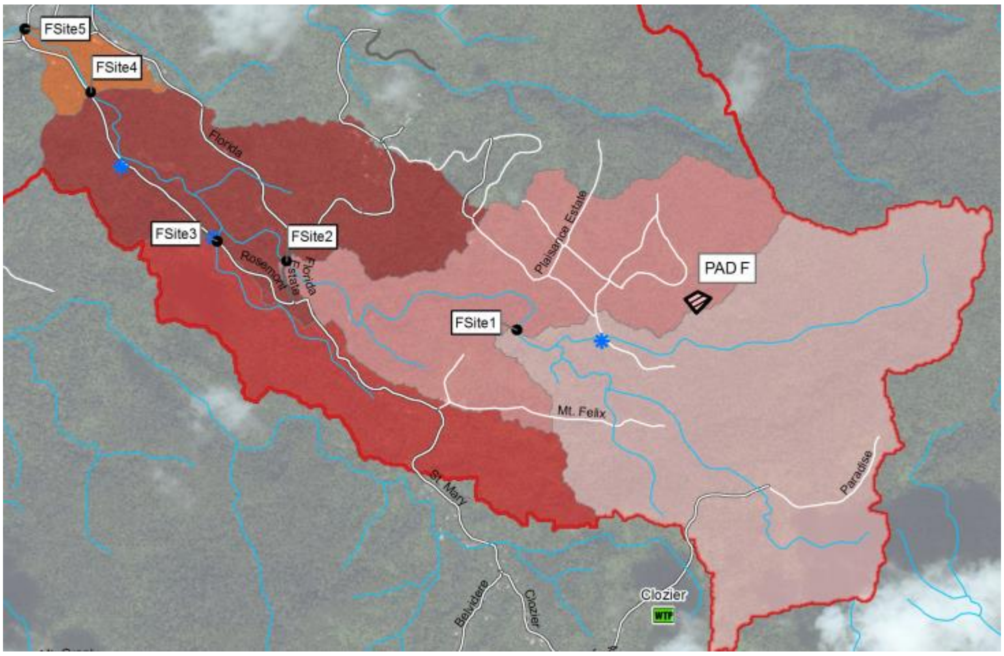
The Grenada Water Resources Study (Jacobs, 2018b) assessed the availability of surface water and groundwater to supply water to the well pads during the operational phase. Because flow data for the area are limited, hydrological modelling was undertaken to simulate the availability of surface water to support drilling.

Baseline flows were simulated at the potential intake locations for each drill pad, for the period May 2014 to May 2018. The modelled sub-catchments, upstream of the proposed intake locations, are illustrated in Figure 9.10.

Note that five intake locations were investigated for Site F, with ‘FSite2’ being the final proposed location for the intake. Both sub-catchments are of a similar size (3.0 km^2 for Site C and 2.6 km^2 for Site F) and altitude.

Figure 9.10: Modelled intake sub-catchments for Site C (CSite1) and Site F (FSite2)





Source: Grenada Water Resources Study (Jacobs, 2018)

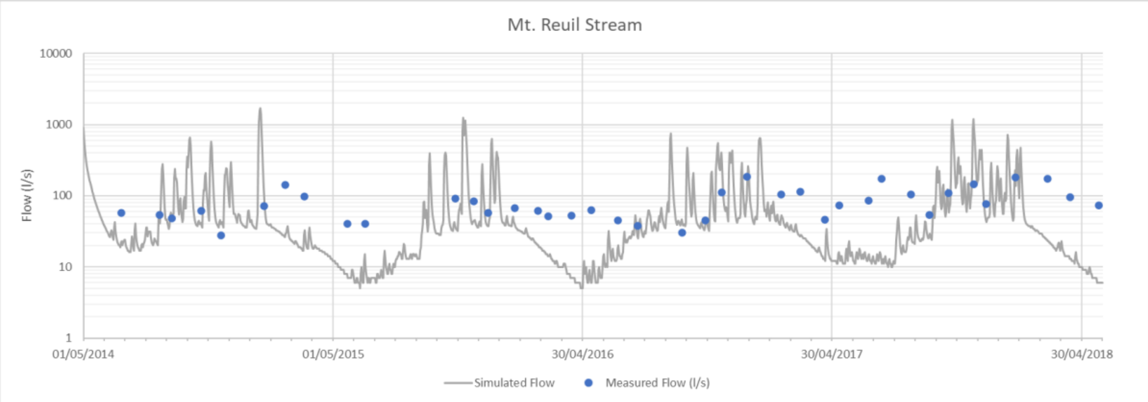
Simulated flow data[3] for the proposed Site C intake location are presented in Figure 9.11, alongside NAWASA instantaneous observed flow data for the same period. This demonstrates that the model simulates wet season flow quite well but tends to underestimate dry season flow. This could be because actual rainfall during the dry season is higher than assumed in the

[3] Note: simulated data are subject to assumptions used in the model and may differ significantly from the actual flows that occurred at the sites, during this period. The data are provided to illustrate the range of flows that could be expected, in the absence of observed data.

model[4]; or, because the model does not simulate the contribution from groundwater springs, which would continue flowing through the dry season.

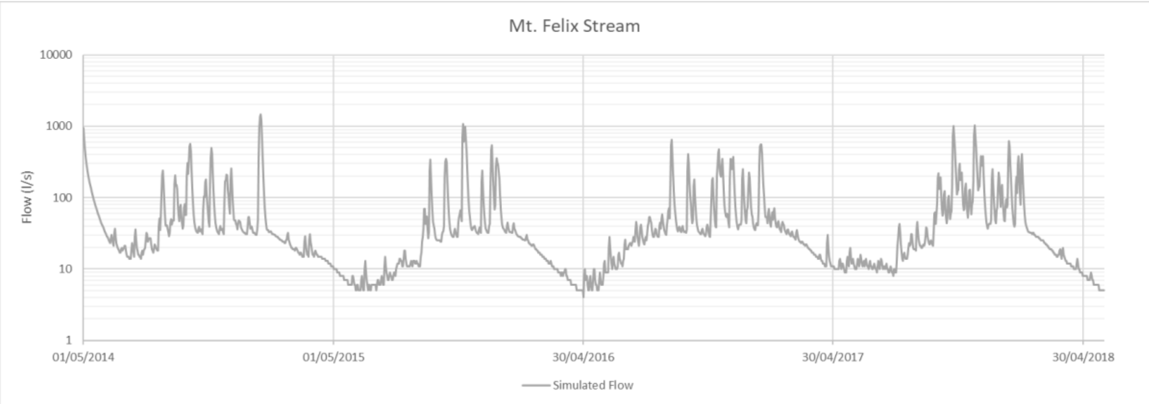
For Site F (see Figure 9.12), the pattern of simulated flow is very similar to and slightly lower than that of Site C (due to the slightly smaller catchment area). There are no measured flow data available for comparison, but a local resident has confirmed that although flow reduces significantly during the dry season, the river never dries out completely.

Figure 9.11: Observed and simulated baseline flow for Site C intake location



Source: Grenada Water Resources Study (Jacobs, 2018) and NAWASA

Figure 9.12: Simulated baseline flow for Site F intake location



Source: Grenada Water Resources Study (Jacobs, 2018)

Flow statistics for the simulated and observed flow data are presented in Table 9.6. Whilst the modelling suggests that minimum flows in both watercourses are around 5 l/s, the measured flow data for Mt. Reuil Stream indicate that dry season flows are generally sustained at around 30 to 40 l/s. For comparison, the average annual observed minimum flow for the modelled period is 27.5 l/s and for 2014 to 2022, is 39.7 l/s.

[4] There are several uncertainties associated with the modelling but a key parameter is rainfall, which is taken from the Peggy's Whim monitoring station, situated in the adjacent catchment to the south of St. Patricks. This was selected as the most reliable dataset for analysis, and use in the hydrological model, because it is the longest rainfall record available for the project area. However, rainfall in Grenada is significantly higher at greater altitudes, and the sub-catchment for both locations is at a higher elevation that the Peggy's Whim rain gauge. It is therefore considered that the simulated baseline flows may be underestimated by the model.

Table 9.6: Simulated baseline flow statistics

Season	Flow statistic	Site C Simulated	Site C Measured*	Site F Simulated
All year	Minimum (l/s)	5	27.48	4
	Mean (l/s)	76	82.88	66
	Maximum	1,694	186.21	1,462
	% time > 10 l/s	88%	-	83%
	% time >40 l/s	39%	-	32%
Dry (Jan – May)	Minimum (l/s)	5	40.63	4
	Mean (l/s)	56	88.54	50
	Maximum	1,694	180.78	1,462
	% time > 10 l/s	81%	-	75%
	% time >40 l/s	25%	-	19%
Wet (Jun – Dec)	Minimum (l/s)	5	27.48	5
	Mean (l/s)	90	78.50	78
	Maximum	1,238	186.21	1,069
	% time > 10 l/s	93%	-	89%
	% time >40 l/s	50%	-	42%

Source: *NAWASA flow data measured upstream of Mt. Reuil intake

Site-specific flow measurements were collected during the baseline surveys, at the locations shown in Figure A.3 (Site C) and Figure A.4 (Site F). and are presented in Table 9.7.

Table 9.7: Site specific surface water flow measurements

Site	Date	Season	Location Ref.	Location description	Flow Rate (l/s)
Mt. Reuil Stream (Site C)	April 2016*	Dry	N/A	Culvert adjacent to Glenelg bottling plant	80
	May 2018**				75
	18/07/2019	Wet	2019-01	Headwaters	3.9
			2019-02	Upstream of Mt. Reuil Dam water intake	4.2
	27/03/2023	Dry	2023-01	Headwaters (downstream)	2.9
			2023-02	Headwaters (upstream)	6.8
			2023-07	Adjacent to Glenelg upstream spring	6.6
			2023-08	Adjacent to Glenelg downstream spring	12.8
Mt. Felix Stream (Site F)	18/07/2019	Wet	2019-03	Downstream of Site F well pad	13.9
			2019-04	Downstream of Mt. Felix Spring water intake	<0.1

Source: *Jacobs, 2016 (measured after 6 weeks of dry weather). **Jacobs, 2018.

At location 2019-02, the flow measured by NAWASA on 10/07/2019 was 58.2 l/s; and measurements taken by Jacobs in the vicinity of the proposed pumping station, in 2016 and 2018, were also significantly higher than the survey measurement. It is therefore considered that some of the Site C survey measurements may not be fully representative of flow within the stream channel, so should be treated with caution.

The very low wet season flow at location 2019-04 may be explained by the presence of a NAWASA water intake immediately upstream.

9.4.3 Soils and geology

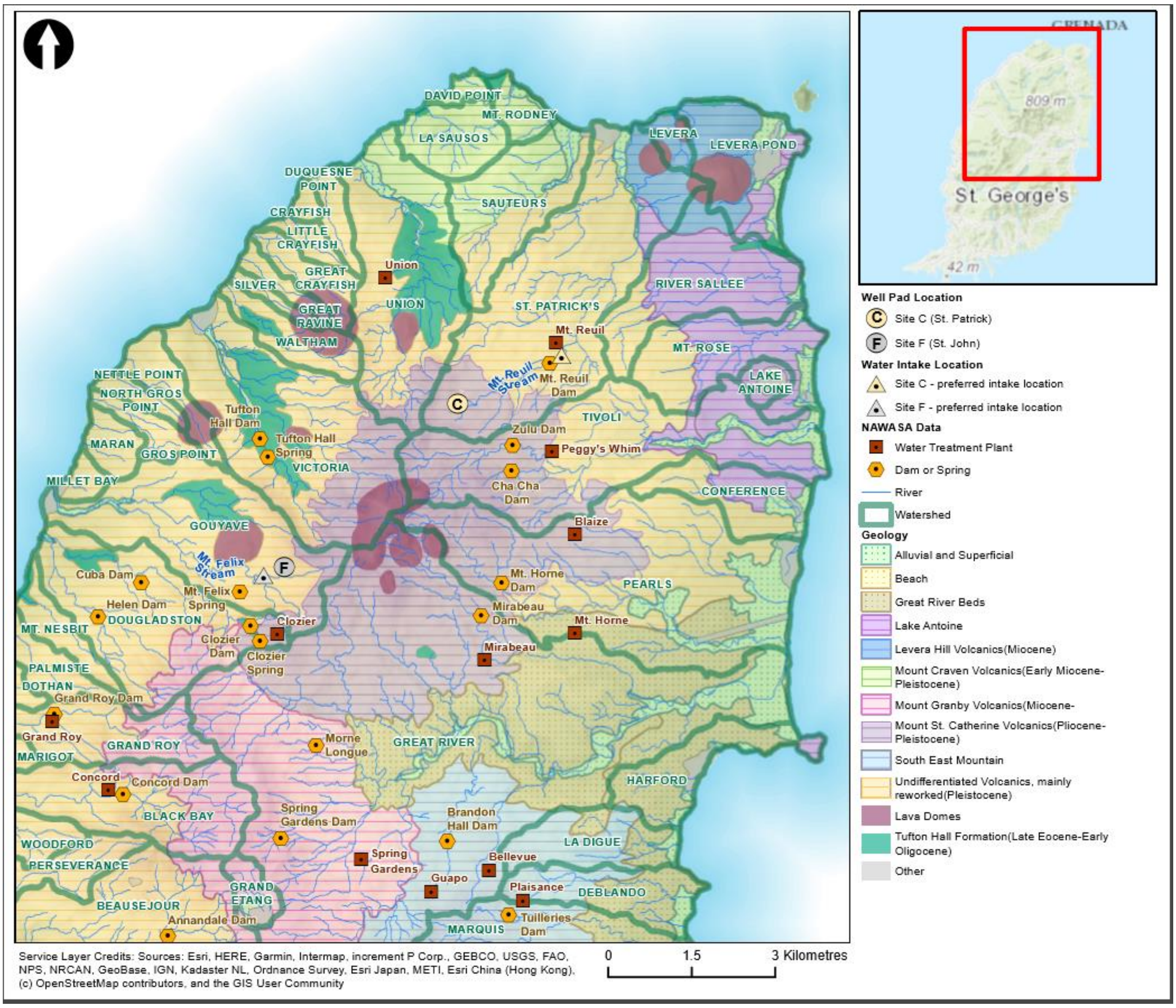
The soil type at both sites is Belmont clay loam, which is considered moderately erodible and tends to be brown in colour, moderately well drained, with good water retention. It tends to occur over basic volcanic ash and agglomerate[5] deposits.

In the Mt St Catherine area, a layer of volcanic rocks approximately 800m thick lies upon a sedimentary layer known as the Tufton Hall Formation. The volcanic rock types (basanitoid, alkaline basalt, subalkaline basalt, andesite and dacite) overlying the Tufton Hall formation are the result of five volcanic activity episodes between the lower Miocene and Pleistocene (the North Domes, South East, Mt. Maitland, Mt. Granby-Fedon's Camp, and Mt. St. Catherine the highest of the major peaks).

The geology of the project area and key water features are shown on Figure 9.13. Site C is underlain by Mt St Catherine Volcanics. Undifferentiated / reworked volcanic deposits outcrop across the lower slopes of the St Patrick's watershed and the whole of the Gouyave watershed, where Site F is situated.

[5] Agglomerate: a rock composed of volcanic fragments of various sizes and degrees of angularity.

Figure 9.13: Key water features and geology



Source: Mott MacDonald

9.4.4 Hydrogeology

All known groundwater sources are located in coastal areas, in the southern regions of St. David and St. George's. However, the potential for groundwater exploitation in northern Grenada is thought to be good and, therefore, potential aquifers should be protected. Little is known about groundwater resources within the north of Grenada but the largest aquifers are likely to be in the Great River, Pearls-Paradise and Antoine watersheds[6], all of which are outside the study area.

Jacobs (Jacobs, 2016) suggest that, based on geochemical studies, a thick, shallow aquifer may be present within the project area, fed by infiltrating rainfall, which dilutes geothermal fluids

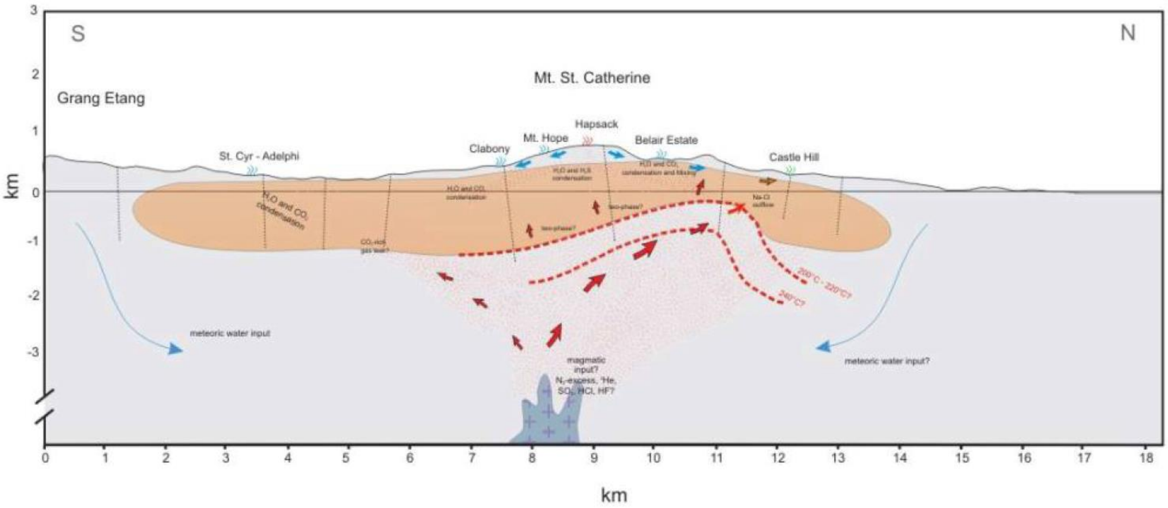
[6] Department of Economic and Social Affairs, 2012. *Climate Change Adaptation Grenada: Water Resources, Coastal Ecosystems, and Renewable Energy*. [pdf]. United States: United Nations Development Account. Available at: https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=635&menu=1515 [Accessed 23 April 2019].

emerging at the surface. This is evidenced by the presence of freshwater and thermal springs at altitude.

The hydro-geochemical conceptual model for the geothermal resource suggests that fresh groundwater would be present between approximately 100 to 250m below ground level at the drill sites, separated from underlying geothermal fluids by a thick layer of low permeability, hydrothermal clay, with a transitional, brackish zone at the base of the aquifer.

An associated geophysical study suggests this aquifer would be present at 50 to 100 m below ground level (BGL) at Site C, and 50 to 200 m BGL at Site F (Jacobs, 2018b). This translates to an estimated groundwater elevation of 255 to 355 m ASL at Site C and 215 to 365 m ASL at Site F.

Figure 9.14: Conceptual model of northern Grenada groundwater system, based on results of geophysical study.



Source: Jacobs, July 2018. Note: Clay cap is denoted by orange fill.

9.4.4.1 Site C hydrogeological setting

Down-gradient of the Site C wellpad there are both thermal and freshwater springs that discharge into the Mt. Reuil Stream. The wellpad elevation is approximately 355m ASL, whilst the freshwater springs, which supply the Glenelg mineral water bottling plant at Mt. Reuil, are situated at approximately 200 and 225 m ASL (see Figure A.4). The hydrogeology of Site C is discussed in detail in the Site C Phase 1 hydrogeology study.

9.4.4.2 Site F hydrogeological setting

In the vicinity of Site F, Mt. Felix Spring (see Figure A.4) is used for public water supply. This spring is at a lower elevation (335 m ASL) than the well pad (415 m ASL), on the opposite side of the valley.

9.4.5 Water resources

9.4.5.1 Public water supply

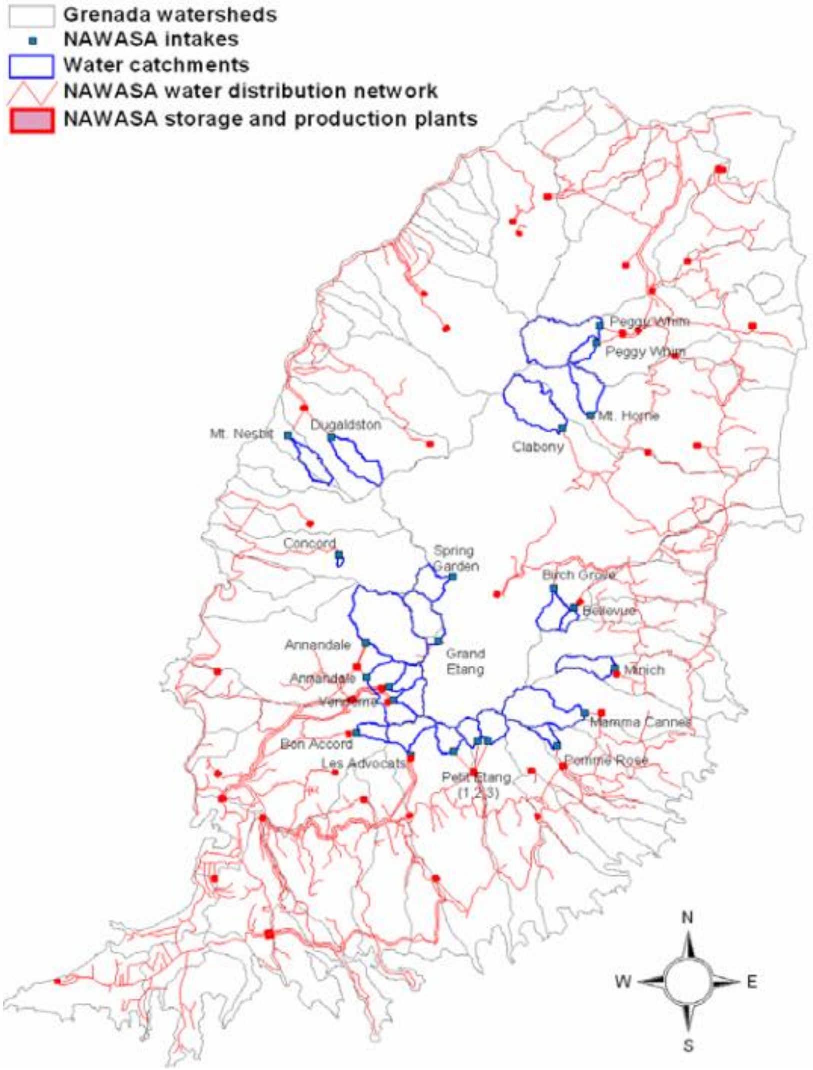
The 2007 Road Map (Caribbean Environmental Health Institute, 2007) reports that the National Water and Sewerage Authority (NAWASA) operates 23 surface water and 11 groundwater supply sources on mainland Grenada, yielding a total of 54,600m^3/day (12mgd). Groundwater sources are limited to low lying areas at the southern end of the Island. Whilst lakes also form an important water storage resource in Grenada, there are none present within the potentially affected catchments.

Approximately 98% of the population is connected to the water supply network, which is fed primarily from surface watercourses located in the mountainous northern region of the island. Communities which are not connected (due to their remoteness) tend to rely on rainwater harvesting. Groundwater supply boreholes are limited to low-lying coastal areas and are mainly used for supply in the dry season.

Agricultural supplies represent approximately 15% of total demand and, for large scale operations, are pumped from surface watercourses. Livestock and small-scale gardening generally use treated water from the supply network (Government of Grenada, 2020).

Demand varies from 45,500m^3/d (7mgd) in the wet season to 54,600m^3/d (12mgd) in the dry season. Grenada's water supply and distribution network is illustrated in Figure 9.15.

Figure 9.15: Water supply and distribution network



Source: Government of Grenada, 2008

Within the study area, NAWASA water takes are located at:

- Mt Rueil Dam, which feeds into the Mt Rueil water treatment plant; and,
- Mt Felix Spring, piped to Clozier treatment plant in the adjacent catchment to the south (Dougladston).

Annual water take volumes are reported by Jacobs as shown below.

Table 9.8: Annual water take from St Patricks and Gouyave watersheds

Catchment	gallons/year	gallons/day	gallons/ second	litres/ second
St Patricks (Levera)	72,000,000	195,519	2.3	10.3
Gouyave	24,000,000	65,173	0.8	3.4

Source: Jacobs, 2016

Production data (slightly lower than water take) provided by NAWASA for the Mt. Reuil and Clozier treatment plants is given in Table 9.9.

Table 9.9: NAWASA production data for 2019 to 2022

	Catchment	St Patricks	Dougaldston/Gouyave
	Plant	**Mt Reuil**	**Clozier/Mt. Felix**
Monthly Average (2019 – 2022) (mg)	January	5.89	1.75
	February	5.52	1.88
	March	6.08	1.42
	April	5.85	1.71
	May	6.15	1.94
	June	5.82	1.42
	July	6.04	1.33
	August	6.15	1.11
	September	5.81	1.53
	October	5.93	1.54
	November	5.60	1.45
	December	6.05	1.14
Yearly Total (mg)		70.88	18.21
Daily Average (mg/d)		0.19	0.05
Daily Average (l/s)		10.23	2.60

Note: mg = million gallons (imperial).

Source: NAWASA

NAWASA observations indicate that, whilst flow at Mt Reuil and Peggys Whim drops significantly during the dry season, production is only affected in a minor way. In contrast, production at Clozier is prone to severe fluctuations based on the precipitation levels. During dry season and droughts production drops by as much as 40%. It should be noted that Clozier is fed from two catchments: Dougaldston and Gouyave.

9.4.5.2 Commercial, agricultural and domestic water use

Information regarding agricultural and domestic water use in the project area was collected from local estate workers during the scoping site visits. This is summarised in Table 9.10.

Table 9.10: Agricultural and domestic water use

Question	Well Pad C	Well Pad F
Location of wells / springs used for private supply in each community? Who looks after these wells?	There is a spring located south west of the well pad that is used for crop irrigation and domestic consumption (see Figure 9.16). Workers reported that it eventually feeds Mt Rose water plant (it was not specified whether this is a treatment or bottling plant). [Note: Whilst there is a NAWASA reservoir at Mt. Rose, the hydrology indicates this spring would flow to Mt. Reuil WTP.]	There are no wells in the area. Water is typically extracted from the river and neighbouring spring and used by farmers living on the estate (location of abstraction point and spring were not provided).
Are there any drought periods where wells or springs run dry? If so, which months do these happen? How Often?	Most farmers have been there for more than 20 years, and have known persons who farmed for more than 50 years. None can attest personally that the springs have ever run dry. During the dry season months (January to May), water levels are somewhat low, but not low enough to affect use.	The respondent indicated that during his time at the estate (since 1974) the springs never ran dry. Even during the dry season, water levels remained high.
What are the main uses you (or others) use water from streams/rivers for? Which ones?	Water from the spring is used for both domestic uses and for plant irrigation.	Water from the river is tapped and distributed via pipelines to caretakers on the estate (approximately 5 houses). They use the water for domestic purposes. Water is also used for plant irrigation.
Are you aware of people in the area who use water for their houses instead of the main water pipes from NAWASA? If so, how many people and where?	Apart from the spring feeding into the Mount Rose Water Plant, which distributes water to the neighbouring community, the spring on the Site is used only by farmers.	When the NAWASA supply to Florida residents (closest community to the estate) is interrupted, several residents drive up to the Estate to fill buckets/barrels for their use. This happens, at most, twice / month, and more frequently during the dry season.

Source: Mott MacDonald

Figure 9.16: Spring near well pad C

Source: Mott MacDonald

9.4.5.3 Glenelg springs

The Glenelg springwater bottling plant at Mt. Reuil (Tricolar) is supplied by two springs located on the Mt. Reuil stream, some distance upstream of the NAWASA Mt. Reuil dam intake. Photographs were taken of the spring sites during a site visit by Jacobs and representatives from Glenelg on 25 September 2019 (see Figure 9.17).

At both locations, a small concrete spring box (collection tank) has been constructed at the spring source near the geological contact in the rock exposure, several metres above the foot of the ravine. The water is piped directly to the bottling facility downstream, via gravity fed pipes. At the time of the visit there were several discharges at the upstream location (Spring 1) that were not being captured and were flowing down the rock face, into the Mt. Reuil Stream. At the downstream location, the majority of the spring waters were being captured.

Glenelg reported that they control flow to the plant using valves at the capture area. If the full spring flow is not required at the bottling plant the valves are closed, causing the spring water to discharge into the watercourse.

Figure 9.17: Glenelg upper (left) and lower (right) spring collection tanks and gravity feed pipework

Source: Mott MacDonald

9.4.6 Water Quality

There are no boreholes within the AOI from which to obtain groundwater samples. Surface water chemical data provided by NAWASA for water supply intakes downstream of the two sites, for the period 2018 to 2023, are supplemented by site specific survey data collected during July 2019 and March 2023. The data are provided in Appendix A and summarised below.

The results were compared against national drinking water compliance and indicator values (Water Quality Act 2015, Schedule 1) and regional / international standards for ambient water quality[7] (see Chapter 4 of the draft ESIA for further details) :

- DENR guideline values for
  – recreational water use (Class B);
  – water used for fishery, agriculture, irrigation and livestock (Class C); and
- T&T WPR 2019 limits for
  – recreational water use, and
  – the protection of aquatic life.

No guidelines limits were available for salinity, conductivity, residual chlorine, total dissolved solids, total organic carbon, calcium, magnesium, potassium, sodium, bicarbonates, reactive silica, total petroleum hydrocarbons, nitrite, sulphide, Antimony, Aluminium, Lithium, Molybdenum, Strontium, most PAHs, hardness, chloroform, bromo-dichloromethane, dibromo-dichloromethane, bromoform and total trihalomethanes, bromide or total coliform.

9.4.6.1 Site C surface water quality

Raw (untreated) water data for the Mt. Reuil intake on the Mt. Reuil Stream, located 1.4km downstream and to the east of Site C, are given in Table A.1. All parameters are within Grenada drinking water standards. Minor exceedances of comparison standards for ammonia (2022/23) and phosphate (all years) are noted.

The 2019 survey sampled Mt Reuil Stream downstream of the proposed well pad site (at location 2019-01, Table 9.4) and upstream of the intake for the Mt. Reuil water treatment plant (at location 2019-02, Table 9.4). The following substances were detected at concentrations greater than the relevant comparison values.

- Arsenic and total / faecal coliforms were present in excess of all comparison values, at both monitoring locations; and,
- at location 2019-01, cadmium, lead, selenium and nickel were present in excess of all comparison values and chromium exceeded DENR standards.

Anecdotal information from estate workers encountered during the scoping site visits indicates that there has never been any quality issue with the spring water they use for agricultural and domestic purposes. Neither are they aware of any historical chemical spills or contamination. The surveyor did observe evidence that agrochemicals (Gramaxone weedicide) have been used at Site C.

Further samples were collected in 2023. All monitoring locations were visually free of garbage, noticeable oil sheens, odours, turbidity and stress to surrounding flora and fauna.

The following exceedances of the guideline limits were noted:

- Total Arsenic concentrations at all six monitoring locations were above the DENR limits for recreational water, as well as for water used for fishery, agriculture, irrigation and livestock.

[7] The following guidelines have been selected, due to their similar climates to the study area:

- Trinidad and Tobago (T&T) Water Pollution Rules, 2019;
- Department of Environment and Natural Resources (DENR) of the Philippines - Water Quality Guidelines (WQG) and General Effluent Standards (GES) of 2016, updated in 2021 (DENR Administrative Order No. 2021-19).

Arsenic concentrations at locations 2023-01, -02, -05 and -06 were also above the WPR 2019 guideline for protection of aquatic life.

- Boron at locations 2023-01,-02 and -05 exceeded the DENR guideline for recreational water (0.5 mg/L). In addition, the concentration at locations -02 and -05 also exceeded the guideline limit of 0.75 mg/L for fishery, agriculture, irrigation and livestock water use.
- Ammonia concentrations at the six monitoring locations exceeded the DENR guidelines limit for recreation, and both the DENR and WPR 2019 limits for fishery, agriculture, irrigation and livestock.
- Alkalinity concentrations at all six monitoring locations were above the WPR 2019 guideline limits for recreation and for the protection of aquatic life.
- Faecal coliform concentrations at all six locations exceeded DENR and WPR 2019 guidelines, as well as Grenada drinking water standards.

9.4.6.2 Site F surface water quality

Raw (untreated) water data for the Mt. Felix Spring intake, located 0.9km to the south-west of Site F, are given in Table A.2. All parameters are within Grenada drinking water standards and comparison standards.

The 2019 survey sampled Mt Felix Stream downstream of the proposed well pad location (2019-03) and downstream of the Mt. Felix Spring intake (2019-04). Arsenic and total / faecal coliforms were present in excess of the national standards, at both monitoring locations.

9.4.7 Flood risk

Significant flooding of varying intensities occurs often in Grenada. Flooding is normally localised and tends to have the greatest impact in the low-lying coastal areas, as this is where most people live. However, flash flooding caused by high intensity rainfall events can occur at any elevation, and many of the upland valleys are populated or are important transport routes. The parishes of St John, St. Mark, St. George, and St. Patrick are particularly vulnerable to significant flood events, due to steep slopes and narrow valleys in the upstream river basins. The Mt St Catherine reserve area is particularly vulnerable to flash flooding due to low permeability clay soils, steep slopes and narrow valleys[8]. As a result, river water levels can rise rapidly, for example from 0.5m to over 4m within 2 hours.

Flash flooding can be exacerbated by human activity such as:

- blocking of drainage channels and pathways caused by accumulation of litter and other human-generated debris;
- creation of diversion channels with insufficient capacity or natural flow paths;
- under-sizing of culverts and road crossings; or,
- construction within the floodplain (which reduces natural flood storage).

The Grenada National Flood Hazard Map[9] identifies four flood hazard zones, indicating areas at risk from at least 0.1m depth flooding due to rainfall events with return periods of 5, 10, 20 and 50 years. Flood hazard zones are illustrated for the St. Patrick's watershed in Figure 9.3 and

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[8] Aucoin , S., 2018. Mount Saint Catherine Forest Reserve Environmental Baseline Assessment. Available at: https://www.researchgate.net/publication/327060097_Mount_St_Catherine_Forest_Reserve_Environmental_Baseline_Assessment

[9] Caribbean Handbook on Risk Information Management, 2016. *Grenada National Flood Hazard Map*. Available at: https://www.cdema.org/virtuallibrary/index.php/charim-hbook/country-data/countrydocs-gnd/maps-gnd . [Accessed on 18 May 2023].

Gouyave watershed in Figure 9.7. Colour coding is darkest for the highest risk areas (1 in 5 years - zone 4) and light for lowest risk areas (1 in 50 years – zone 1).

It should be noted that in the upper reaches of catchments, the model used to produce the flood hazard zones tends over-estimate the potential hazard. In these areas, the extent of flooding suggested by the flood hazard zones may not actually be observed. The map should, therefore, be treated as tool to guide development rather than a definitive predictor of flooding.

Downstream of the Site C well pad, parts of Mt. Rich, Elie Hall, and communities situated adjacent to the St. Patrick's River (where it follows the road to Sauteurs) are at risk of flooding. Locally to Site C, the pumping station at Mt. Reuil would be situated adjacent to the Mt Reuil stream, within flood hazard zone 4. Immediately adjacent to this area is flood hazard zone 2 (1 in 20 years return period) which encroaches on the Glenelg bottling plant and neighbouring properties (see Figure A.3). Anecdotal information from a local resident indicates that the most recent flooding of this general area occurred around 25 years ago.

Downstream of Site F well pad, the greatest risk of flooding in the catchment is at the downstream end of the river in Gouyave, which is densely populated. Higher risk areas upstream are largely unpopulated. The Site F pumping station at Rosemont would be situated adjacent to the Mt. Felix stream but outside of the flood hazard zones (see Figure A.4).

9.4.8 Climate vulnerability

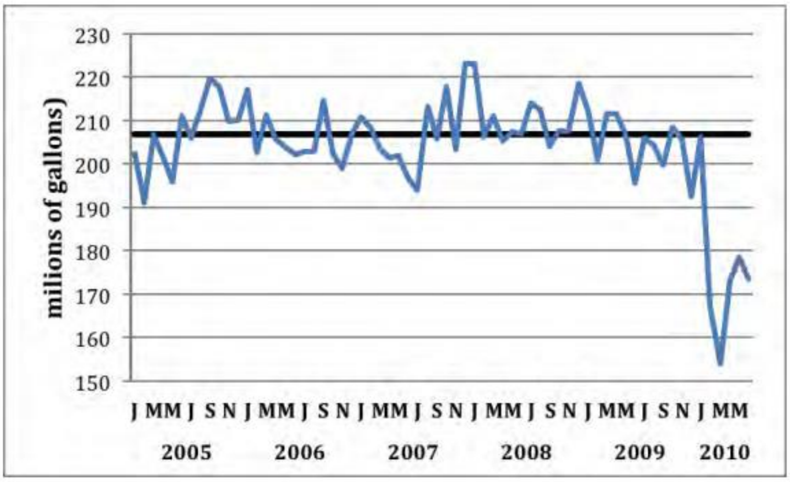
In Grenada, the projected impacts of climate change comprise temperature increases, precipitation changes, sea level rise, ocean acidification, and an increase in frequency and intensity of extreme climatic events. Climate models have predicted Grenada will experience a warming and drying trend in the future, and more frequent heat waves, droughts, and rainfall events with increased intensity. The mean rainfall over Grenada is projected to decrease, with median changes for all seasons to decrease by 13% to 21%.[10].

Grenada has experienced ten periods of drought since 1900. The most recent severe drought occurred in 2009 when the lowest annual rainfall total in 24 years was recorded. This had the effect of reducing water production (supply) by NAWASA by 65%[11] (see Figure 9.18).

[10] Department of Economic and Social Affairs, 2012. *Climate Change Adaptation Grenada: Water Resources, Coastal Ecosystems, and Renewable Energy*. [pdf]. United States: United Nations Development Account. Available at: <https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=635&menu=1515> [Accessed 23 April 2019].

[11] Department of Economic and Social Affairs, 2012. Climate Change Adaptation Grenada: Water Resources, Coastal Ecosystems, and Renewable Energy

Figure 9.18: Effect of the 2009 drought on monthly water production



Source: Department of Economic and Social Affairs, 2012. Climate Change Adaptation Grenada: Water Resources, Coastal Ecosystems, and Renewable Energy (after Peters, 2012)

9.5 Assessment of impacts

This section presents an assessment of the potential beneficial and adverse effects on water resources that may occur as a result of the exploratory drilling phase of the Project. Impacts have been considered and assessed for site preparation (including access road construction and well pad set up), exploratory drilling works and, where relevant, decommissioning.

The assessment of potential impacts takes into account mitigations and enhancements that have been included as part of the scheme design (known as embedded mitigation). Additional measures that are needed to ensure that impacts are limited to an acceptable level (known as secondary mitigation) are excluded from this assessment. The final impacts of the Project, after implementation of secondary mitigation, are assessed in Section 9.8 (Residual impacts).

Both embedded and secondary mitigation measures are described in section 9.6 and the Project Environmental and Social Management Plan (ESMP). The secondary mitigation measures relevant to each impact are identified in this section 9.5 using a reference number, to aid cross-referencing.

9.5.1 Identification of receptors and analysis of sensitivity

Project activities during construction, operation and decommissioning are summarised in Table 9.11 and described in detail in Chapter 2: Project Description.

Table 9.11: Project activities summary

Site establishment (Construction Phase)	Exploratory drilling (Operations Phase)	Site closure (Decommissioning Phase)
Upgrade of access roads and widening of main roads Site clearance Construction of well pads including water and mud sump Construction of water intake and pump stations Construction of temporary water pipeline to supply well pads Temporary materials storage yard Establishment of site camp (if required) Transportation of drilling rig and associated equipment	Exploratory drilling works Pumping of water / drilling muds Drilling rig and ancillary equipment maintenance Geological sampling and analysis Well testing	Removal of drilling equipment and restoration of temporary work sites, including the pumping station

Source: Mott MacDonald

Activities with the potential to impact on the water environment include:

- site stripping and disturbance of the ground during well pad and road construction, which will expose the soil to water and wind erosion;
- construction and drilling will require the use of potentially polluting substances that are typically found on construction sites (e.g. cement, road paint, fuel (diesel) and lubricants);
- abstraction of a significant volume of surface water during drilling and well testing;
- well construction and testing will disturb the groundwater environment;
- storage and separation of drilling mud and cuttings, which are typically not hazardous but may have high pH and contain polymer additives; and,
- well testing, which will bring geothermal brine to the surface (prior to reinjection), which may contain elevated concentrations of naturally-occurring metals such as arsenic, boron, and molybdenum[12].

There is potential for direct effects on:

- surface water and groundwater quality, should any pollutants or silt be accidentally released;
- surface water flow, which will be reduced in the watercourse below the location where water is to be abstracted for drilling;
- surface water drainage pathways and runoff rates, which may be altered by construction of the project infrastructure; and,
- groundwater level and flow direction, which may be affected by changes in the sub-surface hydrogeological environment during well drilling and testing.

These may have indirect effects on receptors such as:

- Public water supply sources;
- Private, agricultural and commercial water supply sources;
- Water amenity sites/recreation/beauty spots;
- Flood risk; and,

[12] Environmental Guidance, Renewable Energy – Geothermal Projects. Overseas Private Investment Corporation, 2012.

- Aquatic ecology (assessed in Chapter 8 – Biodiversity).

Effects resulting from freshwater supply to, and wastewater discharge from, workers accommodation have been scoped out of the water resources assessment because workers will be housed in existing rented accommodation, located in nearby communities.

Table 9.12 shows the identified water related receptors and an analysis of their sensitivity. To reduce repetition, similar receptors at the two sites are analysed together, with receptor references given in brackets to denote the relevant site.

Table 9.12: Water receptors and sensitivity

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1)	Both sites are located within the upper surface water catchment areas of small streams, originating high in the St Patricks (C1) and Gouyave (F1) watersheds.	The streams are of good quality and are used informally by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity (see Chapter 8 Biodiversity). Key dependent receptors are identified and assessed individually.	High
Groundwater in the vicinity of Site C (C2) and Site F (F2)	Site C is underlain by Mt St Catherine Volcanics. Site F is underlain with undifferentiated / reworked volcanic deposits. Springs are present locally in both areas.	Groundwater is not thought to be used directly by local people and there are no known wells in the area. However, shallow groundwater may be important for certain agricultural sites and there are several freshwater springs in the project area, used for irrigation, public water supply or commercial purposes. Key dependent receptors are identified and assessed individually.	Medium
Public water supply intakes at Mt. Reuil Dam (C4) and Mt Felix Spring (F4)	Water intakes comprise a low dam or collection tank and gravity fed pipe to the water treatment plant (WTP). Mt. Reuil Dam supplies surface water to Mt. Reuil WTP. Mt. Felix Spring supplies groundwater to Clozier WTP.	Any reduction in the quantity or quality of water flowing to the treatment plants has the potential to interrupt supplies to NAWASA customers.	High
Glenelg springs (C5)	Groundwater is captured where it emerges from the rock face and piped directly to the Glenelg bottling plant. Excess water discharges into the Mt. Reuil stream. The recharge / source area for the springs is not well understood but may include the Site C wellpad.	This is the sole source of potable water for a commercial spring water producer, supplying the whole of Grenada. A change in the quantity or quality of the spring flow could affect the product directly or disrupt operations, and the perceived risk to water quality in the mind of Glenelg's customers could impact negatively on this business. The springs also flow into Mt. Reuil Stream but provide a minor contribution to the overall flow.	High
Flood risk in St. Patrick (C6) and Gouyave (F5) watersheds	Flooding occurs in low lying coastal areas and some of the steep-sided upland valleys, after heavy rainfall. Communities may be impacted due to inundation of roads and buildings, or damage to infrastructure.	Any increase in site runoff or alterations to the local drainage pathways has the potential to increase flood risk to susceptible communities. Most buildings and roads in the project area are situated outside of the flood hazard zones and the flood hazard zones themselves are unlikely to be sensitive to the type of small changes in the catchment drainage regime that may result from the project.	Medium
Flood risk to local developments at Mt. Reuil (C7)	Parts of the Glenelg bottling plant and buildings immediately to the east are located partially within flood hazard zones 2 and 4 (land at risk from at least 0.1m depth flooding due to rainfall events with return periods	The flood hazard zones are based on modelling, which is known to overestimate the potential for flooding in the upland areas. These developments may therefore be at lower risk than the zones suggest	High

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
	of 1 in 5 years (20% annual probability) and 1 in 20 years (5% annual probability). The Site C pumping station will be constructed between the bottling plant and the river, within flood hazard zone 4.	but, may also have limited capacity to withstand any increase in the level of flood risk to which they are exposed. The operational platform of the pumping station would be constructed approximately 1m above the local ground level, at a similar level to the bottling plant, and would be protected from erosion during flood events by a gabion flood wall to the south and east. Equipment or materials used at the pumping station may be disturbed during a severe flood event.	

Source: Mott MacDonald

9.5.2 Summary of changes, impacts and receptors

Table 9.13 shows the changes that may result from project activities, and the impacts these would have on the identified receptors.

Table 9.13: Changes, receptors and potential impacts

Potential change	Project phase	Key issues and potential impacts	Receptors which may be affected by the change
Reduced surface water flow and level	Construction Decommissioning	Some water may be required during construction but the volumes are unlikely to be large. Water supplies will not be affected as the proposed intakes are located downstream of all known abstraction points (NAWASA, estate supplies and Glenelg spring).	Direct: Surface water (C1+F1)
	Operation	Large volumes of water are required during drilling and testing of the boreholes, which will be abstracted from a local watercourse (approx. 10.5 l/s). Water supplies will not be affected as the proposed intakes are located downstream of all known abstraction points (NAWASA, estate supplies and Glenelg springs). Whilst the proposed water intakes are located on streams that are relatively unaffected by drought, a constant supply of water to the drill pad will be required, which will reduce the water available locally to support aquatic ecology and informal amenity use.	As above
Reduced surface water quality	Construction Decommissioning	There is potential for pollution of surface watercourses from fuel or chemical spillages (if poorly managed) and sediment generated during site clearance and construction, particularly if heavy rainfall occurs.	Direct: Surface water (C1+F1) Indirect: Public water supply intake at Mt. Reuil Dam (C4)
	Operation	There is potential for pollution of surface watercourses from fuel or chemical spillages, or escaped drilling fluid, if poorly managed. Should there be an equipment failure or blowout during testing, geothermal brine could be released.	As above

Potential change	Project phase	Key issues and potential impacts	Receptors which may be affected by the change
Reduced groundwater quality	Construction Decommissioning	There is potential for any fuel or chemical spillages (if poorly managed) to migrate through the soil zone and pollute shallow groundwater (if present), which may then enter surface watercourses via springs.	Direct: Groundwater (C2+F2) Indirect: Surface water (C1+F1), Public water supply intakes (C4+F4), Glenelg springs (C5)
	Operation	There is potential for any spillages of fuel, chemicals or drilling / testing fluids (if poorly managed) to migrate through the soil zone and pollute shallow groundwater (if present), which may then enter surface watercourses via springs. Pollution of deeper groundwater may occur due to potential release of contaminants, drilling fluids or geothermal fluids during drilling.	As above
Effects on groundwater level and spring discharge	Operation	There is potential for groundwater level and spring discharge rates to be affected during drilling and testing, if existing shallow groundwater flow pathways are disrupted (as a result of grout placement or pressure changes within the aquifer, for example). Such effects could be temporary or long term but are difficult to predict, given the complexity of the shallow geology and limited geological information that is available.	Direct: Groundwater (C2+F2) Indirect: Public water supply intakes (F4), Glenelg springs (C5)
Effects on surface water drainage	Construction Decommissioning	Site clearance at the well pads will increase surface runoff during construction. However, the area affected is a small portion of the whole catchment area and, with the correct drainage in place, the downstream effects on flood and erosion risk will be minimal. Any realignment of minor watercourses would be inconsequential, as these drainage channels only flow intermittently, following rainfall.	Direct: Surface Water (C11+F1) Indirect: Watershed flood risk (C6+F5)
	Operation	The well pads will be surfaced with material that allows precipitation to infiltrate, and drainage will be designed to ensure there is no significant change in site runoff characteristics. Drilling fluids will be contained in lined ponds that are bunded to prevent runoff entering during heavy rains. Road improvement works have the potential to reduce flood risk; if the existing road drainage is undersized, it may be contributing to upstream flood risk. However, increasing conveyance capacity could increase downstream flood risk and, therefore, the effects on flood risk will need to be considered during road drainage design.	As above
Floodwater displacement at Mt. Reuil	Construction Operation Decommissioning	Construction of the Site C pumping station within the floodplain, adjacent to the Mt. Reuil stream, would temporarily increase flood risk in the immediate vicinity, until it is removed during site closure. The land available for flood storage would be reduced due to the presence of the pumping station platform and the effect on floodwater conveyance could force floodwater further north than it would otherwise travel, towards the Glenelg bottling plant and neighbouring commercial vegetable wholesaler. The pumping station itself will also be at risk of flooding. Any increase in flood risk could result in damage to, or the mobilisation of materials, equipment or pollutants from, any of these receptors during a flood event.	Direct: Local flood risk at Mt. Reuil (C7)

Source: Mott MacDonald

9.5.3 Analysis of construction impacts

This section details construction phase impacts, which are assessed in accordance with the methodology described in section 9.3. The assessment accounts for the embedded mitigation described in section 9.6.1 and signposts to the necessary secondary mitigation measures for each impact, which are set out in section 9.6.2. Impacts assessed as 'significant' prior to mitigation are highlighted with a grey background in the following tables.

Where some aspects of the assessment are uncertain (e.g. due to a lack of data or, the potential for a natural hazard such as flooding to occur during the project), a conservative but balanced approach has been adopted, which considers the effects of a realistic, worst-case, pre-mitigation impact. This has enabled all significant impacts to be identified and mitigated appropriately.

9.5.3.1 Reduced surface water flow and level

The magnitude of the reduced surface water flow and level is considered moderate because project water demand during construction will be low and surface water abstractions for the project will be situated downstream of known water supply intakes. However, it is possible that without appropriate controls, downstream users and aquatic ecology could be adversely impacted if abstraction occurs during the dry season. The reduced surface water flow and level may occur through the construction phase, so the duration is considered short term (0-5 years). The reduced surface water flow and level could occur downstream of the pumping station intakes, so the scale is considered local. The probability of reduced surface water flow and level occurring is considered medium because overall water demand during site establishment will be low, but some water may be required during the dry season.

Table 9.14: Analysis of reduced surface water flow and level on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Surface water in the Mount Reuil stream (C1) Mount Felix stream (F1)	The sensitivity of surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1) is considered high because the streams are of good quality and are used by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	W1, W6

Source: Mott MacDonald

9.5.3.2 Reduced surface water quality

Construction activities could result in the accidental release of water pollutants or sediment (particularly during site clearance) to the surface water, via rainfall runoff or shallow groundwater pathways. The magnitude of the impact would be dependent on the quantity and nature of the pollutant. Potentially polluting substances will be similar to those typically used on construction sites throughout Grenada (i.e. diesel fuel, lubricants, solvents, road paint, cement, etc). It is unlikely that there would be an irreversible effect on water quality as a result of any release, therefore at worst, the magnitude of any impact is expected to be moderate. If a release occurs, surface water quality may be temporarily affected for a limited period during the construction phase, so the duration is considered short term (0-5 years). The reduced surface water quality will happen close to the drilling sites, pumping stations and road improvement works and the impact will be reduced by dilution with increasing distance from the source of pollution, so the scale of effects on the natural environment is considered local. Effects on water supply sources are assessed to be regional. The probability of reduced surface water quality occurring is considered medium because environmental management procedures will need to be specified as mitigation, to ensure that suitable working practices are rigorously applied, as set out in the ESMP.

Table 9.15: Analysis of reduced surface water quality on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Surface water (C1+F1)	The sensitivity of surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1) is considered high because the streams are of good quality and are used by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	W4, W6
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	The sensitivity of public water supply intake at Mt. Reuil Dam (C4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	W4, W6

Source: Mott MacDonald

9.5.3.3 Reduced groundwater quality

Construction activities could result in the accidental release of water pollutants, which may enter shallow groundwater via infiltration through the soil. Both sites are underlain by soils with good drainage that will provide only limited attenuation of pollutants before they reach the water table.

The magnitude of this impact would be dependent on the quantity and nature of the pollutant and, the distance of a receptor from the source of contamination and the direction of groundwater flow. Potentially polluting substances will be similar to those typically used on construction sites throughout Grenada (i.e. diesel fuel, lubricants, solvents, road paint, cement, etc). It is unlikely that these would cause any irreversible effects on water quality so, at worst, the magnitude of any impact on groundwater quality in the immediate vicinity of the works could be moderate. At Glenelg Springs, the magnitude could be moderate because the Site C wellpad is located 0.8 km to the west, and directly upgradient of the nearest spring, on the groundwater flow path. At Mt. Felix Spring, the magnitude could be minor because the Site F wellpad is located 0.9km to the north-east, at an oblique angle to the probable north-westerly direction of groundwater flow.

The reduced groundwater quality may occur for limited periods during the construction phase or for a longer duration, in the event that a large quantity of a major pollutant is released, so the worst case duration is considered medium term (5-15 years). The reduced groundwater quality could occur close to the drilling sites, pumping stations and road improvement works and the impact would be reduced by dilution with increasing distance from the source of pollution, so the scale of impact on the natural environment is considered local. Effects on water supply sources could have wider reaching consequences, therefore the scale is assessed to be regional for the two public water supply intakes and national for the Glenelg springs source. The probability of reduced groundwater quality occurring is considered medium because, whilst the project will not intentionally discharge any pollutants to groundwater, environmental management procedures are required to ensure that suitable working practices are rigorously applied by the contractor.

Table 9.16: Analysis of reduced groundwater quality on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Groundwater in the vicinity of Site C (C2) and Site F (F2)	The sensitivity of groundwater in the vicinity of Site C (C2) and Site F (F2) is considered medium because groundwater is not thought to be used directly by local people and there are no known wells in the area. However, shallow groundwater may be important for certain agricultural sites and there are several freshwater springs in the project area, used for irrigation, public water supply or commercial purposes. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	W3, W4, W6, W8, W10
Indirect: Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1)	The sensitivity of surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1) is considered high because the streams are of good quality and are used by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream	Nature: negative Magnitude: moderate	W3, W4, W6, W8, W10

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
	supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Duration: medium term (5-15 years) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	The sensitivity of public water supply intake at Mt. Reuil Dam (C4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to a significant number of NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: moderate	W3, W4, W6, W8, W10
Indirect: Public water supply intake at Mt. Felix Spring (F4)	The sensitivity of public water supply intake at Mt Felix Spring (F4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	W3, W4, W6, W8
Indirect: Glenelg springs (C5)	The sensitivity of Glenelg springs (C5) is considered high because this is the sole source of potable water for a commercial spring water producer that supplies a national market. A change in the quantity or quality of the spring flow could affect the product directly or disrupt operations, and the perceived risk to water quality in the mind of Glenelg's customers could also impact negatively on this business. The springs also flow into Mt. Reuil Stream but provide a minor contribution to the overall flow. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: national Probability: medium Sensitivity of receptor: high Significance of impact: moderate	W3, W4, W6

Source: Mott MacDonald

9.5.3.4 Effects on surface water drainage

The magnitude of the effects on surface water drainage is considered moderate because the area affected is a small portion of the whole catchment area but flood and erosion risk could be increased locally. The effects on surface water drainage will occur during construction, so the duration is considered short term (0-5 years). The effects on surface water drainage will happen downstream of the drilling sites and road improvement works. The effect will decrease with distance from the work sites, as the runoff contribution from the wider catchment area increases, so the scale is considered local. The probability of effects on surface water drainage occurring is considered medium because the works may coincide with the rainy season, when high intensity rainfall flash flooding can occur.

Table 9.17: Analysis of effects on surface water drainage on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Indirect: Flood risk in St. Patrick (C6) and Gouyave (F5) watersheds	The sensitivity of flood risk in St. Patrick (C6) and Gouyave (F5) watersheds is considered medium because any increase in site runoff or alterations to the local drainage pathways has the potential to increase flood risk to susceptible communities. Most buildings and roads in the project area are situated outside of the flood hazard zones and the flood hazard zones themselves are unlikely to be sensitive to the type of small changes in the catchment drainage regime that may result from the project. However, any change in the risk of flooding could have a significant impact on the communities that are affected. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	W2

Source: Mott MacDonald

9.5.3.5 Floodwater displacement at Mt. Reuil

The magnitude of the floodwater displacement at Mt. Reuil is considered minor because flood risk to the local area would be slightly increased, due to construction of the pumping station platform within the floodplain. Out of bank flood flows may be obstructed by stockpiled materials, and debris or pollutants could be mobilised from the construction site, if flooding occurs during the works. Local receptors are situated on the margins of flood zone 2, so it is unlikely that they would be affected except during high magnitude (1 in 20 year or greater) flood events. The floodwater displacement at Mt. Reuil may occur during construction, so the duration is considered short term (0-5 years). The floodwater displacement at Mt. Reuil could occur in close proximity to the pump station, with any effects on flood risk likely to be felt in the immediate area, so the scale is considered local. The probability of floodwater displacement at Mt. Reuil occurring is considered high because although flood events are infrequent, should flooding occur, the construction site is likely to have an effect on out of bank flows, due to its position adjacent to the watercourse and within the floodplain.

Table 9.18: Analysis of floodwater displacement at Mt. Reuil on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Flood risk to local developments at Mt. Reuil (C7)	The sensitivity of flood risk to local developments at Mt. Reuil (C7) is considered high because these developments may have limited capacity to withstand any increase in the level of flood risk to which they are exposed. Equipment or materials used during construction of the pumping station may be disturbed during a severe flood event. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: high Sensitivity of receptor: high Significance of impact: minor	W2

Source: Mott MacDonald

9.5.4 Analysis of operation phase impacts (drilling and testing)

This section details pre-mitigation operation phase impacts, which are assessed in accordance with the methodology described in section 9.3. The assessment accounts for the embedded mitigation described in section 9.6.1 and signposts to the necessary the secondary mitigation measures for each impact, which are set out in section 9.6.2.

Where some aspects of the assessment are uncertain (e.g. due to a lack of data or, the potential for a natural hazard such as flooding to occur during the project), a conservative but balanced approach has been adopted, which considers the effects of a realistic, worst-case, pre-mitigation impact. This has enabled all potentially significant impacts to be identified and mitigated appropriately.

9.5.4.1 Reduced surface water flow and level

The magnitude of the reduced surface water flow and level is considered moderate because whilst project water demand during drilling and testing will be high, surface water abstractions for the project will be situated downstream of known water supply intakes and the effects will be short-lived (over 2-3 months), after which the watercourse will recover fully. The reduced surface water flow and level would occur for approximately 75 days during drilling and testing, so the duration is considered short term (0-5 years). The reduced surface water flow and level would occur downstream of the project water intakes. This effect will decrease downstream as the proportion of flow derived from the lower catchment increases, so the scale is considered local. The probability of reduced surface water flow and level occurring is considered certain because water abstraction is required for the project to go ahead.

Table 9.19: Analysis of reduced surface water flow and level on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Surface water in the Mount Reuil stream (C1) Mount Felix stream (F1)	The sensitivity of surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1) is considered high because the streams are of good quality and are used by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	W1, W6

Source: Mott MacDonald

9.5.4.1 Reduced surface water quality

Potential contaminants including oils and solvents (from ancillary plant such as generators), geothermal brine (from pressure testing of the well), drilling mud (bentonite clay slurry) and cement will be used during the operational phase. Drilling mud and geothermal brine will be contained in specially constructed sumps that are protected from flooding during heavy rains, and all materials will be handled and stored in accordance with best practice. Even so, an unexpected event could result in the accidental release of these substances to surface water directly, or via shallow groundwater pathways.

The magnitude of the impact would be dependent on the quantity and nature of the pollutant released. It is unlikely that there would be an irreversible deterioration in water quality as a result of any release, therefore at worst, the magnitude of any impact is expected to be moderate. Surface water quality may be temporarily affected during the operational phase, so the duration is considered short term (0-5 years). The reduced surface water quality could occur close to the drilling sites and road improvement works, and the impact will be reduced by dilution with increasing distance from the source of pollution, so the scale of effects on the natural environment is considered local. Effects on water supply sources are assessed to be regional. The probability of reduced surface water quality occurring is considered low because the scheme will not intentionally discharge any pollutants to the water environment and has been designed to minimise the potential for unintended releases.

Table 9.20: Analysis of reduced surface water quality on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1)	The sensitivity of surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1) is considered high because the streams are of good quality and are used by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	W3, W4, W6
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	The sensitivity of public water supply intake at Mt. Reuil Dam (C4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	W3, W4, W6

Source: Mott MacDonald

9.5.4.2 Reduced groundwater quality

Contaminants including oils and solvents (from ancillary plant such as generators), geothermal brine (from pressure testing of the well), drilling mud (bentonite clay slurry) and cement, could be unintentionally released at the surface during the operational phase, with the potential for pollutants to infiltrate though the soil and into shallow groundwater. Both sites are underlain by soils with good drainage that will provide only limited attenuation of pollutants before they reach the water table.

During drilling, steel casing is cemented into place to line the well as the drilling is progressed, which will physically isolate the well from any groundwater that may be present in the near-surface strata. Therefore, the completed well itself would not provide a pathway to shallow groundwater. However, there is a small risk to shallow groundwater whilst drilling through the shallow, permeable volcanic material.

The magnitude of any impact on groundwater quality would be dependent on the quantity and nature of the pollutant, the distance of a receptor from the source and, the direction of groundwater flow. At both sites, it is unlikely that irreversible effects on water quality could occur as a result of any release, therefore the magnitude of effects on groundwater quality in the immediate vicinity of the wellpad could be moderate, at worst. At Glenelg Springs, the magnitude could be moderate because the Site C wellpad is located directly upgradient of the nearest spring (0.8 km to the west), on the groundwater flow path. At Mt. Felix Spring, the magnitude could be minor because the Site F wellpad is located at an oblique angle to the probable north-westerly direction of groundwater flow (0.9km to the north-east), so is not likely to be on the groundwater flow pathway.

The reduced groundwater quality may occur for limited periods during the operational (exploration drilling and testing) phase, or for a longer duration in the event that a large quantity of a major pollutant is released, so the worst case duration is considered medium term (5-15 years). The reduced groundwater quality could occur close to the drilling sites and the impact would be reduced by dilution with increasing distance from the source of pollution, so the scale of impact on the natural environment is considered local. Effects on water supply sources could have wider reaching consequences, therefore the scale is assessed to be regional for the two public water supply intakes and national for the Glenelg springs source.

The probability of reduced groundwater quality occurring is considered medium because, whilst the project will not intentionally discharge any pollutants to groundwater; and, the wells will be designed and constructed in a manner that limits the potential for unintended releases directly to groundwater, environmental management procedures are required to ensure that suitable working practices are rigorously applied by the contractor.

Table 9.21: Analysis of reduced groundwater quality on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Groundwater in the vicinity of Site C (C2) and Site F (F2)	The sensitivity of groundwater in the vicinity of Site C (C2) and Site F (F2) is considered low because groundwater is not thought to be used by local people and there are no known wells in the area. Shallow groundwater may be important for certain agricultural sites and there are several freshwater springs in the project area, used for public water supply or commercial purposes. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	W3, W4, W6, W10

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Indirect: Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1)	The sensitivity of surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1) is considered high because the streams are of good quality and are used by local people for a range of purposes, including fishing and bathing. The Mt Reuil stream supports a public water supply abstraction. Aquatic habitats are assessed as medium sensitivity and support species ranging from low to high sensitivity. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: local Probability: medium Sensitivity of receptor: high Significance of impact: minor	W3, W4, W6, W10
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	The sensitivity of public water supply intake at Mt. Reuil Dam (C4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: moderate	W3, W4, W6, W10
Indirect: Public water supply intake at Mt. Felix Spring (F4)	The sensitivity of public water supply intake at Mt Felix Spring (F4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor	W3, W4, W6

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Indirect: Glenelg springs (C5)	The sensitivity of Glenelg springs (C5) is considered high because this is the sole source of potable water for a commercial beverage operation, so a change in the quantity or quality of the spring flow could have a critical impact on this business. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: negative Magnitude: moderate Duration: medium term (5-15 years) Scale: national Probability: medium Sensitivity of receptor: high Significance of impact: moderate	W3, W4, W6, W10

Source: Mott MacDonald

9.5.4.3 Effects on groundwater level and spring discharge

The wells will be constructed using well established techniques that will seal them off from any aquifer units that may be situated above the geothermal source which is estimated to be located at approximately 1,500m below ground level. The springs identified in the baseline survey are all situated at significantly higher elevations, only 200-300m below ground level at the well pads, so are very unlikely to be hydraulically connected to the testing horizons. The probability and magnitude of effects due to well testing are therefore considered negligible.

The probability of the effects on groundwater level and spring discharge due to drilling and well construction is considered medium because the ground conditions and shallow hydrogeological regime are uncertain and, whilst the works will be completed using industry standard techniques, in accordance with an internationally recognised code of practice, it is feasible that drilling mud or cement could be lost below ground, if a highly permeable unit is encountered.

An unlikely consequence of this could be the alteration of groundwater flow pathways and spring discharge rates. Should this happen, the total amount of water discharging from springs in the area would not change but it is possible that the point of emergence could change, i.e. the flow rate at one spring could increase whilst another is reduced, or a new spring may emerge at a different location. The magnitude of this impact would be dependent primarily on the distance of a receptor from the wellpad and the direction of groundwater flow. At both sites, the magnitude of effects on groundwater level and spring discharge in the immediate vicinity of the wellpad could be major. At Glenelg Springs, the magnitude could be moderate because the Site C wellpad is located 0.8 km to the west, and directly upgradient of the nearest spring, on the groundwater flow path. At Mt. Felix Spring, the magnitude could be minor because the Site F wellpad is located 0.9km to the north-east, at an oblique angle to the probable north-westerly direction of groundwater flow.

The effects on groundwater level and spring discharge could occur during well construction (operational phase). Should groundwater flow pathways be altered, the effects could be short-lived or permanent, so the duration is considered long term (+16 years). The effects on groundwater level and spring discharge will happen in the immediate vicinity of the well pads and at nearby springs, if they are fed by the affected aquifer, so the scale of effects on the natural environment is considered local. Effects on water supply sources could have wider reaching consequences, therefore the scale is assessed to be regional for the two public water supply sources and national for the Glenelg springs source.

Table 9.22: Analysis of effects on groundwater level and spring discharge on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Direct: Groundwater in the vicinity of Site C (C2)	The sensitivity of groundwater in the vicinity of Site C (C2) is considered medium because groundwater is not thought to be used directly by local people and there are no known wells in the area. However, shallow groundwater may be important for certain agricultural sites and there are several freshwater springs in the project area, used for irrigation, public water supply or commercial purposes. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: major Duration: long term (+16 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	W6, W9, W10
Direct: Groundwater in the vicinity of Site F (F2)	The sensitivity of groundwater in the vicinity of Site F (F2) is considered medium because groundwater is not thought to be used directly by local people and there are no known wells in the area. However, shallow groundwater may be important for certain agricultural sites and there are several freshwater springs in the project area, used for irrigation, public water supply or commercial purposes. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: major Duration: long term (+16 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	W6, W9
Indirect: Public water supply intake at Mt. Felix Spring (F4)	The sensitivity of public water supply intake at Mt Felix Spring (F4) is considered high because any reduction in the quantity or quality of water supplied to the treatment works has the potential to interrupt supplies to NAWASA customers. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: negative Magnitude: minor Duration: long term (+16 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: moderate	W6, W9

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Indirect: Glenelg springs (C5)	The sensitivity of Glenelg springs (C5) is considered high because this is the sole source of potable water for a commercial spring water producer, supplying the whole of Grenada. A change in the quantity or quality of the spring flow could affect the product directly or disrupt operations, and the perceived risk to water quality in the mind of Glenelg's customers could also impact negatively on this business. The springs also flow into Mt. Reuil Stream but provide a minor contribution to the overall flow. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: negative Magnitude: moderate Duration: long term (+16 years) Scale: national Probability: medium Sensitivity of receptor: high Significance of impact: moderate	W6, W9, W10

Source: Mott MacDonald

9.5.4.4 Effects on surface water drainage

The magnitude of the effects on surface water drainage is considered moderate because there will be a negligible change in runoff characteristics at the wellpads and road improvement works have the potential to increase or reduce existing flood risk locally, dependent on whether suitable drainage is put in place. However, the area affected is a very small portion of the whole catchment area and the potential for reducing flood risk to downstream areas is limited. The effects on surface water drainage may occur during and after operations phase, so the duration is considered long term (+16 years). The effects on surface water drainage could occur a short distance upstream or downstream of the road improvement works and will decrease with distance downstream from the work sites, as the proportion of runoff from the wider catchment area increases, so the scale is considered local. The probability of effects on surface water drainage occurring is considered medium because it is uncertain whether any real change to flood risk will be observable on the ground.

Table 9.23: Analysis of effects on surface water drainage on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Indirect: Flood risk in St. Patricks (C6) and Gouyave (F5) watersheds	The sensitivity of flood risk in St. Patricks (C6) and Gouyave (F5) watersheds is considered medium because any increase in site runoff or alterations to the local drainage pathways has the potential to increase flood risk to susceptible communities. Most buildings and roads in the project area are situated outside of the flood hazard zones and the flood hazard zones themselves are unlikely to be sensitive to the type of small changes in the catchment drainage regime that may result from the project. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Nature: negative Magnitude: moderate Duration: long term (+16 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor	W5

Source: Mott MacDonald

9.5.4.5 Floodwater displacement at Mt. Reuil

The magnitude of the floodwater displacement at Mt. Reuil is considered moderate because flood risk to the local area would be increased, due to the presence of the pumping station platform within the floodplain. The platform would be elevated compared to existing ground levels, reducing floodplain storage, and out of bank flood flows may be obstructed. Local receptors are situated on the margins of flood zone 2, so it is unlikely that they would be affected except during high magnitude (1 in 20 year or greater) flood events. The floodwater displacement at Mt. Reuil may occur during operation (after which, the pumping station would be decommissioned), so the duration is considered short term (0-5 years). The floodwater displacement at Mt. Reuil could occur in close proximity to the pump station, with any effects on flood risk likely to be felt in the immediate area, so the scale is considered local. The probability of floodwater displacement at Mt. Reuil occurring is considered certain because although flood events are infrequent, should flooding occur, the pump station would have an immediate effect on out of bank flows, due to its position adjacent to the watercourse and within the floodplain.

Table 9.24: Analysis of floodwater displacement at Mt. Reuil on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Flood risk to local developments at Mt. Reuil (C7)	The sensitivity of flood risk to local developments at Mt. Reuil (C7) is considered high because these developments may have limited capacity to withstand any increase in the level of flood risk to which they are exposed. The operational platform of the pumping station would be constructed approximately 1m above the local ground level, at a similar level to the bottling plant, and would be protected from erosion during flood events by a gabion flood wall to the south and east. Equipment or materials used at the pumping station may be disturbed during a severe flood event. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: certain Sensitivity of receptor: high Significance of impact: moderate	W2, W7

Source: Mott MacDonald

9.5.5 Analysis of decommissioning phase impacts

Decommissioning phase impacts will be the largely the same as construction phase impacts. To avoid duplication, the analysis is not repeated here (details can be found in Section 9.5.3). However, it should be noted that storage tanks, drains and pipelines may contain residual fluids which would need to be managed appropriately to avoid contamination of surface water or groundwater. Specific measures are identified in section 9.6.2.2 to mitigate this risk.

9.6 Mitigation and enhancement measures

This section discusses the mitigation and benefit enhancement measures that have been included in the design already, or will be used in future, to avoid, mitigate, manage and improve the potential water impacts identified.

- Embedded mitigation measures are included in the outline design and are considered in the pre-mitigation impact assessment. These measures will be developed further during the detailed design stage and implemented by the contractor.
- Secondary mitigation will be implemented by the contractor during the construction and operational phases of the project. Secondary mitigation measures are considered in the post-mitigation impact assessment.

9.6.1 Embedded mitigation

9.6.1.1 Project water demand

WB PS3 on Resource Efficiency and Pollution Prevention and Management (2016) has been considered with regard to mitigation measures to offset water consumption. This document states that:

"*… the Borrower will adopt measures, to the extent technically and financially feasible, that avoid or minimize water usage so that the project's water use does not have significant adverse impacts on communities, other users and the environment*."

Continuous wireline coring drilling technology has been adopted in preference to rotary drilling, which has a much higher water requirement. It is estimated that well drilling and testing will require 36,000 m^3 in total, over 75 days, which equates to an average usage rate of 5.6 l/s. This compares to 91,000 m^3 over 55 days for rotary drilling, which averages to 19.1 l/s.

The design flow rate necessary to replenish the drill pad reservoirs was estimated (in 2018) to be 10.5 l/s, based on a 500 m^3 reservoir volume. The project now proposes 1000 m^3 reservoirs, which will provide flexibility in the detailed design stage to reduce the replenishment rate slightly. Drilling water will be supplied (via pumping station and temporary pipeline) from a nearby surface watercourse with sufficient flow. The abstraction rate will be confirmed during the detailed design stage of the project but will not exceed 10.5 l/s.

To ensure that surface water abstraction does not impact adversely on other water users or the aquatic environment, the project water intakes will be located downstream of public water supply intakes; and, a minimum environmental flow (MEF) will be maintained in the source watercourse during water abstraction, to ensure that environmental demand is met. This requirement has informed the selection of water intake locations and the design of water storage and pumping infrastructure. The MEF will need to be set by the national regulator (NAWASA) and is discussed further in section 9.6.2.1.

9.6.1.2 Geothermal well design

Drilling will initially be undertaken within a steel conductor casing, to prevent the egress of any drilling fluids into the soil or shallow groundwater. The borehole will be drilled to a depth of 1,500 m and a steel well lining will be installed to a depth of 1,000 m. This will be cemented into place as drilling proceeds and will prevent fluids migrating into or out of the well, isolating it from shallow groundwater. A blowout prevention valve will be installed upon completion to prevent uncontrolled releases of geothermal fluid (and gases) during testing.

9.6.1.3 Management of drilling mud and cuttings

The main impacts from drilling activities, as identified in the World Bank Group's EHS Guidelines for Geothermal Power Generation, are related to oil-based drilling fluids. These will be avoided through the use of water-based drilling mud. This comprises a slurry of bentonite clay and water, with certain additives to controls its viscosity and chemistry, which includes raising pH by adding sodium hydroxide. Neither drilling mud nor cuttings are typically classified as hazardous material. However, it would be undesirable for them to be released to the water environment, so the design includes features to prevent this from occurring. The mud will be mixed in tanks at the surface, prior to being pumped into the borehole during drilling, to stabilise the borehole and bring cuttings to the surface. Following separation of the cuttings, the mud will flow to a mud sump, and will then be recirculated back to the borehole.

9.6.1.4 Drainage and runoff

Storm drainage has been designed to minimise runoff from the project infrastructure and prevent the mobilisation of silt. The storm drainage system will intercept up-gradient runoff and divert this around the well pad sites. Runoff from the well pad infrastructure will be captured and directed to a sediment settlement pond, prior to discharge at a low flow rate.

9.6.1.5 Flood protection

The pumping station site will be protected by a flood wall, to limit potential erosion and overtopping of the platform under high flow conditions.

9.6.2 Secondary mitigation

9.6.2.1 Water supply management

The design is based on a minimum environmental flow (MEF) requirement set at 70% of the simulated mean annual low flow (MALF), which is considered appropriate for the protection of aquatic life and downstream users, given the relatively small size of the watercourses in question.

To determine the water that would be available for drilling, a daily allowance was removed from the simulated flows (described in section 9.4.2.3) to account for NAWASA water takes and the MEF. Flow duration curve analysis was then used to assess whether the residual flows (after public water supply and environmental needs have been met) at each proposed abstraction point would be sufficient for drilling. Each location was assessed to determine the percentage of time that the available flow would be greater than an assumed constant demand of 10.5 l/s.

For Site C, a single intake location was assessed. For Site F, five intake locations were considered, with F-2 being the preferred location that was eventually selected. Summary statistics for these two locations are presented in Table 9.25.

Table 9.25: Surface water availability assessment

Intake location	7-day MALF (l/s)	Environmental demand (MEF) (l/s)	NAWASA water supply take (l/s)*	Proportion of time that residual flow > 10.5 l/s	
				Whole Year	Wet Season
Site C-1	7.3	5.1	34.6	58%	68%
Site F-2	6.3	4.4	3.5	64%	74%

*Annual total averaged and applied as an instantaneous daily rate in the model. This is a conservative estimate as it ignores that water take would reduce in the dry season, so flow would not in reality be reduced to zero as a result of water supply abstraction.

Observed data for site C indicate the minimum flows during the dry season are significantly higher than modelled, at 30 to 40 l/s. For comparison, the average observed minimum flow for the modelled period is 27.5 l/s and for 2014 to 2022, is 39.7. Applying the 70% approach to the latter values results in a MEF of 27.8 l/s. Whilst there are no observed data for the Site F watercourse, it is likely that the actual MALF is higher than the modelled value, though possibly not as high as at Site C.

The national regulator (NAWASA) will need to stipulate the appropriate minimum flow for both watercourses, which the contractor will need to maintain via an appropriate pumping regime. It is likely that this will necessitate undertaking the drilling and testing during the wet season, when river flows are more than sufficient to meet all demands.

The ESMP will require the contractor to prepare an abstraction management plan (W1), setting out how project water demand will be satisfied, whilst maintaining the defined MEF downstream of the project water intake (See section 9.6.1.1). This will need to be submitted NAWASA in order to obtain an abstraction licence. Regular flow monitoring (W6) will be undertaken by the contractor to demonstrate compliance.

9.6.2.2 Surface water quality and drainage

Risks to surface water and groundwater quality are present throughout all phases of the project. Construction and decommissioning also have the potential to increase flood risk if runoff is not adequately controlled. These risks can all be managed through the application of international best practice, which will be ensured through implementation of the ESMP. The necessary measures will be set out in the following documents, to be prepared by the appointed contractor(s).

- flood risk management plan (W2)
- drilling mud and cuttings management plan (W3)
- water quality management plan (W4)
- surface water and groundwater monitoring plan (W6)

If possible, construction and decommissioning should be undertaken during the dry season to minimise the risks associated with high volumes of runoff (i.e. flooding and silt mobilisation).

Specific measures may be required during site closure, to address the potential impact of dismantling of storage tanks and pipelines, which may contain residual fluids. Appropriate controls will need to be established on a case-by-case basis by the contractor, depending on the location of the component, its operational use and physical state. This need should be assessed prior to site closure and the appropriate measures detailed in the site decommissioning environmental management plan. In all cases, the measures must be designed to minimise the risk of spills and to ensure that, should a spill occur, a response plan is in place to ensure that the release can be controlled and either treated or removed.

The application of best practice would be demonstrated through site inspection records. Monitoring of key receptors would be used to demonstrate compliance.

9.6.2.3 Groundwater quality

The risks to groundwater quality posed by project activities at the surface will be controlled by best practice measures (W3 and W4) to protect surface water quality, as described in 9.6.2.2. The risk of direct contamination of shallow groundwater during drilling will be controlled by the use of a conductor casing (W8), which will isolate the borehole from the surrounding shallow aquifer (if present) during construction. The preliminary design assumes the casing will be used to a depth of between of 4 to 6 m below ground level; but this would be confirmed by a geotechnical investigation at each site, prior to construction.

It is considered unlikely (at the time of writing) that the identified springs are fed by deep groundwater that could be affected by well testing. However, given the uncertainty around the source of the Glenelg springs in particular, additional baseline surface water and groundwater monitoring is currently underway to provide a more detailed interpretation of the hydrogeological regime, which will inform an updated assessment of the risks to the Glenelg springs. This will be reported in the final ESIA (W10).

9.6.2.4 Effects on groundwater level and spring discharge rate

Effects on spring discharge rates are not expected but, should they occur, they are most likely to be temporary, and to occur during the early stages of drilling through the shallow geology. Given the uncertainty around the source of the Glenelg springs in particular, additional baseline monitoring (W10) is currently underway as described above (section 9.6.2.3).

If spring discharge rates do increase or decrease temporarily, this is unlikely to have consequences that require specific mitigation. However, if discharge rates are significantly reduced, or stop altogether, it will be necessary to provide an alternative source of water supply (W9). This would most likely involve constructing a new spring collection tank or borehole at an alternative location and piping the water to the affected receptor (note that if a borehole is needed it would require a pump and power supply). Clearly, the appropriate mitigation would depend on the nature and severity of the impact, so would need to be investigated and agreed with the affected party.

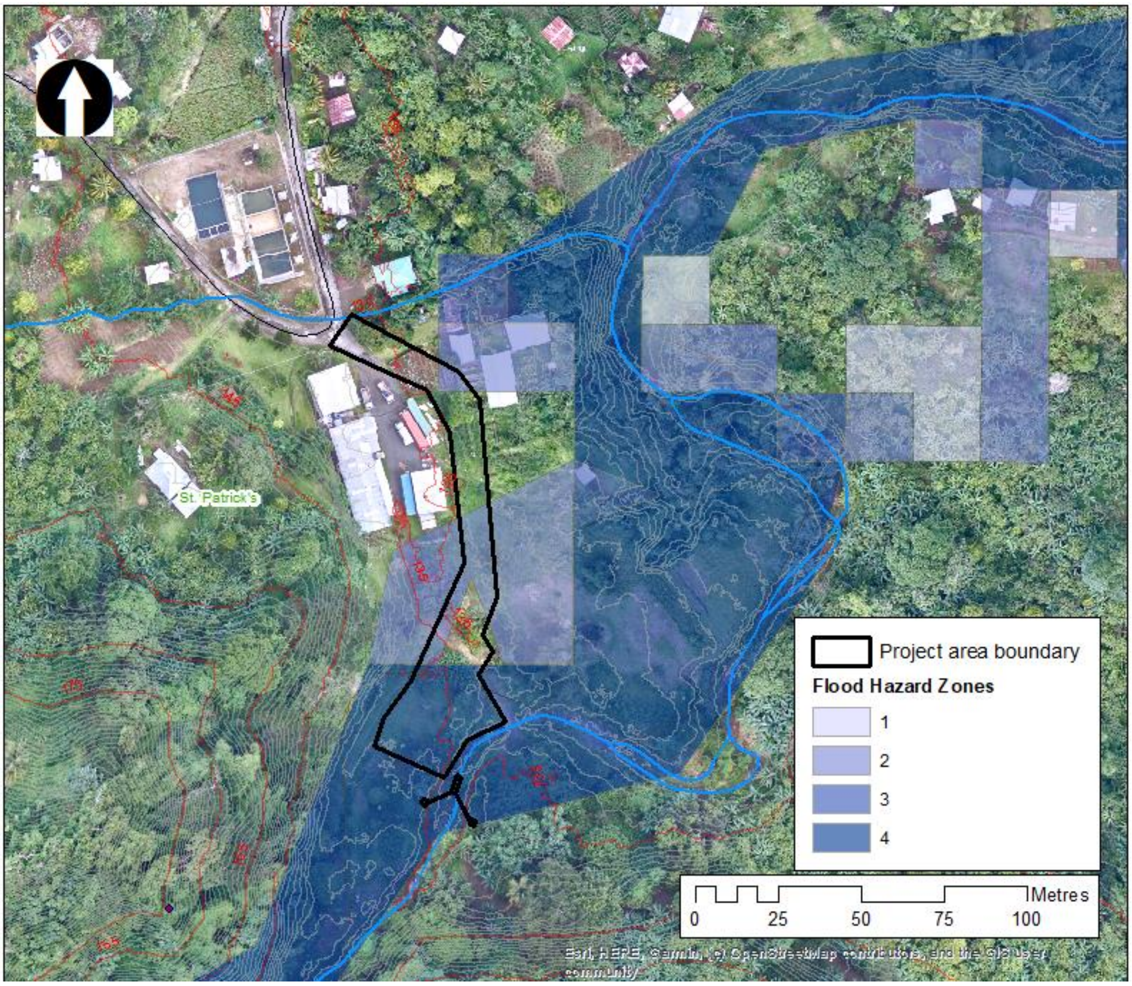
Identification of any impacts on spring discharge during the operational phase will be through the surface water and groundwater monitoring plan (W6). This shall include measurement of discharge flows, surface water and / or groundwater levels, rainfall and key indicator parameters that can be related to flow (i.e. temperature, pH, electrical conductivity).

9.6.2.5 Flood risk mitigation at Mt. Reuil

During a flood event, the Site C pumping station will potentially displace floodwater due to its volume[13] and is also likely to divert some flow northwards, towards identified receptors that are already at risk from a 1 in 20 years (5% annual probability) flood event, as indicated by the extent of flood hazard zone 2 shown in Figure 9.19.

[13] Based on the current design, the level of the pumping station platform will be approximately 1m above existing ground level. Were it to be completely submerged, it would reduce flood storage by approximately 491m^3.

Figure 9.19: Flood hazard zones[14] at Site C pumping station



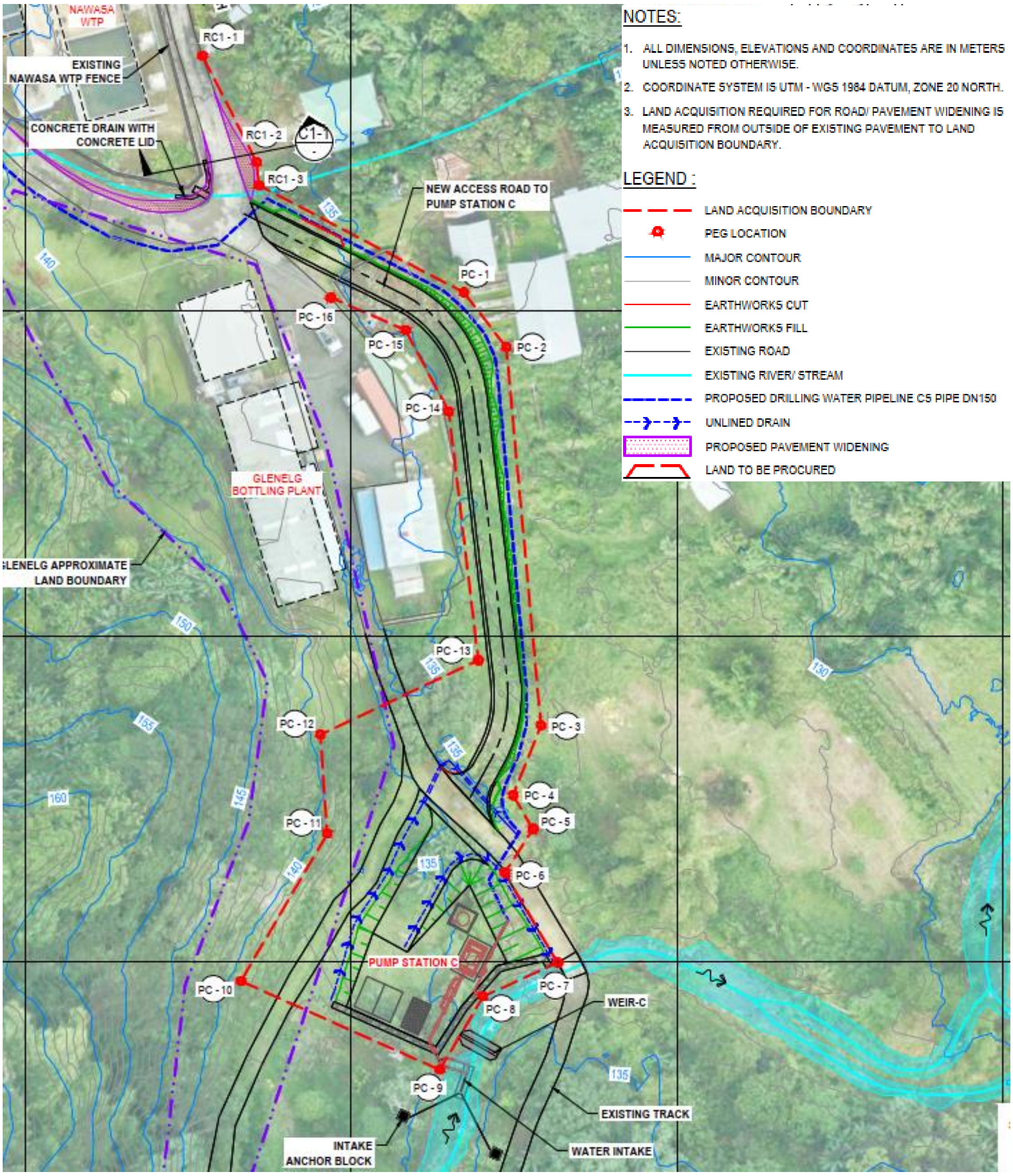
Source: Prepared by Mott MacDonald. Flood hazard zones taken from the Caribbean Handbook on Risk Information Management, 2016

The flood hazard zones are based on modelling that is known to over-estimate the potential for flooding in this upper part of the catchment, and the identified receptors are largely outside the flood hazard zones. Nonetheless, the current pumping station location would increase flood risk locally; therefore, it is proposed to relocate the pumping station platform to minimise its impact on the conveyance of flood flows.

To achieve this, the project land boundary would need to be extended northwards into the ownership area of Glenelg Springs, as shown by the red dashed line in Figure 9.20, so that the pumping station may be constructed as close as possible to the to the north-western side of the valley.

[14] The flood hazard zones indicate areas at risk from at least 0.1m depth flooding due to rainfall events with return periods of 5 years (Zone 4), 10 years (Zone 3), 20 years (Zone 2) and 50 years (Zone 1).

Figure 9.20: Proposed change in project land boundary (red dashed line) to allow relocation of Site C pumping station.



Source: EXISTING ROAD LOCAL UPGRADE LOCATION C1, PUMP STATION C AND NEW ACCESS ROAD LAND ACQUISITION LAYOUT RZ020301-ECC-DG-8002 Rev.B

This would allow the flood wall to be tied-in to the northern side of the valley and aligned with the direction flow, to direct flood water away from the Glenelg bottling plant and adjacent buildings. This should mitigate the impact on floodwater conveyance and, because the platform would be constructed on higher ground, further away from the river channel, it would occupy less floodplain storage volume and have a lower impact on high frequency (low magnitude) flood events than currently.

The relocated pumping station would still result in less flood storage and higher water velocities during a flood event. A flood risk assessment will therefore be required to confirm the level of risk and inform the design of additional mitigation measures, if required (W7). Such measures could include:

- the provision of compensatory flood storage, to mitigate the potential impact of reduced floodplain storage, particularly during higher magnitude, lower frequency events; and,
- the provision of flood protection measures (such as flood berms, walls or gates) for locally affected properties.

In addition, a flood risk management plan (W2) shall be prepared by the contractor, detailing:

- how flood risk will be minimised during construction and operation of the pumping station; and,
- the actions to take during a flood event, to protect the workforce, local population and infrastructure, and the environment.

These measures are expected to fully mitigate the impact of the scheme on flood risk in Mt. Reuil. Furthermore, flood risk to these nearby properties may be reduced compared to the baseline, resulting in a net benefit.

The pumping station is intended to be a temporary installation that will be removed after the drilling and testing operation is complete. The site would be restored, as far as possible, to pre-construction phase conditions. The medium to long term impact on flood risk would therefore be negligible. However, if the platform provides local benefits it may be left in place.

Table 9.26: Water resources mitigation and enhancement measures

Ref	Mitigation measure	Responsibility	Timescales	Monitoring / KPI
W1	Prepare an abstraction management plan detailing how minimum surface water flow requirements will be maintained, whilst meeting project water needs, during the construction and operational phases. This shall be submitted to the regulator (NAWASA) for approval, prior to extraction of any water. The minimum flow shall be set by the regulator as requirement of the project an abstraction licence.	Contractor	Site establishment, drilling and well testing	Site inspection records Flow monitoring Abstraction licence requirements met
W2	If possible, undertake construction work during the dry season and prepare a flood risk management plan, detailing: • standard precautions to minimise flood risk at construction and operational sites; • emergency procedures to be implemented should flooding of the construction or operational sites occur or be anticipated.	Contractor	Site establishment, drilling and well testing	Site inspection records Permit requirements met
W3	Prepare (as part of the Waste and Materials Management Plan (WMMP) detailed in Chapter 14 Waste), and implement, a drilling mud and cuttings management plan, which details: • procedures for monitoring and the available capacity of storage ponds / areas; • measures to prevent uncontrolled releases; • laboratory test requirements for hazardous substances, to confirm the suitability of material for re-use or disposal; • procedures to follow in the event of accidental release of geothermal fluids or drilling mud, to contain the release and notify relevant parties; • an emergency remediation procedure for large spills or releases.	Contractor	Drilling and well testing	Site inspection records Water quality monitoring Waste testing results Permit requirements met
W4	Prepare and implement a water quality management plan, to ensure that best measures to protect surface water and groundwater quality, and manage storm runoff, are adhered to. This should include: • positioning site compounds and laydown areas away from sensitive water features; • refuelling and maintenance of vehicles and equipment in designated bunded areas and off-site where feasible; • use of drip trays, bunded storage, and spill kits on site, to minimise the potential for releases and spills of oils/solvents/hydrocarbons etc; • no direct discharges to surface watercourses; • undertake site stripping during the dry season, if possible; • use of silt traps and other measures to control silt laden run off from sites, especially during the rainy season;	Contractor	Site establishment, drilling and well testing, decommissioning	Site inspection records Water quality monitoring Flow monitoring

Ref	Mitigation measure	Responsibility	Timescales	Monitoring / KPI
	• use cross-drainage structures where building new roads to avoid altering drainage paths or damming waters and causing flooding; • ensure that adequate stormwater containment and settlement areas are provided; • procedures to prevent the release of residual fluids during decommissioning of tanks, pipelines, etc.			
W5	Ensure that all permanent drainage systems are designed in line with the Grenadian technical norms and to take account of future climate variability; and, to ensure that existing flood risk is not exacerbated and is reduced, if possible.	Contractor	Site establishment	Review of design and site inspection by relevant authority
W6	Prepare and implement a comprehensive surface water and groundwater monitoring plan, to enable the early detection of any adverse effects on water quality or flow rates; and demonstrate that other mitigation measures have been effective. • The plan should stipulate trigger levels for key indicator parameters (for water quality and minimum environmental flow) and, the actions to be taken (and by whom) should they be breached. • The plan should be submitted to the relevant authorities for approval prior to implementation. • Monitoring should begin prior to commencement of any construction works, in order to provide baseline data at the chosen monitoring locations. • All chemical analysis must be undertaken at an accredited laboratory and all results / data are to be submitted to the relevant authorities within 15 days of receipt by the contractor. • The relevant authorities are to be notified 5 days in advance of taking the samples, so that they may accompany these surveys.	Contractor	Site establishment, drilling and well testing, decommissioning	Site inspection records Water quality monitoring Flow monitoring
W7	Flood risk assessment to confirm the level of risk presented by construction of the Site C pumping station within the floodplain, and to inform the design of compensatory flood storage or local flood protection measures, if required.	Contractor	Pre-construction	Flood risk assessment report
W8	Use of conductor casing to protect groundwater quality during early stages of drilling. Final depth to be informed by a groundwater risk assessment informed by geotechnical investigation, prior to construction phase.	Contractor	Pre-construction (ground investigation) and drilling	Well design drawings Groundwater risk assessment report Daily site reports
W9	Provide an alternative source of groundwater in the event of significantly decreased spring flow following well construction and testing. This will include a hydrogeological investigation to identify a suitable source of groundwater, followed by construction of new spring collection tank / borehole, pipework, pump etc.	Govt. Of Grenada	Decommissioning	Water quality monitoring Flow monitoring

Ref	Mitigation measure	Responsibility	Timescales	Monitoring / KPI
W10	Site C hydrogeological study and additional baseline monitoring, to address data gaps and inform a more robust assessment of the risks to identified groundwater receptors.	Govt. Of Grenada	Final ESIA	Site C Hydrogeological study report ESIA Addendum report

9.7 Monitoring

9.7.1 Site C hydrogeological study

As described in section 9.6.2, additional data collection, monitoring and investigations are needed to inform a more robust assessment of risks to the springs identified in relation to Site C. A programme of water sampling and flow monitoring is underway, as detailed in the Site C Phase 1 hydrogeological study report.

9.7.2 Surface water and groundwater monitoring plan

As described in section 9.6.2, surface water and groundwater monitoring will be required throughout all phases of the project. A monitoring plan should be developed and implemented by the contractor to meet the W6 requirements set out Table 9.26. The plan should be:

- tailored to the selected site, based on the final design and findings of the geotechnical investigation and any further studies; and,
- approved by the relevant authority prior to implementation.

Because monitoring requirements will be dependent on the findings of future investigations and studies, they cannot be prescribed here. However, as a guide, the plan should include:

- regular (weekly) monitoring of water flow rates at springs and watercourses downstream of the project water intakes, during the operational phase;
- regular (daily) monitoring of groundwater levels in a minimum of one observation well situated adjacent to the well pad site;
- regular (daily) monitoring of groundwater levels at any boreholes installed close to sensitive receptors, during the operational phase;
- regular (monthly) water sampling at key receptors, with samples being analysed in an accredited laboratory for a consistent suite of water quality parameters throughout all phases; and,
- regular (daily) visual assessment of water quality and in-situ measurements (using a multiparameter meter) of key water quality parameters (e.g., pH, temperature, EC, turbidity), at critical receptors during the operational phase.

9.8 Residual impacts

This section presents qualitative assessment of predicted residual water resources impacts expected to occur post mitigation. Impacts that were assessed as ‘significant’ prior to mitigation are highlighted with a grey background in the following tables.

9.8.1 Analysis of residual construction impacts

9.8.1.1 Reduced surface water flow and level

Table 9.27 presents a summary of residual impact (post-mitigation) related to surface water flow and level. The magnitude would be reduced from moderate to minor after mitigation measures are applied; however, significance would remain minor.

Table 9.27: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Surface water in the Mount Reuil stream (C1) Mount Felix stream (F1)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor and the probability from medium to low. Adherence to the abstraction management plan will ensure flows remain sufficient to meet environmental and social needs locally. This results in no change to the significance, which remains minor.

9.8.1.2 Reduced surface water quality

Table 9.28 presents a summary of residual impacts (post-mitigation) for the impacts related to surface water quality. The magnitude of both impacts would be reduced to minor after mitigation measures are applied; however, significance would remain minor.

Table 9.28: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Surface water (C1+F1)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor and probability from medium to low. Implementation of best practice site management, supported by monitoring, will protect surface water quality during all phases of the project. This results in no change to the significance, which remains minor.
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: regional Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor and probability from medium to low. Implementation of best practice site management, supported by monitoring, will protect surface water quality during all phases of the project. This results in no change to the significance, which remains minor.

9.8.1.3 Reduced groundwater quality

Table 9.29 presents a summary of residual impacts (post-mitigation) for the impacts related to groundwater quality. Significance of two impacts would be reduced from moderate to minor.

Table 9.29: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Groundwater in the vicinity of Site C (C2) and Site F (F2)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. Use of conductor casing will protect shallow groundwater during drilling and an improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality. This results in no change to the significance, which remains minor.
Indirect: Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. An improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality in this area. This results in no change to the significance, which remains minor.
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: regional Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. An improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality in this area. This results in a change in the significance from moderate to minor.
Indirect: Public water supply intake at Mt. Felix Spring (F4)	Nature: negative Magnitude: negligible Duration: medium term (5-15 years) Scale: regional Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. This results in no change to the significance, which remains minor.

Receptor	Summary of residual impact (post-mitigation)
Indirect: Glenelg springs (C5)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: national Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. An improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality in this area. This results in a change in the significance from moderate to minor.

9.8.1.4 Effects on surface water drainage

Table 9.30 presents a summary of residual impacts (post-mitigation) for the impacts related to surface water drainage. The magnitude would be reduced from moderate to minor after mitigation measures are applied. However, significance would remain minor.

Table 9.30: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Indirect: Flood risk in St. Patricks (C6) and Gouyave (F5) watersheds	Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude to moderate and probability to low. The contractor's flood risk management plan will ensure that runoff is well managed during the works. This results in a change in the significance from minor to negligible.

9.8.1.5 Floodwater displacement at Mt. Reuil

Table 9.31 presents a summary of residual impacts (post-mitigation) for the impacts related to floodwater displacement. The probability would be reduced to low after mitigation measures are applied. However, significance would remain minor.

Table 9.31: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Flood risk to local developments at Mt. Reuil (C7)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor Implementation of the proposed mitigation measures should reduce the probability to low. Undertaking an assessment of flood risk during construction and application of suitable control measures, will ensure that flood risk to local receptors does not increase. This results in no change to the significance, which remains minor.

9.8.2 Analysis of residual operation phase impacts (drilling and testing)

9.8.2.1 Reduced surface water flow and level

Table 9.32 presents a summary of residual impacts (post-mitigation) for the impacts related to surface water flow and level. The magnitude of impact would be reduced to minor and significance to minor after mitigation measures are applied.

Table 9.32: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Surface water in the Mount Reuil stream (C1) Mount Felix stream (F1)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: high Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor and the probability from certain to high. Adherence to the abstraction management plan will ensure flows remain sufficient to meet environmental and social needs locally. This results in a change in the significance from moderate to minor.

9.8.2.2 Reduced surface water quality

Table 9.33 presents a summary of residual impacts (post-mitigation) for the impacts related to surface water quality. The magnitude of both impacts would be reduced to minor after mitigation measures are applied. However, significance would remain minor.

Table 9.33: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor

Receptor	Summary of residual impact (post-mitigation)
	Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will minimise the potential for accidental releases and ensure that if any water pollution does occur, is detected and dealt with as early as possible. This results in no change to the significance, which remains minor.
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	Nature: Negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will minimise the potential for accidental releases and ensure that if any water pollution does occur, is detected and dealt with as early as possible. This results in no change to the significance, which remains minor.

9.8.2.3 Reduced groundwater quality

Table 9.34 presents a summary of residual impacts (post-mitigation) for the impacts related to groundwater quality. The magnitude of four impacts would be reduced to minor after mitigation measures are applied. For two impacts, significance would reduce from moderate to minor. Others would remain minor.

Table 9.34: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Groundwater in the vicinity of Site C (C2) and Site F (F2)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will minimise the potential for accidental releases and ensure that if any water pollution does occur, is detected and dealt with as early as possible. An improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality in this area. This results in no change to the significance, which remains minor.
Indirect: Surface water in the Mt. Reuil stream (C1) and Mt. Felix stream (F1	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will minimise the potential for accidental releases and ensure that if any water pollution does occur, is detected and dealt with as early as possible. An improved understanding of the Site C hydrogeology will enable more effective management of risk to

Receptor	Summary of residual impact (post-mitigation)
	groundwater quality in this area. This results in no change to the significance, which remains minor.
Indirect: Public water supply intake at Mt. Reuil Dam (C4)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. An improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality. This results in a change in the significance from moderate to minor.
Indirect: Public water supply intake at Mt. Felix Spring (F4)	Nature: negative Magnitude: negligible Duration: medium term (5-15 years) Scale: regional Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of effects to negligible and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. This results in no change to the significance, which remains minor.
Indirect: Glenelg springs (C5)	Nature: negative Magnitude: minor Duration: medium term (5-15 years) Scale: national Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of change to minor and probability to low. Implementation of best practice site management, supported by monitoring, will protect groundwater quality during all phases of the project. An improved understanding of the Site C hydrogeology will enable more effective management of risk to groundwater quality. This results in a change in the significance from moderate to minor.

9.8.2.4 Effects on groundwater level and spring discharge

Table 9.35 presents a summary of residual impacts (post-mitigation) for the impacts related to groundwater level and spring drainage. The magnitude of two impacts would be reduced to minor after mitigation measures are applied. For two impacts, significance would reduce from moderate to minor. Others would remain minor.

Table 9.35: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Direct: Groundwater in the vicinity of Site C (C2)	Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor An improved understanding of the Site C hydrogeology, supported by monitoring, will enable effective management of risk to groundwater level and spring flow. It is anticipated that the hydrogeological study will conclude that the probability and / or magnitude of impact will reduce. Should there be any permanent effect on spring flow, the options for an alternative groundwater supply will be investigated and implemented by GoG, in agreement with the affected parties, reducing the duration from long term to short term. This results in no change in the significance, which remains minor.
Direct: Groundwater in the vicinity of Site F (F2)	Nature: negative Magnitude: major Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor Regular monitoring will enable effective management of risk to groundwater level and spring flow. Should there be any permanent effect on spring flow, the options for an alternative groundwater supply will be investigated and implemented by GoG, in agreement with the affected parties, reducing the duration from long term to short term. This results in no change to the significance, which remains minor.
Indirect: Public water supply intake at Mt. Felix Spring (F4)	Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: regional Probability: medium Sensitivity of receptor: high Significance of impact: minor Regular monitoring will enable effective management of risk to groundwater level and spring flow. Should there be any permanent effect on spring flow, the options for an alternative groundwater supply will be investigated and implemented by GoG, in agreement with the affected parties, reducing the duration from long term to short term. This results in a change in the significance from moderate to minor.

Receptor	Summary of residual impact (post-mitigation)
Indirect: Glenelg springs (C5)	Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: national Probability: low Sensitivity of receptor: high Significance of impact: minor An improved understanding of the Site C hydrogeology, supported by monitoring, will enable effective management of risk to groundwater level and spring flow. It is anticipated that the hydrogeological study will conclude that the probability and / or magnitude of impact will reduce. Should there be any permanent effect on spring flow, the options for an alternative groundwater supply will be investigated and implemented by GoG, in agreement with the affected parties, reducing the duration from long term to short term. This results in a change in the significance from moderate to minor.

9.8.2.5 Effects on surface water drainage

Table 9.36 presents a summary of residual impacts (post-mitigation) for the impacts related to surface water drainage. The magnitude would be reduced to minor after mitigation measures are applied. However, significance would remain minor.

Table 9.36: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Indirect: Flood risk in St. Patricks (C6) and Gouyave (F5) watersheds	Nature: positive Magnitude: minor Duration: long term (+16 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor Implementation of the proposed mitigation measures should reduce the potential for any negative effects on flood risk and result in a positive effect. Compliance with local drainage standards and consideration of climate change in the design will ensure that any new drainage maintains or decreases the existing level of flood risk, beyond the life of the project. This results in a change in the significance from minor negative to minor positive.

9.8.2.6 Floodwater displacement at Mt. Reuil

Table 9.37 presents a summary of residual impacts (post-mitigation) for the impacts related to floodwater displacement. The significance of impact would be reduced from moderate to minor after mitigation measures are applied.

Table 9.37: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Flood risk to local developments at Mt. Reuil (C7)	Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: high Significance of impact: minor Implementation of the proposed mitigation measures should reduce the magnitude of effects to minor and probability to low. Undertaking an assessment to confirm the level of flood risk, and reviewing the design of the pumping station to mitigate this appropriately will ensure that flood risk to local receptors does not increase. This results in a change in the significance from moderate to minor.

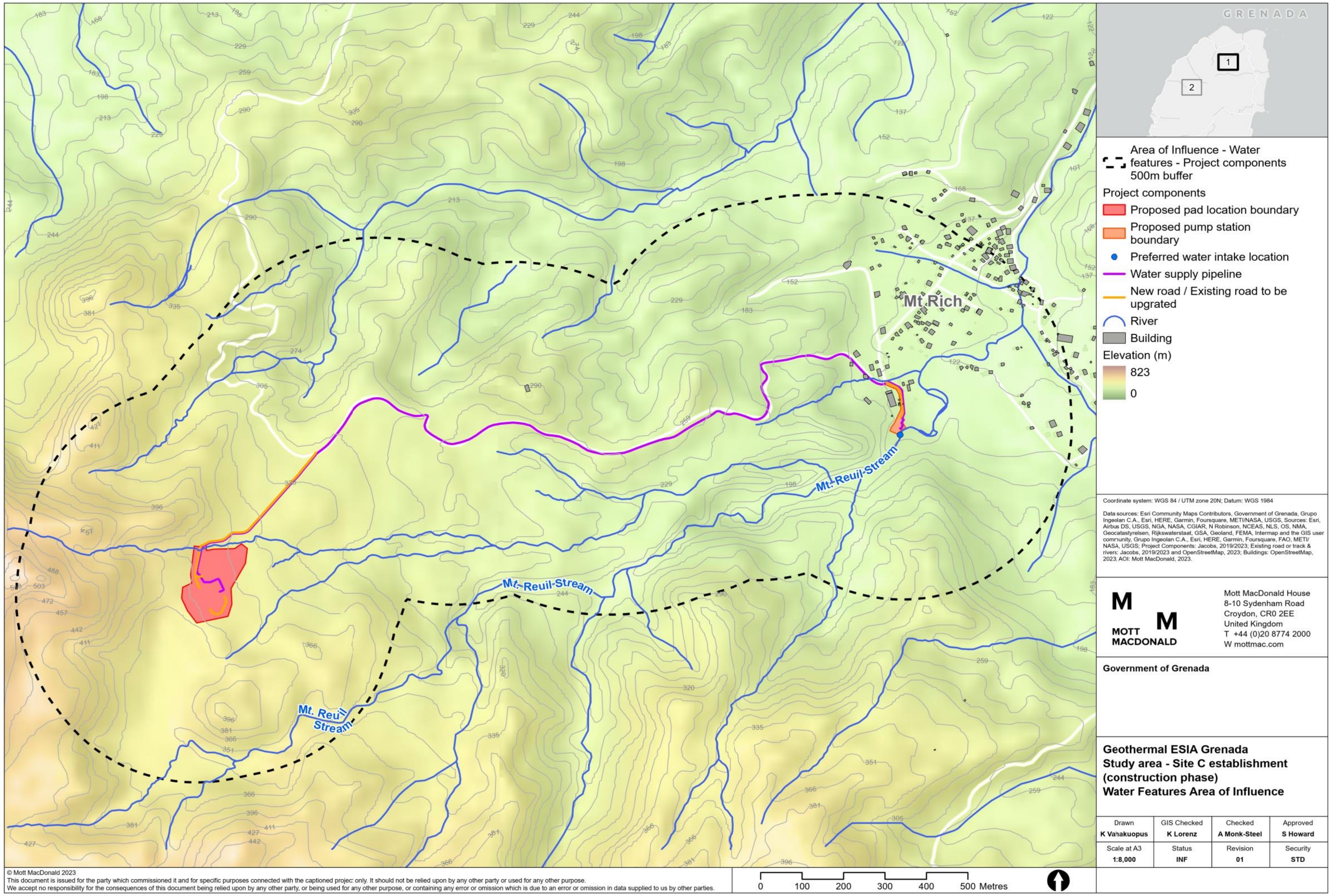
9.8.3 Analysis of residual decommissioning phase impacts

Decommissioning phase residual impacts will be the largely the same as construction phase impacts. To avoid duplication, the analysis is not repeated here (details can be found in Section 9.8.1).

Appendices

A. Figures

Figure A.1: Site C Area of influence



Grenada_Geothermal_ESIA_Water | Grenada Water Area of Influence P01 | 06 Jul 2023

Figure A.2: Site F Area of influence

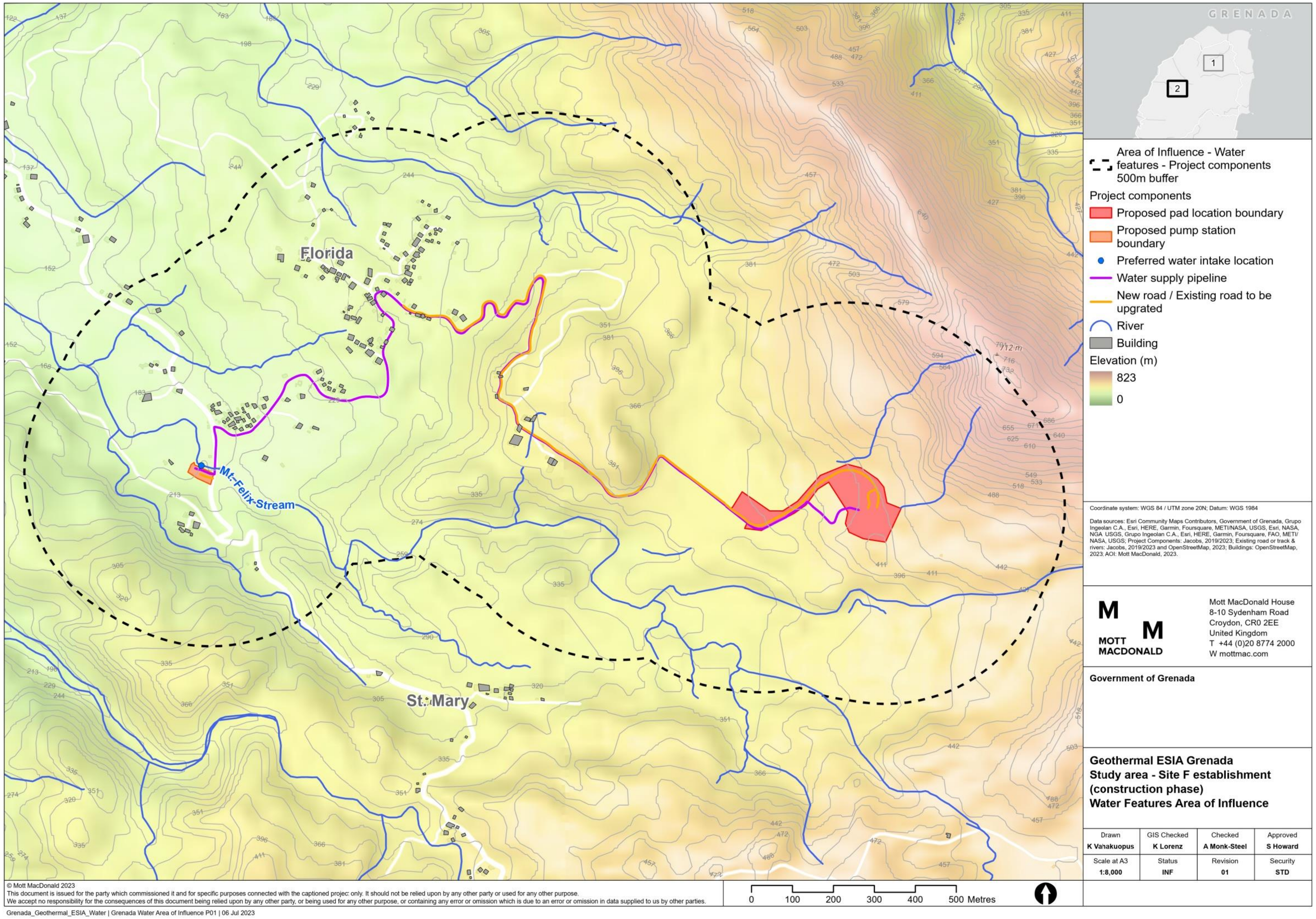


Figure A.3: Site C Key Water Features and Survey Locations

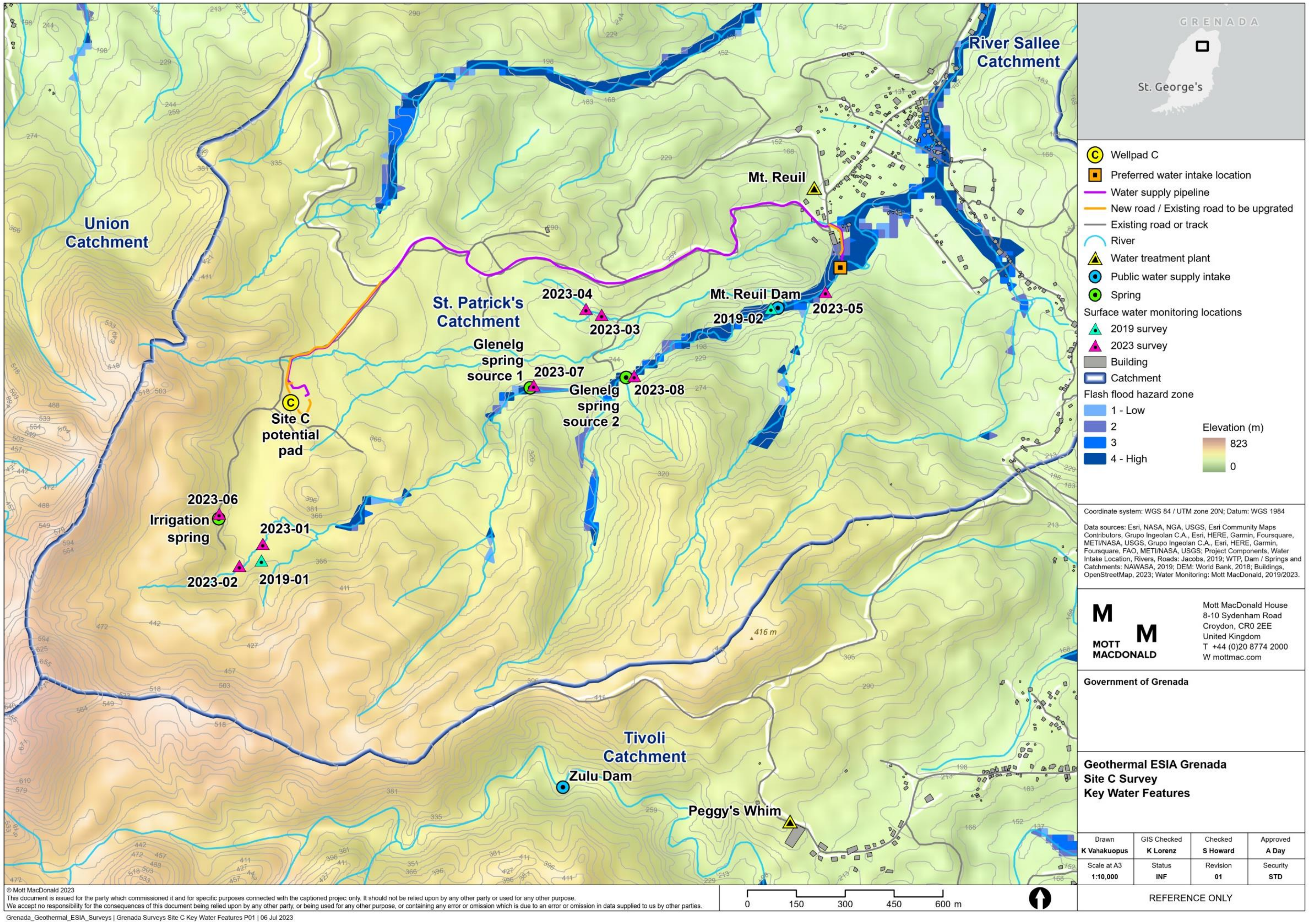
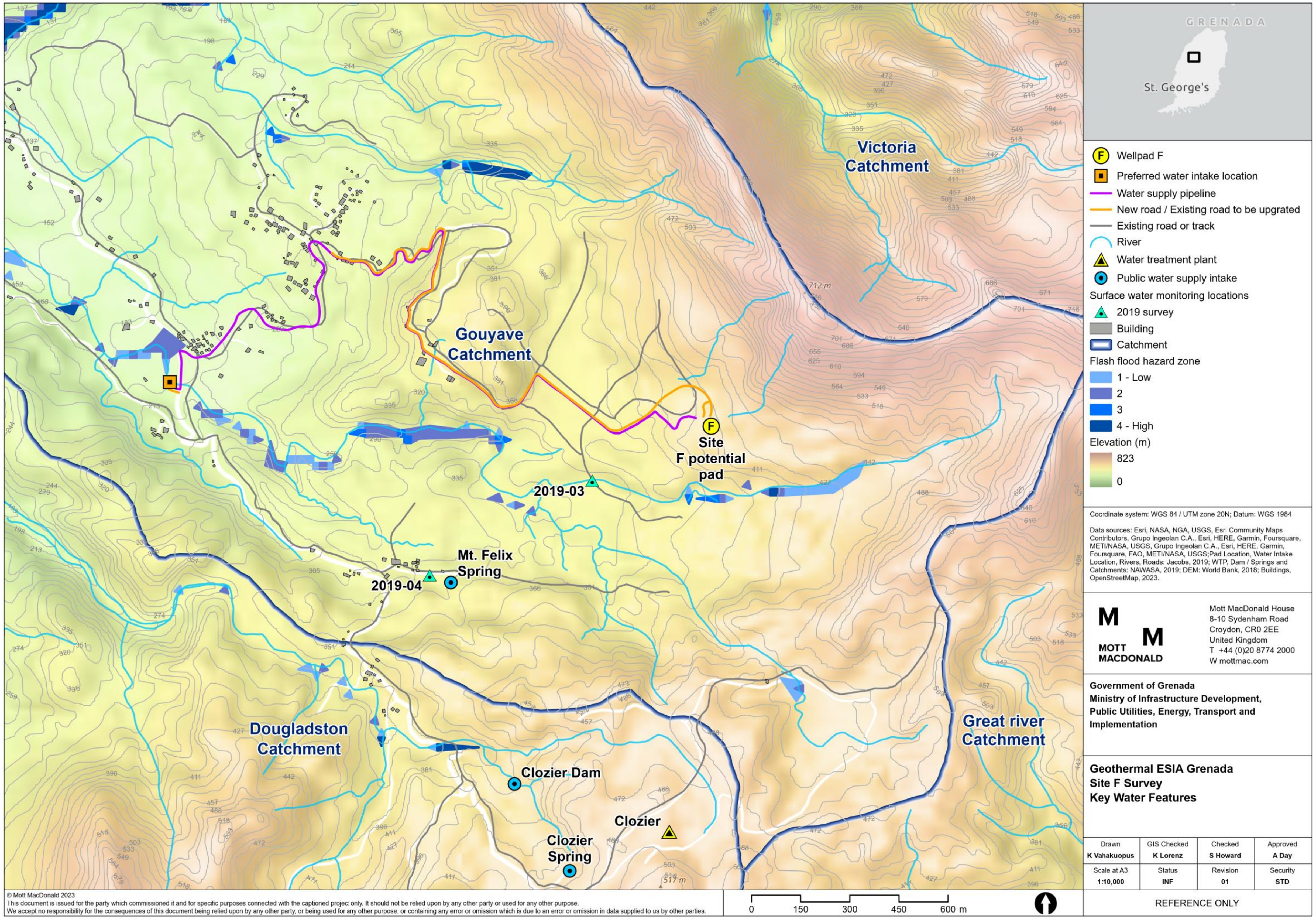


Figure A.4: Site F Key Water Features and Survey Locations



A. Water quality data

Table A.1: NAWASA Surface water quality data at Mt Reuil Treatment Plant (Site C)

Source	**Mt. Reuil Treatment Plant**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**						
Date Sampled	11/05/2018	03/05/2019	13/03/2020	02/06/2021	01/07/2022	17/03/2023	Class B recreational water	Class C fishery, agriculture, etc.	Recreational use	Protection of aquatic life	Compliance / Indicator	Values
Sample Description	Inlet Sump At Sed' Tank (Raw Water)	Inlet Sump At Sedimentation Tank	Inlet Sump At Sedmentation Tank	Inlet Sump At Sedmentation Tank	Inlet Sump At Treatment Plant	Inlet Sump At Sedmentation Basin						
pH	8.3	8.2	8.2	8	8.1	8.5	6.5-8.5	6.5 - 9.0	6.5=8.5	6.5-8.5	I	≥ 6.5 and ≤ 9.5
Temperature (ºC)	25.5	25.5	24.7	28.4	24.8	24.1	26-30	25-31	<30	<30		
Total Dissolved Solids (mg/l)	373	441	433	406	281	367			NA	NA		
Salinity (‰)	0.37	0.44	0.43	0.41	0.28	0.37						
Conductivity (µS/cm at 20°C)	772	915	877	839	575	735			NA	NA	I	2 500 MS cm–1 at 20°C
Free Residual Chlorine (mg/l, Cl2)	N/A	N/A	N/A	N/A	N/A	0						
Turbidity (NTU)	2.93	0.9	1.08	1.44	3.55	1.92			<50	NA		
Alkalinity (mg/l as $CaCO_3$)	118	136	127	138	110	138			<20 mg/L	<20 mg/L		
Chloride (mg/l, Cl-)	162	183	0	177	103	152	250 mg/L	350 mg/L	NA	120-230 mg/L (long term); 640-860 (short term)		

Source	**Mt. Reuil Treatment Plant**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**						
Hardness (Calcium) (mg/l as $CaCO_3$)	124	127	129	120	0	120			NA			
Hardness (Magnesium) (mg/l as $CaCO_3$)	48	66	61	57	0	49						
Hardness (Total) (mg/l as $CaCO_3$)	172	193	190	177	92	169			NA	NA		
Aluminium (mg/l as Al3+)	0.18	< 0.008	0	0.013	0.015	< 0.008			NA	NA		
Nitrate (mg/l, NO3-)	0.4	1.8	1.8	1.6	1.2	2	7 mg/L	7 mg/L	<10 mg/L	<10 mg/L		
Nitrite (mg/l, NO2-)	0.017	0.007	0.013	0.01	0.019	0.03						
Ammonia (mg/l, NH3)	0.04	< 0.03	0.11	0.03	0.09	0.06	0.05mg/L	0.05mg/L	NA	<320 µg/L		
Sulphate (mg/l, SO42-)	< 2	< 2	7	2	<2	<2	250	275	<400 mg/L	<250 mg/L		
Sulphide (µg/l, S2-)	22	< 5	5	< 5	<5	NR						
Phosphate (mg/l PO43-)	0.81	0.6	0.86	0.71	0.56	0.63	0.5 mg/L	0.5 mg/L	<0.5 mg/L	<0.5 mg/L		
Iron (total) (mg/l, Fe)	< 0.02	0.1	0.003	0.03	0.15	0.04	1 mg/L	1 mg/L	NA	<300 µg/L		
Manganese (mg/l, Mn)	0.012	< 0.006	0	0.023	0	0.022	0.2 mg/L	0.2 mg/L	NA	NA		
Silica (mg/l, SiO2)	65	67.3	66.1	65	54.8	65.5			NA	NA		

Source	**Mt. Reuil Treatment Plant**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Mt. Reuil SSF (Raw Water)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**						
Copper (mg/L Cu)	< 0.04	< 0.04	< 0.04	< 0.04	<0.04	< 0.04	0.02 mg/L	0.02 mg/L	NA	<1 µg/L	C	2
Total Organic Carbon (mg/l, C)	1	1.9	0	15.7	1.1	5.2						
Trihalomethanes (ppb as CHCl3)	< 10	<10	31	41	10							

Source: NAWASA.

Table A.2: NAWASA Surface water quality data at Mt Felix Spring / PSS (Site F)

Source	**Mt. Felix Spring (Clozier)**	**N/A**	**Mt. Felix PSS (Raw Water)**	**Mt. Felix PSS (Raw Water)**	**N/A**	**N/A**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**						
Date Sampled	02/11/2018	N/A	09/10/2020	15/10/2021	N/A	N/A	Class B recreational water	Class C fishery, agriculture, etc.	Recreational use	Protection of aquatic life	Compliance / Indicator	Values
Sample Description	Overflow from spring Casing	N/A	Spring At Mt. Felix	Water Under Casing	N/A	N/A						
pH	6.5	N/A	7.2	7.1	N/A	N/A	6.5-8.5	6.5 - 9.0	6.5=8.5	6.5-8.5	I	≥ 6.5 and ≤ 9.5
Temperature (ºC)	25.8	N/A	25.6	24.9	N/A	N/A	26-30	25-31	<30	<30		
Total Dissolved Solids (mg/l)	140	N/A	135.7	138.6	N/A	N/A			NA	NA		
Salinity (‰)	0.14	N/A	0.13	0.14	N/A	N/A						
Conductivity (µS/cm at 20°C)	298	N/A	287	289	N/A	N/A			NA	NA	I	2 500 MS cm–1 at 20°C
Free Residual Chlorine (mg/l, Cl2)	0.04	N/A	N/A	0.1	N/A	N/A						
Turbidity (NTU)	0.62	N/A	0.54	0.46	N/A	N/A			<50	NA		
Alkalinity (mg/l as $CaCO_3$)	114	N/A	115	97	N/A	N/A			<20 mg/L	<20 mg/L		
Chloride (mg/l, Cl-)	-	N/A	14	15	N/A	N/A	250 mg/L	350 mg/L	NA	120-230 mg/L (long term); 640-860 (short term)		
Hardness (Calcium) (mg/l as $CaCO_3$)	81	N/A	80	90	N/A	N/A			NA			
Hardness (Magnesium)	-	N/A	33	26	N/A	N/A						

Source	**Mt. Felix Spring (Clozier)**	**N/A**	**Mt. Felix PSS (Raw Water)**	**Mt. Felix PSS (Raw Water)**	**N/A**	**N/A**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**						
(mg/l as $CaCO_3$)												
Hardness (Total) (mg/l as $CaCO_3$)	-	N/A	113	116	N/A	N/A			NA	NA		
Aluminium (mg/l as Al3+)	<0.008	N/A	0.024	0.013	N/A	N/A			NA	NA		
Nitrate (mg/l, NO3-)	1.4	N/A	1	1.1	N/A	N/A	7 mg/L	7 mg/L	<10 mg/L	<10 mg/L		
Nitrite (mg/l, NO2-)	-	N/A	0.012	0.009	N/A	N/A						
Ammonia (mg/l, NH3)	0.04	N/A	0.29	0.03	N/A	N/A	0.05mg/L	0.05mg/L	NA	<320 µg/L		
Sulphate (mg/l, SO42-)	9	N/A	3	12	N/A	N/A	250	275	<400 mg/L	<250 mg/L		
Sulphide (µg/l, S2-)	< 5	N/A	< 5	<5	N/A	N/A						
Phosphate (mg/l PO43-)	0.35	N/A	0.26	0.27	N/A	N/A	0.5 mg/L	0.5 mg/L	<0.5 mg/L	<0.5 mg/L		
Iron (total) (mg/l, Fe)	< 0.02	N/A	0.02	0.02	N/A	N/A	1 mg/L	1 mg/L	NA	<300 µg/L		
Manganese (mg/l, Mn)	0.008	N/A	0.014	0.012	N/A	N/A	0.2 mg/L	0.2 mg/L	NA	NA		
Silica (mg/l, SiO2)	49.6	N/A	48.7	49.6	N/A	N/A			NA	NA		
Copper (mg/L Cu)	< 0.04	N/A	< 0.04	< 0.04	N/A	N/A	0.02 mg/L	0.02 mg/L	NA	<1 µg/L	C	2

Source	**Mt. Felix Spring (Clozier)**	**N/A**	**Mt. Felix PSS (Raw Water)**	**Mt. Felix PSS (Raw Water)**	**N/A**	**N/A**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**						
Total Organic Carbon (mg/l, C)	0.2	N/A	0.8	0	N/A	N/A						
Trihalomethanes (ppb as CHCl3)	17	N/A	< 10	< 10	N/A	N/A						

Source: NAWASA.

Table A.3: Surface water quality survey data from 2019

Location ref.	2019-01 (Site C)	2019-02 (Site C)	2019-03 (Site F)	2019-04 (Site F)	Philippines DENR Guidelines		Trinidad & Tobago Water Pollution Rules		Grenada Water Supply Quality Standards	
Date Sampled	18/07/2019	18/07/2019	18/07/2019	18/07/2019	Class B recreational water	Class C fishery, agriculture, etc.	Recreational use	Protection of aquatic life	Compliance / Indicator	Values
Conductivity									I	2 500
Temperature (°C)	24.0	25.1	24.3	24.6	26-30	25-31	≤30	≤30		
pH	8.83	8.03	7.80	7.45	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	I	≥ 6.5 and ≤ 9.5
Dissolved Oxygen (mg/L)	7.52	7.13	7.64	6.98	5	5	≥3	≥ 85% saturation		
Total Suspended Solids (TSS) (mg/L)	5	9.17	27.2	7.83	65	80	dry season: ≤25mg/L	dry season: ≤65mg/L		
Total Petroleum Hydrocarbons (TPH) (%)	<0.46	1.18	<0.46	<0.46	NQ					
Total Coliforms (cfu/100ml)	41.5	8	213	14	NQ				I	0
Faecal Coliforms (cfu/100ml)	405.5	282	87	67.5	100 mpn/100ml	200 MPN/ 100 mL			I	0
Total Arsenic (mg/L)	0.06606	0.34554	0.00423	0.00111	0.01	0.02			C	0.001
Total Barium (mg/L)	<0.050	<0.050	0.05	<0.050	0.7	3	NA	NA		
Total Cadmium (mg/L)	0.0146	<0.00040	<0.00040	<0.00040	0.003	0.003			C	0.005
Total Chromium (mg/L)	0.0279	<0.0080	<0.0080	<0.0080	0.01	0.01			C	0.05
Total Lead (mg/L)	0.0213	<0.0030	<0.0030	<0.0030	0.01	0.05 mg/L	NA	<65 µg/L	C	0.01
Total Mercury (mg/L)	<0.000100	<0.000100	<0.000100	<0.000100	0.001	0.006 mg/L	NA	<1.4 µg/L (short term; <0.026 µg/L (long term)	C	0.001
Total Selenium (mg/L)	0.0119	<0.0060	<0.0060	<0.0060	0.01	-	NA	<1 µg/L	C	0.01
Total Copper (mg/L) (as dissolved copper)	0.0393	<0.0080	0.0098	<0.0080	0.02	0.02 mg/L	NA	<1 µg/L	C	2
Total Zinc (mg/L)	0.22	<0.070	0.128	0.091	2	2 mg/L	NA	<120 µg/L (short term); <2.4 µg/L (long term)		

Location ref.	**2019-01 (Site C)**	**2019-02 (Site C)**	**2019-03 (Site F)**	**2019-04 (Site F)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Date Sampled	18/07/2019	18/07/2019	18/07/2019	18/07/2019	Class B recreational water	Class C fishery, agriculture, etc.	Recreational use	Protection of aquatic life	Compliance / Indicator	Values
Total Molybdenum (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	NQ					
Total Nickel (mg/L)	0.0262	<0.0050	0.0135	<0.0050	0.04	0.02 mg/L	NA	<470 µg/L (short term); <25 µg/L (long term)	C	0.02
Total Antimony (mg/L)	<0.0060	<0.0060	<0.0060	<0.0060	NQ				C	0.005
Sulphate (mg/L)	8	<1.23	100	<1.23	250	275	<400 mg/L	<250 mg/L		
Benzene (mg/L)	<0.005	<0.005	<0.005	<0.005	0.01	0.05 mg/L		<370 µg/L	C	0.001
Toluene (mg/L)	<0.006	<0.006	<0.006	<0.006	1	4 mg/L		<2 µg/L		
Ethyl benzene (mg/L)	<0.005	<0.005	<0.005	<0.005	0.3	1.5 mg/L		<90 µg/L		
Total Xylenes (mg/L)	<0.011	<0.011	<0.011	<0.011	0.5	1.5 mg/L				
Naphthalene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	NQ			<1.1 µg/L		
Acenaphthylene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				0		
Acenaphthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<5.8 µg/L		
Phenanthrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<0.4 µg/L		
Anthracene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<0.012		
Fluoranthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<0.04 µg/L		
Pyrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<0.025 µg/L		
Benzo(a)anthracene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<0.018 µg/L		
Chrysene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004						
Benzo(b,j)floranthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004					C	0.1
Benzo(k)fluoranthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004					C	0.1
Benzo(a)pyrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004		1.5 µg/L			C	0.01

Location ref.	**2019-01 (Site C)**	**2019-02 (Site C)**	**2019-03 (Site F)**	**2019-04 (Site F)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Date Sampled	18/07/2019	18/07/2019	18/07/2019	18/07/2019	Class B recreational water	Class C fishery, agriculture, etc.	Recreational use	Protection of aquatic life	Compliance / Indicator	Values
Indeno (1,2,3-c,d)pyrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004					C	0.1
Dibenzo(a,h)anthracene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004						
Benzo(g,h,i)perylene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004					C	0.1
Fluorene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004				<3 µg/L		
Benzo(a)Pyrene Total Potency Equivalents (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.7					

Table A.4 Surface water quality survey data from 2023

Location ref.	2023-01 (loc. 1)	2023-02 (loc. 2)	2023-03 (loc. 3)	2023-04 (loc. 4)	2023-05 (loc. 5)	2023-06 (loc. 6)	Philippines DENR Guidelines		Trinidad & Tobago Water Pollution Rules		Grenada Water Supply Quality Standards	
Date Sampled	28/03/2023	28/03/2023	28/03/2023	28/03/2023	28/03/2023	28/03/2023	Class B recreational water	Class C fishery, agriculture, etc.	Recreational use	Protection of aquatic life	Compliance / Indicator	Values
IN-SITU PARAMETERS (Measurements in brackets taken on 27/03/23)												
Temperature (°C)	(23.65) 23.54	(23.35) 23.71	24.24	24.92	23.85	24.73	26-30	25-31	<30	<30		
pH	(7.86) 7.95	(7.48) 7.22	7.85	7.71	8.12	7.79	6.5-8.5	6.5 - 9.0	6.5=8.5	6.5-8.5	I	≥ 6.5 and ≤ 9.5
Dissolved Oxygen (mg/L) (min)	(7.93) 7.95	(7.95) 8.03	8	7.25	8.28	7.85	5 mg/L	5 mg/L	>80% SATURATI ON	>3 mg/L		
Salinity (ppt)	(0.22) 0.22	(0.22) 0.21	0.15	0.15	0.39	0.12						
Conductivity (µs/cm)	(452) 450.3	(450) 445.1	321.6	321	791	247.6			NA	NA	I	2 500 MS cm–1 at 20°C
Turbidity (NTU)	(0.71) 0.43	(0.68) 0.56	2.48	3.81	3.63	0.94			<50	NA		
Total Residual Chlorine (mg/L)	(0.02) 0.02	(0.04) 0.01	0.03	0.01	0.03	0.01						
Total Suspended Solids (TSS) (mg/L)	<2.56	<2.56	<2.56	3	2.67	<2.56	65mg/L	80mg/L	<65 (DRY SEASON)	<25 (dry season)		
MICROBIOLOGICAL												
Total Coliforms (cfu/100mL)	1000	1400	2700	500	600	3500			NA	NA	I	0
Faecal Coliforms (cfu/100 mL)	400	650	2200	400	550	2400	100MPN/100ml	200 mpn/100ML	<200 counts/100ml	NA	I	0
METALS												
Total Aluminium (mg/L)	0.147	<0.050	0.169	0.051	0.064	0.071			NA	NA		

Location ref.	2023-01 (loc. 1)	2023-02 (loc. 2)	2023-03 (loc. 3)	2023-04 (loc. 4)	2023-05 (loc. 5)	2023-06 (loc. 6)	Philippines DENR Guidelines		Trinidad & Tobago Water Pollution Rules		Grenada Water Supply Quality Standards	
Total Arsenic (mg/L)	0.12936	0.12405	0.00405	0.00384	0.31989	0.09034	0.01 mg/L	0.02 mg/L	NA	<5 µg/L	C	0.001
Total Barium (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.7 mg/L	3 mg/L	NA	NA		
Total Cadmium (mg/L)	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	0.003 mg/L	0.003 mg/L	NA	<2 µg/L (short term); <0.25 µg/L (long term)	C	0.005
Total Chromium (mg/L)	<0.0080	<0.0080	<0.0080	<0.0080	<0.0080	<0.0080	0.01 mg/L	0.01 mg/L	NA	NA	C	0.05
Total Lead (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.01 mg/L	0.05 mg/L	NA	<65 µg/L	C	0.01
Total Manganese (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.2 mg/L	0.2 mg/L	NA	NA		
Total Mercury (mg/L)	<0.000500	<0.000500	<0.000500	<0.000500	<0.000500	<0.000500	0.001 mg/L	0.006 mg/L	NA	<1.4 µg/L (short term; <0.026 µg/L (long term)	C	0.001
Total Selenium (mg/L)	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	0.01		NA	<1 µg/L	C	0.01
Total Copper (mg/L)	<0.0080	<0.0080	<0.0080	<0.0080	<0.0080	<0.0080	0.02 mg/L	0.02 mg/L	NA	<1 µg/L	C	2
Total Iron (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	1 mg/L	1 mg/L	NA	<300 µg/L		
Total Zinc (mg/L)	<0.070	<0.070	<0.070	<0.070	<0.070	<0.070	2 mg/L	2 mg/L	NA	<120 µg/L (short term); <2.4 µg/L (long term)		
Total Lithium (mg/L)	0.1	0.096	<0.080	<0.080	0.257	<0.080						
Total Boron (mg/L)	0.74	0.81	<0.30	<0.30	1.9	<0.30	0.5mg/L	0.75mg/L				
Total Strontium (mg/L)	0.353	0.346	0.148	0.141	0.615	0.12						
Total Molybdenum (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	NQ					
Total Nickel (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.04 mg/L	0.02 mg/L	NA	<470 µg/L (short	C	0.02

Location ref.	2023-01 (loc. 1)	2023-02 (loc. 2)	2023-03 (loc. 3)	2023-04 (loc. 4)	2023-05 (loc. 5)	2023-06 (loc. 6)	Philippines DENR Guidelines		Trinidad & Tobago Water Pollution Rules		Grenada Water Supply Quality Standards	
										term); <25 µg/L (long term)		
Total Antimony (mg/L)	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	NQ				C	0.005
DISSOLVED SOLIDS												
Total Dissolved Solids (TDS) (mg/L)	237.4	238	168.7	167.8	420.3	128.9			NA	NA		
Sulphate (mg/L)	<2.48	<2.48	<2.48	<2.48	<2.48	<2.48	250	275	<400 mg/L	<250 mg/L		
Sulphide (µg/L, S^{2-})	<1000	<1000	<1000	<1000	<1000	<1000						
Total Calcium (mg/L)	30.92	30.42	26.19	26.14	41.82	17.71						
Total Magnesium (mg/L)	12.97	12.89	17.41	17.25	16.87	11.53						
Total Potassium (mg/L)	5.16	5.06	3.56	3.41	9.94	<5.00						
Total Sodium (mg/L)	40.15	39.7	15.77	15.14	75.68	16.91			NA			
Bicarbonate (mg/L)	27.09	30.96	23.22	30.96	32.9	23.22						
Chloride + (mg/L)	39.7	39.7	75.15	39.7	39.7	39.7	250 mg/L	350 mg/L	NA	120-230 mg/L (long term); 640-860 (short term)		
Reactive Silica ^ (mg/L)	66.8	65.3	59.6	61.2	62.7	52			NA	NA		
PLANT NUTRIENTS												
Ammonia + (mg/L)	0.9	0.67	0.9	0.67	0.9	0.67	0.05mg/L	0.05mg/L	NA	<320 µg/L		
Nitrate + (mg/L)	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	7 mg/L	7 mg/L	<10 mg/L	<10 mg/L		
Nitrite (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01						
Phosphate (mg/L)	0.25	0.3	0.29	0.33	0.24	0.26	0.5 mg/L	0.5 mg/L	<0.5 mg/L	<0.5 mg/L		

Location ref.	**2023-01 (loc. 1)**	**2023-02 (loc. 2)**	**2023-03 (loc. 3)**	**2023-04 (loc. 4)**	**2023-05 (loc. 5)**	**2023-06 (loc. 6)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Total Organic Carbon (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50						
HYDROCARBONS AND ADDITIVES												
Total Petroleum Hydrocarbons (TPH) (mg/L)	0.97	6	1.85	1.56	2.2	1.41	NQ					
Benzene (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01 mg/L	0.05 mg/L	NA	<370 µg/L	C	0.001
Toluene (mg/L)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	1 mg/L	4 mg/L	NA	<2 µg/L		
Ethyl benzene (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.3 mg/L	1.5 mg/L	NA	<90 µg/L		
Xylenes (mg/L)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.5 mg/L	1.5 mg/L	NA	NA		
POLYAROMATIC HYDROCARBONS												
Naphthalene (mg/L)	0.000007	0.000009	0.000006	0.000014	0.000009	0.000007	NQ		NA	<1.1 µg/L		
Acenaphthylene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ					
Acenaphthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<5.8 µg/L		
Phenanthrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<0.4 µg/L		
Anthracene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<0.012		
Fluoranthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<0.04 µg/L		
Pyrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<0.025 µg/L		
Benzo(a)anthracene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<0.018 µg/L		
Chrysene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ					
Benzo(b,j)floranthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ				C	0.1 µg/L
Benzo(k)fluoranthene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ				C	0.1 µg/L

Location ref.	**2023-01 (loc. 1)**	**2023-02 (loc. 2)**	**2023-03 (loc. 3)**	**2023-04 (loc. 4)**	**2023-05 (loc. 5)**	**2023-06 (loc. 6)**	**Philippines DENR Guidelines**		**Trinidad & Tobago Water Pollution Rules**		**Grenada Water Supply Quality Standards**	
Benzo(a)pyrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	0.7 µg/L	1.5 µg/L			C	0.01 µg/L
Indeno (1,2,3-c,d)pyrene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ				C	0.1 µg/L
Dibenzo(a,h)anthracene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ					
Benzo(g,h,i)perylene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ				C	0.1 µg/L
Fluorene (mg/L)	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	<0.000004	NQ		NA	<3 µg/L		
Benzo(a)Pyrene Total Potency Equivalents (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.7 mg/L					
HARDNESS AND ALKALINITY												
Hardness (Calcium) (mg/L as $CaCO_3$)	95.7	78.8	65	65	104.9	44.1			NA			
Hardness (Magnesium) (mg/L as $CaCO_3$)	55.7	53.9	73.4	73	71.8	46.6						
Hardness (Total) (mg/L as $CaCO_3$) ^	151.5	132.7	138.9	138.1	176.7	90.7			NA	NA		
Alkalinity (mg/L as $CaCO_3$)	27.09	30.96	23.22	30.96	32.9	23.22			<20 mg/L	<20 mg/L		
DISINFECTANTS AND BY-PRODUCTS												
Chloroform (ppb)	<1	<1	<1	<1	<1	<1						
Bromodichloromethane (ppb)	<2	<2	<2	<2	<2	<2						
Dibromodichloromethane (ppb)	<2	<2	<2	<2	<2	<2						
Bromoform (ppb)	<2	<2	<2	<2	<2	<2						

Location ref.	2023-01 (loc. 1)	2023-02 (loc. 2)	2023-03 (loc. 3)	2023-04 (loc. 4)	2023-05 (loc. 5)	2023-06 (loc. 6)	Philippines DENR Guidelines		Trinidad & Tobago Water Pollution Rules		Grenada Water Supply Quality Standards	
Total Trihalomethanes (ppb)	<8	<8	<8	<8	<8	<8						
Total Calcium (mg/L)	30.92	30.42	26.19	26.14	41.82	17.71						
Total Magnesium (mg/L)	12.97	12.89	17.41	17.25	16.87	11.53						
Total Potassium (mg/L)	5.16	5.06	3.56	3.41	9.94	<5.00						
Total Sodium (mg/L)	40.15	39.7	15.77	15.14	75.68	16.91			NA			
Bromide (mg/L)	0.25	0.23	<0.10	<0.10	0.7	<0.10						
Fluoride (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	1mg/L	1mg/L				

B. Site C Phase 1 hydrogeological study

Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Phase 1 Hydrogeological Study

September 2023

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Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Phase 1 Hydrogeological Study

September 2023

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Executive summary

A preliminary (Phase1) assessment of the risk to groundwater receptors from project activities at Site C has been undertaken based on the available published information and site-specific survey data.

It is concluded that there is a highly permeable, shallow aquifer present in the study area, which feeds local springs. The well pad is located within the groundwater catchment area, upgradient (to the west) of the springs; consequently, there are potential risks to the springs and downstream receptors from project activities at the well pad. Key receptors that are fed by the shallow groundwater system include the Mt. Reuil Stream, springs feeding the Glenelg Springwater bottling plant and NAWASA surface water intake feeding the Mt. Reuil water treatment plant.

A risk assessment has been undertaken to determine the viability of groundwater pathways between project activities (the 'source') and sensitive receptors. This reflects the likelihood that a change in groundwater conditions at the source location would be transmitted to a receptor. It does not take into account the magnitude of that change at the source location, or the likelihood that it would occur. These factors are considered in the overall impact assessment, in the main ESIA report.

The risks are assessed to be high for groundwater quality, low for surface water quality, and low for groundwater level and spring discharge flow rates. The risk to all receptors from well drilling and testing, via the deeper, geothermal groundwater system, is assessed to be negligible.

A supplementary (Phase 2) investigation will be carried out to reduce uncertainties in the current hydrogeological conceptual model and refine the risk assessment. This will include additional water quality sampling, flow monitoring and data collation.

1 Introduction

1.1 Project Background

The Government of Grenada (GoG) has been investigating the potential for the use of geothermal energy as a source of utility-scale power for the island of Grenada. Following a series of preliminary, surface-based studies and investigations completed over several years, the Geothermal Energy Development Project is currently focusing on the exploratory test drilling phase (hereafter referred to as 'the Project'), to assess the potential geothermal resource at two sites in the vicinity of Mt. St. Catherine. Mott MacDonald Ltd. (Mott MacDonald) has been commissioned to undertake an internationally compliant Environmental and Social Impact Assessment (ESIA) to identify potential impacts of the project.

One of the proposed drilling sites (known as Site C) is located in Tricolar, close to two freshwater springs that supply a mineral water bottling plant operated by Glenelg Spring Water Inc. (Glenelg). Glenelg is a well-known supplier of mineral water in Grenada, and employs more than 60 people.

During an ESIA stakeholder consultation held in 2019, Glenelg raised a concern about the potential that exploratory drilling at Site C could negatively impact the water quality of the springs, which are the sole source of water upon which their business depends. Local people were also concerned about effects on water quality in general, and the public water supply intake for the Mt. Reuil water treatment plant (WTP), which is situated downstream of the springs. In response, this study has been commissioned by the GoG to investigate whether project activities pose risks to groundwater; and if so, how the risks may be mitigated.

1.2 Approach

The available information upon which to develop an understanding of the hydrogeological risks to the springs is currently very limited. The shallow geology of the site is uncertain. A comprehensive geotechnical (soils) investigation of the site will be undertaken, the findings of which will provide a better understanding of geological characteristics, but these findings are unlikely to be available within the timescale required to inform the ESIA. A staged approach to this hydrogeological study has therefore been adopted.

- The Phase 1 study (this report) presents a preliminary understanding of the groundwater system feeding the Glenelg springs, based on the available baseline data. The Phase 1 study has informed the impact assessment that is reported in the Water Resources chapter of the ESIA.
- The Phase 2 study will aim to present a more robust interpretation of the hydrogeological regime at Site C, so that the impact assessment may be updated. The Phase 2 study will be based on supplementary field survey data and reported in autumn 2023 alongside the Final ESIA.

1.3 Objectives

The objectives of the Phase 1 Hydrogeological Study are to:

- develop a preliminary understanding (conceptual site model) of hydrogeological processes and groundwater risks associated with drilling at Site C, with a particular focus on the Glenelg spring sources; and
- set out field survey requirements to inform the Phase 2 study.

1.4 Scope of Phase 1 Hydrogeological Study

This report presents the following key information:

- baseline data for surface water and groundwater receptors located within the Site C area of influence (AOI);
- a preliminary conceptual site model, drawing together all geological and hydrological data that are available to the project, to develop a hypothesis for groundwater flow in the site C catchment;
- a preliminary groundwater risk assessment, applying the source-pathway-receptor approach to identify potential pollutant linkages between project activities and groundwater receptors, including the Glenelg springs; and,
- recommendations for supplementary field investigations to substantiate the preliminary baseline and, confirm assumptions made in the phase 1 study.

1.5 Site location and study area

Site C is located on the north-eastern slopes of Mt. St. Catherine, in northern Grenada. The location of the Site C project area is shown in Figure 1.1.

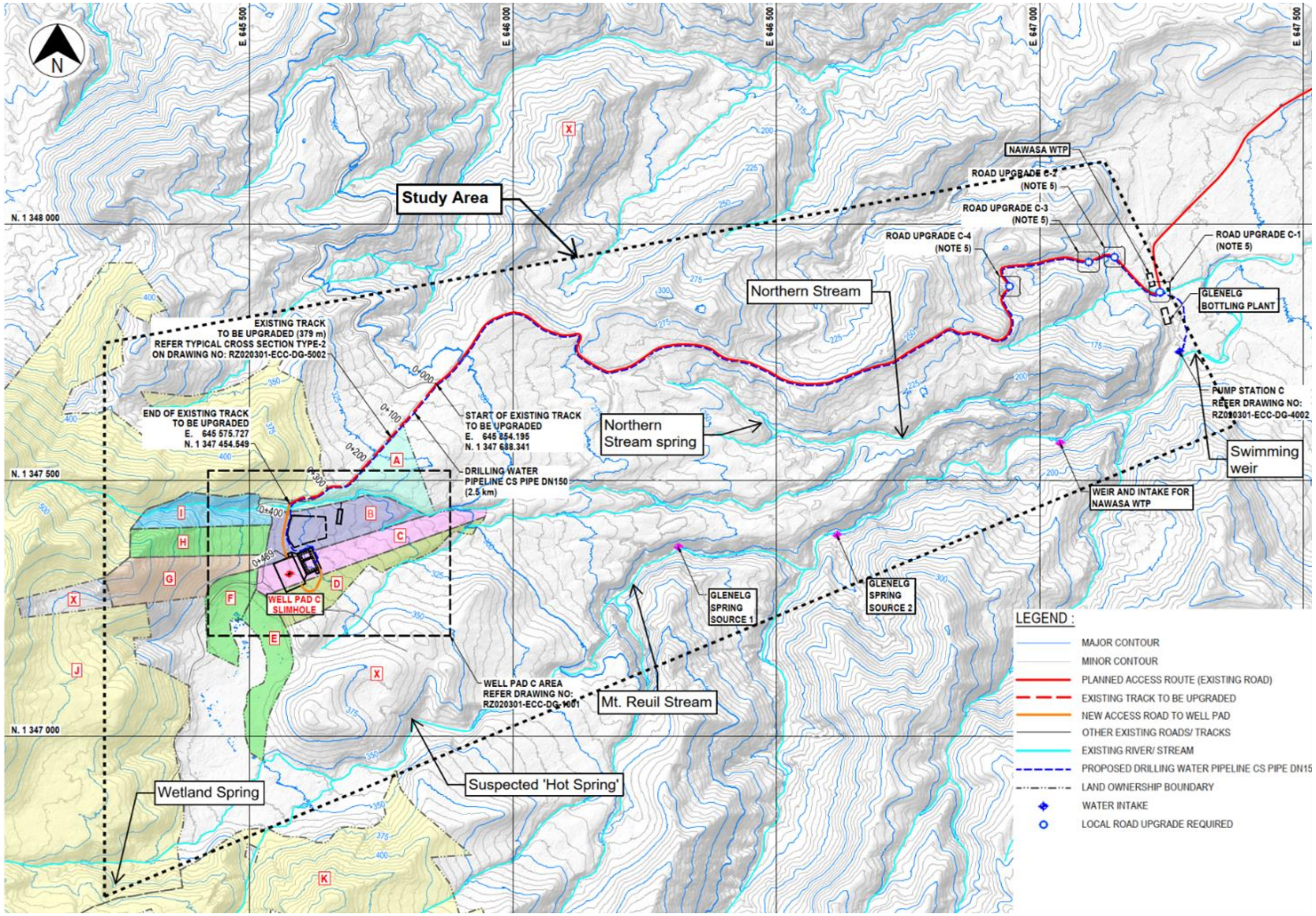
Figure 1.1: Site location

Source: OVERALL SITE LAYOUT RZ020301-ECC-DG-0004 Rev. A

The study area and key locations referred to in the text of this report, are shown in Figure 1.2. The Glenelg springs discharge into the southernmost stream (referred to hereafter as the Mt. Reuil Stream), which supplies the Mt. Reuil water treatment plant (WTP) at Mt. Rich.

The overall hydrogeological study (both phases) will focus on the area downslope from the Site C well pad. Based on current available information, this is thought to be underlain by permeable volcanic deposits and is the probable recharge area for the Glenelg springs.

Figure 1.2: Study area



Source: WELL PAD C AND ACCESS ROAD GENERAL ARRANGEMENT RZ020301-ECC-DG-0005 Rev.C

1.6 Sources of Information

The study draws on a wide range of published and project-specific technical references and datasets, provided by the following organisations:

- Government of Grenada (GoG) – Ministry of climate resilience, the environment and renewable energy (MCRERE)
- Grenada National Water and Sewage Authority (NAWASA)
- Glenelg Spring Water Inc. (Glenelg)

This is supplemented by field survey data, collected during 2019 and 2023 by Mott MacDonald and our sub-contractors, Eco-engineering. A full list of references can be found in Section 7.

1.7 Limitations

This assessment is based on information available at the time of writing. Geological information is limited, as ground investigations have not yet been undertaken within the study area. The assessment of potential impacts on groundwater is therefore qualitative and based primarily on professional judgment.

2 Project definition

2.1 Overview

The project is described fully in Chapter 2 of the Draft ESIA. This section describes key project components and activities that are relevant to this study of Site C.

The key project components to be constructed are:

- access roads (new ones and upgrade of existing ones);
- the well pad, (including drilling platform, laydown / storage area and ponds for drilling mud and water);
- the test well; and,
- water-supply infrastructure (including intake pumping station and pipeline).

The footprint of these key project components is referred to as the 'project area' within the Draft ESIA.

2.2 Key project activities

In order to develop a conceptual site model, it is necessary to understand how project components could interact with the water environment. Details of key activities are presented below.

2.2.1.1 Road upgrades

The existing earth tracks up to the well pad site are accessible by four-wheel drive vehicles and will require upgrading to account for the volume of traffic (truck-mounted drill rig, drilling materials, rig labour and supervisors) and the different seasonal conditions they must withstand . Construction works on the access roads should take approximately 1-2 months and will be completed prior to the drilling rig arriving in Grenada.

2.2.1.2 Well pad construction

The well pad layout plan is provided in Appendix A. The well pad will comprise a working area of 60m x 40m plus additional areas for mud and water ponds, spoil disposal areas and an additional laydown area of 55m x 30m. It will be constructed following the removal of vegetation, removal of topsoil material (approximately 200mm), cut and fill, grading and laying and compacting of the gravel surface. Earthworks activities will include the excavation of areas for a mud pond and water storage. No blasting will be undertaken during the construction works. Earthwork quantities are expected to be around 10,000 – 12,000 m^3 in total.

The well pad surface will be a compacted crushed rock pavement of typically 300mm thickness. Slimhole drilling does not typically require a special foundation to support the rig. However, a 1.2m deep concrete pit (cellar) will be constructed at the wellhead.

Adjacent to the well pad, the ponds will be designed with two compartments – one for drilling mud management and the other for drilling water storage. The ponds will be lined and protected from surface storm water inflow by ring ditches and will incorporate an earthworks berm around part of the perimeter. The site will incorporate appropriate drainage to accommodate heavy flows. The site preparation works will require approximately 10-15 workers.

2.2.1.3 Exploratory drilling

Drilling and installation of the single exploration well at this site is expected to take around 77 days. Slimhole continuous coring and drilling technology will be used. The drilling activities are undertaken using progressively smaller drill bits as the sections become deeper. Each diameter of the drilled borehole will be lined with steel casings, which serve several purposes, including:

- prevention of ingress or loss of fluid into or from the well;
- control of drilling fluids; and,
- maintaining the structure and integrity of the well itself.

Cement is pumped into the 'annular' space between the borehole and the casing. The final section of the well will incorporate a perforated liner (not cemented), which will allow geothermal fluid to flow up the well. After completion, a valve structure designed to prevent blowouts will be fitted to the wellhead.

A drilling supervisory firm would be responsible for the detailed design and planning of the well. The drilling will be performed using proven geothermal drilling methods and in accordance with internationally recognized engineering and safety standards. No hydraulic fracturing (fracking) techniques will be used. Preliminary drilling depths are provided in Table 2.1.

Table 2.1: Preliminary well design

Casing	Description
Drilling Method	Slimhole continuous coring
Conductor	13-3/8" outside diameter (OD) casing set at 4-6 m
Surface	**Casing**: 9-5/8" OD, set at 50 m. **Hole**: 12-1/4 " OD
Intermediate	**Casing**: 7" OD, set at 300 m **Hole**: 8-1/2" OD
Production	**Casing**: 4-1/2" OD, set at 650 m **Hole**: 6-1/8" OD
Liner	**Casing**: 3-1/2" OD, *NW* perforated liner set at 1500 m **Hole**: HQ core hole (3.98" OD)
Measured depth	1500 maximum measured depth (mMD)
Vertical depth	~1350 mVD
Inclination and throw at target depth	30° - Throw of approximately 500m

Source: (Jacobs, 2018b)

A significant activity in the drilling phase is the management of the drilling mud. Drilling mud serves many purposes, including as a lubricant that reduces the friction at the cutting bit, assists with transporting cuttings from the wellbore back to the surface, provides borehole stability and assists in keeping the well cool during drilling. The deeper parts of the well are usually drilled with plain water.

The mud is mainly composed of a slurry of bentonite clay and water and is theoretically recyclable and typically non-hazardous. Bentonite tends to form an impermeable filter cake, which means that as drilling passes through permeable layers, this benign material, due to swelling properties, tends to seal off the layer. It is therefore also used to prevent any contamination of voids, and aids in partial sealing. It is likely that the mud will also contain other additives such as surfactants that change its viscosity and surface chemistry.

For the preparation of the drilling mud, the water pH is raised to approximately 10-11 by addition of sodium hydroxide at the rig tanks. The remainder of the additives are also added and mixed in these tanks prior to being used for drilling.

Cuttings from the well will be separated from the drilling fluid at the shale shakers on the rig and fall into a pit/container. From the pit, the cuttings will be removed via a back-hoe to the spoil disposal area. From here, the cuttings may be transported off-site to waste facility or stored for re-use during decommissioning. The residual fluid will gravity flow from the wellhead pit to the mud pond, either by a covered trench/ditch or a buried pipe.

Drilling mud and drilling cuttings from geothermal drilling (which are separated using air/aerated fluid or water-based substances), are typically not classified as hazardous waste. However, continuous daily sampling and laboratory testing of drill mud and drilling cuttings are undertaken as a standard precautionary measure on geothermal drilling sites (the drilling contractor is required to maintain a fully-resourced sampling and testing lab on the site for this purpose). If testing indicates that the drill mud and drilling cuttings material is classified as a hazardous waste, it shall be handled and stored (temporarily) and ultimately disposed of off-site by a licensed hazardous waste operator to a licensed hazardous waste management facility. Cuttings classified as non-hazardous have been used for local roading material on past projects or could be spread on site.

2.2.1.4 Well testing

Once drilling is complete, the characteristics of the well need to be tested. This process is expected to take around 30 days.

A well completion test will be undertaken once the production liner is in place, to assess the permeability of the well. This usually comprises an injectivity test, by pumping water at a range of pumping rates whilst monitoring the downhole pressure and temperatures, followed by a pressure fall off test. These tests give an indication of the likely productivity of the well.

During testing, the well will be discharged for a sufficient period to determine well productivity (stabilised conditions) and estimates of likely well run-down over time. The well will be discharged into a separator that will enable measurements of flow and enthalpy. Discharge chemistry will be monitored throughout the discharge test to ensure fluid is non-corrosive and to track clearing of drilling fluids. Discharge water, gas and stable isotope samples will be collected under stabilised conditions.

During the well completion test, the two-phase geothermal fluid from wells travels to a silencer structure where it is flashed to ambient conditions. The design structure of the silencer is such that not only is the noise level reduced but some of the steam condenses to form boiling hot water (geothermal brine). This brine may contain many different naturally occurring minerals, but especially silicates, that crystalize as the temperature drops. This fluid will pass from the silencer and is then piped to the sump.

Drilling residues would be tested and, the drilling contractor is required to have in place a handling and disposal plan for any hazardous components that may be identified.

2.2.1.5 Site closure

Due to the characteristics of the exploration phase, as the results can only be established at the end of the phase, two alternative site closure activities are defined.

a. In the case that exploratory results are found to be favourable, preparation for the next stage of the project would occur. The wellhead will be secured and monitored.
b. In the case that exploratory results are not favourable, decommissioning and abandonment of the well will occur.

At the end of the exploratory drilling phase, all temporary equipment, and temporary facilities at the platform sites (machinery, warehouses, temporary offices, portable latrines), will be dismantled and removed. The area will be cleared of materials and wastes generated during the drilling process.

If the exploratory results are not successful, and the development of the geothermal source is not considered feasible, then the following site restoration activities will be implemented:

- site earthworks and access roads will remain as constructed;
- the pumping station will be decommissioned and removed;
- sumps will be decommissioned by filling in (for safety reasons – some of the well pad base-course pavement can be used for this fill) and water supply pipelines removed;
- topsoil will be spread on the remaining well pad area, which will be allowed to re-vegetate naturally;
- fencing will be removed; and,
- the wellhead will be plugged and abandoned (P&A) below ground level. A nameplate will be installed on the surface for the record and future reference.

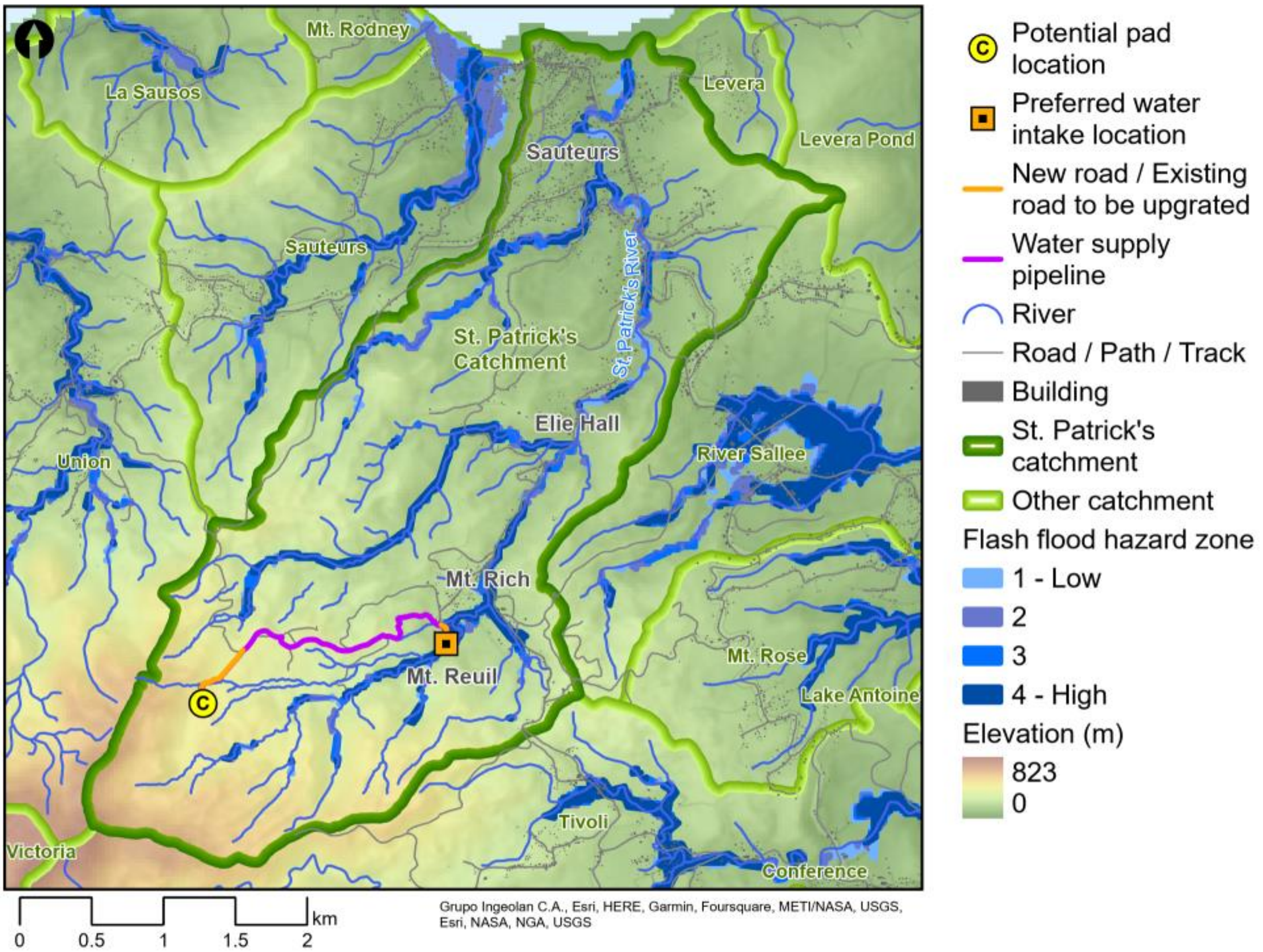
3 Site setting and baseline

3.1 Hydrological setting

3.1.1 Overview

Site C is situated on the north-east slopes of Mt. St. Catherine, within one of three headwater catchments of the St. Patrick's River catchment (1,253 ha), which drains towards Sauters and Irvine's Bay on the northern coast (see Figure 3.1). The study area is situated within the central headwater catchment, which drains north-eastward through Mt. Rich, where it is joined by a tributary from the south. The river then flows north, through Elie Hall, where it is joined by a tributary from the west.

Figure 3.1: St Patricks watershed map with flood hazard zones



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Source: Flood hazard zones taken from the Caribbean Handbook on Risk Information Management, 2016

As shown on Figure 3.1, Site C is located between, and drains towards, two small streams, which converge to form a small tributary of the Mt. Reuil stream. The tributary joins the Mt. Reuil stream downstream of the NAWASA water supply intake at Mt. Reuil. The two streams may need to be diverted around the site dependant on final design.

Key water features in the study area are shown on Figure 3.2 and described below.

- The main watercourse to the south of the wellpad, referred to herein as **Mt. Reuil Stream**, originates to the south-west of Site C and flows north-eastward through Mt. Rich.
- The wellpad would be located between two drainage channels, which converge with a small tributary of the Mt. Reuil Stream, referred to herein as the **Northern Stream**.
- There is a wetland basin slightly down-slope and to the south-west of Site C. This is fed by a small spring used for irrigation **(Wetland spring)**, and drains southwards to the Mt. Reuil stream.
- The **Glenelg springs** are located approximately 0.6 km (Spring 1) and 0.9 km (Spring 2) to the east of the wellpad, and discharge into Mt. Reuil Stream.
- Anecdotal evidence indicates that there is a 'hot spring' on Mt. Reuil Stream, approximately 0.3 km south-east of the well pad, although no firm information regarding this has been reviewed.

3.1.2 Mt. Reuil Stream and water intake

- Mt. Reuil Stream has a permanent flow so is thought to be spring-fed in its upper reaches, in the high ground to the south-west of the project area. It is unlikely to receive any surface runoff directly from the well pad but is the receiving water for discharges from the hot spring, Glenelg springs and Northern Stream.
- The public water supply intake for Mt. Reuil water treatment plant (WTP), operated by NAWASA, is situated immediately upstream of the confluence of Mt. Reuil Stream with the Northern Stream. The intake comprises a concrete dam and inlet structure, which impounds the water level approximately 2m above the downstream level, as shown in Figure 3.2.

Figure 3.2: Mt. Reuil dam and water intake

Source: Mott MacDonald

The pool upstream of the dam contains crayfish and is used for fishing. Approximately 300m downstream of the dam an informal weir has been constructed to create a swimming pool, used by local residents.

3.1.3 Northern Stream

Project mapping indicates that the well pad is situated between two channels that converge and then flow into the Northern Stream, approximately 1 km downstream of the well pad site. During the March 2023 survey visit these channels were dry, but a small flow was observed in the Northern Stream (see Figure 3.3), issuing from a spring in the side of the valley. The Northern Stream enters the Mt. Reuil Stream downstream of Mt. Reuil Dam, and upstream of the informal swimming weir.

Figure 3.3: Northern stream

Source: Mott MacDonald

3.1.4 Wetland spring

The wetland spring is located approximately 400m to the southwest of the well pad site and emerges from the hillside at an elevation of approximately 400 m ASL. The stream flows approximately 100 m eastward, to a small pool that is protected by a stack of boulders and discharges from a pipe, as shown in Figure 3.4. The water flows to a low-lying wetland area within the crater, which is used (in places) for the cultivation of crops such as cabbage, green peas and banana, and discharges to the Mt. Reuil Stream. Water levels are held artificially high by a drystone retaining wall, situated to the southeast (see Figure 3.9).

During the dry season months (January to May), water levels are somewhat low, but not low enough to affect use. Local farmers use the water for drinking water and domestic purposes, and report that is not known to ever have dried out.

Figure 3.4: Wetland spring

Source: Mott MacDonald

3.1.5 Glenelg springs and bottling plant intake

The Glenelg springs issue from the northern side of the Mt. Reuil Stream valley (a steep sided ravine), approximately 5 m above the level of the stream bed. A portion of their flow is captured and piped to the Glenelg bottling plant at Mt. Reuil, where the water is tested and packaged for distribution.

Figure 3.5 shows photographs taken of the spring sites during a site visit by Jacobs and representatives from GOG and Glenelg on 25 September 2019.

Figure 3.5: Glenelg upper (left) and lower (right) spring collection tanks and gravity feed pipework

Source: Mott MacDonald

At both locations, a small concrete spring box (collection tank) has been constructed at the spring source near the geological contact in the rock exposure, several metres above the foot of the ravine. The water is piped directly to the bottling facility downstream, via gravity fed pipes. At the time of the visit there were several springs at the upstream location (Spring 1) that were not being captured and were flowing down the rock face, into the Mt. Reuil Stream. At the downstream location, the majority of the spring waters were being captured.

Glenelg reported that they control flow to the plant using valves at the capture area. If the full spring flow is not required at the bottling plant the valves are closed, causing the spring water to discharge into the watercourse.

3.1.6 Hot spring

No information relating to the hot spring is available at this stage, other than its reported location (annotated on a map). Its temperature is unknown and there are no visual or olfactory observations to indicate whether the discharge has a significantly different chemical composition to meteoric water. It is thought to emerge immediately adjacent to the volcanic dome (the circular hill visible in Figure 3.9), at an elevation of approximately 340 m ASL, which is notably higher than the Glenelg springs discussed above.

3.2 Hydrology

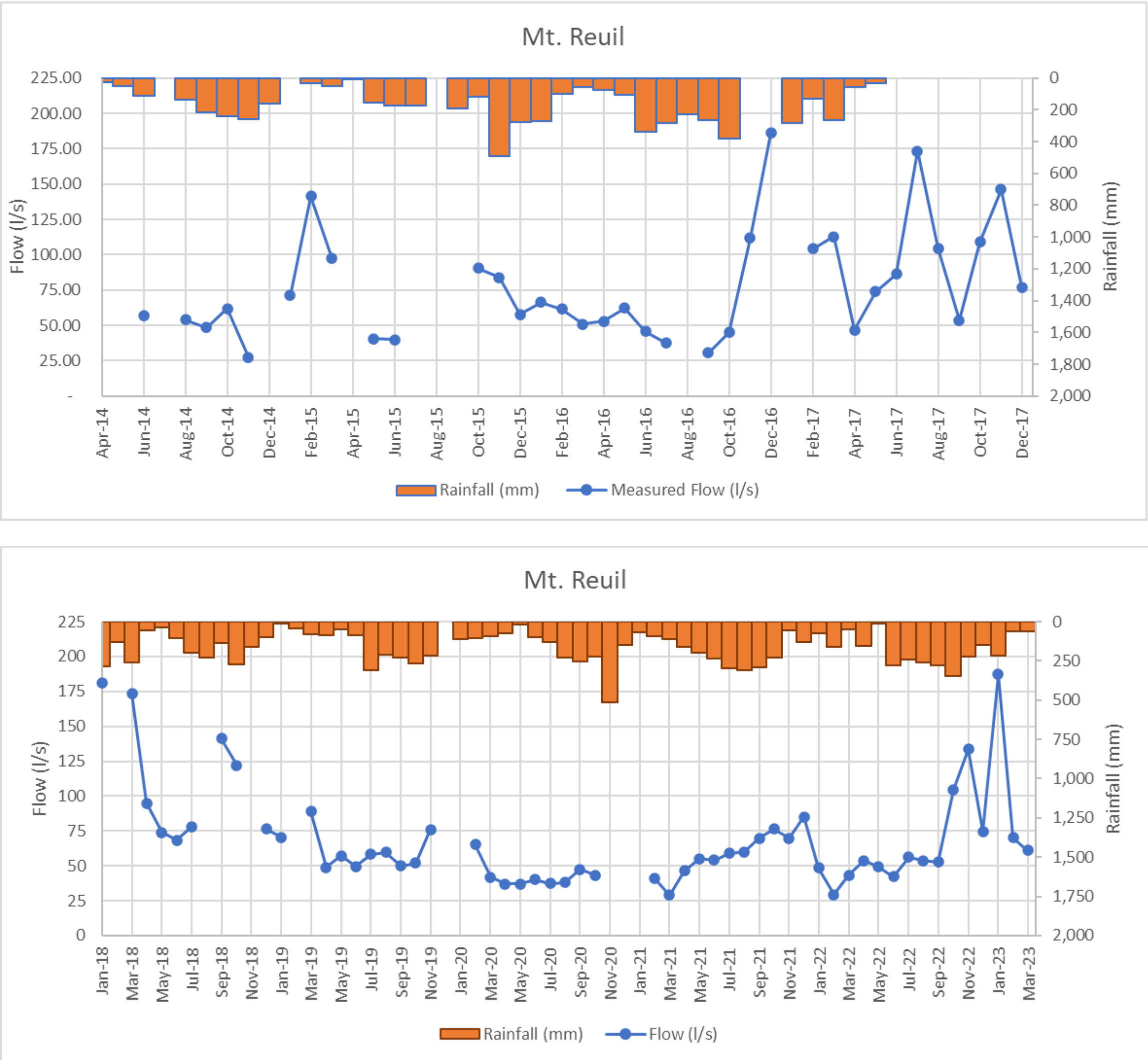
Rainfall and river flow data for the project area are presented in Figure 3.6, measured at Mt. Reuil WTP and river intake. These are broadly consistent with the regional wet and dry seasons, which run from July to December and January to June respectively.

Mean annual rainfall measured at Mt. Reuil WTP is 1,990 mm for the calendar years 2018 – 2023 and monthly totals range from 0 – 500 mm. The WTP is located at an elevation of approximately 140 m ASL, at the bottom of the Glenelg springs' catchment. Rainfall in the source area for Glenelg springs is likely to be higher (3,000 – 4,000 mm), due to the greater altitude (Caribbean Environmental Health Institute, 2006).

Monthly evapotranspiration for the study area has been estimated to vary between 50 – 100 mm, and there are two or three months each year when this exceeds the total rainfall.

Flow data for Mt. Reuil Stream indicate that dry season flows are generally sustained at around 30 to 40 l/s, which may be due to the contribution from groundwater springs.

Figure 3.6: Instantaneous flow and total monthly rainfall for Mt. Reuil monitoring station



Source: Prepared by Mott MacDonald based on information provided by NAWASA

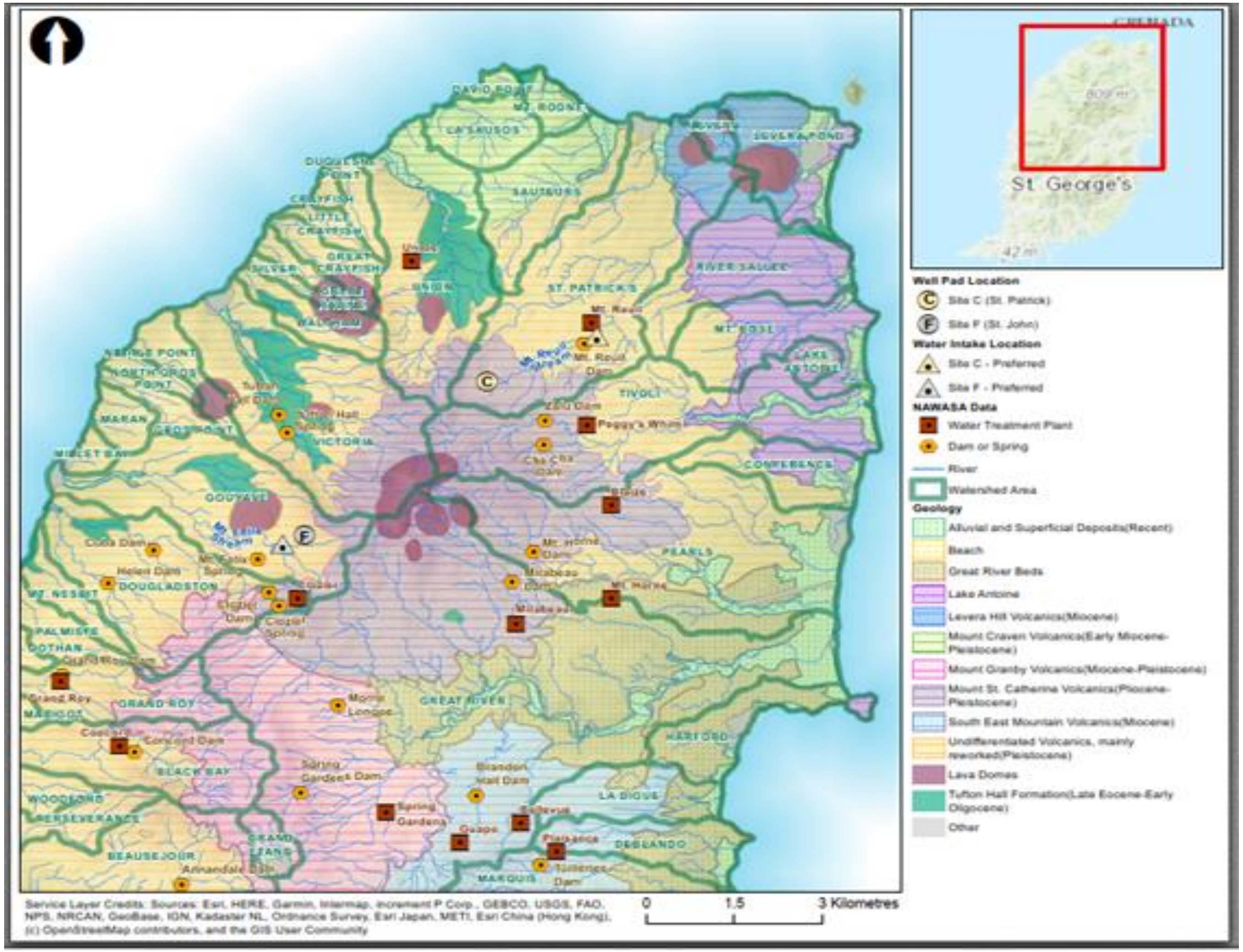
3.3 Hydrogeological setting

3.3.1 Regional geology

The dominant geology of Grenada is volcanic deposits of varied age and nature, overlying a sedimentary basement. The lithology of the interior is dominated by lava and pyroclastic flows and the lithology of the coastal deposits are dominated by "reworked" volcanic rocks, including fluvial and mudslide deposits. This accounts for the eastern side's gentle downwards slope towards the sea. The western side of the island is steeply contoured with deep valleys, due to the asymmetric historic eruption to the west. The southern part of the island is characterised by long, narrow bays, that cut into the sedimentary and volcano-sedimentary deposits.

In the Mt St Catherine area, a layer of volcanic rocks approximately 800m thick lies upon a sedimentary layer known as the Tufton Hall Formation. The volcanic rock types (basanitoid, alkaline basalt, subalkaline basalt, andesite and dacite) overlying the Tufton Hall formation are the result of five volcanic activity episodes between the lower Miocene and Pleistocene (the North Domes, South East, Mt. Maitland, Mt. Granby-Fedon's Camp, and Mt. St. Catherine, the highest of the major peaks). Mt. St. Catherine has a Pleistocene age and is characterised by three large craters, open on the southern, western and eastern sides with diameters of 1.2km. Thermal features are present in the northern and central parts of the island, and include bubbling pools and hot springs at elevations between 20 and 560m ASL. Based on geological mapping, Site C is located in an area of Mt. St. Catherine volcanics.

Figure 3.7: Geology map of Northern Grenada



Source: Mott MacDonald GIS developed from public sources

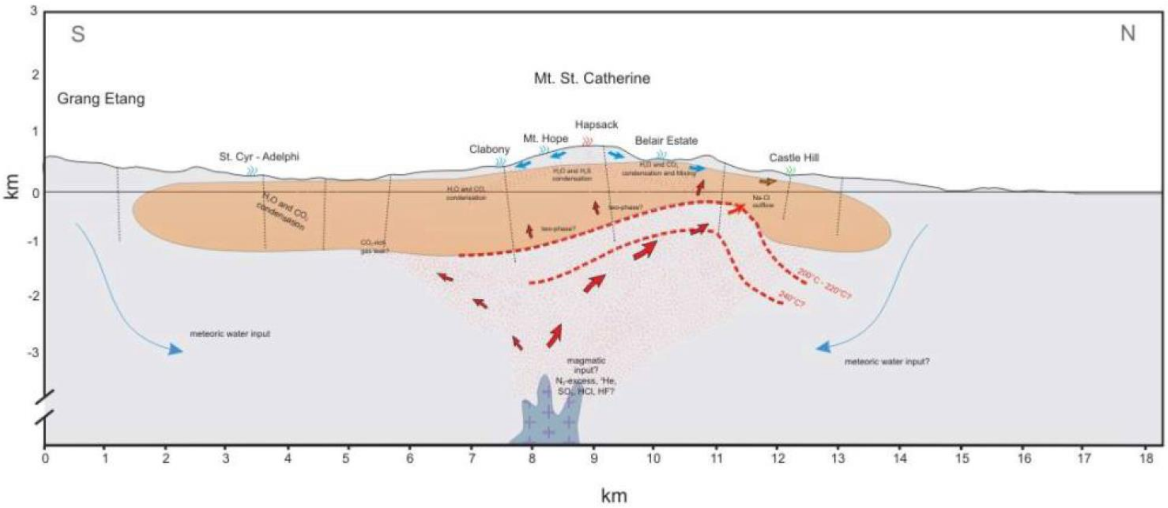
3.3.2 Regional hydrogeology

Jacobs (Jacobs, 2016) suggest that, based on geochemical studies, a shallow aquifer may be present within the project area, fed by infiltrating rainfall, which dilutes geothermal fluids emerging at the surface. This is evidenced by the presence of freshwater and thermal springs at altitude.

The hydro-geochemical conceptual model for the geothermal resource suggests that fresh groundwater would be present between approximately 100 to 250m below ground level at the drill sites, separated from underlying geothermal fluids by a thick layer of low permeability, hydrothermal clay, with a transitional, brackish zone at the base of the aquifer.

An associated geophysical study suggests this aquifer would be present at 50 to 100 m below ground level (BGL) at Site C (Jacobs, 2018c), which translates to an estimated groundwater elevation of 255 to 355 m ASL. This is illustrated in Figure 3.8, below.

Figure 3.8: Conceptual model of northern Grenada groundwater system, based on results of geophysical study.



Source: (Jacobs, 2018c). Note: Clay cap is denoted by orange fill.

3.3.3 Site C geology

Geological mapping indicates that the westernmost part of the study area (above 325 m ASL) is underlain by Mount St. Catherine Volcanics of Pliocene-Pleistocene age. To the east are Undifferentiated Volcanics, mainly reworked, of Pleistocene age.

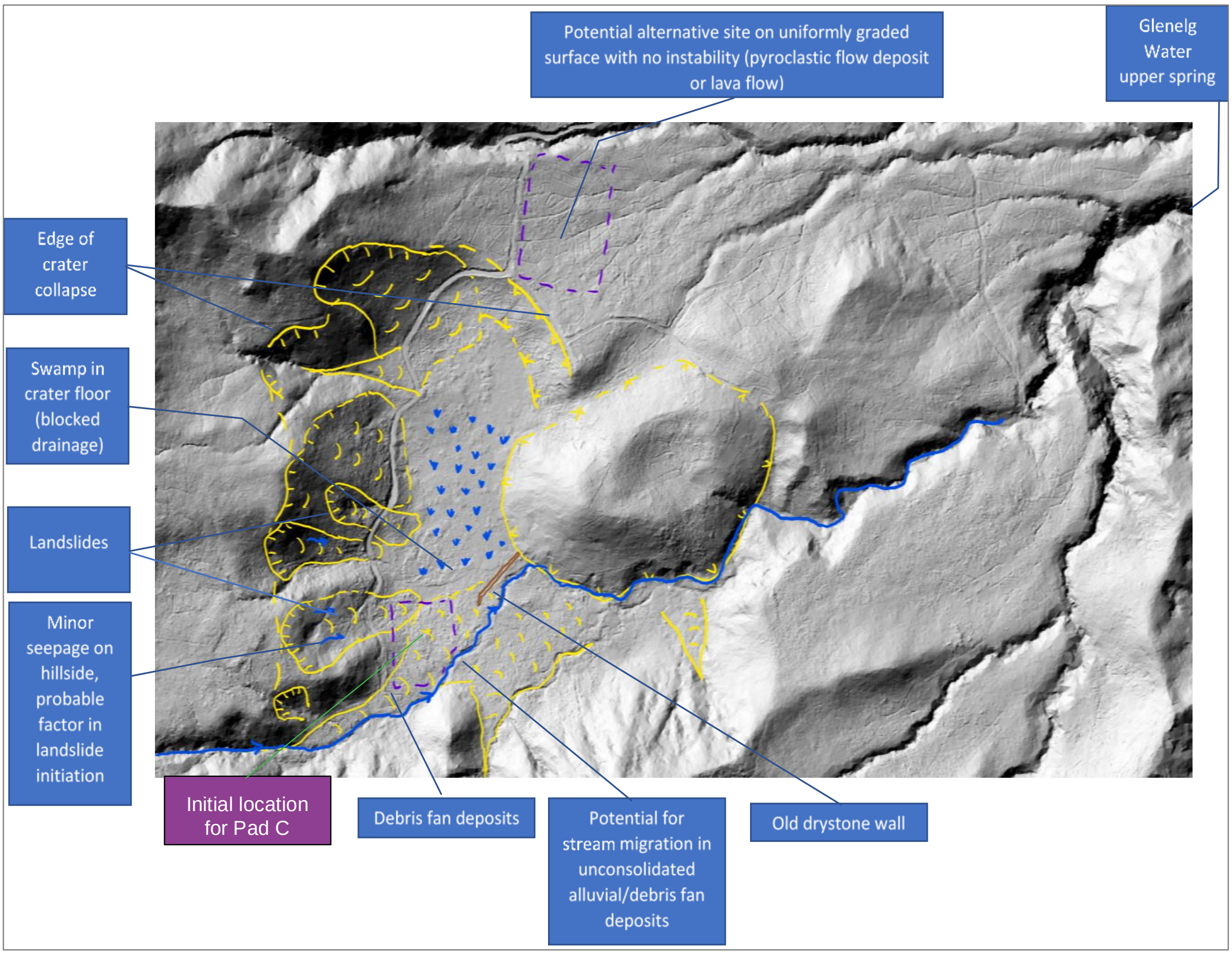
The site initially proposed for the wellpad was located on the south side of the wetland basin, adjacent to Mt. Reuil stream. The feasibility of drilling at this location was assessed during a site visit undertaken by engineers from Jacobs in September 2019. The initial location for the wellpad was rejected for geotechnical reasons, in favour of the current proposed site, which is situated on higher ground, to the north of the wetland basin.

The geology of the study area and observations regarding the springs are described in the *Site Visit Report for Design of Civil Infrastructure* (Jacobs, 2019) as follows, with reference to Figure 3.9. At the initial wellpad location:

"there is evidence of historical landslides and active shallow instability on the hillside directly to the West of the site. Water seepage is evident on the hillside above the wellpad, indicating high groundwater or poor drainage, which is a major contributing factor to the landslides. The wellpad location is predominantly located on a slightly undulating and low-lying

debris fan emanating from the narrow valley to the west. The debris fan deposits are unconsolidated bouldery deposits. Groundwater level is very shallow. The stream is currently eroded into the debris fan deposits and has the potential to migrate laterally over time. It appears that the debris fan may be deposited over previous soft alluvial deposits and marginal areas of swampy ground."

Figure 3.9: Geological setting at Drilling Site C



Source: (Jacobs, 2019)

3.3.4 Site C hydrogeology

Springs are known or suspected to be present at the locations and elevations given in Table 3.1. The well pad elevation is approximately 355 m ASL.

Table 3.1: Location and elevation of known springs

Spring reference	Elevation (m ASL)	Easting	Northing
Wetland Spring	400	645255	1346935
Hot spring (suspected)	340	645817	1347026
Glenelg Spring 1 (upper)	225	646314	1347364
Glenelg Spring 2 (lower)	200	646608	1347395
Northern Stream spring	400	645255	1346935

Note: UTM coordinates. All locations and elevations are approximate.

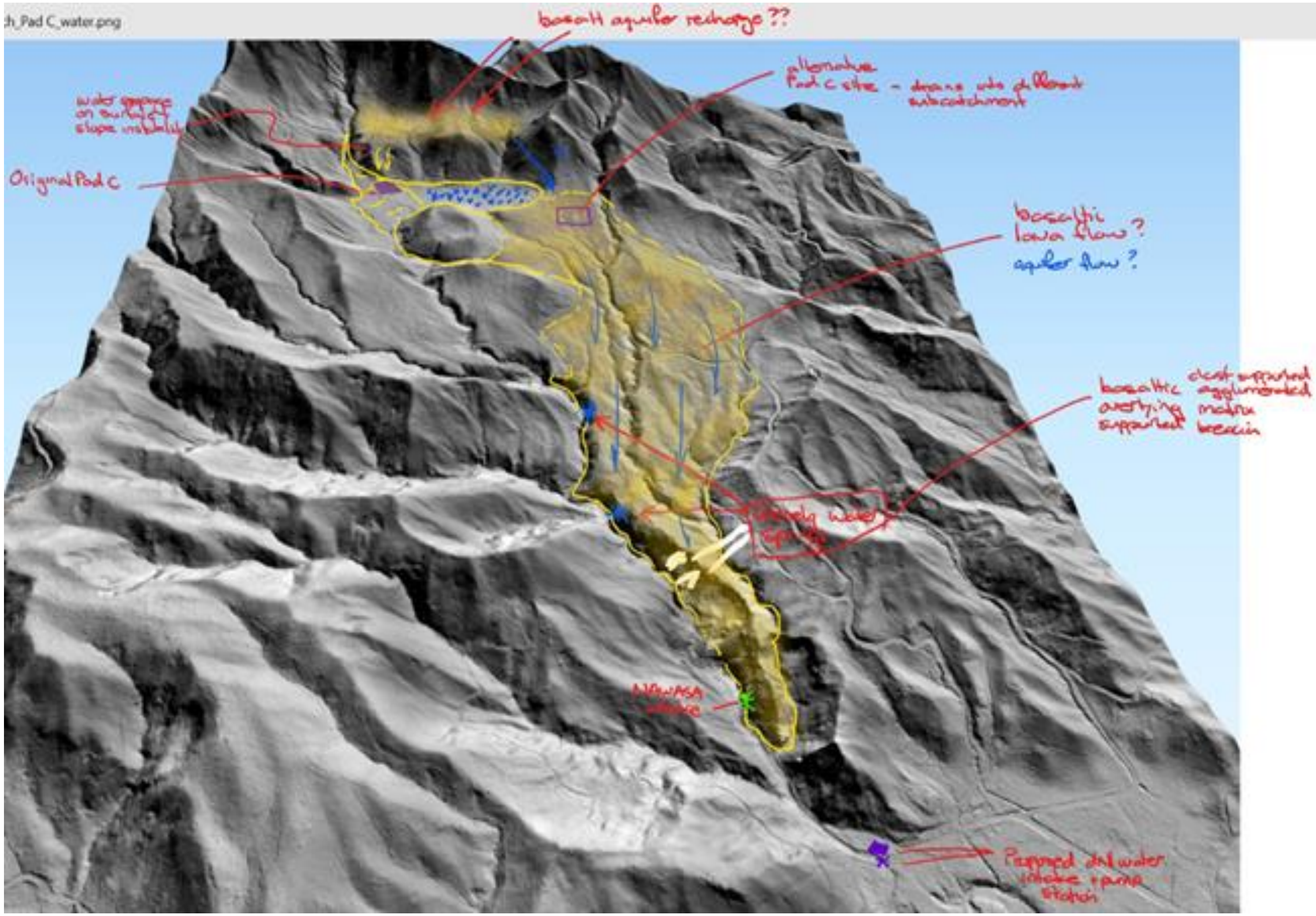
The Glenelg springs were visited by Jacobs during September 2019, who reported the following observations (Jacobs, 2019).

“It was observed that the springs exit the ground at a boundary of highly permeable, clast supported basalt agglomerate layer, overlying a relatively impermeable, finer grained, matrix supported volcanic breccia. The springs occur where this boundary daylights in the deeper incised river valley.”

Figure 3.10 illustrates the geological model developed by Jacobs for the study area. This highlights the potential recharge area supplying the springs in yellow, which indicates:

“the rough extent of a basalt lava flow which could be acting as the main aquifer source for the spring water. It is not sure where this is recharged from, but likely further up the mountain side. A younger crater collapse feature and small dome have interfered with the western edge of it at the Pad C site. This also may be the source of some of the water seepage feeding the swampy area around Pad C.”

Figure 3.10: Geological model



Source: (Jacobs, 2019)

3.4 Water quality

Surface water samples have been collected from several locations within the study but not from the Glenelg springs themselves. The available water quality data are reported in the Chapter 9 of ESIA. In summary, water quality is generally good but faecal coliforms, indicative of sewage contamination, were present throughout the study area.

4 Preliminary hydrogeological conceptual site model

4.1 Conceptual site model

The available evidence suggests that meteoric water percolates down through a highly permeable basalt lava flow until it reaches a low permeability layer (known as an aquiclude), whereupon it flows laterally to emerge at the Glenelg springs.

Field observations indicate that the aquifer material comprises a "clast supported basalt agglomerate[1] layer" and that the overlying debris fan deposits are poorly consolidated. This material is likely to be highly permeable, with a hydraulic conductivity[2] possibly as high as 10^2 – 10^4 m/d (the range for vesicular[3] and scoriaceous[4] basalt (Brassington, 2017)). In this case, the residence time for groundwater would be very short (days to weeks) and its chemical composition is unlikely to be significantly different to rainwater.

The elevation of the Glenelg springs is 200 to 225 m ASL. The Northern Stream appears to originate from a spring situated directly to the north of the Glenelg springs, at a similar elevation of 225 m ASL. This suggests that the low permeability material may extend laterally northward, which would be consistent with the expected stratification of volcanic deposits at this location.

The aquifer therefore appears to cover the area between the Mt. Reuil Stream and Northern Stream. Assuming that the base of the aquifer is sub-horizontal and the eastern extent can be defined by the 220 m contour; and that the western boundary is defined by the edge of the crater collapse (adjacent to the well pad – see Figure 3.9), the aerial extent of the aquifer would be approximately 0.5 km^2. If the crater area containing the wetland and landslides to the west is included, the area would be 0.6 km^2.

No borehole data are available, so the thicknesses of the volcanic strata are unknown. However, the aquifer thickness, estimated from the spring elevations and topographic contours, may be in the order of 125 m in the west, tapering to 25 m in the east.

Groundwater flow within the study area is likely to be generally eastward, veering towards the deeper valleys where springs are located. An east-west oriented groundwater divide may be present through the centre of the study area, if the permeability distribution is relatively homogeneous. However, this may not be the case if channel or tubular features formed during deposition of the lava flow are present, which would provide preferential groundwater flow pathways and thus control the location of springs.

A further groundwater divide is likely to be present to the north of the existing road, at the northern boundary of the study area. To the north, groundwater flow is likely to be northward, feeding springs that ultimately flow into the Elie Hall tributary of the St. Patrick River.

It is assumed that there must be a flow of geothermally heated water from the 'hot spring'; but without further information, it is not possible to speculate with any confidence on the origin of

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[1] Agglomerate: coarse pyroclastic material ejected from the volcano.

[2] Hydraulic conductivity: a measure of how easily water may travel through a rock mass. For comparison, the hydraulic conductivity of unconsolidated sand and gravel is typically lower than for scoriaceous basalt, in the order of 10 - 10^3 m/d.

[3] Vesicular: containing small cavities formed by bubbles when the rock solidified.

[4] Scoriaceous: formed from vesicular pyroclastic material or froth on the top of a lava flow.

this water. Possibly, it is fed by a deeper groundwater system that is hydraulically isolated from the shallow system described above.

4.2 Assumptions and uncertainties

The preliminary conceptual model is based on limited information and necessarily relies on several key assumptions:

- The base of the shallow aquifer is sub-horizontal, with an eastward gradient
- Recharge occurs across the whole area between the Mt. Reuil Stream and Northern Stream

Key uncertainties in the preliminary conceptual model are outlined below.

- The chemical composition and flow rate of the spring discharges are unknown.
- The spring water is considered likely to be meteoric in origin, that has passed through the shallow lava deposits with a short residence time. However, this is unconfirmed, and it is possible that there is a geothermal component, originating at depth.
- It is unclear whether or not the wetland area within the volcanic crater is part of the groundwater catchment. The edge of the crater collapse (shown in Figure 3.9) may form a barrier to groundwater flow, such that all precipitation flows into the crater bowl drain to the Mt. Reuil stream.
- The thickness and extent of the aquifer are unknown and it is unclear what the lithological controls on groundwater flow are.

5 Preliminary groundwater risk assessment

5.1 Methodology

A source-pathway-receptor model has been applied to determine potential effects of the scheme on potential receptors. For the project to affect a receptor, there must be a viable pathway between the source and receptor. For the purposes of this study, these components broadly comprise the following:

- Potential source: project activities within the study area
- Potential pathway: groundwater flow, as described by the hydrogeological conceptual model
- Potential receptor: groundwater springs within the study area

Effects on groundwater in the immediate vicinity of the well pads could include:

- changes to groundwater quality (due to release of pollutants or particulates) or
- changes to groundwater level and spring discharge (due to physical changes within the aquifer, affecting groundwater flow rate or flow direction).

The magnitude of these changes at a receptor will be partly dependent on the length and nature of the pathway. The magnitude will typically decrease with distance from the source of the effect. For example, contaminants will usually be diluted as they travel down-gradient and effects on groundwater level will dissipate with distance from the source, as the proportion of total flow derived from the wider catchment increases and other, nearer influences predominate.

This section identifies the potential sources and receptors, and considers the viability of pathways between them based on the conceptual site model discussed in Section 4. Risk is assessed qualitatively (from 'High' to 'Negligible'), using professional judgement.

It is important to note that the risk assessment only reflects the likelihood that a change in groundwater conditions at the source location would be transmitted to a receptor. It does not take into account the likelihood that a particular activity would cause a change at the source location or, the magnitude of that change. These factors are considered in the overall impact assessment, in the main ESIA report.

5.2 Sources

Activities that have the potential to impact on groundwater receptors at different stages in the project have been identified from the project definition (see section 2.2) and are presented in Table 5.1 below. These activities are concentrated in two distinct areas:

- along the existing road at the northern boundary of the study area; and
- at the well pad.

Table 5.1: Potential impacts on groundwater prior to mitigation

Potential change	Project phase	Activities	Key issues and potential impacts prior to mitigation
Reduced groundwater quality	Construction Decommissioning	Road upgrades, well pad construction and site closure.	There is potential for fuel or chemical spillages to migrate through the soil zone and pollute shallow groundwater (if present), which may then enter surface watercourses via springs.
	Operation	Exploratory drilling and well testing	There is potential for spillages of fuel, chemicals or drilling / testing fluids onto ground to pollute shallow groundwater (if present), which may then enter surface watercourses via springs. Particulates could be released during drilling or well construction, affecting water clarity (turbidity). Pollution of deeper groundwater may occur due to potential release of contaminants, drilling fluids or geothermal fluids during drilling.
Effects on groundwater level and spring discharge	Operation	Exploratory drilling and well testing	There is potential for groundwater level and spring discharge rates to be affected during drilling and testing, if existing shallow groundwater flow pathways are disrupted (as a result of grout placement or pressure changes within the aquifer, for example). Such effects could be temporary or long term but are difficult to predict, given the complexity of the shallow geology and limited geological information that is available.

5.3 Receptors

Receptors that could potentially be affected by any effects the project may have on groundwater have been identified from the baseline hydrological and hydrogeological setting, described in section 3. These are:

- Springs in the near vicinity of the well pad (including the Wetland Spring);
- Glenelg Springs and bottling plant intake;
- The spring feeding the Northern Stream;
- The Mt. Reuil Stream and intake for Mt. Reuil WTP; and
- The Mt. Reuil Stream downstream of the Northern Stream confluence.

5.4 Pathways

The conceptual site model has identified the following potential pathways for the transmission of groundwater effects to receptors:

- groundwater flow within the shallow basalt lava aquifer; and,
- geothermal groundwater within a deep aquifer.

Table 5.2 shows which sources and receptors are potentially linked by these pathways and what type of effects could potentially be transmitted. The viability of these pathways and the associated risk is discussed below, in Section 5.5.

Table 5.2: Potential groundwater pathways

Pathway	Source	Direction from Source to Receptor	Primary Receptor	Secondary Receptor	Potential effects
Shallow Pleistocene agglomerate aquifer	Road upgrades	South	Northern Stream spring	Mt. Reuil Stream downstream of Northern Stream confluence	Groundwater quality
	Well pad construction and site closure	East	Northern Stream spring	Mt. Reuil Stream downstream of Northern Stream confluence	Groundwater quality
		East	Glenelg Springs and bottling plant intake	Mt. Reuil Stream and WTP intake	Groundwater quality
	Exploratory drilling and well testing	East	Northern Stream spring	Mt. Reuil Stream downstream of Northern Stream confluence	Groundwater quality, level and spring discharge
		East	Glenelg Springs and bottling plant intake	Mt. Reuil Stream and WTP intake	Groundwater quality, level and spring discharge
		South-west	Wetland spring	Mt. Reuil Stream and WTP intake	None
Deep geothermal groundwater system	Exploratory drilling and well testing	South-east	Hot spring	Mt. Reuil Stream and WTP intake	None

5.5 Risk assessment

The risk that receptors will be affected by changes in groundwater conditions at the source is assessed using professional judgment, based on the information currently available.

Deep geothermal groundwater pathway

The existence of the hot spring is not confirmed and no information regarding the discharge is available. In the absence of such information, it is assumed that the discharge is not significant (in terms of volume or water quality) compared with overall flow in the Mt Reuil Stream. Furthermore, it is assumed that well drilling and testing at over 650 m below ground is unlikely to affect any minor hot spring discharge. The risk to the hot spring, if present, is therefore assessed to be negligible.

All the available information suggests that the other identified receptors are fed by the shallow aquifer and there is no indication that this is connected to any deeper, geothermal groundwater system. In any case, it is considered unlikely that any effects of well drilling and testing at over 650 m below ground would be observable at or close to the surface. The risk that that well testing could affect any of the other identified receptors is therefore assessed to be negligible.

Shallow groundwater pathway to Wetland Spring

The Wetland spring is situated up-gradient of the well pad and topographically higher, so is unlikely to be hydraulically connected to groundwater beneath the well pad site. Groundwater contaminants introduced at the well pad or during road improvements would therefore migrate in a direction away from this receptor. It is feasible but unlikely that effects on groundwater level at the well pad site would affect spring flow rates, therefore the risk is assessed to be low.

Shallow groundwater pathway – effects on groundwater quality

The conceptual model suggests that the Pleistocene volcanic deposits are likely to be highly permeable. Transit times between the source of any contamination and the identified receptors may therefore be short (days-weeks). However, there is a year-round, constant flow from the Glenelg springs, indicating plentiful recharge to this relatively small catchment; therefore, any groundwater contamination would be somewhat diluted before it reaches any springs.

Contamination could potentially reach the Glenelg springs or the Northern Stream spring with little warning, which could have serious consequences for operations at the bottling plant or the heath of anyone consuming this water directly from the receptor. The risk to these two receptors is therefore assessed to be high.

The effects on Mt. Reuil Stream as a result of contaminated spring discharge would be much less severe, due the dilution effect of the much greater flow in the receiving water. Dilution would increase as the pollutants move downstream towards the WTP intake and swimming weir, due to inflows from the wider catchment. The risk to these receptors is therefore assessed to be low.

Shallow groundwater pathway – effects on groundwater level and spring discharge

It is possible that drilling mud or cement could be lost to voids within the shallow aquifer during construction of the well. An unlikely consequence of this could be the alteration of groundwater flow pathways, affecting groundwater levels and spring discharge rates. Should this happen, the total amount of water discharging from springs in the area would not change. However, it is possible that the point of emergence could change, i.e. the flow rate at one spring could increase whilst another is reduced, or a new spring may emerge at a different location.

Effects on groundwater level (should they occur) would most likely be confined to the immediate vicinity (tens of metres) of the well bore (which will be drilled at an angle towards the south-west). The springs are located over 500 m down-gradient from the well pad and, therefore, the chance that the groundwater flow to these receptors would be affected seems exceedingly small. Nonetheless, as the geology of the groundwater system is not well understood, the risk is assessed to be low (rather than negligible).

5.6 Risk assessment summary

The available information has been interpreted as follows.

- There is a highly permeable, shallow aquifer present in the study area, which feeds springs discharging to the Northern Stream and Mt. Reuil Stream.
- The well pad is located within the groundwater catchment area, upgradient (to the west) of the springs; consequently, there are risks to those receptors from project activities at the well pad.
- Road improvement works would be undertaken in the north of the study area, so present a risk only to the Northern Stream, which could intercept southward flowing groundwater.
- The Wetland Spring is located upgradient of the project area, at a higher elevation, and is unlikely to be hydraulically connected to the shallow aquifer of interest. Whilst there is no risk to water quality, it is feasible that discharge rate could be affected by a change in groundwater level.
- The risk of chemical or physical effects reaching receptors via the shallow aquifer is assessed as follows:
  - Reduced water quality at the Northern Stream / Glenelg springs: **high**
  - Reduced water quality in the Mt. Reuil Stream and at the WTP intake: **low**
  - Reduced water quality at the Wetland Spring: **negligible**

  - Effects on groundwater level and spring discharge at the Wetland Spring / Northern Stream spring and Glenelg springs: **low**
- The risk to all receptors (including the hot spring) from well drilling or testing, via the deeper, geothermal groundwater system, is assessed to be **negligible**.

6 Phase 2 investigation

6.1 Phase 2 hydrogeological study objectives

The purpose of the Phase 2 Hydrogeological Study will be to reduce uncertainties in the preliminary conceptual site model (see section 4.2) and, thereby, refine and increase confidence in the groundwater risk assessment. The objectives of the Phase 2 study will be as follows:

- Investigate whether there is a hydraulic connection between a shallow aquifer underlying the proposed location of the well-pad at site C and the springs that supply the Glenelg bottling plant;
- Confirm the baseline groundwater quality of the Glenelg spring discharges; and,
- Review the Phase 1 risk and impact assessments in the light of new data.

On the basis of the Phase 2 findings, the mitigation measures set out in the Draft ESIA will be reviewed and amended as required, to ensure there are no significant impacts as a result of the project.

6.2 Scope of phase 2 hydrogeological study

The Phase 2 hydrogeological study will comprise the following key activities:

- a site visit (by a Mott MacDonald hydrogeologist) to:
  - confirm the water sampling locations; and,
  - meet with Glenelg, to understand their concerns and follow up on any queries arising from the Phase 1 study.
- collect supplementary survey data (water quality samples and flow measurements) from targeted locations within the Site C study area;
- install a continuous water quality monitoring probe at one of the Glenelg springs to measure key water quality parameters at hourly intervals;
- review of any additional water quality or hydrological data provided by NAWASA or Glenelg;
- confirmation of existence and characteristics of the reported hot spring;
- review of geotechnical data and interpretative reports for Site C, if available;
- analyse supplementary water quality and flow data, with the aim of confirming the recharge area for the Glenelg springs and testing the conclusions of the Phase 1 study;
- prepare a technical report, to include the following key elements:
  - an updated conceptual site model, based on the findings of the supplementary field investigations and any additional data provided by stakeholders;
  - an updated groundwater risk assessment, based on the updated conceptual site model, (to include any newly identified receptors); and
  - conclusions, indicating whether or not the project poses a significant risk to any receptors (including Glenelg springs), and explaining the level of uncertainty associated with the conclusions.

6.3 Phase 2 hydrogeological study schedule

The Phase 2 surveys commenced in March 2023 and the findings will be reported during the Autumn of 2023, for inclusion in the final ESIA report.

7 References

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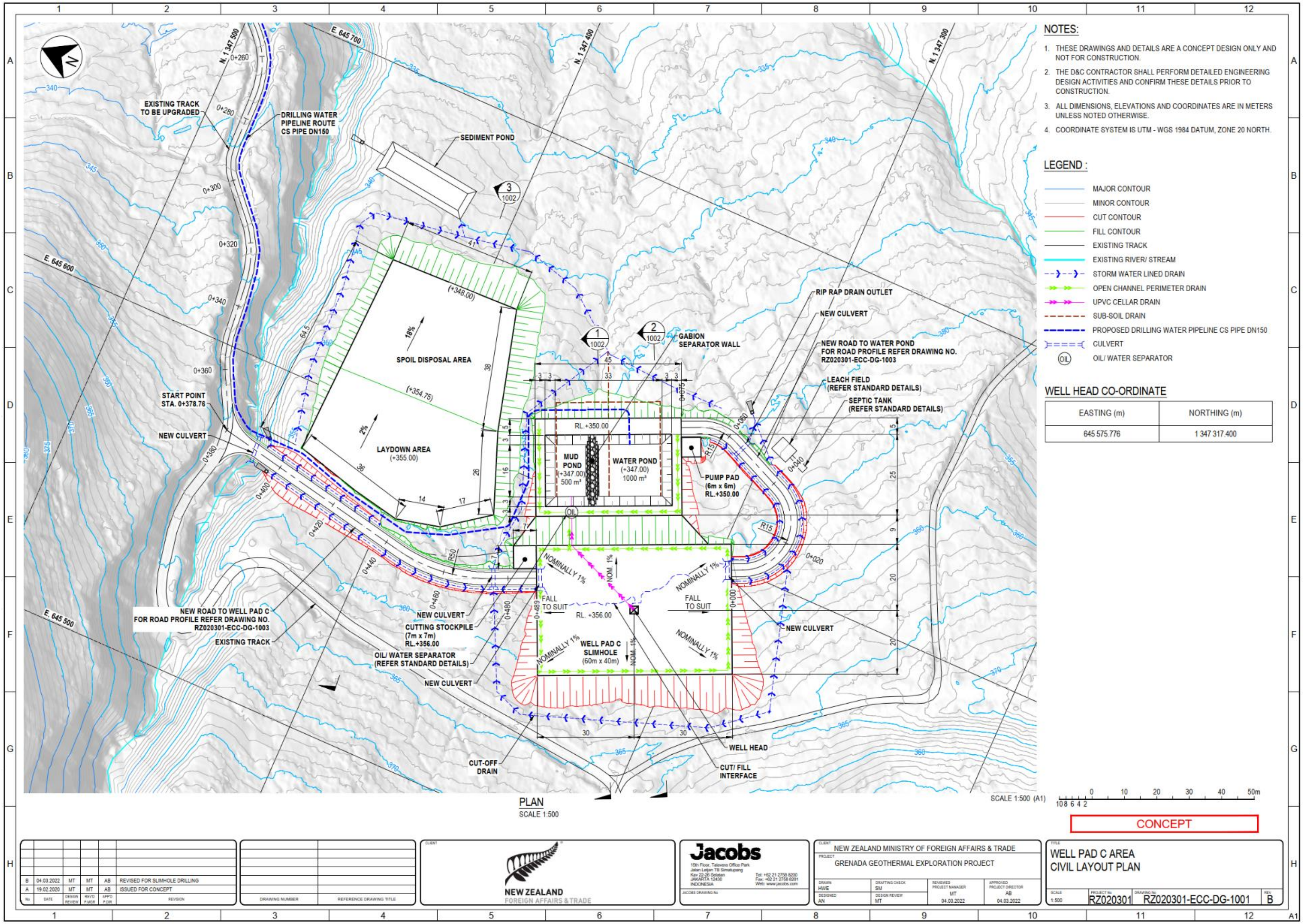
Appendices

A. Drawings


NOTES:
1. THESE DRAWINGS AND DETAILS ARE A CONCEPT DESIGN ONLY AND NOT FOR CONSTRUCTION.
2. THE D&C CONTRACTOR SHALL PERFORM DETAILED ENGINEERING DESIGN ACTIVITIES AND CONFIRM THESE DETAILS PRIOR TO CONSTRUCTION.
3. ALL DIMENSIONS, ELEVATIONS AND COORDINATES ARE IN METERS UNLESS NOTED OTHERWISE.
4. COORDINATE SYSTEM IS UTM - WGS 1984 DATUM, ZONE 20 NORTH.
LEGEND:
MAJOR CONTOUR
MINOR CONTOUR
CUT CONTOUR
FILL CONTOUR
EXISTING TRACK
EXISTING RIVER/ STREAM
STORM WATER LINED DRAIN
OPEN CHANNEL PERIMETER DRAIN
UPVC CELLAR DRAIN
SUB-SOIL DRAIN
PROPOSED DRILLING WATER PIPELINE CS PIPE DN150
CULVERT
OIL/ WATER SEPARATOR
WELL HEAD CO-ORDINATE
EASTING (m) 645 575.776
NORTHING (m) 1 347 317.400
EXISTING TRACK TO BE UPGRADED
DRILLING WATER PIPELINE ROUTE CS PIPE DN150
SEDIMENT POND
SPOIL DISPOSAL AREA
LAYDOWN AREA (+355.00)
START POINT STA. 0+378.76
NEW CULVERT
RIP RAP DRAIN OUTLET
GABION SEPARATOR WALL
NEW ROAD TO WATER POND FOR ROAD PROFILE REFER DRAWING NO. RZ020301-ECC-DG-1003
LEACH FIELD (REFER STANDARD DETAILS)
SEPTIC TANK (REFER STANDARD DETAILS)
MUD POND (+347.00) 500 m²
WATER POND (+347.00) 1000 m²
PUMP PAD (6m x 6m) RL.+350.00
RL.+350.00
RL. +356.00
WELL PAD C SLIMHOLE (60m x 40m)
NOMINALLY 1%
FALL TO SUIT
NEW ROAD TO WELL PAD C FOR ROAD PROFILE REFER DRAWING NO. RZ020301-ECC-DG-1003
EXISTING TRACK
CUTTING STOCKPILE (7m x 7m) RL.+356.00
OIL/ WATER SEPARATOR (REFER STANDARD DETAILS)
WELL HEAD
CUT/ FILL INTERFACE
CUT-OFF DRAIN
PLAN
SCALE 1:500
SCALE 1:500 (A1)
CONCEPT
B 04.03.2022 MT MT AB REVISED FOR SLIMHOLE DRILLING
A 18.02.2020 MT MT AB ISSUED FOR CONCEPT
NEW ZEALAND FOREIGN AFFAIRS & TRADE
Jacobs
NEW ZEALAND MINISTRY OF FOREIGN AFFAIRS & TRADE
GRENADA GEOTHERMAL EXPLORATION PROJECT
WELL PAD C AREA
CIVIL LAYOUT PLAN
RZ020301 RZ020301-ECC-DG-1001 B

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Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Volume II - ESIA
Chapter 10 - Noise and vibration

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10 Noise and Vibration

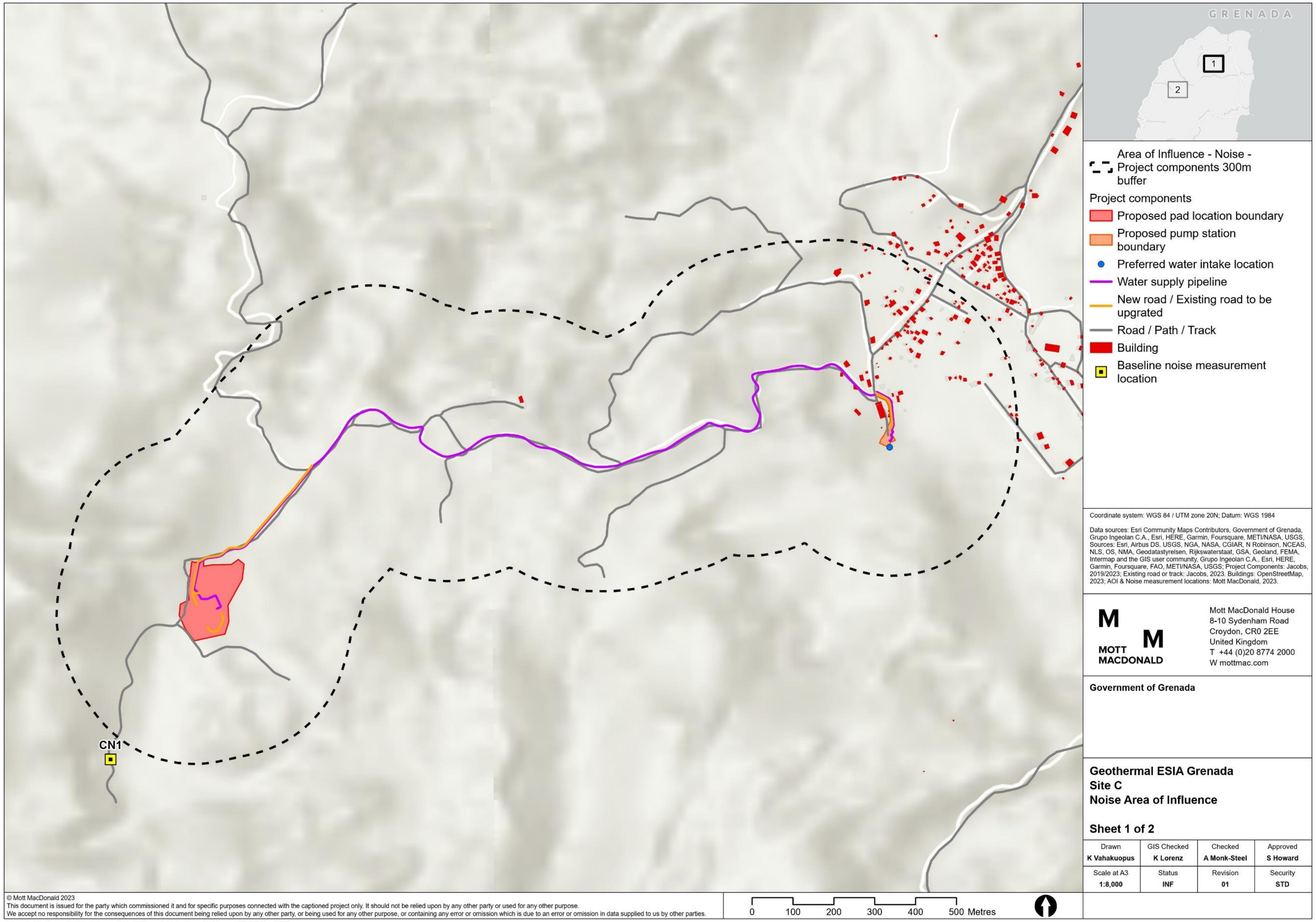
10.1 Overview

This chapter presents an assessment of predicted noise and vibration impacts that are expected to arise as a result of the site set-up, exploratory drilling and decommissioning phases of the Project. The assessment describes the methodology used to assess baseline conditions, identifies the Area of Influence, its baseline and the sensitive receptors within it, and assesses the potential impacts to identify whether significant effects are expected to arise. Impacts have been considered and assessed for the site preparation (including access road construction and well pad set up), exploratory drilling works and, where relevant, decommissioning.

10.2 Study area and area of influence

The study area for the assessment of noise and vibration impacts is dependent on the magnitude of the predicted impacts and the presence of sensitive receptors within the extent that the predicted impacts exceed relevant criteria. However, for general construction activities, a distance of 300m is typically used to describe the extent of potential effects. Figure 10.1 and Figure 10.2 show the project components, a 300m buffer, nearby buildings and the locations where baseline noise monitoring was undertaken.

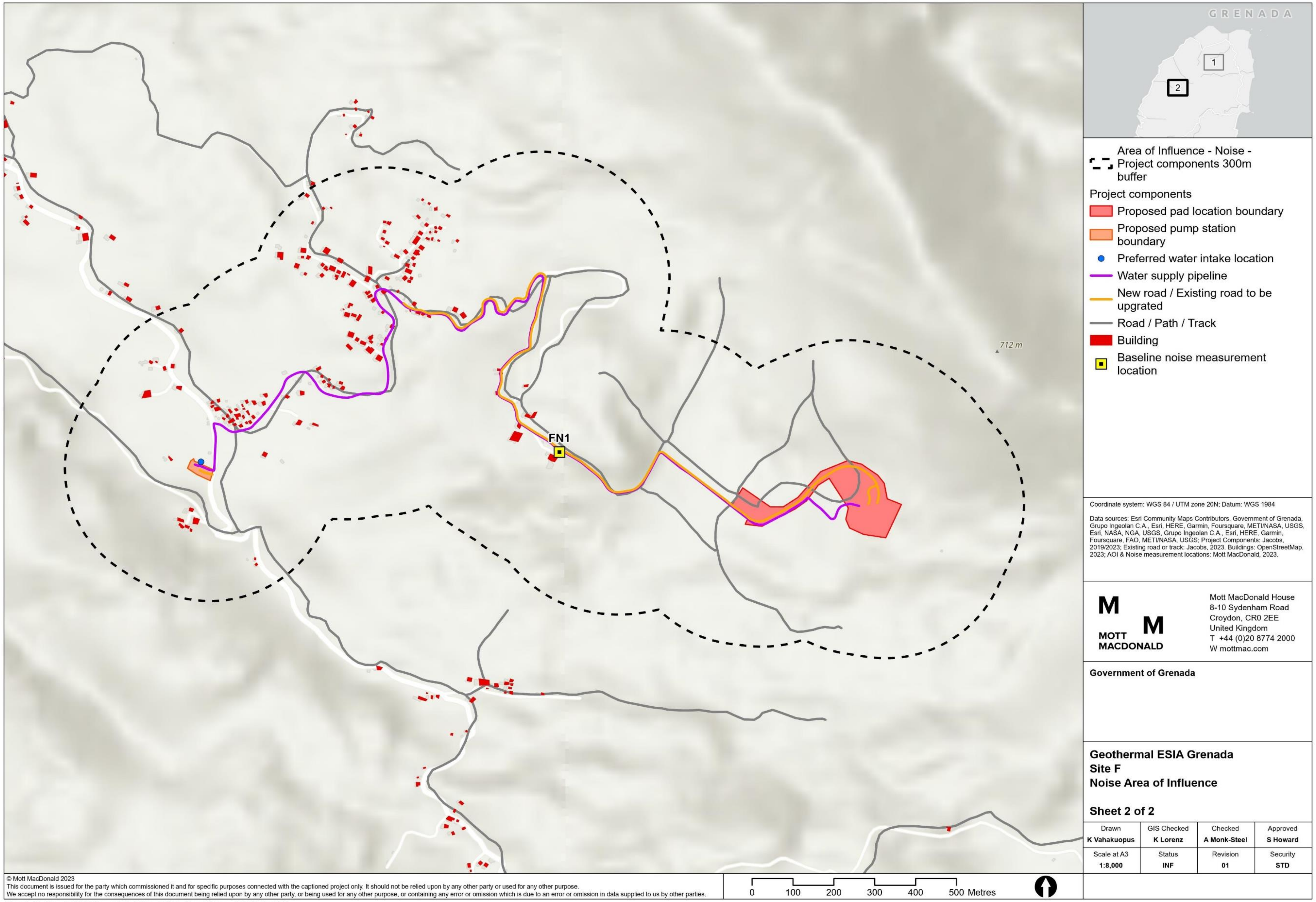
Figure 10.1: Noise area of influence for Site C



Grenada_Geothermal_ESIA_Noise_and_Dust | Grenada Noise Area of Influence P01 | 23 May 2023

Source: Mott MacDonald

Figure 10.2: Noise area of influence for Site F



Grenada_Geothermal_ESIA_Noise_and_Dust | Grenada Noise Area of Influence P01 | 23 May 2023

Source: Mott MacDonald

10.3 Applicable standards

Applicable standards specific to noise and vibration is presented in Chapter 4 Policy, legal and institutional framework´ of this ESIA.

10.4 Methodology

The understanding of the baseline noise climate is based on observations made during the scoping site visit and the findings of a baseline noise survey. The understanding of the potential impacts is based on information provided by the Government of Grenada and Jacobs (technical engineering consultants). This is used with the relevant assessment criteria to identify activities with the potential to result in significant effects, and consider the scope to adequately mitigate residual impacts to acceptable levels.

10.4.1 Approach

The assessment of noise impacts during the construction, operational and decommissioning phases has been based on a comparison of predicted levels received at sensitive receptors with the Noise Level Guidelines of the IFC/World Bank Group General EHS Guidelines or National standards, whichever is more stringent.

Reference is made to measured baseline noise levels in assessing impacts where the level of noise impacts at any sensitive receptors due to the Project exceed the absolute thresholds of the IFC/World Bank Group Noise Levels Guidelines or the thresholds of National standards if they are more stringent.

For the assessment of potential vibration impacts, for example during road upgrade construction, reference has been made to the thresholds for perception and the onset of cosmetic damage to buildings give in the British Standard 5228 ‘Code of practice for noise and vibration control on construction and open sites’ – Part 2: Vibration’ 2009 +A1:2014.

There is no prescribed, widely accepted methodology to assess the effects of noise and vibration on fauna. However, where appropriate, the ESIA has included measures to mitigate potential impacts of noise and vibration on animal species of conservation importance in the area of influence.

10.4.2 Surveys

A baseline noise survey was undertaken in the area of both sites to represent the closest noise sensitive receptor. Each survey was carried out over a continuous period of 24 hours.

At Site C, the sensitive receptor selected was a shelter used by farm workers. It should be noted that the position of Site C was refined since the noise survey was undertaken, however, the measured levels at the receptor location are still considered to apply despite the subsequent relocation of the project elements, given that the baseline noise climate was observed to be reasonably uniform across the local area. At Site F, the closest sensitive receptor was a nearby dwelling.

Observations made during site visits indicate that the baseline noise climate is relatively uniform such that a single baseline measurement position representative of the closest receptor to the extents of works would provide a suitable description of the area in the general. The measured levels for Site C are still considered to apply despite the subsequent relocation of the project elements. Furthermore, given the remote rural nature of the Project extents, baseline noise levels are expected to have the potential to be low such that Project impacts would be assessed against the absolute levels (lower fixed thresholds) rather than in respect of changes in ambient levels.

10.4.3 Sensitivity of receptors

The sensitivity of the receptors is accounted for by the application of criteria for the magnitude of impact depending on the receptor type and time of day. The sensitivity of receptor takes into account their ability to adapt to an increase in the exposure to noise and vibration. Table 10.1 presents the guideline criteria that have been used to categorise sensitivity of receptors to be consistent with the applicable guidelines and standards.

Table 10.1: Criteria for determining receptor sensitivity

Sensitivity	Definition / receptor types
High	Hospitals, nursing homes and places of worship
Medium	Residential (permanent or seasonal residences, hotels/motels), institutional (including parks and campgrounds) and educational (schools, day cares)
Low	Commercial
Negligible	Industrial

Source: Mott MacDonald

10.4.4 Magnitude of change

The magnitude of noise impacts is determined with reference to the most stringent criteria of the applicable guidelines and standards. Threshold noise levels that are used in magnitude of impact criteria are given in Table 10.2.

Table 10.2: Threshold noise levels

Definition / receptor types	Daytime	Night-time
Permanent or seasonal residences, hotels/motels, schools and day cares, hospitals and nursing homes, places of worship, parks and campgrounds	55	45
Industrial and commercial	70	70

Source: IFC/WBG EHS Guidelines

Table 10.3 summarises the categories of magnitude of impact and apply for all phases of the project.

Table 10.3: Magnitude of impact criteria for noise impacts

Categorisation	Definition
Major	Threshold noise level exceeded by 3 dB or more and ambient level increased by 3 dB or more
Moderate	Threshold noise level exceeded by 3 dB or more and ambient level increased by less than 3 dB
Minor	Threshold noise level exceeded by less than 3 dB and ambient level increased by less than 3 dB
Negligible	Threshold noise level not exceeded and ambient noise level increased by any amount

Source: Mott MacDonald

Part 2 of BS 5228 (2009+A1:2014) provides guidance on the effects of vibration and the likelihood it will cause complaint and cosmetic damage to buildings. The guidance does not indicate whether particular levels of vibration are significant. The standard states: "*Vibrations above these levels [0.14mm/s to 0.3mm/s] can disturb, startle, cause annoyance or interfere* *with work activities. At higher levels they can be described as unpleasant or even painful. In residential accommodation, vibrations can promote anxiety….*"

In addition, British Standard 5228 – 2:2009+A1:2014 provides the following guidance on effects based on exposure expressed as peak particle velocity (PPV) in millimetres per second:

- At a vibration level of 0.14mm/s vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction
- At a vibration level of 0.3mm/s vibration might be just perceptible in residential environments
- At a vibration level of 1.0mm/s it is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents
- At a vibration level of 10mm/s vibration is likely to be intolerable for any more than a very brief exposure to this level.

BS 5228-2:2009+A1:2014 also considers vibration in terms of potential cosmetic and structural damage to buildings. It states that transient levels of vibration, expressed as PPV of 15mm/s at low frequency may cause cosmetic damage in un-reinforced or light framed structures e.g. for residential/light commercial use. However, dynamic loading due to more continuous vibration and a resonant response of the structure can give rise to dynamic magnification especially at lower frequencies. BS 5228 – 2:2009+A1:2014 advises that, in these cases, thresholds are reduced by 50% to test for the onset of damage. Therefore, sustained PPVs of 7.5mm/s are considered to be an appropriate indicator where risks of damage become significant.

With reference to the British Standard 7385 Part 2, BS 5228 – 2:2009+A1:2014 notes that the probability of damage tends towards zero at vibration levels below 12.5mm/s peak component particle velocity.

- Therefore, the criteria given in Table 10.4 have been defined on the basis of the thresholds described above. Although a quantitative assessment of vibration impacts due to blasting has not been carried out due to the inherent uncertainty of the influencing parameters, the criteria are also given as a reference to inform monitoring during blasting activities.

Table 10.4: Magnitude of impact criteria for vibration impacts

Categorisation	Definition
Major	Vibration of 12.5mm/s and above
Moderate	Vibration of 7.5mm/s or above not exceeding 12.5mm/s
Minor	Vibration of 1mm/s or above not exceeding 7.5mm/s
Negligible	Vibration below PPV of 1mm/s

Source: BS 5228 - Part 2: 2009+A1:2014

10.4.5 Limitations and assumptions

Where some specific design aspects of the project are not completely finalised at this stage, assumptions have been made to undertake this assessment. These assumptions are based on experience of similar projects and knowledge of the likely impacts. Professional judgement has been used to reduce the level of subjectivity within these assumptions as far as possible and explanation for assumptions provided.

Noise and vibration arising during construction is inherently variable in nature due to the variation in the location of plant and activities. Furthermore, activities may occur in multiple locations such that a sensitive receptor may be exposed to noise as a result of simultaneous activities. Consequently, noise impacts during construction are predicted based on the assumed utilisation of equipment and dominated by each activity individually when it occurs at the closest point to the sensitive receptor.

10.5 Baseline monitoring

10.5.1 Outline

The baseline noise climate in the area of both drilling sites is characterised by natural noise sources such as wind in the trees and foliage, insects, birdsong and fauna. The baseline at both sites is largely unaffected by anthropological sounds. Therefore, the project is anticipated to result in a change in character of the noise climate even if the received levels of noise would be relatively low.

Noise monitoring was conducted in July 2019 at two locations:

- Site CN1 is situated at Tricolar (Site C), to the north-east of Mount St Catherine and is located in a valley surrounded by pasture, agriculture and agroforestry.
- Site FN1 is located in Florida/Plaisance (Site F) to south-west of Mount St Catherine and borders a forested area, which is also partly used as a Plantation. The meters were set up fairly close to the Barracks and Harvest Shed.

Table 10.5 provides GPS coordinates for these sites, and they are also shown at Figure 10.1 and Figure 10.2 above.

Table 10.5: GPS coordinates for baseline noise monitoring locations

Noise monitoring locations	Co-ordinates (decimal degrees)	
	Latitude	Longitude
Site CN1	12.181415°	-61.663879°
Site FN1	12.155953°	-61.699321°

Source: Mott MacDonald

Noise monitoring was undertaken at each location for a period of 24 hours from 16 to 19 July, 2019.

10.5.2 Equipment

Noise monitoring was undertaken using a Quest Sound Pro DL Type 2 sound level meter conforming to the following standards:

- IEC 61672-1-2002 Class 2;
- ANSI S1.4-1983 (R2001) Class 1;
- ANSI S1.43-1997 (R2002) Type 2; and
- IEC 61260: 2014 Class 1.

The instrument has a total measurement range of between 20 and 140 dB with selectable response characteristics (slow, fast, peak and impulse), 3 weighting options (‘A’, ‘C’ and ‘Linear’).

10.5.3 Quality control

The sound level meter is factory calibrated annually. In addition, prior to the start of monitoring at each location, the instrument was field-calibrated using a manufacturer-certified Quest QC-10 calibrator producing a 1kHz signal at 114 dB.

10.5.4 Monitoring

The sound level meter was assembled according to manufacturer's specifications. The equipment was then powered on both external and internal diagnostics specific to each monitor and then run to ensure that proper calibration was achieved for the instrument. A windshield was placed over the microphone to minimise the influence of wind noise.

The exchange rate was set at 3 dB; the meter was set on the 'Fast' time-weighting and 'A' weighted frequency characteristic for recording both L_{eq} sound pressure levels and L_{peak} sound pressure levels. The parameters set for measurement were:

- L_{eq} dB(A) sound pressure level
- L_{peak} dB(A) sound pressure level

The microphone was supported at approximately 1.5 metres above the ground and away from any solid structures. The logging interval was set at 10 minutes. At the end of each monitoring period, the data collected was downloaded to a computer using the specified software for the instrument.

10.5.5 Site conditions

Noise monitoring was not conducted during periods of inclement weather. However, other weather conditions (e.g. slight rainfall, overcast, damp and wet conditions, etc.) were encountered during the noise monitoring. Additionally, any factors present (such as operating equipment) that may affect the noise levels at the locations were also noted. The weather conditions encountered during the noise monitoring on each of the two monitoring days are shown in Table 10.6

Table 10.6: Site weather conditions and noise sources

Location	Date	Weather conditions	Observed noise sources
Site CN1	16 July 2019	Overcast, damp, windy	Creaking of bamboo stool, insects, birds chirping, vehicles, workers from plantation, dogs barking, door from building opening and closing
Site FN1	18 July 2019	Overcast, damp, windy, occasional light rainfall	Workers from plantation, people talking, birds chirping

Source: Mott MacDonald

10.5.6 Results

Table 10.7 below presents the hourly daytime and night-time L_{eq} sound pressure levels for sites CN1 and FN1. Rows shaded in grey fall within the night-time period.

Table 10.7: Hourly daytime and night-time L_{eq} sound pressure levels measured at sites CN1 and FN1

Interval start time	CN1	FN1
	$L_{eq,1h}$ dB(A)	$L_{eq,1h}$ dB(A)
22:00 Night-time	68.7	64.6
23:00	66.4	63.8
00:00	65.1	62.9
01:00	65.5	62.6
02:00	64.7	63.6
03:00	65.7	61.7
04:00	66.5	61.6
05:00	66.8	62.2
06:00	57.9	51.1
07:00 Daytime	59.8	53.6
08:00	57.5	51.3
09:00	60.0	51.2
10:00	58.5	50.9
12:00	60.2	49.9
13:00	59.1	50.3
14:00	62.4	50.2
15:00	59.0	51.5
16:00	57.2	51.7
17:00	65.3	61.2
18:00	67.8	64.0
19:00	68.0	65.1
20:00	67.6	61.9
21:00	58.1	53.1

Source: Mott MacDonald

Table 10.8 presents the daytime and night-time L_{peak} noise levels for the monitoring period.

Table 10.8: Mean baseline L_{peak} sound pressure levels

Location	Mean measured peak sound pressure L_{peak} dB(A)	
	Daytime	**Night-time**
Site CN1	108.8	96.8
Site FN1	102.1	87.1

Source: Mott MacDonald

10.5.7 Discussion

At site CN1, the measured daytime hourly L_{eq} values ranged between 57.2 and 68.0 L_{eq} dB(A), and the mean peak level was 108.8 L_{peak} dB(A). During the daytime, the main sources of noise were noted to be local farmers talking. During the night-time, the measured hourly values ranged between 57.9 and 68.7 L_{eq} dB(A), and the mean peak level was 96.8 L_{peak} dB(A). Night-time values were attributed to insects, frogs and other nocturnal species.

At site FN1, the measured daytime hourly L_{eq} values ranged between 49.9 and 65.1 L_{eq} dB(A), and the mean peak level was 102.1 L_{peak} dB(A). During the daytime, the main sources of noise were local farmers and the occasional vehicle / car horn. The meter was placed close to the barracks and harvest shed for the plantation. During the night-time, the hourly values ranged between 51.1 and 64.6 Leq dB(A), and the mean peak level was 87.1 L_{peak} dB(A). Night-time values were attributed to insects, frogs and other nocturnal species.

In conclusion, the results show that the baseline noise levels (expressed using the L_{eq} dB(A) descriptor) measured at both locations considered by the survey exceeded the guideline values for residential receptors given in the IFC/WBG EHS. The main sources of noise were identified as non-anthropological sources such as insects or due to noise from personnel working on the adjacent land.

10.6 Assessment of impacts

This section presents a qualitative assessment of the predicted noise impacts expected to occur as a result of the exploratory drilling phase of the Project and assesses the beneficial and adverse effects by predicting their significance prior to mitigation. Impacts have been considered and assessed for the site preparation (including access road construction and well pad set up), exploratory drilling works and, where relevant, decommissioning.

Mitigation measures are listed for each impact; refer to section 10.7 for a description of each mitigation measure listed in this section 10.6.

10.6.1 Identification of receptors and analysis of sensitivity

The Project is expected to generate noise and vibration with the potential to affect local people. These impacts are described below for both the construction, operational and decommissioning phases. Table 10.9 shows the noise related receptors and an analysis of their sensitivity. Sensitive receptors are those located in the area near the sites and the access roads, and adjacent to routes used by traffic accessing the sites.

The types of sensitive receptors include residential, institutional (e.g. hospitals, places of worship), educational industrial and commercial where appropriate. Habitats of animal species of conservation importance within the area of influence are also considered.

To reduce repetition, similar receptors at the two sites are analysed together.

Table 10.9: Noise and vibration receptors and sensitivity

Receptor	Brief description	Analysis of sensitivity	Sensitivity
Dwellings	Nearby residents and residents of Florida and Mt Rich/Tricolar (the closest village to sites F and C respectively)	People who live in the adjacent areas are considered to be of medium sensitivity	Medium
Land users	People who farm the land near the project area	People who work in the area are considered to be of medium sensitivity as they will only be in the area for part of the day and have capacity to adjust to changes in noise level	Medium
Access route dwellings	Residents of dwellings along access routes	People who live along the access route are considered to be of high sensitivity as they have low capacity to mitigate	High

Receptor	Brief description	Analysis of sensitivity	Sensitivity
		the impact or adapt the changes caused	
Project workers	People who work on the project	Project workers are considered to be of low sensitivity as they have good capacity to protect themselves from noise with appropriate PPE	Low

Source: Mott MacDonald

10.6.2 Summary of changes, impacts and receptors

Typically, noise from construction activities is attenuated with distance such that adverse effects beyond 300m are generally limited. Furthermore, the reliability of calculations reduces with distance due to the influence of meteorological effects on how noise propagates in the environment (mainly due to wind direction). Considering the proximity of nearby noise sensitive receptors to the vicinity of project works (>500m) and the absence of particularly noise sensitive ecological receptors, it has not been deemed necessary to undertake quantitative noise modelling at this time.

During the construction phase, temporary noise and vibration impacts are expected to arise in clearing the sites during site establishment and in preparing site access roads. Works are expected to be limited to the daytime (07:00 to 19:00). The main sources of noise and vibration is expected to be the items of plant and machinery used to undertake the works (excavators, dumpers etc). The level of noise at sensitive receptors would be variable as the location of plant items move around the site/along the access roads and as different items of plant are used. The movement of materials to and from the sites by local roads is also expected to generate noise from heavy vehicles.

During operation the main noise impacts are expected to arise due to drilling and during well testing. These operations are expected to occur during the daytime and night-time, and that noise from well testing can be relatively high and will occur continuously during the daytime and night-time during drilling operations. Key activities which will create noise are:

- Rig engine, compressors, boosters, pumping unit engine
- Power system (mechanical drive such as belts, chains, couplings)
- Rig vibrations from moving parts
- Pneumatic and hydraulic equipment to operate equipment

In decommissioning, noise impacts during the reinstatement of the sites would arise due to the use of plant and machinery, and the removal of equipment and materials by heavy vehicles.

Table 10.10 shows the changes caused by construction activities, the potential receptors and the potential impact of the change.

Table 10.10: Changes, receptors and potential impacts

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Increase in noise from general site establishment works and access road upgrade construction	Construction	The activities of the various site establishment works and the construction of the water pipeline will cause noise impacts to the human and ecological receptors. Activities that will create noise are listed below and they are expected to be in operation approximately 25% of the time during the duration of the access road upgrade construction period (total of three months at each site (F and C): ● Distribution of material: Dump truck (tipping fill) ● Rolling and compaction: Vibratory roller The water pipeline does not require excavation as the pipe sections are laid above the ground and bolted together. The main noise impacts are expected to be mainly associated with the delivery of pipe sections by road vehicle rather than the use of small tools to fix the sections together.	Dwellings Land users Access route dwellings Project workers
Increase in noise from traffic	Construction	The flow of traffic is expected to be variable and intermittent such that it would not be possible to make a meaningful quantitative assessment of the associated noise impacts. The nearby properties could be adversely affected from a small number of movements or even the passage of a single heavy vehicle in close proximity to receptors at a sensitive time of the day.	Access route dwellings
	Operation	Low levels of traffic are expected during the operation phase	Access route dwellings
	Decommissioning	As for construction	Access route dwellings
Increase in noise from exploratory drilling	Operation	Noise during the drilling phase is assumed to be represented by the sound power levels obtained through previous experience and reports for other geothermal projects. These are reproduced in Table 10.11 It is expected that the separation distances between the pad locations and closest sensitive receptors are sufficiently great (>500m) such that noise levels during site activity will not exceed the relevant threshold values.	Dwellings Land users Project workers

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Increase in noise from Site restoration	Decommissioning	The activities of the various site restoration works are deemed to be similar to the ones from the site establishment phase.	Dwellings Land users Access route dwellings Project workers

Source: Mott MacDonald

Table 10.11 presents noise emission values for the main activities during the drilling and well testing stages.

Table 10.11: Assumed sound power levels

Item	Sound power level dB(A)
Drill preparation	102
Establishing drilling rig	100
Drilling	110 to 114
Testing/clearing well discharge	95*
Production testing venting	97

*Sound Power Level for a rock muffler (Lahendong Pertamina Geothermal Project (7)'

10.6.3 Analysis of construction impacts

10.6.3.1 Increase in noise from general site establishment works and access road upgrade construction

The magnitude of the increase in noise is considered moderate because the site establishment work is predicted to mean the threshold noise level is exceeded by 3 dB or more and ambient level increased by less than 3 dB. The increase in noise will occur through the construction phase so the duration is considered short term (0 to 5 years). The increase in noise will happen at both of the construction sites and along the access routes so the scale is considered regional. The probability of increase in noise occurring is considered High because the activities are inherently noise creating.

Table 10.12: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Dwellings	As defined in the baseline chapter the sensitivity of Site dwellings is considered medium because they are classed as a residential area. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: medium Significance of impact: minor	N1: General measures N2: Construction traffic
Land users	As defined in the baseline chapter the sensitivity of Land users is considered medium because the workers will only be there for part of the day. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: medium Significance of impact: minor	N1: General measures
Access route dwellings	As defined in the baseline chapter the sensitivity of access route dwellings is considered high because people living along the route cannot move and have few options to adapt to the change. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: moderate	N1: General measures N2: Construction traffic

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Project workers	As defined in the baseline chapter the sensitivity of project workers is considered low because they have good capacity to protect themselves from noise. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: low Significance of impact: minor	N1: General measures

Source: Mott MacDonald

10.6.3.2 Increase in noise from traffic

The magnitude of the increase in noise from traffic is considered moderate because there will be a significant increase in the number of vehicles using the road during the establishment phase. The increase in noise from traffic will occur through the construction phase so the duration is considered short term (0 to 5 years). The increase in noise from traffic will happen along access routes so the scale is considered regional. The probability of increase in noise from traffic occurring is considered high because the activities are inherently noise creating.

Table 10.13: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Access route dwellings	As defined in the baseline chapter the sensitivity of access route dwellings is considered high because people living along the route cannot move and have few options to adapt to the change. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: moderate	N1: General measures N2: Construction traffic

Source: Mott MacDonald

10.6.4 Analysis of operation phase impacts (drilling and testing)

10.6.4.1 Increase in noise from traffic

The magnitude of the increase in noise from traffic is considered minor because there will be a relatively low number of traffic movements during the drilling phase. The increase in noise from traffic will occur through the drilling phase so the duration is considered short term (0 to 5 years). The increase in noise from traffic will happen along access routes so the scale is considered regional. The probability of increase in noise from traffic occurring is considered high because the activities are inherently noise creating.

Table 10.14: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Access route dwellings	As defined in the baseline chapter the sensitivity of access route dwellings is considered high because people living along the route cannot move and have few options to adapt to the change. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: minor Duration: short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: minor	N2: Construction traffic

Source: Mott MacDonald

10.6.4.2 Increase in noise from exploratory drilling

The magnitude of the increase in noise from exploratory drilling is considered major because some aspects of the drilling, particularly venting, can create significant noise. The increase in noise from exploratory drilling will occur through the drilling phase so the duration is considered short term (0-5 years). The increase in noise from exploratory drilling will happen just at the drill site so the scale is considered local. The probability of increase in noise from exploratory drilling occurring is considered high because the activities are inherently noise creating.

Table 10.15: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Dwellings	As defined in the baseline chapter the sensitivity of dwellings near the site is considered medium because they are classed as a residential area. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: major Duration: short term (0 to 5 years) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor	N1: General measures N3: Drilling and well testing
Land users	As defined in the baseline chapter the sensitivity of land users near the site is considered medium because they are only there for part of the day and have opportunities to mitigate impacts. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: major Duration: short term (0 to 5 years) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor	N1: General measures N3: Drilling and well testing

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Project workers	As defined in the baseline chapter the sensitivity of project workers is considered low because they have good options to mitigate the impacts of elevated noise levels. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: major Duration: short term (0 to 5 years) Scale: local Probability: high Sensitivity of receptor: low Significance of impact: minor	N1: General measures N3: Drilling and well testing

Source: Mott MacDonald

10.6.5 Analysis of decommissioning phase impacts

Decommissioning phase impacts will be the same as construction phase impacts, to avoid duplication we have not repeated the analysis here, please refer to Section 10.6.3 for details.

10.6.6 Discussion regarding residual significant impacts

The potential noise and vibration impacts during construction, exploratory drilling and well testing and decommissioning, with general measures and construction noise mitigation applied, are not expected to result in residual significant effects.

10.7 Mitigation and enhancement measures

The qualitative assessment undertaken for the Project has indicated that, generally, the predicted effects due to noise will not be significant with mitigation measures to minimise noise impacts applied as a matter of course. This is also recommended for the purposes of minimising the exposure of site operatives regarding risks of potential hearing damage in the workplace.

General methods of noise control are listed in Table 10.16 below and the means for implementing this is defined in the ESMP. These will be particularly relevant to road construction works and drilling.

Table 10.16: Noise and vibration mitigation and enhancement measures

Ref	Activity	Action	Responsibility	Timescale	Monitoring / KPI
N1	Site establishment	The contractor will prepare a site-specific noise control plan specifically focussing on the well pads. It should include the following general methods of noise control: The selection of low noise plant and equipment using equipment with lower comparative sound power levels where possible. Plant and equipment to be examined on a daily basis for defect prior to the start of works and under no circumstances should defective equipment be used Avoid unnecessary revving of engines Equipment to be switched off when not in use Noisy activities to be limited to daytime working hours where possible Plant and equipment to be positioned as far as possible from sensitive areas Location of static plant (e.g. generators) to take advantage of any screening to break the line of sight from receptors Site operatives to be briefed in keeping noise to a minimum Identify and implement appropriate Personal Protective Equipment (PPE) requirements	Contractors	Establishment	Site inspection records Noise monitoring reports
N2	Construction traffic	Limit vehicle speeds on site and access roads, particularly close to the buildings and sensitive receptors identified Traffic should be managed to avoid the need for traffic to queue up Schedule timing of deliveries to avoid disturbance at the residential receptors Maintain access roads to minimise discontinuities in the road surfaces which may give rise to vehicle body noise and rattle	Contractors	Establishment	Site inspection records Noise monitoring reports
N3	Drilling and well testing	Place barriers or shrouds close to the main sources of noise of the drilling rig and the testing equipment to limit the spread of noise Prioritising quiet equipment in the selection process Informing nearby dwellings on the timing and duration of works and when the noisiest stages are likely to occur Display warning signs about high noise levels around the well pad site boundary	CCP CLO / Project team Drilling contractor and other contractors	Operation	Noise monitoring reports Community grievance mechanism (showing resolution of any noise complaints)

Ref	Activity	Action	Responsibility	Timescale	Monitoring / KPI
		Provision of hearing protection to those working within 250m of all drilling and well testing sites			
		Spot check monitoring at commencement of activities at well pad using sound level meter at the nearest residential properties/sensitive receptor for comparison against standards			
		Record and investigate complaints using sound level meter via the community grievance mechanism			
		Identify and implement appropriate PPE requirements			

Source: Mott MacDonald

10.8 Monitoring

Table 10.17: Noise monitoring requirements

Measure	Frequency	Method	Responsibility
Noise	Once a week	Spot check monitoring at commencement of activities at each well pad using sound level meter, and at the nearest residential properties/sensitive receptors, for comparison against standards Monitoring equipment to be calibrated in line with manufacturers requirements	CCP

Source: Mott MacDonald

10.9 Residual impacts

This section presents a qualitative assessment of the predicted residual noise impacts expected to occur as a result of the exploratory drilling phase of the Project and assesses the beneficial and adverse effects by predicting their significance prior to mitigation. Impacts have been considered and assessed for the site preparation (including access road construction and well pad set up), exploratory drilling works and, where relevant, decommissioning.

10.9.1 Analysis of residual construction impacts

10.9.1.1 Increase in noise from general site establishment works and access road upgrade construction

Table 10.18 presents a summary of residual impacts (post-mitigation) for the impacts related to increase in noise from general site establishment works and access road upgrade construction. For two impacts, significance would be reduced post-mitigation. For other two impacts, although significance has not changed, it is important to note that significance is minor even prior to mitigation.

Table 10.18: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Dwellings	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor. However, significance remains minor.
Land users	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor. However, significance remains minor.

Receptor	Summary of residual impact (post-mitigation)
Access route dwellings	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor. This results in a change in the significance from moderate to minor.
Project workers	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: low Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor. This results in a change in the significance from minor to negligible.

Source: Mott MacDonald

10.9.1.2 Increase in noise from traffic

Table 10.19 presents a summary of residual impacts (post-mitigation) for the impact related to increase in noise from traffic, for which significance would be reduced.

Table 10.19: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Access route dwellings	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor. This results in a change in the significance from moderate to minor.

Source: Mott MacDonald

10.9.2 Analysis of residual operation phase impacts (drilling and testing)

10.9.2.1 Increase in noise from traffic

Table 10.20 presents a summary of residual impacts (post-mitigation) for the impact related to increase in noise from traffic. Although significance has not changed, it is important to note that significance is minor even prior to mitigation.

Table 10.20: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Access route dwellings	Parameter Judgement Nature: negative Magnitude: negligible Duration: Short term (0 to 5 years) Scale: regional Probability: high Sensitivity of receptor: high Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from minor to negligible. However, significance remains minor.

Source: Mott MacDonald

10.9.2.2 Increase in noise from exploratory drilling

Table 10.21 presents a summary of residual impacts (post-mitigation) for the impacts related to increase in noise from exploratory drilling. For one impact, significance would be reduced post-mitigation. For other two impacts, although significance has not changed, it is important to note that significance is minor even prior to mitigation.

Table 10.21: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Dwellings	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0-5 years) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from major to minor. However, significance remains minor.
Land users	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0-5 years) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude of change from major to minor. However, significance remains minor.
Project workers	Parameter Judgement Nature: negative Magnitude: minor Duration: Short term (0-5 years) Scale: local Probability: high Sensitivity of receptor: low Significance of impact: negligible

Receptor	Summary of residual impact (post-mitigation)
	The implementation of the proposed mitigation measures should reduce the magnitude of change from major to minor. This results in a change in the significance from minor to negligible.

Source: Mott MacDonald

10.9.3 Analysis of residual decommissioning phase impacts

Decommissioning phase residual impacts will be the same as construction phase residual impacts, to avoid duplication we have not repeated the analysis here, please refer to Section 10.9.1 for details.

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11 Air quality

11.1 Overview

This chapter assesses air quality related impacts as a result of the exploratory phase of the Project. It considers beneficial and adverse effects and determines their significance prior to and then after mitigation. This assessment identifies the area of influence, its baseline and the sensitive receptors within it, and presents an assessment of the potential impacts to identify where significant effects are expected to arise. Impacts have been considered and assessed for the site construction phase (site preparation including access road construction and well pad set up), exploratory works and where relevant decommissioning.

The assessment has been divided into construction, operation and decommissioning phase impacts; these include the following activities:

- Construction phase:
  - Site clearance and site establishment
  - Well pad construction
  - Water pipeline construction
  - Water pumping station construction
- Operation phase
  - Drilling of exploratory wells
  - Testing of wells
- Decommissioning:
  - In the case exploratory results are not favourable restoration activities as specified in Chapter 2 will be undertaken
  - In the case exploratory results are favourable the wellhead will be secured and monitored.

The potential impacts of each of these separate activities on air quality have been assessed in the subsequent sections.

The proposed Project can lead to a range of emissions. In the construction phase these include dust and a range of combustion related pollutants including oxides of nitrogen (NO_x), particulates (PM_{10}, $PM_{2.5}$ and TSP[1]). In the operation phase, emissions include combustion related pollutants in addition to the potential for hydrogen sulphide (H_2S) and mercury (Hg) emissions from the steam released from the well.

11.2 Study area and area of influence

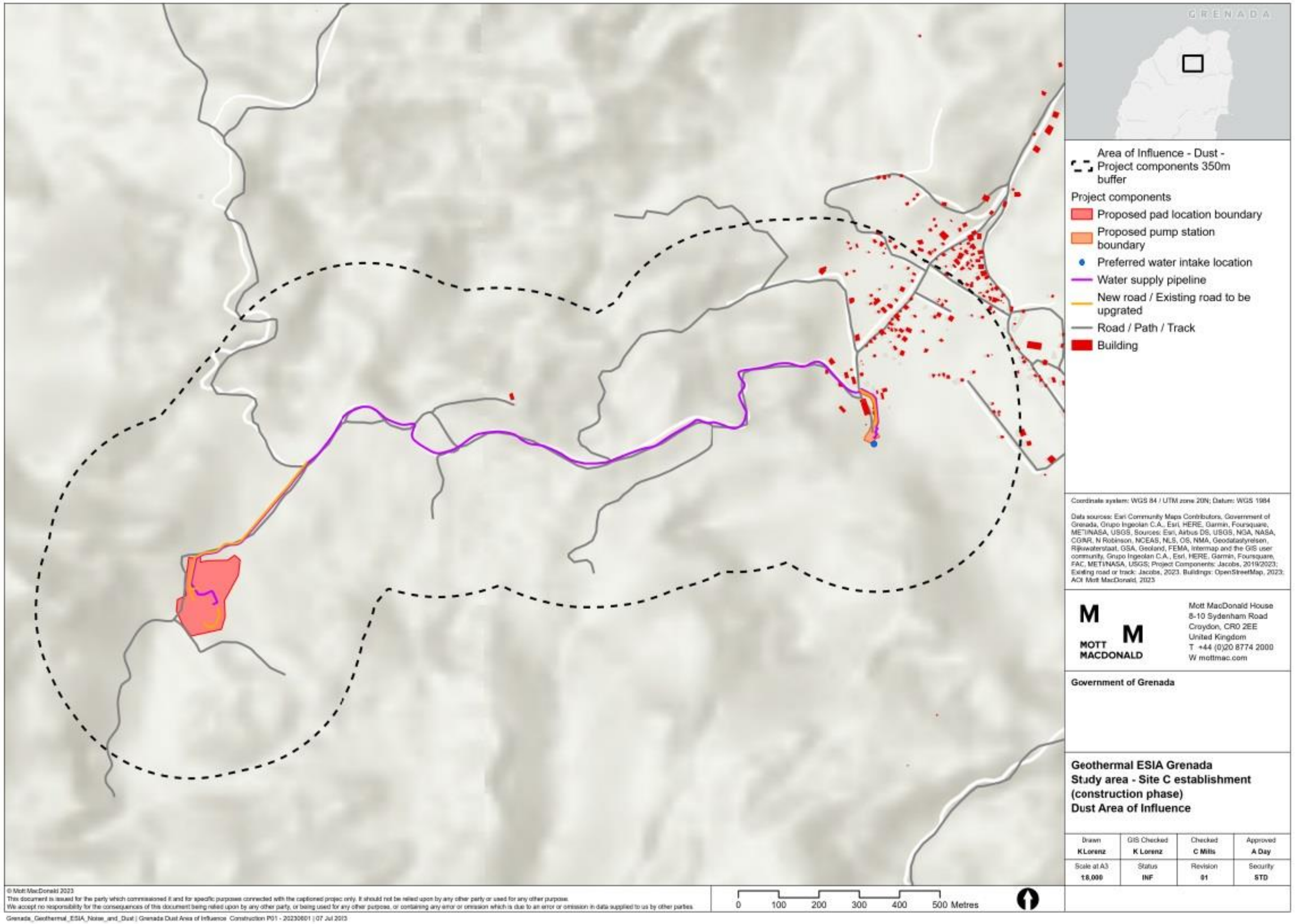
The study area for the construction phase is limited to 350m from the construction activities. This is in accordance with guidance from the Institute of Air Quality Management (IAQM). The study area for the construction phase and along with potentially affected receptors is presented in Figure 11.1 and Figure 11.2.

During the operation phase, there is no defined guidance which sets the study area for well drilling and testing. Emissions from the drilling and well testing will have the highest impact at locations close to the emission source and therefore the study area is defined as 2km from the

[1] PM_{10} refers to particulate matter with a diameter of 10 microns or less. $PM_{2.5}$ denotes particulate matter with a diameter of 2.5 microns or less. TSP stands for Total Suspended Particulates, which refers to all particles suspended in the air, regardless of their size.

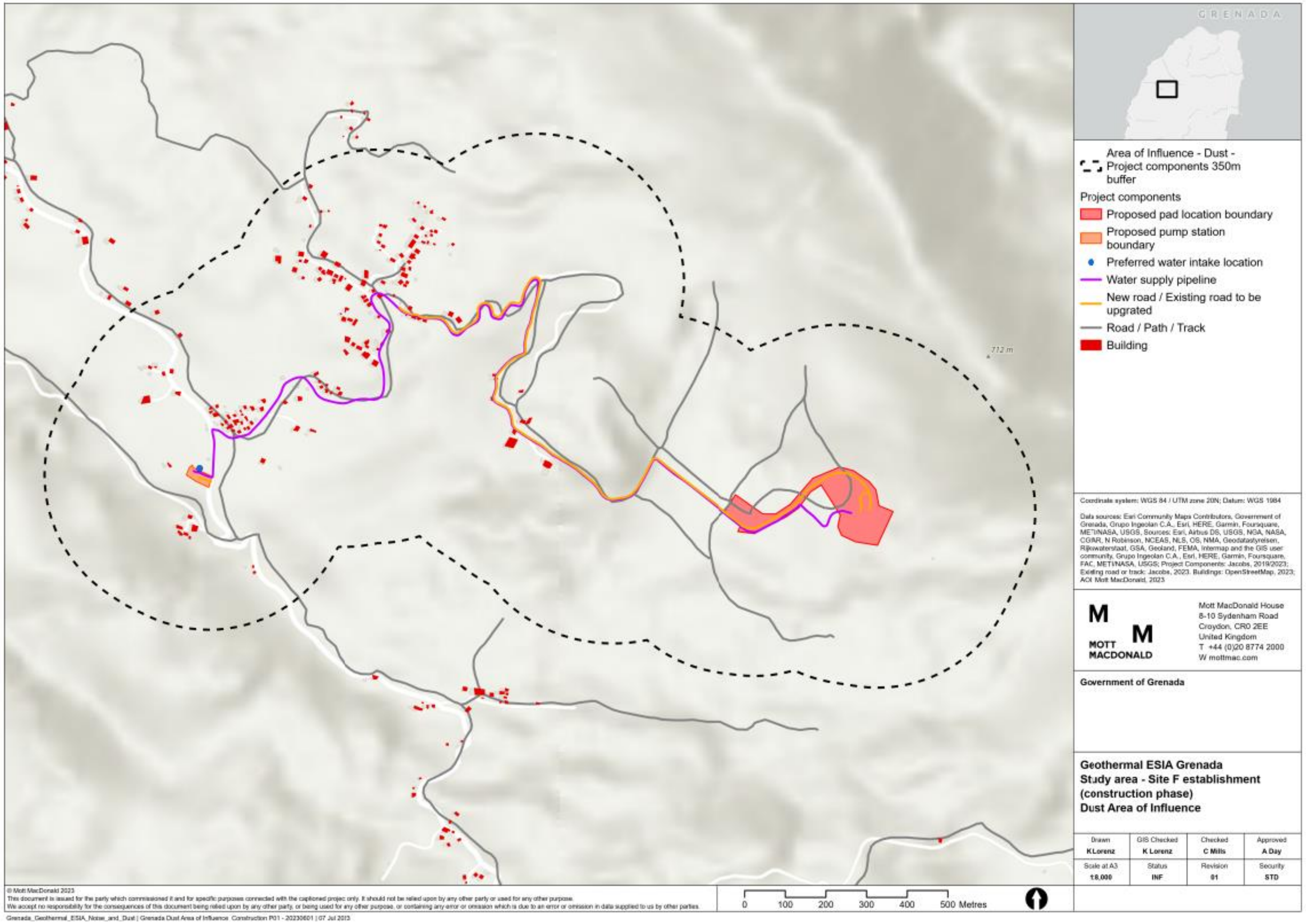
respective well pads. Figure 11.3 and Figure 11.4 presents the study area and the receptors included within the operation study area.

Figure 11.1: Dust area of influence for construction phase – Site C



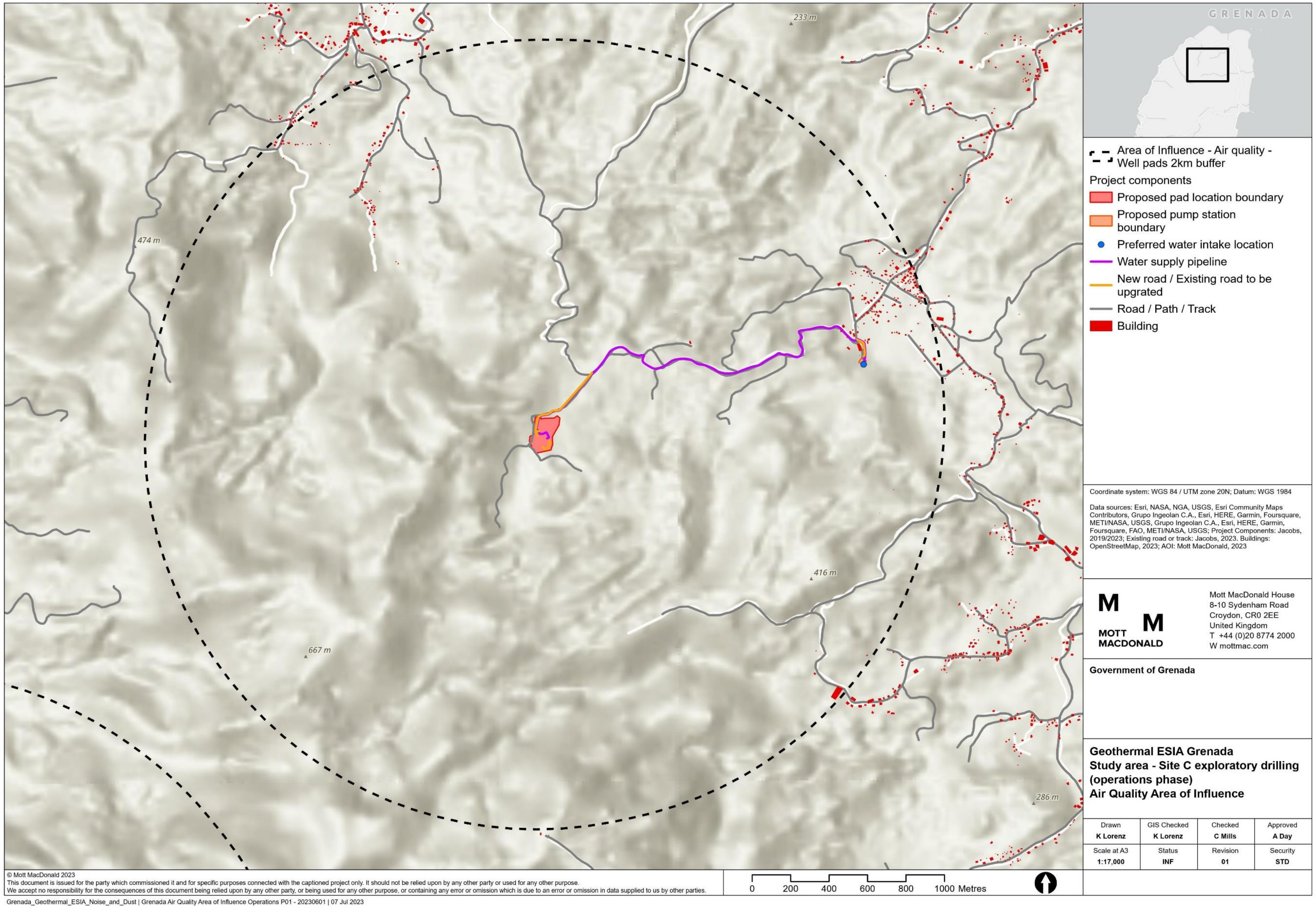
Source: Mott MacDonald

Figure 11.2: Dust area of influence for construction phase – Site F



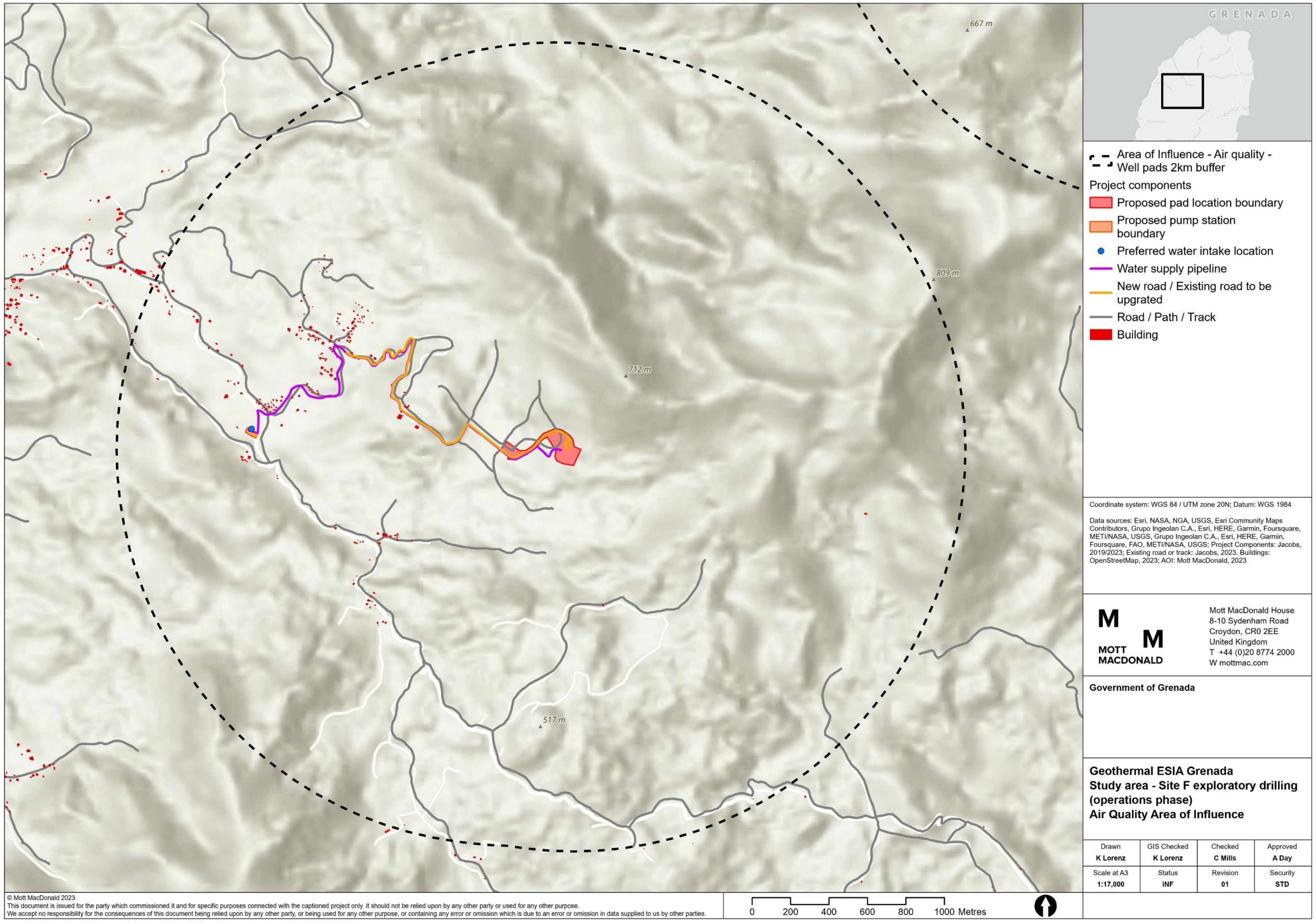
Source: Mott MacDonald

Figure 11.3: Air quality area of influence for operations phase – Site C



Source: Mott MacDonald

Figure 11.4: Air quality area of influence for operations phase – Site F



Grenada_Geothermal_ESIA_Noise_and_Dust | Grenada Air Quality Area of Influence Operations P01 - 20230601 | 07 Jul 2023

Source: Mott MacDonald

11.3 Applicable standards

This section provides an overview of the applicable air quality standards for the project.

IFC Performance Standard 3: Resource Efficiency, Pollution Prevention and Control aims to:

"Prevent or minimize adverse impacts on human health and the environment by preventing or minimizing pollution from project activities."

To meet this objective, the IFC provides both industry-specific and general guidance on Good International Industry Practice in relation to ambient air quality and emissions to air. The Project will be required to meet the IFC Performance Standards, and the standards set out in the IFC General EHS Guidelines. The IFC General EHS Guidelines state that "relevant standards" for ambient air quality are national standards mandated by law or, in their absence, existing World Health Organization (WHO) Air Quality Guidelines (AQGs) for Europe, 2nd Edition 2000, ("the WHO guidelines") or other internationally recognized sources. Grenada does not currently have its own mandated ambient air quality standards or emission requirements and therefore standards from the neighbouring CARICOM country of Trinidad and Tobago have been adopted for the assessment.

The use of these standards is considered appropriate given the ambient standards broadly align numerically with those set out in other international jurisdictions, such as those used in the European Union. The standards also broadly align with those set out within the WHO Ambient Air Quality Guidelines, Global Update, 2005.

As noted above, the construction (site clearance and preparation) and operation (drilling and testing) phases of the Project could potentially lead to emissions of a range of combustion related pollutants including NO_x, particulates and SO_2. During the initial well testing phase, and in the unlikely event of fugitive emissions or a well blowout, hydrogen sulphide (H_2S) may also be released. The Project shall be designed to comply with the relevant Trinidad and Tobago standards and for the case of H2S, which is the main pollutant of concern, additional guidelines from the WHO.

11.3.1 Standards applied to the project

The Air Pollution Rules, 2014 define an air pollutant as any parameter listed in the First or Second Schedule of the rules which is emitted into the air. Table 11.1 and Table 11.2 provide the maximum permissible concentrations in ambient air and the maximum permissible emission limit for stack releases of applicable pollutants to the project.

Table 11.1: Ambient Air Polluants

Compound	Short Term Maximum Permissible Level		Long Term Maximum Permissible Level	
	Maximum Permissible Limit ($\mu g/m^3$)	Averaging Time	Maximum Permissible Limit ($\mu g/m^3$)	Averaging Time
Particulates				
Total Suspended Particulates (TSP)	150	24-hours		
PM_{10}	75	24-hours	50	1 year
$PM_{2.5}$	65	24-hours	15	1 year
Non-Metallic Inorganic Substances				

Compound	Short Term Maximum Permissible Level		Long Term Maximum Permissible Level	
	Maximum Permissible Limit (µg/m^3)	Averaging Time	Maximum Permissible Limit (µg/m^3)	Averaging Time
Nitrogen dioxide (NO_2)	200	1 hour	40	1 year
Sulphur dioxide (SO_2)	500	10 minutes	50	1 year
	125	24 hour		
Hydrogen Sulphide (H_2S)	30	30 minutes		
Metallic Substances				
Mercury (Hg)	1.5 of total alky; Hg compounds	30 minutes		
	5.0 of total Hg in free and combined form	30 minutes		

Source: Environnemental Management Authority, 2014

Table 11.2: Stack Release Limits

Parameter	Maximum Permissible Limit (mg/m^3)
Particulate Matter	100mg of particulate matter in each normal cubic meter of residual gases (adjusted to a basis of 12% CO2 for air emissions from fuel burning equipment, if required by the specified test method)
Oxides of Nitrogen (NOx)	500 as NO_2
Carbon Monoxide	1000
Hydrogen Sulphide	15

Source: Environmental Management Authority, 2014

As noted above, operation of the project could potentially lead to emissions of a range of combustion related pollutants. During the initial well testing phase, and in the unlikely event of fugitive emissions or a well blowout, H_2S may also be released. The project shall be designed to comply with the relevant standards set out in Table 11.1 but will also consider the H_2S air quality guideline set out by the WHO.

The WHO H_2S guideline is presented instead in Table 11.3. Although covered by the standards adopted for the assessment, these only provide a standard for a 30 minute average whereas the WHO guidelines is based on a 24hr averaging period and has considered a wide range of epidemiology studies to derive this guideline.

Table 11.3: WHO Ambient Air Quality Guidelines

Pollutant	Averaging Period	Value (µg/m^3)
Hydrogen Sulphide	24 Hour	150 (guideline)

Source: The WHO guidelines (WHO, 2000)

The WHO guidelines, from which the guideline for H_2S is sourced and draws heavily on international data, acknowledges that when States use the guidelines for setting legally binding standards, considerations such as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, and social, economic and cultural conditions should be taken into account.

The WHO defines a guideline as "…any kind of recommendation or guidance on the protection of human beings or receptors in the environment from adverse effects of air pollutants". This assessment has interpreted the application of the WHO standard as being relevant to those locations only where receptors can reasonably be expected to be exposed for the specified averaging period. This is in accordance with the application of, for example, the EU Air Quality Directive (2008/50/EC) where application of ambient air quality objectives excludes areas of non fixed habitation (i.e. residential areas), work and industrial locations and within roads. In the case of H_2S, the averaging period is 24 hours and therefore this guideline has only been applied to locations where receptors can reasonably be expected to be located for this duration, i.e. residential locations. This approach is consistent with international interpretation of air quality standards such as those in Europe.

Project workers and nearby agriculture workers exposure to H_2S is a key air quality risk to the Project. The United Kingdom's Health and Safety Executive has set a workplace exposure limit for H2S of 5ppm for a time weighted average of 8hrs which is equivalent to 7,000µg/m^3. This standard has been considered when assessing potential occupational air quality impacts from the Project.

Some studies of the potential impacts of H_2S on vegetation have been undertaken in the US and Canada which has included studies on plants in the biosphere as well as in laboratory experiments. In general, studies have found that negative effects on vegetation occur only with prolonged exposure to H_2S, and that lower levels can stimulate growth in certain types of plants. No formal guidelines have been set for the impacts of H_2S on vegetation, but a report published by Alberta Environment (Assessment Report On Reduced Sulphur Compounds, 2004) recommended a limit of 140µg/m^3 as a no observable effect concentration, for long-term exposure (long-term exposure usually being interpreted, for example within the EU, as annual average periods). Therefore, in the present assessment, this limit has been adopted as an annual mean to assess the potential effects of H_2S on vegetated areas.

11.3.2 IFC EHS Guidelines for geothermal projects

The IFC EHS Guidelines for geothermal projects provide recommendations on how to manage environmental, health, and safety risks, including air quality concerns, throughout the lifecycle of a project. The guidelines aim to minimize air emissions and prevent adverse impacts on the environment, worker health, and nearby communities. When it comes to air quality, the IFC EHS Guidelines for geothermal projects address the following key aspects:

- Emission control: The guidelines recommend the use of best available technologies and practices to reduce emissions of pollutants such as PM_{10}, $PM_{2.5}$, NOx, SO_2 and volatile organic compounds (VOCs).
- Air dispersion modelling: To assess the potential impact of emissions on local air quality, the guidelines advise conducting air dispersion modelling to predict pollutant concentrations and evaluate compliance with applicable ambient air quality standards.
- Monitoring and reporting: Regular monitoring of emissions and air quality is advised to ensure compliance with relevant emission limits and standards. The guidelines also recommend reporting the monitoring results to relevant authorities and stakeholders.
- Emergency preparedness: The guidelines suggest developing and implementing emergency response plans to address potential accidental releases of air pollutants, ensuring the safety of workers and local communities.
- Section 11.4 sets out how these guidelines have been adopted, where relevant for the assessment.

11.4 Impact Assessment Method

11.4.1 Overview

The assessment approach included:

- Establishing the baseline using monitoring data and site reconnaissance during the scoping site visit, where available
- Review of available information on construction methods in relation to air quality issues
- Assessment of receptor sensitivity, impact magnitude and overall impact significance based on the above information and in accordance with pre-defined assessment criteria

Given the nature of the Project, the exploration, construction and drilling activities required have the potential to impact air quality beyond the Project boundaries. Each phase of the Project may impact on air quality differently; the following sections outline the potential impacts from the construction, drilling and decommissioning phases.

11.4.1.1 Baseline assessment

A monitoring survey was carried out by for the project to establish term pollutant concentrations of particulates, NO_2, SO_2 and H_2S. Data collected from the monitoring survey have been reviewed in 11.4.3 and the current baseline established.

11.4.1.2 Construction Phase Impacts

Three main types of air quality impacts have been identified during the construction phase:

- Dust generation from the road construction, site clearing, earthworks and other construction activities such as the construction of the well pad (referred to as ‘construction dust’)
- Combustion related emissions from on site plant and vehicles (referred to as ‘on site plant and vehicle exhaust emissions’)
- Dust generation and exhaust emissions from off site vehicles (referred to as ‘off site vehicle emissions’)

11.4.1.3 Operation Phase Impacts

Four main types of air quality impacts have been identified during the operation phase:

- Combustion related emissions from the drilling rig and generators
- Dust generated from drilling activities
- Particulate and gaseous emissions from well testing (referred to as ‘well testing emissions’); and
- Fugitive and uncontrolled emissions from chemical spills, well blowout etc. (referred to as ‘fugitive and well blowout emissions’).

11.4.1.4 Decommissioning Phase Impacts

Two main types of air quality impacts have been identified during the decommissioning phase:

- Combustion related emissions from on site plant and vehicles (referred to as ‘on site plant and vehicle exhaust emissions’)
- Dust generation and exhaust emissions from off site vehicles (referred to as ‘off site vehicle emissions’)

The potential effects and assessment methodology (including, where appropriate, criteria for sensitivity, magnitude and significance) for each of these impacts is described in detail in the following sections.

11.4.2 Surveys

11.4.2.1 Monitoring locations and schedule

Air Quality was measured in July 2019 at the two drilling locations (Sites C and F) for Total Suspended Solids (TSP), Particulate Matter <10 micrometres (PM_{10}), Particulate Matter <2.5 micrometres ($PM_{2.5}$), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2) and Hydrogen Sulphide (H_2S). Table 11.4 provides the GPS Coordinates of the monitoring locations.

Location C is located to the north-east of Mount St Catherine.. The nearest resident is located approximately 1 mile north of the proposed drill pad, and the nearest village – Tricolar, is located 1.5 km north-east of the proposed drill pad.

Site F is located in the Florida/Plaisance area, south west of Mount St Catherine. This Site lies close to the border of the proposed Mt. St. Catherine Forest Reserve. The area is also primarily agricultural, with crops such as cocoa, citrus, banana and nutmeg. The closest receptors are the barracks, located approximately 700 m west of the proposed drill pad, where the plantation workers live. The Florida village is also located approximately 1.3 km east of the proposed well site.

Table 11.4: GPS Coordinates for Air Monitoring Locations

Location	Co-ordinates (Decimal Degrees)		Monitoring Date	
	Latitude	Longitude	Start	End
CA1 (MiniVOLs and MultiRAE)	12.181415°	-61.663879°	18-07-2019	19-07-2019
CA1 (PDTs)			18-07-19	11-08-19
FA1 (MiniVOLs and MultiRAE)	12.154310°	-61.692281°	16-07-2019	17-07-2019
FA1 (PDTs)	12.155953°	-61.699321°	16-07-2019	11-08-19

Source: Eco Engineering, 2019

11.4.2.2 Equipment

Three types of samplers were used to monitor air quality:

- An Airmetrics MiniVol portable air sampler was used to monitor Total Suspended Particulate Matter (TSP) and Particulate Matter (PM_{10} and $PM_{2.5}$) over a 24-hour period at each site.
- Concentrations of NO_2, SO_2 and H_2S were monitored using the MultiRAE Lite Wireless Portable Multi-Gas Monitor over a 24-hour period at each site.
- Passive Diffusion Tubes (PDTs) were used to measure concentrations of NO_2, SO_2 and H_2S over periods of twenty-four and twenty-five days at Site C and Site F, respectively.

Airmetrics MiniVol Portable Air Sampler

Particulate matter was measured using Airmetrics MiniVol Portable Air Samplers. The choice of this meter was on the basis of its ability to give a better level of accuracy in the high humidities expected at the two sites.

Each MiniVol Portable Air Sampler was stationed approximately 1.5m from the ground. Pre-weighed filters were placed into the MiniVol unit. The flow rate of the meters were adjusted to

0.5 L/min and allowed to run for the duration of the 24-hour monitoring period at each site. The filters were then removed and stored in sterile holders.

The filters were sent to the laboratory at R.O.S.E. Environmental Services in Trinidad under a strict Chain of Custody to be weighed. At the lab, each filter was weighed (after moisture equilibration) before and after sampling to determine the net gain in weight.

The total volume of air sampled was determined from the measured flow rate and the sampling time. The concentration of particulate matter and total suspended particulate matter in the ambient air is computed as the mass of collected particles divided by the volume of air sampled, corrected to standard conditions, and is expressed in micrograms per cubic metre (µg/m^3).

MultiRAE Lite Wireless Portable Multi-Gas Monitor

Sulphur Dioxide, Nitrogen Dioxide and Hydrogen Sulphide were measured at each site using a MultiRAE Lite Wireless Portable Multi Gas Monitor. This monitor was chosen as it is a standard piece of equipment used in the Caribbean for air quality monitoring of these gases and has been accepted in previous Environmental Impact Assessments.

The range, and resolution of parameters measured with the MultiRAE Lite meter are presented below.

Table 11.5: Parameters

Parameter	Range	Resolution
SO_2	0-20 ppm	0.1 ppm
NO_2	0-20 ppm	0.1 ppm
H_2S	0-200 ppm	0.1 ppm

Source: Eco Engineering, 2019

The Multi-RAE Plus meter was stationed approximately 1.5 m from the ground and allowed to run for the duration of the 24-hour monitoring period at each site. The meters were set according to factory recommendations, and peak, minimum and time weighted average (TWA) values were recorded.

Passive Diffusion Tubes (PDTs)

PDTs were used to monitor SO_2, NO_2 and H_2S as follow:

- NO_2 – 20% TEA/WATER, Analysis UKAS Method – GLM7 and GLM9;
- SO_2 – Analysis UKAS Method – GLM1; and
- H_2S – Analysis UKAS Method – GLM5

Diffusion tubes are categorized as an “indicative” monitoring techniques but are widely used to provide long term pollutant concentrations in a cost effective way. The PDTs were positioned at a height of 2-4 m above the ground and left in place for 24 and 25 days at Site C and Site F, respectively. The PDTs were done in triplicate for each parameter at each site; however, it should be noted that only two PDTs for NO_2 were successfully analysed for Site C as a Paper Wasp built a nest in the third tube thereby compromising it. The tubes were deployed according to laboratory recommendations. The PDTs were dismounted and transported to the Gradko Environmental Laboratory in the United Kingdom for analysis by gas chromatography.

11.4.2.3 Site Weather Conditions

The weather conditions experienced during each day of 24-hour monitoring programme are given below in Table 11.6.

Table 11.6: Site weather conditions

Location	Date	Weather Conditions
CA1	18/19-07-2019 (24 hours)	Overcast, Damp, Windy
FA1	16/17-07-2019 (24 hours)	Overcast, Damp, Windy, Occasional light rainfall

Source: Eco Engineering, 2019

11.4.3 Construction phase (site establishment and access)

Construction activities can result in temporary effects from dust. 'Dust' is a generic term which usually refers to particulate matter in the size range 1-75 microns in diameter. Emissions of construction dust are associated with the movement and handling of minerals and are therefore predominantly composed of the larger fraction of this range which does not penetrate far into the respiratory system. Particles such as PM_{10} (defined as airborne particles with an aerodynamic diameter of 10 microns or less) which have a greater potential for health effects normally represent a smaller fraction of construction emissions. Therefore the primary air quality issue associated with construction phase dust emissions is loss of amenity and/or nuisance caused by, for example, soiling of buildings, vegetation and reduced visibility. Dust deposition can be expressed in terms of mass per unit area per unit time, e.g. $mg.m^{-2}.day^{-1}$. There is no specific applicable deposition criterion in Grenada, however, the usefulness of numerical criteria to determine effects from construction dust is limited as the perception of loss of amenity or nuisance is affected by a wide range of factors such as character of the locality and sensitivity of receptors. Because of this, the assessment methodology proposed for this assessment is based on a qualitative / risk-based approach.

11.4.3.1 Sensitivity

Receptors with the potential to be significantly affected by dust emissions have been identified. The distances from source where construction dust effects are felt are dependent on the extent and nature of mitigation measures, prevailing wind conditions and the presence of natural screening by, for example, vegetation or existing physical screening such as boundary walls on a site. However, research indicates that effects from construction activities that generate dust are generally limited to within 150-200 metres of the source but can travel up to 350m. Therefore, all potential receptors within 350 metres of the construction activities have been considered, and their sensitivity to effects determined in accordance with Table 11.7.

Table 11.7: Receptor sensitivity

Sensitivity		
High (4)	**Medium (3)**	**Low (2)**
Health facilities	Schools	Farms / agriculture
Food processing	Residential areas	Light and heavy industry
	Food retailers	Outdoor storage
	Offices	On site workers

Source: Mott MacDonald, numbers in brackets refers to scoring criteria in accordance with overall ESIA approach defined in Chapter 6.

11.4.3.2 Magnitude

The assessment has involved the identification of specific construction activities which have the potential to generate dust emissions, and the degree of that potential, in accordance with the generic activities presented in in Table 11.8.

Table 11.8: Generic dust generating activities

Stage	Description	Potential Dust Emitting Activities	Dust Emission Magnitude	Score
Setup and enabling works	Rerouting of utilities	Excavation works	Moderate - Major	4
Roads and Infrastructure	Installation of new access roads as required. Installation of infrastructure below road level.	Excavation works Transport of materials Resuspension of dust on unsurfaced roads.	Moderate	3
Site clearance and ground works	Vegetation clearing, levelling, foundations support, import / export of soil / rocks	Earthmoving. Excavation. Demolition. Crushing. Transport of materials. Resuspension of dust on unsurfaced roads.	Moderate - Major	4
Construction of well pads	Concrete buildings, delivery of heavy equipment, use of raw materials and waste generation. Crushing of materials for the well pad	Transport of materials. Storage of materials. Preparation of materials (cutting or crushing etc.). Resuspension of dust on unsurfaced roads.	Moderate - Major	3
Access to the site	Movement of HGVs on unpaved roads	Resuspension of dust from HGV movements.	Moderate	3

Source: Table adapted from: a) Minerals Policy Statement 2: Controlling and Mitigating the Environmental Effects of Minerals Extraction in England, Annex 1: Dust. b) Building Research Establishment (2003). The 'Control of Dust from Construction and Demolition Activities'.

11.4.3.3 Duration

The duration of construction works is less than five years and therefore considered short term. An assessment score of one has been applied to the construction activities.

11.4.3.4 Scale

All construction impacts are considered to be local in nature and therefore an assessment score of one has been applied to all construction activities.

11.4.3.5 Probability

The probability of the activity taking place that has been assessed are described as certain and therefore an assessment scope of four has been applied to all construction activities.

11.4.3.6 Construction activities scoped out

Air quality impacts from on site construction plant exhaust emissions could occur as a result of emissions of NOx, PM_{10} and $PM_{2.5}$. Based on the project type, relatively few on site vehicles or plant are expected to be operating at any one time. On site plant and vehicle emissions during the construction phase are therefore considered to be of negligible significance. These impacts have not been assessed further, however; mitigation measures have still been proposed in section 11.7 as a matter of good practice.

Site establishment and access requires associated construction traffic, comprising contractors' vehicles and heavy goods vehicles (HGVs). This will result in emissions of NOx, PM_{10} and $PM_{2.5}$. In addition, movement of heavy vehicles on non-asphalt roads can result in dust resuspension. Impacts from combustion related pollutants are considered to be negligible, given the likely number of vehicle movements and temporary nature of the works.

11.4.4 Operation Phase

11.4.4.1 Sensitivity

To determine the receptor sensitivity for the operational phase, with the exception of operational impacts associated with dust, the approach has been based on the existing baseline obtained from the monitoring undertaken for the Project. The General EHS Guidelines classify ‘poor quality airsheds’ as those where relevant standards are exceeded significantly. Therefore, receptors experiencing baseline ambient pollutant concentrations above the relevant standards are concluded to be of ‘High’ sensitivity. Where existing pollutant concentrations are judged to be less than 50% of the relevant air quality standards the receptor sensitivity is classed as ‘Negligible’.

Table 11.9: Determination of Receptor Sensitivity – Operational Phase

Ground Level Pollutant Concentrations in Relation to Standard	Receptor Sensitivity	Score
Above Standard	High	4
75 to 100% of the Standard	Medium	3
50 to 75% of the Standard	Low	2
Below 50% of the Standard	Negligible	1

Source: Mott MacDonald

11.4.4.2 Magnitude

Combustion related emissions from the drilling rig and generators

Combustion related pollutants will be emitted from the drilling rig (which includes three 600kW diesel-powered generators). Diesel combustion can produce NOx, PM_{10}, $PM_{2.5}$ and SO_2. In the absence of detailed information on the generators their location and stack design, professional judgement based on the likely magnitude of the emissions and their impacts has been used rather than dispersion modelling.

Dust generation from operational traffic

Operational traffic has the potential to generate dust from suspension on roads accessing the site. The same approach to determine magnitude as highlighted in section 11.4.3.2 has been applied.

Well testing emissions

Following completion of the well drilling, the well and associated reservoir will be tested to understand it geothermal potential. During this process emissions to air are released and can include emissions such as H_2S and Hg. Given the current status of the project development there is currently no available information on the H_2S, Hg and other Non-Condensable Gas (NCG) such as methane and ammonia in the steam that would be released during the testing.

Without the necessary information to carry out dispersion modelling, it is not possible to assess the significance of well testing impacts at this stage using a quantitative method. Therefore, in lieu of dispersion modelling results, a qualitative assessment has been undertaken by identifying potential effects. As key information such as the H_2S content is not known, generic precautionary mitigation measures have also been proposed in section 11.7 such that the Project workers are not put at risk from high H_2S concentrations.

Fugitive emissions and well blow out

Fugitive emissions other than H_2S releases are generally considered to be of negligible significance, however this significance can typically be quantified through dispersion modelling of well testing scenarios. As stated above, there is currently not enough available information to undertake dispersion modelling, therefore it is not possible to comment of the significance of potential impacts from fugitive emissions of H_2S and well blowout emissions. Precautionary mitigation measures have also been proposed in section 11.7 such that the Project workers are not put at risk from high H_2S concentrations.

11.4.4.3 Duration

The duration of drilling and well testing will be less than five years and therefore a score of one has been applied to all activities.

11.4.4.4 Scale

All impacts will be local in scale and therefore a score of one has been applied to all activities.

11.4.4.5 Probability

When considering the probability of the emissions occurring the potential likelihood of the activity has been considered.

11.4.4.6 Operational activities scoped out

Dust generation from drilling activities

Drilling may generate dust through the separating and storing of cuttings and the earthworks directly involved in the drilling process. The impacts of proposed drilling activities are unlikely to be significant given the cuttings will be wet and therefore have not been assessed further. Nevertheless, good practice mitigations have been presented in section 11.7 such that the impacts are not significant.

Combustion emissions from operational traffic

Due to the low numbers of operational vehicles and the low baseline pollutants no further assessment of operational traffic emissions has been undertaken.

11.4.5 Decommissioning phase

The decommissioning phase is likely to have similar air quality impacts as the construction phase due to the similarity in activities involved. These have not been assessed in full and cover the following activities.

11.4.5.1 On site plant and vehicle exhaust emissions

Air quality impacts from on site construction plant required to demobilise the drilling rig could occur as a result of exhaust emissions of NOx, PM_{10}, $PM_{2.5}$ and other combustion related pollutants. Considering the temporary nature of these impacts and the short duration of effects, on site plant and vehicle emissions during the decommissioning phase are considered to be of negligible significance. These impacts have not been assessed further, however, mitigation measures have still been proposed in Section 11.7 as a matter of good practice.

11.4.5.2 Off site vehicle emissions

Mobilisation and decommissioning require associated traffic, comprising contractors' vehicles and HGVs. This will result in emissions of NOx, PM_{10}, $PM_{2.}$and other combustion related pollutants. In addition, movement of heavy vehicles can cause dust resuspension. Impacts from combustion related pollutants are considered to be negligible, given the likely number of vehicle movements and temporary nature of the works. As the roads will be upgraded as part of the project dust resuspension is also considered negligible. Therefore, no further assessment of off-site vehicles during decommissioning has been made. However, mitigation measures proposed in Section 11.7 for construction activities would remain applicable for the decommissioning phase and should be reviewed prior to any decommissioning works commencing.

11.4.6 Impact evaluation and determination of significance for air quality

The approach to identify magnitude and sensitivity described for the construction and operation impacts discussed in the sections above have been used in conjunction with the approach set out within Chapter 6 to determine overall significance of effects. For each aspect, the significance of impacts will be discussed before and after mitigation (i.e. residual impact). Impacts identified as having major or moderate significance based on the above approach are classified as significant impacts.

11.4.7 Limitations and assumptions

In undertaking the air quality impact assessment, the following data limitations have been identified:

- Baseline data presented in section 11.5 is based on monitoring undertaken for a limited duration only.
- No information on NCG and H_2S content of the steam; this information is required to undertake quantitative dispersion modelling of well testing operations and, on the basis of this, to determine the likely significance of fugitive emissions and well blowouts using quantitative modelling.
- No specific information on construction activities, such as the expected number and timing of heavy goods vehicles (HGVs), plant and staff movements.
- No information on drilling methodology.
- No information on venting.

We have taken a conservative assessment approach and heightened the level of risk identified to any potential sensitive receptors for air quality exposure to dust and other related impacts and reflected this in more stringent mitigation measures to be adopted during all Project phases.

11.5 Baseline – description of pre project conditions

11.5.1 Overview

Geothermal surface exploration undertaken in the area surrounding the Sites C and F reported no fumaroles or steaming ground, however H_2S and acid sulphate springs were found[2]. Strong H_2S smells were also detected during a comprehensive geothermal investigation undertaken by Jacobs in 2016[3]. However, gas sampling found that H_2S concentrations in these areas were

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[2] Jacobs (2016). Geothermal Surface Exploration in Grenada – Govt Stakeholders 21 June 2016 (powerpoint presentation)

[3] Jacobs (2016). Integrated Report: Geology, Geochemistry & Geophysics, RZ020300.04-TEC-RPT-007 | C (Final Report).

below the detection limit[4] during the sampling period and during the recent site visit, no sulphurous odours were detected.

Local biomass burning and vehicle traffic may represent a small contribution to ambient concentrations of NOx, PM_{10}, $PM_{2.5}$ and SO_2. Wind-blown dust from the Sahara is also reported to result in elevated ambient concentrations of particulates in Grenada. However, the area is sparsely populated and there is no large industry or combustion plants so concentrations of NO_x, particulates and SO_2 are expected to be below the relevant ambient air quality standards.

Air quality monitoring has been undertaken by Eco Engineering in 2019 to quantify ambient concentrations of key pollutants such as particulates, NO_2, SO_2 and H_2S at the proposed project sites.

11.5.2 Sources of air emissions

Both Locations C and F are situated in rural areas, with agriculture as the primary activity. Therefore, sources of air emissions are minimal. The main sources identified were exhaust emissions from vehicles (which contain NO_2 and SO_2) which enter the area. During field surveys, traffic was noted to be very low (approximately three vehicles per day at Site C and approximately one vehicle per day at Site F). Access roads to the drill pad were noted to be unpaved, and it is expected that wind, as well as the 'kick-up' of dust from the contact of tyres on the roadway will be a source of dust emissions.

11.5.3 Air quality results

The results recorded during the monitoring exercise are shown in Table 11.10, Table 11.11, Table 11.12 and Table 11.13 below. These results are compared to the air quality standards applied to the assessment.

Table 11.10: 2019 Air quality results for particulates (24-Hour TWA)

Location	TSP (µg/m3) (24-hr period)	PM10 (µg/m3) (24-hr period)	PM2.5 (µg/m3) (24-hr period)
C	26.4	30.6**	13.9
F	19.4	12.5	11.1
AQ standard	-	**75**	65

Source: Eco Engineering, 2019

Note: **Anomalous Value – PM10 is a subset of TSP and therefore should not exceed it.

Table 11.11: 2019 Air Quality Results for NO_2, SO_2 and H_2S (24-Hour Mean), collected with MULTIRAE gas monitor

Location	NO_2 (µg/m^3) (24-hr period)	SO_2 (µg/m^3) (24-hr period)	H_2S (µg/m^3) (24-hr period)
C	0	0	0
F	0	0	0
AQ standard	**200** (1 hr standard)	**125**	**30** (30 minute standard

Source: Eco Engineering, 2019

4 Jacobs (2016). Integrated Report: Geology, Geochemistry & Geophysics, RZ020300.04-TEC-RPT-007 | C (Final Report).

Table 11.12: 2019 Air Quality Results for NO_2, SO_2 and H_2S (PDTs) at Site C

Parameter	Period	Concentration (µg/m^3)	AQ Standard (µg/m^3)
NO_2	24 days average	<0.66	200 (1hr standard) 40 (annula standard)
SO_2	24 days average	<0.90	500 (10 minute standard) 125 (24hr standard) 50 (annual standard)
H_2S	24 days average	<0.06	30 (30 minute standard) 150 (24hr WHO standard)

Source: Eco Engineering, 2019

Table 11.13: 2019 Air Quality Results for NO_2, SO_2 and H_2S (PDTs) at Site F

Parameter	Period	Concentration (µg/m^3)	AQ Standard (µg/m^3)
NO_2	25 days average	<0.64	200 (1hr standard) 40 (annula standard)
SO_2	25 days average	<0.93	500 (10 minute standard) 125 (24hr standard) 50 (annual standard)
H_2S	25 days average	<0.05	30 (30 minute standard) 150 (24hr WHO standard)

Source: Eco Engineering, 2019

11.5.4 Discussion

11.5.4.1 Particulates

At both Sites C and F, short-term (24-hour) PM_{10} and $PM_{2.5}$ concentrations were well below the 75 and 65µg/m^3 level stipulated in applicable standards. Site C had slightly higher values of all three particulate parameters in comparison to Site F. Although monitoring was only undertaken for one day, considering the concentrations recorded it is likely the annual mean maximum permissible levels would also be met at both Site C and F.

11.5.4.2 Other Air Pollutants

At both Sites C and F, NO_2, SO_2 and H_2S were not detected during 24-hour monitoring using the MultiRAE Gas Monitor. This is likely to be because concentrations were below the level of detection of the equipment and confirms pollutant concentrations are low.

This is supported by the results obtained using the PDTs. At both Sites C and F, only trace concentrations of NO_2, SO_2 and H_2S were detected using the PDTs. For NO_2, these minimal concentrations were well below the long-term (1-year period) concentration stipulated in the applicable AQ standards (40 µg/m^3 for NO_2). The AQ standards provide a long terms SO_2 standard and the results indicate that there would be no risk of this being exceeded. The monitoring data shows H_2S concentrations are also very low, and although a direct comparison cannot be made to either the AQ standards applied to the project or the WHO standard, the risk of these being exceeded is very low.

11.5.4.3 Summary

In summary, it can be concluded that the existing airshed for all pollutants of concern can be categorised as non degraded and existing concentrations are very low, significantly below the applicable air quality standards applied to the Project.

11.6 Assessment of impacts

11.6.1 Overview

This section predicts air quality impacts expected to occur as a result of the exploratory phase of the Project and assesses the beneficial and adverse effects by determining their significance prior to mitigation. Impacts have been considered and assessed for the following phases:

- Construction -site preparation (including access road construction and well pad set up)
- Operation - drilling works and well testing
- Decommissioning.

11.6.2 Summary of changes, impacts and receptors

This section presents the identification and assessment of the following effects of the Project during construction, operation and decommissioning along with the key receptors associated with each activity. As there is some overlap with the same types of impacts between phases the impacts have been presented on an activity basis.

Table 11.14: Changes caused by the project, potential impacts and affected receptors

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Increase in dust from general site establishment works and access road construction	Construction	**Site C** During the construction phase there will be earthmoving, stockpiling, land clearance and excavation have the potential to create air quality impacts. Different activities will create different levels of dust, so the magnitude of change will vary throughout the construction phase. Nevertheless, considering activities will include creating the new well pads, and improving access roads it has conservatively been assumed that the construction activities at the well pad will have a 'major' dust raising magnitude whilst in other areas the dust raising potential is described as 'moderate'. **Site F** During the construction phase there will be earthmoving, stockpiling, land clearance and excavation have the potential to create air quality impacts. Different activities will create different levels of dust, so the magnitude of change will vary throughout the construction phase. Nevertheless, considering activities will include creating the new well pads, and improving access roads it has conservatively been assumed that the construction activities at the well pad will have a 'major' dust raising magnitude whilst in other areas the dust raising potential is described as 'moderate'.	**Site C** The closest receptors located to the proposed Site C will be farm workers and residential property. There are also a number of residential receptors located within 350m of the proposed pump station boundary. By conservatively assuming, all receptors within the study area are residential, or receptors with equal sensitivity, the receptor sensitivity for impacts associated with construction dust is considered to be 'medium'. **Site F** The closest residential receptors located to the proposed Site F well pad is more than 700m but agricultural land is located with 350m. There are also a number of residential receptors located within 350m of the proposed pump station boundary and access road to the drill pad site. By conservatively assuming, all receptors within the study area are residential, or receptors with equal sensitivity, the receptor sensitivity for impacts associated with construction dust is considered to be 'medium'.

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Increase in dust from traffic	Construction	**Site C and F** Dust resuspension can be caused by movement of HGVs on tracks and roads during the access road upgrade works. Once roads are complete, the Project site will be accessed via paved roads. Dust impacts of these improvements to road infrastructure are expected to last for a short duration only. The magnitude of the impact is described a 'moderate'	**Site C** There are less than 50 residential receptors within 350m of the access roads and therefore the receptor sensitivity is described as 'medium'. **Site F** There are less than 100 residential receptors within 350m of the access roads and therefore the receptor sensitivity is described as 'medium'.
	Operation	Operation phase traffic is expected to be limited to fuel and chemical supply, waste disposal and staff movements. Roads will be surfaced prior to operation which will reduce dust. Considering the low traffic volumes and the surfaces roads following upgrades the dust raising potential is described as 'minor'.	**Site C** There are less than 50 residential receptors within 350m of the access roads and therefore the receptor sensitivity is described as 'medium'. **Site F** There are less than 100 residential receptors within 350m of the access roads and therefore the receptor sensitivity is described as 'medium'.
	Decommissioning	As for operation and not considered further	

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Drilling rig emissions	Operation	Emissions of combustion-related pollutants from drilling rigs and other on-site plant have the potential to impact on air quality in the Project area. The exploration wells will be drilled using a large rig of 300 tons of hook load. The drilling rigs will include three 600kW diesel-powered generators. The use of these will be incrementally used during drilling as power requirement increases, so that all four will not be operating at the same time when drilling commences but will all be working towards the end of the drilling process. The combustion of diesel emits emissions of NOx, particulates and CO. The composition of exhaust gases will depend on the fuel used (for example its sulphur content) and combustion conditions (i.e. old or poorly maintained generators are likely to produce emissions with a greater percentage of harmful pollutants than newer equipment). The potential magnitude of impacts associated with the drilling rig is considered to be 'moderate' on the basis that whilst the total installed MW capacity will be low, air quality impacts from the generators have the potential to lead to air quality impacts in locations located within 1km of the well pad if they are not managed appropriately.	**Site C** The closest receptors will be the farm workers and those residential properties located nearby. Other receptors will include the project workers and agricultural workers. Given the existing baseline pollutant concentrations, the existing receptor sensitivity is described as 'low'. **Site F** The closest residential receptors located to the proposed Site F well pad is more than 700m. Other receptors include the Project workers and agricultural workers. Given the existing baseline pollutant concentrations, the existing receptor sensitivity is described as 'low'.

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Well testing emissions	Operation	**Applicable to Site C and F** Testing a geothermal well typically involves releasing steam, water, and other gases from the wellbore into the atmosphere. The specific emissions that may be released depend on several factors, including the temperature, pressure, and chemical composition of the geothermal fluids. Some of the common emissions that may occur during geothermal well testing include: • Steam: The primary emission from geothermal well testing is steam, which is produced when hot geothermal fluids are released to the atmosphere. Steam emissions from geothermal wells are generally considered to be relatively benign, as they are primarily composed of water vapor. • SO_2: Some geothermal fluids contain sulphur compounds, which can be converted to SO_2 when exposed to air. SO_2 emissions can contribute to acid rain and other environmental problems and cause human health impacts. • (H_2S: Geothermal fluids can also contain H_2S, which is a toxic gas that can pose health risks to humans and animals. H_2S emissions are typically closely monitored during geothermal well testing to ensure that they remain at safe levels. The exact emissions from geothermal well testing will depend on a variety of factors and can vary from site to site. At the time of writing there is insufficient information on the composition of the steam to quantitatively assess the impacts of well test emissions on air quality. Therefore, considering the potential health consequences associated with high H_2S concentrations and no data being available, there are potential significant adverse effects. On this basis appropriate mitigation measures in the form of onsite monitoring and a development of an emergency response plan have been included as part of the project mitigations.	**Applicable to Site C and F** Emissions from well testing would affect receptors in close proximity to the well. This would include Project workers and nearby agricultural workers. Considering the low existing background concentrations and the high standard that has been adopted for H2S with regard occupational exposure the receptor sensitivity is described as 'low' On the basis that any releases of H2S from well testing would likely be for a limited duration (weeks and not years) impacts on vegetation are not likely to be significant and therefore these receptors have not been considered further.

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Fugitive and uncontrolled emissions	Operation	**Applicable to Site C and F** Although unlikely to occur, well blowouts may occur during well drilling, however the risk is reduced through the employment of a blowout preventer. The main impacts are on workers' health and safety due to uncontrolled releases of H_2S. However, due to the lack of available information, it is not possible to determine the significance of impacts from uncontrolled emissions. On this basis appropriate mitigation measures in the form of onsite monitoring and a development of an air quality action plan have been set out.	**Applicable to Site C and F** Emissions from fugitive and uncontrolled emissions would affect receptors in close proximity to the well. This would include Project workers and nearby agricultural workers. Considering the low existing background concentrations and the high standard that has been adopted for H2S with regard occupational exposure the receptor sensitivity is described as 'low' On the basis that any releases of H_2S from well testing would likely be for a limited duration (weeks and not years) impacts on vegetation are not likely to be significant and therefore these receptors have not been considered further.

11.6.3 Analysis of construction impacts (site preparation and access)

Table 11.15 presents a summary of the impact without mitigation, an overview of key mitigation measures and the residual significance. This is based on the impact magnitude and sensitivity discussed within section 11.6.2 and the impact assessment criteria presented in section 11.4.6. The assessment demonstrates following the application of effect onsite mitigation measures to reduce dust generation, which is predicted to reduce the impacts by at least one level, the impacts are 'minor' and not considered significant.

Table 11.15: Summary of Potential and Residual Impacts: Air Quality

Potential change	Receptors	Analysis of impact (without mitigation)	Summary of impact without mitigation	Mitigation to be applied	Analysis of change to impact with mitigation	Residual Significance
Increase in dust from general site establishment works and access road construction	Residential receptors near to access roads and off-site occupational receptors	As set out in Table 11.14 the sensitivity of receptors is 'medium' and the magnitude is 'major'. When combined with the other factors included within the methodology the overall score is 30 which is 'minor' and not significant.	Nature: Negative Magnitude: Moderate to major (4) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Certain (4) Sensitivity of receptor: Medium (3) Impact: Minor (30)	Dust suppression and control measures, visual monitoring.	The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor This does not result in a change of impact or the overall significance but would reduce the potential for effects.	Nature: Negative Magnitude: Minor (1) Duration: Short term (0-5 years))1) Scale: Local (1) Probability: Certain (4) Sensitivity of receptor: Medium (3) Significance of impact: Minor (24)
Increase in dust from construction traffic	Residential receptors and off-site occupational receptors	As set out in Table 11.14 the sensitivity of receptors is 'medium' and the magnitude is moderate'. When combined with the other factors included within the methodology the overall score is 27 which is 'minor' and not significant.	Nature: Negative Magnitude: Moderate (3) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Certain (4) Sensitivity of receptor: Medium (3) Significance of impact: Minor (27)	Appropriate speed limits, covering of loads	The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor This does not result in a change of impact or the overall significance but would reduce the potential for effects.	Nature: Negative Magnitude: Minor (2) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Certain (4) Sensitivity of receptor: Medium (3) Significance of impact: Minor (24)

11.6.4 Analysis of operation phase impacts (drilling and testing)

Table **11.16** presents a summary of the impact without mitigation, an overview of key mitigation measures and the residual significance for the operation phase. This is based on the impact magnitude and sensitivity discussed within section 11.6.2 and the impact assessment criteria presented in section 11.4.6. The assessment demonstrates following the application of effect onsite mitigation measures to reduce emissions, which is predicted to reduce the impacts by at least one level, the impacts are ‘Negligible’ and not considered significant for the well drilling. As the magnitude of subsequent impact of emissions of H_2S cannot be quantified, suitable mitigation for the protection of onsite workers and the requirement to have an H2S site response plan are considered appropriate to manage the potential risks.

Table 11.16: Summary of operation phase impacts

Activity	Receptors	Analysis of impact (without mitigation)	Summary of impact without mitigation	Mitigation to be applied	Analysis o change to impact with mitigation	Residual significance
Increase in dust from traffic	Residential receptors and off-site occupational receptors	As set out in Table 11.16 the sensitivity of receptors is ‘medium’. Operation phase traffic is expected to be limited to fuel and chemical supply, waste disposal and staff movements. Roads will be surfaced prior to operation which will reduce dust. Considering the low traffic volumes and the surfaces roads following upgrades the dust raising magnitude is described as ‘Minor	Nature: Negative Magnitude: Minor (2) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Medium (2) Sensitivity of receptor: Medium (3) Impact: Minor (18)	Good site management to keep roads clean	The implementation of the proposed mitigation measures should reduce the magnitude of change from minor to negligible. This reduces the overall impact negligible.	Nature: Negative Magnitude: Negligible (1) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Medium (2) Sensitivity of receptor: Medium (3) Impact: Negligible (15)
Drilling rig emissions	On-site occupational receptors, off site occupational receptors	As set out in Table 11.16 the sensitivity of receptors is ‘negligible’. The potential magnitude of impacts associated with the drilling rig is considered to be ‘moderate’ on the basis that whilst the total installed MW	Nature: Negative Magnitude: Moderate (3) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Certain (4) Sensitivity of receptor: Negligible (1)	Engines used to power the drilling rig are required to meet best international practices such as the emissions guidelines included in the IFC EHS general guidelines.	The implementation of the proposed mitigation measures should reduce the magnitude of change from moderate to minor. This reduces the overall impact but is still described as negligible.	Nature: Negative Magnitude: Minor (2) Duration: Short term (0-5 years) (1) Scale: Local (1) Probability: Certain (4) Sensitivity of receptor: Negligible (1) Impact: Negligible (8)

Activity	Receptors	Analysis of impact (without mitigation)	Summary of impact without mitigation	Mitigation to be applied	Analysis o change to impact with mitigation	Residual significance
		capacity will be low, air quality impacts from the generators have the potential to lead to air quality impacts in locations located within 1km of the well pad if they are not managed appropriately.	Impact: Negligible (9)	Engines to have an appropriate stack height to aid dispersion		
Well testing emissions	On-site occupational receptors, off site occupational receptors Nearby vegetation	As set out in Table 11.16 the sensitivity of receptors is 'negligible'. As described in section11.4.1.3 insufficient information is available to assess quantitatively or quantitatively and therefore best practice mitigation measures to managed potential impacts have been included in section 11.7.	N/A	No vertical well testing. Use of rock mufflers to elevate emission source. Personal exposure monitoring equipment Emergency preparedness and response plan	The implementation of the proposed mitigation measures should reduce the potential impacts and identify if there is a potential issue such that appropriate actions can be undertaken	N/A
Fugitive and uncontrolled emissions	On-site occupational receptors Nearby vegetation	As set out in Table 11.16 the sensitivity of receptors is 'negligible'. As described in section11.4.1.3 insufficient information is available to assess quantitatively or qualitatively and therefore best practice	N/A	Personal exposure monitoring equipment Emergency preparedness and response plan	The implementation of the proposed mitigation measures will identify if there is a potential issue such that appropriate actions can be undertaken	N/A

Activity	Receptors	Analysis of impact (without mitigation)	Summary of impact without mitigation	Mitigation to be applied	Analysis o change to impact with mitigation	Residual significance
		mitigation measures to managed potential impacts have been included in section 11.7.				

11.6.5 Analysis of decommissioning impacts

As described in section 11.4.1.4 no further assessment of decommissioning phase impacts has been undertaken. Nevertheless, mitigation measures suitable for mitigation are included within section 11.7.

11.6.6 Discussion regarding residual significant impacts

Following the application of the mitigation measures outlined in section 11.7 there are not predicted to be any significant residual effects with regards to air quality.

11.7 Mitigation and enhancement measures

The following mitigation measures for controlling air quality impacts (Table 11.17) have been developed for incorporation into the ESMP. The mitigation measures to be applied during site restoration will be similar and in proportionate measure to the ones applied at site establishment.

Table 11.17: Air Quality mitigation and enhancement measures

Objective	Activity	Action	Responsibility	Timescale	Monitoring / KPI
Minimise dust emissions during construction	Site clearance, earthworks, material handling	• Provide personal protective equipment to workers on site, such as dust masks where dust levels are likely to be excessive • Locate activities and rock / earth stockpiles away from identified receptors (The farmers rest hut at Site C) • Cover, seed or fence stockpiles to prevent wind whipping • Bunding and sealing of topsoil and subsoils • Keep stockpiles for the shortest possible time • Consider the prevailing wind direction when siting stockpiles to reduce the likelihood of affecting sensitive receptors • No bonfires • Minimise amounts of material handling and avoid double handling • Sealing or re-vegetate completed earthworks as soon as reasonably practicable after completion • Ensuring all vehicles carrying loose or potentially dusty material to or from the site are fully sheeted • Use of modern (less than 5 years old) vehicle / construction fleet to minimise emissions • Ensuring that the engines of all vehicles and drilling equipment on site are not left running unnecessarily • Plan site layout – machinery and dust causing activities (e.g. access roads, stockpiles) should be located away from the site boundary and sensitive receptors where practicable • Minimise dust generating activities • Use water as a dust suppressant where applicable (e.g. using towed water bowsers with spreader bars) and ensure an adequate water supply • No site runoff of water or mud • Minimise movement of construction traffic around site • Regular (bi-weekly) visual monitoring of dust episodes, soiling of vegetation, dust resuspension on the roads and dust clouds	Contractors	During the construction phase	Site inspection records

Objective	Activity	Action	Responsibility	Timescale	Monitoring / KPI
		• Maintained logbook: record any exceptional incidents that cause dust, either on- or off- site, and the action taken to resolve the situation in the log book			
Minimise NOx, PM_{10}, SO_2 emissions: On-site occupational receptors Off-site occupational receptors Off-site flora and fauna	Drilling of Well	• Use of modern (less than 5 years old) vehicles which achieve internationally recognised emission limits for NO_x • Provide Project workers with personal exposure H2S monitors during the periods when drilling is taking place • Release of engine combustion emissions from sufficient height to allow proper dispersion • Engines used to power the drilling rig are required to meet best International practices such as the emissions guidelines included in the IFC EHS general guidelines • Use of low sulphur-content diesel fuel where feasible • Locate engines away from common working areas and on-site receptors to reduce exposure to emissions where practicable • Ensure engines are modern and properly maintained through regular inspections • Plan site layout – machinery and dust causing activities (e.g. access roads, stockpiles) should be located away from the site boundary and sensitive receptors where practicable • Ensure mud and cutting stockpiles are kept for the shortest possible time • Use water as a dust suppressant where applicable (e.g. using towed water bowsers with spreader bars) and ensure an adequate water supply • Minimise amounts of material handling and avoid double handling • Regular (bi-weekly) visual monitoring of dust episodes, soiling of vegetation, dust resuspension on the roads and dust clouds • Maintained logbook: record any exceptional incidents that cause dust and/or air emissions, either on- or off- site, and the action taken to resolve the situation in the log book • Resolve all dust issues identified through reinforcing the measures above	Contractors	Throughout the drilling activities	Site inspection records
Minimise H_2S emissions on:	Well testing	• Have a H_2S detector and CO_2 and CH_4 monitor for monitoring air emissions at all of the well pad installation sites	Contractors	Throughout well testing	H2S monitoring reports

Objective	Activity	Action	Responsibility	Timescale	Monitoring / KPI
On-site occupational receptors Off-site occupational receptors Off-site flora and fauna		• Provide Project workers with personal exposure H2S monitors during the periods when well testing is taking place • During each well test, collect data on steam volume, temperature, NCG and other pollutant levels • Release of steam via a silencer/rock muffler • Provision of facility emergency response teams, and workers in locations with high risk of exposure with personal H_2S monitors, self-contained breathing apparatus and emergency oxygen supplies, and training in their safe and effective use • Provision of adequate ventilation of occupied buildings and rig spaces to avoid accumulation of H_2S and CO_2 • Provide workers with a fact sheet or other readily available information about the chemical composition of H_2S with an explanation of potential implications for human health and safety • Site emergency preparedness and response plan to be put in place for drilling activities at each drilling location to control the effects of well blowout, in the unlikely event that it occurs (and to be aligned with municipality emergency response plans) • Disclose the emergency response plan to relevant receptors (farm workers at both Site C and F and the nearby village at Site F)			Preparation of fact sheet Emergency preparedness and response plan

11.8 Monitoring

The following sections present a summary of the monitoring requirements during the construction and operation phases of the Project.

11.8.1 Construction phase

Table 11.18: Air Quality requirements

Measure	Frequency	Method	Responsibility
Air quality – dust emissions	Regular (twice weekly)	Visual monitoring of dust episodes, soiling of vegetation, dust resuspension on the roads and dust clouds Monitoring to include records of mitigation implementation Records to be keep in site log book	Contractor

11.8.2 Operational phase

Table 11.19: Air Quality requirements

Measure	Frequency	Method	Responsibility
Air quality – H2S concentrations	Continuous real time H2S during drilling and well testing	• Project workers to wear personal exposure monitors • Monitoring equipment to be maintained in line with manufacturers requirements	Contractors

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12.1 Overview

This assessment describes the methodology used to assess landscape and visual impacts, identifies the Area of Influence, its baseline and the sensitive receptors within it, and presents an assessment of the potential impacts to identify where significant effects are expected to arise. The assessment of landscape and visual effects are separate but linked procedures. Landscape is assessed as an environmental resource and visual effects are considered as one of the interrelated effects on population. Both aspects have been considered in this assessment.

The following activities have been included in the landscape and visual effects assessment for the Scheme:

- Allocation of value and susceptibility to change to the landscape features
- An assessment of the sensitivity of people exposed to the views
- Determination of the magnitude of impact and the likely effects of the Project on the landscape and visual amenity of the area
- The identification of appropriate mitigation and or compensation as appropriate

12.2 Study area and area of influence

The study area includes the area from which the Project will be visible. The extent of the study area has been supported by use of digitally mapping the zone of theoretical visibility (ZTV) of the Project, based on the latest understanding of the design.

It should be noted that ZTV modelling is based on digital terrain data only, as such this tends to overestimate the visibility of a development because the data used does not register the screening effects of existing vegetation. This is particularly important for both wellpad sites C and F in this case, as both sites are surrounded by significant vegetation.

12.3 Applicable guidelines and standards

12.3.1 International

IFC Performance Standard 6 (PS6; IFC 2012a) and the associated Guidance Note 6 (GN6; IFC 2012b) focus on the protection and conservation of biodiversity. Under PS 6, ecosystem services are organized into four categories, with visual / aesthetic benefits falling into the category of cultural services, which are the non-material benefits people obtain from ecosystems (IFC, 2012) which may include natural areas that are sacred sites and areas of importance for recreation and aesthetic enjoyment. IFC also states that protecting landscapes is also important due to their role in maintaining biological diversity.

12.3.2 Landscape character

The landscape baseline study considers the constituent elements, features and other factors that contribute to existing landscape character within the study area including:

- Physical influences on the landscape resource - including topography, geology, soils, microclimate, water bodies and water courses;

- Influence of human activity – including land use, open space, transport routes, land management, the character of settlement and buildings and the pattern and type of fields and enclosure;
- Aesthetic and perceptual aspects of the landscape – including scale, complexity, openness, tranquillity and wildness; and
- Heritage features – including recognised designation and protection under international, national and local legislation and other elements contributing to historic landscape character and cultural associations

Distinctive areas of different character are defined into separate landscape character areas (LCA) as appropriate.

12.4 Methodology

Note: the method used to assess landscape and visual impacts is slightly different to that used for the other topics, acknowledging the uniquely subjective judgement which have to be made.

12.4.1 Visual baseline

The visual baseline identifies people in the area and important, designated or protected views potentially affected by the Project. Viewpoints are considered to represent various visual receptor types in the study area including residential, educational and employment. The viewpoints are based on the extent of the zone of theoretical visibility (ZTV) and findings of site visit reconnaissance. Photographs were taken during March 2019.

12.4.2 Determining Magnitude, Sensitivity and significance

The criteria for determine magnitude and sensitivity are defined in the tables below.

12.4.2.1 Landscape

The sensitivity of the landscape was evaluated by considering the existing value of the landscape and its susceptibility to the type of change arising from the proposed development. There can be a complex relationship between the value attached to the landscape and its susceptibility to change, especially if the change is within or close to a designated landscape. A landscape may have a high susceptibility to change but, depending on the type of development, it might accommodate the change without detrimental effect on its key characteristics. In this case its susceptibility to change could be medium or low. The evaluation of sensitivity was based on the criteria set out in the table below.

Table 12.1: Criteria for determining sensitivity of landscape character

Sensitivity	Landscape value and susceptibility to change
High	Typical features may include: Designated landscape. Landscape of high scenic quality with a distinctive combination of features, elements and characteristics, outstanding views and a strong sense of place. A scarce or fragile landscape with cultural, historic or ecological elements which make a major contribution to landscape character. No or very few landscape detractors. Has components which are difficult to replace (such as mature trees). A tranquil landscape in good condition, with an unspoilt, wilderness character. A high susceptibility to change due to the type of development proposed. No or very limited potential for substitution or replacement.
Medium	Typical features may include: Landscape locally designated or locally valued. Some scenic quality and a moderate sense of place. A landscape with some distinctive features, elements and characteristics. Some cultural, historic or ecological elements which contribute to landscape character. Overall medium tranquillity. Few landscape detractors. A landscape in moderate condition, with some unspoilt

Sensitivity	Landscape value and susceptibility to change
	characteristics and a moderate susceptibility to change due to the type of development proposed. Some potential for substitution or replacement.
Low	Typical features may include: Undesignated landscape, not valued for its scenic quality, with a disparate combination of features, elements and characteristics and a weak sense of place. Mainly common features and few or no cultural, historic or ecological elements that contribute to landscape character. Many landscape detractors. A landscape of low tranquillity, in poor condition and a low susceptibility to change due to the type of development proposed. Good potential for substitution or replacement.

The magnitude of change to landscape character was determined by considering:

- the nature of an impact - whether the introduction of a proposed development will be of benefit or detriment to the existing landscape character;
- the scale of the change - extent of the loss of landscape elements, the degree to which aesthetic features or perceptual aspects of the landscape are altered;
- the geographical extent of the area affected; and
- the duration of the change and its reversibility.

Table 12.2: Criteria for determining impact magnitude for landscape character

Category	Description
Major	Total loss or substantial alteration to key elements/features/characteristics of the LCA and/or its setting. Addition of new elements which conflict with key characteristics of the existing landscape. Changes that alter a substantial proportion of the LCA. Introduction of long-term and/or irreversible changes to an LCA or its setting.
Moderate	Partial loss or alteration to key elements/features/characteristics of the LCA and/or its setting. Addition of new elements or features that are prominent in the landscape but which do not necessarily conflict with key characteristics of the existing landscape. Changes that alter part of an LCA or its immediate setting. Introduction of medium to long term and/or irreversible changes to part of an LCA or its setting.
Minor	Slight loss or alteration to one or more key characteristics of the LCA and/or its setting. Addition of new elements or features that are largely characteristic of the existing LCA and/or its setting. Introduction of short to medium term changes to the LCA and/or irreversible changes to a small proportion of the LCA.
Negligible	No change to, or barely perceptible loss or alteration to key characteristics of the LCA and its setting. Addition of new elements or features that are characteristic of the existing LCA and/or its setting. Changes experienced close to the proposed development site at a very localised level.

12.4.2.2 Visual amenity

The sensitivity of visual receptors was evaluated by considering the value attached to specific views and the susceptibility of visual receptor to changes to views and visual amenity. The susceptibility to change depends on the occupation or activity of the receptor and the extent to which their attention is focused on the view and visual amenity.

Table 12.3: Criteria for determining visual receptor sensitivity

Sensitivity	Landscape value and susceptibility to change
High	Occupiers of residential or tourist properties orientated towards the development and where attention is focused on a landscape of recognised high quality. Walkers and visitors to cultural, heritage or tourist assets whose attention is focused on a landscape of recognised high quality. Designated or protected views.
Medium	People travelling along scenic roads through the landscape. Walkers and visitors to cultural, heritage or tourist assets whose attention is focused on a landscape of moderate quality.

Sensitivity	Landscape value and susceptibility to change
	Occupiers of residential or tourist properties with oblique views of the development.
Low	People at work and in educational institutions. People engaged in formal sports activities. People on main roads whose attention is not focused on the landscape (such as long-distance travellers).

The magnitude of change to views was determined by considering:

- Nature of an impact by judging whether the introduction of a proposed development would be of benefit or detriment to the existing view. The impact of a proposed development can be adverse or beneficial.
- Context of the existing view (e.g., whether it is across a natural landscape or whether detracting elements are present);
- Scale and appearance of the proposed development and the degree of contrast/ integration with the existing view;
- Distance of the visual receptor from the development and the angle/ position of view
- Duration and reversibility of the effect; and
- Geographical extent of the changes to the view.

The evaluation of the magnitude of change was based on the criteria set out in Table 12.4

Table 12.4: Criteria for determining impact magnitude for views

Category	Description
Major	Total loss or substantial alteration to key characteristics of the view. Addition of new features or components that are continuously highly visible across the majority of the view and incongruous with the existing view. Substantial changes in close proximity to the visual receptor and within the direct frame of view. Introduction of long term or permanent change uncharacteristic of the view
Moderate	Noticeable change or alteration to one or more key characteristics of the view. Addition of new features or components that may be continuously highly visible across much of the view, but are largely characteristic of the existing view. Changes a relatively short distance from the receptor, but partially filtered by intervening vegetation and/or built form, or viewed obliquely. Introduction of medium to long term change uncharacteristic of the view and/or permanent changes largely characteristic of the existing view or affecting a small proportion of the view.
Minor	Slight loss or alteration to one or more characteristics of the view Addition of new features or landscape components that may be continuously or intermittently visible in part of the view, but are largely characteristic of the existing view from a receptor Changes within the background of the view, largely filtered by intervening vegetation and/or built form, or viewed obliquely Introduction of short to medium term change uncharacteristic of the view and/or long term/permanent changes in a small proportion of the view
Negligible	No change to, or barely perceptible loss or alteration in the view. Addition of new features or landscape components that are largely inconspicuous and characteristic of the existing view. Changes within the background of the view, viewed as an inconspicuous element within the wider panorama. Change almost entirely obscured by intervening vegetation and/or built form. Short term change affecting a small proportion of the view

12.4.3 Significance of effects

Effects may be adverse or beneficial. Major and moderate effects are considered significant. Professional judgement was used to determine the overall level of significance of effects on landscape and visual receptors in weighing the sensitivity of the receptors against the magnitude of change. The evaluation of the significance of effects was based on the criteria set out in the tables below.

Table 12.5: Significance of effects on landscape character

Significance of effects	Typical Criteria
Major beneficial	A clear improvement or enhancement of existing character. Restoration of characteristic features previously wholly or largely lost through inappropriate management or previous development.
Moderate beneficial	A noticeable improvement or enhancement of existing character. Restoration of valued characteristic features previously largely lost through inappropriate management or previous development.
Minor beneficial	A small improvement or enhancement of existing character. Restoration of valued characteristic features previously partly lost through inappropriate management or previous development
Negligible	Maintenance of the existing character, sense of place and/or local distinctiveness of the landscape.
Minor adverse	A small deterioration in the existing character due to the loss of characteristic features and or the introduction of uncharacteristic features which detract from the sense of place or local distinctiveness. Effects may relate to a small proportion of the character area.
Moderate adverse	A noticeable deterioration in the existing character due to the loss of characteristic features or the introduction of uncharacteristic features or elements which detract from the sense of place or local distinctiveness. Effects may relate to a part of the character area
Major adverse	A clear deterioration in the existing character due to the loss of key characteristic features or the introduction of uncharacteristic features or elements which detract from the sense of place or local distinctiveness. Effects may relate to all or a large proportion of the character area

Table 12.6: Significance of effects on visual receptors

Significance of effects	Typical criteria
Major beneficial	A substantial improvement, affecting a large extent of the view
Moderate beneficial	A noticeable improvement, affecting part of the view
Minor beneficial	A small improvement, affecting a small extent of the view.
Negligible	No discernible deterioration or improvement in the existing view
Minor adverse	A small deterioration, affecting a small extent of the view.
Moderate adverse	A noticeable deterioration, affecting part of the view.
Major adverse	A substantial deterioration, affecting a large extent of the view.

To achieve consistency in the evaluation of the significance of effects, the assessment was also guided by the matrix shown in Table 12.7.

Table 12.7: Significance of effects on visual receptors

Magnitude	Sensitivity		
	High	Medium	Low
Major	Major	Major/moderate	Moderate/minor
Moderate	Major/moderate	Moderate	Moderate/minor
Minor	Moderate/minor	Minor	Minor/negligible

Magnitude	Sensitivity		
Negligible	Minor/negligible	Minor/negligible	Negligible

12.4.4 Limitations and assumptions

Some specific information relating to the final siting of the wellpad, drill rig, and water infrastructure has meant that some assumptions have been made in the undertaking of this assessment. These assumptions are based on experience of similar projects and also information provided by the technical consultant. The exact micro siting of the wellpad and drill rig would only be determined during the detailed design stage. Professional judgement has been used to reduce the level of subjectivity within these assumptions as far as possible.

12.5 Baseline

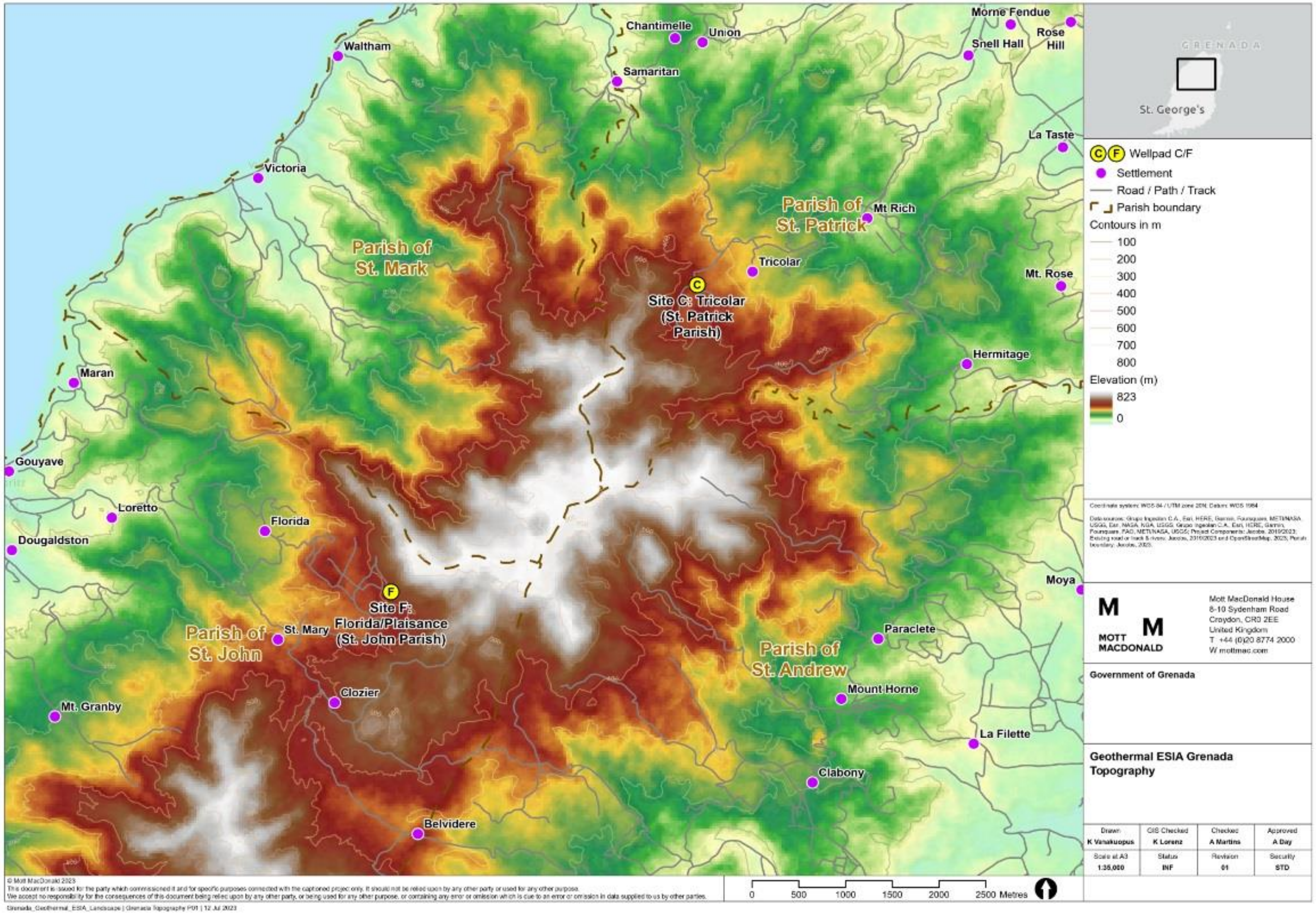
- The assessment of baseline conditions provides the reference point against which the extent and significance of predicted landscape and visual effects were assessed. The landscape character of the study area and the nature of existing views were established through desk-based research and site visits.

12.5.1 Landscape setting

12.5.1.1 Topography

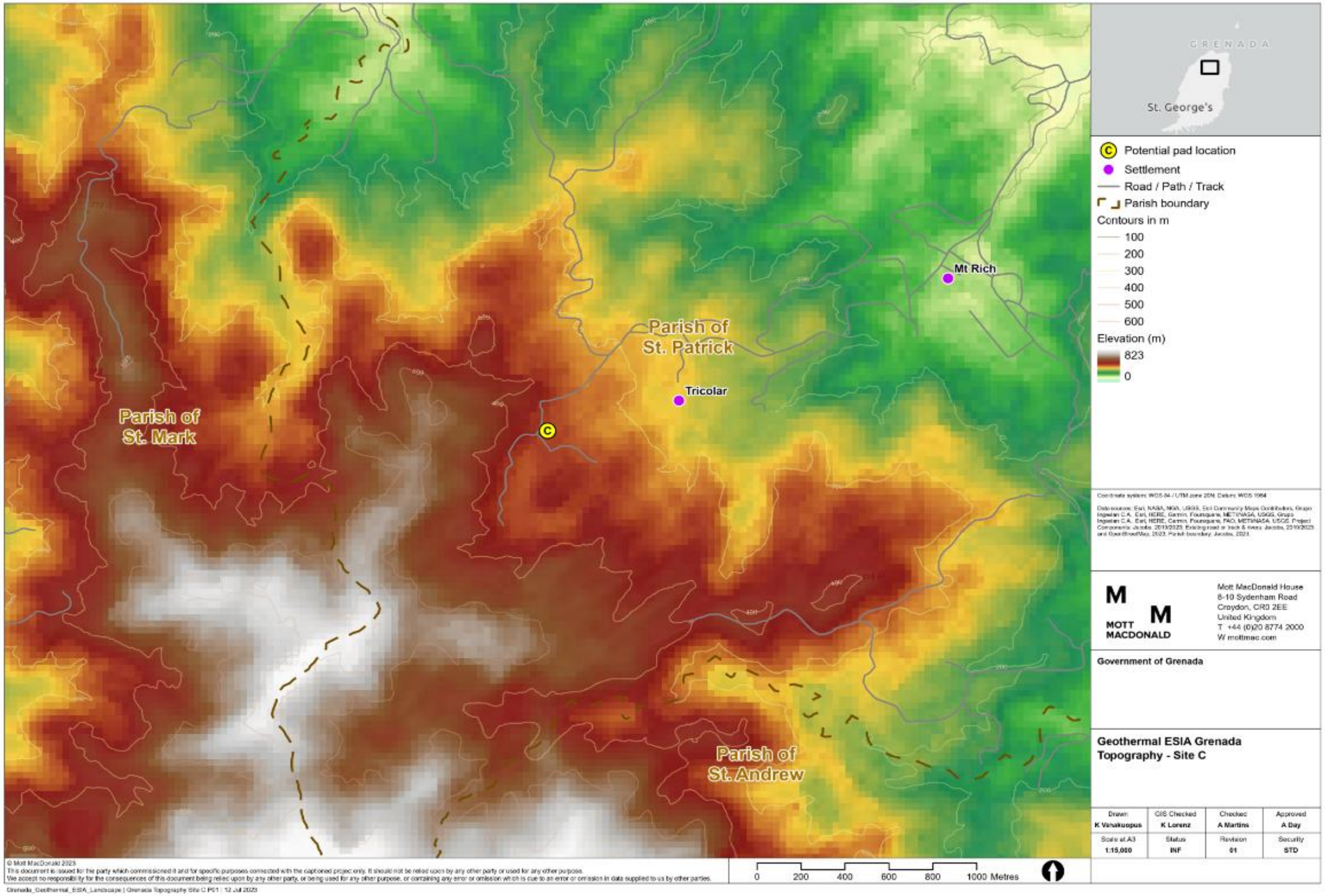
Northern central Grenada where both wellpad sites are proposed to be situated, is well vegetated, characterised by steep topography of the Mt St Catherine complex towards the interior of the island, with the flanks of the mountains slowly sloping down towards the coast. A map of local topography is shown in Figure 12.1 below.

Figure 12.1: Elevation map showing Northern Grenada topography



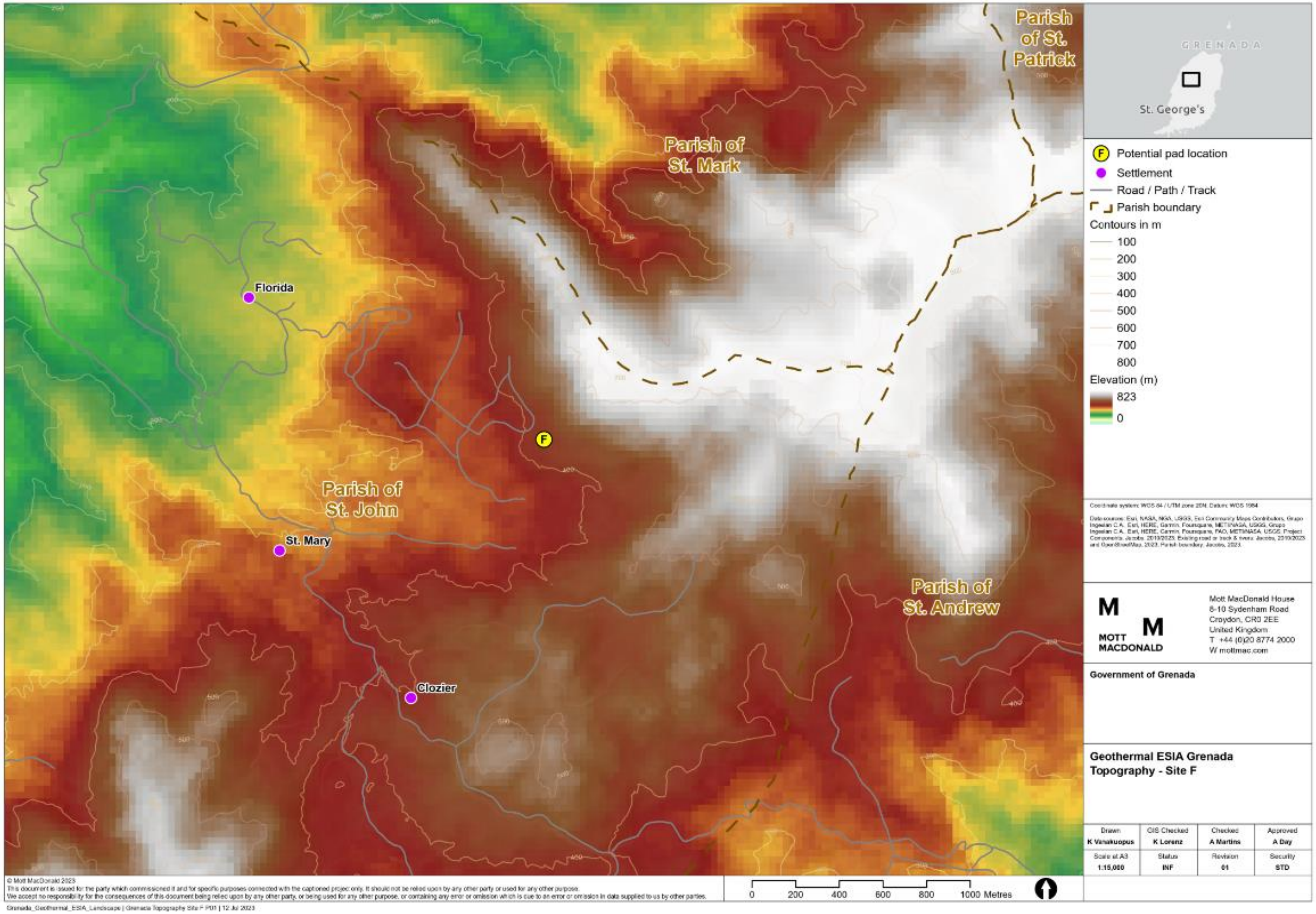
Source: Mott MacDonald (using CHARIM data)

Figure 12.2: Site C topography



Source: Mott MacDonald (using CHARIM data)

Figure 12.3: Site F topography



Source: Mott MacDonald (using CHARIM data)

12.5.1.2 Vegetation and land use

The slopes of the Mount St Catherine area where both Project sites are located, are covered in a mixture of lush tropical vegetation (at higher altitudes), followed by increasing levels of scattered agriculture and modified habitat types towards lower altitudes and around roads and small settlements, with increasing human influence. Within the wider Study Area, natural habitats include cloud-forest (including elfin woodlands, palm brake and montane thickets), rainforests and lower montane rainforest, evergreen and semi evergreen forest, deciduous forest and dry woodlands. More human affected landscapes include woody agriculture, settlements and small-scale farming.

In the direct vicinity of Site C, the dominant land use includes a mixture of cultivated plots of nutmeg and mixed woody agriculture and semi-deciduous secondary forest, pastures, and cultivated land. Visibility is restricted by some areas of dense vegetation across and surrounding the site.

Figure 12.4: View of site C

Source: Mott MacDonald

Figure 12.5: View of site C

Source: Mott MacDonald

Site F is gently sloped and is flanked to the north side by a large vegetated peak. Views downhill to the south are currently blocked by an area of raised ground and high vegetation. In the direct vicinity of Site F, the dominant land use includes a mixture of cultivated plots of nutmeg and mixed woody agriculture (e.g., cacao, coconut, banana), evergreen and semi-deciduous secondary forest, pastures, and cultivated land. Visibility is restricted in most directions by dense vegetation.

Figure 12.6: Site F well pad location – facing east

Source: Mott MacDonald

12.5.1.3 Human settlements

The most densely populated settlement near to site F is the town of Gouyave, located on the west coast. Small settlements are scattered along the public road between coastal Gouyave and Florida. Florida is a small settlement of residential houses. From where the public road in Florida becomes a track, enroute to the site, there are a few scattered properties (example shown in Figure 12.7).

Near site C, the main settlement is Mt Rich, a small village to the east of the proposed site. One or two residential properties are located uphill of Mt Rich enroute to the Project site.

Figure 12.7: One of the residential properties adjacent to the access track to site F

Source: Mott MacDonald

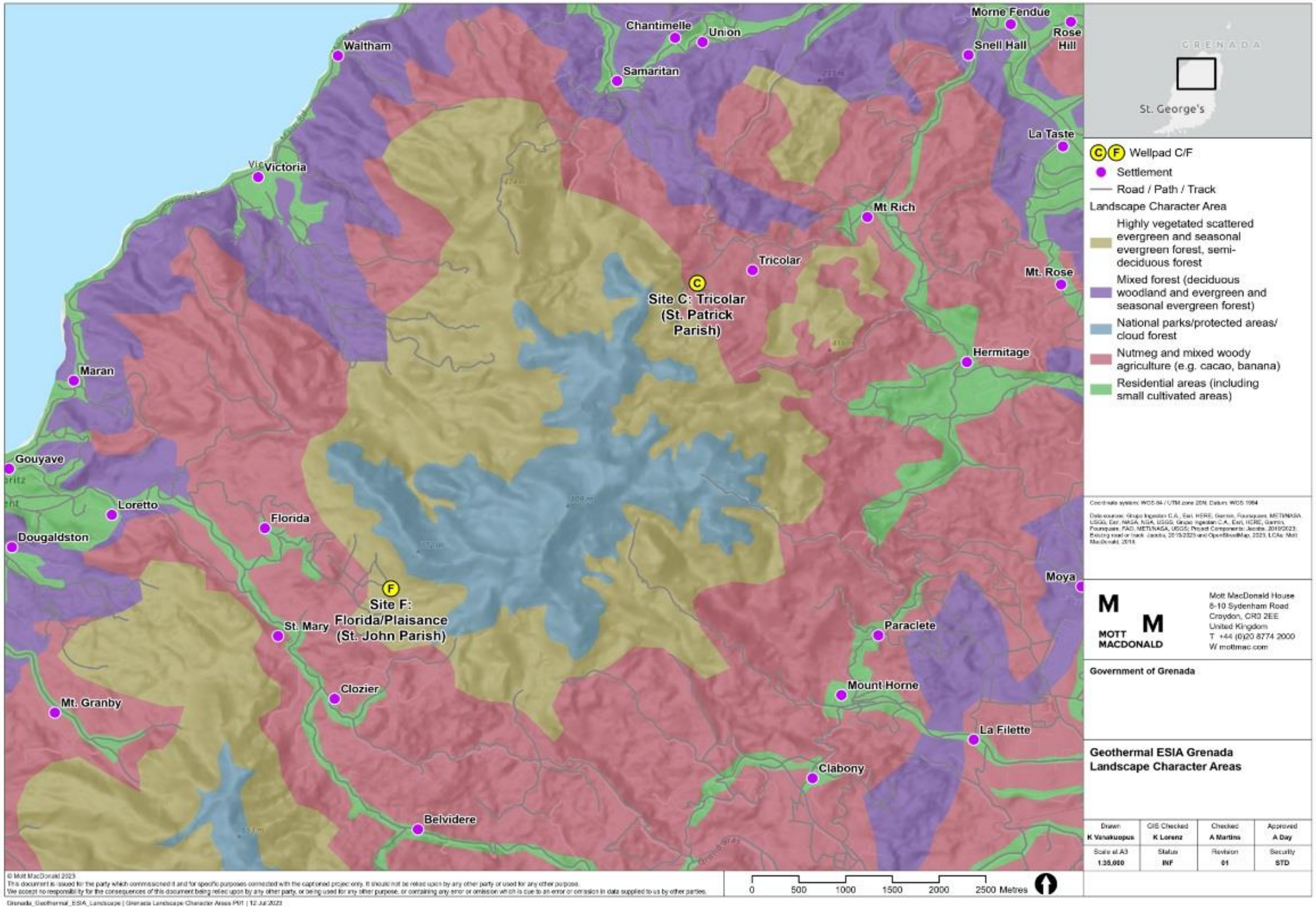
12.5.1.4 Protected/ designated areas

Mount Saint Catherine proposed protected area and Grand Etang National Park and Forest Reserve are the nearest protected areas. The proposed sites are located outside of these areas. Site C is likely to be visible from some small eastern areas of Mt St Catherine, and Site F likely to be visible from some small areas both Mt St Catherine and Grand Etang. The main three walking trails across Mt Hope and St Catherine area are located further into the national park.

12.5.2 Landscape character areas

The study area has been defined by the extent of the Zone of Theoretical Visibility (ZTV), complemented with site reconnaissance. The findings of the desk study were reviewed in conjunction with the site survey to identify local LCAs. These are broadly homogeneous units of distinct features and elements. The landscape character areas within the study area are described below. The steep topography and vegetation cover of the study area lead to vistas constantly changing on the local scale. Site C is located at 355m above sea level (ASL), and Site F at 415m ASL. The map below identifies the LCAs.

Figure 12.8: Landscape character area



Source: Mott MacDonald

Table 12.8: Landscape character areas

LCA	Description	Sensitivity
Protected areas/cloud forest	High-altitude/ steep sloped areas. Generally confined to the high altitude areas of the two proposed protected areas/ protected areas of Mt St Catherine and Grand Etang. Grand Etang is a designated forest reserve, and also a sanctuary for specific wild animals and birds. Few landscape detractors, limited evidence of human activity with a high wilderness quality. A tranquil landscape in good condition, with an unspoilt, wilderness character. Some areas have footpaths/tracks but human activity in these areas is low. High scenic quality with outstanding views of the island and coastal regions from elevated viewpoints.	High
Seasonal evergreens and forest	Surrounding both wellpad sites is densely vegetated woodland areas with varying composition of scattered evergreen, seasonal evergreen forest and semi-deciduous forest. These types of vegetated areas surround the mid-lower altitudes of the Mt St Catherine complex, and become sparser towards settlements as forest gives way to more woody agriculture and residential areas.	Medium
Nutmeg and mixed woody agriculture (e.g. cacao, banana), including small areas of cultivated land and herbaceous agriculture	Mixed woody agriculture (both utilised and abandoned) borders and mixes with vegetated woodland areas, referred to above with increasing woody agriculture surrounding residential properties and historic plantation areas (particularly around site F). Some small scale cultivated land and herbaceous agriculture. Some scenic quality.	Medium
Residential areas (including small cultivated areas)	Residential areas close to both sites are generally sparsely populated and follow the local road networks. The more densely populated villages are located near the coastline (e.g. Gouyave). Below the Mt St Catherine's complex, a main road leads between Gouyave, in the west, and Grenville on the east coast. On the western portion of this road, small settlements such as Florida and Rosemont, and St Mary are closely located. Many of the rural settlements include small areas of cultivated land. Overall medium tranquillity.	Medium

12.5.3 Zone of theoretical visibility and visual receptors

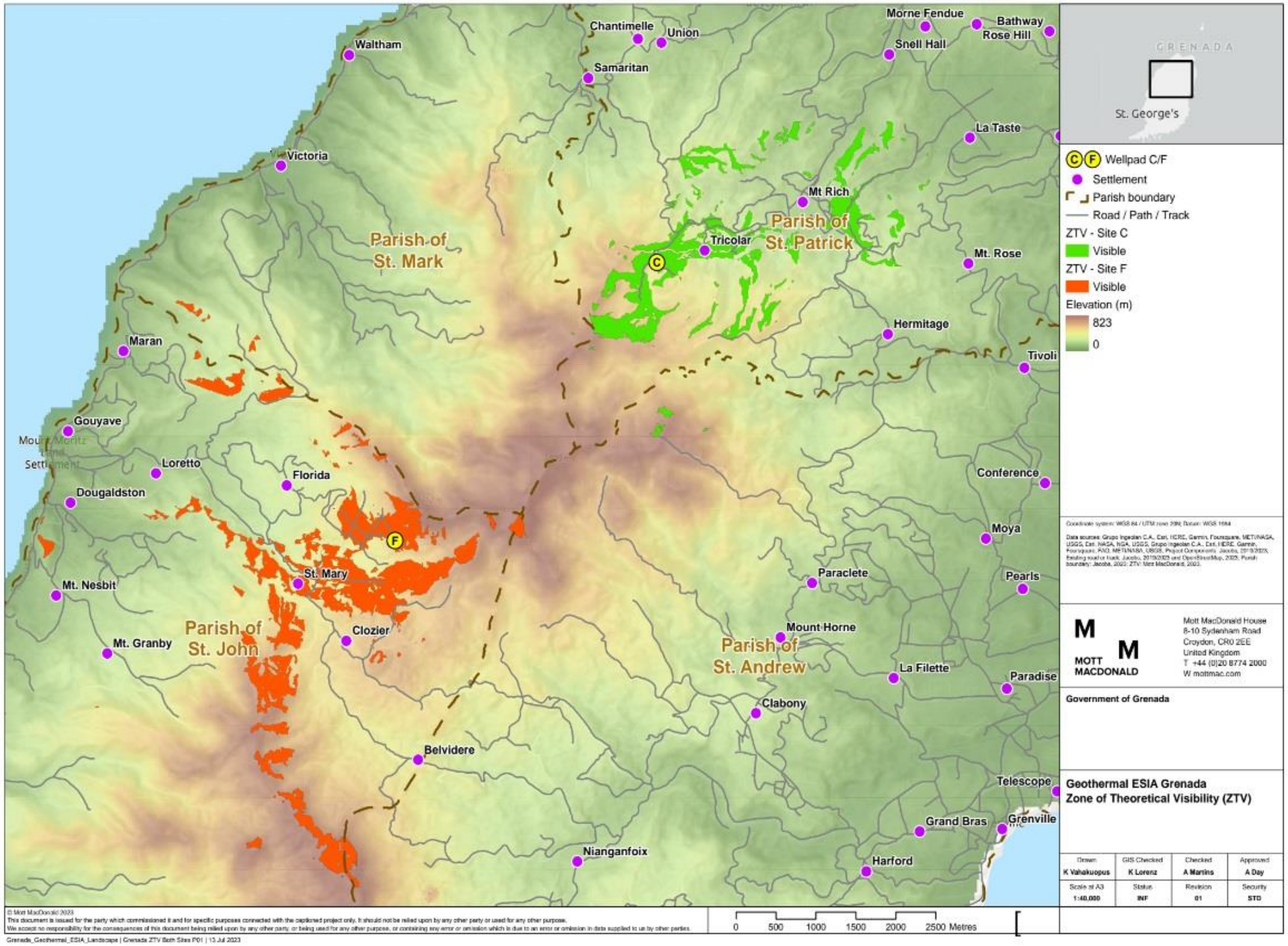
The land where the Project sites are both located is mainly steep heavy vegetated relief, with both sites located on the slopes of Mt St Catherine complex. As a consequence, the characteristic terrain and presence of dense vegetation generally draw a highly localised zone of visual influence, restricted by topographic and vegetative screening.

The extent of the study area was determined by modelling the ZTV, generated for the drilling phase by the presence of the proposed Project.

By creating a ZTV (Zone of Theoretical Visibility), the visibility of an object within the surrounding landscape can be determined. The ZTV was calculated using a Geographic Information System (GIS) based upon elevation information gained from a digital terrain model (DTM). In this case a terrain surface generated from LiDAR data (5m resolution) supplemented with STRM data (30m resolution) was sourced from the CHARIM (Caribbean Handbook on Risk Information Management) project website. The tallest piece of infrastructure was inputted into the model, which is the drill rig at a height of 12m. The modelling helps to determine the relevant area of study. The algorithm then tests the surrounding area to calculate all locations from which the observer can see the object, considering the object height and observer height which are added to the DTM. A standard observer height of 1.5 metres was used.

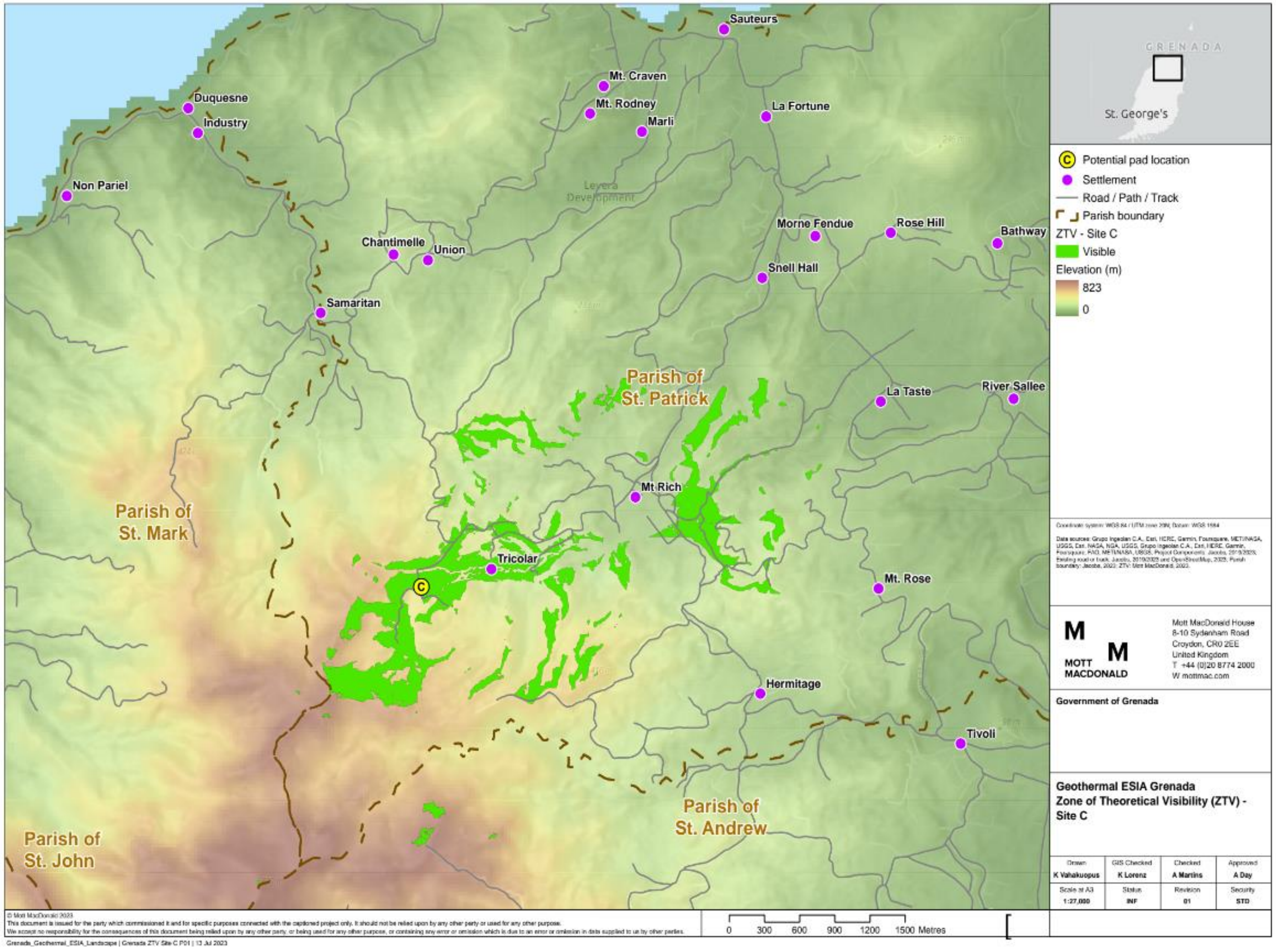
Figure 12.9 below presents the ZTV for the exploratory drilling operations. It should be noted that ZTV mapping tends to overestimate the visibility of a development because the data used does not register the screening effects of existing vegetation or existing buildings, and the fact that the top of the drill rig at c.12m is the worst-case scenario with general lower-level construction activities not likely to be visible.

Figure 12.9: Zone of theoretical visibility during exploratory drilling phase



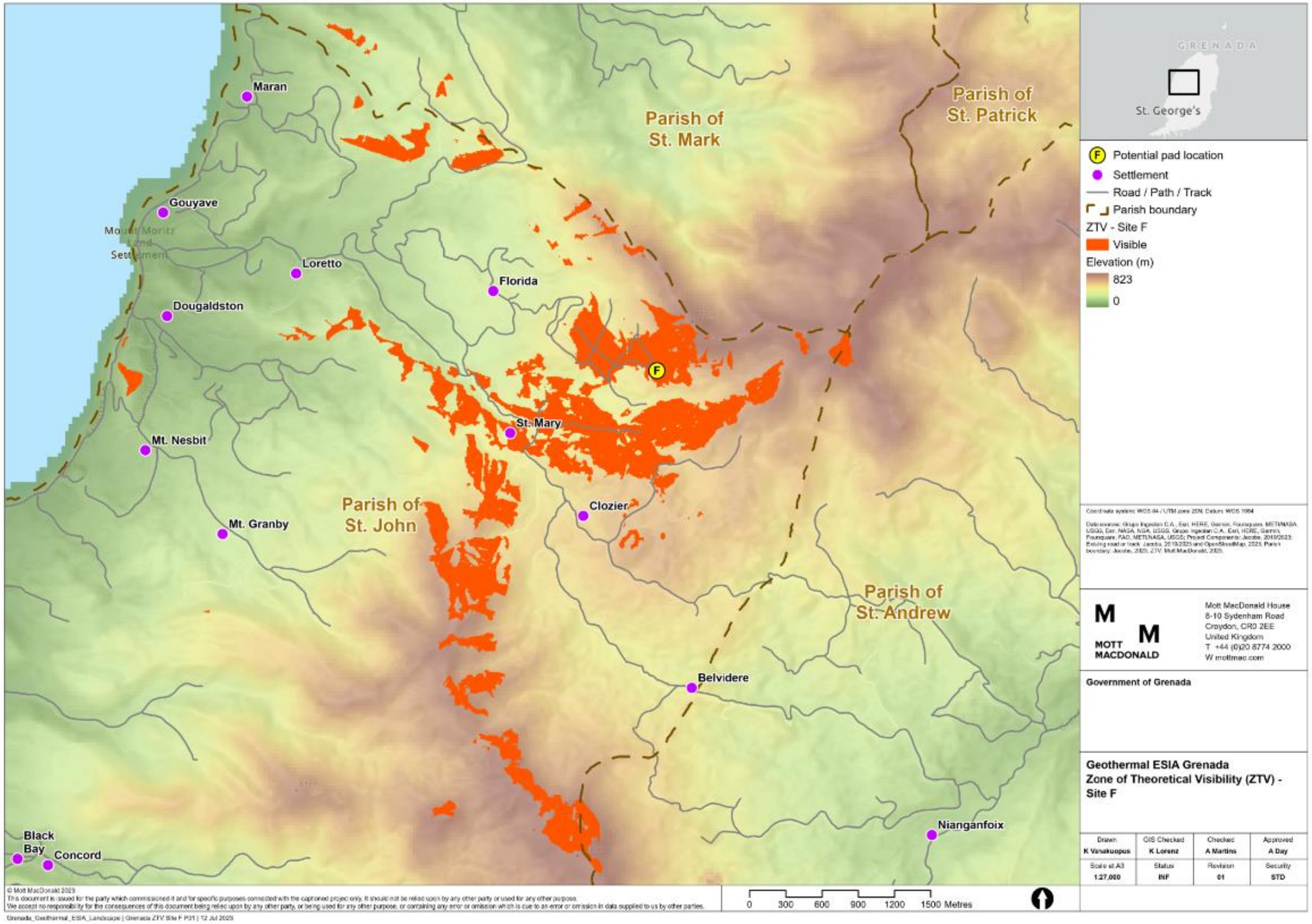
Source: Mott Macdonald

Figure 12.10: ZTV site C



Source: Mott MacDonald

Figure 12.11: ZTV site F



Source: Mott MacDonald

At Site C, based upon the ZTV, a number of visual receptors would be able to see for the drill rig and lower level construction activities including farm workers in the vicinity of the project. Further afield some residential properties including those in Tricolar would be able to see the top of the drilling rig, but it is considered likely that existing vegetation on the periphery of the site is likely to provide a screening effect of the lower level construction activities. At site F, there are also a number of visual receptors, including residents in St Marys, some scattered residents towards Gouyave and possible viewpoints from one ridge heading North from Mount Granby peak.

The selection of representative viewpoints was based on extent of the ZTV, an understanding of the project infrastructure required, and findings of site reconnaissance, which made clear the screening effect from topography as well as vegetation present at both sites. Representative viewpoints are discussed in the table below with a narrative on the selection criteria and existing characteristics of the typical view. While the viewpoints do not represent an exhaustive list of visual receptors, they present some of the most likely affected receptors due to proximity, views of the Project or project elements (e.g., construction traffic).

Table 12.9: Visual receptors

Wellpad site	Receptor name	Sensitivity	Description of the view	Receptor selection criteria
C	Settlement of Tricolor	Medium	No direct view of the lower levels of the wellpad site is anticipated but views of the drill rig likely across the settlement of Tricolar. Some properties located along the public road proposed for access to the site. Some existing detracting man-made elements in views (other houses, water bottling plant).	Selected as the nearest settlement to the wellpad location, to represent the visual changes to the village area as a result of the Project.
C	Mount Rich Amerindian remains centre	High	The Amerindian remains are primarily stone carvings on rocks in the river valley. No view of the wellpad site. Presence of detracting man-made elements in views when looking North towards the site. Visitors likely to be more focused on heritage and landscape.	Selected as nearest culturally sensitive receptor.
C	Tivoli junction to Mt Rich road	Medium	Road users will not have full views of the complete wellpad site. Receptors will be most affected by road traffic given their proximity. Some people travelling along route may be focused on landscape, however the majority will be those going about day-to-day activities.	Selected to represent receptors travelling along the road through the landscape and also roadside residential properties.
Both sites	Ridge views from Mt St Catherine	High	Elevated points with some possible views towards the two wellpad sites, which are broadly screened by the presence of vegetation and undulating steep terrain. Human receptors from these viewpoints would likely have an attention focused on landscape. There are likely to be very few visitors to these areas.	Selected to represent receptors travelling through area of beauty (e.g. hikers)
Both sites	Agricultural workers	Low	Workers in agricultural practices who work nearby to both sites (agricultural land near site C, and plantations at site F) are likely to have views of the Project when nearby. Receptors are at work rather than in the area for tourism.	Represents agricultural workers in the close proximity to both sites
Both sites	Residential receptors	Medium	Residential properties in close proximity to site C. Several properties on the farm track leading up to site F. Unlikely to be direct views of the wellpad site	Closest residents likely to observe access track

Wellpad site	Receptor name	Sensitivity	Description of the view	Receptor selection criteria
			but some views of the farm track which will be upgraded.	upgrading activity and top of drill rig
F	Settlements of St Marys, Florida and Plaisance estate	Medium	No view of the Wellpad site. Some properties located along the public road proposed for access to the site. Moderate presence of detracting man-made elements in view (other houses)	Selected as the nearest settlement to the wellpad location, to represent the visual changes to the village area as a result of the Project.
F	Gouyave to Florida road	Medium	Majority of road route will not have any view of wellpad site. Receptors will be most affected by road traffic given their proximity. Some people travelling along route may be focused on landscape, however the majority will be those going about day-to-day activities.	Selected to represent receptors travelling along the road through the landscape and also residential roadside properties
F	Ridge views from North of Mt Granby	High	Elevated points with some possible views towards wellpad site F. Human receptors from these viewpoints would likely have an attention focused on landscape,. These areas are extremely challenging to access and there are no main trails located there. There are likely to be very few visitors to these areas.	Selected to represent receptors travelling through area of beauty (e.g. hikers)
F	Long distance views from outskirts areas of Gouvaye	Low	Some minor long distance views are possible from two outskirt areas of Gouyave. Frequent presence of detracting man-made elements in views (town setting) from most viewpoints. Vegetated hills in the distance or man-made structures in the nearer view are likely to screen the majority of viewpoints.	Selected to represent the long distance views from the outskirts of Gouvaye as identified in the ZTV

Source: Mott MacDonald

Example typical views from some of the receptors identified above are shown in the below photographs.

Figure 12.12: Settlement of Mt Rich (view uphill north towards site C)

Source: Mott Macdonald

Figure 12.13: Amerindian remains centre in Mt Rich

Source: Mott MacDonald

Figure 12.14: Settlements of St Mary's, Florida and Plaisance estate (looking east towards site F)

Source: Mott MacDonald

Figure 12.15: Gouyave to Florida road (looking east towards site F)

Source: Mott MacDonald

Figure 12.16: Long distance views from outskirts areas of Gouyave looking east towards Project direction

Source: Mott MacDonald

Figure 12.17: View from near Florida facing south towards Mt Granby, to demonstrate thick vegetated nature of the area.

Source: Mott MacDonald

12.6 Assessment of effects

12.6.1 Construction (site establishment)

During construction and decommissioning, the main tasks with a potential to cause landscape and visual effects will include:

- Soil stripping, temporary stockpiling of excavated materials and other earthworks relating to upgrading of access tracks
- Presence of construction compound and the clearance of existing vegetation
- Presence of construction traffic, construction plant, including private vehicles belonging to site staff
- Construction of the temporary water pipeline
- Upgrading of existing access tracks (approx. 400m at site C and 1.6km at site F)
- Minor road works on public roads

12.6.2 Operation (drilling and testing)

- During drilling and testing the main tasks with a potential to cause landscape and visual effects will be:
- Presence of floodlighting during night time works
- Introduction of built structures at the wellpad site, most prominently the top portion of the drill rig
- Plumes of steam during well testing which may be noticeable above the vegetation
- Existence of the temporary water pipelines (one for each site)

12.6.2.1 Landscape impacts in construction

The main landscape impact will be the change of landuse of the wellpad footprints and the excavation of soil material and establishment of a construction area. The construction works, including construction traffic and associated noise and presence of workers would temporarily change the local landscape character, due to the presence on the site of plant equipment and construction activities. Change will primarily be limited to a relatively small area of secluded land, and cause localised changes only. 24 hour lighting or extended working hours are not anticipated. There are no direct impacts from construction sites upon protected areas or protected views.

12.6.2.2 Landscape impacts in operation

Given the duration of the drilling and testing phase new infrastructure and lighting will be required to undertake the works. Impacts from this phase will be short-term and temporary. The drilling rig as a tall man-made structure would be out of character with the setting in the vicinity of the Project area and would be prominent man-made landscape features. As the distance from the site increases, the drilling rig and local removal of vegetation would be less noticeable due to the other landscape elements filtering and obscuring views. This would also be the case with the steam plumes which may occur. It is possible that the steam produced during testing will be visible above the vegetation although this will be largely dependent upon localised weather conditions (i.e., wind, visibility) patterns at the time of testing.

Water abstraction is unlikely to lead to noticeable visual impacts to the majority of receptors, given the highly vegetated banks at each stream preventing views, and that an environmental flow will be maintained.

12.6.2.3 Visual impacts in construction

The main visible impacts for the majority of receptors during the construction phase will be the presence of construction traffic, minor works carried out on public roads or access tracks and the construction of the temporary water pipeline and small intakes.

The actual wellpad sites themselves, through topography and vegetation screening is unlikely to be seen clearly by nearby residences . The main manmade structure likely to be visible from both sites is the erection of the drill rig towards the end of the construction period.

It is theoretically possible (as identified in the ZTV) that longer-range receptors at site C and F such as local residents and those residents along road routes and road users, could have some level of view of the site, however the peripheral vegetation is likely to provide a screening effect.

12.6.2.4 Visual impacts in operation

Nearby residences are not likely to see significant proportions of the wellpad site infrastructure during drilling and testing, aside from the temporary water pipeline.

This is due to a combination of topography, significant vegetation cover and weather conditions. It is possible that the steam produced during testing will be visible above the vegetation although this will be largely dependent upon localised weather conditions (i.e. wind, visibility) patterns at the time of testing.

The visual receptors affected by the Project would include farmers working in the vicinity of the pad locations, and residential receptors (as identified in the ZTV) who may have views of the top of the drill rig or steam from a significant distance away (such as some residents on the outskirts of Gouyave, and people driving along certain roads).

Some residents and road users will be able to see the temporary road works in place on the public roads (both sites) and residents along the track to sites will also have views of the upgraded track. Water abstraction is unlikely to lead to noticeable visual impacts for the majority of receptors, given the highly vegetated banks at each stream preventing views, and that an environmental flow will be maintained.

12.6.3 Decommissioning

Decommissioning of the Project (assuming further development does not take place) would reduce the number of man-made elements in the view. There will be increased activity in the area during decommissioning with similar impacts to that of construction, but the removal of structures and the cessation of activity will eventually reduce visual impacts. If the site is rehabilitated, then there will be a valve placed on each well head. However, the valve is small and once vegetation and crops are reinstated on the sites there would be limited visibility of the valve. Reclamation activities would include regrading of the sites, revegetation and removal of all equipment meaning avoidance of long term impacts on the landscape.

Should the project drilling be successful, the above ground man-made elements of the drilling (drill rig, containers) would be removed, and the site securely fenced.

12.6.4 Landscape assessment

The following table describes the likely effects on landscape character.

Table 12.10: Effects on landscape character

LCA	Existing landscape character	Impacts	Effect	Relevant Site
Protected areas/cloud forest	High-altitude/ steep sloped areas. Generally confined to the high altitude areas of the two proposed protected areas/ protected areas of Mt St Catherine and Grand Etang. Some areas have footpaths/tracks but human activity in these areas is low and based on consultation the main paths across Mt St Catherine are not within visibility of the Project areas. Few landscape detractors, limited evidence of human activity with a high wilderness quality. A tranquil landscape in good condition, with an unspoilt, wilderness character. Some areas have footpaths/tracks but human activity in these areas is low. High scenic quality with outstanding views of the island and coastal regions from elevated viewpoints.	**Construction**: No construction activity will occur in the National Park areas. There will be no views of either site from the majority of Mt St Catherine's protected area or Grand Etang National Park; only specific ridges would potentially have views of the site which could be considered to have a slight loss or alteration to the main characteristics of the protected area.	The overall **minor magnitude** combined with a **high sensitivity** will result in a minor adverse impact effect on the landscape character of the LCA during construction.	C and F
		Operation: No drilling or testing activity will occur in the national park areas. There will be no views of either site from the majority of Mt St Catherine's protected area or Grand Etang National Park; only specific ridges would potentially have views of the drill rig and steam plumes which could be considered to cause a perceived slight loss or alteration to the main characteristics of the protected area views. The drill rig and steam plumes are both only temporary activities. The extent of these viewpoints and therefore perceived landscape changes is significantly decreased by the level of vegetative screening and natural topography.	The overall **minor magnitude** combined with a **high sensitivity** will result in a minor adverse impact effect on the landscape character of the LCA during operation.	C and F
Seasonal evergreens and forest	Surrounding both wellpad sites is densely vegetated woodland areas with varying composition of scattered evergreen, seasonal evergreen forest and semi-deciduous forest. These types of vegetated areas surround the mid-lower altitudes of the Mt St Catherine complex, and become sparser towards	**Construction**: The main impact on this LCA during construction will be removal of vegetation, along with earthworks during the site preparation works. The vegetation removed will be limited to the edges of the two proposed sites where dense vegetation gives way to more open woody agriculture areas where the wellpad will be located, and human influence is already evident. The exact amount of vegetation and earthworks removed will largely depend on final micro siting of the wellpad. Along with the wellpad, some trees may need to be removed along the access tracks, however this will be limited by the use of the existing farm tracks and will have limited impact upon the existing landscape character. Changes to this LCA, including the presence of construction works	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse impact effect on the landscape character of the LCA during construction.	C and F

LCA	Existing landscape character	Impacts	Effect	Relevant Site
	settlements as forest gives way to more woody agriculture and residential areas.	would likely only be noticeable at the localised level due to thick vegetation and natural topography at both sites. The Project will introduce short to medium term changes will alter a small proportion of the LCA The magnitude of change is therefore considered to be minor.		
		Operation: The main impacts during operation will be similar to that of construction in that the presence of the wellpad, associated infrastructure and the decrease in vegetation will be noticeable at the localised level only at both sites. The Project will introduce short to medium term changes will alter a small proportion of the LCA The magnitude of change is therefore considered to be minor.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect on the landscape character of the LCA during operation.	C and F
Nutmeg and mixed woody agriculture (e.g. cacao, banana), including small areas of cultivated land and herbaceous agriculture	Mixed woody agriculture (both utilised and abandoned) borders and mixes with vegetated woodland areas, with increasing woody agriculture surrounding residential properties and historic plantation areas (particularly around site F).	**Construction**: The proposed project wellpad footprint locations are mainly plots of mixed woody agriculture. The main impact on this LCA will result in land use change of the Project footprint from woody agriculture to construction compounds, works and wellpads. The changes are localised, temporary and will only cause changes to a small proportion of the overall LCA. The magnitude of change is therefore considered to be minor.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect on the landscape character of the LCA during construction.	C and F
		Operation: The main impact on this LCA will result in land use change of the Project footprint a wellpad, drill rig and water pond. The changes are localised, temporary and will only cause changes to a small proportion of the overall LCA. The magnitude of change is therefore considered to be minor.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect on the landscape character of the LCA during operation.	C and F
Residential areas (including small cultivated areas)	Residential areas close to both sites are generally sparsely populated and mainly follow the local road networks. These areas are considered to be common feature area in Grenada. The level of density of the character area is variable, and	**Construction:** The main impact upon the landscape character of the residential LCA will be from increasing traffic passing along existing roads to the sites as a result of construction traffic. The only new features along the majority of the access road which would be noticeable would be minor road widening works which would be largely characteristic of typical road maintenance activities. Although this will not alter the key characteristics of the LCA substantially it may be considered to temporarily decrease the perception of tranquillity for residential areas, resulting in an overall minor magnitude of change	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect on the landscape character of the LCA during construction.	C and F

LCA	Existing landscape character	Impacts	Effect	Relevant Site
	generally more densely populated villages are located near the coastline (e.g. Gouyave). Below the Mt St Catherine's complex, a main road leads between Gouyave, in the west, and Grenville on the east coast. On the western portion of this road, small settlements such as Florida and Rosemont, and St Mary are closely located. Many of the rural settlements include small areas of cultivated land.	**Operation:** The impacts during operation will be similar but slightly less than that of construction, due to a decreased impact from traffic movements in the drilling and testing phase. Overall there will be a minor magnitude of change.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect on the landscape character of the LCA during operation.	C and F

Source: Mott MacDonald

12.6.5 Visual assessment

The following table describes the likely effects on visual receptors.

Table 12.11: Effects on visual receptors

Relevant site	Receptor and viewpoint	Sensitivity	Existing view description	Selection	Impacts	Effect
C	Settlement of Tricolar	Medium	No view of the Wellpad site. Some properties located along the existing public road proposed for access to the site. Presence of detracting man-made elements in view (other houses, water bottling plant).	Selected as the nearest settlement to the wellpad location, to represent the visual changes to the village area as a result of the Project.	**Construction:** Wellpad will not be visible. The main additional new feature will be the temporary water pipeline at ground level running through top part of Mt Rich. Main visual impact will be from construction traffic.. These impacts will be of a short term infrequent nature leading to an overall minor magnitude of change to views.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.

Relevant site	Receptor and viewpoint	Sensitivity	Existing view description	Selection	Impacts	Effect
					Operation: Wellpad will not be visible but the top of the drill rig will be visible. Steam during testing is unlikely to be viewed. Main visual impacts will be from worker traffic which will be extremely limited during drilling and testing phase, and the temporary water pipeline at ground level running through top part of Mt Rich. Minor road widening may be perceived as a positive impact. The magnitude of change to views is therefore likely to be minor during operations.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.
C	Mount Rich Amerindian remains centre	High	The Amerindian remains are primarily stone carvings on rocks in the river valley. No view of the wellpad site. Presence of detracting man-made elements in view when looking North towards the site. Visitors likely to be more focused on heritage and landscape.	Selected as nearest culturally sensitive receptor.	**Construction:** Wellpad will not be visible. Only visual impact will be from construction traffic and possible road widening works if needed nearby. These impacts will be of a short term infrequent nature leading to an overall minor magnitude of change to views.	The overall **minor magnitude** combined with a **high sensitivity** will result in a moderate adverse effect.
					Operation: Wellpad and drill rig will not be visible. Steam during testing is unlikely to be viewed. Only visual impact will be from worker traffic which will be extremely limited during drilling and testing phase. Minor road widening may be perceived as a positive impact. The magnitude of change to views is therefore likely to be negligible during operations.	The overall **minor magnitude** combined with a **high sensitivity** will result in a minor adverse effect.
C	Tivoli junction to Mt Rich road	Low/Medium	Majority of road route will not have any view of wellpad site. Receptors will be most affected by road traffic given their proximity. Some people travelling along route may be focused on landscape, however the majority will be those going about day-to-day activities.	Selected to represent receptors travelling along the road through the landscape and also roadside residential properties.	**Construction:** Wellpad will not be visible. Only visual impact will be from construction traffic and possible road widening works on route. Additional changes to the view (road widening) will be largely inconspicuous along the majority of the route. The presence of increased HGVs will be highly dependant on timing of drivers and whether coinciding with construction traffic. Very limited numbers of residents located	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.

Relevant site	Receptor and viewpoint	Sensitivity	Existing view description	Selection	Impacts	Effect
					along the road may have the possibility to see road widening works in combination with HGV movements for a very short period of time. The magnitude of change to views is therefore likely to be low.	
					Operation: Wellpad will not be visible but the rig is likely to be. Steam plume unlikely to be seen given the topography and vegetation cover. The magnitude of change to views is therefore likely to be minor during operations.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.
Both sites	Ridge views from Mt St Catherine	High	Elevated points with some possible views towards the two wellpad sites, which are however broadly screened by the presence of vegetation and undulating steep terrain. Human receptors from these viewpoints would likely have an attention focused on landscape. There are likely to be very few visitors to these areas given that main paths are not located in areas which overlook the sites.	Selected to represent receptors travelling through area of beauty (e.g. hikers)	**Construction and operation:** Although the ZTV suggests that some small areas of two ridges above the Project site may have views of the top of the drill rig, this is considered highly unlikely due to the level of tall vegetation cover across the Mt St Catherine area. Views towards the drill rig and Project site are likely to be almost entirely obscured by intervening vegetation and topography. From possible breaks in vegetation at viewpoints, the Project components would be considered an inconspicuous element within the wider panorama. It would be unlikely that any steam from the testing phase would be visible, however if visible it would likely considered as smoke from residential properties which occurs in the area[1]. Impacts would be short term in nature.	The overall **negligible magnitude** combined with a **high sensitivity** will result in a negligible adverse effect.
Both sites	Agricultural workers	Low	Workers in agricultural practices who work nearby to both sites (agricultural land near site C, and plantations at	Represents agricultural workers in the close	**Construction and operation:** Agricultural workers at the Plaisance estate (site F) and smallholding farmers in the vicinity of site C	The overall **moderate magnitude**

[1] Smoke was observed from high viewpoints during site reconnaissance.

Relevant site	Receptor and viewpoint	Sensitivity	Existing view description	Selection	Impacts	Effect
			site F) are likely to have views of the Project when nearby. Receptors are at work rather than in the area for tourism.	proximity to both sites	would have views of the wellpad locations, construction and drilling works and access roads if working in agricultural areas in the immediate vicinity of the wellpad, however even at the localised level there is intervening and natural topography which will filter the view.	combined with a **low sensitivity** will result in a minor adverse effect for both construction and operation.
Both Sites	Residential buildings	Medium	Residential property in close proximity to site C. Several properties on the farm track leading up to site F. No views of the wellpad site but some views of the farm tracks which will be upgraded.	Closest residents likely to observe access track upgrading activity and drill rig.	**Construction and operation:** The main impact upon the small number of residences located close to the farm tracks will be during site setup when the track will be upgraded, and equipment materials and vehicles will use this track on their way to the wellpads, as well as the view of the small water pipeline which will follow the access road. During the operational phase there will be less traffic but the rig would be visible to some local residents. Magnitude of this impact is considered minor.	The overall minor magnitude combined with medium sensitivity, will result in a minor adverse effect in both construction and operation.
F	Settlements of Florida and Plaisance estate and St Marys	Medium	No view of the Wellpad site. Some properties located along the public road proposed for access to the site. Small amount of properties scattered along the track which will be upgraded in order to access the site from the end of the public road. Moderate presence of detracting man-made elements in view (other houses)	Selected as the nearest settlement to the wellpad location, to represent the visual changes to the village area as a result of the Project.	**Construction**: The wellpad will not be visible from Florida, Plaisance estate residential properties or St Marys, due to the wellpad being situated at a higher altitude and surrounded by thick vegetation. The main visual impact will be from construction traffic and track upgrades. This will impact upper Florida and the residential properties along the track which will be upgraded between Florida and the wellpad site. These impacts will be of a short term infrequent nature leading a slight loss in the characteristics of the views from these receptors. Overall, a low magnitude of change to views.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.

Relevant site	Receptor and viewpoint	Sensitivity	Existing view description	Selection	Impacts	Effect
					Operation: The wellpad and drill rig will not be visible. Although the ZTV suggests the area of St Marys would have views of the top of the drill rig, from site reconnaissance this is considered not to be the case, given the difference in altitude, the steep topography and the screening effect caused by vegetation in the areas between the two sites. Steam from testing may be visible at some limited viewpoints. Minor traffic along the access track. Track upgrade likely to be considered as a positive change. Overall a low magnitude of change to views.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.
F	Gouyave to Florida road	Moderate	Majority of road route will not have any view of wellpad site. Receptors will be most affected by road traffic given their proximity. Some people travelling along route may be focused on landscape, however the majority will be those going about day-to-day activities.	Selected to represent receptors travelling along the road through the landscape and also residential roadside properties	**Construction:** Wellpad will not be visible. Only visual impact will be from construction traffic and possible road widening works on route. Additional changes to the view (road widening) will be largely inconspicuous along the majority of the route. The presence of increased HGVs will be highly dependant on timing of drivers and whether coinciding with construction traffic. Very limited numbers of residents located along the road may have the possibility to see road widening works in combination with HGV movements for a very short period of time. The magnitude of change to views is therefore likely to be low.	The overall **minor magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.
					Operation: Wellpad and drill rig will not be visible. Steam plume unlikely to be seen given the topography and vegetation cover. Only visual impact will be from worker traffic which will be extremely limited during drilling and testing phase. Minor road widening may be perceived as a positive impact. The magnitude of change to views is therefore likely to be negligible during operations	The overall **negligible magnitude** combined with a **medium sensitivity** will result in a minor adverse effect.

Relevant site	Receptor and viewpoint	Sensitivity	Existing view description	Selection	Impacts	Effect
F	Ridge views from North of Mt Granby	High	Elevated points with some possible views towards wellpad site F. Human receptors from these viewpoints would likely have an attention focused on landscape, as these areas are extremely challenging to access and there are no main trails located there. There are likely to be very few visitors to these areas.	Selected to represent receptors travelling through area of beauty (e.g. hikers)	**Construction and Operation**: The construction works and wellpad will not likely be visible from the ridge views due to vegetative screening. The top of the drill rig may theoretically visible from some north east facing viewpoints if there is a gap in vegetation. This viewpoint is around 2.5km from the site and therefore the small addition of drill rig and/or steam plume during drilling stage is likely to be considered largely a short term inconspicuous element within a much wider panorama.	The overall **minor magnitude** combined with the high sensitivity will result in minor adverse effect.
F	Long distance views from outskirts areas of Gouvaye	Low	Some minor long distance views are possible from two outskirt areas of Gouyave. High presence of detracting man-made elements in view (town setting) from most viewpoints. Vegetated hills in the distance or man-made structures in the nearer view are likely to screen the majority of viewpoints.	Selected to represent the long distance views from the outskirts of Gouvaye as identified in the ZTV	**Construction and Operation**: There will be a barely perceptible loss or alteration to the view from this viewpoint. Possible views of the top of the drill rig are theoretically possible but are considered extremely unlikely given the distance from site (around 4km). Landscape components between this receptor and the Project site are likely to entirely or almost entirely obscure the any view of the Project (buildings of Gouyave, steep topography and vegetation). If drill rig seen from this receptor, likely to be viewed as an inconspicuous element within a wider panorama. Magnitude of impact is considered negligible.	The overall **negligible magnitude** combined with a **low sensitivity** will result in a negligible effect.

Source: Mott MacDonald

12.7 Mitigation and enhancement measures

Mitigation and enhancement measures proposed for landscape and visual impacts are outlined in the table below.

The main mitigation measure at both project sites will be to minimise where possible the level of vegetation clearance. Due to the temporary nature of the exploratory drilling phase, limited mitigation is proposed. However, good housekeeping practices should be implemented to maintain the appearance of the site. Construction is expected to be carried out using industry best practice to reduce potentially adverse effects (including dust control which could increase visibility of the construction area).

Table 12.12: Mitigation and enhancement measures

Ref	Mitigation/ enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
L1	Footprint and vegetation removal minimisation	• The footprint of the construction activities should be designed to be as small as reasonably practical. • Limit the amount of vegetation removed from both the main construction sites and sides of access tracks insofar as possible, so that natural screening between the site and receptors is maximised • Water supply pipeline to follow existing roads and tracks where possible. • Access tracks to follow existing track • Careful siting of construction compounds • Implement measures identified in the biodiversity chapter	Project Design
L2	Pre-construction record	• Prior to construction, contractor to take photographs of the wellpad area and access roads, so that pre-construction conditions are documented	ESMP – prior to construction
L3	On site mitigation measures	• Construction activities should be restricted to designated construction sites, without disturbing the surrounding area and minimising loss of existing vegetation • Minimise dust through the AQMP • Lighting associated with the construction phase of the proposed development will be designed to minimise light pollution at night, whilst being consistent with the requirements of site safety and security. Directional and task focussed lighting will be used where possible, rather than lighting on tall columns, and will be designed to face away from sensitive residential receptors. Construction works will be limited to daylight hours.	ESMP – all phases AQMP – all phases
L4	Spoil and soil management	• Spoil disposal and stockpiling would need to be regulated and locations, profiles and volumes should be designed to minimise adverse effects on existing landscape character and visual amenity	ESMP – all phases

Ref	Mitigation/ enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
L5	Traffic management measures	• Minimising traffic interactions near junctions with other road users and residential receptors along the site access road • Minimise number of vehicle movements through appropriate planning	TMP – all phases
L6	Housekeeping	• Implement good housekeeping practices including stockpile areas and dust suppression measures	ESMP – all phases
L7	Site closure and restoration	• All working areas, structures and site equipment to be dismantled and removed from site • Pits and sumps to be filled in and graded to match the area. • Grading and restoration of site shall be in accordance with the baseline and previous landscape character • Compacted areas to be uncompacted, and original topsoil to be respread to enable vegetation growth • Restoration of the site shall be documented by the contractor in post-construction report including pre- and post-construction photographs	Site decommissioning and restoration plan

12.8 Summary of impacts, mitigation and residual significance

There are no significant residual impacts from the Project, after the application of mitigation measures, but some minor adverse impacts will occur during both construction and operation.

A summary of effects before and after application of mitigation measures is presented in Table 12.13.

Table 12.13: Summary of potential impacts and effects – after application of mitigation/benefit enhancement measures

Impact	Receptor(s)	Categorisation	Sensitivity of receptor	Magnitude of impact	Significance of effect – prior to mitigation	Magnitude of impact – post mitigation	Significance of effect – post mitigation
Construction Phase (site establishment) and site closure (temporary closure or decommissioning)							
Visual impact from representative viewpoints	Settlement of Tricolar	Adverse Temporary	Medium	Minor	Minor – Not significant	Minor	Minor – Not significant
	Mount Rich Amerindian remains centre	Adverse Temporary	High	Minor	Minor – Not significant	Minor	Minor – Not significant
	Tivoli junction to Mt Rich road	Adverse Temporary	Medium	Minor	Minor – Not significant	Minor	Minor – Not significant
	Ridge views from Mt St Catherine	Adverse Temporary	High	Negligible	Negligible – not significant	Negligible	Negligible – not significant
	Agricultural workers	Adverse Temporary	Low	Moderate	Minor – not significant	Moderate	Minor – not significant
	Residential properties	Adverse Temporary	Medium	Minor	Minor – Not significant	Minor	Minor – Not significant
	Settlements of Florida and Plaisance estate and St Marys	Adverse Temporary	Medium	Minor	Minor – not significant	Minor	Minor – not significant
	Gouyave to Florida road	Adverse Temporary	Medium	Minor	Minor – not significant	Minor	Minor – not significant
	Ridge views from North of Mt Granby	Adverse Temporary	High	Minor	Minor – not significant	Minor	Minor – not significant
	Long distance views from outskirts areas of Gouvaye	Adverse Temporary	Low	Negligible	Negligible – not significant	Negligible	Negligible – not significant
Operations Phase (drilling and testing)							
Visual impact from representative viewpoints	Settlement of Mt Rich	Adverse Temporary	Medium	Minor	Minor – Not significant	Minor	Minor – Not significant
	Mount Rich Amerindian remains centre	Adverse Temporary	High	Minor	Minor – not significant	Minor	Minor – not significant
	Tivoli junction to Mt Rich road	Adverse Temporary	Medium	Minor	Minor – not significant	Negligible	Minor – not significant
	Ridge views from Mt St Catherine	Adverse Temporary	High	Negligible	Negligible – not significant	Negligible	Negligible – not significant
	Agricultural workers	Adverse Temporary	Low	Moderate	Minor – not significant	Moderate	Minor – not significant
	Residential properties along access tracks	Adverse Temporary	Medium	Minor	Minor – Not significant	Minor	Minor – Not significant
	Settlements of Florida and Plaisance estate and St Marys	Adverse Temporary	Medium	Minor	Minor – not significant	Minor	Minor – not significant
	Gouyave to Florida road	Adverse Temporary	Medium	Negligible	Minor – not significant	Negligible	Minor – not significant
	Ridge views from North of Mt Granby	Adverse Temporary	High	Minor	Minor – not significant	Minor	Minor – not significant
	Long distance views from outskirts areas of Gouvaye	Adverse Temporary	Low	Negligible	Negligible – not significant	Negligible	Negligible – not significant

Source: Mott MacDonald

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Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

Volume II - ESIA
Chapter 13 - Traffic and transport

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Volume II - ESIA
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13 Traffic and transport

13.1 Overview

This chapter predicts traffic and transportation impacts expected to occur as a result of the exploratory drilling phase of the Project and assesses the beneficial and adverse effects by predicting their significance prior to mitigation. This assessment describes the methodology used to assess baseline conditions, identifies the Area of Influence, its baseline and the sensitive receptors within it, and presents an assessment of the potential impacts to identify where significant effects are expected to arise.

Impacts have been considered and assessed for the site preparation (including access road construction and well pad set up), exploratory works and where relevant decommissioning.

13.2 Study area and area of influence

The Project exploration drilling will occur in the parishes of St Patricks and St Johns. Short sections of existing tracks will be upgraded from the existing local roads. The assessment therefore focuses on the local road stretches and upgraded access roads nearest to the sites, but also considers the impacts of wider traffic and transport impacts which may be caused by the Project.

13.3 Applicable standards

13.3.1 International guidelines and standards

- IFC General EHS guidelines: community health and safety

13.4 Methodology

The assessment involved establishing a baseline understanding of the nature of the existing roads which will be used by the project. We did this using site reconnaissance during the scoping site visit and via the ESIA baseline surveys. We made an assessment of impacts based on information provided by the Sponsor and Jacobs, the technical consultants. Possible impacts arising as a result of the additional traffic have been identified and their significance assessed.

13.4.1 Sensitivity of receptors

The criteria used to determine the sensitivity of receptors to the changes which the Project will cause is defined in Table 13.1.

Table 13.1: Criteria for determining receptor sensitivity

Category	Description/Examples
High	Vulnerable receptor (human or infrastructure) with little or no capacity to absorb proposed changes or minimal opportunities for mitigation.
Medium	Vulnerable receptor (human or infrastructure) with limited capacity to absorb proposed changes or limited opportunities for mitigation.
Low	Vulnerable receptor (human or infrastructure) with some capacity to absorb proposed changes or moderate opportunities for mitigation.
Negligible	Receptor (human or infrastructure) with good capacity to absorb proposed changes or and good opportunities for mitigation.

13.4.2 Magnitude of change

The criteria used to determine the magnitude of the changes which will be created by the project is defined in Table 13.2.

Table 13.2: Criteria for determining impact magnitude

Category	Description
Major	Fundamental change to the specific environmental conditions assessed resulting in long term or permanent change, typically widespread in nature (regional national and international), would require significant intervention to return to baseline; exceed national standards and limits.
Moderate	Detectable change to the specific environmental conditions assessed resulting in no fundamental temporary or permanent change.
Minor	Detectable but minor change to the specific environmental conditions assessed.
Negligible	No perceptible change to the specific environmental conditions assessed.

The magnitude of transport impacts is, to an extent, subjective. The determination of the magnitude will therefore be based upon professional judgement taking into account the perceived sensitivity of the receiving environment.

13.4.3 Limitations and assumptions

As part of our assessment, several assumptions have been made based on our experience of undertaking similar assessments and assignments. In particular, these assumptions include the likely transportation routes used for the delivery and supply of materials.

13.5 Baseline – description of pre project conditions

Grenada has two main coastal roads which extend from St Georges in the southwest: heading along the west coast of the island up to Gouyave, and along the east coast towards St Patrick.

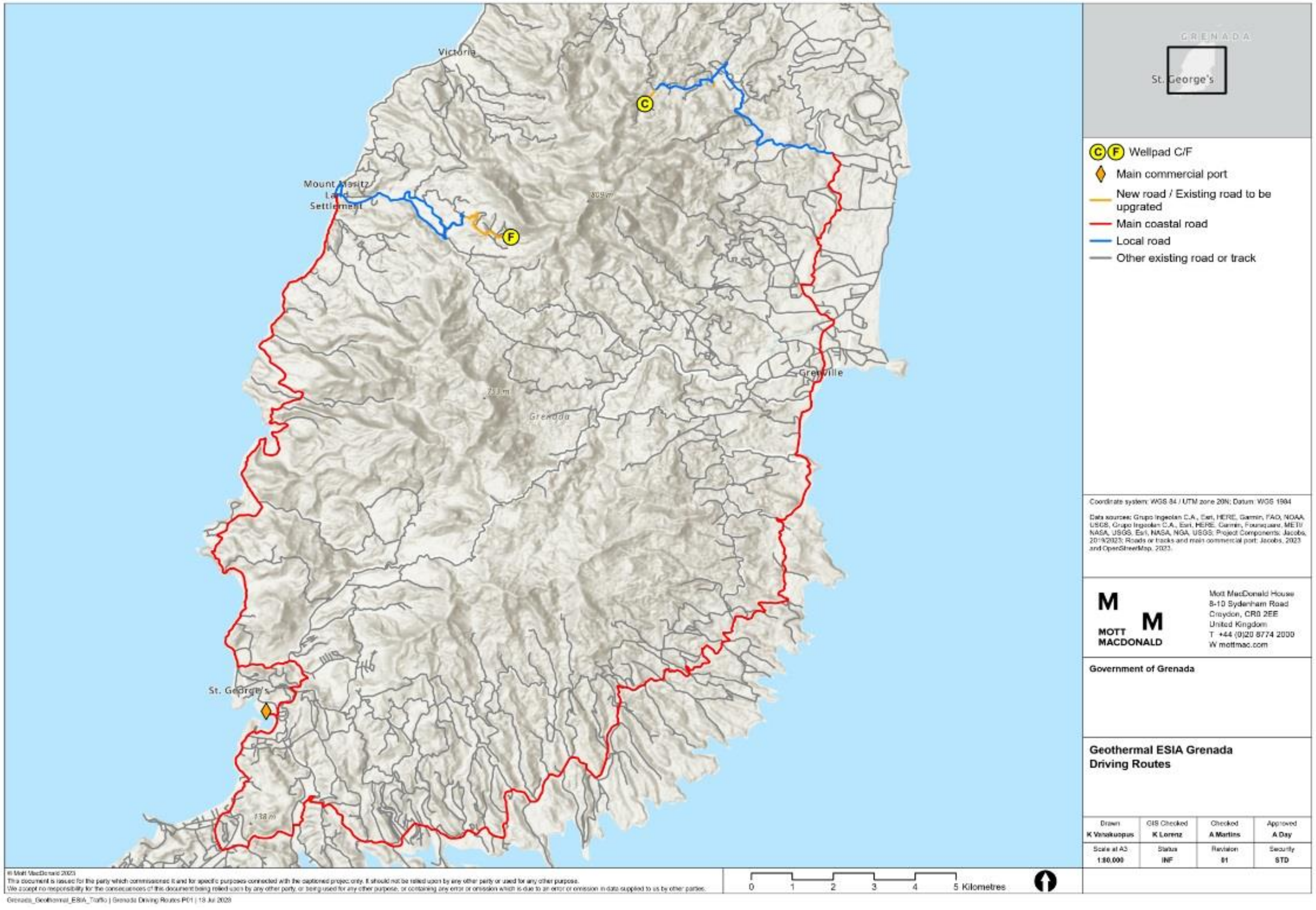
The roads unit of the Ministry of Infrastructure and Physical Development, Public Utilities, Civil Aviation & Transportation is responsible for the planning, implementation, and supervision of road projects across Grenada. It is understood that the detailed designs are complete for the rehabilitation of the main road connecting the capital city, St. George's in the southwest of Grenada, and Victoria in the northern parish of St. Mark.

13.5.1 Existing road network and site access

The main port of entry into Grenada is the St Georges port, which will be used for the offloading of 12 meter-long (40 ft) shipping containers needed to bring the drilling rig and equipment to Grenada. The port is understood to have the capacity to receive and temporarily store the containers.

The west coast road will be used to access site F, and the east coast road from St Georges will be used for site C. Given that the road across the centre of the island is not suitable for containers and trucks, the drilling rig would be transported back via St Georges when moving it from one site to another. Figure 13.1 outlines the likely routes to the sites from St Georges.

Figure 13.1: Envisaged route from port



Source: Jacobs (adapted by Mott MacDonald)

13.5.1.1 West coast route (to site F)

The west coast route from the port to site F takes approximately 60 minutes in a car. The road is generally of reasonable quality between the port and Gouyave. There are two tight corners with culverts which may need to be widened to accommodate the 12-meter containers. In Gouyave, there is a tight 90 degree turn which would be taken at the west coast road/Plaisance junction. It is understood that container trucks have used this turn before; however careful management and planning will be needed here with regard to local residents and traffic. Electricity wires hanging over the road may need temporary lifting to avoid damage.

Figure 13.2: Example of the west coast road route (taken halfway along the route)

Source: Mott MacDonald

Figure 13.3: West coast road/ Plaisance junction in Gouvaye

Source: Mott MacDonald

The road becomes more rural after passing through Gouyave and gradually steeper as the altitude increases. Traffic on this route up to the site is generally low. On the way from Gouyave up to the proposed drilling site, the exact route from Gouyave to the site is not yet confirmed, and could potentially take one of the following two route options through Florida (a small settlement):

- Via the main road, passing over the rebuilt Brothers bridge and via Brothers road, or;
- Taking a turnoff just before Gillette corner onto the Rosemount road, before re-joining Brothers road at Florida. This route would require some minor works to improve the surface and widen three corners.

After passing through Florida, the public road becomes a track for the final 1.6km up to the proposed site location. This 1.6km will require upgrading. It would be upgraded by stripping the top surface to approximately 150mm depth and then rebuilding using 300mm of subbase material together with open channel stormwater drainage. This will include widening of corners for the passage of the vehicles. This final 1.6km section, is predominantly edged by vegetation with a small number of properties located near the route. Depending on the final route option selected, 10 to 14 locations would require corner widening.

Figure 13.4: Bridge at Gillette corner

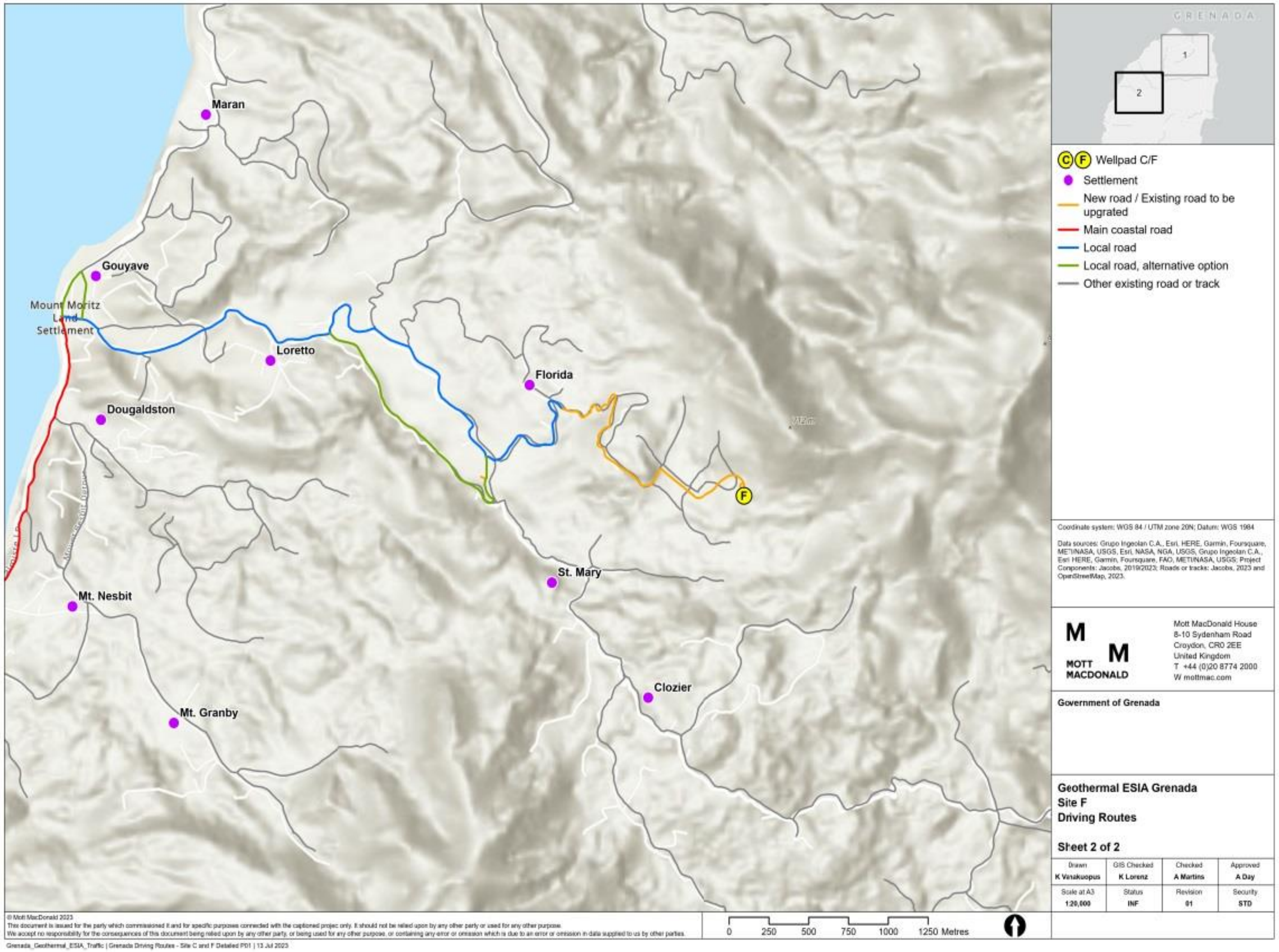
Source: Mott MacDonald

Figure 13.5: The point at which road becomes a track, on the route up to site F

Source: Mott MacDonald

Figure 13.6 below shows the likely route between Gouyave and site F.

Figure 13.6: Route to Gouyave to Site F



Source: Jacobs

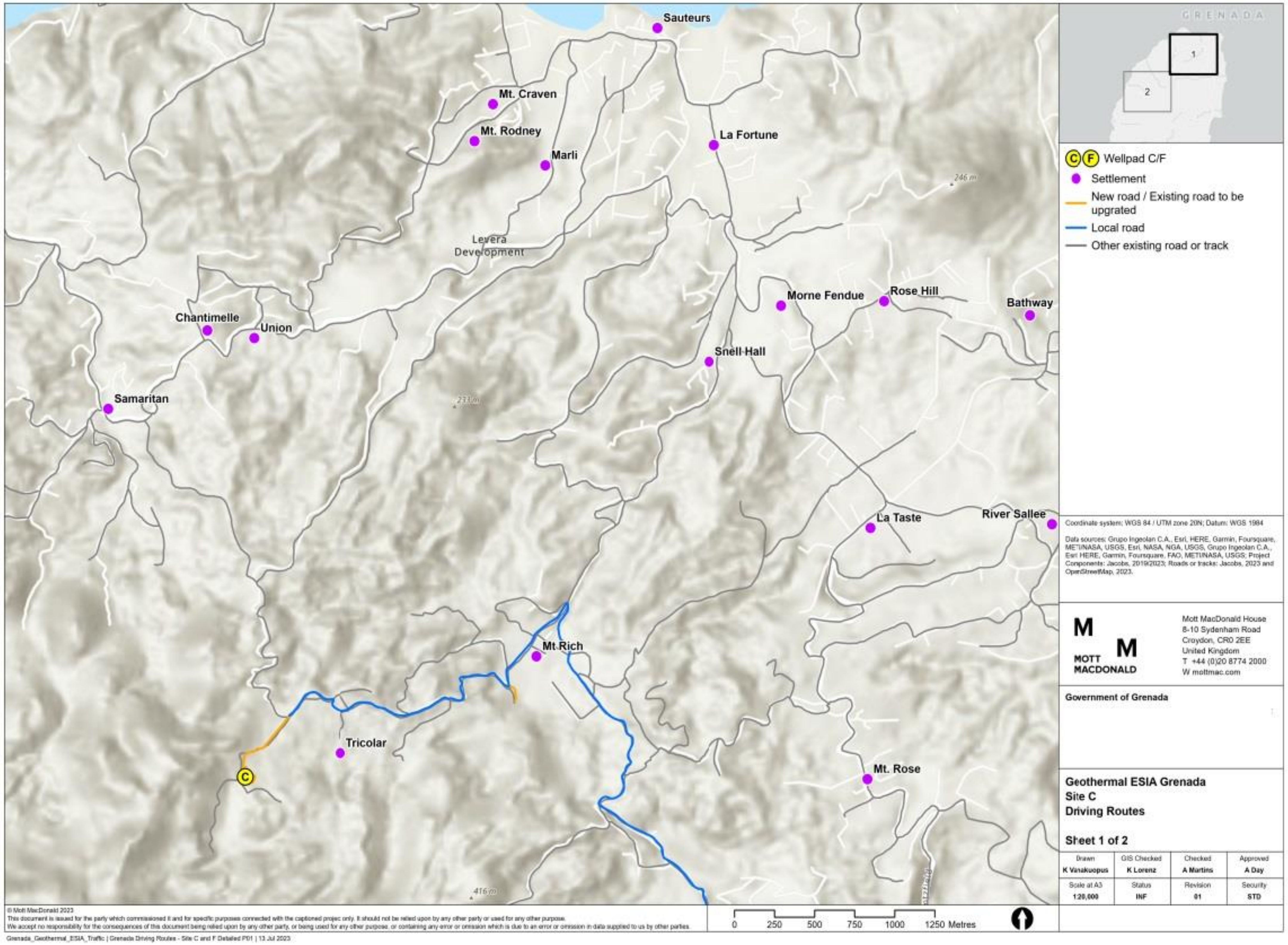
13.5.1.2 East coast route (to site C)

The East coast road route would be used to transport equipment to site C (Tricolar), around a 90-minute journey from the port at St Georges. The road is of a reasonable condition, with a few tight bends which would require careful negotiation with larger container vehicles. It was noted by Jacobs that the route from the port to near the proposed site has frequently been used by trucking companies to transport 40ft containers.

The road becomes more difficult to navigate after passing through Grenville, once the road begins to ascend into the hillier areas towards the site towards Tricolar. Five corner locations will require widening on the public road. Traffic on this road is generally low and the road is of a better surface quality and width than that at site F.

After leaving the public road, there is approximately 400m of unpaved track which would need stripping to approximately 150mm depth and then rebuilding using 300mm of subbase material together with open channel stormwater drainage. There is a section of 30m which may require cutting out and backfilling with engineered fill.

Figure 13.7: Planned route to site C



Source: Jacobs (adapted by Mott MacDonald)

13.5.1.3 Public transport and other transport infrastructure

Public transportation provided by small, privately-owned buses which run mostly along main road routes. No state-owned public transport or railway service exists on Grenada.

13.5.2 Projected traffic from the project

The works required to public roads are relatively minor with no major new structures (bridges, retaining walls, etc) expected to be required to facilitate exploration drilling. Materials for construction will be sourced locally where possible. Gravel, fine aggregate, stone are available from the local Mt Harman Quarry. At this stage it is anticipated that sand and fine aggregate will need to be imported from Guyana (due to sand mining being prohibited in Grenada). Concrete will likely be prepared at an on-site batching plant. In terms of construction traffic movements, it is estimated that **10 trucks will visit each site per day for around six weeks.** The construction period accompanied by the movement of any drilling rig is likely to result in the highest volume of traffic.

13.6 Assessment of impacts

13.6.1 Identification of receptors and analysis of sensitivity

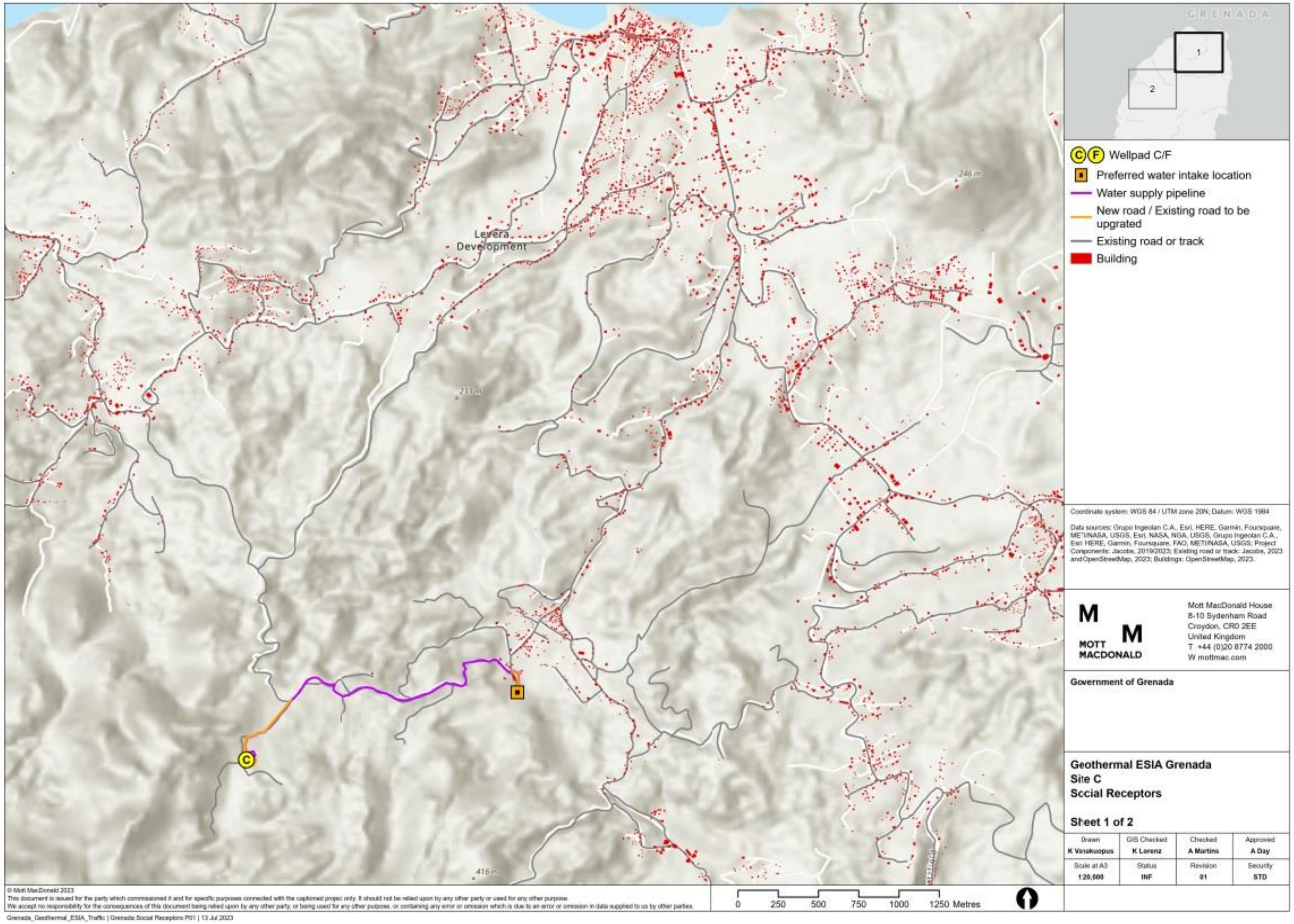
The Project will lead to changes in traffic and access, with resulting potential impacts to the road network and risks to local people. These potential impacts and risks are described below for both the construction and operational phases. Whilst the decommissioning phase should be considered similar to construction, the decommissioning will result in less traffic and impact as the upgraded roads will remain in situ and will not be removed. Sensitive receptors within the study area are noted to be:

- Existing roads
  - Local road from site F through Florida to Gouyave
  - Local road from site C through Tricolar
- Motorists
- Pedestrians/ cyclists
- Livestock
- Residents who live near the access routes

There are sensitive residential receptors near the public road, in particular when passing through Tricolar (houses) down to Tivoli. As the road heads towards Grenville and St Georges, houses near to the roads are more used to heavy traffic (given that they are located on the main east coastal road).

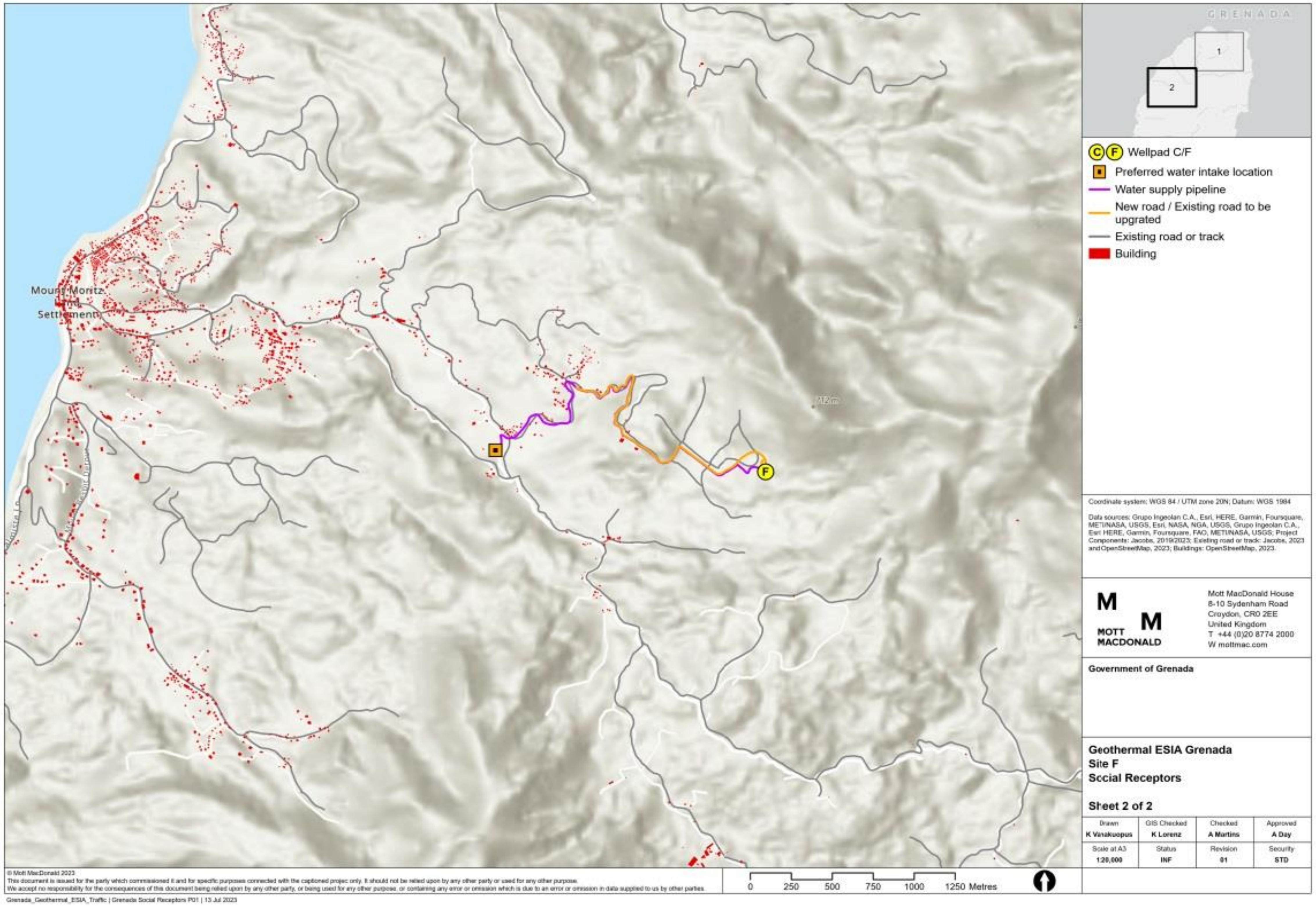
At site F, there are several houses located along the farm track leading from the public road to the wellpad location. Other sensitive receptors are the houses and schools near the access road from the site to Gouyave. Once reaching Gouyave the houses located near to the main coastal road to St Georges are more used to the effects of heavy traffic.

Figure 13.8: Map showing social receptors near to the access road to site C



Source: Mott MacDonald

Figure 13.9: Map showing social receptors near to the access road to site F



Source: Mott MacDonald

Table 13.3 shows the existing traffic levels will affect sensitivity to the changes which will occur through the construction and operation of the project.

Table 13.3: Traffic receptors and sensitivity

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
Roads in the project area	The existing roads are of good quality or will be upgraded by the project.	The relatively high quality of the existing roads and existing low levels of traffic make the roads in the project area of low sensitivity to change	Low
Motorists	Local people driving from A-B could experience slower journeys than normal	Given the relatively low volume of traffic motorists are likely to be of low sensitivity to a change in journey speed	Low
Pedestrians/ cyclists /livestock	People walking or cycling could be endangered by larger than normal trucks passing	Given the low number of trucks at present, people and animals are likely to be sensitivity to an increase in large vehicles	Medium.

13.6.2 Summary of changes, impacts and receptors

Table 13.4 shows the changes caused by construction activities, the potential receptors and the potential impact of the change.

Table 13.4: Changes, receptors and potential impacts

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Increase in traffic due to: • Delivery of equipment and drilling rig to site • Delivery of construction materials • Movement of construction workers to and from site (if worker accommodation is not at the site) • Earthworks and excavations • Removal of waste materials (particularly in decommissioning)	Construction	Wear and tear to road surface - the transportation of heavy equipment and materials has the potential to result in damage to roads near to the proposed existing routes.	Existing road network
	Construction	Congestion and increased journey time – as a result of large slow moving construction traffic	Motorists
	Construction	Increased risk of accident - the traffic increase that will result from the site restoration area may pose a risk to the safety of the wider community outside the immediate area of influence	Motorists Pedestrians/ cyclists /livestock
	Operation	Increased risk of accident - the traffic increase that will result from the site restoration area may pose a risk to the safety of the wider community outside the immediate area of influence	Motorists Pedestrians/ cyclists /livestock
	Decommissioning	As for construction	

13.6.3 Analysis of construction impacts

13.6.3.1 Wear and tear to existing road network

The magnitude of the wear and tear to existing roads is considered moderate because there will be around 10 trucks per day which is a notable increase in the current volume of traffic. The wear and tear to existing roads will occur for around 6 weeks in the initial phases of the construction period so the duration is considered short term (0-5 years). The wear and tear to existing roads will happen along the two access routes to site C and F so the scale is considered local. The probability of wear and tear to existing roads occurring is considered medium because whilst the roads are of good quality, some wear is possible.

Table 13.5: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Existing road network	As defined in the baseline chapter the sensitivity of the existing road network is considered low because of the high quality of the existing roads and existing low levels of traffic. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: Moderate Duration: Short Term (0-5 Years) Scale: Local Probability: Medium Sensitivity of receptor: Low Significance of impact: Negligible	(T8) Speed restrictions (T11) Road maintenance (T5) Routing video

13.6.3.2 Inconvenience to motorists (congestion, increased journey time)

The magnitude of the inconvenience to motorists is considered moderate because there will be around 10 trucks per day which could lead to some congestion. The inconvenience to motorists will occur for around 6 weeks in the initial phases of the construction period so the duration is considered short term (0-5 years). The inconvenience to motorists will happen along the two access routes o site C and F so the scale is considered local. The probability of inconvenience to motorists occurring is considered medium because it is likely that the trucks will move slower than existing traffic.

Table 13.6: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Motorists	As defined in the baseline chapter the sensitivity of motorists is considered low because current journey times are relatively short. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: Moderate Duration: Short Term (0-5 Years) Scale: Local Probability: Medium Sensitivity of receptor: Low Significance of impact: Negligible	(T1) Pre-construction road survey and test run (T2) Re-use construction material (T6) Road signage and traffic control (T7) Controlled vehicle movements (T8) Speed restrictions

13.6.3.3 Increased risk of accidents

The magnitude of the risk of increased accidents is considered moderate because there will be around 10 trucks per day which could increase accident risk. The risk of increased accidents will occur for around 6 weeks in the initial phases of the construction period, so the duration is considered short term (0-5 years). The risk of increased accidents will happen along the two access routes to site C and F, so the scale is considered local. The probability of risk of increased accidents occurring is considered medium because trucks are larger the normal traffic so will change how road users have to behave. The two key receptors are motorists and pedestrians, analysed below.

Table 13.7: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Motorists	As defined in the baseline chapter the sensitivity of motorists is considered low because they have good capacity to adapt to the additional traffic on the road. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter Judgement Nature: Negative Magnitude: Moderate Duration: Short Term (0-5 Years) Scale: Local Probability: Medium	(T8) Speed restrictions (T11) Road maintenance (T5) Routing video

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
		Sensitivity of receptor: Low Significance of impact: Negligible	
Pedestrians, cyclists and livestock	As defined in the baseline chapter the sensitivity of pedestrians, cyclists and livestock is considered high because they are vulnerable to big trucks. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter: Judgement Nature: Negative Magnitude: Moderate Duration: Short term (0-5 years) Scale: Local Probability: Medium Sensitivity of receptor: High Significance of impact: Minor	(T13) Designated crossing points (T14) Community traffic awareness

13.6.4 Analysis of Operational impacts (drilling and testing)

The exploratory drilling and testing phase of the project will include much more limited traffic than that of the construction and decommissioning phases. This is likely to be limited to 5-10 light vehicle movements per day from staff working on the project. As such most of the operational phase impacts have been scoped out, with just risk of accident to pedestrians, cyclists and livestock requiring analysis.

13.6.4.1 Increased risk of accident for pedestrians, cyclists and livestock

The magnitude of the increased risk of accident for pedestrians, cyclists and livestock is considered minor because there will be a low number of light vehicle movements per day. The increased risk of accident for pedestrians, cyclists and livestock will occur throughout the operation phase so the duration is considered short term (0-5 years). The increased risk of accident for pedestrians, cyclists and livestock will happen along the two access routes to site C and F so the scale is considered local. The probability of increased risk of accident for pedestrians, cyclists and livestock occurring is considered medium because road traffic accidents are always a risk. As defined in the baseline chapter the sensitivity of pedestrians, cyclists and livestock is considered high because they are vulnerable to vehicles. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.

Table 13.8: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (pre-mitigation)	Pre mitigation impact	Mitigation to be applied
Existing road network	As defined in the baseline chapter the sensitivity of the existing road network is considered low because of the high quality of the existing roads and existing low levels of traffic. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a negligible impact, which is not considered significant.	Parameter: Judgement Nature: Negative Magnitude: Moderate Duration: Short Term (0-5 Years) Scale: local Probability: Medium Sensitivity of receptor: Low Significance of impact: Negligible	(T8) Speed restrictions (T11) Road maintenance (T5) Routing video

13.7 Mitigation and enhancement measures

This section discusses the mitigation and benefit enhancement measures that will be used to avoid, mitigate, manage and improve the traffic impacts identified.

The main implementation method for mitigation measures outlined will be through a traffic management plan (TMP), which will define the requirements to be implemented to avoid mitigate and manage negative risks to communities, workers and the environment resulting from project traffic. The TMP will draw on international best practice in developing and ensuring the implementation of suitable strategies. Consultation with the appropriate highway authority (e.g. ministry of works, Grenada police force) will occur to ensure identified measures take into account local circumstances.

The management plan should be implemented throughout all phases of the Project.

Table 13.9: Mitigation and enhancement measures

Ref	Mitigation/enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
T1	Pre-construction road survey and test run	• Pre-construction road survey to be undertaken with early planning of the route for the transportation of heavy equipment, including preventive widening/strengthening measures, identification of pinch points and high-hazard areas, and marking of overhead utility lines which may need to be temporarily lifted or repositioned, prior to construction deliveries commencing. • Carry out a test run of a large vehicle travelling from the main road up to sites to understand pinch points and identify actions needed well in advance of transportation to site. Some actions may include: consultation; road adjustments; consideration of overhang onto private land and other properties.	Prior to construction
T2	Re-use construction material	• Re-use of construction material as much as possible on site.	Planning prior to construction, implementation throughout.
T3	On site concrete production	• Production of concrete on site. Concrete mixing plant located at construction site limiting traffic movements associated with concrete delivery to site access roads	
T4	Road modification	• All modifications to public roadways shall be designed in accordance with applicable road and traffic safety laws of Grenada.	
T5	Routing video	• Contractor should record a video of the road route before equipment is taken to site and after it is delivered to site to prevent any road deterioration claims that are not substantiated.	Prior to and after main equipment deliveries.
T6	Road signage and traffic control	• Road signs will be erected to clearly indicate the route of construction traffic and speed limits, thus to ensure that traffic follows the pre-planned routing	TMP

Ref	Mitigation/enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
		• Erect signs in each direction along the key transport routes where the road is single carriageway about the dangers of overtaking and of upcoming pinch-points (i.e., the roads from the coastal roads to the wellpads) • Traffic control signs will be in accordance with local laws and rules • Where road or lane closures occur which could cause disruption to traffic circulation, informational signage should be posted a week prior to the planned closure to inform motorists and other road users. Alternative routes will be identified for road users. • Flagmen will be appointed and located at intersections in the case of intensive periods of traffic (e.g. delivery of drilling rig) • Where the access roads join the coastal roads, illuminated and flashing signs should be erected to warn road users of the crossing points	
T7	Controlled vehicle movements	• The timing and routes of abnormal deliveries will be carefully scheduled to avoid coinciding with peak periods (e.g. school drop offs, livestock movements) • Consideration of access to essential services such as medical and other important services • Notification of residents near the gravel track at site F • Project vehicles will follow agreed routes • Trucks with abnormal loads should be escorted by at least two vehicles (before and behind). • Use of banksmen should any reversing be required • Traffic movements will be prohibited during extreme weather conditions such as heavy rainfall, to avoid potential road accidents associated with driver's visibility and road hazards • If road crossing is required, movements will be timetabled to ensure that vehicles arrive and leave at the same time (two-way movement) • Aim for site workers to vehicle share when travelling to and from the site	TMP
T8	Speed restrictions	• All national and specific area speed limits will be adhered to • Lower speed restrictions for Project traffic travelling through communities (to be agreed with the local transport authority) • To prevent speeding by drivers, ensure that delivery schedules are reasonable and achievable	TMP

Ref	Mitigation/enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
		• Vehicle speed limits will be monitored on a regular basis and action taken against drivers breaking speed limits	
T9	Vehicle monitoring	• Routine vehicle inspections and monitoring will take place on an on-going basis • A hazard identification and risk assessment will be undertaken for vehicles on a regular basis • Vehicles will be prohibited from being overloaded • Utilise low emissions vehicles for the transportation of materials (wherever practicable)	TMP
T10	Trained drivers and licenced contractors	• Drivers will be fully trained in road safety and appropriately licensed for the vehicle's operation on and off site. This will include training on the various mitigation measures outlined in the TMP, including consideration of sensitive receptors and timings (e.g., children) • Ensure all vehicles are road worthy, drivers are qualified and are made aware of the potential noise and dust issues • Only licensed contractors will be used for waste and fuel transportation	TMP
T11	Road maintenance	• Regular inspection and maintenance of roads used by the Project • Repair to damaged road surfaces and other road infrastructure caused by Project construction traffic	TMP
T12	Dust suppression	• To reduce dust levels on the two gravel access roads up to each pad, if dust is identified to cause an issue, the roads should be watered or treated with chemical binders and the gravel surface should be kept well maintained • Vehicles carrying material to and from site should be covered with plastic sheeting to prevent dust.	TMP
T13	Designated crossing points	• Designated crossing points should be established along the access roads, and these should be decided on based on consultation with local communities	TMP
T14	Community traffic awareness	• Pedestrian and traffic awareness programme along the main site access routes • Provision of information regarding construction activities and activities throughout the lifetime of the Project through stakeholder consultation.	TMP
T15	Accident action plan	• Have an action plan in place on what should be done in case of an accident (this should be communicated to all drivers) • Any accident/incident will be reported to Contractor and will be investigated appropriately	TMP
T16	Implement Construction Traffic Management Plan (TMP)	• Measures to reduce the risk to vulnerable road users and occupants of residential properties in the vicinity of roads which will be affected by	TMP

Ref	Mitigation/enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
		construction and operational traffic will be identified as part of the detailed TMP prior to construction. ● The TMP will draw on international best practice in developing and ensuring the implementation of suitable strategies. Consultation with the appropriate highway authority will occur to ensure identified measures take into account local circumstances. ● Non-significant impacts will also be managed by the CTMP.	
T17	Implement Air Quality Management Plan (AQMP)	● Implement AQMP to mitigate any potential negative risks to the environment, workers or the community resulting from air emissions	AQMP
T18	Implement Noise and Vibration Control Plan (NVCP)	● Implement NVCP during construction to control noise and vibration caused by construction traffic and plant/equipment movements (refer to Section 10)	NVCP
T19	Traffic awareness program	● Traffic awareness programme to be implemented along the main site access routes	TMP

13.7.1 Cumulative impacts

Impacts associated with the development of access roads and potential for increased encroachment on forest areas are discussed within the ecology chapter.

13.8 Monitoring

Monitoring will be undertaken to determine the effectiveness of mitigation measures in terms of safety and nuisance. Reporting on monitoring and KPIs should be provided to the local transport authority every three months, including:

- Number of complaints relating to traffic and transport
- Reporting of accidents and statistics by contractor to the Sponsor
- Reporting of road conditions
- Procedures for monitoring the effectiveness of the mitigation measures proposed in this Section are outlined in the table below and should be expanded upon in the Project specific TMP.

Table 13.10: Monitoring requirements

Monitoring activity	Responsibility (e.g., Project Company, Main contractor)	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
Accidents/ incidents	Contractor	Traffic accidents and incidents. Target of zero accidents / incidents associated with project activities.	Construction areas and transport routes	Weekly	Throughout project traffic movements
Information disclosure	Ma Contractor in contractor	Provision construction information to communities / stakeholders regarding construction activities. Implement pedestrian awareness programme. No complaints or grievances from community	Construction areas and transport routes	Monthly	Throughout project traffic movements
Inspection of dust levels	Contractor	Visual inspection and records of dust levels	Construction areas and transport routes	Weekly	Throughout project traffic movements
Traffic movement inspections	Contractor	Delivery timing Route used for delivery Speed checks Traffic movements during extreme weather conditions Re-use construction material	Construction areas and transport routes	Weekly	Throughout project traffic movements

Monitoring activity	Responsibility (e.g., Project Company, Main contractor)	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
Vehicle and driver inspections	Contractor	Licences in place (for vehicles and drivers) Vehicles roadworthiness check - pass rate Driver training records Waste collectors' licences reviewed	Construction areas and transport routes	Weekly	Throughout project traffic movements
Inspections of road damage / wear and tear	Contractor	Number of sites showing damage by project traffic; number of sites damaged that remain un-repaired	Construction areas and transport routes	Weekly	Throughout project traffic movements
Traffic movements and road quality during operation	Sponsor	Monitor and assist in resolving any reasonable complaints received relating to traffic along access roads	Project area including access routes	Routine and, if necessary, in response to a complaint through the Grievance Mechanism	Throughout project lifetime

13.9 Residual impacts

This section presents qualitative assessment of predicted residual traffic and transport impacts expected to occur as result of the exploratory drilling phase of the Project and assess the beneficial and adverse effects by predicting their significance prior to mitigation.

13.9.1 Analysis of residual construction impacts

13.9.1.1 Wear and tear to existing road network

Table 13.11 presents a summary of residual impacts (post-mitigation) for the impacts related to traffic and transport. The magnitude of impact would be reduced from moderate to minor after mitigation measures are applied. However, significance of impact would remain same.

Table 13.11: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Existing road network	Parameter Judgement Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: low Significance of impact: negligible Mitigation measures reduce magnitude of change from moderate to minor.

13.9.1.2 Inconvenience to motorists (congestion, increased journey time)

Table 13.12 presents a summary of residual impacts (post-mitigation) for the impacts related to traffic and transport. The magnitude of impact would be reduced from moderate to minor after mitigation measures are applied. However, significance of impact would remain same.

Table 13.12: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Motorists	Parameter Judgement Nature: Negative Magnitude: Minor Duration: Short term (0-5 years) Scale: Local Probability: Medium Sensitivity of receptor: Low Significance of impact: Negligible Mitigation measures reduce magnitude of change from moderate to minor.

13.9.1.3 Increased risk of accidents

Table 13.13 presents a summary of residual impacts (post-mitigation) for the impacts related to traffic and transport. The magnitude of both impacts would be reduced from moderate to minor after mitigation measures are applied. However, significance of both impacts would remain same.

Table 13.13: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Motorists	Parameter Judgement Nature: Negative Magnitude: Minor Duration: Short term (0-5 years) Scale: Local Probability: Medium Sensitivity of receptor: Low Significance of impact: Negligible Mitigation measures reduce magnitude of change from moderate to minor.
Pedestrians, cyclists and livestock	Parameter: Judgement Nature: Negative Magnitude: Minor Duration: Short term (0-5 years) Scale: Local Probability: Medium Sensitivity of receptor: High Significance of impact: Minor Mitigation measures reduce magnitude of change from moderate to minor.

13.9.2 Analysis of residual operation phase impacts (drilling and testing)

13.9.2.1 Increased risk of accident for pedestrians, cyclists and livestock

Table 13.14 presents a summary of residual impacts (post-mitigation) for the impacts related to traffic and transport. The magnitude of impact would be reduced from moderate to minor after mitigation measures are applied. However, significance **of** impact would remain same.

Table 13.14: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Existing road network	Parameter Judgement Nature: Negative Magnitude: Minor Duration: Short term (0-5 years) Scale: Local Probability: Medium Sensitivity of receptor: Low Significance of impact: Negligible Mitigation measures reduce magnitude of change from moderate to minor.

Receptor	Summary of residual impact (post-mitigation)
Pedestrians, cyclists and livestock	Parameter: Judgement Nature: Negative Magnitude: Minor Duration: Short term (0-5 years) Scale: Local Probability: Medium Sensitivity of receptor: High Significance of impact: Minor Mitigation measures reduce magnitude of change from moderate to minor.

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Geothermal Energy Development Project - Exploratory Test Drilling Environmental and Social Impact Assessment

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Chapter 14 - Waste and materials management

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14 Waste and materials management

14.1 Overview

This chapter outlines the key sources and types of waste and associated waste management likely to arise during the construction, operation and decommissioning phases of the Project. This chapter identifies and assesses potential significant adverse impacts of waste generated by the project on the environment and receptors, before defining appropriate mitigation measures that will be implemented as part of the Project.

14.2 Study area and area of influence

Considering the consumption of raw materials (including receipt, handling and storage) and subsequent management and disposal of waste, the spatial scope of the Project encompasses the exploration drilling well pad sites and also the other project component sites identified in the project description. The temporal scope covers the potential impacts related to the consumption of raw materials (including receipt, handling and storage) and subsequent management and disposal of waste arising from the construction, operation and decommissioning phases of the Project. Project timeframes are outlined in the project description.

14.3 Methodology

After identifying and, where possible, quantifying the potential sources of waste, the assessment focuses on measures to reduce, reuse and recycle, as well as the solutions available for waste disposal. The assessment approach taken included desktop study of readily available information on the Project activities including drilling materials and drilling plans, publicly available information regarding waste management in Grenada, and site visits to the various Project components.

A range of impacts can occur from the mismanagement of waste arising from the phases of an exploratory drilling geothermal project. Therefore, materials and waste handling impact assessment are primarily about identifying waste streams and adopting an appropriate approach in line with Good international industry practice (GIIP), which seeks to avoid the generation of waste in the first instance, rather than mitigating potential impacts to a defined baseline environment. As such the sensitivity and magnitude approach is very difficult to employ in this chapter. Our analysis seeks to demonstrate the different expected outcomes and impacts associated with waste generated in the non-management/ management strategy scenarios. After identifying the potential sources of waste arising from each phase of the project, the assessment focuses on measures to reduce, reuse and recycle, as well as the solutions available for waste disposal.

14.3.1 Limitations and assumptions

Assumptions included in the waste assessment section are based on preliminary design information provided by the client and technical consultant. Whilst materials to be used and wastes likely to be generated during the different phases of the project have been identified, exact quantities of wastes have not yet been defined and the quantities of materials specified may be subject to change following detailed design.

14.4 Baseline – description of pre project conditions

The government of Grenada produced the National Waste Management Strategy for Grenada in April 2003. The strategy defined waste and specified that a National Waste Inventory must identify the total tonnage of waste generated in Grenada, identify proportions of waste by specific categories, and estimate the proportion of the total waste stream generated by the residential sectors, service industry, and industrial, commercial and institutional sector. Consequently, the Grenada Solid Waste Management Authority (GSWMA) was established to deliver public waste management services and manage the sectoral/operational aspects of public awareness and education.

The Perseverance Landfill, located in the parish of St. George, is the primary waste disposal site on the island. The landfill handles both residential and commercial solid waste, including non-hazardous waste from households, businesses, and industries. The landfill is managed by the GSWMA, which is responsible for maintaining the facility and ensuring waste is disposed of in an environmentally-friendly manner.

To reduce the amount of waste sent to the landfill and promote a circular economy, the GSWMA has implemented recycling programs for various materials, including paper, plastic, glass, and aluminium. Some recycling facilities on the island also process electronic waste and other hazardous materials. These recycling programs encourage residents and businesses to separate recyclable materials from their general waste, which are then collected and processed for reuse or repurposing.

Composting is another waste management strategy on the island, focusing on turning organic waste into valuable compost for agricultural and landscaping purposes. The GSWMA operates several community-based composting facilities, where residents can bring their organic waste (such as food scraps and yard trimmings) to be composted. These facilities contribute to reducing the amount of organic waste sent to the landfill and promote sustainable agriculture on the island.

Some waste types, such as medical waste and chemicals, require special handling and disposal. The GSWMA collaborates with other government agencies and private companies to ensure the proper disposal of hazardous waste. Specialized facilities on the island handle the collection, transportation, treatment, and disposal of hazardous waste materials, ensuring they do not pose risks to public health or the environment.

Public awareness and education are critical components of waste management in Grenada. The GSWMA, in collaboration with other stakeholders, runs various campaigns and initiatives to educate the public about the importance of waste reduction, recycling, and proper waste disposal. These initiatives aim to encourage behavioural change and foster a culture of environmental responsibility among the island's residents.

During the site visit, it was confirmed that only the main landfill at Perseverance is currently in operation. Waste is now weighed and categorised upon disposal. There is limited publicly available information on the location of facilities which deal with and manage hazardous wastes.

14.5 Impact identification

The main potential impacts which can arise from the generation of waste and handling of materials are as follows:

- Contamination of receiving environments (particularly surface watercourses, groundwater and soils) due to leakage and spillage of wastes associated with poor waste handling and storage arrangements (these impacts are assessed separately in the hydrogeology section)
- Hazardous material management
- Use of landfill - where waste re-use or recovery is not feasible - which is a finite resource
- Disposal of spoil, excavation material and the various waste streams.

Three general classifications of wastes have been applied for the assessment: namely non-hazardous wastes, hazardous wastes and inert wastes. Each waste stream has been identified as belonging to one of the following classifications:

- Inert construction wastes are wastes that are solid and when disposed of are not expected to undergo physical, chemical or biological changes to such an extent as to produce substances that may cause an adverse effect. Such wastes include but are not limited to debris, concrete, glass, ceramic materials, unpainted scrap metal, and dry timber or wood that has not been chemically treated.
- Non-hazardous wastes are all wastes that are not hazardous wastes and are not inert construction wastes. This includes common garbage, office wastes, construction wastes such as boxes, and treated sewage effluent and sewage sludge.
- Waste materials are classified as hazardous wastes when they exhibit on or more of the characteristics such as explosive, flammable, spontaneous combustion potential, oxidizing potential, toxic, and corrosive.

14.6 Assessment of impacts

Waste will be generated by the project but if properly managed, the area impacted will not go beyond the project site limits. However, if any hazardous substances or spoil/excavated materials require special disposal treatment offsite or are not handled and stored properly, there is potential that groundwater and/or the aquatic environment could become contaminated outside the project area. For the purposes of this chapter, sensitive receptors are identified as various potential receiving environments which surround the project site, for example forest areas, nearby streams, soils and agricultural land. Potential impacts generally associated with the wider handling and use of raw materials includes the following;

- Use of potentially finite and / or scarce resources;
- Handling and storage of hazardous materials; and
- Spills and leakages of hazardous materials which lead to an environmental incident.

At the time of writing, it is assumed there is no intentional emptying of the waste sump during drilling. Prior to well testing, the sump will be emptied by injecting the fluid into the well. Alternative options are to have the fluids and solids collected by a vacuum truck and if required treated at suitable facilities.

14.6.1 Analysis of construction phase impacts (site establishment)

14.6.1.1 Material management

Materials used during site establishment will principally comprise the items of equipment for the Project, as well as materials used for site preparation. Site preparation materials include:

- Gravel
- Sand
- Cement
- Liners for sumps
- Gabions
- Steel rebar

Smaller quantities of other materials will be used throughout construction.

14.6.1.2 Waste generation

Table 14.1 summarises the waste streams which are anticipated to be generated as part of the construction phase of the Project, as well as their potential impacts, and how wastes will be handled and stored, and the method of disposal for each waste stream.

Table 14.1: Analysis of waste streams during construction

Waste type	Potential unmitigated impact	Proposed management method
Inert construction wastes		
Excavation spoil	Contamination of receiving environments such as sedimentation of water bodies Fugitive dust emissions Disposal of spoil and excavation material which results in land take	Temporary storage in stockpiles, for further reuse on site following drilling and decommissioning. Spoil suitably compacted, covered and stored to prevent runoff. Surface water management measures considered and implemented when locating and designing spoil storage.
Concrete	Fugitive emissions Additional pressure on the use of existing landfill, where waste re-use or recovery is not feasible Increased 'waste-miles' from transporting waste materials from the Project site	To be segregated and suitably stored on a temporary basis in a waste management area. Reuse in other work locations (e.g., as an aggregate) or returning unused cement to the vendor can minimise the volume of waste.
Concrete Washings	Contamination of receiving environments (for example sedimentation of waterbodies).	To be reused on site wherever possible in line with best practice. Wash water which cannot be immediately reused is to be stored in an open lined pit or open tanks so as to aid sedimentation or other on-site treatment as appropriate.
Non-hazardous construction wastes		
Iron and steel scrap Non-ferrous scrap Paper and Cardboard Timber Woody debris Bricks and tiles Pallets Glass	The use of landfill, where waste re-use or recovery is not feasible Increased impact from transporting waste materials from the Project site Visual amenity impacts associated with poor storage of waste	Segregated and suitably stored on a temporary basis in a waste management area. Collected by a competent carrier for recycling/reuse. Additional options could include donation to local community initiatives (if applicable)
General domestic waste	The use of landfill, where waste re-use or recovery is not feasible Visual amenity impacts associated with poor storage of waste Windblown litter and potential odour and health risks by attracting pests Increased waste miles from transporting waste materials from the Project site	Appropriate segregation, storage and covering of waste storage on site. Appropriately handled and disposed of in accordance with the relevant international and local requirements.
Plastics and packaging Drums, barrels and containers from non-hazardous materials	The use of landfill, where waste re-use or recovery is not feasible Visual amenity impacts associated with poor storage of waste Increased waste miles from transporting waste materials from the Project site.	To be segregated and suitably stored on a temporary basis in a waste management area. Collected by or delivered to local vendors for recycling. Drums and barrels may be disposed of by returning to the vendor for reuse.
Hazardous construction wastes		
Oils and lubricants and contaminated cloths	Contamination of receiving environments The use of landfill, where waste re-use or recovery is not feasible	Collected in bunded, segregated drums within a waste management area Recovery and re-use options to be fully explored. Collected by a competent carrier.

Waste type	Potential unmitigated impact	Proposed management method
		Where recovery and re-use is not feasible then disposal in a licensed waste treatment facility.
Batteries Fluorescent tubes Paints and chemicals	Contamination of receiving environments The use of landfill, where waste re-use or recovery is not feasible	Waste will be segregated according to waste code and suitably stored in a waste management area. Recycling options to be fully explored. Collected by a competent carrier to be disposed of in a licensed waste facility.
Medical waste	Contamination of receiving environments Health and safety: risk of infection and exposure to diseases	Containers will be puncture-proof (usually made of metal or high-density plastic) and fitted with covers and stored in locked containers Bags and containers for infectious waste will be marked with the international infectious substance symbol Transported to a medical facility with a licence for waste incineration Colour coded medical waste
Contaminated material Oily debris from sumps and spill clean-ups	Improper handling, storage, and collection of hazardous waste Discharge of untreated wastewater at construction site Accidental spillage and leakage of chemicals including fuel, oil and lubricant from on-site fuel storage tanks and equipment maintenance During the transport of materials to the designated treatment/disposal facilities may pose a risk of contamination to the land, groundwater and surface water	Collected and stored on an impermeable bunded area and appropriately covered. Appropriately handled and disposed of in accordance with the relevant international and local requirements
Sewage sludge and sanitary chemicals	Contamination of receiving environments Discharge of untreated wastewater at workers accommodation and construction site	Wastewater collected in tank/similar on site. Any chemicals or wastes to be taken off site to licensed facility.

Source: Mott MacDonald

Excavation materials from the access tracks, well pad sites and ancillary areas will potentially represent the largest volume of waste. Where possible the excavation material should be used for landscaping on site.

All the wastes identified above should be minimised, sorted, reused and recycled wherever possible. There may be the opportunity of further community benefit through waste reuse where possible. Special care will also need to be given to food waste, which will be kept separate in enclosed areas to avoid pest and odour or composted / disposed of rapidly.

14.6.2 Analysis of operational phase impacts (drilling and testing)

14.6.2.1 Materials use

The main materials which will be used during the drilling and testing phase are water-based drilling muds, cement and metal casings which are used in drilling and lining the well. Table 14.2 presents typical operational phase materials. The drilling mud is comprised of water, bentonite clay and other additives (e.g., walnut shells, polymers).

Table 14.2: Example materials and chemicals used in operation

Material	Typical type	Estimated quantity (tonnes unless otherwise stated)
Drilling muds and additives		
Bentonite	Non-hazardous	80
Walnut Shells	Non-hazardous	Variable
Coase Mica Flakes	Non-hazardous	Variable
Caustic Soda	Hazardous	0.7
Salts	Non-hazardous	10
Barium Sulphate	Non-hazardous	45
Calcium hydroxide (lime)	Hazardous	0.5
Chrome Free Lignosulphonate	Non-hazardous	0.5
Other additives	Various	Variable
Cement additives		
Wyoming bentonite	Non-hazardous	10
Mica flakes	Non-hazardous	10
High temperature retarder powder	Hazardous	3
Friction reducer / dispersant	Hazardous	3
Fluid loss control cement additive	Hazardous	3
Cement accelerators	Hazardous	3
Cement	Hazardous	Variable
Diesel Fuel for on-site generators (auxiliary and drilling)	Hazardous	n/a

Source: Mott MacDonald

14.6.2.2 Waste generation

Waste streams that will arise from the operation of the Project will require adequate handling and disposal procedures to ensure adverse environmental impacts are kept to a minimum and to comply with international standards.

Drilling wastes are the most significant waste arising from the operational phase. Environmental impacts could potentially occur from the poor handling of this waste stream and inappropriate disposal methodology resulting in contaminated discharges to the receiving environment, in particular the land and groundwater.

Typically, a large amount of the drilling mud is recycled during drilling, however some is commonly lost down the well and into surrounding rock because of porosity. Drilling mud and drilling cuttings from geothermal drilling (using water based substances), are typically not classified as hazardous waste. However, sampling and laboratory testing of drilling mud and cuttings are undertaken on a daily basis as a precautionary measure. If testing indicates that the drill mud and drilling cuttings material is classified as a hazardous waste it shall be handled and stored (temporarily) and ultimately disposed of off-site by a licensed hazardous waste operator to a licensed hazardous waste management facility, which would be identified by the drilling contractor and GoG. Cuttings classified as non-hazardous have on other Projects been used for local roading material.

The geothermal testing process also produces geothermal brines, which typically contains high concentrations of minerals and chemicals. These liquids will be stored in the lined site sump prior to reinjection back into the well once testing is completed. As above, any residues would be tested to determine the appropriated disposal methodology.

Table 14.3: Analysis of waste streams during operation

Waste type	Potential unmitigated impact	Proposed management method
Drilling muds and cuttings	Contamination of receiving environments (specifically pollution of watercourses, groundwater and soils)	Using water-based drilling fluids. Cuttings and muds will be stored in the on-site lined sump. Cuttings and muds to be tested prior to reuse. Drill muds to be recycled during drilling if appropriate.
Geothermal liquid/brines	Contamination of receiving environments (specifically pollution of watercourses, groundwater and soils)	Cuttings and muds will be stored in the on-site lined sump. After the discharge test, the fluids will be reinjected back into the lined well once the testing is finished. Any remaining residue will be tested for hazardous material - if classified as non-hazardous, it can be removed (back-hoe or manually) and disposed of at a pre-determined disposal area within the site. If residue was classified as hazardous, it would be disposed of in accordance with Grenada's management for hazardous wastes.
Sewage sludge and sanitary chemicals	Contamination of receiving environments Discharge of untreated wastewater at workers accommodation and construction site	Wastewater collected in tank/similar on site. Any chemicals or wastes to be taken off site to licensed facility.
Contaminated packaging Oily contaminated materials, such as oily rags Lubricating and auxiliary oils Empty chemical containers	Contamination of receiving environments	Collected and stored on an impermeable bunded area and appropriately covered. Appropriately handled and disposed of in accordance with the relevant international and local requirements
Waste collected as a result of spills, leakages and/or accidental damage	Contamination of receiving environments	Collected and stored on an impermeable bunded area and appropriately covered. Appropriately handled and disposed of in accordance with the relevant international and local requirements
General waste	Contamination of receiving environments	Appropriate segregation, storage and covering of waste storage on site. Appropriately handled and disposed of in accordance with the relevant international and local requirements.

Cuttings are stored in a sump which provides an impervious surface with some cuttings being taken off site for testing. Following toxicity tests on the cuttings quality, to determine whether they contain any pollutant that could percolate and contaminate the ground water, the option of disposal will be assessed.

14.6.3 Analysis of decommissioning phase impacts (site closure)

Decommissioning of the Project will include the complete removal of facilities and well abandonment, including associated equipment, material, and waste disposal or recycling.

The principal pieces of infrastructure which will require removal as part of the decommissioning phase are as follows:

- Drill rig and generators
- Fuel storage tanks
- Removal of site offices
- Dismantling and backfilling of water reservoirs and sumps
- Dismantling and removal of water pipeline and pumping
- Auxiliary structures

The impacts and effects of from waste and materials are considered to be similar to the impacts during the construction phase.

14.7 Mitigation and enhancement measures

Potential impacts are not expected to be significant provided GIIP for materials handling and storage and waste management and disposal is adhered to throughout the construction and operation phases of the project as specified below.

Materials and waste management will be managed for the construction and operational phases as follows:

- Detailed Waste and Materials Management Plans (WMMP) will be required to be developed by each contractor. This plan will also be required to include drill mud/ cuttings plan for implementation during the drilling phase.
- A Spill prevention and response plan will also be required to be developed by each contractor.

Waste and materials management plan (WMMP)

For each phase, the WMMPs will identify predicted waste streams, appropriate handling, reuse and recycle opportunities and, as a last resort, disposal methods. Each WMMP will be prepared in accordance national waste regulations and the IFC General EHS Guidelines.

The WMMP will include the following key aspects, as well as mitigation measures in the below sections as a minimum:

- Identify who is responsible for each key stage and inform individuals of their responsibilities. They will be required to hold sufficient authority to ensure compliance with the WMMP by other site operatives.
- Identify the types and quantities of waste - all waste streams that will be produced during construction, operation and decommissioning require to be identified.
- Identify waste management options - Where hazardous wastes are being generated, particular attention to the arrangements for identifying and managing such waste will need to be addressed and procedures put in place.
- Identify suitable waste management sites - the location of waste management sites will need to be identified (through co-ordination with government), ideally the most local sites should be used to minimise transportation costs, provided they are appropriate. Use licensed waste disposal contractors that comply with the environmental legislative requirements of the local and national area.
- Training - all staff must be trained to ensure they understand the requirements of the WMP.
- Plan - using the steps above, establish indicative percentages of the waste quantities to be produced over the life span of the Project.
- Measure - the quantities of wastes produced should be recorded on monthly basis, and where possible measures taken to re-use, reduce or recycle waste as appropriate.

- Monitor - throughout the Project life cycle, waste management on site should be monitored, to ensure compliance with the WMP.
- Hazardous Classes – hazardous wastes should be classified and treated according to national requirements.
- Identify waste management options - as described in the construction and operational ESMPs provided in Volume II, a waste hierarchy of reduce, reuse, and recycle and needs to be considered and prepared. Where hazardous wastes are being generated, particular attention to the arrangements for identifying and managing such waste will need to be addressed and procedures put in place.

Detailed mitigation and enhancement measures are outlined in Table 14.4.

Table 14.4: Mitigation and enhancement measures

Type of measure	Mitigation/ enhancement measure	Details of mitigation/enhancement measure
Embedded mitigation / design measures – mitigation which is built into project during the design and procurement process	Identification of disposal facilities	Identification of appropriate waste facilities (including for hazardous waste).
	Re-use construction material	Re-use of construction material as much as possible on site.
	On site concrete production	Production of concrete on site. Concrete mixing plant located at construction site limiting traffic movements associated with concrete delivery to site access roads
Mitigation of significant and non-significant effects	Material Use	• Re-using materials on site wherever possible; the most significant opportunity in the construction phase is with respect to excavated spoil • Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off-specification, contaminated, damaged, or excess to needs • Instituting procurement measures that recognise opportunities such as ordering the correct amount of materials to be delivered when needed and establishing a take back system with suppliers • Major supply requirements outside of what is sourced on-site (e.g. stone, concrete) should be sourced from certified sources or local sources. • Substituting raw materials or inputs with less hazardous or toxic materials wherever economically and technically feasible
	Waste segregation	• Wastes will be appropriately segregated in designated storage areas, such that hazardous and non-hazardous wastes are not mixed and to allow for recycling and reuse where appropriate • Hazardous waste (such as oils, lubricants, batteries, chemicals and medical waste) will be segregated from other waste types to avoid cross contamination
	Storage measures	• Wastes generated shall be correctly identified and stored pending collection/transfer for reuse, recovery, recycling or disposal in an environmentally sound manner • The waste storage areas will be located on areas of hard standing or similar to prevent leaching of any contaminants should spillage or leakage occur • All skips to be suitably covered (to avoid dispersion of light materials by wind or filling of skip with rain); • Liquid wastes/oil/chemicals to be stored in tanks or drums located in bunded areas which can hold 110% of the capacity of the largest tank or drum or, for multiple drum storage, 25% of the total volume of material stored • Spill kits to be located nearby along with MSDS

Type of measure	Mitigation/ enhancement measure	Details of mitigation/enhancement measure
		• Store hazardous waste in closed containers away from direct sunlight, wind and rain in designated storage areas. Locate storage area away from sensitive receptors. • Provide adequate ventilation where any volatile wastes are stored • Provide readily available information on chemical compatibility to workers including labelling each container, demarcation of the area (e.g. on a facility map/site plan) • Visual and emissions management measures implemented as appropriate
	Handling measures	• Handling and storage shall be carried out by trained staff • Spill response equipment will be made available and maintained in areas where hazardous wastes may be spilt and an appropriate number of site personnel will be trained in spill response techniques • Prepare and implement spill prevention and response plan and emergency preparedness and response plan to address any accidental release and leakage • Each waste transport will be appropriately tracked and a register kept for recording all waste transports leaving the site and their disposal location • A Waste Transfer Note will accompany all waste consignments from the construction site to the disposal destination • Periodic spot checks as appropriate to follow waste transports to their destination
	Disposal measures	• No waste to be dumped or burned • Offsite waste treatment or disposal facilities used will be appropriately permitted, or if not available based on the most suitable site in consultation with authorities • The contractors will not release the waste if there is concern about the standard of transport or destination of the waste • Disposal of any medical waste must be undertaken at licensed facilities
	Drill cutting and mud management plan	• A drill cuttings and mud management plan should be developed by the drilling contractor to ensure the appropriate handling of the materials and liquids produced as part of the drilling and testing stage. This will include: • Specific training required for workers who will be managing muds and cuttings on site • Use of non-toxic water based drilling fluids • Sump arrangements to prevent pollution (e.g., sizing, suitable liners) • Testing procedures and monitoring for all drilling muds, cuttings and fluids to ensure that contaminant levels do not exceed acceptable standards and that drilling wastes are disposed of and managed in an appropriate manner. • Reuse/ dispose of cuttings in line with national regulations, dependent upon toxicity test results • Drilling muds/fluids to be recycled during drilling where possible to minimise water demand.

14.8 Monitoring

Monitoring will be undertaken to determine the effectiveness of mitigation and enhancement measures and to identify additional issues which will require further action. The contractor will set out a programme for a material usage and waste management to address all activities that have been identified to have potentially significant impact on the environment during the construction, operation and decommissioning. The procedures for monitoring the effectiveness of mitigation proposed within this chapter will be incorporated within the WMMP.

The monitoring will be sufficient to provide representative data for the parameter being monitored and conducted by trained individuals following monitoring and record-keeping procedures. Monitoring data will be analysed and reviewed at regular intervals and will be compared with the operating standards so that any necessary corrective actions can be taken.

14.9 Residual impacts

The mitigation measures identified in the section 14.7 will ensure that wastes generated as a result of the Project will be managed according to environmental best practice and the risk to the environment is reduced to acceptable levels.

Following application of proposed mitigation and management measures, the disposal of spoil and excavation material which results in land take is still expected to remain as a residual impact.

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15.1 Overview

This chapter assesses the impacts on soils, surface geology, slope stability and erosion and changes in the morphology of the area due as a result of the Project.

15.2 Study area and area of influence

Potential impacts to soils and geology are most likely to occur at the construction / exploratory drilling sites, site facilities and along the access tracks.

15.3 Applicable guidelines and standards

There are no national or international standards specifically for geological thresholds to be used for ESIA and hence the assessment of impacts relies to a large degree on professional judgement.

15.4 Methodology

The methodology used to assess the impact on soils and surface geology (e.g., slope stability and erosion) include:

- Site visits in March 2019 and June 2023 to understand site setting, land use, and identify areas which could be subject to erosion and decreased slope stability at some point during the project;
- Desk-based research of secondary information contained in Project related materials by the Government of Grenada (e.g. Jacobs technical reports), information requested from government departments, publicly available information, and
- Review of excavation activities information available
- Analysis through geographical information systems (GIS) using publicly available, and government provided datasets

15.4.1 Determining sensitivity, magnitude and significance

An assessment of the significance of impacts of the Project on geology, erosion and slope stability has been made for the construction and operational phase of the Project as well as the decommissioning phase. The significance of potential impacts is a function of the presence and sensitivity of features and the magnitude (duration, spatial, extent, reversibility, likelihood and threshold) of the impact.

The criteria for determining magnitude and sensitivity for soils and geology are defined in the tables below.

Table 15.1: Criteria for determining receptor sensitivity

Category	Description
High	Receptor (human, physical or biological) with little or no capacity to absorb proposed changes or minimal opportunities for mitigation. e.g., soils with a high erosion potential
Medium	Receptor with little capacity to absorb proposed changes or limited opportunities for mitigation. e.g., soils with a medium erosion potential
Low	Receptor with some capacity to absorb proposed changes or moderate opportunities for mitigation.

Category	Description
	e.g., soils with low erosion potential.
Negligible	Receptor with good capacity to absorb proposed changes or good opportunities for mitigation.

Table 15.2: Criteria for determining impact magnitude

Category	Description
Major	Fundamental change to the specific conditions assessed resulting in long term, irreversible or permanent change, typically widespread in nature and requiring significant intervention to return to baseline; would violate national standards or Good International Industry Practice (GIIP) without mitigation.
Moderate	Detectable change to the specific conditions assessed resulting in non-fundamental temporary or permanent change.
Minor	Detectable but minor change to the specific conditions assessed.
Negligible	No perceptible change to the specific conditions assessed.

15.4.2 Limitations and assumptions

It is always possible that unexpected ground conditions may be encountered during the course of the construction or operation works. No intrusive ground investigation works were undertaken at the ESIA stage but a variety of geological studies and literature have been drawn upon.

15.5 Baseline

The geological setting of the region has been covered by several studies, including most recently in an integrated geology, geochemistry and geophysics report by Jacobs[1]. This report was the result of a comprehensive geothermal investigation carried out by Jacobs which included geological, geochemical and geophysical (magnetotelluric) data collection and interpretation (and also summarised previous studies).

15.5.1 Regional and local geology

The dominant geology of Grenada is volcanic deposits of varied age and nature, overlying a sedimentary basement. The lithology of the interior is dominated by lava and pyroclastic flows and the lithology of the coastal deposits are dominated by "reworked" volcanic rocks, including fluvial and mudslide deposits. This accounts for the eastern sides gentle downwards slope towards the sea. However, the western side of the island is steeply contoured with deep valleys, due to the asymmetric historic eruption to the west. The southern part of the island is characterised by long, narrow bays, that cut into the sedimentary and volcano-sedimentary deposits[2].

In the Mt St Catherine area, a layer of volcanic rocks approximately 800m thick lies upon a sedimentary layer known as the Tufton Hall Formation. The volcanic rock types (basanitoid, alkaline basalt, subalkaline basalt, andesite and dacite) overlying the Tufton Hall formation are the result of five volcanic activity episodes between the lower Miocene and Pleistocene (the North Domes, South East, Mt. Maitland, Mt. Granby-Fedon's Camp, and Mt. St. Catherine the highest of the major peaks). The Mt St Catherine edifice has a Pleistocene age and is characterised by three large craters, open on the southern, western and eastern sides with diameters of 1.2km. Thermal features on Grenada occur in the northern and central parts of the

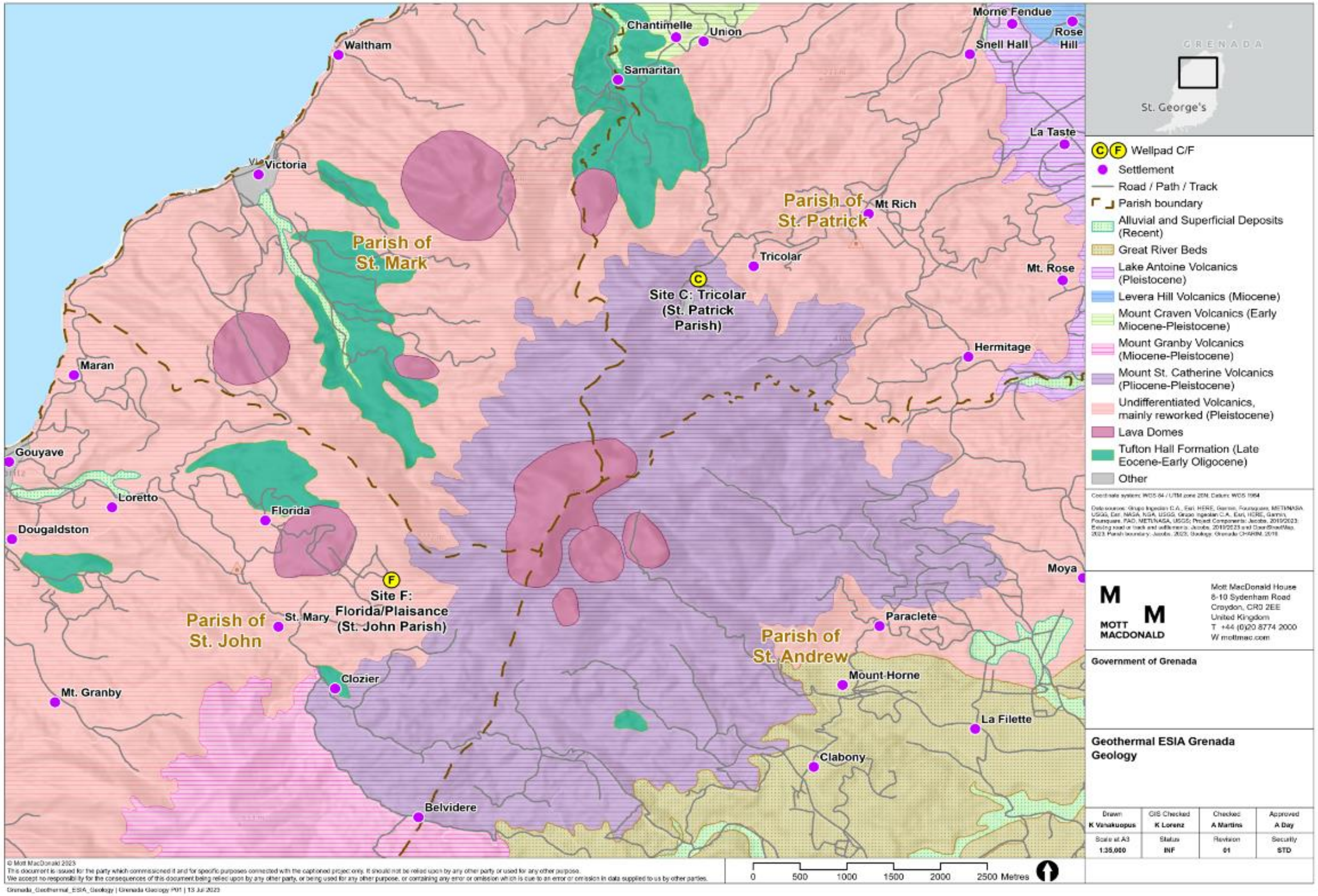
[1] Jacobs, Grenada Geothermal Surface Exploration, Integrated Report: Geology, Geochemistry & Geophysics, 22 June 2016

[2] Jacobs, 2016. *Jacobs Geothermal Surface Exploration Grenada*. [pdf]. Auckland, New Zealand: Jacobs New Zealand Limited

island, and include bubbling pools and hot springs located between 20 and 560m ASL[3]. Based on geology mapping, Site C is located in an area of Mt St Catherine volcanics, and Site F is located in undifferentiated volcanics (mainly reworked material).

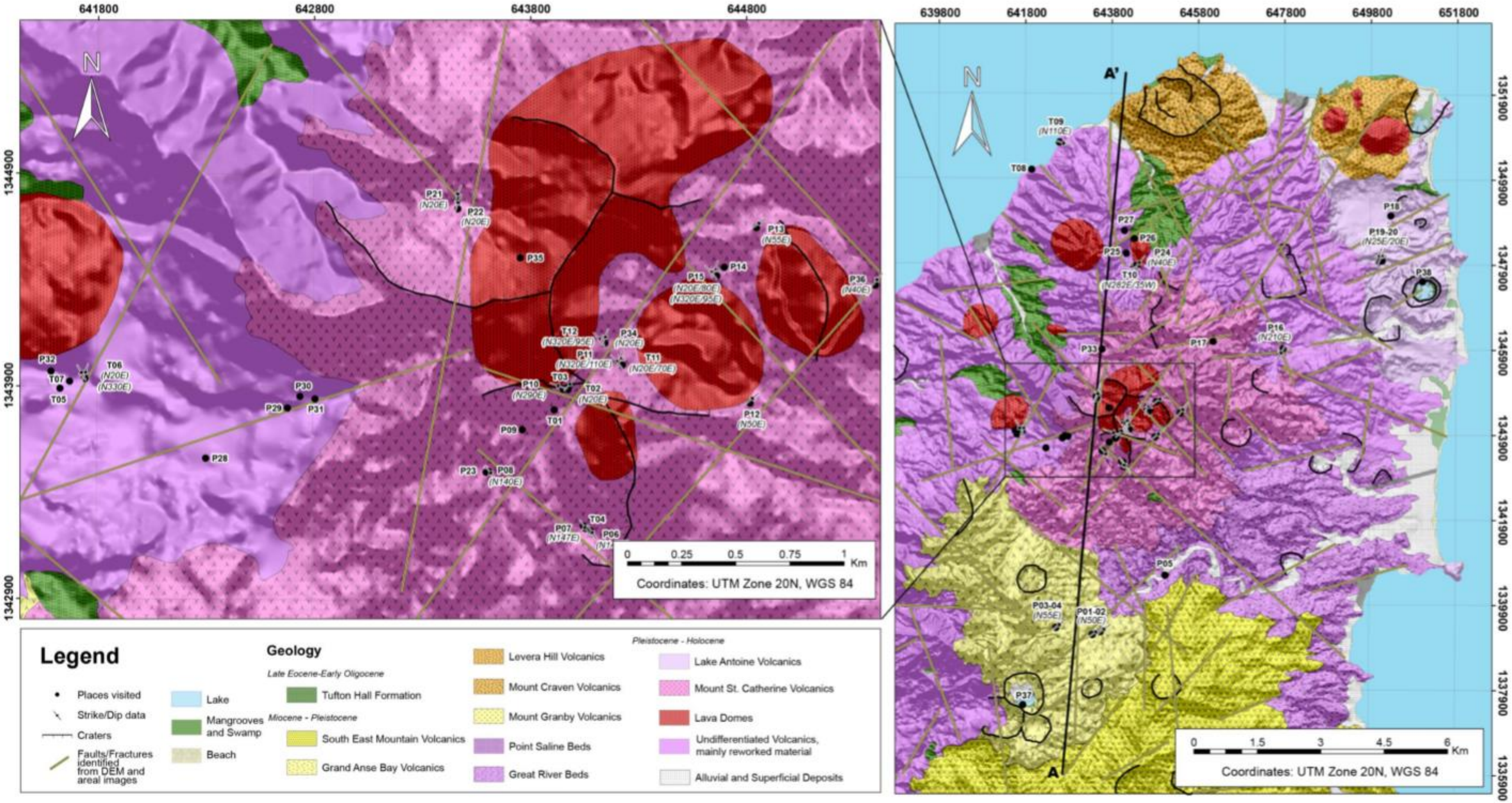
[3] Jacobs, 2016. *Jacobs Geothermal Surface Exploration Grenada*. [pdf]. Auckland, New Zealand: Jacobs New Zealand Limited.

Figure 15.1: Northern Grenada geology



Source: Mott MacDonald

Figure 15.2: Jacobs geological mapping of the central and north parts of Grenada (right 1:50,000, left 1:10,000).



Source: Jacobs, 2016. *Jacobs Geothermal Surface Exploration Grenada*. [pdf]. Auckland, New Zealand: Jacobs New Zealand Limited.

15.5.2 Soils and erosion

There are three main soil types in Grenada, which are clay loams (84.5%), clays (11.6%) and sandy loams (2.9%). Over 66% of the soil in Grenada is susceptible to landslides[4], and soil erosion is a significant problem in Grenada.

The main contributing factors to soil erosion in Grenada in the north of the island have been principally due to loss of forest cover (both human caused development, and natural loss through storms and hurricanes such as Hurricane Ivan in 2004) and lack of appropriate soil conservation practices in agriculture (e.g. use of terracing, contour ploughing and other methods). Loss of soil quality includes inappropriate activities during land preparation such as use of agrochemicals, slash and burn, and illegal dumping of wastes.

Northern Grenada is mainly characterised by Belmont clay loam, while the centre is mainly characterised by capitol clay loam[5]. In the interior of the island where there is more rainfall, there is a higher degree of weathering resulting in leached clays. Belmont clay loam is considered only moderately erodible, and tends to be of a brown colour, is moderately well drained, with good water retention. Water is the principle erosive agent upon soils. Capitol clay loam is a brick-red, well weathered "red earth" (latosol) which usually occurs over highly weathered basic igneous rocks. Rocky, shallow phases of these two soils can be found in mountainous areas with steep slopes and high rainfall. When cleared of vegetation, particularly on steep slopes with high rainfall, high erosion can occur and landslides. Both wellpad locations are located in areas of Belmont clay loam.

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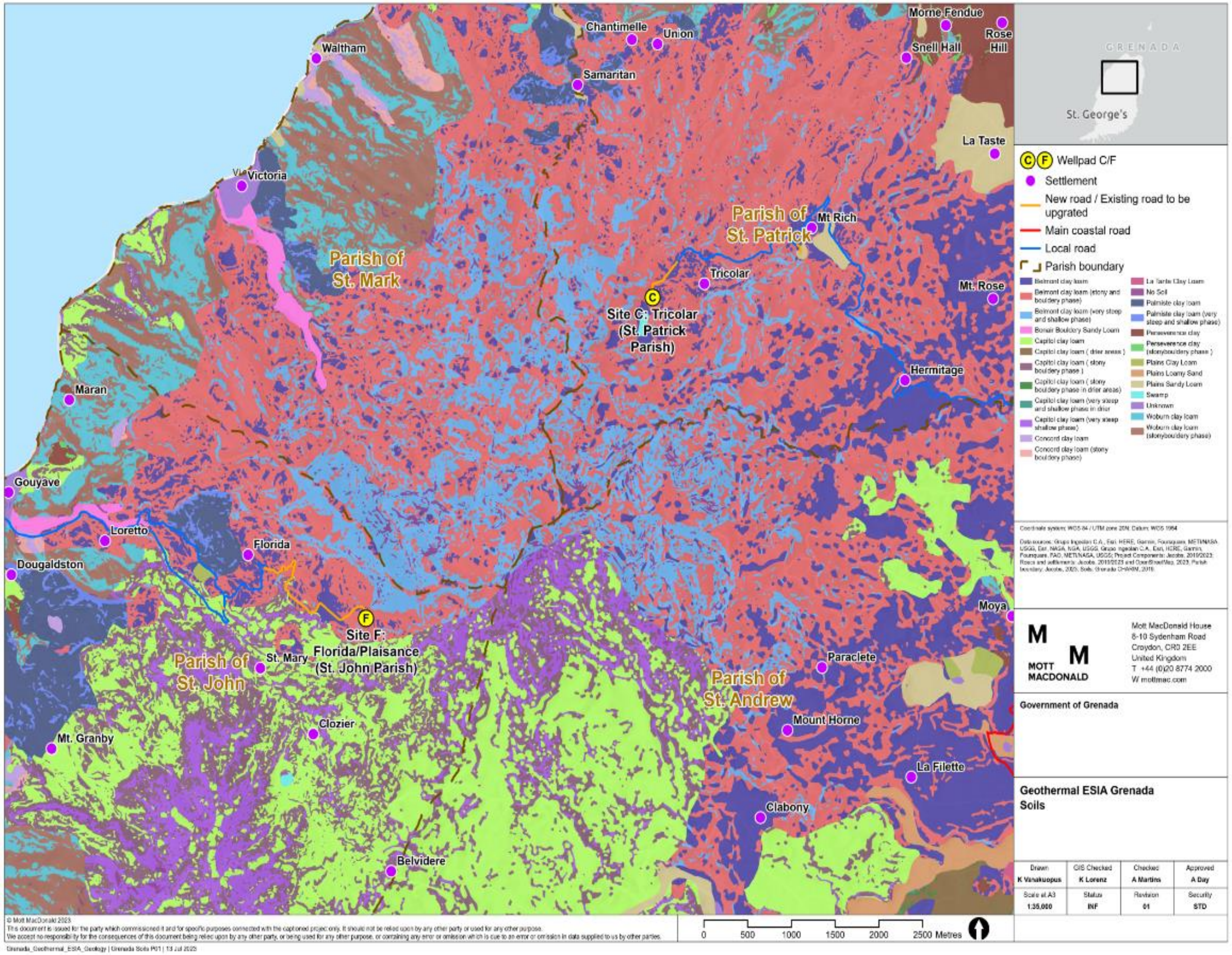
[4] Van Westen, C.J. (2016) *National Scale Landslide Susceptibility Assessment for Grenada*. CHARIM Caribbean Handbook on Risk Information Management, World Bank GFDRR, ACPEU Natural Disaster Risk Reduction Program.Development of landslides hazards maps for St Luci and Grenada, CDB, CDEMA, 2016. Available at: http://www.charim.net/sites/default/files/handbook/maps/GRENADA/Landslide%20susceptbility%20report%20Grenada%20May%202016.pdf.

[5] Charles, L., 2014. *Country Document on Disaster Risk Reduction for Grenada 2014*. [National Disaster Management Agency (NaDMA). Available at: <http://dipecholac.net/docs/files/871-documento-pais-grenada-web.pdf> [Accessed 23 April 2019].

Figure 15.3: Soil map of Grenada



Source: Van Westen, C.J. (2016) National Scale Landslide Susceptibility Assessment for Grenada and CHARIM.

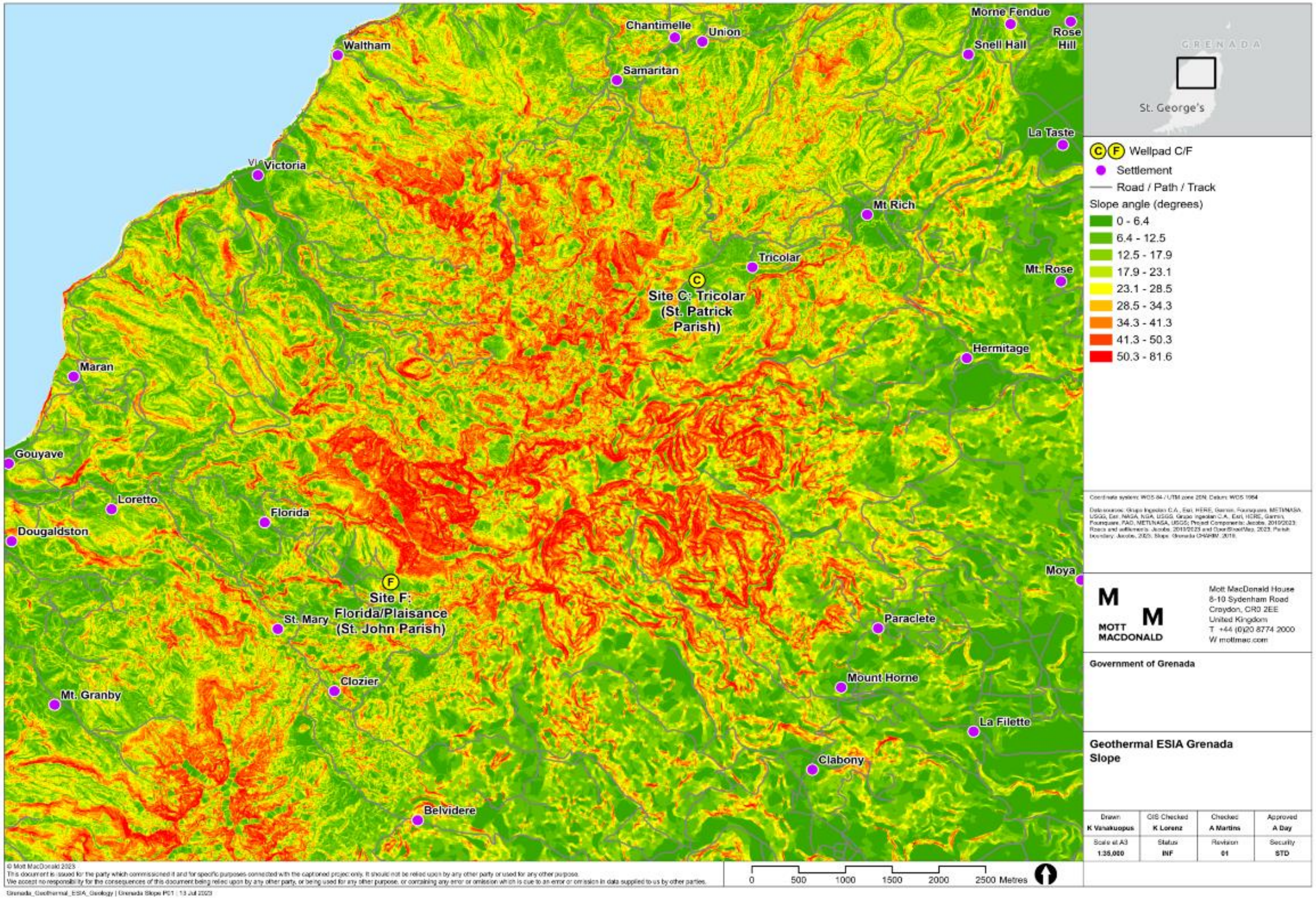
15.5.3 Slopes, topography and landslides

Grenada is susceptible to landslides and whilst there are no comprehensive historical records or inventories of landslides, anecdotal information indicates that landslides have occurred over the years across the island, especially during the rainy season. Hurricane Ivan caused a significant numbers of landslides in Grenada. In addition, rock falls (caused when roads are cut into steep slopes) are of increasing concern, particularly on the western side of the island where the land slopes steeply into the sea.

The proposed Project sites are located at heights of 355m ASL (site C) and 415m ASL (site F) and are located in the vicinity of Mt St Catherine where the topography is generally steep.

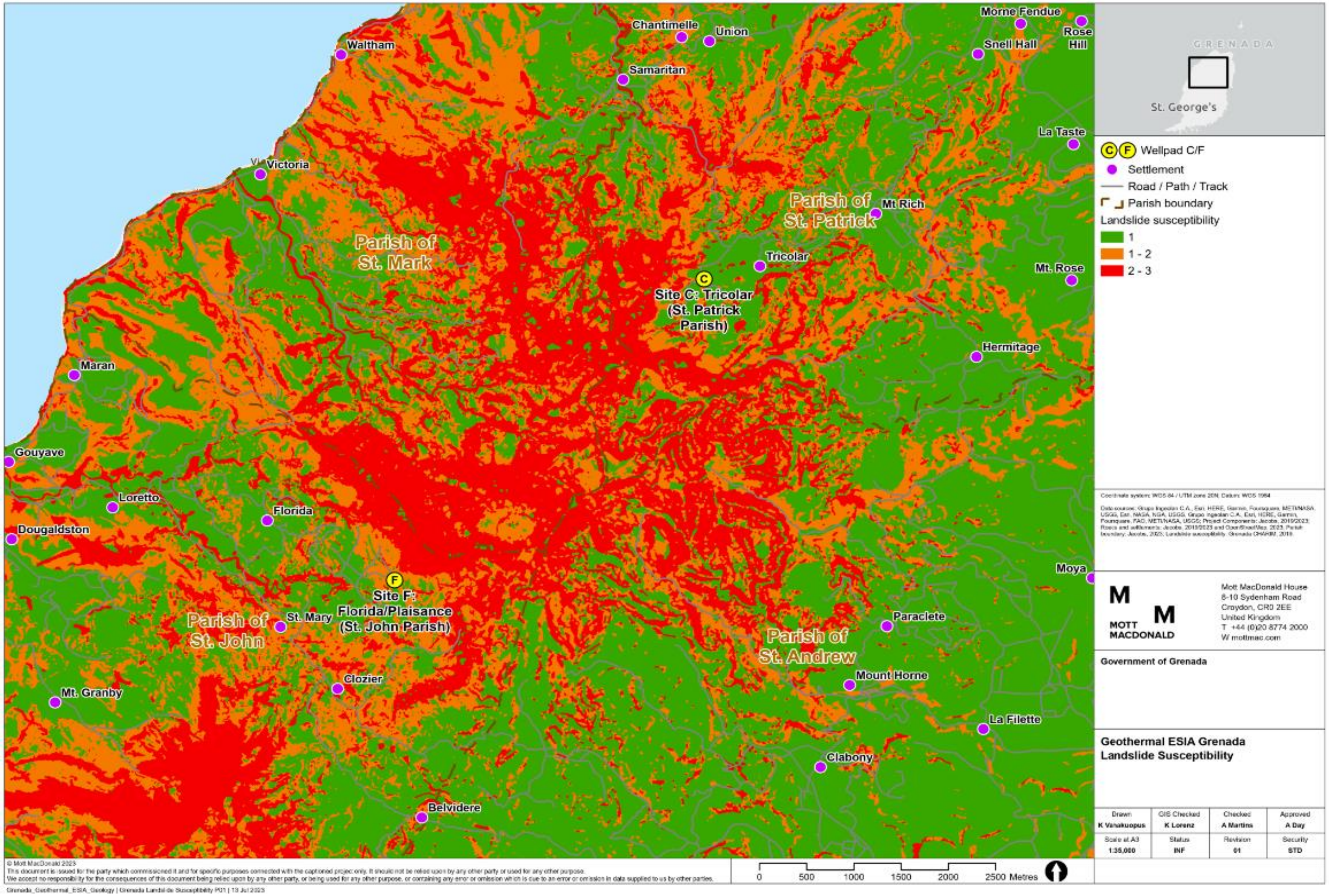
The two wellpad sites themselves are generally less steep with currently present flat to moderate slope areas of 0 – 23 degrees. The characteristics of the area mean that both surrounding areas are potentially prone to landslides, particularly after prolonged intense rainfall and storms in the rainy season. Figure 15.4 below shows slope angle calculated in GIS for northern Grenada, and Figure 15.5 presents landslide susceptibility based on analysis undertaken by CHARIM. A detailed map of the topography of Grenada is provided in the landscape and visual chapter.

Figure 15.4: Slope angles in Northern Grenada



Source: Mott MacDonald

Figure 15.5: Landslide susceptibility in Northern Grenada



Source: CHARIM

15.5.4 Other natural hazards

Because of Grenada's geographic location and setting, Grenada is exposed to a variety of natural hazards such as hurricanes and tropical storms, landslides, volcanic activity, seismic events and floods.

Table 15.3: Hazards impacting Grenada, 1800-2014

Hazard	Number of impacts
Floods (rainfall)	12
Tropical cyclones	34
Droughts	10
Landslides	0
Rockfalls	1
Earthquakes	22
Road accidents (2009-2013)	1503/yr
Fires (2009-2013)	425 acres/yr

Source: Taken from NaDMA Country Document on Disaster Risk Reduction for Grenada, 2014

15.5.4.1 Tropical cyclones

Located in the hurricane belt, Grenada has experienced a number of tropical cyclones in the past 100 years, of which several were significant hurricanes. 80% of all recorded tropical cycles took place in August or later in the year. Due to the small size of the island, tropical cyclones can have devastating impacts on the entirety of the island and have a huge impact on its economy. The most recent significant hurricane to affect Grenada was Hurricane Ivan (2004), in which 90% of the buildings on the island were either damaged or destroyed. Ivan cost Grenada an estimated USD $900 million[6], around twice the country's GDP. Hurricane Emily one year later in 2005, is also reported to have caused landslides on the slopes of Mt St Catherine and led to flash floods on the west coast, notably Victoria and Gouyave. A high strength hurricane would have the potential to damage the project infrastructure

15.5.4.2 Volcanoes and earthquakes

The island only has one potential centre of volcanic activity, Mt St Catherine[7]. There are no historical records of eruptions of Mt. St. Catherine to date. Thermal activity is mainly characterised by hot springs and bubbling pools present at several locations on or around Mount St. Catherine.

Kick 'em Jenny, an active submarine volcano located 8 km north of Grenada with a summit 185m below sea surface, has erupted 12 times since 1939 and has been assigned a yellow alert level by the University of the West Indies Seismic Research Centre, indicating that "the volcano is restless: seismicity and/or fumarolic activity are above the historical level, or other unusual activity has been observed/can be expected without warning".

The Eastern Caribbean is an area which earthquakes are a common occurrence. However, Grenada has not recently been at the epicentre of any major earthquakes. Earthquake risk is

[6] World Bank, 2009. Grenada: Dealing with the Aftermath of Hurricane Ivan. Available at: http://go.worldbank.org/UDTZTQTQO0

[7] Jacobs, Grenada Geothermal Surface Exploration, Integrated Report: Geology, Geochemistry & Geophysics, 22 June 2016

considered moderate to low and Grenada is in a seismic zone level 2 of a 4 zone system, however, an eruption of Kick 'em Jenny has the potential to produce a significant earthquake[8].

During the ESIA scoping public consultation event (held in July 2019), some stakeholders raised concerns regarding the potential for the project to induce seismicity and/or cause local subsidence. Generally, induced seismicity has been observed to occur in some cases where projects employ Enhanced Geothermal Systems (EGS) technology (where hydraulic fracturing, or "fracking" is used by pumping fluids at extreme pressure to enhance or create artificial permeability in the rock layer). This practice has typically induced small magnitude events normally associated more with an annoyance factor rather than significant earthquakes[9]. The Grenada exploratory drilling does not propose to use EGS technology or any fracking-type practice.

Regarding local subsidence, the long-term production of geothermal fluids associated with the production (power generation) phase of geothermal projects has been reported in some site-specific circumstances to cause subsidence through the lowering of pressure and has generally been caused by failure to reinject post-generation geothermal fluids back into the reservoir. It is now typical geothermal industry practice for geothermal fluids to be reinjected via reinjection wells to maintain reservoir pressure to avoid this impact.

15.6 Assessment of impacts

This section predicts soil and geology impacts expected to occur as a result of the exploratory drilling phase of the Project and assesses the beneficial and adverse effects by predicting their significance prior to mitigation. Impacts have been considered and assessed for the site preparation (including access road construction and well pad set up), exploratory drilling works and where relevant decommissioning.

15.6.1 Identification of receptors and analysis of sensitivity

The Project could lead to increases in soil erosion with resulting impacts to rivers, biodiversity and local people. These impacts are described below for both the construction and operational phases. Table 15.4 shows the soil related receptors and an analysis of their sensitivity. This topic is unusual in that there is only one receptor, the soil itself, which is similar in both project locations.

Table 15.4: Soil receptors and sensitivity

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
Soil at project sites	Soils at both sites are mostly comprised of Belmont clay loam	Belmont clay can be susceptible to erosion under certain conditions. Clay soils, such as Belmont clay, can be more susceptible to erosion due to their fine-grained texture and low permeability. This can cause water to flow over the surface rather than	Medium

[8] National Disaster Management Agency (NaDMA), 2014. Country document on Disaster Risk Reduction for Grenada, 2014. Available at: http://dipecholac.net/docs/files/871-documento-pais-grenada-web.pdf

[9] US Department of Energy (DOE), 2012. Protocol for Addressing Induced Seismicity Associated with Enhanced Geothermal Systems 2012.

Receptor	Brief Description	Analysis of sensitivity	Sensitivity
		infiltrating the soil, which can increase the risk of erosion. Factors that can contribute to erosion include rainfall, slope, vegetation cover, land use practices, and human activities. Given the moderate slopes and good landcover we judge the soil at the project site to be of medium sensitivity.	

The construction and operation of the Project have the potential to result in impacts upon soils, geomorphology and landscape.

15.6.2 Summary of changes, impacts and receptors

During the construction phase, there is the potential for large volumes of soil to be excavated for levelling of the wellpads and other associated activities.

The main Project activities which may impact upon the landscape and soils of the Project area are:

- Land vegetation clearance
- Topsoil removal and storage
- Excavation works (including well pad area, grading of site, excavation of sumps and reservoir)
- Road widening and upgrading
- Temporary pipeline and water intake installation
- Heavy construction vehicles moving around the site during earthworks and construction activities
- Waste management practices on site

The main impacts during construction from these activities are discussed below.

Table 15.5 shows the changes caused by construction activities, the potential receptors and the potential impact of the change.

Table 15.5: Changes, receptors and potential impacts

Potential change	Phase	Key issues / impacts and potential effects	Receptors which will be affected by the change
Increased soil exposure	Construction	Vegetation clearing, excavation works and wellpad construction could all cause soil erosion and the loss of topsoil in the project areas. For each wellpad and associated infrastructure a footprint of up to 2ha will be required at each site. High levels of erosion, particularly during the rainy season could affect the stability of slopes and lead to increased sediment transport as a result leading to the uncontrolled loss of soils from the areas.	Soil at project site
Decreased slope stability	Construction	Decreased slope stability due to slope cuttings is a well-known problem when cuttings are made into slopes and not supported, resulting in landslides or mudflows. If the well pads are levelled and steep slopes above the pad have been “cut” without any support to the wall, then decreased slope stability could occur. This danger increases if the soil becomes saturated with water in the wet season.	Soil at project site
Increased risk of contamination	Construction	The construction of the wellpad drilling and testing stages could result in soil contamination impacts, from accidental spills and releases. Vehicles and equipment will be used to undertake the main construction activities, such as earthworks and the clearing of vegetation. Accidental spills from either the vehicles/equipment, as well as from areas on site where lubricants oils and fuels would be stored could lead to accidental releases to soils around the work areas.	Soil at project site
	Operation	During the operations phase the drilling works will be undertaken on a stabilised well pad, and therefore there will not be any additional activities disturbing soils. Well blowouts may occur during well drilling although the risk is reduced through the employment of a blowout preventer. The main impacts are on workers’ health and safety, as well as uncontrolled releases of gases and geothermal fluids to soils.	Soil at project site
	Decommissioning	As per construction	Soil at project site

15.6.3 Analysis of construction impacts

15.6.3.1 Increased soil exposure and erosion

The magnitude of the soil erosion as a result of increased soil exposure is considered moderate because an area of approximately 1 hectare will need to be cleared of existing vegetation. The erosion will occur through the construction and operation phase so the duration is considered short term (0-5 years). The erosion will happen just at the project site so the scale is considered local. The probability of erosion occurring is considered high because without mitigation exposed soil will be eroded by run off when it rains.

Table 15.6: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Soil at project site	As defined in the baseline chapter the sensitivity of the soil at the project site is considered medium because Belmont clay can be susceptible to erosion under certain conditions. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: short term (0-5 years) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: minor	(2) Sediment/drainage control measures (3) Topsoil removal and storage (4) Best practice land clearance

15.6.3.2 Decreased slope stability

The magnitude of the decrease in slope stability is considered minor because the main project sites are relatively flat, and the areas affected are relatively small. The decrease in slope stability will occur through the construction and operation phase so the duration is considered short term (0-5 years). The decrease in slope stability will happen just at the project sites so the scale is considered local. The probability of decrease in slope stability occurring is considered medium because without mitigation exposed slopes could be less stable.

Table 15.7: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Soil/slope stability at project sites	The sensitivity of the slopes/soil to landslides at the project site is considered medium. Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	(1) Geotechnical study

15.6.3.3 Increased risk of contamination

The magnitude of the potential contamination of soil at project sites is considered moderate because there will be a range of contaminants on site which could be spilled to the soil without suitable mitigation. Any potential soil contamination could occur through the construction phase, but effects could extend for a long period of time so the duration is considered long term (life of project). Any potential soil contamination would happen just at the project sites so the scale is considered local. The probability of potential soil contamination occurring (prior to any mitigation) is considered medium because spills of contaminants are likely if contaminants are not managed properly. Note that contractors will be required to implement the necessary mitigation measures to prevent spills (as per Table 15.8 and further discussed in section 15.7).

Table 15.8: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Soil at project sites	As defined in the baseline chapter the sensitivity of the soil at the project site is considered medium Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a minor impact, which is not considered significant.	Parameter Judgement Nature: negative Magnitude: moderate Duration: long term (life of project) Scale: local Probability: medium Sensitivity of receptor: medium Significance of impact: minor	(5) Spill prevention and management

15.6.4 Analysis of operation impacts

The magnitude of the potential soil contamination from a well blow out is considered major because, if a well blow out occurred, a large area of soil could become contaminated. Any potential soil contamination from a well blow out would occur during the test drilling phase (operation) but effects of any contamination could extend for a longer period of time, so the duration is considered long term (life of project). The potential soil contamination from a well blow out would happen just at the project site so the scale is considered local. The probability of potential soil contamination from a well blow out occurring is considered high without mitigation.

Table 15.9: Analysis of impact of change on specific receptors

Receptor	Analysis of impact (without-mitigation)	Summary of impact without mitigation	Mitigation to be applied
Soil at project site	As defined in the baseline chapter the sensitivity of the soil at the project site is considered medium Combining the expected characteristics of the predicted change with the sensitivity of the receptor creates a moderate impact, which is considered significant.	Parameter Judgement Nature: negative Magnitude: major Duration: long term (life of project) Scale: local Probability: high Sensitivity of receptor: medium Significance of impact: moderate	(5) Spill prevention and management (6) Emergency Preparedness and Response Plan

15.6.5 Analysis of decommissioning impacts

Decommissioning phase impacts will be the largely the same as construction phase impacts. To avoid duplication, the analysis is not repeated here (details can be found in Section 15.6.3).

15.7 Mitigation and enhancement measures

This section discusses the mitigation and benefit enhancement measures that will be used to avoid, mitigate, manage and improve the impacts identified. Soil erosion, slope instability and soil contamination impacts can be readily prevented/managed through implementation of best practice construction techniques as outlined below.

Table 15.10: Mitigation and enhancement measures

Ref	Mitigation/ enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
1	Geotechnical study	A geotechnical study to be completed prior to initiating land clearance and civil works. Contractors must implement recommendations to manage geohazard risks (e.g., install slope protection in vulnerable areas, gabion retaining walls, site infrastructure in low risk areas).	Prior to construction
2	Sediment/drainage control measures	Implement best practice sediment control measures, and temporary and permanent drainage to control and direct water (including along tracks). Construct sediment control system to direct any silt runoff into sedimentation ponds. Measures to include appropriate methods such as silt fences, straw bale barriers, filter berms, sediment traps. Install oil/water separators where appropriate. Provide adequate road drainage based on road width, surface material, compaction, and maintenance.	Construction
3	Topsoil removal and storage	Remove and suitably store topsoil (for the duration of the Project). Topsoil should be covered and stored in a way to prevent any wind/water caused erosion. Replace topsoil to similar grading and level of compaction during site rehabilitation.	All phases
4	Best practice land clearance	Where possible, implement best practice construction measures, specifically: ● Minimise land clearance to specified worker areas only ● Keep the level of bare soil exposed to a minimum at any one time ● Scheduling to avoid heavy rainfall periods (i.e. during the dry season) to the extent practical ● Implement soil erosion prevention measures such as geotextile and geogrid in sloped areas ● Contouring and minimizing length and steepness of slopes ● Limiting access road gradients to reduce runoff-induced erosion ● Stabilise disturbed areas as soon as is possible to do so, for example through revegetation, or covering.	Construction
5	Spill prevention and management	● Undertake a preventative maintenance program for all vehicles and equipment across the site. This should follow the recommendations of manufacturers as well as best practice. ● Ensure that site procedures are in place and adhered to as part of the waste management plan (e.g., regarding waste storage, handling and transportation) ● Spill kits should be located on the construction site to manage and contain any fuel or hazardous substance spillage. Workers to be trained in their use. ● Implement a spill prevention and response plan	All phases

Ref	Mitigation/ enhancement measure	Details of mitigation/enhancement measure	Implementation method and timing
6	Emergency Preparedness and Response Plan	• Implement an emergency preparedness and response plan. This should be implemented throughout the Project which describes the procedures which should be followed in the event of both anticipated (e.g. tropical cyclone or upcoming bad weather), and unanticipated natural hazards such as an earthquake. This would include plans for site evacuation in addition to securing the sites materials and equipment. • Blow out preventers and wellheads implemented in line with appropriate standards	• All phases

15.7.1 Cumulative impacts and transboundary impacts

No cumulative or transboundary impacts are expected although it is noted that sediment transport from well pads if unmitigated and possible landslides can have an impact on downstream water and land quality beyond the study area.

15.8 Monitoring

Monitoring will be undertaken to determine the effectiveness of mitigation and design measures, and to identify additional issues which require further action.

Table 15.11: Monitoring requirement

Monitoring activity	Responsibility (e.g., Project Company, Main contractor)	Monitoring parameters	Monitoring locations	Monitoring frequency	Monitoring timing / duration
Site inspections to identify accidental releases	Contractor	Daily inspections to identify any signs of: • sediment leaving the site / areas of new erosion • evidence of spills / leaks • integrity of drainage and sediment control measures	Project areas, including: • downhill of project sites • Wellpad and locations of all other site infrastructure • Water pipeline • Access tracks	Daily	Throughout construction, operation and decommissioning
Erosion / slope instability monitoring	Contractor	Magnitude of movement of surface monitoring points	Project areas, in particular slope areas.	Weekly during construction, more frequently during and immediately after periods of heavy rain	Throughout construction, operation and decommissioning

15.9 Residual impacts

This section presents qualitative assessment of predicted residual geology and soil erosion impacts expected to occur as result of the exploratory drilling phase of the Project and assess the beneficial and adverse effects by predicting their significance prior to mitigation.

15.9.1 Analysis of residual construction impacts

15.9.1.1 Increase soil exposure and erosion

Table 15.12 presents a summary of residual impacts (post-mitigation) for the impacts related to geology and soil erosion. The magnitude of the impact would be reduced from moderate to minor after mitigation measures are applied. Also, significance would be reduced from minor to negligible.

Table 15.12: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Soil at project site	Parameter Judgement Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor, and the probability from high to low. This results in a change in the significance from minor to negligible

15.9.1.2 Decreased slope stability

Table 15.13 presents a summary of residual impacts (post-mitigation) for the impacts related to geology and soil erosion. The magnitude of the impact would be remain same. However, significance would be reduced from minor to negligible after mitigation measures are applied.

Table 15.13: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Soil/slope stability at project sites	Parameter Judgement Nature: negative Magnitude: minor Duration: short term (0-5 years) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: negligible The implementation of the proposed mitigation measures should reduce the probability from medium to low. This results in a change in the significance from minor to negligible.

15.9.1.3 Increased risk of contamination

Table 15.14 presents a summary of residual impacts (post-mitigation) for the impacts related to geology and soil erosion. The magnitude of the impact would be reduced from moderate to minor after mitigation measures are applied.

Table 15.14: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Soil at project sites	Parameter Judgement Nature: negative Magnitude: negligible Duration: long term (life of project) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to negligible, and the probability from high to low.

15.9.2 Analysis of residual operation phase impacts (drilling and testing)

Table 15.12 presents a summary of residual impacts (post-mitigation) for the impacts related to geology and soil erosion. The magnitude of the impact would be reduced from major to minor after mitigation measures are applied. Also, significance would be reduced from moderate to minor.

Table 15.15: Analysis of residual impacts of change on specific receptors

Receptor	Summary of residual impact (post-mitigation)
Soil at project sites	Parameter Judgement Nature: negative Magnitude: minor Duration: long term (life of project) Scale: local Probability: low Sensitivity of receptor: medium Significance of impact: minor The implementation of the proposed mitigation measures should reduce the magnitude from moderate to minor, and the probability from high to low. This results in a change in the significance from moderate to minor.

15.9.3 Analysis of residual decommissioning phase impacts

Decommissioning phase impacts will be the largely the same as construction phase impacts. To avoid duplication, please refer to Section 15.9.1.

15.9.4 Discussion regarding residual significant impacts

No significant residual impacts are considered likely to occur provided that the proposed mitigation is adopted and adhered to.

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16 Cumulative impacts

16.1 Overview

The purpose of this section is to identify if there are potential significant cumulative impacts that could arise from the incremental impact of the proposed project when considered against other developments.

This identification relates to project activities described under the exploratory phase works only, and to other major Grenada projects (present and probable future projects/developments) that the Grenada Ministry of Infrastructure, Public Utilities, Civil Aviation and Transportation is aware of and considers probable to be developed from 2023 to 2025 (see Appendix A).

For "future" projects/developments, this ESIA considers other developments that are either in the planning process currently and are considered likely to be constructed or to become operational at the same time as the Project.

This identification of cumulative impacts scopes out any project that is substantially further back in the planning process and for which application for consent is unlikely to be submitted until after the Project is consented or where there is unlikely to be any overlap with the Project.

Furthermore, a detailed cumulative impact assessment (CIA) following the approach outlined in IFC's Good Practice Handbook: Cumulative Impact Assessment and Management (2013) has not been deemed necessary at this stage due to the temporary nature and limited spatial extend of the Project's construction and drilling/testing and because no other significant infrastructure projects are known to be planned or being developed within the project area of influence.

16.2 Impact identification

Cumulative impacts associated with the works may be:

- Combined effects (e.g., air quality, water quality, noise, transportation)
- Strategic impacts (e.g., multiple geothermal projects)
- Spatial and temporal crowding (planned future activities within the area of influence)

The following assumptions have been applied to the identification of projects to be considered as part of the cumulative assessment:

- Environmental effects of any other development that is already built and operational is effectively included within the environmental baseline against which impacts are being assessed within the ESIA, so are excluded from further consideration in the cumulative impacts to avoid being accounted for twice.
- The cumulative impacts consider projects that are in the planning process. Efforts have been made to ascertain which, if any, are likely to become operational prior to this Project but we have assumed that none are in the pipeline to be in a position to cause potential cumulative impacts.

16.3 Impact assessment

Combined effects are those likely to occur at areas where there is a concentration of activity and where there are receptors that have limited ability to accommodate additional change. They also occur when construction activities related to this project and others happen at the same time.

Through our baseline review, consultation and impact assessment we have identified the following potential activities that could give rise to cumulative impacts if other developments are implemented in the same area and at the same time:

- Traffic impacts: associated with the movement of heavy vehicles and volume of traffic during site establishment works and transfer of drill rigs resulting in increased traffic flow and impacts from wear and team to existing infrastructure.
- Impact on other water users (irrigation needs, agricultural needs, domestic needs).
- Community health and safety, and tourism: energy and industrial projects could impact on the provision of social infrastructure and use of community resources because they create population movements, especially temporarily during construction but also over the longer term when some workers or those attracted to the work opportunities choose to remain in the region.
- Land use impacts: significance of these impacts have been considered in the relevant chapters including combined effects and no significant impacts have been determined.

However, considering the information currently available about other major Grenada projects (present and probable future projects/developments) likely to be developed from 2023 to 2025 (see Appendix A), and the project impacts identified for this project, this ESIA has not identified the potential to generate a spatial or temporary crowding[1] from the combination of the project and other developments.

[1] This occurs when many activities are carried out in the same area at the same time.

Appendices

A. List of infrastructure projects

No.	Project Name/Description	Estimated Project Cost	Type	Location	Project Start	End Date	Potential Impacts
1.	St. Patrick's Road Project - Phase III. The St. Patrick's Road Network Upgrade project – Phase II involves the rehabilitation/upgrade to 3.43 km x 6.0 m wide asphalt pavement along between Morne Fendue and Mt. Rich and the construction of 0.74 km x 5.0 m of bypass road. The works also include the rehabilitation of four (4) bridges, the provision of the necessary side drainage facilities. The project also includes rehabilitation/upgrade 6.20 km x 5.2 m wide asphalt pavement road from Duquesne to Sauteurs and the construction of 0.61 km of link road. The works also include the rehabilitation of five (5) bridges, Duquesne bridge Bridge to replace existing masonry stone arch bridge Petite Anse /Mt. Alex Box Culvert Mt. Craven Box Culvert Sauteurs Bridge Hermitage Bridge	$16M	Road Upgrade & Bridges	St. Patrick's	No available at this time. (NA)	NA	• Traffic flow • Waste from construction • Soil erosion • Habitat biodiversity
2.	Natural Disaster Rehabilitation & Reconstruction Programme - Extreme Rainfall / Gouyave Flood Mitigation Project Under this project, the Brothers Bridge is earmarked for reconstruction at a cost of XCD$2.9 with slope stabilization being at a cost of XCD $3.0 in the following areas: Millette, Market	$5.9M	Slope Stabilization & Bridge	St. John's: Brothers Millette Market Square Maran Gross Point & Clozier	Project is ongoing. Construction of the Bridge is on hold until completion of work on Millette Road.	NA	• Traffic flow • Construction waste • Noise pollution • Sedimentation

No.	Project Name/Description	Estimated Project Cost	Type	Location	Project Start	End Date	Potential Impacts
	Square, Brothers, Maran, Gros Point and Clozier.						
3.	Coastal Study and Protection Design for the Shoreline of the Sauteurs Bay (Sauteurs Break Water) This project entails a Coastal Study and Protection Design for the Shoreline of the Sauteurs Bay. A series of 5 emergent breakwaters combined with a revetment in the most damaged areas of the shoreline will be constructed. The implementation of this project will prevent the further deterioration of the shoreline and allow the regeneration of the beach which has been degrading since 2019.		Study Sea Defense Revetment	Sauteurs Bay		December 2023 NA	• Biobiversity loss • Siltation/sedimentation • Erosion • Noise pollution
4.	Agricultural Feeder Roads Project This project seeks to construction of 20.25 Km of Road including bridges and ancillaries throughout Grenada.	$103M	Roads Bridges	1. Claboney Road 2. Bacolet Bridge 3. Morne Delice – Old Westerhall Road 4. Concord Road 5. Brothers Mount Cenis Road 6. Red Mud Road 7. La Borie Road	2020	2025	• Noise pollution from cutting digging etc. causing disturbances to the natural environment and the surrounding communities • Air pollution • Waste from construction material • Habit loss • Possible soil erosion

No.	Project Name/Description	Estimated Project Cost	Type	Location	Project Start	End Date	Potential Impacts
				8. Willis to Constantine Road 9. Telescope Road			
5.	Molinere Landslip Rehabilitation Project The proposed design solution consists of three (3) main components, i.e., a Mechanically Stabilized Earth (MSE) Wall (with a RC façade), micro piles and a reinforced concrete wall. The MSE wall will be used to re-establish the roadway to its previous elevation (pre-landslip level) and the micro piles will provide additional bearing capacity and lateral support. MSE Wall technology uses geosynthetic reinforced soil technology, which is somewhat new to the island. The reinforced concrete (RC) wall will support the roadway and act as a barrier wall as well. The design will see the creation of two (2) observation decks (upper and lower linked via staircases) in the area which will contribute to the tourism product.		Road work Road stabilization	Molinere, St. George's	Project ongoing	NA	• Biodiversity loss • Erosion • Traffic flow
6.	Implementation of the Western Main Road Corridor Upgrade Project The project has two phases which entail the preparation of a feasibility study and detailed designs under phase one. Phase one is anticipated at 8 months to complete the detailed designs and the construction phase will be approximately 24 months. Under the project 27 Kilometers of roads will be refurbished from the Stadium to St. Marks Secondary School. Deteriorated and narrow bridges will be demolished and reconstructed, drains and culverts will be reconstructed, and slopes will be stabilized.	$33M	Road	Queens Park, St. George's to St. Mark's	Pending	NA	• Traffic flow • Waste from construction material • Noise pollution • Dust/air pollution

No.	Project Name/Description	Estimated Project Cost	Type	Location	Project Start	End Date	Potential Impacts
7.	Grenada Resilience Improvement Project GRIP This project was approved by the World Bank in May 2022 and the Financing Agreement was in the process of signing in June. The objective of the project is to increase the population's access to disaster-resilient, critical infrastructure. It consists of the following components: Reconstruction of Balthazar Bridge Coastal protection and flood risk reduction of the Eastern Main Road at Soubise and Marquis. Technical assistance to improve Institutional capacity for increasing resilience	$15M	Balthazar Bridge Construction Coastal Protection Soubise Marquis area Rockfall Stabilization Assessments Heritage Building Assessments	Balthazar Soubise, Marquis Balthazar, River Road Town of St. George	2024 2024 2024 2024	2026 2026 2025 2025	• Traffic flow • Noise pollution • Erosion & sedimentation • Impacts on the biodiversity in the area

Source: Ministry of Infrastructure, Public Utilities, Civil Aviation and Transportation, List of Projects 2023 – 2025 with possible Environmental impacts, 2023

MOTT MACDONALD

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Contents

17 Summary and conclusions

17.1 Summary

The key findings from the ESIA can be summarised as follows:

1. The Project is an exploration drilling undertaking, which will be a key milestone towards confirming (or otherwise), a geothermal resource potential in Grenada that can support utility-scale power generation in the amount of 15 MW in the first instance. Ultimately, the successful implementation of a 15 MW geothermal power project will support Grenada's objective to meet more than 50% of its energy production through renewables by 2035.
2. The Project can be developed in accordance with the Physical Planning and Development Authority (PPDA) national requirements, if the PPDA grants approval/permit for Land Development.
3. The exploration drilling will be performed using proven geothermal drilling methodologies and in accordance with internationally recognized engineering, operational and safety standards. No hydraulic fracturing (fracking) techniques will be used.
4. The Project may generate negative environmental and social impacts all of which can be reduced to acceptable levels with mitigation as set out in the environmental and social management plan (ESMP), Volume V of this ESIA.
5. Considering the mitigation measures to be implemented as per the ESMP, the Project can be developed in a way that the only significant impact on biodiversity features is the disturbance and displacement of high sensitivity terrestrial fauna during construction and operation. This impact will be short term (three to six months), but during this time it will be of moderate significance. No other impacts on biodiversity features will be significant. However, this will need to be reassessed following the Critical Habitat Assessment (CHA) (see below).
6. Following the implementation of mitigation measures, the significance of habitat loss and degradation because of the project is considered minor for all forest habitats and species present within them. The project will implement a Habitat Removal and Restoration Plan (HRRP) which will aim to achieve no net loss of natural habitats and therefore the exploratory phase of the Project is not likely to have significant residual impacts to natural habitat.
7. A CHA in line with IFC PS6 and IFC Guidance Note 6 should be prepared at the exploratory drilling phase, with pre-construction wet season data collected at Site C prior to any site disturbance. If the Project is found to be within an area of Critical Habitat and the Project will not proceed to the next phase, the management and monitoring of critical habitat removal and restoration will be undertaken through the HRRP. If the exploratory phase is successful and found to be in Critical Habitat, a Biodiversity Action Plan (BAP) detailing additional biodiversity mitigation measures and how the project will achieve no net loss/net gain will be required.
8. One of the mitigation measures proposed is that the Site C pumping station will need to be relocated in the final design to avoid increasing flood risk locally. This will require a moderate extension of the project land boundary at the pump station location, in a northwards direction, which will require access to privately-owned lands.
9. The available information indicates that the Project is unlikely to have a significant adverse impact on groundwater resources. At site C this risk is higher than at Site F, due to the proximity of springs that supply the Glenelg water bottling plant, to the well pad. A hydrogeological study is in progress to investigate this specific issue. This will be reported in autumn 2023 alongside the final ESIA.

10. In the unlikely event that there is an irreversible deterioration in the quality or quantity of water available to an established (groundwater dependent) public or commercial water supply source, the proposed mitigation is to provide access to an alternative source of groundwater. Ultimately, there would be no significant impacts on water resources.
11. No areas of cultural heritage significance have been identified within the direct area of influence of the project. However, a Chance Finds Procedure will be implemented as part of the ESMP to manage potential unexpected discovery of archaeological remains and/or artefacts.
12. Stakeholders will welcome a clear communication program that the GoG will implement as set out in the stakeholder engagement plan (SEP), Volume III of this ESIA.
13. Land needed for the Project is yet to be acquired or leased. Approximately 13 landowners, including the State, have been identified so far, at the well pad areas, road widening and new access areas, as well as pump station locations.
14. Preliminary calculations based on land plot boundaries indicates that the permanent and/or temporary loss of land will be less than 3% of the land for nine out of the thirteen private land plots. In the remaining four plots, the losses are estimated to be 10%, 19%, 32% and 53% of the total plots. No physical displacement of dwellings has been identified so far.
15. The Project will consider any land requirements and existing land users through negotiated settlement where possible as set out in the Livelihood Restoration framework (LPF), Volume IV.

17.2 Conclusion

The Project is deemed able to be developed in accordance with national requirements and in accordance with the International Finance Corporation Performance Standards (IFC PSs) considering the implementation of mitigation set out in the ESMP.

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