Environmental and Social Impact Assessment for the Renewstable® Barbados Hybrid Solar Power Plant with Hydrogen Storage

Final Report

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ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR THE RENEWSTABLE® BARBADOS HYBRID SOLAR POWER PLANT WITH HYDROGEN STORAGE

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Executive Summary

Renewstable (Barbados) Inc. (RSB) is proposing to construct and operate a baseload hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados (the Project). The Project will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas. The Project will generate approximately 56,000 megawatt-hours per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually (based on an average electricity consumption of 3,480 kilowatt-hour per inhabitant per year).

With the release of the *Barbados National Energy Policy 2019–2030* (Government of Barbados 2019a), the Government of Barbados officially announced its intention for the island to achieve 100% renewable energy and carbon neutral transformational goals by 2030. As a baseload clean asset, the Project will help Barbados achieve its renewable energy and carbon neutrality targets. Where other solar PV approaches provide intermittent power with little or no storage, the Project offers a baseload solution that combines solar power with hydrogen and lithium technologies.

The electricity generated by the Project will be purchased by Barbados Light & Power Company at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. The tentative Project schedule is for construction to occur between April 2023 and April 2025. Operation and maintenance would begin in May 2025 with the designed operational lifetime of the Project being up to 30 years. The decommissioning phase of the Project will commence following the conclusion of Project operations and is anticipated to last approximately 12 months.

The energy facility components of the Project will consist of a solar PV power plant and associated battery and hydrogen energy storage systems. These components will be controlled and optimized via an integrated Energy Management System. The Project will convert sunlight into electricity via the solar PV power plant. A capped and consistent level of output from the power plant will be directed to the grid, while the remainder will be used to split water molecules into hydrogen and oxygen via an electrolyser system. The resultant hydrogen will be stored as compressed gas. Fuel cells will then be used to produce electricity whenever needed from the stored hydrogen gas, thereby enabling the delivery of stable power to the national grid. The power plant will occupy a plot totaling 73.6 ha, among it approximately 59.1 ha and will consist of an array of 96,154 solar panels, equipped with PV cells, which will be ground-mounted in a fixed-tilt, south-oriented configuration. This configuration has been selected because it is well-adapted to solar grazing and is efficient for energy generation while limiting land use requirements.

The Project will be designed to accommodate at least 1,830 Blackbelly sheep. On-site agricultural facilities will include sheep pens, a barn for hay storage, a feed silo, water storage tanks, a designated waste skip area on a concrete pad, and a farm building/staff facility, all of which will occupy a total of approximately 2.3 ha. The sheep will be allowed to graze between and beneath the solar panels of the power plant within a solar grazing area that is approximately 57.4 ha in size to which shall be added approximately 10 ha dedicated to agricultural activities: grazing and/or fodder pasture.

Project construction will be managed by an international engineering, procurement, and construction contractor that will subcontract with the local workforce. It is estimated that the construction phase of the Project will provide temporary employment for up to approximately 150 local people. Following construction, it is estimated that approximately 20 full-time-equivalent local jobs will be created to support Project operation, maintenance, and security requirements. The sheep farming aspect of the Project is expected to create 10 full-time-equivalent local jobs as farmers and farm staff. In addition to their pay, Project personnel will also gain valuable experience and training.

This Environmental and Social Impact Assessment (ESIA) has been prepared to support RSB's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project. It has been developed in consideration of the Terms of Reference for the ESIA and relies on several Project-specific studies that have been conducted in support of the impact assessment, including baseline surveys, various modelling studies, and a quantitative risk assessment for accidental events.

The ESIA describes the routine activities and components of the Project, the existing baseline conditions at the Project Property. It also discusses the potential physical, biological, and social impacts associated with routine Project activities, and mitigation measures to reduce the potential for adverse impacts during each phase of the Project. In addition, the ESIA assesses potential impacts that could occur as a result of accidents, malfunctions and disasters, as well as the potential cumulative impacts of the Project in combination with other past, present and reasonably foreseeable activities. Further, the ESIA identifies the proposed management and monitoring plans (including emergency response procedures) that would be in place to protect the environment and human health and safety.

Specifically, the ESIA assesses potential Project impacts for the following valued components (VCs):

- Atmospheric and Acoustic Environment
- Surface Water and Groundwater Resources
- Flora and Fauna
- Visual Environment
- Agriculture and Other Land Uses
- Health and Safety
- Human Capital
- Economy
- Cultural Values
- Infrastructure and Services
- Social Dynamics

The assessment predicts that for routine Project activities during construction, operation and/or decommissioning, residual adverse effects (following consideration of proposed mitigation measures) are negligible to moderate in magnitude, reversible and not significant, with a high degree of confidence. With application of mitigation, the potential cumulative environmental impacts of the Project in combination with other planned developments are predicted to be adverse in direction, low to moderate in magnitude, reversible and not significant, with a moderate degree of confidence. For accidents, malfunctions and disasters, specifically accidental spills or leaks of hazardous materials or a loss of containment of flammable vapours or hydrogen gas, the impacts from a worst-case event could be significant for several VCs, including surface water and groundwater resources, agriculture and other land uses, and health and safety. An Emergency and Disaster Management Plan has been prepared as part of the Environmental and Social Management Plan (ESMP) to identify procedures and protocols to be carried out in the event of a natural, accidental or human-made disaster at the facility that will serve to respond to and reduce the potential impacts of the events. The plan includes protocols for emergencies and disasters such as explosions, fire, spills, and hurricanes.

The ESMP also incorporates and operationalizes the design mitigation and environmental protection procedures that have been identified in the ESIA, both as general construction and operation environmental protection procedures and VC-specific mitigation measures. The ESMP is intended to be a “living” document that is revised as necessary to remain relevant to the applicable stage of Project planning, design, and execution. Through the ESMP, RSB will manage and reduce the potential adverse environmental and social impacts of the Project and enhance benefits to the community and Barbados as a whole. RSB is committed to developing and operating this Project in keeping with best practices and in a manner that is protective of the environment and public health and safety.

ABBREVIATIONS

°	degree(s)
μS	microsiemens
AIA	Agricultural Impact Assessment
AMSL	above mean sea level
AOI	Area of Influence
ARC	anti-reflective coating
ASCE	American Society of Civil Engineers
BAMC	Barbados Agricultural Management Company
BBD	Barbadian dollar(s)
BESS	battery energy storage system
BLPC	Barbados Light & Power Company
BMSL	below mean sea level
BNEP	*Barbados National Energy Policy 2019–2030* (Government of Barbados 2019)
Board, the	Planning and Development Board
BREA	Barbados Renewable Energy Association
BWA	Barbados Water Authority
C	Celsius
CAC	criteria air contaminant
CIA	Cumulative Impact Assessment
cm	centimetre(s)
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPC	conventional plant cane
CTP	Chief Town Planner
dBA	decibel, A-weighted
DC	direct current
EIA	Environmental Impact Assessment
EIA Committee	Environmental Impact Assessment Committee
EIS	Environmental Impact Statement
EMS	Energy Management System
ENSO	El Niño Southern Oscillation
EPD	Environmental Protection Department
EPFI	Equator Principles Financial Institution

ESCP	Environmental and Social Commitment Plan
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Assessment and Management System
FTC	Fair Trading Commission
GCM	General Circumation Model
GHG	greenhouse gas
GWh	gigawatt-hour(s)
H_2	molecular hydrogen / hydrogen gas
H_2O	water
ha	hectare(s)
HVAC	heating, ventilation, and air conditioning
HyPCe	Hydrogen Power Centre
IADB	Inter-American Development Bank
IBA	Important Bird Area
KOH	potassium hydroxide
kWh	kilowatt-hour(s)
L	litre(s)
L_{eq}	equivalent continuous sound pressure level
Lithium-ion	Li-ion
L_{max}	maximum sound pressure level
LOC	loss of containment
L_{peak}	peak sound pressure level
m^3	cubic metre(s)
MBtu	1,000 British thermal units
mg	milligram(s)
MSL	mean sea level
MW	megawatt(s)
MWh	megawatt-hour(s)
MWp	megawatt peak
NFPA	National Fire Protection Association
NPFA 59a	*Standard for the Production, Storage, and Handling of Liquefied Natural Gas* (NFPA 2019)
O	oxygen
OHS	occupational health and safety

Order, the	*Town and Country Planning Development Order, 1972*
P&D Act	*Planning and Development Act, 2019*
P&D Amendment Act	*Planning and Development (Amendment Act), 2020*
PDA	Project Development Area
PDD	Planning and Development Department
PDP	*Physical Development Plan* (Government of Barbados 2003)
PEM	proton-exchange membrane
PPA	power purchase agreement
Project, the	Renewstable® Barbados Project
PV	photovoltaic
QRA	Quantitative Risk Assessment
RCM	Regional Circulation Model
RER	Renewable Energy Rider
RMI	Rocky Mountain Institute
RoW(s)	right(s)-of-way
RSA	Regional Study Area
RSB	Renewstable (Barbados) Inc.
SGHAT	Solar Glare Hazard Analysis Tool
SIA	Social Impact Assessment
SMP	Social Management Plan
SPL	sound pressure level
t	metric tonne(s)
TCDO	Town and Country Development Planning Office
TCPA	*Town and Country Planning Act*, Cap. 240
TWA	time-weighted average
UNEP	United Nations Environmental Programme
UWI	University of the West Indies
VC	valued component
VIA	Visual Impact Assessment
WC	watercourse
WHO	World Health Organization
WHO Guidelines	*Guidelines for Community Noise* (WHO 1999)

1.0 INTRODUCTION

Renewstable (Barbados) Inc. (referred to herein as “RSB” and “the Proponent”) is proposing to construct and operate a hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados. The Renewstable® Barbados Project (referred to herein as “the Project”) will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas.

This Environmental and Social Impact Assessment (ESIA) has been prepared to support the Proponent’s application to Barbados’ Planning and Development Department for Planning Permission to proceed with the Project.

1.1 PROJECT OVERVIEW, CONTEXT, AND RATIONALE

The Project will generate approximately 56,000 megawatt-hours (MWh) per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually[1]. The electricity generated by the Project will be purchased by the privately-owned utility Barbados Light & Power Company (BLPC), which is currently the sole electricity utility provider in Barbados, at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. During the term of this agreement, the Project will deliver the following power supplies to Barbados’ national grid daily:

- 13 megawatts (MW) between the hours of 8:00 and 17:00;
- a two-hour dispatchable block of 13 MW firm to meet the end-of-day peak, when the marginal cost of generation in Barbados is the highest (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid); and
- 3 MW firm the rest of the time (i.e., during the night).

To achieve this, the Project will entail construction and operation of the following key components:

- A ground-mounted solar PV power plant that generates a carbon-free primary source of electricity;
- A long-term energy storage solution using hydrogen that includes electrolysers, a gaseous hydrogen storage tank farm, and a fuel cell system; and
- A short-term energy storage solution using batteries.

[1] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

The Project involves dual land uses, as the site of the solar PV power plant will also accommodate a commercial Blackbelly sheep farm that is specifically designed to be financially viable and environmentally sustainable in the long-term and is proposed to be the largest in Barbados. The agricultural facilities associated with the Project will be used to raise sheep livestock; for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets.

With the release of the *Barbados National Energy Policy 2019–2030* (BNEP) (Government of Barbados 2019a), the Government of Barbados officially announced its intention for the island to achieve 100% renewable energy and carbon neutral transformational goals by 2030. However, over 90% of the energy used for electricity production in Barbados is currently derived from imported fossil fuels (Ministry of Energy and Water Resources 2019). BLPC and the Barbados Renewable Energy Association (BREA) have advised that the government's BNEP goals cannot be achieved without baseload renewable power implementation (HDF 2019).

As a baseload clean asset, the Project will help Barbados achieve its 100% renewable energy and carbon neutrality targets. Where other solar PV approaches provide intermittent power with little or no storage, the Project offers a baseload solution that combines solar power with hydrogen and lithium technologies. Thus, the Project will enable:

- carbon-free and renewable baseload generation;
- the storage of a large quantity of energy for long-term service over extended time periods; and
- the reliable delivery of non-intermittent power on a 24 hours per day seven days per week basis,
- the delivery of power to help periods of peak consumption.

1.2 PURPOSE AND SCOPE OF THE ESIA

As indicated above, this ESIA has been prepared to support the Proponent's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project. It has been developed in consideration of the Terms of Reference (TOR) for the ESIA (Appendix A), which were finalized and accepted by the government in November 2021. The purpose of the ESIA is to describe the planned activities and components of the proposed Project, to identify the potential impacts associated with these activities, and to develop appropriate mitigation measures and controls to reduce the potential for adverse environmental impacts during each phase of the Project. Further, the ESIA identifies the proposed management and monitoring plans (including emergency response procedures) that would be in place to protect the environment and human health and safety.

The scope of this ESIA includes the construction, operation / maintenance, and decommissioning of the Project. Further information on the scope of this assessment is found in Section 6.

1.3 PROJECT, PROPONENT, AND CONSULTANT INFORMATION

Table 1.1 presents the title of the Project and provides contact information for the Proponent and the Consultant.

Table 1.1 Project, Proponent, and Consultant Information

Project Title	Renewstable® Barbados Project ("the Project")
Project Proponent	Renewstable (Barbados) Inc. ("RSB" or "the Proponent")
Proponent Contact	Thibault Ménage
Consultant	Stantec Consulting Caribbean Ltd.
Consultant Contact	Justin Jennings-Wray

RSB is a special purpose vehicle company that at the time of writing is jointly owned by Rubis Caribbean Holdings Inc. and HDF Energy.

HDF Energy is a global pioneer in hydrogen power develops and operates high-capacity, large-scale hydrogen-to-power infrastructure to provide firm or on-demand electricity from renewable energy sources (wind or solar), combined with high power multi-megawatt fuel cells.

Rubis Caribbean is a subsidiary of Rubis Energie, which is a public company headquartered in France and traded on the Paris Euronext exchange. Rubis Caribbean's operating areas include the marketing, sale and transport of petroleum, petroleum products and aviation fuels within the Caribbean region.

Table 1.2 provides an overview of ongoing Renewstable® power plant projects around the world, including the CEOG Project in French Guyana, which is a power plant with a similar structure to RSB. HDF Energy is an accelerator of the global energy transition by offering grid-friendly and stable decarbonized electricity solutions that make 100% renewable energy grids possible.

Table 1.2 Renewstable® Power Plant Projects in Development

Project Name	Project Location	Project Details	Project Website
CEOG	French Guiana	• The world's first multi-megawatt hydrogen power plant • Firm power of 10 MW day and evening / 3 MW night • Will provide 24/7 clean and reliable electricity to 10,000 French Guiana Households • Start of construction: Autumn 2021 • Commissioning: 2024	www.ceog.fr
Energía Los Cabos	Mexico	• Firm power 40 MW day and evening / 9 MW night • Land secured, permitting development • Start of construction 2023 • Commissioning: 2025	www.energia-loscabos.com
SUMBA	Indonesia	• Pipeline of projects under development • Firm power > 20 MW • Commissioning: 2025	www.renewstable-sumba.com
CYR	Australia	• Firm 2 MW power • First renewable project in Cape York	www.cape-york-renewstable.com

Table 1.2 Renewstable® Power Plant Projects in Development

Project Name	Project Location	Project Details	Project Website
CAGOU	New Caledonia	• Firm 160 MW baseload • Tender to substitute fossil fuel power plant	www.cagou-energies.com
RSWK	Namibia	• Firm Power 30 MW day and evening peak / 6 MW night • Land approved by council; permitting in progress • Start of construction: 2023 • Commissioning: 2025	www.renewstable-swakopmund.com
Source: HDF 2022.			

This ESIA was prepared by Stantec Consulting Caribbean Ltd. (Stantec; the Consultant), an independent third-party consultant that has been engaged by RSB to assist with the ESIA and management in support of the Project. The team of consultants for this Project (Table 1.3) also includes Dr. Janice Cumberbatch, who has been sub-contracted by Stantec as a Social and Gender Specialist to lead the Social Impact Assessment (SIA) portion of the ESIA. In addition, RSB has engaged Richard Gill Associates Limited as the Planning Application consultant for the Project and ENSMART as the Electrical Grid Consultant for the Project.

Table 1.3 Team of Consultants

Consultant	Role
Stantec Consulting Ltd.	Environmental and Social Impact Assessment and Management
Dr. Janice Cumberbatch	Social and Gender Specialist
Richard Gill Associates Limited	Planning Application Consultant
ENSMART	Electrical Grid Consultant

1.4 REPORT OUTLINE

As indicated in Section 1.2, the content of the ESIA has been guided by the requirements of the TOR (Appendix A). The ESIA includes the following sections:

1. Introduction – provides background on the Project and scope of the ESIA, as well as a description of RSB and the Study Team.
2. Legal, Policy and Administrative Frameworks – provides the national legal and policy frameworks that are potentially applicable to the Project, as well as international standards and guidelines that were considered during preparation of the ESIA. This section also discusses the associated environmental regulatory processes and approvals that may be required to enable the Project to proceed.

3. Project Description – provides a description of the Project, including the proposed location, components, activities, and schedule. It also contains a description of anticipated emissions, discharges and wastes for each Project phase and the environmental protection procedures that would be in place. An assessment of Project alternatives is also provided.
4. Energy Production and Benefits of the Project – describes both the environmental, social and economic benefits of the Project.
5. Public and Stakeholder Consultation and Engagement – identifies stakeholders and potential issues of concern, as well as providing an overview of the public and stakeholder consultation and engagement activities that have been undertaken to date in support of the Project, the outcomes of those consultation and engagement efforts, and future plans for Project-related consultation and engagement.
6. ESIA Scoping Considerations and Impact Assessment Methods – further describes the scope of the Project to be assessed, the selection and scoping of Valued Components (VCs), the spatial and temporal boundaries for the assessment and the overall impact assessment approach.
7. Existing Environment – provides an overview of the existing conditions in the vicinity of the Project, including the biological and ecological environment (climate, acoustic environment, topography, geology and surficial soils, surface water and drainage, groundwater resources and flora and fauna), anthropogenic environment (land use and visual environment) and social environment. This information was collected from previously completed studies, publicly available literature and reports, and a site survey to document flora and fauna.
8. Environmental Impact Assessment and Mitigation – outlines the environmental impact assessment methods, assesses potential environmental impacts that could arise as a result of Project activities, and identifies the mitigation and monitoring measures that have been developed to manage these potential impacts. The impacts of routine Project activities are assessed for each VC. The potential impacts of accidents and malfunctions are also assessed in Section 8.7.
9. Social Impact Assessment and Mitigation – provides the results of the social baseline survey and assessed the potential impacts on the social environment during construction and operation, as well as potential cumulative effects. Mitigation measures are identified.
10. Cumulative Impact Assessment and Mitigation – assesses the cumulative impacts of the Project on the biophysical and social environment in combination with other past, present and reasonably foressable activities and undertakings. Potential cumulative impacts are assessed in cases where the residual impacts of the Project on a VC have potential to overlap spatially and temporally (and therefore interact cumulatively) with the residual impacts of another past, present, or reasonably foreseeable future project or activity on the same VC. Mitigation measures are identified.
11. Monitoring and Management Plans – describes the Environmental and Social Management Plan, which is appended to this ESIA and includes a Construction Management Plan and Emergency and Disaster Management Plan.
12. Conclusions and Recommendations – summarizes the results of this ESIA and relevant recommendations.
13. References – provides the literature, reports, and personal communications cited in the ESIA.

Table 1.4 provides a table of concordance between this ESIA and the key requirements of the TOR (Appendix A).

Table 1.4 Table of Concordance with TOR

TOR Requirement	Relevant Section of the ESIA
Description of the Proposed Project	Chapter 3
Legislative and Regulatory Considerations	Chapter 2
Project Alternatives	Section 3.9
Description of the Environment	Chapter 7
• Physical	Sections 7.1.1 to 7.1.6
• Biological	Section 7.1.7
• Social and Cultural	Sections 7.2 and 7.3
Potential Impacts to be Studied	Chapter 8
• Land Use Impacts	Section 8.6
• Social Impacts	Section 9.2
• Visual Impacts	Section 8.5, Appendix G
• Reflection (Glint and Glare) Impacts	Section 8.5, Appendix H
• Ecological Impacts	Section 8.4, Appendix F
• Agricultural Impacts	Section 8.6, Appendix C
• Noise Impacts	Section 8.2, Appendix E
• Stormwater Drainage	Section 8.3, Appendix B
• Hydrogeological Impacts	Section 8.3
• Waste Disposal Impacts	Section 3.6, Section 9.2, Appendix C
• Construction, Site Management and End-of-Life	Chapter 8, Appendix C, Appendix I
• Energy Production and Potential Benefits	Chapter 4
Hazard Study	Section 8.7, Appendix D
Environmental Management and Monitoring	Section 11.1, Appendix I
Emergency (Disaster) Management Plan	Section 11.3, Appendix I
Construction Management Plan	Section 11.2, Appendix I
Deficiencies and Challenges	Sections 8.2.5, 8.3.5, 8.4.5, 8.5.5, 8.6.5

2.0 LEGAL, POLICY, AND ADMINISTRATIVE FRAMEWORK

2.1 BARBADIAN LEGISLATION AND POLICIES

Table 2.1 provides an overview of key Barbadian legislation and policies that are potentially relevant to the Project and this ESIA. In addition to Table 2.1, Sections 2.1.1 to 2.1.5 below provide further information regarding the aspects of selected laws and policies that are considered most relevant to the Project, as well as associated environmental regulatory processes and approvals that may be required to enable the Project to proceed. A relatively greater level of detail is provided regarding the selected laws and policies due to their relevance to Project activities and implications for Project planning and permitting.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Legislation Associated with Renewable Energy in Barbados	
Electric Light and Power Act, 2013 and associated amendments and *Fees Regulations*	"An Act to revise the law relating to the supply and use of electricity, to promote the generation of electricity from sources of renewable energy, to enhance the security and reliability of the supply of electricity and to provide for related matters." • Allows for the generation and supply of electricity by independent power producers. • Establishes the requirement for licences to supply, distribute, store, transmit, and dispatch electricity. • Sets out licence application fees. • Allows for the public utility to make interconnections for electricity supply. • Allows for the Minister to set targets for the supply of electricity from sources of renewable energy. • Sets out licencees' powers, obligation, and restrictions in respect of electricity supply (e.g., in relation to the carrying out of works, the placement of electrical lines, etc.).
Fair Trading Commission Act, Cap. 326B	"An Act to provide for the establishment of a Fair Trading Commission to safeguard the interests of consumers, to regulate utility services supplied by service providers, to monitor and investigate the conduct of service providers and business enterprises, to promote and maintain effective competition in the economy, and for related matters." • Establishes a Fair Trading Commission to enforce the *Utilities Regulation Act.* • Allows for the Commission to set maximum rates and determine standards of service for providers of utility services, including the supply and distribution of electricity. • Empowers the Commission to investigate suspected breaches of the *Utilities Regulation Act* and take appropriate enforcement action.
Utilities Regulation Act, Cap. 282	"An Act to provide for the regulation of utility services." • Sets out requirements and principles for setting utility rates. • Establishes a duty to provide adequate utility service. • Allows for joint use of equipment by more than one service provider.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Electricity Act, Cap. 277	"An Act to provide for the inspection and control of electrical works and for other purposes in connection therewith." • Establishes requirements for inspection of electrical installations prior to the supply of electricity, and for inspection of alterations and extensions to installations. • Establishes requirements for reporting of accidents involving electrical works and circuits.
Legislation Governing Physical Development in Barbados	
Town and Country Planning Act, Cap. 240	"An Act to make provision for (a) the orderly and progressive development of land; (b) the grant of permission to develop land; (c) powers to regulate land use and development; and (d) related matters" • Regulates physical development, defined as "the carrying out of building, engineering, mining or other operations in, on, over or under any land, the making of any material change in use of any buildings or other land or the subdivision of land". • Establishes requirements for environmental impact assessments. • Superseded by the *Planning and Development Act, 2019*.
Planning and Development Act, 2019 and associated amendments and regulations	"An Act to make provision for (a) the orderly and progressive development of land; (b) the grant of permission to develop land; (c) powers to regulate land use and development; and (d) related matters" • Regulates physical development, defined as "the carrying out of building, engineering, mining or other operations in, on, over or under any land; the making of any material change in use of any building or land; or the subdivision of land". • Establishes requirements for environmental impact assessments. • Establishes a new Planning and Development Board and a new Planning and Development Department.
Safety and Health and Work Act, *2005* Cap. 356	"An Act to make provision (a) for securing the health, safety and welfare of persons at work; (b) for protecting other persons against risks to health and safety in connection with the activities of persons at work; (c) for controlling certain emissions into the environment; (d) to consolidate the law relating to health, safety and (e) for related matters." • Sets out general duties of occupiers and employers as well as duties and requirements in relation to safety, health, employee welfare, medical examinations. • Includes specific provisions for building operations and works of engineering construction; storage, handling and use of hazardous substances and articles in the workplace; processes involving special risks to safety and health of employees; use and management of pressure vessels.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Health Services Act, *1969*, Cap. 44 and associated amendments and regulations	"An Act relating to the promotion and preservation of the health of the inhabitants of Barbados." • Includes provisions for the abatement of nuisances and the removal or correction of conditions injurious to public health. • Authorises the Minister to compel works in the interest of public health. • The associated *Health Services (Nuisance) Regulations* allow for the control of nuisance, including any "matter, thing, deposit, or accumulation of liquid or solid matter" deemed unsanitary, injurious, or dangerous to health, or likely to become so; unpermitted discharge of industrial waste or other noxious matter; conditions that promote the proliferation of public health disease vectors. • The associated *Health Services (Building) Regulations* regulate the construction, extension, or alteration of buildings, with specific reference to drainage, sanitation, and ventilation.
Emergency Management Act, 2006	"An Act to provide for the effective organization and management of disasters and other emergencies in Barbados." • Authorises disaster hazard inspections in the event that the "condition of any premises is reasonably suspected of posing a danger of serious injury to persons outside of the premises in the event of an emergency or an impact of a hazard."
Trees (Preservation) Act, *1981*, Cap. 397	"An Act to provide for the preservation of trees." • Restricts the removal of trees over a certain size. • Authorises the Chief Town Planner to require planting, re-planting, maintenance, and protection of trees to preserve and enhance the amenity of "any land abutting upon, adjoining or near a public road".
Marine Pollution Control Act, 1998, Cap. 392A	"An Act to prevent, reduce and control pollution of the marine environment of Barbados from whatever source. " • Prohibits release of any pollutant into the environment if such releases violate standards, conditions or requirements specified under the Act or associated regulations. • Scope includes land-based sources of marine pollution.
Policies Associated with Renewable Energy in Barbados[1]	
National Strategic Plan of Barbados 2006–2025	The *National Strategic Plan of Barbados 2006–2025* was developed to enhance Barbadian society to become prosperous and globally competitive by 2025. One objective within the Plan was to ensure an efficient and reliable energy sector. The objective included programs to expand the supply of renewable energy. Specific targets included meeting 30% of energy requirements from renewable energy by 2025 and substantially increasing the number of renewable energy businesses by 2025 (Government of Barbados 2007).
National Sustainable Development Policy	The *National Sustainable Development Policy* attempted to encourage an integrated and holistic approach to sustainable development. In addition, the Policy emphasized that measures to support and promote the adoption of renewable energy, energy efficiency, and energy conservation would help Barbados to meet its obligations as a party to the *United Nations Framework Convention on Climate Change* (Government of Barbados 2004).

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Sustainable Energy Framework for Barbados	The Sustainable Energy Framework is an ongoing technical assistance program with the Inter-American Development Bank, the objective of which is to promote renewable energy and energy efficiency to reduce fossil fuel dependency while enhancing energy security and environmental sustainability. The most recent instalment of the program includes a focus on further development and modernization of the electricity framework in Barbados to support adoption of renewable energy technologies (Government of Barbados 2019b).
Draft *National Sustainable Energy Policy*	Developed as a complementary policy to the Sustainable Energy Framework, the Draft *National Sustainable Energy Policy* addressed the high importation of fossil fuels. It sought to increase efficiency and sustainability in the energy supply and demand. In addition, the Policy aimed to encourage economically viable utility-scale renewable energy, promote energy cost reduction technologies, reduce fossil fuel dependency, and decrease the impacts of global warming (Government of Barbados 2019c).
Barbados National Energy Policy 2017–2037	The *Barbados National Energy Policy 2017–2037* aimed to provide a direction for Barbados to transition from a fossil fuel-based economy to mainly renewable energy. The Policy sought to ensure affordable energy security, a sustainable energy sector, and increased renewable energy and energy efficiency (Government of Barbados 2019d).
Barbados National Energy Policy 2019–2030 (BNEP)	The BNEP outlines the transition to a 100% renewable energy and carbon-neutral island by 2030. The policy attempts to ensure the provision of reliable, sustainable climate-friendly energy with zero domestic fossil fuel consumption and expansion of research and development in renewable energy (Government of Barbados 2019a).
Renewable Energy Rider (RER) Program	The former RER Program allowed domestic customers to sell energy back to the electrical grid at 1.6 times the level of the Fuel Clause Adjustment. In 2016, the RER credit rate began to be calculated using a resource cost approach, rather than being tied to the Fuel Clause Adjustment (Howard 2019). In 2019, the RER was replaced by a feed-in tariff, and RER agreements were grandfathered for a period of 20 years (FTC 2019).
Policies Associated with Physical Development in Barbados	
National Groundwater Protection Zoning Policy, 1963 (revised in 1973 and 2010) and Green Paper on the 2020 Water Protection and Land Use Zoning Policy	The *National Groundwater Protection Zoning Policy* delineates the island into five zones. Public water supply wells are located in the most restricted Zone 1 areas (Stantec 2022). The Green Paper (i.e., a tentative government consultation document of policy proposals for debate and discussion, which was produced by the Ministry of Energy and Water Resources, the Government of Barbados, and the Barbados Water Authority [BWA]) proposes that the groundwater protection zones introduced in the *National Groundwater Protection Zoning Policy* be re-configured for the following purposes (Stantec 2022): • To boost groundwater water quality protection due to the presence of more recalcitrant persistent pollutants. • To release more lands in the current Zone 1 protection areas for development.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
	More specifically, the Green Paper states the following (Stantec 2022): • The existing *National Groundwater Protection Zoning Policy* is over 50 years old and does not protect against persistent chemical pollutants. • The existing Zones 1 to 5 are proposed to be replaced with Zones A to E, with Zone A termed a strict exclusion zone smaller than the existing Zone 1. • Only agriculture Class Two will be permitted within Zone A; this type of agriculture includes “horticulture, fruit growing, seed growing, use of lands for farmers markets, bursary grounds, woodland or forestry”. • Solar PV farms and wind farms – deemed to have low environmental impact – may also be allowed in Zone A areas under specific permitting conditions. • As described in Appendix B, the Project is currently located within a Zone 3 groundwater protection zone as per the existing Policy. If the Policy is revised as proposed in the Green Paper, the Project will be located within a Zone D groundwater protection zone.
Physical Development Plan (PDP) and associated 2003 amendment and draft 2017 amendment	The purpose of the PDP is to promote sustainable growth and development within Barbados by setting out policies and regulations to guide proponents of proposed developments, including requirements related to the conduct of an Environmental Impact Assessment (EIA) or ESIA.

Note:
[1] The information regarding policies associated with renewable energy in Barbados was adapted from Evelyn (2020). Other sources are cited throughout the table where applicable.

Critical to implementing the legislation and policies identified herein are the competent authorities with regulatory responsibilities to monitor the construction and operation of projects in Barbados. These authorities are listed in Table 2.2.

Table 2.2 Relevant Barbadian Regulatory Authorities

Agency	Responsibilities
The Prime Minister’s Office Planning Unit	• Enforces the Barbados *Physical Development Plan*. • Regulates EIA in Barbados. • Controls the development of land having regard to proper planning standards and environmental management practices.
Planning and Development Department (PDD; formerly the Town and Country Development Planning Office [TCDPO])	• Governed by the *Town and Country Planning Act.* • Enforces the Barbados *Physical Development Plan*. • General development planning, control, and regulation, including ongoing monitoring of the implementation of construction activities (TCDPO n.d.). • Implementation of the *Trees (Preservation) Act*.

Table 2.2 Relevant Barbadian Regulatory Authorities

Agency	Responsibilities
Fair Trading Commission	• Enforces the *Utilities Regulation Act* and associated regulations. • Monitors and establishes the rates to be passed to consumers while determining a maximum rate charge (REEEP 2013).
Environmental Health Department, Ministry of Health and Wellness	• Enforces the *Health Services Act, 1969* and associated *Health Services (Nuisance) Regulations*.
Environmental Protection Department (EPD), Ministry of Environment and National Beautification	• Enforces the *Marine Pollution Control Act* • Enforces the *Health Services Act (Building) Regulations.* • Monitors and controls "conditions likely to affect environmental quality and environmental well-being" (Government of Barbados 2019e).
Government Electrical Engineering Department, in the Ministry of Transport, Works, and Water Resources	• Enforces the *Electricity Act.* • Carries out inspections of electrical installations, including inspections for the purpose of determining whether installations meet requirements of safety from personal injury and fire. • Is to be notified of, and is authorised to investigate, accidents (including but not limited to explosion and fire) occurring in connection with electrical installations, works, and circuits, as per the *Electricity Act*. • The Department's Chief Electrical Officer approves the provision of electricity interconnection services at points along the public grid, as per the *Electricity Act*.
Ministry of Energy, Small Business, and Entrepreneurship	• The Minister assigned responsibility for Energy is responsible for the issuance, renewal, amendment, revocation, etc. of electricity supply licences under the *Electric Light and Power Act, 2013*. • Is required under the *Electric Light and Power Act, 2013* to maintain a register, open to public inspection, that includes a list of all renewable energy generation systems installed in Barbados and their installed capacity.
Department of Emergency Management	• Enforces the *Emergency Management Act.*
Labour Department	• Enforces the *Safety and Health at Work Act.* • Ensures decent work standards.
Energy Conservation and Renewable Energy Unit, Ministry of Energy, Small Business, and Entrepreneurship	• Enforces the Barbados National Energy Policy and associated *Implementation Plan.* • Mandates includes "advising on policy and legislation through ongoing research and analysis; programmes to promote a viable, competitive and sustainable energy sector; and deepening collaborations across the many internal and external stakeholders across the public and the private sectors" (Government of Barbados 2021a).

2.1.1 National Energy Policy

The *Barbados National Energy Policy 2019–2030* (BNEP) (Government of Barbados 2019a) outlines the Government of Barbados' goal of achieving 100% renewable energy usage and carbon neutrality by 2030. It provides a framework for moving Barbados from a fossil fuel-based economy to one completely reliant on renewable energy sources. Related transformational goals that the BNEP is designed to achieve include (Ministry of Energy and Water Resources 2019):

- Providing reliable, safe, affordable, sustainable, modern and climate friendly energy services to all residents and visitors;
- Eliminating the domestic consumption of fossil fuels economy-wide;
- Exporting of all hydrocarbons produced both on land and offshore;
- Maximizing local participation (individual and corporate) in distributed renewable energy generation and storage (democratization of energy);
- Minimizing the outflow of foreign exchange; and
- Creating a regional centre of excellence in renewable energy research and development.

The Project supports Barbados' transition away from reliance on its existing fossil fuel burning power plants and towards achieving the goals of the BNEP.

2.1.2 Town and Country Planning Act

Historically, physical planning in Barbados has been directed by the former *Town and Country Planning Act* (TCPA), Cap. 240, which was established in 1968 and amended in 2007. The TCPA makes provisions "for the orderly and progressive development of land in both urban and rural areas to preserve and improve the amenities thereof, for the grant of permission to develop land and for the other powers of control over the use of land, to confer additional powers in respect of the acquisition and development of land for planning, and for purposes connected with matters aforesaid."

According to Part IV, section 14 of the TCPA, proponents must obtain Planning Permission from the Town and Country Development Planning Office (TCDPO) prior to carrying out "any development of land within any area in respect of which an order is made or is deemed to have been made under section 15" of the Act. The *Town and Country Planning Development Order, 1972* (the Order) states that "no development shall be undertaken upon any land in Barbados without the permission of the Chief Town Planner [CTP] or the Minister or an application made in that behalf". Section 17(1) of the TCPA empowers the CTP to require that an "assessment of the impact that the development […] is likely to have on the environment of Barbados" be undertaken as part of the Planning Permission application process, while Section 17(1B) of the TCPA gives the CTP additional authority to require the applicant to submit such further information as the CTP deems necessary.

The TCPA and the Order specify certain exclusions, limitations, and modifications; however, none of these exclusions, limitations, or modifications exempt the Project from the requirement to obtain Planning Permission. Accordingly, an Application for Planning Permission was initiated for the Project in November 2021 and an ESIA is being conducted as part of that process. The former TCPA was repealed and replaced by the new *Planning and Development Act, 2019* (P&D Act) in December 2021, and it is anticipated that the modified permitting and assessment processes established under the new P&D Act (as outlined in Section 2.1.3 below) will apply to the Project going forward.

2.1.3 Planning and Development Act

Issue No. 87 of *The Official Gazette* of Barbados, published on December 7, 2021, includes a proclamation indicating that the new P&D Act officially came into operation on that date, thereby also repealing the former TCPA in accordance with section 106 of the new P&D Act. The same issue of *The Official Gazette* also includes *Planning and Development (Environmental Impact Assessment) Regulations, 2021* (EIA Regulations) established under section 30(4) of the P&D Act, as well as the *Planning and Development (Amendment Act), 2020* (P&D Amendment Act). The following information refers to the version of the P&D Act that is currently in force, which includes the revisions specified in the P&D Amendment Act.

Similar to the former TCPA, the new P&D Act makes provisions for "the orderly and progressive development of land; the grant of permission to develop land; powers to regulate land use and development; and related matters".

Part II of the P&D Act

- establishes a Planning and Development Board (the Board) that consists of the Director and 12 appointees.
- establishes a new Planning and Development Department (PDD) that is headed by the Director and replaces the former TCDPO. The mandate of the PDD is to assist the Minister and the Board in the administration and enforcement of the P&D Act, including by reviewing and evaluating all applications submitted under Part IV of the P&D Act and facilitating the carrying out of Environmental Impact Assessments (EIAs) and other studies that may be required in connection with those applications.
- formalizes related administrative matters such as the procedures of the Board, which include appointing a Design and Engineering Committee, Environmental Impact Assessment Committee (EIA Committee), and "such other *ad hoc* committees or working groups as it thinks fit to assist in the performance of its functions"; applications to be determined by the Board; and the duties of the Director.

  The Third Schedule of the P&D Act sets out the constitution, functions, and procedures of the EIA Committee and states that the EIA Committee shall include persons with expertise in: ecology; geology, hydrology, and soil conservation; environmental, coastal, and civil engineering; marine science; disaster risk mitigation and management; public health; economics; sociology; and physical planning. The mandate of the EIA Committee is to advise the Board and the Minister with respect to EIA studies through performance of the following functions: screening Applications for Planning Permission to determine whether an EIA is required; reviewing the Environmental Impact Statement (EIS) submitted by the applicant; reviewing public comments on the EIS; making recommendations to the Board with respect to the environmental impacts of proposed development projects; and making recommendations to the Board with respect to the imposition of conditions of approval for the purposes of avoiding, mitigating, or offsetting adverse environmental impacts.

Part IV of the P&D Act pertains to the regulation of land development and includes the following requirements that are particularly relevant to the Project:

- Section 21 of the P&D Act states that Planning Permission must be obtained by a proponent prior to commencing or carrying out "any development of land in Barbados". Planning Permission is therefore required to enable the Project to proceed.
- Section 30(1) of the P&D Act states that the Director may require that an applicant conduct an EIA "in respect of any application for permission to develop land, if the proposed development, by reason of its nature, scale or location, could significantly affect the environment." Section 30(2) of the P&D Act further states that, unless the Minister directs otherwise, the Director shall require an EIA "in respect of an application for a development of any kind mentioned in the Sixth Schedule." The Sixth Schedule of the P&D Act specifies matters for which an EIA is required, including an "alternative energy generation plant having a capacity greater than one megawatt, including but not limited to hydro-electric plants, geo-thermal energy plants, wind-power plants, solar-voltaic arrays, and waste-to-energy plants." The Project therefore triggers EIA requirements under the P&D Act due to its inclusion of a solar PV power plant with a capacity of 13 MW.

The Board is responsible for the determination of all Applications for Planning Permission, other than those referred to the Minister under section 33 of the P&D Act[2], and may delegate this responsibility to the Director. However, complex applications of any class specified in the Fourth Schedule of the P&D Act must be determined by the Board. The Fourth Schedule includes "[a]ll applications, except applications to be determined by the Minister under section 33, for which an [EIA] is required" and "[a]ll applications for a material change in the use of […] agricultural land of 1 hectare [or] more in area". The Application for Planning Permission in support of the Project must therefore be determined by the Board, rather than delegated to the Director, since the Project triggers EIA requirements and entails changing the use of approximately 73.2 ha of agricultural land (as described in Section 3.1 below).

2.1.4 Physical Development Plan

The *Physical Development Plan* (PDP) was developed in 1970 under the former TCPA and subsequently amended in 2003. Although a 2017 amendment to the PDP (Government of Barbados 2017) has been prepared, it is still in draft pending amendments to align it to recently approved planning legislation. As such, the proposed development must comply with the existing 2003 version of the PDP (Government of Barbados 2003). The purpose of the PDP is to promote sustainable growth and development within Barbados by setting out policies and regulations to guide proponents of proposed developments.

The Project, as a proposed electricity generating plant, falls within the classes of development that are identified in both versions of the PDP (i.e., under section 2.5 of the 2003 PDP and under section 5 of the 2017 draft amended PDP) as requiring an impact assessment to be completed and submitted to the PDD (formerly the TCDPO) for review and approval. The 2003 PDP specifies the requirement to conduct an

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[2] Section 33(1) of the PDA states that the Minister may give directions to the Director requiring that "any application or class of applications for planning permission specified in the direction, being development which would involve either a significant departure from the approved physical development plan or is of strategic economic or environmental significance, shall be referred to the Minister for determination."

EIA, whereas the 2017 draft amended PDP specifies the requirement to conduct an ESIA. The matters to be included in an ESIA are outlined in section 5 of the 2017 draft amended PDP and include the following (TCDPO 2017):

- Identification of nearby natural features and their associated functions
- Identification and assessment of the potential environmental and social impacts of the Project
- Identification and assessment of potential mitigation measures
- Identification and assessment of opportunities for restoration and assessments
- Identification and assessment of net or residual effects

As described in Section 3.1, the Project will be located at Harrow Plantation. Both the 2003 PDP and the 2017 draft amended PDP designate Harrow Plantation as agricultural land and contain policy requirements related to the conservation of designated agricultural lands. Refer to section 2.3 of the Agricultural Impact Assessment (Appendix C) for an overview of key agricultural land conservation policy requirements in both versions of the PDP that are relevant to the Project. For example, the draft 2017 amended PDP includes a Food and Agriculture Land Use Designation and a Soil Protection Overlay as two of four proposed protection measures proposed to safeguard agricultural lands. Lands within the Food and Protection Land Use Designation are to: accommodate food production and “restrict alienation of land to any other use” unless proposed land use meets set criteria. Within the Soil Protection Overlay, non-agricultural uses will not be permitted, and the Government of Barbados will encourage the return of idle agricultural lands to productive use (Bain 2021).

2.1.5 Building Development Application

In addition to the Application for Planning Permission and ESIA submissions to the PDD (formerly the TCDPO) that are required under the P&D Act (Section 2.1.3) and the PDP (Section 2.1.4), an application for a building development approval must also be submitted to Barbados’ Environmental Protection Department (EPD) prior to commencing construction of the Project. However, a proponent is not required to submit an application for building development approval if the Application for Planning Permission made to the PDD under the P&D Act (Section 2.1.3) includes the required six copies of plans, one of which will be submitted to the EPD by the PDD.

The building development application is required to outline a detailed process description that explains the activities to be conducted, hazardous chemicals stored, the hazards associated with each activity, and the mitigation measures to be employed.

2.2 RELEVANT INTERNATIONAL STANDARDS AND GUIDELINES

The Proponent has partnered with the Inter-American Development Bank (IADB)-Invest to fund the ESIA. To this end, the ESIA has been conducted in consideration of international financial institution standards, such as those mandated by the IADB, where practicable and relevant. The following international policies and standards were considered in the development of this ESIA:

- the IADB’s *Environmental and Social Performance Standards* (IADB 2020)
- the Caribbean Development Bank's *Environmental and Social Review Procedures* (CDB 2014)

- the United Nations Environmental Programme's *Goals and Principles of Environmental Impact Assessment* (UNEP 1987)
- the International Finance Corporation's *Performance Standards* (IFC 2012)
- the World Bank's *Environmental and Social Framework* (World Bank Group 2017) and *Environmental, Health, and Safety Guidelines* (World Bank Group 2007a)
- the *Equator Principles* (EPA 2020)

3.0 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The Project will be located at Harrow Plantation, in the Parish of Saint Philip, Barbados, which is situated on the southeastern end of the island (Figure 3.1).

Harrow Plantation consists of approximately 123.0 hectares (ha) of privately-owned land, of which approximately 73.2 ha will be leased by RSB for the purpose of carrying out the Project. The RSB leasehold area (referred to herein as "the Project Property") will encompass the following proposed Project components and activities:

- Approximately 59.1 ha will be used for the solar PV power plant, including associated rights-of-way (RoWs) and various restrictions, such as drainage reserves. Most of this land (approximately 57.4 ha) will also support solar grazing (i.e., the practice of grazing livestock, in this case Blackbelly sheep, between and beneath the solar panels of the power plant).
- Approximately 1.6 ha will be used to implement energy storage and management systems in support of the solar PV power plant. These systems will be contained within an area referred to as the "Hydrogen Power Centre" (HyPCe).
- Approximately 2.3 ha will be used for buildings and facilities associated with the on-site Blackbelly sheep farm as well as general office and storage facilities.
- Approximately 10.3 ha will be left as green space (i.e., undeveloped land that is covered with grass) to be used for additional grazing and as a fodder pasture for grass harvesting and bailing.

The approximate geographic coordinates of the centre of the Project Property are as follows: 13.127548, -59.472712.

The land within the Project Property is existing agricultural land that is currently used for sugarcane farming augmented by rotational crops (e.g., cotton). Cultivation of existing sugarcane fields and rotational crops within the Project Property will continue until the start of Project construction.

3.2 PROJECT COMPONENTS

Figure 3.2 depicts the proposed site layout for the main components of the Project, including the solar PV power plant, the HyPCe area containing the energy storage and management systems for the power plant, and the agricultural facilities associated with the Blackbelly sheep farm.

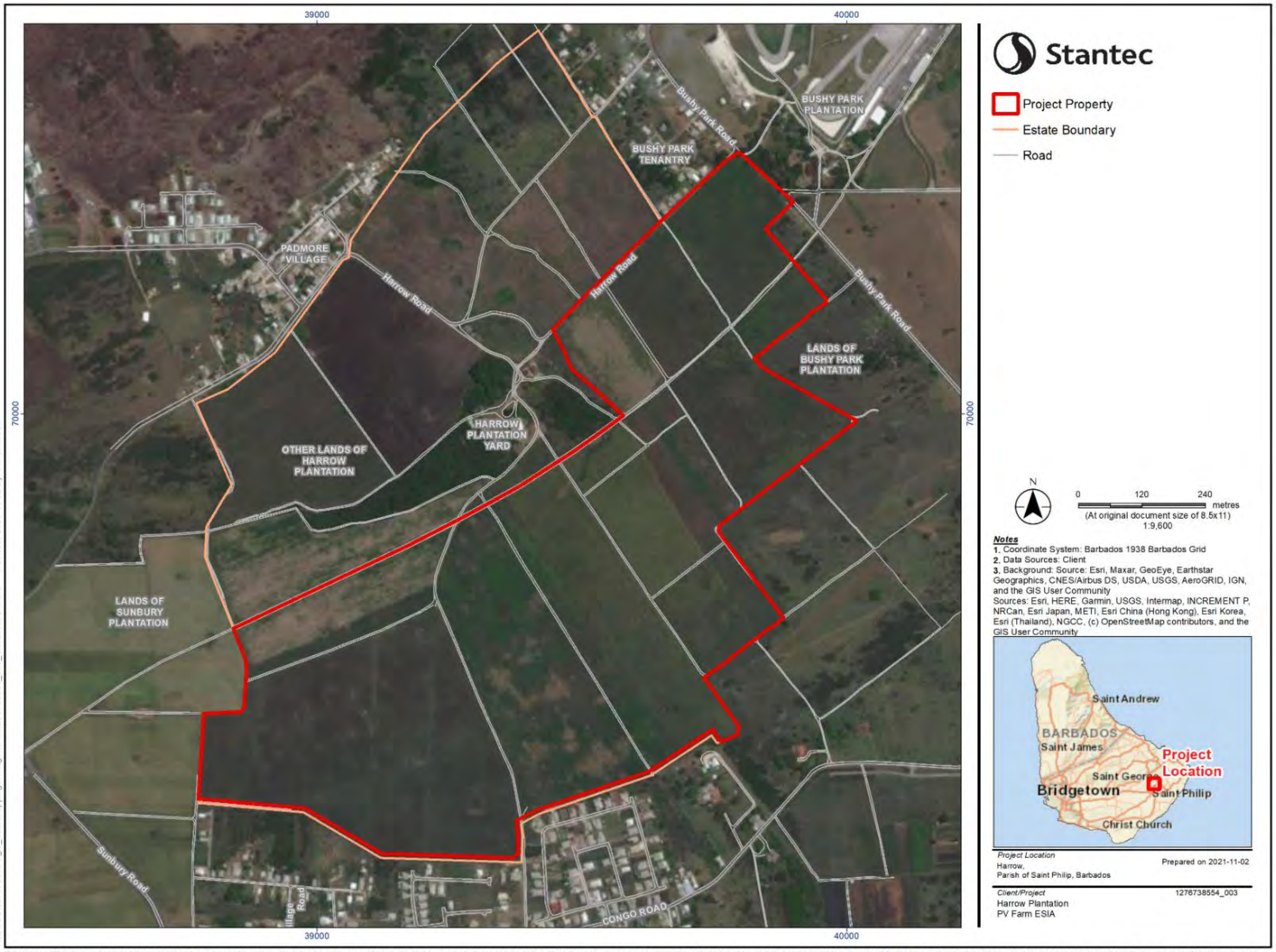


Figure 3.1 Project Location

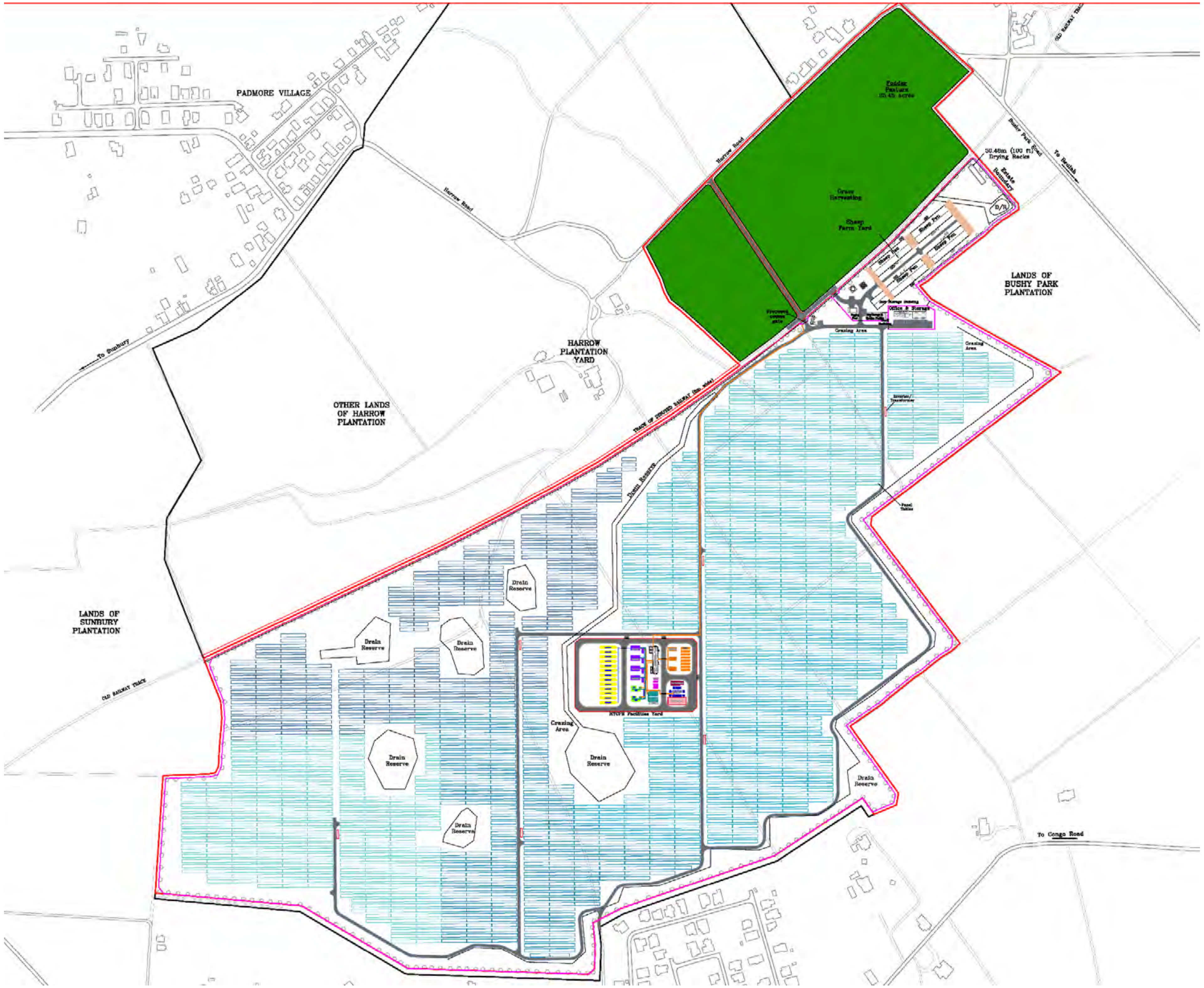


Figure 3.2 Overall Site Plan

3.2.1 Energy Facility

The energy facility components of the Project will consist of a solar PV power plant and associated battery and hydrogen energy storage systems (Figure 3.3). These components will be controlled and optimized via an integrated Energy Management System (EMS). The term "power plant" refers only to the solar PV power plant (as described in Section 3.2.1.1 below), while the term "energy facility" refers collectively to the solar PV power plant, energy storage systems (as described in Section 3.2.1.2 below), and EMS (as described in Section 3.2.1.3 below).

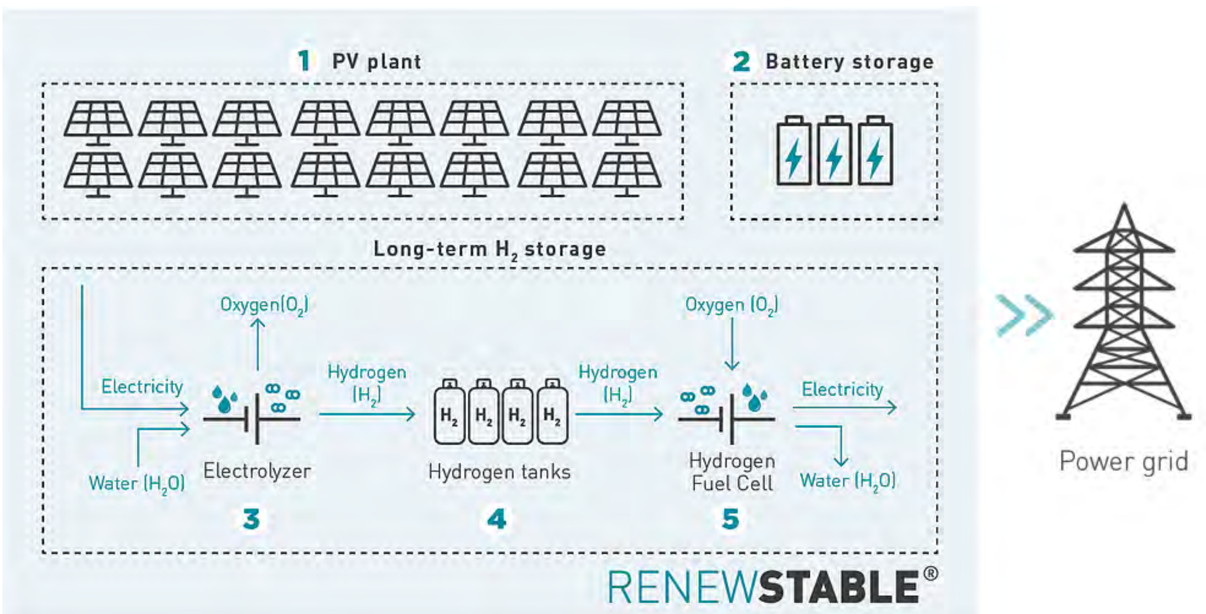


Figure 3.3 Energy Facility Components of the Project

The Project will convert sunlight into electricity via the solar PV power plant. A capped and consistent level of output from the power plant will be directed to the grid, while the remainder will be used to split water molecules (H_2O) into hydrogen and oxygen via an electrolyser system. The resultant hydrogen will be stored as compressed gas. Fuel cells will then be used to produce electricity when needed from the stored hydrogen gas, thereby enabling the delivery of stable power to the national grid. The Project process for hydrogen production and use involves breaking water molecules down in the electrolysers and then recomposing them in the fuel cells (Figure 3.4). The water treatment and storage facilities required to support this process are described in Section 3.2.3.5.

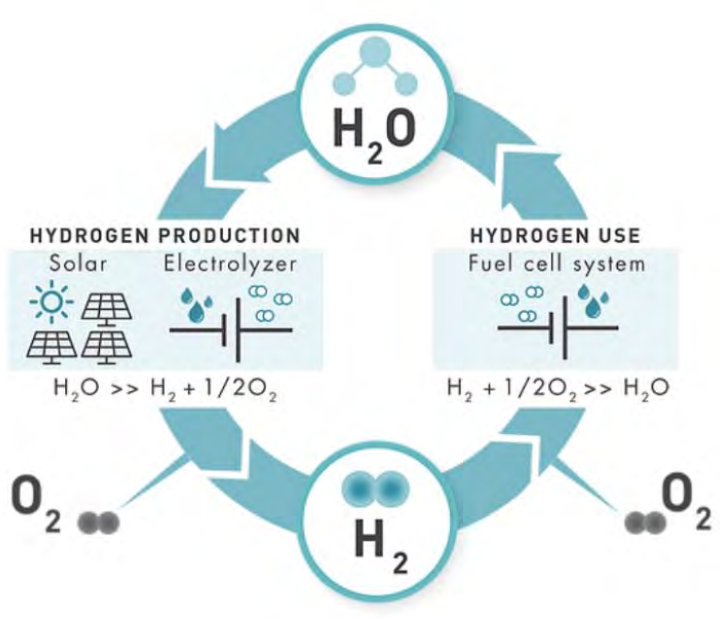


Figure 3.4 Overview of Project Process for Hydrogen Production and Use

3.2.1.1 Solar Photovoltaic Power Plant

The primary source of energy for the Project will be a 50-megawatt peak (MWp) solar PV power plant.

The power plant will occupy approximately 59.1 ha and will consist of an array of 96,154 solar panels, equipped with PV cells, which will be ground-mounted in a fixed-tilt, south-oriented configuration. This configuration has been selected because it is well-adapted to solar grazing and is efficient for optimizing energy generation while reducing land use requirements.

Solar panels (or PV modules) consist of several layers of materials. The top layer is typically composed of glass with high transmissivity and low reflectance values. This layer can be specially treated with an anti-reflective coating (ARC) to lower the reflectance of the panel and improve its efficiency by increasing the amount of light absorbed into the cell. An ARC can be applied to smooth or textured glass. Textured glass was predominantly used to reduce the reflectivity of solar panels before ARCs became more affordable. The benefits of using textured glass in this application include improved solar energy capture efficiency and reduced glare, as incoming light is reflected off the raised surface of the glass and is re-directed to other portions of the surface. However, the disadvantages of textured solar PV glass structures include higher cost (due to additional material requirements) and potential reductions in the amount of transmitted energy and the device's efficiency (if dirt becomes trapped in the textured surface).

Semi-conductor solar PV cells and electrical circuitry are usually between the glass and the back sheet and bound together by encapsulating materials on the front and back of the PV cell layer. The PV cells consist of two or more layers of silicon or similar semi-conducting material. Electrical charges are generated when the semi-conductor in the cell is exposed to light, and these charges are conveyed away as direct current (DC). A metal frame is used to further stabilize and protect the edges of the solar panel.

Solar panels work best when their absorbing surface is perpendicular to the rays of the sun. A panel's orientation is its horizontal angle relative to North; a panel facing southwards, for example, would have an orientation of 180 degrees from North (Figure 3.5). To maximize exposure to the direct sun rays, panels should be oriented towards the terrestrial equator. Since Barbados is in the Northern Hemisphere, the solar panels for the Project will face southwards. The tilt of a solar panel is the angle between the panel surface and the earth's surface. The currently proposed tilt of the solar panels for the Project is 13 degrees; this will be confirmed or refined during detailed design.

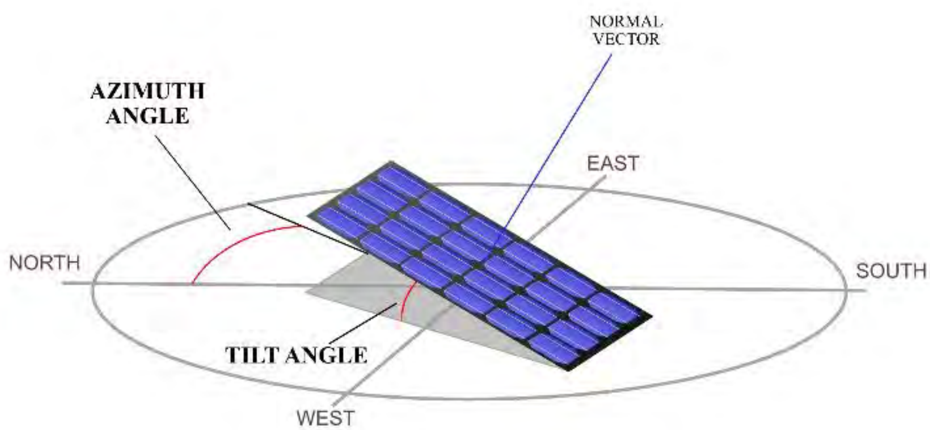


Figure 3.5 Solar Panel Orientation

The solar panels will be fixed to a galvanized steel frame or racking to form solar panel tables, as illustrated on Figure 3.6. The racking will be constructed from steel channels fixed and propped to a pole mount spaced typically at 2–3 m. Transverse steel channels will span between pole-mounted support and associated channels. Solar panels will be fixed to transverse channels. To prevent the pull out of pole supports during high wind scenarios, poles will be fixed to the ground via connection to steel piles that are augered or driven into the soil and/or rock. Cement binder may be used to reinforce the foundations, if necessary.

Generally, the power cabling between the solar panel tables will run under the racking for each table and will be held together and in place by proprietary hangers or within cable trays spanning between pole mounts. An accurate design and construction of cable pathways is important to facilitate solar grazing. Cables will be run in trenches from the solar panel tables to the power conversion station.

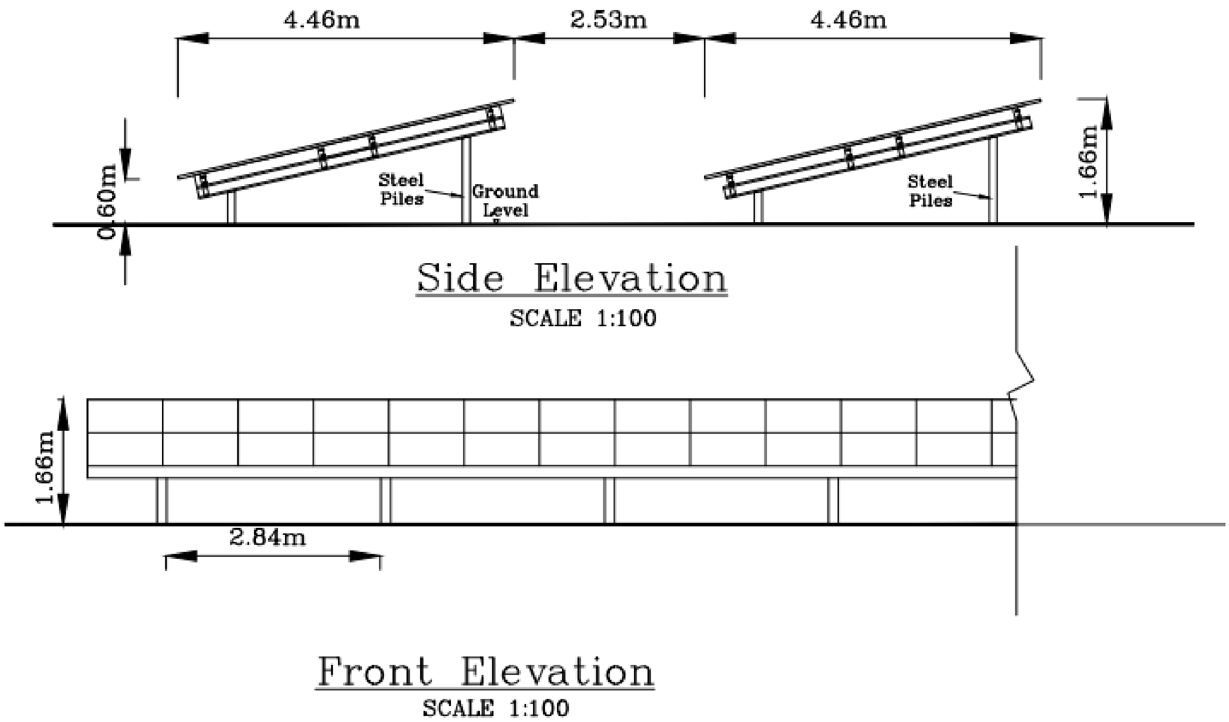


Figure 3.6 Typical Solar Panel Tables

The solar panel structures for the Project will be designed in accordance with local and international standards, and in particular to withstand Category 4 hurricanes. A certified engineer will review the selected structures for compliance with applicable codes from the American Society of Civil Engineers (ASCE).

3.2.1.2 Energy Storage Systems

The Project will include a short-term battery energy storage system (BESS) and a long-term hydrogen energy storage system (HESS).

The BESS and HESS, as well as related utilities and auxiliary systems, will be centralized and contained within a fenced HyPCe area that will be approximately 1.6 ha in size and located near the middle of the Project Property (refer to Figure 3.2 and Figure 3.7). The HyPCe area will be specifically designed to mitigate the risks associated with the energy storage equipment (e.g., fire or explosion due to a battery malfunction or hydrogen leak), for the protection of Project personnel and the surrounding community. A large setback, with a radius of more than 200 m between the HyPCe area fenceline and the Project Property boundary, is proposed as a safety zone. Further information regarding Project-related hazards and risks is provided in the Quantitative Risk Assessment (QRA) (Appendix D) that was conducted for the Project. The results of the QRA have been incorporated into the assessment of potential impacts that could occur in the event of an accident, malfunction, emergency, or disaster (Section 8.7).

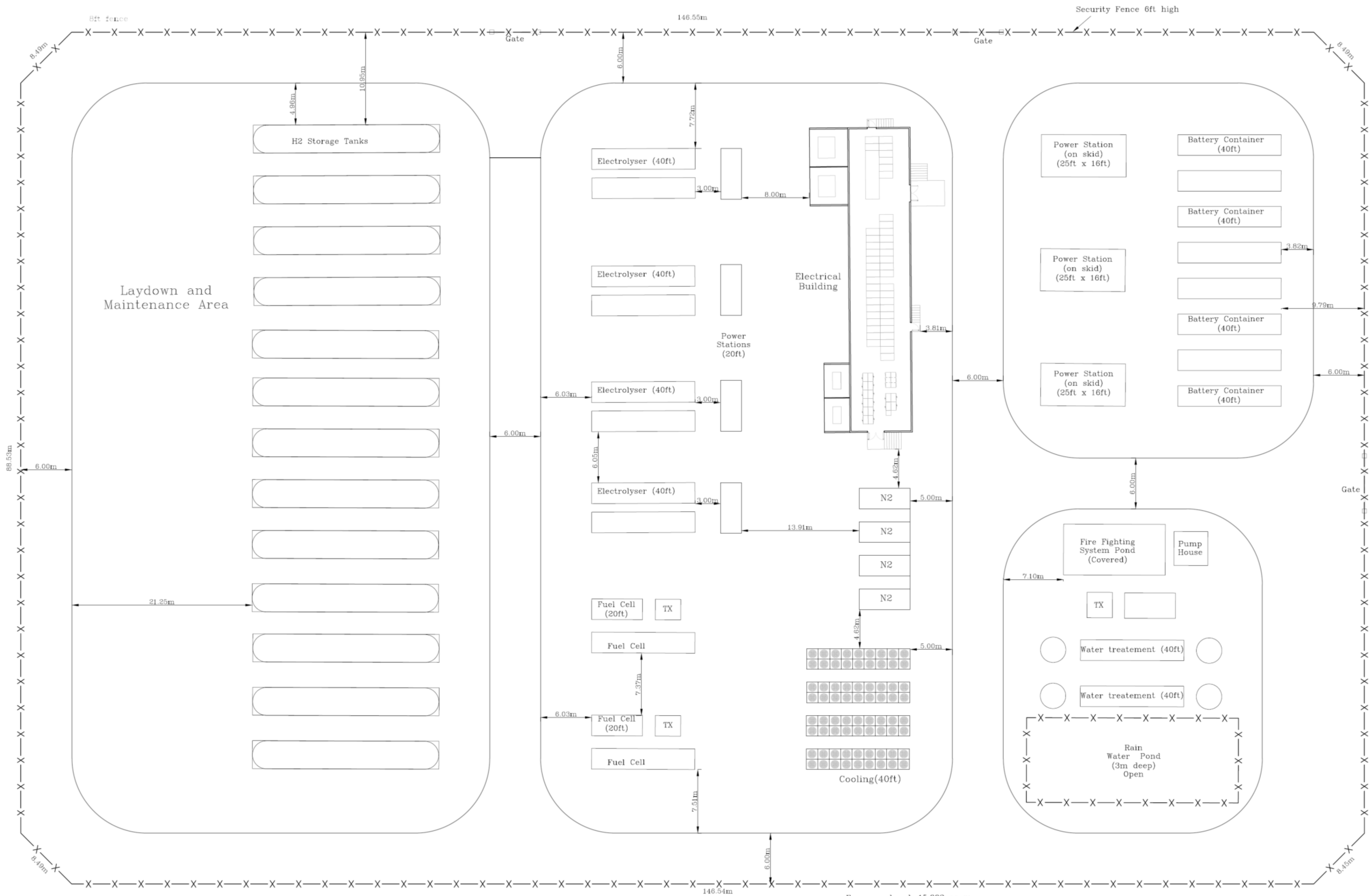


Figure 3.7 HyPCe Area

Battery Energy Storage System

The BESS will consist of eight units housed in cabinets (Figure 3.8). These units will include the Li-ion battery cells, as well as associated management systems, auxiliaries, cooling, fire safety, security systems, and comprehensive fault detection in charge/discharge cycles. The dimensions of each unit will be approximately 16.2 m x 2.9 m x 2.6 m and the maximum capacity of each unit will be 2 MW / 6 MWh.

Figure 3.8 Examples of in Prefabricated Enclosures for Battery Energy Storage System Units

The BESS will provide a total installed power of 14 MW, with a capacity of 3 hours of short-term energy storage. The enclosure will be a cabinet unit of typically 4–5 MWh. The units will be integrated in at least three independent modules. The role of the BESS will be to:

- Deliver a two-hour dispatchable block of 13 MW firm power to meet the end-of-day-peak demand (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid).
- Provide a quick energy response as needed to mitigate potential temporary sources of intermittency (e.g., high cloud cover) and deliver stable and optimized energy service during the day.
- Provide additional power for absorbing peak power during the day when the electrolysers are running at maximum power and solar power is available in excess.

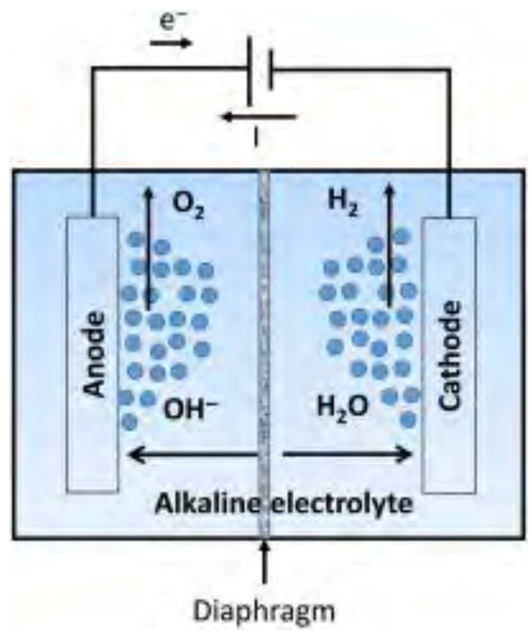
The BESS will be designed in accordance with applicable international standards, including NFPA 855 (the National Fire Protection Association's *Standard for the Installation of Stationary Energy Storage Systems*). Each unit will be individually sealed and separated to avoid fire propagation between units, with fusing and electrical protection adapted to shut-down each module individually if necessary. Each unit will have a fire resistance rating of at least two hours, in accordance with ANSI/CAN/UL 9540A: 2019 (*Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*). The battery cells will be designed to withstand temperatures of up to 50 degrees Celsius (°C). At the system level, heating, ventilation, and air conditioning (HVAC) and building management control systems will be able to shut the units down and put them in safe mode in the event that the range of safe operating conditions is exceeded. The ventilation system will also enable the safe evacuation of gases and flames through the top of the unit and passive deflagration venting to control the risk of fire and explosion. Fire detection systems will typically include integrated sensors and multi-spectrum infrared systems, or similar technology, capable of detecting fire-related thermal or gas emissions.

Hydrogen Energy Storage System

The HESS will provide long-term storage of energy generated from the solar PV power plant, thereby facilitating baseload generation over extended time periods and enabling the Project to supply stable (non-intermittent) power 24 hours per day, seven days per week. As illustrated on Figure 3.9, this will be achieved by using electrolysers and water to convert electricity from the power plant into hydrogen, storing the hydrogen, and then using it when needed to produce water and electricity again through fuel cells.

The HESS will be composed of:

- **Electrolysers with a total capacity equivalent to 16 MW:** The electrolysers will absorb energy output from the solar PV power plant and generate hydrogen for long-term storage. The system will employ alkaline-technology electrolysers and DC power to induce an electrochemical reaction (i.e., water electrolysis) that causes the water molecules (H_2O) in demineralized water to split apart into separate hydrogen (H_2) and oxygen (O_2) molecules (Figure 3.10). The final products of the water electrolysis process will be hydrogen gas, which will be stored, and oxygen, which will be released to the atmosphere. The electrolysers will be housed in prefabricated and containerised enclosures for easy integration into the HyPCe area of the power plant (Figure 3.11). These enclosures will be equipped with H_2 detectors (set to 20% of the lower explosive limit) and ventilation switch detectors, and will be actively ventilated to maintain a non-explosive atmosphere.
  Up to 100 m^3 of 25% potassium hydroxide (KOH) solution, or caustic potash, will be used in the process of alkaline electrolysis. The KOH will not be consumed during electrolysis since it will serve as an electrolyte in a closed-loop process. In this type of application, KOH typically needs to be replaced approximately every 10 years.
- **Compressors and pressurized containers:** The hydrogen gas produced from the electrolysis process will be compressed and stored in cylindrical steel tanks that are arranged horizontally and stacked two-by-two, as shown on Figure 3.12. The HESS will include a total of 26 tanks, each of which will have a storage capacity of 115 m^3 and will measure 22 m in length and 2.8 m in diameter. These tanks will enable the long-term storage of approximately 7,300 kg of hydrogen, representing the equivalent of 90 MWh of energy. The maximum operating pressure and temperature of the tanks will be 30 barg and 40°C, respectively.
- **Hydrogen fuel cells with a total capacity equivalent to 3 MW:** The fuel cells will employ proton-exchange membrane (PEM) technology to combine the stored hydrogen with the oxygen that is available in the surrounding air; this will essentially reverse the electrolysis process by transforming the hydrogen and oxygen back into electricity and pure water vapour (i.e., gaseous H_2O) that is anticipated to be free of contaminants. The fuel cells will be housed in prefabricated and containerised enclosures for easy integration into the HyPCe area of the power plant (refer to Figure 3.13). As will be the case for the electrolyser enclosures, the hydrogen fuel cell enclosures will also be equipped with H_2 detectors (set to 20% of the lower explosive limit) and ventilation switch detectors, and will be actively ventilated to maintain a non-explosive atmosphere.



Source: Coutanceau et al. 2018.

Figure 3.9 Alkaline Water Electrolysis – Chemical Principle

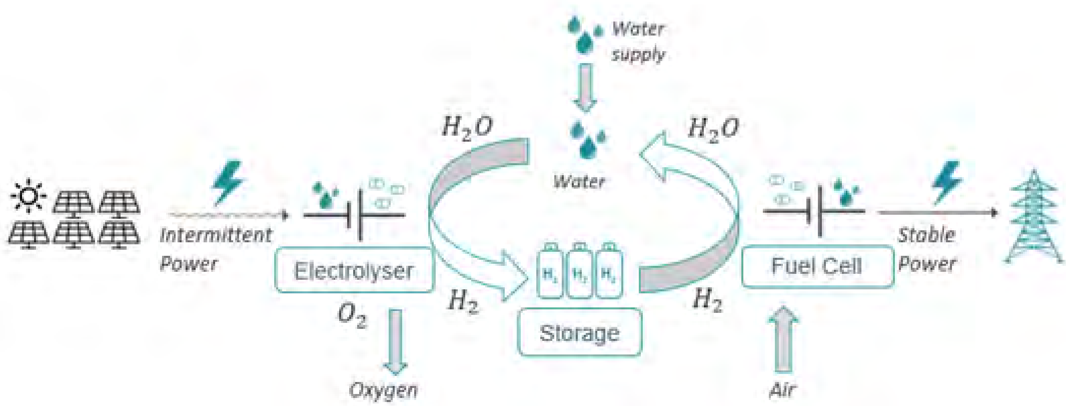


Figure 3.10 Overview of Hydrogen Energy Storage System

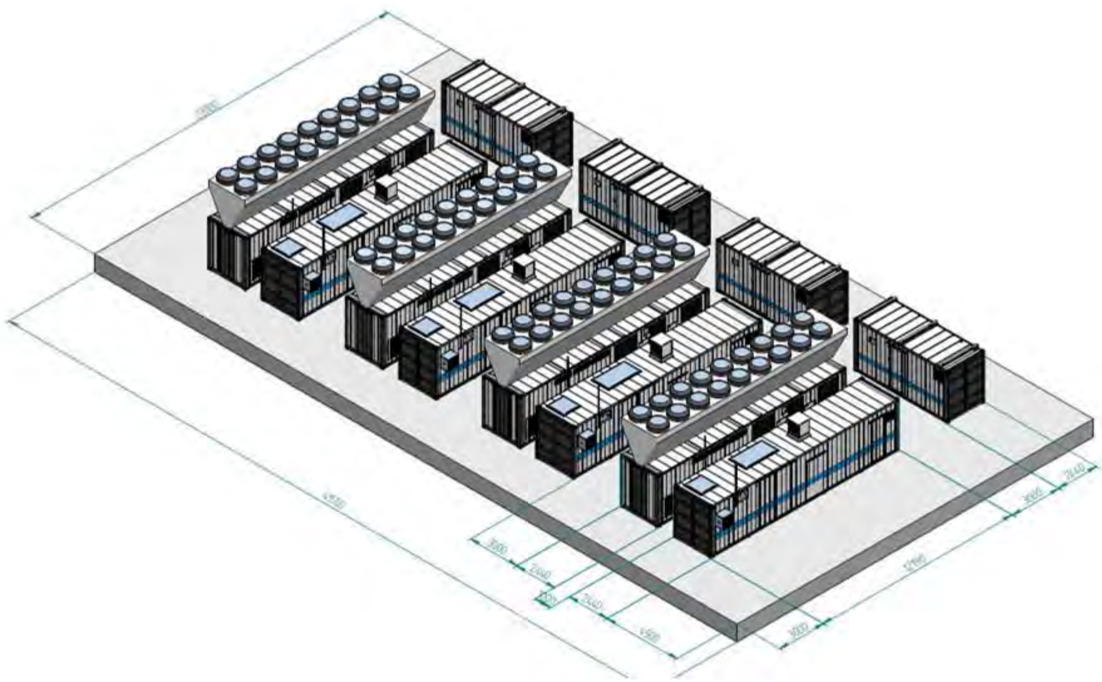


Figure 3.11 Example of Containerised Electrolysis System with Capacity Equivalent to 20 MW

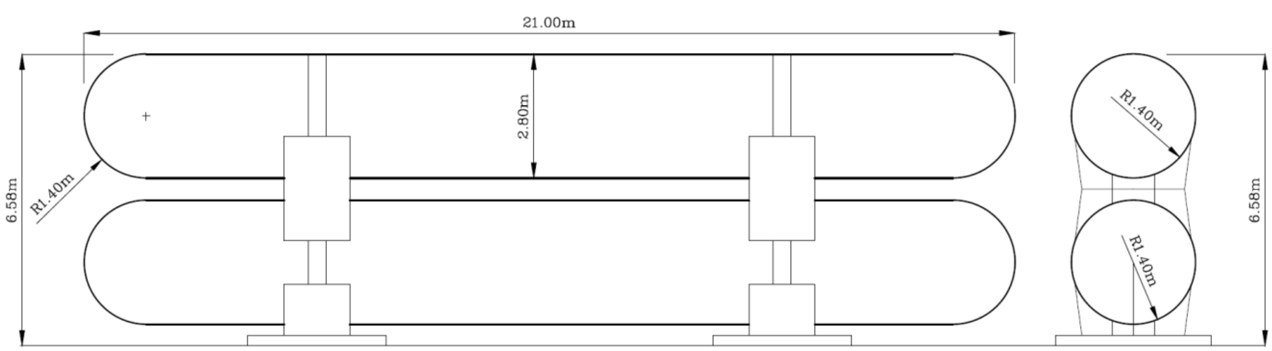


Figure 3.12 Proposed Arrangement of Hydrogen Storage Tanks – Side View (Left) and Front View (Right)

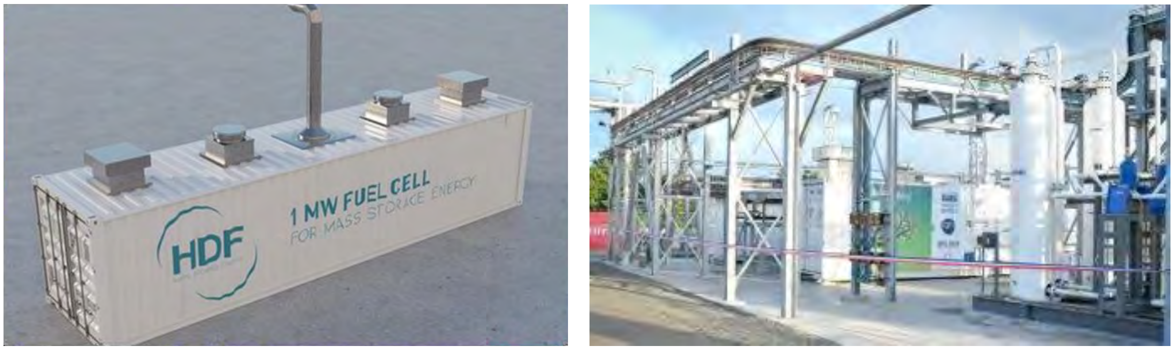


Figure 3.13 Examples of Containerised Fuel Cell (Left) and Containerised Fuel Cell System with Hydrogen Purification System (Right)

3.2.1.3 Energy Management System

The EMS will be located in the HyPCe area (Figure 3.7) and will serve as the “brain” of the Project energy facility. EMS software will compute the solar irradiance forecast in advance and control the power plant and its energy storage systems (i.e., the BESS and HESS) in real-time to deliver the optimal amount of power to the grid and reduce energy losses. When the power plant is producing energy, the EMS will distribute the energy as necessary to deliver power to the grid and to charge the energy storage systems (Figure 3.14). When the energy generated by the power plant is insufficient to deliver the required amount of power to the grid (e.g., in cases of low solar resources), the EMS can draw on the Project’s energy storage systems and adapt the generation profile as necessary to increase the power supply to the grid and comply with contractual obligations (Figure 3.14).

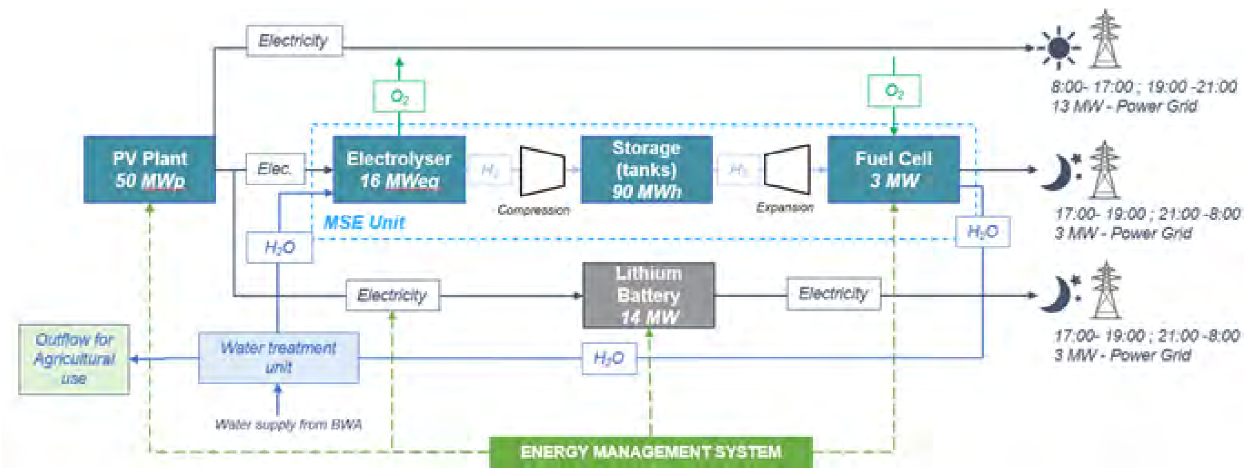


Figure 3.14 Energy Management System Process Flow Diagram

3.2.2 Agricultural Facilities

The Project Property will also be used to support what is proposed to be the largest commercial Blackbelly sheep farm in Barbados. The agricultural facilities will be used to raise sheep livestock for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets. However, no butchering will take place on-site.

The individual who has been pre-selected to carry out the agricultural aspects of the Project is an established commercial sheep farmer with previous experience raising sheep as part of dual land use projects. This farmer has expressed a strong desire (including through submission of a letter of preliminary commitment to RSB) to expand his operations as part of the Project.

The Project will be designed to accommodate at least 1,830 Blackbelly sheep. On-site agricultural facilities will include sheep pens, a barn for hay storage, a feed silo, water storage tanks, a designated waste skip area on a concrete pad, and a farm building/staff facility, all of which will occupy a total of approximately 2.3 ha. The sheep will be allowed to graze between and beneath the solar panels of the power plant within a solar grazing area that is approximately 57.4 ha in size. A further approximately 10.3 ha of the Project Property will be left as green space, which will provide a supplementary grazing area, as well as an open fodder pasture for grass harvesting and bailing. The farmer will use the fodder produced from this area to feed the sheep through the dry season. Thus, approximately 96% (or 70 ha) of the Project Property will be available for agricultural use and approximately 92% (or 67.7 ha) of the Project Property will be grazable.

The soil quality at the Project Property (Class IIb) is suitable for growing high-protein grass and hay as feed for livestock. Although no irrigation supply wells are available on the Project Property, the mineralized water by-product from the water treatment plant, process water from the HESS, and/or harvested rainwater could be used to irrigate struggling grass areas as needed (refer to Section 3.2.3.5).

Figure 3.15 shows the proposed site layout for the agricultural facilities associated with the Project, including a portion of the solar grazing area. However, the full spatial extent of the solar grazing area is better reflected on Figure 3.2, which shows the proposed layout of the solar panels that the sheep will be allowed to graze amongst.

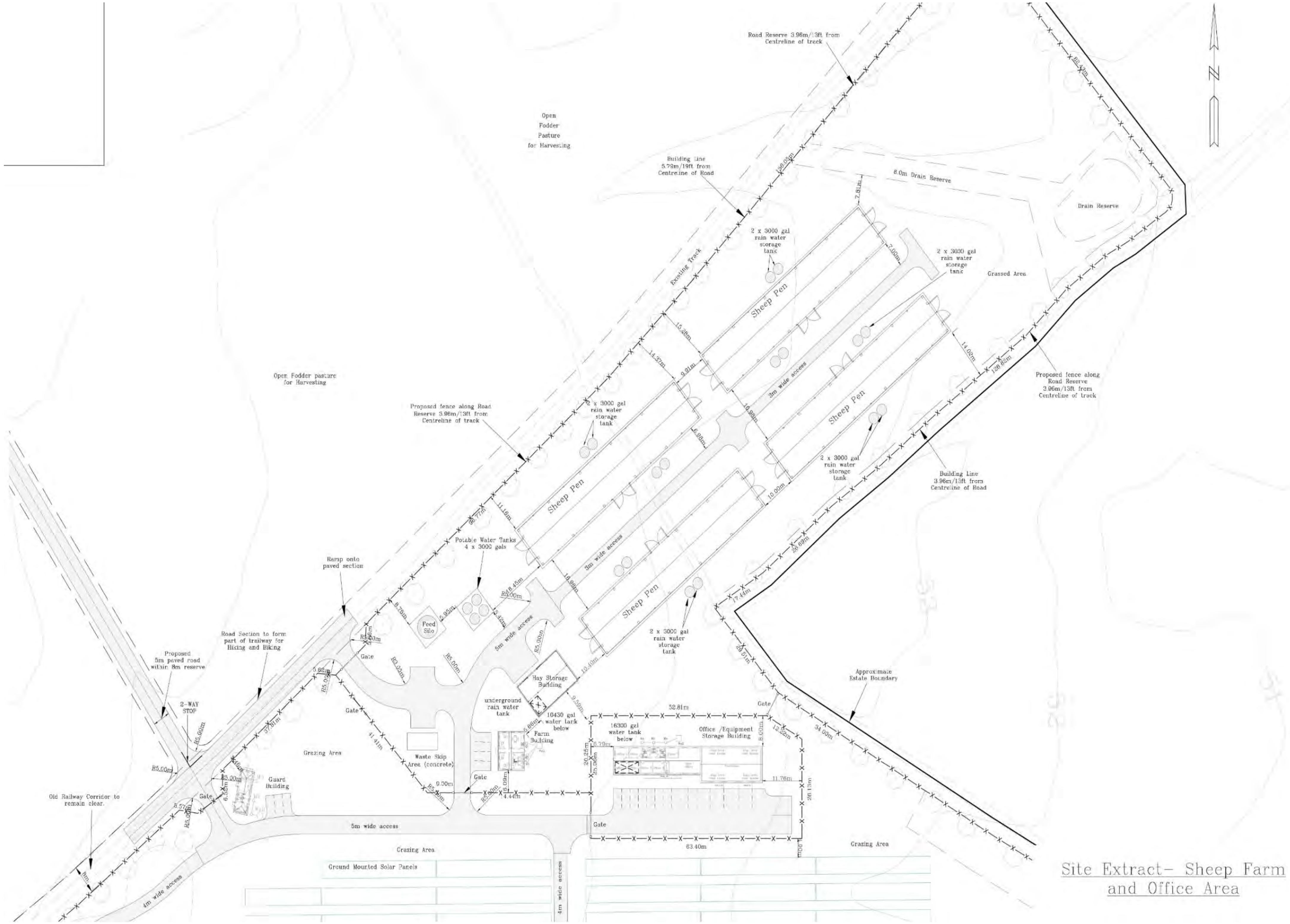


Figure 3.15 Layout of Agricultural Facilities and Office Area

3.2.3 Supporting Infrastructure, Facilities, and Utilities

3.2.3.1 Buildings and Yards

Several buildings are proposed for the Project Property and will be amalgamated where possible without compromising Project requirements for efficiency, power, functionality, and safety. Proposed Project buildings, which include a guard building/security booth, farm building/staff facility, hay storage barn, feed silo, and office/equipment storage building, are anticipated to occupy a total of approximately 2.3 ha within the Project Property. The approximately 1.6-ha HyPCe area (or HyPCe facilities yard) will also contain buildings such as an electrical building, power stations and various utilities on skids, a pump house, and a package water treatment plant.

Laydown areas will be required for the outdoor storage of vehicles, heavy equipment, machinery, prefabricated Project components, construction materials, and other supplies for construction, operation, and maintenance. Laydown areas will also include platforms for equipment assembly/installation.

3.2.3.2 Site Roads, Access, and Security

Access to the Project Property will be provided via Harrow Road, branching off Bushy Park Road to the east and Sunbury Road to the west. Internal site roads and parking areas throughout the Project Property will facilitate the transportation of Project personnel, equipment, and materials/supplies within and between the solar PV power plant, the HyPCe area, and the area in which the agricultural facilities will be located. These roads will range between 3 m and 5 m in width. The main access roads, HyPCe area access roads, and roads to and within the administrative area, including the parking area, will be paved; the remainder of the internal site roads will be unpaved. Near the northeastern extent of the Project Property, a 5-m wide paved access road will cross the fodder pasture to connect the internal site roads with the public Harrow Road (refer to Figure 3.2).

The Project Property will be surrounded by fencing on all sides. The access road near the northeastern extent of the Project Property will lead to an access gate with a dedicated guard building/security booth; this will serve as the primary entrance to the secure portion of the Project Property, restricting access to the power plant, HyPCe area, and agricultural facilities (other than the open fodder pasture). The HyPCe area will be further enclosed by a security fence that has a height of approximately 1.8 m (i.e., 6 feet) (Figure 3.7). Additional fencing will separate the agricultural facilities and the office/equipment storage building from the rest of the secure portion of the Project Property. Although the height, material, and configuration of this additional fencing remains to be determined during detailed design, it is anticipated that the fencing around the agricultural facilities will have deep footings to help prevent predatory animals (e.g., dogs) and pests from digging under it.

There will be adequate 24-hour security to prevent curious onlookers or passers-by from wandering into Project-related construction or operational areas. Additional provisions that will be made to enforce safety in and around the Project Property include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meets the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways.

3.2.3.3 Site Lighting

General site lighting will be a combination of power line pole-mounted fixtures and building-mounted fixtures at the guard building/security booth, farm building/staff facility, office/equipment storage building, and other miscellaneous buildings. Lighting will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Project components and facilities are not anticipated to be permanently lit; detection sensors or manual switches will be used to engage lighting when required for operational tasks, and for security or safety reasons.

3.2.3.4 Transmission Lines and Cables

The Project will power the national grid via a new transmission line connecting the proposed power plant to BLPC's existing Hampton substation, which is located approximately 3.5 km away from the Project Property. It is anticipated that BLPC will independently undertake any necessary upgrades to off-site grid infrastructure beyond the boundaries of the Project Property. It is therefore assumed that the new transmission line extending off-site from the Project Property to the Hampton substation will be assessed, owned, and operated by BLPC; as a component of Barbados' national power distribution system, this transmission line will be entirely under the care and control of BLPC.

The Project will also require connection to the local telecommunications network and will be hooked up to the existing fibre optic cable system that services the area.

3.2.3.5 Water Supply, Treatment, and Storage

During the operational phase of the Project, water will be required to enable long-term energy storage – through hydrogen production – from the solar PV power plant, as well as to support agricultural operations. Standard Project-related operational water consumption requirements are estimated to be 64.5 cubic metres (m^3) per day. However, the Project Property does not have an irrigation supply groundwater well available on-site. It is anticipated that the Project water supply will primarily be sourced from existing public water main pipelines that are owned and operated by BWA, and will be used for the following purposes:

- An average of approximately 60 m^3/day of potable water will be required to enable energy storage from the power plant. This water will be treated via reverse osmosis at an on-site package water treatment plant to remove minerals (e.g., salt, manganese, iron, fluoride, lead, and calcium) and produce approximately 30 m^3/day of demineralized water suitable for hydrogen electrolysis (as described in Section 3.2.1.2). The remaining 30 m^3/day of water will be a mineralized by-product of the treatment process that can be harvested and used for local irrigation or equipment maintenance (washdown).
- An average of approximately 4.5 m^3/day of potable water will be required for sheep farming and staff operations (i.e., for drinking water and sanitary purposes).

The maximum flow of water that will be required by the HESS to enable energy storage from the power plant is 5 m^3/hour; this amount would allow the electrolysers to operate for their entire maximum daily operating time of 12 hours. The process water emitted from the HESS when the fuel cells convert the hydrogen and oxygen back into electricity and water (as described in Section 3.2.1.2) will be recirculated to the electrolysers for re-use in the electrolysis process.

On-site water storage tanks for operations water will smooth out the flow of withdrawal from BWA's public water mains during the day. The water in these storage tanks can be drawn upon as needed during Project operations to supplement the water supply from BWA, thereby reducing the Project's reliance on that external resource, and/or as a contingency reserve in the event of interruption to water service from BWA. Approximately 150 m^3 of demineralized water will be stored in tanks on-site in the HyPCe area. This quantity of stored water will be sufficient to allow the power plant and HESS to run for five days at full load without access to potable water from external sources. Water tanks will also be located on-site within the office area and agricultural facilities. These additional tanks will store enough water to supply five days of potable water for offices and sheep, and to provide 15 days of rainwater storage for sheep drinking and pen washdown.

Potential opportunities for the reduction and optimization of water use are being studied. The option of reducing Project-related potable water use through the harvesting of rainwater via water tanks located beneath Project buildings/infrastructure will be evaluated. Water from this storage would be captured during the rainy season for use throughout the year, thus offsetting the quantity of potable water that may be required from the public mains.

3.2.3.6 Drainage Works

Drainage reserves are included in the proposed layout of the power plant (as shown on Figure 3.2) for the management of surface run-off (refer to Section 3.6.2). The proposed drainage reserve areas will be graded and contoured to direct runoff towards suckwells (i.e., artificial shafts excavated in soft carbonates to relieve surface flooding). A hydrological assessment was undertaken to determine the proper positioning and sizing of the drainage reserves to accommodate a sufficient volume of runoff (Appendix B).

3.3 PROJECT ACTIVITIES

3.3.1 Construction

The main activities associated with the construction phase of the Project will consist of site preparation, physical construction and equipment installation, and finalization commissioning. The Project is expected to employ up to 150 people during peak construction activities, such as installation of the PV modules. Given the proximity and availability of potential accommodations in the local communities surrounding the Project Property, no workforce accommodation camps are currently proposed in support of the Project. However, the contractor may consider the use of construction camps to accommodate their workers as a means of limiting competition for housing on the island between workers and local community members.

3.3.1.1 Site Preparation

Project construction will begin with the clearing of vegetation and the levelling of soils where necessary throughout the Project Property. Only light vegetation removal will be required since the Project Property is currently mostly used for farming sugarcane and rotational crops and is therefore not forested or heavily vegetated other than with agricultural crops. Temporary laydown areas will be established for the outdoor storage of vehicles, heavy equipment, machinery, prefabricated Project components, construction materials, and other supplies. Site preparation activities will also include access road construction, internal road construction, platform levelling for the HyPCe area and other buildings, and the digging of trenches and construction of the drainage system for surface runoff management.

3.3.1.2 Physical Construction and Equipment Installation

Once site preparation is complete, physical construction and equipment installation of the main Project components will commence and will involve the following:

- Construction of solar PV power plant, including:
  - PV structure foundation construction
  - PV structure assembly
  - PV modules installation, which may require pile driving to secure panel support racking into the earth below
  - Power station installation
  - Installation of cabling, boxes, and auxiliaries connecting the PV modules to the power station and connecting the individual components of the HyPCe area to their respective power supplies
- Construction of HyPCe area facilities (i.e., BESS, HESS, and EMS), including:
  - Foundation construction
  - Electrical building construction
  - Installation of integrated systems, containers, and associated power stations for the batteries, electrolysers, and fuel cells
  - Erection of electrical and mechanical balance of plant components (e.g., cabling, piping, and auxiliaries)
- Construction of buildings associated with the agricultural facilities.
- Construction/installation of remaining supporting infrastructure, facilities, and utilities, including other Project buildings (e.g., guard building/security booth and office/equipment storage building), fencing, lighting, package water treatment plant, water storage tanks, and drainage works.

The Project components required for physical construction and equipment installation will be transported to the Project Property by truck, primarily in 12-m shipping containers, although some raw materials may be transported in bulk and the hydrogen tanks will be transported as out-of-gauge cargo. It is estimated that approximately 450 trucks will be required to transport key Project components to the Project Property, including 350 trucks for the PV modules and structures, six trucks for the power stations, 50 trucks for containerized and skid systems associated with the HyPCe area, 10 trucks for bulk spare parts (e.g., cabling), and 26 trucks for the hydrogen tanks.

3.3.1.3 Finalization and Commissioning

Finalization of Project construction will include pre-commissioning of sub-systems (e.g., solar panels and PV cells, batteries, fuel cells), connection of the power plant, and connection to the grid. The electrical and mechanical systems associated with the Project will be commissioned as construction/finalization is completed, including full commissioning of the entire power plant and associated energy storage and management systems.

3.3.2 Operation and Maintenance

As described in Section 1.1, the Project will generate approximately 56,000 MWh per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 Barbadians annually[3]. The electricity generated by the Project will be purchased by the privately-owned utility BLPC, which is currently the sole electricity utility provider in Barbados, at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. During the term of this agreement, the Project will deliver the following power supplies to Barbados' national grid daily:

- 13 megawatts (MW) between the hours of 8:00 and 17:00;
- a two-hour dispatchable block of 13 MW firm to meet the end-of-day peak, when the marginal cost of generation in Barbados is the highest (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid); and
- 3 MW firm the rest of the time.

As described in Section 3.2, the Project will achieve this by converting sunlight into electricity via the solar PV power plant, converting the electricity from the power plant into hydrogen using an electrolyser system, storing the hydrogen as compressed gas, and then using fuel cells to produce electricity whenever needed from the stored hydrogen gas; the resultant electricity will be delivered to the national grid. These processes will occur during the operational phase of the Project.

A dedicated team of Project personnel will be responsible for carrying out Project operation and maintenance activities, with support from subcontractors as needed. The EMS will enable aspects of the power plant and energy storage systems (i.e., the BESS and HESS) to be controlled remotely during Project operations. Since Project components in the HyPCe area will be mainly automated, the primary job of the operator will be to monitor the infrastructure (including associated cooling, fire safety, security, and fault detection systems) to support their safe, secure, and efficient operation.

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[3] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

Operation and maintenance of the power plant and associated energy storage and management systems in the HyPCe area will entail: regular visual inspections of the PV modules, cables, power stations, and other equipment; thermal control of electrical equipment (e.g., boxes and inverters); cleaning of the PV modules; grass cutting within the grounds of the power plant if solar grazing is insufficient to manage the vegetation in certain areas; transformer oil sampling and testing, and potential transformer retreatment (if necessary) at a specialized third party facility off-site; control of water quality (electrolysis input and output) through filtration, treatment, and product changing when necessary; and waste management.

Maintenance activities will also include corrective or preventative replacement of components such as electrolyte solution, PV modules, inverters, battery cells, and fuel cell stacks. It is expected that the KOH solution to be used as an alkaline electrolyte in the electrolysers (refer to Section 3.2.1.2) will need to be replaced at least once during the operational lifetime of the Project (i.e., approximately every 10 years during Project operations), and that the batteries, fuel cell, and electrolyser stacks will require replacement once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations).

Agricultural activities during the operational phase of the Project will include sheep husbandry (i.e., the raising and breeding of approximately 1,830 domestic Blackbelly sheep) and the provision of associated feeding, watering, and veterinary care; the solar grazing of sheep between the solar panels of the power plant; irrigation of the fodder pasture as needed; the harvesting, bailing, and storage of grass from the fodder pasture; and washdown, sanitation, and waste management activities. The sheep will be raised for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets. No butchering will take place on-site.

3.3.3 Decommissioning

The Project will be designed, built, and maintained to be in operation for at least 25 years. While decommissioning or abandonment of the new facility is not currently envisioned, the Project will at some point be decommissioned or rebuilt at the end of its useful service life, in accordance with the applicable standards and regulations that are in effect at that time. Potential future decommissioning activities will likely involve dismantling and removal of the power plant and other on-site buildings, equipment, and facilities, including possible excavation and removal of concrete pads; transferring of waste materials to disposal, recycling, and/or treatment facilities, as applicable (where re-use is not possible); backfilling of ponds and ditches and re-establishment of natural drainage patterns; and recontouring and revegetation (via natural regrowth and/or seeding with non-invasive plant species) of disturbed areas of the site as necessary to facilitate the desired end land use of the Project Property by the landowner.

3.4 PROJECT SCHEDULE

The Project planning and permitting process began in July 2021 and is scheduled be completed in March 2023. Critical tasks to be completed during this timeframe include finalizing Project financing and agreements; obtaining permission from the TCDPO to develop the land comprising the Project Property; obtaining ESIA approval for the Project; and obtaining an independent power producer licence from the Ministry of Energy, Small Business and Entrepreneurship to permit the Project to supply electricity to the national grid.

The electricity generated by the Project will be purchased by BLPC at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant.

The tentative Project schedule and approximate duration of the key Project phases are as follows:

- **Construction (June 2023 to June 2025):** Financial close and Project initiation are anticipated to occur in June 2023, at which point Project construction will commence. Detailed engineering, procurement and construction activities are expected to last 24 months (i.e., from June 2023 to June 2025), including approximately 3-month period of commissioning and testing.
- **Operation and Maintenance (July 2025 to July 2050, with possibility of extension):** The Project will be designed with an operational lifetime of 30 years, but the contractual duration of the current power purchase agreement is anticipated to be for 25 years. The potential for future extension of the contract will depend on the status of various internal and external factors at the time that such an extension is considered, if applicable (e.g., the condition of Project components; power demand in Barbados). The operational phase of the Project is therefore anticipated to begin in July 2025 and continue for at least 25 years. Maintenance activities will be conducted on an as-needed basis during Project operations.
- **Decommissioning (following conclusion of Project operations):** The decommissioning phase of the Project will commence following the conclusion of Project operations and is anticipated to last approximately 12 months.

3.5 HAZARDOUS MATERIALS

The main hazardous materials that will be present on-site are:

- **Petroleum Hydrocarbons:** Petroleum hydrocarbons, such as fuels (i.e., diesel and/or gasoline), hydraulic fluids, and lubricants, will be used in Project vehicles, heavy equipment, and machinery.

  Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays and spill berms) will be used in areas of storage and transfer. Table 3.3 in Section 3.7.2 below outlines additional relevant environmental protection procedures for spill prevention, control, and response in relation to these substances.

- **Li-ion batteries:** Li-ion batteries will be used in the BESS for the short-term storage of electricity from the solar PV power plant. Batteries are susceptible to fire, and this hazard has been assessed in a Project-specific Quantitative Risk Assessment (Appendix D). The batteries associated with the Project will be integrated in pre-assembled enclosures that will include cooling, fire detection, and comprehensive fault detection in charge/discharge cycles, and will be compliant with NFPA 855 and ANSI/CAN/UL 9540A: 2019, as described in Section 3.2.1.2.

  The Li-ion batteries will require replacement once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations). Used Li-ion batteries will be sent back to the manufacturer or to an independent approved facility for end-of-life disposal or recycling, in accordance with applicable regulatory requirements.
- **Potassium hydroxide (KOH), also known as caustic potash:** Up to 100 m^3 of a 25% KOH solution will be required for use in the electrolyser components of the HESS. The accidental spillage of this KOH solution could cause soil and water pollution. To mitigate this risk, the electrolysis process equipment will be housed in sealed enclosures in a secure area equipped with additional spill containment (e.g., spill berms). A spill retention tray will be used for storage of the KOH solution that may occur outside of the enclosure for the electrolyser process equipment, if applicable.

  As described in Section 3.2.1.2, the KOH will not be consumed; rather, it will serve as an electrolyte in the closed-loop electrolysis process. In this type of application, KOH typically needs to be replaced approximately every 10 years, although more frequent replacement may be required if it becomes contaminated. When replacement and disposal of the used KOH solution is required, RSB will manage the safe removal, handling, and transportation of the product for recycling at an approved facility, in accordance with applicable regulatory requirements.
- **Pressurized gaseous hydrogen:** Gaseous hydrogen will be produced and stored on-site as part of the HESS, as described in Section 3.2.1.2. The maximum amount of hydrogen to be stored on-site is 7,300 kg. The hydrogen will be compressed at 30 barg and stored in 115 m^3 cylindrical steel tanks.

  As explained in Section 3.6 below, there will be no hazardous emissions, discharges, or wastes associated with Project-related hydrogen storage or use; the only emissions will be small quantities of hydrogen gas (which may be purged in a controlled manner during operation and maintenance of the electrolysers and fuel cells), oxygen, and water. However, pressurized hydrogen gas tanks have potential to pose a fire/explosion risk in the event of an uncontrolled hydrogen leak. Accordingly, worst-case scenarios have been assessed in a Project-specific Quantitative Risk Assessment (Appendix D) to determine an appropriate security zone perimeter around the hydrogen tanks contained in the HyPCe area.
- **Oil in electrical transformers:** There will be 18 electrical transformers associated with the Project, including six for the solar PV power plant, three for the batteries, four for the electrolysers, two for the fuel cells, two for auxiliary systems, and one spare. A total of approximately 40 m^3 of oil will be contained within these transformers (i.e., approximately 2.2 m^3 of oil per transformer).

  At the end of its useful life, transformer oil will be collected by a local specialist oily waste contractor for disposal at the Barbados National Oil Terminal, or for disposal by other approved means, in accordance with applicable regulatory requirements.

  Standard transformer oils represent a potential danger to third parties and the environment since they can pollute soil and water and cause harm to terrestrial and aquatic biota in the event of an accidental leak or spill. To mitigate this risk, transformers will be properly operated and maintained, and drip pans or spill containment trays will be installed where possible. Spill response kits will also be available on-site.

Refer to Section 8.7 for consideration of the potential impacts that could occur in the event of a Project-related accident, malfunction, emergency, or disaster, including potential incidents related to hazardous materials, and proposed mitigation measures.

3.6 ANTICIPATED EMISSIONS, DISCHARGES, AND WASTES

As described further below (and depending on their nature), Project-related emissions and discharges will be released to the environment, re-used, directed to on-site drainage and collection systems, or discharged to the municipal sewage system. Solid and liquid wastes that are destined for off-site disposal will be temporarily stored on-site in rubbish bins, containers, or water-tight barrels. Appropriately licensed third-party service providers will be engaged to remove non-hazardous and hazardous wastes for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. Waste containment receptacles containing food wastes will be secured to prevent the attraction of birds or other wildlife. Efforts will be made to divert solid waste materials from the landfill through re-use or recycling wherever practical to do so, and solid wastes will be sorted on-site to facilitate these efforts.

An overview of proposed environmental protection procedures, including those pertaining to waste management, is provided in Section 3.7.

3.6.1 Construction

Potential emissions, discharges, and wastes associated with Project construction activities will be relatively short-term in duration (i.e., occurring over a part or the whole of the approximately 24-month construction period) and in many cases will be the responsibility of the construction contractor, in consultation with the Proponent. They will include, but may not be limited to:

- **Air and noise emissions:** Project vehicles, heavy equipment, and machinery will burn petroleum fuel, either diesel or gasoline, which will generate greenhouses gases (GHGs) and other by-products of combustion. Fugitive dust emissions may be generated by vehicles, such as trucks delivering materials to the Project Property, or by automobiles, trucks, or heavy equipment and machinery used at the site. Potential pile driving (if required) would be associated with noise and vibration. Noise will also be generated by various other construction activities.
- **Construction and demolition waste and debris:** Construction and demolition waste and debris materials, such as concrete, steel, scrap iron, and wood, will be collected and temporarily contained on-site in a designated area until they can be transported to an approved existing disposal facility or landfill site.

- **Garbage from construction personnel:** Human activities on-site will generate garbage, which if not properly managed can lead to pollution and littering. This waste will be handled through the existing municipal solid waste disposal system in the Parish of Saint Philip. If the amount of waste generated is greater than the volumes that the existing waste disposal system can handle, the contractor will be responsible for ensuring that construction wastes are properly collected, handled, and transported to an approved landfill or disposal site.
- **Sanitary sewage from construction workers:** Contractors will be responsible for establishing portable toilet facilities for construction workers and for ensuring that sanitary sewage is appropriately collected and treated prior to disposal.

3.6.2 Operation and Maintenance

Table 3.1 indicates the types and quantities of certain solid and liquid wastes that will be produced during the operation and maintenance phase of the Project.

Table 3.1 Types and Quantities of Certain Project-Related Solid and Liquid Wastes

Type of Waste	Quantity	Storage Site
Sheep manure	1,300 t/year	Disposal bins / designated area
Municipal solid waste	10 m^3/year	Containers according to type of material
Metal scrap and cables	75 kg/year	Warehouse / designated area
Septic tank cleaning	10 m^3/year	Impermeable container
Mineralised water	30 m^3/day	Water tank
Electrolysis electrolyte	100 m^3 every 10 years	Specific tanks
Ion exchange resin	80 kg/year	Waterproof container
Activated carbon	80 kg/year	Waterproof container
Particulate air filters	200 kg/year	Waterproof container
Chemical air filters	1,000 kg/year	Waterproof container
DEOXO catalyst (palladium on alumina beads)	1,000 kg/year	Waterproof container
Used oils and greases and contaminated rags	2 m^3/year	Waterproof container
Oil separator cleaning	10 m^3/year	Waterproof container

Figure 3.16 presents a flow diagram of Project processes, inputs, and outputs associated with operation of the solar PV power plant and energy storage systems, including the main emissions and discharges. Further details regarding these anticipated Project-related emissions and discharges, as well as anticipated Project-related solid wastes, is provided below.

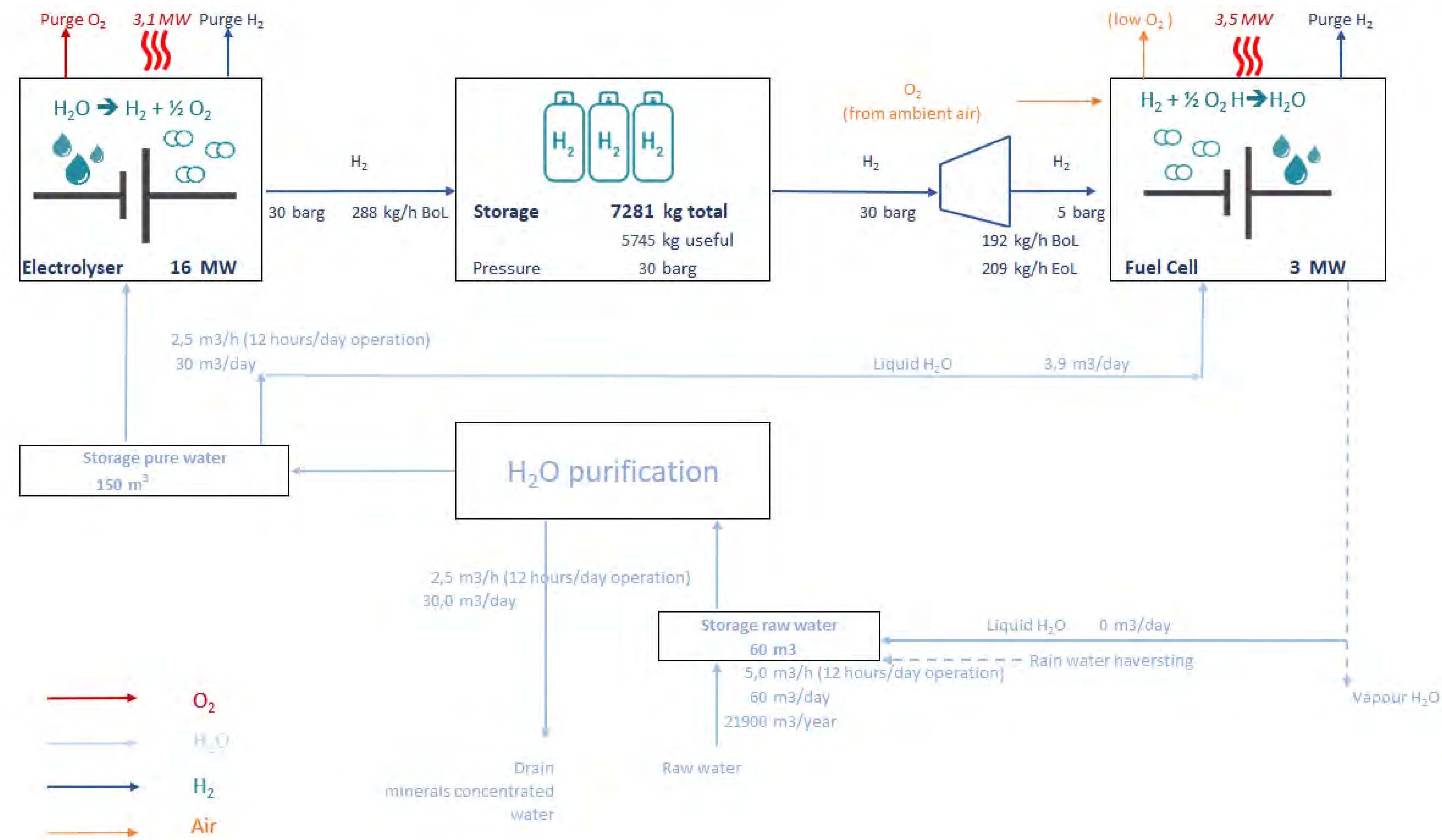

Figure 3.16 Flow Diagram of Project Inputs and Outputs

Potential emissions, discharges, and wastes associated with Project operation activities will occur continuously or periodically over a longer term and the responsibility for the control and management of these wastes will lie with the Proponent. They will include, but may not be limited to:

- **Air and noise emissions:** Air contaminants and noise will be generated from the operation of Project vehicles, heavy equipment, and machinery (including farming equipment and machinery), which will result in small increases in the overall level of air contaminants (i.e., GHGs and other by-products of combustion) in the atmosphere, as well as localized noise levels. The presence of sheep will also be associated with GHG emissions (e.g., methane), as well as noise emissions (e.g., the bleating of the sheep). According to Weeks et al. (2009), the sound pressure levels within a sheep pen containing approximately 100 sheep range from 57 to 62 A-weighted decibels (dBA). Sheep manure typically dries out and breaks down quickly without producing strong odours, unlike chicken and pig waste.

  The following gaseous emissions will be released from the HESS during the operation and maintenance phase of the Project (refer to Figure 3.16):
  - Pure oxygen will be released from the water electrolysis process.
  - Small quantities of hydrogen gas (H_2) may be purged in a controlled manner during operation and maintenance of the electolysers and fuel cells.
  - Air containing a low level of oxygen (O_2) will be released during operation of the fuel cells.
  - Water vapour (pure H_2O) will be released during operation of the fuel cells.

  These gaseous emissions are anticipated to be non-polluting.

  According to the results of a Project-specific Acoustic Assessment (Appendix E) conducted in support of the ESIA, the main noise sources during Project operations will include the transformers, inverters, electrolysers, and battery packs. Operation of these Project components is anticipated to produce sound pressure levels ranging from 78.5 dBA (for the inverters) to 106 dBA (for the fuel cells).

- **Solid wastes from Project operations:** As noted in Section 3.6.2, Project maintenance activities will include corrective or preventative replacement of non-hazardous electronic components, such as PV modules, inverters, and fuel cell stacks. For example, it is anticipated that the fuel cell stacks and electrolyser stacks will need to be replaced once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations). These types of solid waste will be handled by specialized electronics recycling/disposal facilities or returned to the manufacturer.

  The main waste stream from the sheep farm will be manure from the sheep stock. This is estimated at 1,200 metric tonnes per year, assuming a herd of 1,830 mostly adult sheep, and will be stored in disposal bins in a designated bio-waste storage area. This waste will be bagged and sold to fertilizer distributors and/or directly to local farmers, and/or will be removed and disposed of by a local bio-waste disposal company. It is anticipated that a fully operational manure bagging plant would safely manage 100% of the sheep manure generated at the farm. Other streams from the farm would be from plant equipment and vehicles, which are anticipated to be minimal, and sanitary sewage from farm employees.

  Other (standard) non-hazardous solid wastes, including solid wastes from human activities on the site, will be disposed of through the local municipal waste disposal system.

- **Sanitary sewage from Project employees:** Wastewater from sanitary uses within Project buildings will be discharged to the municipal sewage system.
- **Mineralized water by-product of reverse osmosis:** In water treatment applications of reverse osmosis, the solvent stream is purified water and the solute stream is concentrated waste. As shown on Figure 3.16 and described in Section 3.2.3.5, approximately 30 m^3/day of water concentrated in minerals will be released from the on-site package water treatment plant as the by-product of the reverse osmosis process that will be undertaken to demineralize water for use in the electrolysers as part of the HESS. Given that potable water supplies from BWA's existing public water mains will be used as the input into the reverse osmosis process, the resultant mineralized by-product water is not anticipated to contain potential contaminants other than the minerals that were removed during reverse osmosis (e.g., salt, manganese, iron, fluoride, lead, and calcium). The concentration of minerals in this by-product water is anticipated to be suitable for irrigation of the grazing and fodder pasture areas of the agricultural facilities, as well as for washdown. Table 3.1 below indicates the tolerance of different forages to electrical conductivity and total dissolved solids, according to research performed in California, USA (CCME 1987).

Table 3.2 Tolerance of Selected Crops to Electrical Conductivity and Total Dissolved Solids in Irrigation Water

Degree of Tolerance	Forages
Electrical Conductivity < 3,600 μS/cm Total Dissolved Solids < 2,500 mg/L	Oat hay Wheat hay Mountain brome Tall fescue Sweet clover Reed Canary grass Birdsfoot Trefoil Perennial ryegrass
Electrical Conductivity < 5,000 μS/cm Total Dissolved Solids < 3,500 mg/L	Barley hay Tall wheatgrass
Notes: μS/cm = microsiemens per centimetre mg/L = milligrams per litre Source: CCME 1987.	

- **Process water from the HESS:** The process water emitted from the HESS when the fuel cells convert the hydrogen and oxygen back into electricity and water (as described in Section 3.2.1.2) will be recirculated to the electrolysers for re-use in the electrolysis process (i.e., to reduce water consumption by the electrolysers).

- **Surface runoff:** Surface runoff from rainwater/stormwater and Project sources (including potential excess water from the washdown and sanitation of Project facilities and the irrigation of grazing and fodder pasture areas) will be managed through on-site drainage works (refer to Section 3.2.3.6). On-site rainwater harvesting, if implemented (Section 3.2.3.5), will also reduce runoff during precipitation events.
- **Agricultural wastes:** Sheep manure from the pens will be collected in skips and sold to soil mix and landscape companies as needed. Some will also be spread across the site as fertilizer to assist with healthy grass growth. No butchering will take place on site, and any dead animals will be removed and disposed of at approved facilities.
- **Hazardous wastes**: The main hazardous wastes associated with the Project are the Li-ion batteries that will comprise the BESS, the KOH solution that will serve as an alkaline electrolyte in the electrolyser components of the HESS, and the oil in electrical transformers. None of these hazardous wastes are process outputs (and therefore they do not pose an operating environmental risk as such), but they will nonetheless require end-of-life disposal. As described in Section 3.5, these hazardous wastes will be disposed of as follows:
  - Used Li-ion batteries will be sent back to the manufacturer for end-of-life disposal at an approved facility, in accordance with applicable regulatory requirements.
  - When replacement and disposal of the used KOH solution is required, RSB will manage the safe removal, handling, and transportation of the product for recycling at an approved facility, in accordance with applicable regulatory requirements.
  - At the end of its useful life, transformer oil will be collected by a local specialist oily waste contractor for disposal at the Barbados National Oil Terminal, or for disposal by other approved means, in accordance with applicable regulatory requirements.

3.6.3 Decommissioning

It is anticipated that the types of potential emissions, discharges, and wastes that will be generated during the decommissioning phase of the Project will be comparable to those generated during the construction phase. They will similarly be relatively short-term in duration (i.e., occurring over a part or the whole of the approximately 12-month decommissioning period) and in many cases will be the responsibility of the decommissioning contractor, in consultation with the Proponent.

It should be noted that the HESS infrastructure will be almost entirely recyclable upon completion of Project operations.

3.7 DESIGN MITIGATION AND ENVIRONMENTAL PROTECTION PROCEDURES

3.7.1 Design Mitigation

Key design mitigation features that will be incorporated into the Project include the following:

- The design of the Project as a dual land use project with integrated energy and agricultural facilities, which will enable baseload renewable energy production while preserving local agricultural activities and saving foreign exchange (refer to Section 4.2).
- The design of the BESS and HESS as consisting mainly of cabinets and containerised enclosures equipped with internal systems to maintain safe operating conditions (refer to Section 3.2.1.2) and mitigate the potential impacts of an accident, malfunction, emergency, or disaster (refer to Section 8.7).
- The design of the Project energy facility to employ clean technologies that produce baseload renewable energy without any harmful operational emissions or process outputs (refer to Section 3.6.2).
- The possible sale of animal by-products from the agricultural facilities (i.e., sheepskin and manure), in addition to the production of lamb/mutton meat (refer to Section 3.2.2).
- The planned re-use of the mineralized water by-product of reverse osmosis for irrigation and washdown purposes, which will reduce Project-related consumption of potable water (refer to Section 3.2.3.5).
- The planned recirculation of process water from the HESS to the electrolysers for re-use in the electrolysis process, which will reduce Project-related consumption of potable water (refer to Section 3.2.3.5).
- Evaluation of the viability of rainwater harvesting via water tanks located beneath Project buildings/infrastructure and the planned establishment of drainage reserves for runoff management, which reduce Project-related consumption of potable water as well as mitigate potential erosion and sedimentation impacts (refer to Section 3.2.3.5 and Section 3.2.3.6).

3.7.2 Environmental Protection Procedures and Mitigation Measures

Table 3.3 provides a preliminary list of the general standard environmental protection procedures and VC-specific mitigation measures that are proposed to be implemented during the construction, operation and maintenance, and decommissioning phases of the Project. The general standard environmental protection procedures are broadly applicable to multiple VCs (i.e., the components of the biophysical/ecological, anthropogenic, and social environment that are identified in Section 6.2), while the VC-specific mitigation measures have been compiled from the impact assessments conducted for the various VCs in Sections 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, and 9.2 of this ESIA.

The list of general standard environmental protection procedures and VC-specific mitigation measures may be modified as the design of the Project progresses and becomes finalized. Various monitoring and management plans will be developed and implemented for the Project, and will also outline relevant environmental protection procedures and mitigation measures, including an Environmental and Social

Management Plan (ESMP), which will contain a Construction Management Plan and an Emergency and Disaster Management Plan (refer to Chapter 11). Note that mitigation recommendations have been included in the various studies (appended to this ESIA). As each of these studies was prepared independently, in some cases, there are slight variations in recommendations. For this reason and for consistency and clarity, the mitigation measures identified in the following table and in the ESMP (Appendix I) represent the commitments of RSB in relation to this Project and supersede recommended mitigation measures in the appended studies.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
General Standard Environmental Protection Procedures	
Waste Management	
Construction	• During construction, the contractor will deal with surplus waste materials responsibly. Relevant waste and resource management procedures will be communicated to employees during the initial site induction. This will include procedures on segregation, handling, recycling, re-use, and return methods to be used. A specific area will be set out to facilitate separation of the various types of waste. • Appropriately licensed third-party service providers / waste contractors will be engaged to remove non-hazardous and hazardous wastes for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. • Proof of appropriate waste disposal, recycling, and/or treatment at approved waste management facilities must be provided by the contractor. • Separate secure containers will be provided for the collection of food wastes and other solid wastes, and the contents of these will be regularly disposed of at an approved landfill. • Materials defined as hazardous or toxic waste will be placed in appropriate designated containers. • Metals, wood, and other recyclable waste materials will be diverted to appropriate recycling facilities. • Waste will be reused / recycled as much as practical to reduce the total volume going to the landfill. • Paper, plastic, polystyrene, corrugated cardboard, and packaging material will be collected and separated for disposal in appropriate on-site bins for recycling. • Metal banding will be folded, flattened, and placed in designated areas for recycling. • Packaging materials will be removed from site and disposed of at appropriate recycling facilities. • General debris will be removed from the Project Property and disposed of at an approved site. • Dirt, dust, and debris will be collected from the roadway drainage gutters and properly disposed of on a regular basis. • Waste materials and debris will be collected in acceptable containers on-site and disposed of off-site in an environmentally acceptable and approved site. • Volatile wastes and materials, such as fuel, mineral spirits, oil, or paint thinner will be stored appropriately and will not be permitted to enter into waterways, storm drains, or sanitary sewers. • Project-related wastes will not be deposited in a location or manner that obstructs the flows of surface drainage or natural watercourses. • Vegetation removed from the site will be chipped and used as mulch on-site and/or disposed of at an appropriate off-site waste disposal facility.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• To help prevent silt runoff and dust creation, waste soils that have been excavated from the site will be reused as backfill materials or re-distributed around the site and used for remediation and biodiversity enhancement features. • Portable toilet waste will be removed from the site by the supplier in a timely manner. • Fires and the burning of rubbish and waste materials on-site will not be permitted. • Rubbish and waste materials will not be buried on-site.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • Solid waste generated on-site will be removed on a regular basis throughout the operational phase. • Sheep manure will be removed from the sheep pens daily to prevent the infestation of flies and other insects. • A waste inventory will be developed to support the management of general and hazardous operational waste streams.
Decommissioning	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Spill Prevention, Control, and Response	
Construction, Operation and Maintenance, and Decommissioning	• Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer. • Spill response kits will be available on-site. • Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorized personnel. • Fueling and servicing will be conducted at designated sites furnished with spill containment equipment. • Fueling and servicing areas will be sited away from watercourses and drainage works where possible. • The potential for spills will be reduced through the use of standard good practices, such as the use of appropriate containers, and avoiding overfilling. • In the event of a spill, dry clean up and mopping techniques will be used as appropriate. The area will not be "washed down" as this could cause the spills to spread to the surrounding environment and potentially enter drainage works or environmentally sensitive areas. • Spilled material and spent lubricants will be collected and removed from site for disposal at an approved location. • Vehicles, heavy equipment, and machinery will be properly maintained to reduce the risk of leakage. Routine preventative maintenance and inspection of hydraulic equipment and machinery will be undertaken to avoid a hazardous material release. • Soil which may have become contaminated during the course of construction will be remediated. This may be done on-site or removed from site for disposal at an approved location. • Project vehicles will be equipped with appropriately sized spill kits containing the necessary supplies to handle the quantity and type(s) of hazardous materials that are on-site. • Communication systems will be in place and functioning.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor.
VC-Specific Mitigation Measures	
Measures to Mitigate Impacts on the Atmospheric and Acoustic Environment (including Vibration)	
Construction	• Only areas required for construction will be cleared. • Where practical, Project vehicles, heavy equipment, and machinery will be sized to the smallest needed to perform the work. • Air and acoustic emissions from Project vehicles, heavy equipment, and machinery will be managed by conducting regular inspection, repair, and maintenance activities as required for operation in accordance with manufacturer's recommendations and to reduce instances of visible sooty emissions or abnormally high sound levels. Defective vehicles or equipment will be taken out of service and not permitted to resume operations until they are repaired. • Project vehicles, heavy equipment, and machinery will be outfitted with mufflers (and/or other appropriate sound attenuation devices) that meet international design standards. • Project vehicles, heavy equipment, machinery, and associated exhaust systems and mufflers (and/or other appropriate sound attenuation devices) will be regularly inspected and maintained so that they remain operating in accordance with manufacturer's recommendations. • Project vehicles, heavy equipment, and machinery will be shut down when stationary for long periods of time. The idling of vehicles and equipment will be avoided whenever practical. • Dust from Project activities will be controlled where required by using applications of water. Waste oil will not be used for dust control, but other agents, such as wood chips, calcium chloride, matting, and revegetation may be considered on a site-specific or as needed basis. • Project-related fugitive road dust will be controlled through measures such as: – Establishing speed limits of less than 20 km/hour on Project-controlled gravel roads – Conducting road watering on an as-needed basis – Washing truck tires before leaving the construction area onto existing paved roads – Requiring trucks hauling material to have tarps to cover the load • Dust emissions during Project activities will be further reduced by covers, screens, enclosures, or other similar methods, where necessary. • Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors, which will help to prevent the movement of dust onto surrounding areas. • Cleared areas will be paved or revegetated, where possible. • A cover of native grass will be planted and maintained under and between rows of solar PV panels and routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could produce dust emissions during dry conditions. • Stockpiles of topsoil, overburden, and other potentially dust-generating materials will be kept covered and used as soon as practical. • Waste materials will not be burned on-site. • Haul distances to disposal sites will be reduced as much as possible. • A construction fence will be retained along the perimeter of the site where feasible; this will act as a barrier to prevent the movement of dust onto surrounding areas. • Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• Blasting will be avoided, where possible, during construction. • If required and if feasible, augering will be conducted rather than pile driving. If pile driving cannot be avoided, it will be scheduled during daytime hours only and a vibratory hammer will be used since it is quieter and generates less vibration than an impact hammer. • Nearby residents will be notified prior to potential pile driving (if required). • With respect to potential vibration impacts, the contractor will have the required insurance policies in place to cover legitimate claims that may result from damage due to vibration during the construction phase. • Project vehicles will drive within the speed limit to reduce engine noises as vehicles travel on roadways within adjacent communities and horns will be used only as necessary for safety purposes. • Acoustical barriers (e.g., engineered materials or stockpiled overburden) will be used near loud sources during construction, if feasible. • Walled enclosures may be constructed around especially noisy activities, or clusters of noisy equipment or machinery. In cases where it is technically and economically feasible to do so, physical noise controls (e.g., an enclosure for the BESS and physical barriers for transformers and inverters) will be established and Project components with noise reduction capabilities will be preferentially selected. • Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential impacts to various receptors, including flora and fauna, surface water resources, and surrounding agricultural and other land users, residents, and businesses.
Operation and Maintenance; Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project maintenance and decommissioning activities.
Measures to Mitigate Impacts on Surface Water and Groundwater Resources	
Construction	• Existing drainage systems within the Project Property – including land slopes, watercourses, depressions, suckwells, and dry ponds – will be retained and maintained where possible. • A cover of native grass will be planted and maintained under and between rows of solar PV panels to help slow the rate of runoff, control erosion, and reduce the transport of sediment/topsoil off-site. • Paved roadways within the Project Property will consist of kerb and slipper drains, with sets of catchbasins including gully grates to drain captured runoff to culverts leading to suckwells. • A 9-m wide drainage reserve has been proposed along the entire southern boundary of the Project Property. This would involve construction of a runoff interceptor drainage system within the aforementioned drainage reserve. This system may consist of an earthen swale with sloped embankments or an infiltration trench with vertical side faces. Suckwells/infiltration wells may be added to the interceptor drain to assist with the sub-surface drainage of captured rainwater. A hydrological study will be performed during detailed design which will seek to finalise drainage mitigation measures, including final selection of any interceptor drainage system(s) that would be required. • A vegetated buffer strip will be established at the downstream site boundary to control excess runoff. • Silt screens and/or bales of hay will be installed where necessary to contain and prevent the erosion and loss of topsoil from localized areas. • Temporary boulder barriers will be installed at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands. • Temporary stockpiles of topsoil that are not required for re-instatement will be removed from site as soon as possible to avoid migration of topsoil into the natural drainage system.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor. • The drainage system for the site will be designed to limit stormflows from the site. • The drainage system design for areas on-site where impermeable areas are to be added will focus on draining runoff to suckwells, and ultimately to groundwater, to reduce the amount of surface water runoff that could potentially impact communities downstream. • During detailed design, the implementation of a dry pond will be studied. If needed, the dry pond will be constructed on land to the west of the area proposed for sheep grazing, north of the Old Train Line Road (i.e., at the location shown on Figure 17 in Appendix B), to capture a portion of runoff from the North Watershed, promote the infiltration and percolation of runoff to groundwater zones, and reduce to some extent the quantity of runoff that crosses the Old Train Line Road and enters the Project Property. The dry pond shall have shallow slopes, be grassed to facilitate grazing by sheep, and include suckwells with top and side entry inlets along its perimeter.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • Routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could result in a change of the runoff characteristics in those areas. • Paved areas within the HyPCe area and administration areas will be drained by a system of catchment basins, drainpipes, and suckwells. The use of suckwells is intended to promote on-site drainage of runoff to groundwater, rather than to natural drainage courses that convey runoff south and off-site. • The cleaning of PV panels will only be done with clean water. No detergents or cleaning chemicals will be used so that the water that runs off onto the ground does not have chemicals entrained. • Septic tanks and soakaways will be routinely inspected at least once every six months and cleaned as necessary.
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on Flora and Fauna	
Construction	• The mitigation measures identified above and in Section 8.2.2 with respect to the Atmospheric and Acoustic Environment VC will be implemented to mitigate the potential impacts of air, noise, vibration, and dust emissions on flora and fauna. In addition, Project-specific noise and dust management. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna. • Only areas required for construction will be cleared, and construction equipment and vehicles will only operate in previously disturbed areas, where possible. Sensitive areas and habitats (if identified) will be fenced off to prevent damage by Project vehicles, heavy equipment, and machinery. • The vegetation/tree screens, which are proposed for reducing visual impacts (refer to Section 8.5.2), will also reduce sensory disturbance to fauna off-site. • Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce the attraction of birds.Native plants will be used for landscaping. • Cleared areas will be revegetated, where possible.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• To avoid attracting wildlife, wastes will be securely stored, frequently removed from site, and properly disposed of in an environmentally acceptable manner at an approved site. • Erosion and sediment control measures will be established to reduce the potential for silty water runoff from construction areas to migrate off-site and/or into environmentally sensitive areas. Further details regarding proposed erosion and sediment control measures are provided in Section 8.3.2 in the context of the Surface Water and Groundwater Resources VC. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels. • Regular monitoring for evidence of avian mortalities / collisions with Project infrastructure will be conducted. Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations.
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on the Visual Environment	
Construction	• Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted in areas where potential off-site visual impacts are of such a nature and magnitude that warrants the introduction of vegetation/tree screens. • During the growing-in period of the vegetation/tree screens, the perimeter fencing around the Project Property will be fitted with an opaque privacy screen. • Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce visual impacts.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels. • An adaptive management approach will be employed if complaints regarding glint and glare are received from local residents or other surrounding land users, potentially including implementation of some or all of the following mitigation measures: – the establishment of additional and/or taller vegetation/tree screens and/or additional opaque privacy screens to further shield or obscure offending panels so that they cannot be seen – replacement of the offending solar panels with those that have a deeply textured surface, to reduce glare intensity – removal or reorientation of the offending solar panels • More generally, if complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on Agriculture and Other Land Uses	
Construction	• Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential sensory/nuisance impacts to nearby land users (e.g., agricultural workers on the site or on adjacent lands), residents, businesses, and other off-site receptors. The ESMP also includes details of how RSB will liaise with the local community before each phase of development. • Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays). • Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors and will act as a buffer to adjoining lands.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • RSB will consult with neighboring landowners and request that the spraying of herbicides on adjoining fields be limited to days that are not windy in order to reduce dispersion onto the operational renewable energy facility and the sheep farm. • If complaints are received from agricultural or other land users regarding perceived Project-related impacts, RSB will work with the affected land users to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on the Social Environment	
	Health and Safety • Measures to mitigate potential impacts on the health and safety of Project personnel (including contractors and employees) and site visitors include: – Project personnel will conduct weekly occupational health and safety (OHS) meetings. – OHS plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans. – The Project will be compliant with the legal and statutory labour requirements, to safeguard community and worker safety and health. – Personnel will be required to use protective gear to guard against on-the-job injuries. – Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers. – Only trained and/or certified persons will use specialised equipment and handle dangerous chemicals. – There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site. – Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorised personnel. – An emergency and disaster management plan (Section 11.3) will be implemented as part of the ESMP (Appendix I), with emergency drills regularly conducted so that Project personnel are able to respond swiftly and appropriately in the event of an incident.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	– Traffic management measures will be put in place and consistently implemented to control on-site traffic, as well as the practices of construction drivers to and from the construction site. – There will be adequate 24-hour security to prevent unauthorized entry into restricted Project areas, through CCTV or equivalent monitoring systems. Additional provisions that will be made to enforce safety in and around construction areas include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meet the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways. • Measures to mitigate potential impacts to public health and safety include the following: – Adequate signage, fencing, guardrails, and/or warning tape will be installed so that members of the public, particularly children, cannot wander into restricted Project areas, and sufficient security will be in place to monitor and enforce these restrictions. – Safety warning signs will be strategically placed near construction works to inform the public of prohibited activities. These signs will include both printed words and international symbols and will meet the universal design environmental access requirements/standards for persons with disabilities. – Notices will be published in the media to alert the public of the proposed construction works at least two weeks prior to the start of activities. – 24-hour security measures will be used to prevent unauthorized entry of persons after working hours, through CCTV or equivalent monitoring systems. – Potentially hazardous areas within and adjacent to the site will be left in a safe condition (e.g., securing materials and equipment, fencing off or preventing entry into excavations or trenches). – If detours are planned, relevant local authorities will be notified of the alternative routes in advance. – Project drivers will be cautioned to obey the speed limit and other traffic laws, and should ideally be trained in defensive driving. – Unauthorized persons who enter the site will be escorted off the site as soon as they are discovered. – The area will be well-lit and the public advised on site restrictions. **Human Capital and Social Dynamics** • In addition to regular OHS training and the proposed capacity-building and skills development, contractors will be required to provide gender sensitization training to address critical on-the-job issues and facilitate positive interactions between workers and the surrounding residents. Topics to be included in the training include gender-responsive behaviour and interactions, avoiding sexual harassment, and conflict resolution skills. In addition, there will be transparent disclosure of the requirements for adequate work facilities and decent work, to allow employees to be apprised of their worker rights and benefits. **Economy** • To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being made available to unemployed residents of specifically neighbouring communities.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	Cultural Values • Concerns about the potential change to the aesthetics of the area will be addressed through a carefully planned and implemented public awareness campaign to address the typical concerns raised about the construction of solar facilities on the scale of the Project. An important component of this campaign will be to clearly explain the design of the facility and the potential benefits that could accrue to Barbados. • Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the Project Property. In this event, the contractor will work with the Museum to develop and implement a plan to protect the artefacts. • Public service announcements will be provided so that commercial operators, residents, and the public are updated on and given appropriate advance notice of the construction activities, especially those, such as construction activities planned outside of typical work hours, such as late evening or night, that could be disruptive. • Construction will be based on approved construction management measures in the ESMP to reduce the impacts of noise, dust, vibration, wastes, and traffic (refer to Chapter 11 and Appendix I). **Infrastructure and Services** • As indicated above, traffic management measures will be put in place and consistently implemented to control on-site traffic, as well as the practices of construction drivers to and from the construction site. • Measures to mitigate potential impacts on the use of public roadways include: – Transport of material and equipment will be scheduled for off-peak hours, to the extent practical. – The use of long convoys or trucks during construction and operation will be avoided. – Transport of over-sized loads (such as hydrogen tanks) will be coordinated with local traffic management authorities and / or the police. Arrangements will be made for police outriders to accompany long or wide loads during construction. – Flag-persons will be used at intersections with existing roads, or where single lane traffic is created during construction. – Signs will be used to indicate construction zone and movement of trucks and equipment. – High occupancy vehicles like buses will be used to transport workers to and from the site to the extent practical. – Roads, culverts, and bridges which are located along the access routes to the construction site will be inspected prior to the start of construction to check the stated load capacity. This should determine whether they can withstand the expected traffic loads and necessary mitigation should be carried out such as strengthening works, signing, diversions of routes. – Roads, culverts, or bridges which may be damaged as a direct result of construction traffic will be repaired. The nature of repairs will be determined in consultation with the Ministry of Transport, Works, and Water Resources, with repairs done as soon as practical. – Utilities will be properly mapped and considered during construction, and especially prior to ground disturbance activities. – Appropriate consultation will be carried out with utility providers and operators and arrangements will be made for addressing conflicts. – Prior to work, the contractor will consult with the local police service, the local fire service, and the local health authority to discuss proposed activities and possible implications for community services.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. When operational, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. In addition to addressing the impacts of noise, air quality, vibrations, worker health and safety, and public health and safety, the ESMP (Appendix I) includes a Social Management Plan that comprises both a stakeholder engagement plan and a grievance redress mechanism, which are designed to allow the best interests of relevant stakeholders to be considered during the Project. The ESMP also includes a Social Monitoring Plan.
Decommissioning	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.

3.8 OCCUPATIONAL HEALTH AND SAFETY

Occupational health and safety (OHS) plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans. Personnel will be required to use protective gear to guard against on-the-job injuries. Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers. Only trained and/or certified persons will use specialised equipment and handle dangerous chemicals. There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site. Weekly OHS meetings will be held.

3.9 PROJECT ALTERNATIVES

3.9.1 Do-Nothing Scenario

To do nothing would result in the Project Property continuing to be used as it currently is – for farming sugarcane and rotational crops (e.g., cotton). Conversely, proceeding with the Project as proposed will enable dual land use of the Project Property to generate renewable electricity while also maintaining the availability of the land for agricultural activities (i.e., sheep farming).

Chapter 4 describes the Project's anticipated contribution to energy production as well as several environmental, social, and economic benefits of the Project, including advancement of Barbados' progress towards achieving its BNEP goals (Government of Barbados 2019a) of attaining 100% renewable energy usage and carbon neutrality by 2030. These Project benefits would not be realized in a do-nothing scenario.

3.9.2 Alternative Renewable Energy Project

The production of wind energy via the installation of wind turbines on the Project Property is an alternative renewable energy solution that could be considered to advance Barbados' progress towards achieving the transformational goals stated in the BNEP (Government of Barbados 2019a). It may be possible to erect several smaller turbines or possibly two or three larger turbines on the site, that is to say less than 10 MW of installable capacity. However, the feasibility of this alternative is unknown since no site-specific wind study has been undertaken to determine whether the natural wind regime of the Project Property is even suitable for the development of a wind power project. In addition, a wind power project would be associated with several potential adverse impacts that are not anticipated for the Project, including visual impacts to surrounding communities, shadow flicker from the rotating turbine blades, nuisance impacts from turbine noise, and the risk of bird and bat kills.

3.9.3 Alternative Location for the Project

Harrow Plantation was selected as the preferred Project location for several reasons, including the following:

- The Project Property is large enough to accommodate Project components and activities while maintaining a substantial setback around the HyPCe area (i.e., with a radius of more than 200 m from the nearest permanent residence) as a safety zone.
- The immediate vicinity of the Project Property is not densely populated, and the Project Property is sufficiently separated from surrounding residences, businesses, and institutions to help reduce potential sensory disturbances or nuisance impacts to sensitive off-site receptors.
- The Project Property is located approximately 3.5 km away from BLPC’s existing substation in Hampton, Saint Philip, Barbados, where the power plant will be connected to the national grid.
- The Project Property has relatively flat and uncomplicated topography.
- The Project property has good soil for growing high-protein grasses suitable for use by grazing sheep and as fodder.
- The Project Property is in close proximity to adaptable transmission infrastructure.

The initial site that was considered for the Project location was Orange Hill Plantation, in the Parish of Saint Peter, which is situated near the northern end of the island of Barbados. Although Orange Hill Plantation would have been a possible Project location due to its remoteness and proximity to existing high-capacity electricity transmission infrastructure, use of that site for the Project was ultimately determined to be not feasible due to complications during the land procurement process and presence of gullies and water runoffs.

3.9.4 Alternative Electrolyser Technology

Three different technologies of electrolyser exist on the market: alkaline, PEM, and solid oxide. The main difference between the technologies is the electrolyte used. Two technologies may be suitable for the Project: alkaline and PEM. Alkaline technology, which uses KOH as an electrolyte in a closed-loop process, was selected because it is more mature than PEM technology.

3.9.5 Alternative Solar Energy Storage Technology

Batteries have been selected as the preferred technology for the short-term storage of solar energy from the Project and hydrogen fuel cells have been selected as the preferred technology for the longer-term storage of solar energy from the Project.

Potential alternative solar energy storage technologies include pumped-storage hydropower, thermal energy storage, flywheel storage, and compressed air storage. However, these alternative technologies are not preferred for the following reasons:

- Implementation of pumped-storage hydrogen technologies would require quite specific topographical conditions, large quantities of water, and an extensive surface area. Pumped-storage hydropower projects are usually very large-scale (GigaWatts) and entail high capital expenditures because of the complexity of their engineering requirements.
- Thermal, flywheel, and compressed air energy storage alternatives are low-maturity technologies, with no relevant commercial solution on the market for a project of the size of the Renewstable® Barbados Project.

Batteries (especially Li-ion batteries) are a well-matured technology, while hydrogen technologies (i.e., electrolysis, fuel cells, storage) are well-known worldwide and scaling up for use in a variety of industries. The Proponent has deemed a combination of Li-ion battery and hydrogen technologies to be the best technically and economically feasible solution to achieve short-term and long-term energy storage.

3.9.6 Alternative Battery Storage Technology

There are many battery storage technologies available on the market, but the current leading technology – and the technology most suitable for the Project – employs Li-ion batteries. The Proponent stays informed regarding new technologies in development for potential BESS applications (e.g., Lithium-sulphur batteries or solid-state batteries) and has determined that those new technologies have not yet reached sufficient maturity to be relied on for the Project. Conversely, Li-ion BESS manufacturing is rapidly scaling up worldwide due to the growing demand for use in electric vehicles and for stationary storage for residential, commercial, and utility purposes.

3.9.7 Alternative Hydrogen Fuel Cell Technology

Three different hydrogen fuel cell technologies exist on the market: alkaline, PEM, and solid oxide. The main difference between the technologies is the electrolyte used. The only fuel cell technology that is suitable for the Project is PEM. Of the fuel cell systems that are currently available on the market, only those employing PEM technology have sufficient capacity to be used for multiple-megawatt applications. The fuel cells to be used for the Project will be supplied by HDF Energy.

4.0 ENERGY PRODUCTION AND BENEFITS OF THE PROJECT

The total annual electricity demand for Barbados is approximately 900 gigawatt-hours (GWh), with a maximum load of approximately 170 MW. Average daily power consumption ranges from approximately 155 MW during the day to approximately 100 MW at night, with end-of-day consumption peaking at approximately 130 MW around 19:30.

Barbados' current installed dispatchable thermal power capacity is approximately 239.5 MW (Table 4.1), which allows a reserve margin for unscheduled downtimes and scheduled equipment maintenance. As shown in Table 4.1, Barbados' existing large-scale power plants primarily rely on imported petroleum products, such as heavy fuel oil, diesel, and jet fuel (kerosene). The steam turbines associated with these power plants are aging assets that need to be decommissioned.

Table 4.1 Large-Scale Power Plants in Barbados

Type of Power Plant	Power Installed	Type of Fuel	Specific Consumption	Carbon Dioxide (CO_2) Emissions
Steam Turbine	40 MW	Heavy Fuel Oil	3.78 kilowatt-hours (kWh) per litre (L)	1.39 tonnes (t) of CO_2 per MWh
Low-Speed Diesel Engine	113.5 MW	Heavy Fuel Oil	4.93 kWh/L	0.69 tCO_2/MWh
Gas Turbine	86 MW	Diesel and Jet Fuel	2.82 kWh/L to 2.94 kWh/L	0.95 tCO_2/MWh
Solar	10 MW	Solar	–	–
Source: Compiled by HDF Energy, based on publicly available data from the Fair Trading Commission (FTC).				

As noted in Section 1.1, the BNEP outlines the Government of Barbados' goals of achieving 100% renewable energy usage and carbon neutrality by 2030 (Government of Barbados 2019a), and BLPC and BREA have stressed the importance of implementing baseload renewable power generation to achieve these goals. The Project has been designed to deliver reliable baseload renewable power when it is most needed, including 13 MW of firm baseload power during periods of peak demand (i.e., typically between the hours of 8:00–17:00 and 19:00–21:00, as shown on Figure 4.1) when the price of conventional power generation is the highest due to the use of open cycle gas turbines running at a cost of between $250–$600 USD per megawatt. Thus, the Project will support Barbados' transition away from reliance on its existing fossil fuel burning power plants, whose components need to be decommissioned according to BLPC's retirement schedule (IADB 2016), and towards achieving the goals of the BNEP (Government of Barbados 2019a).

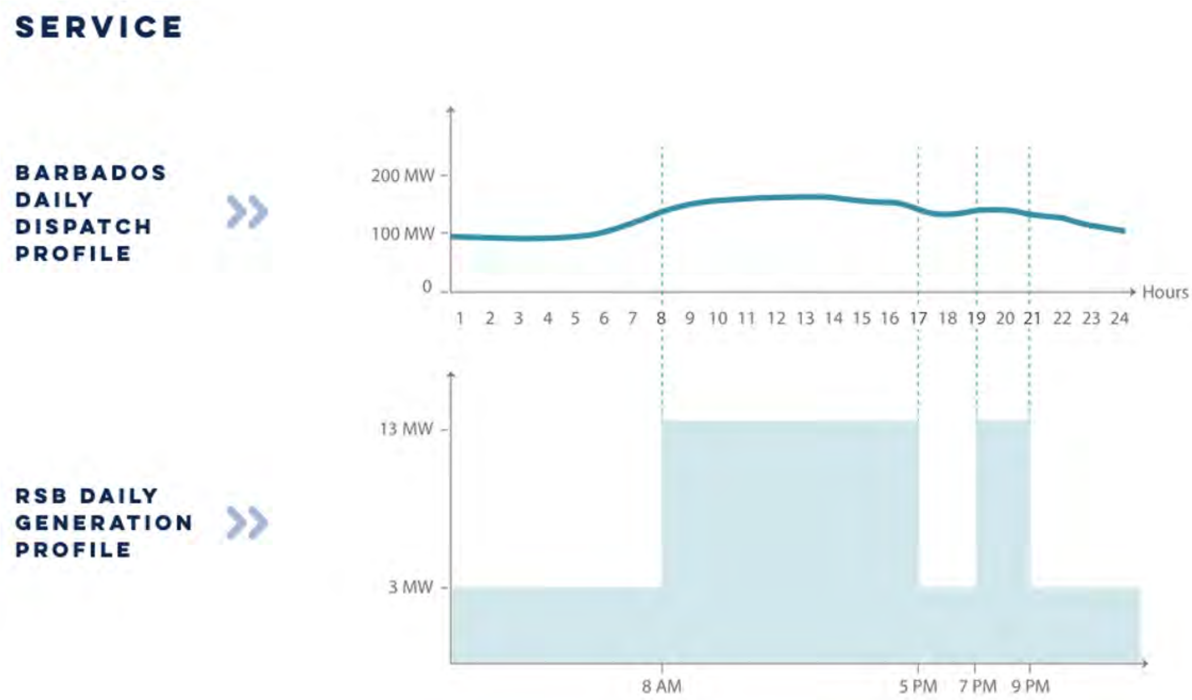

Figure 4.1 Barbados' Typical Daily Grid Dispatch Profile and Anticipated Project Generation Profile

Numerous small-scale to commercial-scale solar projects are expected to be developed in the upcoming years, and some large-scale solar projects (5–10 MW intermittent power plants) are in development as well. The existing small-scale solar PV systems on the island were installed under the Renewable Energy Rider (RER) Program with a feed-in tariff. In September 2019, the Barbados Fair Trading Commission (FTC) released new feed-in tariffs for renewable energy projects with generating capacities under 1 MW, thereby providing a regulatory framework for such size solar projects. It is anticipated that the future solar PV systems developed under these new feed-in tariffs will provide non-dispatchable electricity only during daytime hours and will be subject to intermittency, and that BLPC will therefore need to restrict power usage by its customers and/or invest in storage to dispatch this intermittent power without compromising energy security. A stand-alone storage investment by BLPC would likely be recovered through the FTC process and eventually transferred to the customer through the price of electricity.

The Project differs substantially from solar PV systems that provide intermittent power with minimal or no storage and will therefore help increase the penetration of renewable energy without causing intermittency issues. By combining hydrogen and lithium storage technologies, the Project offers a clean, carbon-free, viable, non-intermittent and renewable baseload solution that will help to sustain the stability of the grid at a competitive cost and with no hidden costs. It will deliver baseload power to the grid operator 24 hours per day, seven days a week, with an availability (i.e., capacity factor) higher than 85%. The Project EMS will enable RSB, based on the solar irradiance forecast and energy storage level data, to notify the grid operator 24 hours in advance regarding the availability of power so that storage can be optimized as necessary to deliver the maximum amount of power to the grid and reduce energy losses.

This predictable firm power will eliminate the additional operating costs and infrastructure upgrade requirements that BLPC would typically face when implementing traditional renewable energy projects (i.e., intermittent wind and solar).

In addition to offering substantial technical advantages over traditional renewable energy projects and advancing Barbados' progress towards achieving its BNEP goals of attaining 100% renewable energy usage and carbon neutrality by 2030, the Project is also anticipated to result in several other important environmental, social, and economic benefits, as outlined in the subsections below.

4.1 ENVIRONMENTAL BENEFITS OF THE PROJECT

4.1.1 Reduced Reliance on Non-Renewable Resources

Given the nature of the Project (i.e., a renewable power project), it will inherently reduce Barbados' reliance on finite fossil fuel resources for energy production, as well as the international and domestic environmental impacts associated with extracting, processing, transporting, and burning those fossil fuels.

4.1.2 Reduced Emissions

The Project energy facility will generate and deliver renewable power without emission of greenhouse gases or other air pollutants (however, limited GHG emissions will be associated with sheep farming and the operation of Project-related vehicles and equipment). By generating an average of approximately 56,000 MWh of carbon-free electricity per year, the Project is anticipated to reduce Barbados' total CO_2 emissions by approximately 48,000 tons annually[4].

Refer to Section 3.6 for a description of anticipated Project-related emissions, discharges, and wastes, which are generally anticipated to be minimal in comparison with those that would typically be associated with power generation from fossil fuels.

4.2 SOCIAL AND ECONOMIC BENEFITS OF THE PROJECT

4.2.1 Fixed and Competitive Pricing

RSB will derive its remuneration through a long-term power purchase agreement with BLPC that will be validated by the FTC. Compared to other firm renewable power solutions, the price is competitive and benefits from economies of scale. The cost of generation will be set and known for at least 25 years in the power purchase agreement, which will reduce the impacts of variable and unpredictable fuel cost adjustments on end-consumers.

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[4] Calculation based on average specific CO_2 emissions of 0.87 tCO_2/MWh, as per BLPC figures.

4.2.2 Employment

Project construction will be managed by an international engineering, procurement, and construction contractor that will subcontract most of the local workforce. It is estimated that the construction phase of the Project will provide temporary employment for up to approximately 150 local people. Following construction, it is estimated that approximately 20 full-time-equivalent local jobs will be created to support Project operation, maintenance, and security requirements. The sheep farming aspect of the Project is expected to create 10 full-time-equivalent local jobs as farmers and farm staff. In addition to their pay, Project personnel will also gain valuable experience and training.

4.2.3 Optimized Land Use and Agricultural Benefits

As a dual land use project that accommodates commercial sheep farming within the grounds of the solar PV power plant, the Project will enable baseload renewable energy production while preserving local agricultural activities and saving foreign exchange (refer to Section 4.2.4 below). Since achieving the BNEP's 100% renewable energy target will likely require substantial changes to land use throughout Barbados, including impacts to the island's agricultural lands, it is a noteworthy benefit of the Project that it has been designed in such a way that allows agricultural activities to co-exist with solar energy production.

The Project Property is ideal for the location of a sheep farm due to the quality of its soils, which support high-quality grass for grazing and fodder. Although the Project Property does not have a working groundwater well suitable for irrigation available on-site, the Project will be designed to ease the impact of the dry season on sheep farming. The mineralized water by-product from the water treatment plant can be re-used for irrigation and washdown, while the fodder pasture area and feed silo will allow the harvesting, bailing, and storage of grass for use as livestock feed when needed.

The grounds of the power plant will also provide a secure, fenced environment for grazing sheep. This will reduce the risks of predation and livestock theft, which are major challenges faced by sheep farmers in Barbados.

4.2.4 Reduced Reliance on Imports and Provision of Products for Domestic and Export Markets

By generating an average of 56,000 MWh/year of renewable energy for delivery to the national grid over the life of the Project, it is anticipated that operation of the Project will enable Barbados to reduce consumption of imported heavy fuel oil by 13 million litres[5] annually, representing savings of approximately $13.6 million Barbadian dollars (BBD) per year[6].

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[5] Calculation based on an average specific consumption of heavy fuel oil of 0.23 L/kWh, based on BLPC figures.
[6] Calculation based on a price of $25 BBD/MBTu, data from Barbados IRPP (Mott Macdonald). Average price projected between 2020 and 2030.

The agricultural component of the Project will raise sheep livestock for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets. It will therefore enable Barbados to reduce lamb/mutton meat imports, which will save over $1 million BBD per year of foreign exchange.

4.2.5 Improved Energy Security and Resilience of National Grid

The existing power plants in Barbados that rely on imported fossil fuels are inherently vulnerable to potential fuel supply issues that could arise due to factors such as extreme weather, natural disasters, price volatility, and political and/or economic instability. In the event of such issues compromising the availability of fuel in Barbados, the Project would still be able to deliver stable electricity to the grid, thereby improving local energy security and the resilience of the national grid as well as reducing the risk of a general power outage and any associated social and economic repercussions.

4.2.6 Local Development and Transfer of Technological Knowledge

As the first large-scale industrial application of hydrogen technology in Barbados, the Project presents an opportunity for the country to develop local expertise in a highly promising industry and pave the way for other projects of this nature. For example, the Proponent's parent company, HDF Energy, has expressed an interest in developing other hydrogen-related projects in Barbados, including Renewstable® power plants, hydrogen mobility projects, desalination power plants running on solar power and hydrogen, and waste recovery through hydrogen.

The Project will enable the potential creation of a hydrogen skills program in Barbados, which could position Barbados as an expert in the field and allow Barbados to export its knowledge throughout the Caribbean region. HDF Energy intends to support a local education program or specific class related to renewable energy storage and hydrogen. In June 2021, HDF Energy secured a letter of intent from the University of the West Indies' (UWI) campus in Cave Hill, Barbados indicating a preliminary commitment to collaborate on research and knowledge transfer. The UWI is willing to conduct research focusing on carbon-free hydrogen power solutions in the Caribbean context. HDF Energy is willing to integrate knowledge transfer as part of the Project and is prepared to commit resources to help add value to existing UWI research programs in Barbados if and when Project development success is demonstrated at financial close. There are also additional strong potential synergies between the UWI and HDF Energy capabilities regionally. Further opportunities for collaboration will be explored in other countries in which HDF Energy develops projects and in which UWI has a local campus or other institutional presence.

If desired, HDF Energy is also open to participating with the Barbadian government on a national scientific research program focusing on Barbados' energy strategy objectives, working in collaboration with regulators as well as local and international industry leaders, scientists, and relevant stakeholders. This research should focus on emerging technologies such as "green hydrogen" and its various uses. Potentially relevant applications in the Caribbean region include the promotion of energy independence of territories and the development of clean regional ferries running on hydrogen.

5.0 PUBLIC AND STAKEHOLDER CONSULTATION AND ENGAGEMENT

Engagement with the individuals, communities, groups, and organizations interested in or potentially affected by a project is a key step in understanding potential issues and concerns, mitigating adverse effects and enhancing potential positive impacts. RSB is committed to building and maintaining positive relationships with the local community.

As part of the Social Impact Assessment (SIA) described in Chapter 9, a survey of 155 households was conducted. The objective of the survey was to establish baseline conditions, but respondents were also provided with a flyer that offered a brief description of the Project and questions were asked about the potential benefits and adverse effects of the Project. Table 5.1 is a list of the potential concerns that were raised and identifies where these are addressed in the ESIA.

Table 5.1 Potential Concerns about the Project Identified During Surveys

Project Concerns	Where Addressed in the ESIA
Noise pollution during construction	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for noise is outlined in Section 3.7.2
Dust pollution during the construction phase	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for dust is outlined in Section 3.7.2
Removal of trees and other vegetation during the during construction phase	• Section 8.4 – Flora and Fauna • As indicated in Section 8.5, a tree barrier will be established around the facility to reduce visual impacts on the community
Unsafe/hazardous work sites	• Section 9.2 – Social Impact Assessment • Mitigation measures to protect public and worker health and safety are provided in Section 3.8 and Section 9.2.3
Noise from livestock during the operational phase	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for noise is outlined in Section 3.7.2
Vibration damage to structures nearby during construction phase	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for vibration is outlined in Section 3.7.2
Lower water pressure in area due to water usage by the power plant during the operational phase	• Section 3.2.3.5 – Water Supply, Treatment, and Storage • Section 9.2 – Social Impact Assessment
Odours from the animals during the operational phase	• Section 8.6 – Agriculture and Other Land Uses
Release of hazardous emissions and products from the power plant during the operational phase	• Sections 3.5 and 3.6 of the Project Description • Section 8.7 – Accidents, Malfunctions, Emergencies, and Disasters

In addition to the surveys described above, RSB has completed the following public and stakeholder consultation and engagement activities:

- Four (4) public announcements on the Project were published in the local media in 2021
- Two (2) live television interviews were conducted in 2022 introducing the Project and the expectations for its development
- A technical presentation was made to the Barbados Association of Professional Engineers (BAPE) in March 2022
- Preliminary engagement with potential local Project service providers has commenced (construction contractors, etc.)
- A personal engagement with a local community representative was carried out, in which questions were fielded regarding environmental concerns and potential investment opportunities for the Project
- Planning with respect to potential contributions to the Six Roads Village community development has commenced

In addition, RSB intends to conduct additional public and stakeholder consultation and engagement activities as described below:

- Engage third-party consultant and/or Project Liaison to implement and maintain the Social Management Plans (SMP), Grievance Redress Mechanism, and associated processes (refer to Section 11.1)
- Directly engage with interested individuals and corporate entities
- Continue preliminary engagement with potential local service providers
- Publish the endorsed ESIA on the Project website
- Plan and facilitate Community meetings (1 minimum)
- Provide regular Project updates via the Project website and / or local media
- Perform personal introductory visits by the Project Liaison to community members and businesses
- Generate regular social media communications on issues of public interest / concern (e.g., via Instagram, Community WhatsApp group, etc.)
- Seek feedback on the success / adequacy of social management initiatives from stakeholders and implement feasible recommendations
- Maintain key stakeholder engagement records

6.0 ESIA SCOPING CONSIDERATIONS AND IMPACT ASSESSMENT APPROACH

6.1 SCOPE OF THE PROJECT TO BE ASSESSED

The scope of the Project to be assessed generally includes the components and activities described in Chapter 3, but excludes the following components and activities that will be entirely under the care and control of independent third parties (Table 6.1).

Table 6.1 Activities and Components Excluded from the Scope of the Project to be Assessed

Components and Activities Excluded from Assessment	Rationale for Exclusion from Assessment
Construction and operation of a new transmission line extending off-site from the Project Property to the Hampton substation	As indicated in Section 3.2.3.4, the Project will power the national grid via a new transmission line connecting the proposed power plant to BLPC's existing Hampton substation, which is located approximately 3.5 km away from the Project Property. It is anticipated that BLPC will independently undertake any necessary upgrades to off-site grid infrastructure beyond the boundaries of the Project Property. It is also assumed that the new transmission line extending off-site from the Project Property to the Hampton substation will be assessed, owned, and operated by BLPC; as a component of Barbados' national power distribution system, this transmission line will be entirely under the care and control of BLPC.
Potential upgrades to off-site telecommunications infrastructure beyond the boundaries of the Project Property (if applicable)	As indicated in Section 3.2.3.4, the Project will require connection to the local telecommunications network and will be hooked up to the existing fibre optic cable system that services the area. It is anticipated that the service provider will independently undertake any necessary upgrades to off-site telecommunications infrastructure beyond the boundaries of the Project Property (if applicable). Any upgrades that may be required beyond the Project Property will be assessed, owned, and operated entirely under the care and control of the service provider and are therefore excluded from the scope of the Project to be assessed.
Potential upgrades to off-site water utility infrastructure beyond the boundaries of the Project Property (if applicable)	As indicated in Section 3.2.3.5, the Project water supply will primarily be sourced from existing public water main pipelines that are owned and operated by BWA. It is anticipated that BWA will independently undertake any necessary upgrades to off-site water utility infrastructure beyond the boundaries of the Project Property (if applicable). Any upgrades that may be required beyond the Project Property will be assessed, owned, and operated entirely under the care and control of BWA and are therefore excluded from the scope of the Project to be assessed.
Off-site butchering activities	As indicated in Section 3.3.2, butchering activities will take place off-site at an approved facility. These activities will be carried out entirely under the care and control of an independent third party (i.e., a qualified professional butcher) and are therefore excluded from the scope of the Project to be assessed.

Table 6.1 Activities and Components Excluded from the Scope of the Project to be Assessed

Components and Activities Excluded from Assessment	Rationale for Exclusion from Assessment
Off-site waste management activities	As indicated in Section 3.6, Project-related wastes will be temporarily stored on-site in rubbish bins, containers, or water-tight barrels for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. The on-site collection, storage, handling, and transportation of waste materials is included within the scope of the Project to be assessed. However, any subsequent waste management activities that take place after the waste materials leave the Project Property (i.e., for off-site disposal, recycling, and/or treatment) will be carried out entirely under the care and control of an independent third party (e.g., a qualified and accredited professional waste hauler, an accredited waste management facility, and/or the manufacturer) and are therefore excluded from the scope of the Project to be assessed.

Refer to the first column of Table 8.1 (in Section 8.1.1 below) for an overview of the scope of the Project activities to be assessed.

6.2 SELECTION AND SCOPING OF VALUED COMPONENTS

This ESIA focuses on the identification and assessment of potential adverse impacts of the Project on VCs. VCs are components of the biophysical/ecological environment, the anthropogenic (i.e., built/developed) environment, and the social environment (including economic and cultural aspects) that have potential to be impacted by the Project and that are of value or interest because they have been identified to be of concern by regulatory agencies, the Proponent, resource managers, scientists, key stakeholders, and/or the general public.

Table 6.2 identifies the VCs that have been selected for the ESIA, defines their scopes, and explains the rationales for their selection.

Table 6.2 Valued Components Selected for the Assessment

Valued Component	Scope and Rationale for Selection
Biophysical/Ecological VCs	
Atmospheric and Acoustic Environment	The Atmospheric and Acoustic Environment VC includes air quality, GHGs, noise (i.e., unwanted sound), and vibration. These components constitute a VC in consideration of the following: • In general, the atmospheric and acoustic environment is a pathway for the potential transport of air contaminants, GHGs, noise, and vibration to terrestrial, freshwater, marine, and human environments. • Air quality has intrinsic importance to the health and wellbeing of humans, wildlife, vegetation, and other biota. Some Project activities will result in the release of substances to the atmosphere that are classed as air contaminants. The release of these substances during Project-related activities may change air quality, and exposure to air contaminants is a potential health hazard.

Table 6.2 Valued Components Selected for the Assessment

Valued Component	Scope and Rationale for Selection
	• GHGs contribute to human-induced climate change (IPCC 2021). Emissions of GHGs and their accumulation in the atmosphere are therefore issues of scientific and regulatory concern, and GHGs are the subject of domestic and international reduction targets. • Noise and vibration from the Project have potential to cause sensory disturbance affecting human health and wellbeing, land and resource use, and wildlife and wildlife habitat. Noise from potential pile driving (if required) could also cause auditory injury to humans or wildlife in proximity to the source, while vibration from potential pile driving (if required) could also cause damage to nearby buildings and infrastructure.
Surface Water and Groundwater Resources	Surface water includes freshwater waterbodies and watercourses, as well as storm water drainage. Groundwater includes domestic, commercial, and industrial groundwater-source water supplies, and the groundwater component of freshwater ecosystems. Surface Water and Groundwater Resources was selected as a VC for assessment in consideration of the following: • Potential Project-related changes in surface water quantity and surface water quality warrant assessment due to the importance of surface water as a source of potable water for humans; its importance to wildlife and freshwater aquatic biota as habitat; its importance for supporting commercial, recreational, and industrial activities; and the potential impacts of storm water drainage on surrounding habitats. • Potential Project-related changes in groundwater quantity and groundwater quality warrant assessment because groundwater resources have potential to be a source of potable water and are important in maintaining ecological habitats by supporting stream flow, vegetation, and wetlands.
Flora and Fauna	The Flora and Fauna VC comprises terrestrial plant and wildlife (i.e., mammal, herptile, and bird) species and their habitats. It also includes marine bird, shore bird, and waterfowl species that make use of terrestrial habitat during their life history and have potential to interact with the Project while doing so. The scope of this VC includes both secure species and species at risk. Project activities (e.g., vegetation clearing; use of vehicles, heavy equipment, and machinery; and solar grazing), and Project-related emissions, discharges, and wastes, will directly and indirectly impact flora, fauna, and terrestrial habitat by causing changes in risk of injury or mortality and changes in habitat use. In addition to its ecological importance, the Flora and Fauna VC is also important to humans, who value plants, wildlife, and the terrestrial environment for recreational, aesthetic, and traditional/cultural purposes.
Anthropogenic VCs	
Visual Environment	The Visual Environment VC includes consideration of visual aesthetics, reflection (i.e., glint and glare), and lighting. This VC warrants assessment because the Project will alter the visual landscape and aesthetics of the Project Property and may result in glint and glare and lighting impacts that could cause sensory (visual) disturbance to adjacent and nearby land users.

Table 6.2 Valued Components Selected for the Assessment

Valued Component	Scope and Rationale for Selection
Agriculture and Other Land Uses	The Project will alter the existing agricultural land within the Project Property and repurpose it for the following dual industrial and agricultural uses, which will supersede and replace the current cultivation of existing sugarcane and rotational crops on the Project Property. The new industrial use to be introduced at the Project Property is the operation of a solar PV power plant and associated energy storage and management systems. The new agricultural use to be introduced at the Project Property is the operation of a commercial Blackbelly sheep farm. Other existing surrounding land uses that could be affected by the Project include residential and commercial developments as well as tourism/recreation and historical/cultural facilities (e.g., Bushy Park Raceway, Sunbury Greathouse, and Bushy Park Cemetery).
Social VCs	
Health and Safety	The development of the site and the operation of the Project could directly or indirectly affect human health.
Human Capital	Construction and operation of the facility can provide opportunities for human capital development.
Economy	The Project may provide new economic and employment opportunities.
Cultural Values	The Project will alter the aesthetic of the area.
Infrastructure and Services	The Project could affect the integrity, quality or capacity of local infrastructure and services.
Social Dynamics	In-migration of temporary workers could affect social networks and dynamics in nearby communities.

6.3 ASSESSMENT BOUNDARIES

Spatial boundaries set the geographic areas over which the assessment will be conducted. Temporal boundaries set the timeframe to be considered. These boundaries provide a meaningful and manageable focus for the assessment, as they define the areas within which and the periods during which the VCs are likely to interact with or be influenced by the Project.

6.3.1 Spatial Boundaries

Spatial boundaries for the assessment have been selected based on the geographic extent over which Project activities and their effects are likely to occur, as well as other ecological, technical, and social considerations. The following three geographic areas are defined for VC assessment purposes:

- The **Project Development Area (PDA)** encompasses the immediate area in which Project components and activities will occur and is the anticipated area of direct physical disturbance associated with the construction, operation and maintenance, and decommissioning of the Project (i.e., the Project footprint). For the purposes of this ESIA, the boundaries of the Project Property also constitute – and are identical to – the boundaries of the PDA.

- The **Area of Influence (AOI)** encompasses the area in which Project-related impacts (direct or indirect) will be experienced and can be predicted or measured with a level of confidence that allows for assessment, and in which there is a reasonable expectation that those potential impacts may be a concern. It is also the area in which potential cumulative impacts may occur. The AOI for the ESIA is limited to a 1-km buffer centered on the PDA.
- The **Regional Study Area (RSA)** is a broader area used to describe existing (baseline) conditions and to provide context for the assessment of potential impacts. The RSA encompasses both the PDA and the AOI, as well as the surrounding Parish of Saint Philip, Barbados.

6.3.2 Temporal Boundaries

Temporal boundaries for the assessment address the potential effects during the Project's construction, operation and maintenance, and decommissioning phases over relevant timescales. These temporal boundaries are used in the assessment of residual impacts and are also considered applicable for the assessment of cumulative impacts. The overall Project schedule is presented in Section 3.4. The temporal boundaries for the assessment consist of the Project phases indicated in Table 6.3.

Table 6.3 Temporal Boundaries for the Assessment

Project Phase	Anticipated Timing (Approximate)	Anticipated Duration (Approximate)
Construction	June 2023 to June 2025	24 months
Operation and Maintenance	July 2025 to July 2050, with the possibility of extension	25+ years
Decommissioning	Following the conclusion of Project operations	12 months

6.4 OVERVIEW OF IMPACT ASSESSMENT APPROACH

The impact assessment approach for this ESIA incorporates the following main steps:

- Identify key Project components and activities (Chapter 3) and define the scope of the Project to be assessed (Section 6.1).
- Identify VCs that have potential to be impacted by the Project and that are of value or interest because they have been identified to be of concern by regulatory agencies, the Proponent, resource managers, scientists, key stakeholders, and/or the general public (Section 6.2).
- Define the spatial and temporal boundaries of the assessment (Section 6.3).
- Describe the existing conditions of the biophysical/ecological environment, anthropogenic environment, and social environment within the spatial boundaries of the assessment (Chapter 7 and Section 9.1).
- Describe and evaluate potential Project-related changes to the biophysical/ecological, anthropogenic, and/or social environment (as applicable) and the likely impacts on the identified VCs (Section 8.2.1 to Section 8.6.1 and Section 9.2).
- Identify measures to mitigate potential adverse environmental and social impacts on the identified VCs (Section 8.2.2 to Section 8.6.2 and Section 9.2.3).

- Characterize the residual environmental and social impacts of the Project (i.e., the Project-related impacts that are anticipated to remain following the implementation of mitigation measures) in consideration of the residual impact characterization criteria that are defined for the EIA in Section 8.1.2.3 (Section 8.2.3 to Section 8.6.3) and the evaluation criteria that are defined for the SIA in Section 9.2 (Section 9.2.1 and Section 9.2.2).
- Determine whether the residual environmental and social impacts are predicted to be significant or not significant, in consideration of the VC-specific significance criteria that are defined for the EIA in Section 8.1.2.4 (Section 8.2.4 to Section 8.6.4) and the general significance criteria that are defined for the SIA in Section 9.2 (Section 9.2.1 and Section 9.2.2).
- Summarize the results of the impact assessment (Section 8.2.4 to Section 8.6.4 of the EIA, Section 9.2.1 and Section 9.2.2 of the SIA, and Chapter 12).
- Identify deficiencies and challenges related to the assessment, where applicable (Section 8.2.5 to Section 8.6.5 and Section 9.2).
- Develop follow-up and monitoring programs to verify both the accuracy of the impact assessment and the effectiveness of mitigation measures (Section 8.2.6 to Section 8.6.6 and Chapter 11).
- Assess the potential environmental and social impacts that could be associated with the Project in the event of an accident, malfunction, emergency, or disaster (Section 8.7 and Section 9.2).
- Assess the Project's contribution to potential cumulative impacts on the identified VCs, if applicable (i.e., if there is potential for the residual impacts of the Project to overlap spatially and temporally with, and to therefore interact cumulatively with, the residual impacts of other projects or activities) (Chapter 10).

7.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

7.1 BIOPHYSICAL AND ECOLOGICAL ENVIRONMENT

7.1.1 Climatic Conditions

The following overview of climatic conditions in Barbados is based on climatological data for the period of 1991–2020, which was collected at the Grantley Adams International Airport, in Seawell, Christ Church, Barbados, and reported by Barbados Meteorological Services (2021):

- There is little variation in diurnal or seasonal temperatures. The temperature is moderate with monthly mean temperatures ranging from 25.9 to 27.9°C. The monthly minimum and maximum mean temperatures range from 23 to 31 °C. There is day to night variations of approximately 8°C.
- The climate is humid with a mean monthly relative humidity ranging from 75 to 82%. There are few cloudy days. Monthly mean sunshine ranges from 7.5 to 8.8 hours/day.
- The northeast trade winds are persistent over much of the year. Mean wind speed is 4.6 to 7.2 m/s, creating a gentle to moderate breeze; maximum monthly wind speeds ranges from 11.3 to 13.4 m/s. Winds usually increase in velocity during the dry season and have a desiccating effect. Many parts of the windward coast are severely affected by salt spray carried on the wind.

- Rainfall varies throughout the island due to elevations, ranging from >2,000 mm per year in the central highland regions, to 1,100–1,250 mm/year along the coastlines (Rouse 1962, in Humphrey 1997). Barbados has a wet and a dry season with monthly mean rainfall ranging from 38.9 mm (March) to 179.6 mm (October); maximum monthly rainfall ranges from 87.2 mm (March) to 513.9 mm (November). The amount and distribution of rainfall is the major climatic factor limiting crop growth and there is considerable variation in rainfall from year to year. Generally, the dry season extends from January to May and the wet season from June to December, but the inception of seasons is not the same every year and "transitional" months occur. The amount of rainfall for the island is also influenced by El Niño Southern Oscillation (ENSO) trends. ENSO is the interaction between the ocean and atmosphere in the equatorial pacific which results in periodic departures from the expected sea surface temperatures. Barbados experiences both phases: La Niña, the cold phase of sea surface temperatures which results in higher rainfall and El Niño, the warm phase which results in lower rainfall.

7.1.2 Acoustic Environment

A baseline noise assessment was completed to measure noise levels originating from current site conditions in the vicinity of the PDA. The complete Baseline Noise Assessment report, including detailed methods and results, is provided in Appendix E (i.e., is appended to the Acoustic Assessment therein).

Baseline noise measurements were recorded at seven points (i.e., monitoring stations) over three separate weekdays between the hours of 7:00 AM and 5:00 PM (Table 7.1). Six of the seven monitoring stations were situated along the PDA boundary – to the north, west, and south of the PDA – and one monitoring station was situated more centrally within the PDA (Figure 7.1). Each station was monitored for one hour during the morning period and for one hour during the afternoon period. The monitoring stations were selected based on proximity to the PDA as well as the potential impact that receptors at those locations may experience.

Table 7.1 Baseline Noise Monitoring Stations and Sampling Schedule

Monitoring Station	Description	Remarks	Sampling Date and Time
M1	Open agricultural field within the PDA	The approximate location proposed for much of the power production infrastructure for the Project (i.e., the HyPCe area)	• September 1, 2021 (7:17 to 8:17) • September 2, 2021 (12:05 to 13:05)
M2	Private residence	Located on the southeastern border of the PDA, adjacent to two houses	• September 1, 2021 (10:52 to 11:52) • September 2, 2021 (15:35 to 16:35)
M3	Residential community	Located on the southern border of the PDA, adjacent to a residential community	• September 1, 2021 (8:29 to 9:29) • September 2, 2021 (13:13 to 14:13)
M4	Residential community	Located on the southwestern border of the PDA, adjacent to a residential community	• September 1, 2021 (9:41 to 10:41) • September 2, 2021 (13:27 to 14:27)

Table 7.1 Baseline Noise Monitoring Stations and Sampling Schedule

Monitoring Station	Description	Remarks	Sampling Date and Time
M5	Private business, residence	Located 400 m to the west of the PDA, adjacent to a veterinary clinic and private residence	• August 31, 2021 (11:07 to 12:07) • September 1, 2021 (14:44 to 15:44)
M6	Private residence	Located on the northern border of the PDA, adjacent to two private residences	• August 31, 2021 (8:53 to 9:53) • September 1, 2021 (13:36 to 14:36)
M7	Residential community	Located on the northeastern border of the PDA, adjacent to a major road and a residential community	• August 31, 2021 (7:45 to 8:45) • September 1, 2021 (12:29 to 13:29)

Figure 7.1 Locations of Baseline Noise Monitoring Stations

Baseline noise monitoring results were compared against the World Health Organization (WHO) *Guidelines for Community Noise* (WHO Guidelines; WHO 1999). The WHO Guidelines are summarized in Section 2.1.6 of the Baseline Noise Assessment, which is appended to the Acoustic Assessment in Appendix E. Existing ambient noise levels at five of the seven monitoring stations were found to be below the WHO Guideline threshold for outdoor residential areas. The only exceptions occurred at monitoring stations M5 and M7, both of which exhibited ambient sound levels that slightly exceeded WHO Guidelines. Maximum noise levels (i.e., during sporadic and momentary instances of increased sound pressure levels [SPLs]) at all seven monitoring stations were consistently above WHO Guidelines. Table 7.2 presents an overview of the baseline noise monitoring results. Detailed results are included in the Baseline Noise Assessment (Appendix E).

Generally, noise sources observed at each monitoring station were limited to the wind interacting with vegetation and various noises originating from nearby communities (e.g., power tools, animals, and vehicles). Much of the PDA and surrounding area consists of open agricultural fields with nothing to obstruct wind flow, and a strong, steady breeze persisted throughout the collection of baseline noise measurements. The two monitoring stations with the lowest recorded ambient sound levels – M2 and M6 – were the two stations located the furthest away from a major residential community or public road.

Table 7.2 Overview of Baseline Noise Monitoring Results

Monitoring Station	Results	Analysis
M1	• The average ambient equivalent continuous SPL value (L_{eq}) over the two hours of monitoring was 46.3 A-weighted decibels (dBA). • The average maximum SPL value (L_{max}) (i.e., the highest sound level measured during a single noise event) was 68.2 dBA. • The highest peak SPL value (L_{peak}) (i.e., the absolute highest sound pressure of the noise signal of either the positive or negative part of the sound wave) was 98.1 dBA. • The average time-weighted average (TWA) SPL value was 37.4 dBA. • SPLs exceeded 48.3 dBA 10% of the time and 46 dBA 90% of the time.	• Monitoring station M1 was located in the center of the open field slated for Project development. There was very little ambient noise other than the wind through the grass. On one occasion, a truck transporting field workers passed within 5 m of the sound meter, resulting in the 98.1 dBA peak value recorded. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.
M2	• The average ambient L_{eq} SPL value over the two hours of monitoring was 46 dBA. • The average L_{max} SPL value was 63.3 dBA. • The highest L_{peak} SPL value was 88.0 dBA. • The average TWA SPL value was 36.9 dBA. • SPLs exceeded 47.5 dBA 10% of the time and 46.3 dBA 90% of the time.	• Monitoring station M2 was located immediately south of the PDA, on the edge of an open field and adjacent to two private residences. The occasional dog bark and other noises were heard from the nearby residence. Cars could be heard in the distance driving along the main road to the Southeast. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.

Table 7.2 Overview of Baseline Noise Monitoring Results

Monitoring Station	Results	Analysis
M3	• The average ambient L_{eq} SPL level over the two hours of monitoring was 47.4 dBA. • The average L_{max} SPL value was 66.8 dBA. • The highest L_{peak} SPL value was 86.7 dBA. • The average TWA SPL value was 38.4 dBA. • Noise levels exceeded 49.4 dBA 10% of the time and 46.6 dBA 90% of the time.	• Monitoring station M3 was located immediately south of the PDA (east of monitoring station M2), on the edge of an open field and adjacent to a cane field and a private community. Occasional noise could be heard from the nearby residences. There was also noise resulting from the wind passing through the sugarcane. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.
M4	• The average ambient L_{eq} SPL over the two hours of monitoring was 49.7 dBA. • The average L_{max} value was 66.1 dBA. • The highest L_{peak} SPL value was 92.1 dBA. • The average TWA SPL value was 40.7 dBA. • SPLs exceeded 52.1 dBA 10% of the time and 47.7 dBA 90% of the time.	• Monitoring station M4 was located immediately southwest of the PDA, on the edge of an open field and adjacent to a residential community. Consistent noise could be heard from the community, including a powered garden tool, power tools, dog barks, and vehicles. The highest peak value of 92.1 dBA resulted from a loud vehicle exiting a nearby driveway. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.
M5	• The average ambient L_{eq} SPL over the two hours of monitoring was 53.2 dBA. • The average L_{max} SPL value was 70.2 dBA. • The highest L_{peak} SPL value was 88.9 dBA. • The average TWA SPL value was 44.1 dBA. • SPLs exceeded 56 dBA 10% of the time and 48.3 dBA 90% of the time.	• Monitoring station M5 was located immediately west of the PDA, on a cart road connected to Sunbury Road. Tall sugarcane flanks the cart road on either side. Most of the ambient noise could be attributed to cars constantly passing on the main road nearby and to the wind passing through the cane. • Ambient sound levels at this location exceeded the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.

Table 7.2 Overview of Baseline Noise Monitoring Results

Monitoring Station	Results	Analysis
M6	• The average ambient L_{eq} noise level over the two hours of monitoring was 45.9 dBA. • The average L_{max} value was 63.9 dBA. • The highest L_{peak} SPL value was 84 dBA. • The average TWA SPL value was 36.8 dBA. • SPLs exceeded 47.3 dBA 10% of the time and 46.1 dBA 90% of the time.	• Monitoring station M6 was located immediately north of the PDA, on the edge of an open field and adjacent to a residence. Thick vegetation sheltered the monitoring point to the east. Some noise could be attributed to wind passing through the vegetation. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.

7.1.3 Topography

The following information on the topography of the PDA was obtained by conducting field reconnaissance in support of a site-specific drainage assessment for the Project (Appendix B), as well as by reviewing 1:10,000 and 1:5,000 topographical mapping available from the Lands and Surveys Department of the Government of Barbados and a higher resolution topographical survey of the site made available by RSB:

- Along the northern boundary of the PDA, adjacent to the Old Train Line Road, ground elevations range from 52 m above mean sea level (AMSL) in the west to 56 m AMSL in the east.
- Along the southern boundary of the PDA, land elevations range from 46.0 m AMSL in the west to 43 m, 47.0 m, and 48 m AMSL going eastwards. Land elevations are in the region of 50 m AMSL at the eastern end of the southern PDA boundary.
- In between the northern and southern PDA boundaries, the land is relatively flat with site slopes from north to south in the region of 1.5%.
- There are several relatively small (compared to the overall PDA) natural depressions – possibly past collapsed caves. Natural drainage watercourses lead to these depressed areas.

7.1.4 Geology and Surficial Soils

Barbados is a coral-capped sea mount emerging from a broad and ill-defined submarine ridge which separates the ocean depths of the Tobago Trough to the west from the Atlantic depths to the east. Barbados owes its origin to geanticlinal folding beginning in the Late Cretaceous. Coral now covers approximately 85% of the island (Stantec 2013). Periodic erosion of the coral has created subterranean caves and holes in the subsurface. As a result, the island is pervasively karstified, as demonstrated by the occurrence of more than 100 caves, hundreds of gullies, and over 2,800 sinkholes (Kambesis and Machel 2013).

On the remainder of the Barbados cap, coral has been removed by erosion and the older sedimentary rocks of the sea mount outcrop at the surface. The oldest rocks of Barbados, the Scotland formations, are very thick sediments deposited into a rapidly and continuously subsiding geosynclinals foredeep. They frequently show evidence of large-scale slumping and sliding features. The Scotland formations are strongly folded, and the limbs of the folds are often overturned and thrusted.

The greater part of Barbados is characterized by kandoid clay and smectoid clay soils overlying coral limestone. Each group of soils consists of two associations with a gradual transition in properties between the two associations that is difficult to discern in the field. The PDA is located in the Coral Region of Barbados, which is characterised by shallow topsoil followed by limestone rock of significant depth. The surficial geology of the PDA predominantly consists of a Saint Philip Plain Association soil cover layer that is over 900 mm in thickness (Vernon and Carrol 1966). Southwestern sections of the PDA consist of a Grey-Brown Association soil that is less than 450 mm in thickness. A Coral Limestone rock layer that is approximately 30–55 m in depth underlies the site, with the deeper depths occurring towards the southern extent of the PDA. The limestone layer is underlain by the impermeable Oceanics layer, which is known to have a westerly dip towards the sea and to be several hundred metres in depth (Poole and Barker 1983). Figure 7.2 shows the locations of the different soil types within the PDA.

The Grey Brown Association soil layer is composed of approximately 65% clay, 10% sand, and 18% silt, with calcium carbonate and moisture accounting for the balance of the composition. The Saint Philip Plain Association generally resembles the Grey-Brown Association but has a different parent material. Both soil covers are slated to have slow to moderate permeability.

The limestone rock layer has a very high effective porosity. This porosity, coupled with the extensively cracked and fissured nature of the rock, makes it an extremely permeable stratum. The permeable coral limestone rock and impermeable Oceanics geological structure described above collectively form an unconfined aquifer through which groundwater flows.

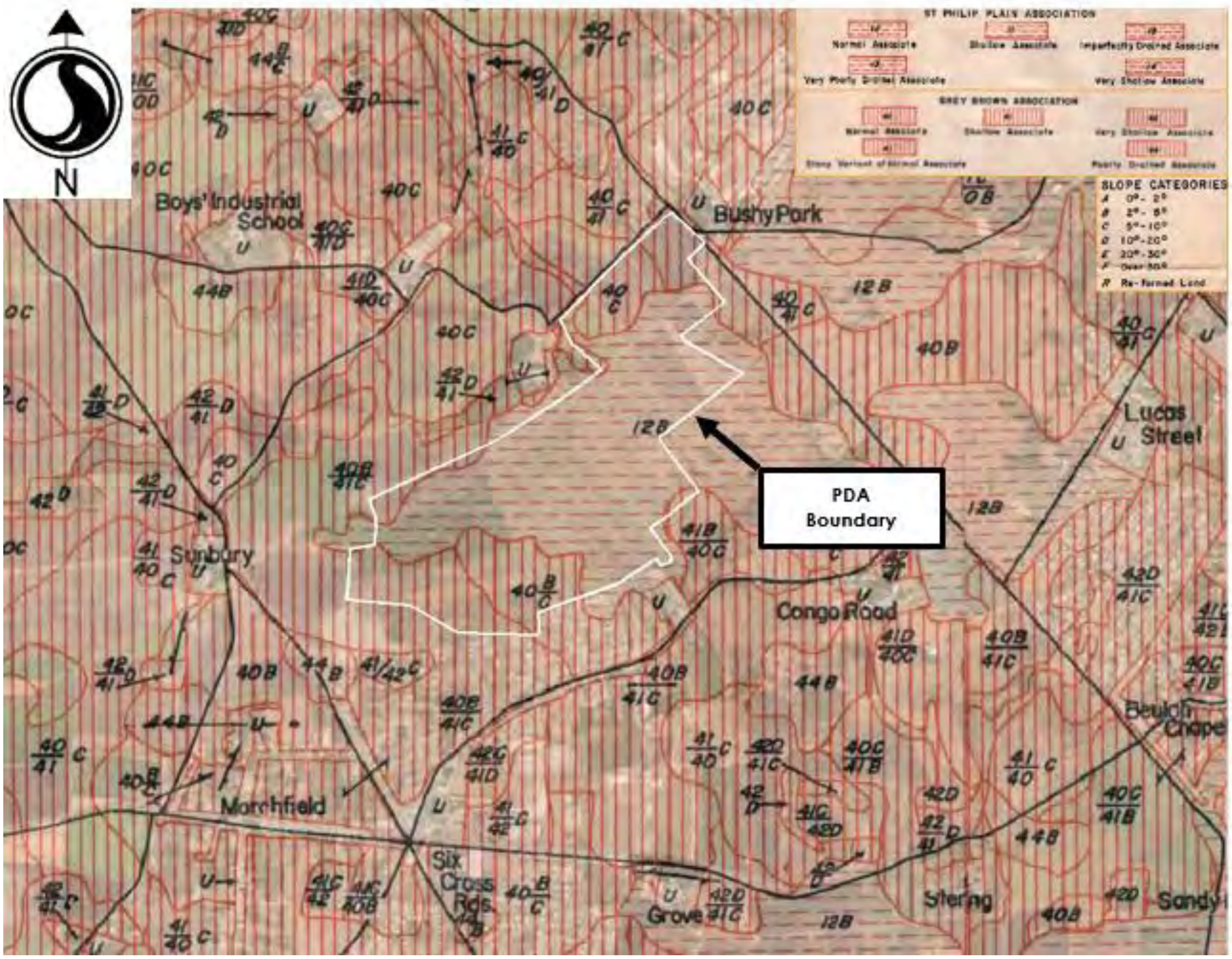

Figure 7.2 Project Development Area Overlaid on Soils Map (Vernon and Carrol 1966)

7.1.5 Surface Water and Drainage

The lands to the north of the PDA have higher elevations than lands within the PDA, while the lands to the south of the PDA have lower elevations than those within the PDA. The net result is that runoff from rainfall flows from lands to the north of the PDA (hereafter referred to as the "North Watershed") onto lands within the PDA. This runoff combines with runoff generated from rainfall directly on the PDA, thereby resulting in cumulative runoff that discharges south of the PDA to the adjacent community and towards the town of Six Roads. Given the highly vegetated nature of both the North Watershed and the PDA catchment area (hereafter referred to as the "South Watershed"), considerable interception and depression storage are expected to occur, with infiltration and percolation of captured runoff to groundwater zones. The North Watershed and South Watershed are depicted on Figure 7.3, and the hydrological characteristics of each of these watersheds are presented in Table 7.3.

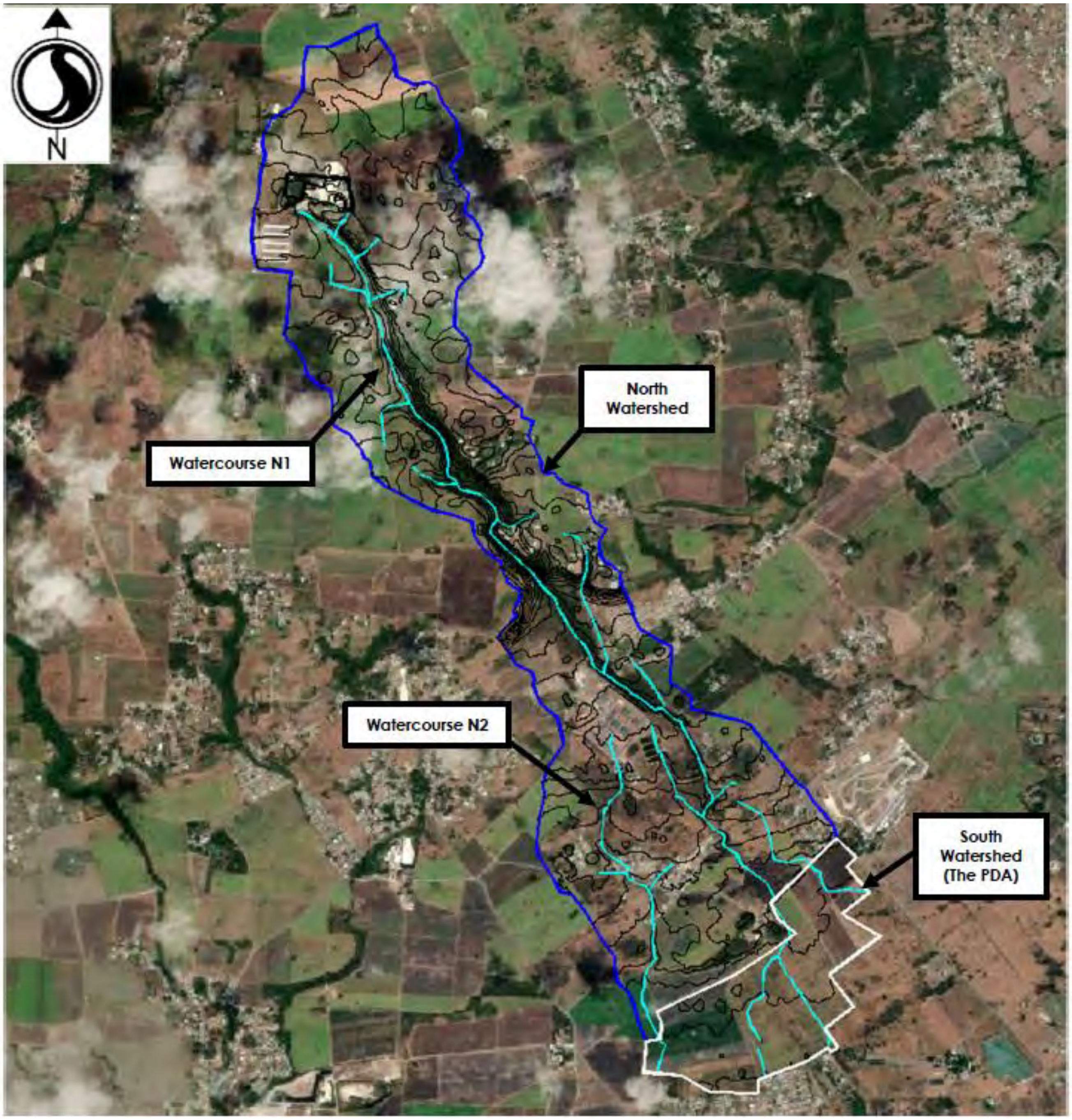

Figure 7.3 Watersheds and Prominent Watercourses in the Vicinity of the PDA

Table 7.3 Hydrological Characteristics of the North and South Watersheds

Description	Parameter	
	North Watershed	South Watershed
Watershed Area	474.22 ha	73.00 ha
Vegetation Area (grass)	457.62 ha	69.44 ha
Impermeable Area (e.g., roads, pavement, and buildings)	16.6 ha	3.64 ha
Longest drainage path	4.74 km	1.1 km
Average slope of longest watercourse	2.53%	1.37%
Average Annual Rainfall	1,300 mm	

7.1.5.1 Existing Conditions to the North of the PDA

The North Watershed resulting in runoff towards the PDA is quite large, extending from the northern boundary of the PDA in a northwesterly direction to the general vicinity of Guinea, Victoria, and Colleton plantations. The North Watershed contains several catchments and drainage watercourses that lead in some instances to natural depressions, which are commonplace throughout the watershed. These depressions help to promote depression storage and the percolation of captured water to groundwater zones attenuating or lessening the amount of runoff that is conveyed to the site. Based on the 1:10,000 topographical map of the area, the North Watershed has 29 infiltration wells (suckwells) within its boundary.

Though there are several sub-catchments with associated watercourses within the North Watershed, there are two prominent watercourses that traverse substantial distances within the watershed in northern to southern directions; the locations of these watercourses – referred to as “Watercourse N1” and “Watercourse N2” – are indicated in Figure 7.3. Both watercourses result in runoff entering the PDA.

The Old Train Line Road (i.e., an unpaved “cart” road) effectively represents the southern boundary of the North Watershed; this road generally slopes with reducing elevation in a westerly direction implying that any captured runoff could be conveyed in westerly directions away from the PDA. However, there are several points where sags in the road direct runoff captured from the North Watershed onto the PDA.

7.1.5.2 Existing Conditions Within the PDA

The PDA is relatively flat and totally vegetated, including with agricultural crops. In addition to runoff from the North Watershed, the PDA itself also forms a rainwater catchment (i.e., the South Watershed) onto which runoff is generated when rain falls. There are 23 infiltration wells within the PDA to augment surface water drainage.

Drainage of runoff from the PDA is predominantly via overland flows in a southward direction with infiltration and percolation of runoff to groundwater zones. The furrows and rows of cultivated lands aid in retarding runoff and promoting infiltration. The several infiltration wells on-site also promote the drainage of captured runoff to groundwater zones.

There are five well-defined drainage paths/watercourses (WCs) within the PDA, which are labelled as “WC-A”, “WC-B”, “WC-C”, “WC-D”, and “WC-E” on Figure 7.4 below. Four watercourses are connected to upstream watercourses within the North Watershed introduced above. WC-C originates within the PDA and possibly connects to WC-B during heavy rainfall events. WC-B, WC-D, and WC-E terminate within existing natural depressions within the PDA, while WC-A and WC-C extend past the southern PDA boundary. The existing watercourses that channel runoff to natural depressions promote the storage and percolation of runoff to groundwater zones; those watercourses that pass through the PDA convey captured runoff downstream of the site.

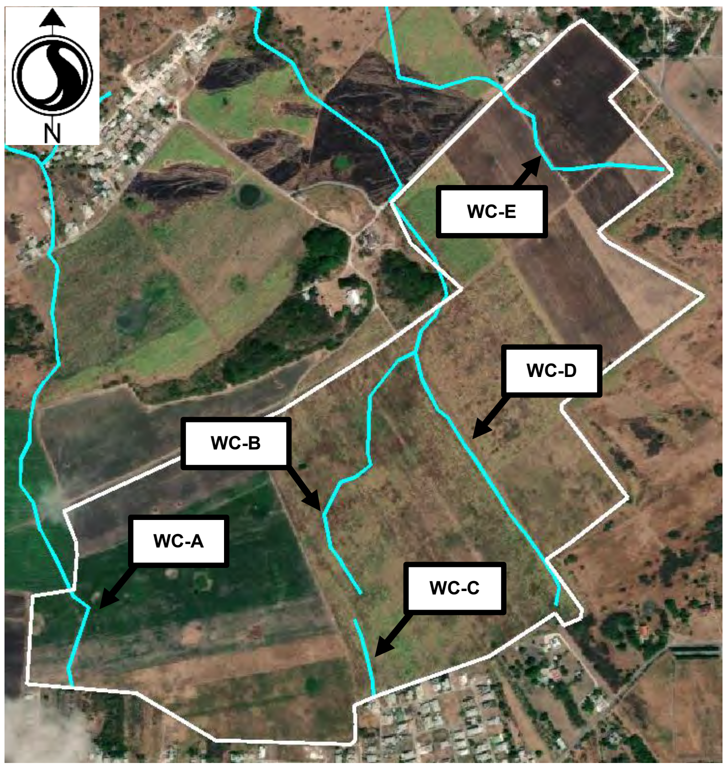

Figure 7.4 Existing Watercourse Flow Paths Within the PDA

During prolonged rainfall events, runoff enters the PDA from the North Watershed predominately following the natural watercourses within the watershed and those introduced above within the PDA. Rainfall onto the lands of the PDA also adds to the volume of runoff on-site. Some watercourses within the PDA direct runoff to natural depressions. The 23 infiltration wells/suckwells (i.e., artificial shafts excavated in soft carbonates to relieve surface flooding) within the PDA assist with draining surface runoff. When depressions are filled, runoff overflows the banks of the depressions and flows southwards predominantly via overland flow. As the PDA becomes flooded, the roadways/cart paths within the PDA become watercourses conveying runoff in southwards directions towards the PDA site boundary. Once the PDA is flooded and suckwells are at their drainage capacity, runoff effectively passes through the site to downstream areas.

7.1.5.3 Existing Conditions to the South of the PDA

South of the PDA are the densely populated residential/commercial areas of Farm Garden and Marchfield Village. An examination of contour information in that area – further confirmed by field reconnaissance carried out in support of a site-specific drainage assessment for the Project (Appendix D) – reveals that there is a drainage watercourse that follows a north to south roadway through the village and which further traverses in a southward direction through the Six Roads Industrial Park and the Six Roads town centre. There have been instances in the past where prolonged and intense rainfall has resulted in runoff from the North and South Watersheds flowing to the mentioned areas to the South of the PDA causing flooding. Several years ago, a cannery within the industrial park was completely flooded causing equipment damage during a prolonged rainfall event. Field reconnaissance of this area revealed the construction of culverts and several infiltration wells as means to improve drainage within this southern zone. Appendix D provides further information regarding the existing drainage systems to the south of the PDA, including photographs.

7.1.6 Groundwater Resources

The level of the surface of the Oceanics layer with respect to mean sea level (MSL) defines whether groundwater in the unconfined aquifer (refer to Section 7.1.3) exists as streamwater or as sheetwater. Oceanic levels below mean sea level (BMSL) indicate that groundwater may exist as sheetwater, whilst levels above MSL indicate the possible existence of streamwater. Streamwater, found in the higher land elevations of Barbados, is defined as groundwater flowing at the interface of coral rock and the Oceanic clay layer towards the sea, after having percolated through overlying coral rock and its fissures. Sheetwater, found at lower elevations, is a thin layered reservoir of freshwater resting above saline water, in the coral rock medium, at the interface with the sea level.

Based on the map series entitled *The Geology of Barbados* (Poole and Barker 1983), the elevation of the Oceanics layer beneath the site ranges from approximately 35 m AMSL in the northeast to -15 m AMSL in the south. Consequently, groundwater beneath the PDA exists predominantly as streamwater, with some sheetwater present in southern sections of the PDA. An examination of the Oceanic contours implies that groundwater flows are in a southerly direction.

To validate the interpolated limestone-oceanic contouring included in the mapping by Poole and Barker (1983), a review of nearby water wells surveyed by Alfred Senn was conducted. Senn's (1946) geological investigations of the groundwater resources of Barbados included physical surveys of water wells in the environs of the PDA. This historical well data confirms depths to Oceanics as previously described and indicates that the depth of groundwater within the PDA is likely approximately 1.8 m (Table 7.4).

Table 7.4 Results of Historical Well Survey Completed by Senn (1946) in the Vicinity of the PDA

Location (as shown on Figure 7.5)	Surface Elevation	Well Depth	Elevation of Base	Water Depth	Water Elevation	Approx. Interface Elevation	Aquifer Type
	(m AMSL)	(m)	(m AMSL)	(m)	(m AMSL)	(m AMSL)	
Sunbury	46.9	48.2	-1.2	1.2	0.0	< 0	*Sheetwater*
Harrow	**62.2**	**37.5**	**24.7**	**1.8**	**26.5**	**27**	**Streamwater**
Chapel	77.1	60.7	16.5	1.8	18.3	18	*Streamwater*
Marchfield	40.4	41.5	-1.1	1.1	0.0	< 0	*Sheetwater*
Summervale	102.4	68.9	33.5	0.6	34.1	34	*Streamwater*
Farm #1	43.6	41.8	1.8	0.0	–	–	–
Farm #2	37.2	34.1	3.1	0.0	–	–	–
Bushy Park	61.0	22.3	38.7	0.9	39.6	40	*Streamwater*
Fairfield	78.9	29.0	50.0	2.4	52.4	52	*Streamwater*
Source: Senn 1946.							

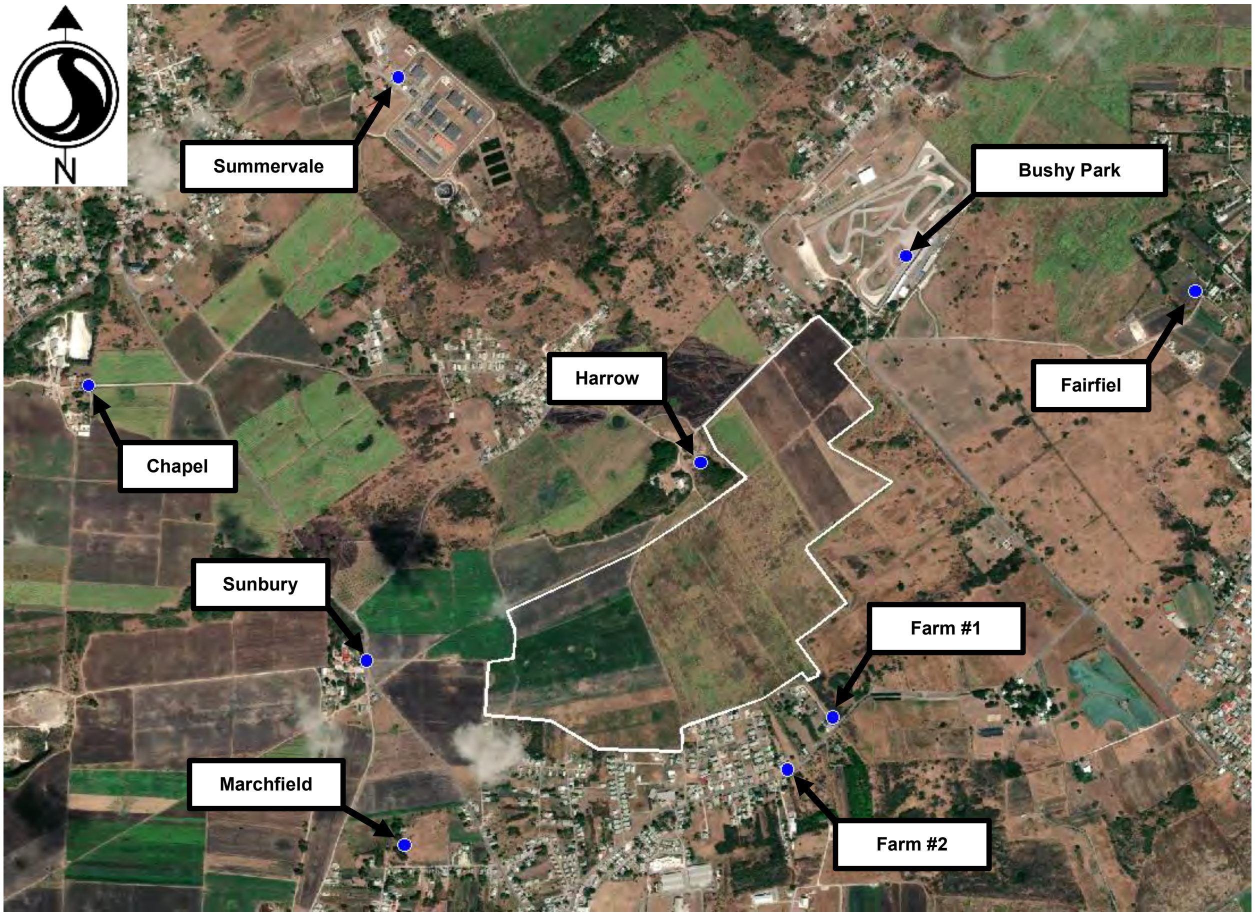

Figure 7.5 Locations of Wells Surveyed by Senn (1946)

7.1.7 Flora and Fauna

A baseline ecological assessment was completed to gather information on the availability and distribution of habitat for various species of flora and fauna, including for rare or protected species, in the vicinity of the PDA. Baseline information was collected through a field reconnaissance survey combined with a review of existing literature and databases related to rare species. The field survey, which was undertaken in mid-September 2021, consisted of walking along a series of transect lines within the PDA and recording observations (e.g., flora, evidence of fauna, landscape features). Forested areas adjacent to the PDA and dark spots (i.e., potential waterbodies) were identified via Google Earth and surveyed, where accessible. The roads/tracks used to access the Project Property and the residential area to the south of the PDA were also travelled/surveyed. Figure 7.6 shows the transects and adjacent habitats that were surveyed in mid-September 2021.

Transect lines where similar habitat features were observed were grouped together, resulting in three main habitat types within the PDA: cleared agricultural land, grassy areas, and sugarcane fields. The species of flora found in the PDA are common in Barbados and are not considered rare or endangered. The fauna recorded in the PDA and surrounding area included secure species of mammals, birds, and arthropods that are not considered rare or endangered. The diversity of species encountered during the survey was limited, which was expected given that the surveyed area primarily consists of agricultural land.

The complete Baseline Ecological Assessment report, including detailed methods and results, is provided in Appendix F. Appendix F also includes photographs of representative habitat types, wildlife and evidence of wildlife (e.g., paw prints and burrows), and potential habitat features (e.g., settled water and forested areas) encountered during the survey. The subsections below summarize the main findings of the Ecological Baseline Assessment.

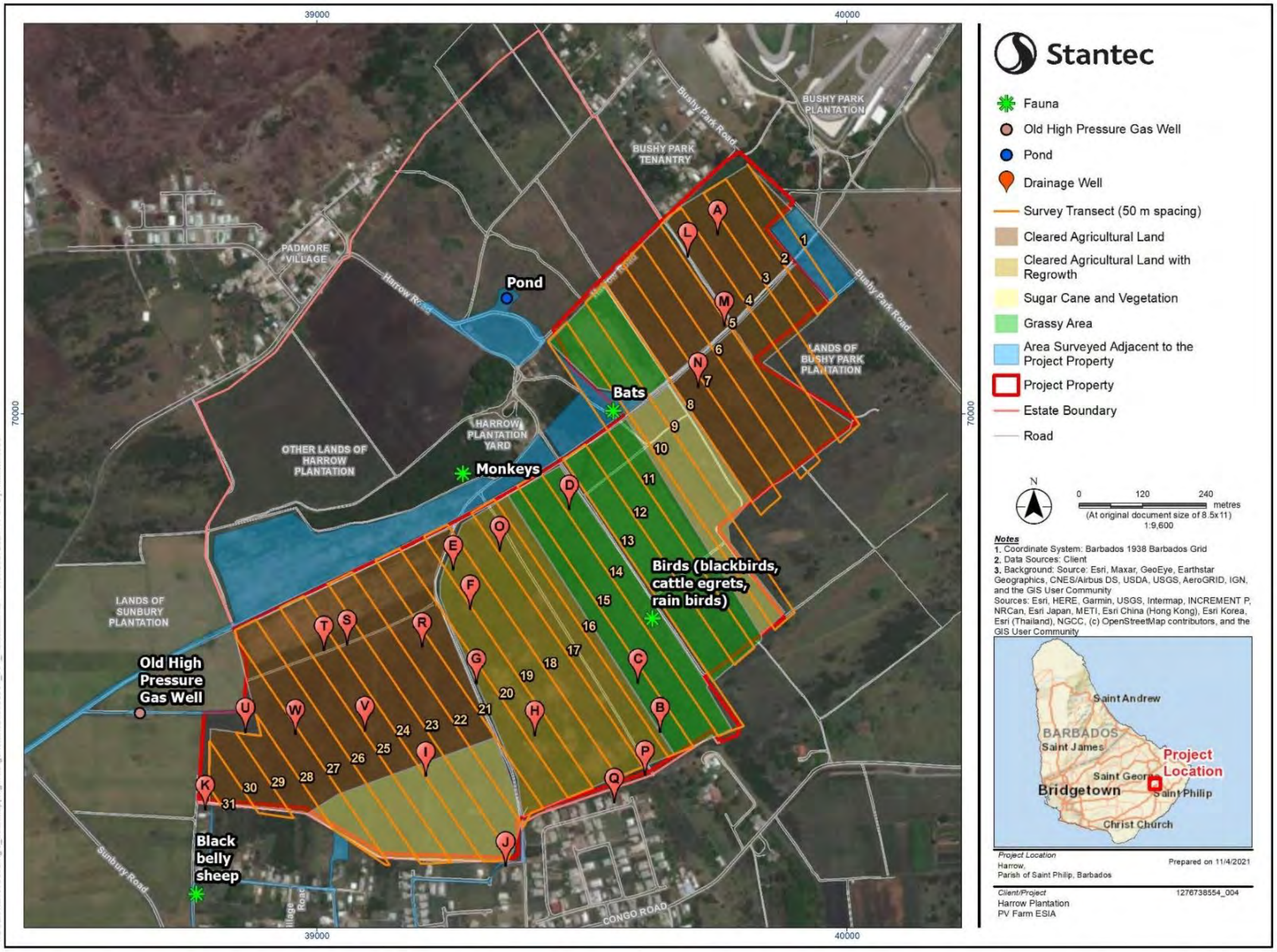

Figure 7.6 **Transects and Adjacent Habitats Surveyed in Support of the Ecological Baseline Assessment, Observations Recorded, and General Layout of Habitats in the PDA**

7.1.7.1 Habitat Types

The PDA generally consists of areas of cleared agricultural land, grassy areas, and sugarcane fields. Throughout the PDA, there was little wildlife beyond a few species of birds which were seen more frequently and more abundantly in areas with greater vegetation. Another notable feature was the number of wells found. In general, habitat features were common among groups of transects.

Transect lines 1 to 8 was cleared agricultural land with very little habitat change noted (Figure 7.6). This area was divided by paths/tracks and showed little signs of wildlife. There were ant nests scattered throughout this section and occasionally wood doves (*Zenaida aurita*) and blackbirds (*Quiscalus lugubris*) were seen. The vine known locally as wild cucumber (*Cucumis melo var. dudaim (L.) Naudin*) was found sporadically in this area. Four drainage wells were observed (Figure 7.6).

The upper area of transect lines 8 to 11 was a grassy area (Figure 7.6) with ant nests scattered throughout. An isolated rain tree (*Albizia sp.*) exists near the center of the area and three coconut trees (*Cocos nucifera*) border the northern property boundary by the roadside. Between transect lines 10 and 11, a small ditch was observed outside of the Project Property boundary. The ditch, overgrown with vegetation, appears to follow the outline of the Project boundary in that area. South of the main track that runs perpendicular to transect lines 8 to 11 is one of two cane fields found on the property (Figure 7.6).

Transect lines 10 to 15 were on land that was mostly grassy (Figure 7.6), with grass and elephant grass (*Pennisetum purpureum*) growing freely. Birds were seen more frequently and in bigger groups in this section. Toward the end of transect line 7, there was settled water where water beetles, dragon flies, flies, and an unidentified paw print (possibly canine) were found. Three drainage wells were identified (Figure 7.6).

The flora in the PDA consisted mostly of grass and shrub regrowth after the land had been left unattended, and there were sugarcane (*Saccharum officinarum*) rows in some areas. The “forested” areas identified on the outside of the PDA were mostly observed to consist of river tamarind trees (*Leucaena leucocephala*) and rain trees. There was limited wildlife and evidence of wildlife found in the area. Most of the animals seen were birds.

Flora

There are roughly 700 species of flowering plants found in Barbados, two which are endemic to the island, a gully shrub *(Phyllanthus andersonii)* and slender climber (*Metastelma barbadense*). These endemic species are neither rare or endangered and are found in wooded areas (Government of Barbados 2021b), making it unlikely they would be found on the predominantly agricultural lands of the PDA.

Twenty-three species plants on the island have been identified as needing protection, fifteen of which are found in one location, Turner’s Hall Woods (S. Carrington, personal communication, 2020) in northern Barbados, with eight of them being considered rare or endangered. These species were not observed on the Project Property and are not likely to be in the vicinity as they are found mostly in moist more sheltered regions.

The cleared agricultural land mostly consisted of plants, such as grasses, vines, and the occasional tree. The vine known locally as wild cucumber could be found sporadically throughout the cleared land and along the edges of the PDA. Grasses could also be found along the paths/tracks cut through the cleared agricultural land. A lightning rod plant (*Leonotis nepetifolia*) was found along one of these paths. Elephant grass was found on the southern borders of the transect lines 1 to 9. Amongst them were castor oil plants (*Ricinus communis*). Sugarcane also occurs on the lands of the PDA. Shrubby false buttonweed (*Spermacoce verticillata*) and cupid's shaving brush (*Emilia fosbergii*) were found in the area of cleared agricultural land with more substantial regrowth.

Butterfly pea vines (*Clitoria ternatea*) and other vines from the sweet potato family (e.g., *Merremia dissecta (Jacquin) Hallier f.*) were found in the bushy areas outside of the PDA. The areas that could be identified as possibly forested from satellite images were predominantly rain trees and river tamarind trees. On the ground around them were coarse grass and plants from the daisy family, which are normally considered weeds.

Other flora encountered during the field survey included clammy cherry tree (*Cordia obliqua*), khus khus grass (*Chrysopogon zizanioides*), and *tridax procumbens*. None of the flora recorded during the field reconnaissance survey are considered rare or endangered, and the habitats in the area are considered unlikely to support such species.

7.1.7.2 Fauna

The mammalian fauna of Barbados is dominated by introduced species including rats, green monkeys, and mongooses. Barbados has only six extant indigenous mammals, which are all species of bats. None of the mammals found in Barbados are considered rare or endangered and the population of all six bat species are "in good condition" (Genoways et al. 2012).

The only mammals observed within the PDA were bats, which were observed flying overhead around the trees found north of transect line 10 in the evening; however, the species could not be identified. In the residential area to the south of the PDA, three Blackbelly sheep (*Ovies aries*) were observed grazing and green monkeys (*Chlorocebus sabaeus*) were heard in the forested areas north of transect lines 14 to 17. The introduced green monkey is known to be adaptable and thrives in the human-disturbed environments of Barbados (Government of Barbados 2002) and are considered an agricultural pest (Government of Barbados 2021b). In addition, a paw print was found in an area of settled water located at southern end of transect lines 6 and 7.

The island's bird fauna is much more diverse compared to the mammalian fauna. Much of this diversity is a result of migratory species travelling to South America towards the end of the year. These birds are attracted to swamp areas in Barbados, such Graeme Hall swamp, Chancery Lane swamp, Green Pond, and Long Pond. There is an Important Bird Area (IBA) (i.e., IBA #BB006 – St. Philip Shooting Swamps) located approximately 1.2 km to the south of the PDA. The IBA aims to attract the neotropical migratory species that head south between the months of July and October. It also provides a habitat for other wetland birds, including populations of three (of the four) Lesser Antilles Endemic Bird Area (EBA) restricted-range birds (Burke 2008). Due to the proximity of one IBA and ponds in the area, there is potential to see more species of birds in the vicinity of the PDA, including restricted-range birds. However, these restricted-range species would be expected to preferentially use wetlands/swamps rather than agricultural habitats and are therefore unlikely to use the Project Property.

They are approximately 36 resident species of birds nesting on the island, the majority of which have adapted well to human-altered habitats and are considered common. Birds made up a large proportion of the fauna observed within the PDA. Rain bird (*Tyrannus dominicensis*), blackbirds, and cattle egrets (*Bubulcus ibis*) were observed primarily in the parts of the PDA with higher vegetation, such as the grassy areas between transect lines 10 to 15 (Figure 7.6). A green heron (*Butorides virescens*) was observed standing in settled water which collected in a tractor tire mark left on the ground just south of the Project Property border between transect lines 9 and 10. In addition, a group of approximately six grassland yellow finches *(Sicalis luteola*) was observed west of the PDA in mostly cleared agricultural land with a green patch of grass in the center. A hummingbird (*Orthorhyncus cristatus*) was also observed at the flowers of a rain tree at the top of transect line 13. None of the birds observed during the field survey are considered rare or at risk, however they are all protected under the *Wild Birds Protection Act*.

The terrestrial reptile population of Barbados is comprised of snakes, lizards, and tortoise species. In 2011, the gecko, which was previously considered extinct, was found on Barbados' Culpepper Island. Colonies of geckos were found in the Parish of Saint Philip in 2013 (CBD 2019). However, no geckos or other reptiles were observed during the field survey.

Approximately 1,300 species of insects and allied arthropods have been recorded in Barbados, the most common being odonates (dragonflies), hemipterans (bugs), coleopterans (beetles), and dipterans (flies) (Government of Barbados 2021b). Arthropods, such as arachnids, myriapods, and insects, were found within the PDA and the adjacent forested areas. Ants were the most abundant type of insect observed during field reconnaissance, with numerous nests found throughout the surveyed area. Millipedes were also observed above-ground around the PDA, and a centipede was found under a rock. Small spiderwebs were documented in areas with elephant grass, and the silver argiope spider (*Argiope argentata*) was found outside of the PDA in bushy areas among the river tamarind and rain trees. In addition, numerous insects, such as flies, dragonflies, butterflies, water beetles, grasshoppers, and mosquitoes were found within the PDA, mostly close to settled water or bushy areas. A termite nest was found among fallen cane and black worms were also found in the same area of the PDA. Honeybee (*Apis mellifera*) was also recorded during the field survey. All of the insects and allied arthropods encountered during the field survey are common in Barbados.

Giant African snail (*Lissachatina fulica*), which is an invasive species that was formally recognized in Barbados in 2002 (Paliwal et al. 2011), was also recorded during the field survey.

7.2 ANTHROPOGENIC ENVIRONMENT

7.2.1 Land Use

The PDA is located at Harrow Plantation, Saint Philip, in an area that has traditionally been rural in character and dominated by agricultural land use. Harrow Plantation is bounded by Padmore Village to the north, Bushy Park Tenantry and Bushy Park Road (Highway M) to the east, the agricultural lands of Bushy Park Plantation and the Six Cross Roads settlement to the south, and the lands of Sunbury Plantation to the west (Figure 7.7).

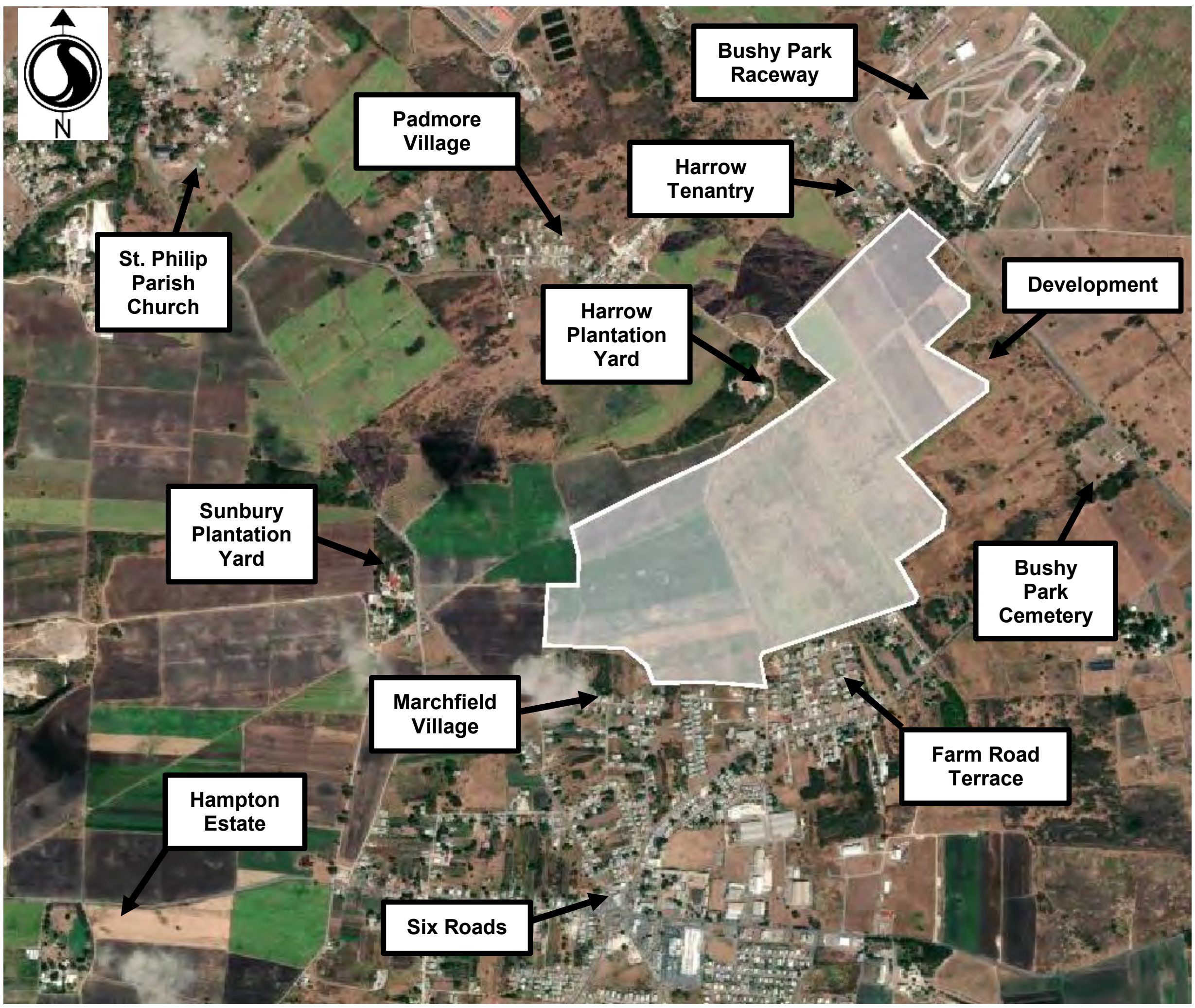

Figure 7.7 Land Uses Surrounding the PDA

The PDA itself is situated on agricultural land that is currently used for sugarcane farming augmented by rotational crops (e.g., cotton), with the immediate and expanded surroundings predominantly consisting of residential and agricultural land. Residential communities exist adjacent to the northern and southern PDA boundaries. Harrow Plantation Yard is located immediately adjacent and north of the portion of the

PDA in which the solar PV power plant is proposed to be located (i.e., west of the proposed sheep grazing area). A small community is located adjacent and north of the sheep grazing area, and a larger community – Marchfield Village – is situated along much of the southern PDA boundary (Figure 7.7). A veterinary clinic is located at Sunbury Plantation, approximately 400 m west of the PDA. Bushy Park Raceway is located approximately 250 m northeast of the PDA, and Bush Park Cemetery is located approximately 300 m to the southeast of the PDA (Figure 7.7).

The following description of existing agricultural land use within the PDA is based on information on baseline conditions that was collected in support of a Project-specific Agricultural Impact Assessment (Appendix C).

Harrow Plantation has an area of approximately 123.0 ha, with most of the productive lands having been traditionally in sugarcane. Agricultural production at Harrow Plantation is managed and operated by the Barbados Agricultural Management Company (BAMC). There are currently approximately 102.2 ha in arable production, of which the PDA will occupy approximately 73.2 ha.

Harrow Plantation falls within Agro-ecological Group C. Agro-ecological Group is defined by soil type, land capability (i.e., slope, fertility, drainage), and effective rainfall (i.e., annual total and distribution within the growing season that meets the need for a specific crop during its growth cycle). Group C is regarded as a less productive zone because of the above factors, with effective rainfall ranked highest as the most binding constraint to crop development within the area.

Traditionally, mono-cropping of sugarcane with rotation of secondary crops has been the production pattern at Harrow Plantation. At present, sugarcane accounts for approximately 78.4 ha under various rotations, with approximately 7.1 ha of cotton grown as a rotation enterprise, while approximately 36.1 ha are fallowed/rested.

The irrigation well at Harrow Plantation requires extensive refurbishment and this can facilitate year-round growth of cash crops once it is renovated.

Within the recent past, farms managed by the BAMC have underperformed given cash-flow constraints of the parent company. Actual productivity indicators suggest underperformance within crop production at Harrow Plantation.

Given good management practices (e.g., effective weed control, high plant population, varieties suitable for the area) within the present crops, an estimate of potential output can be made for the area. Table 7.5 below shows BAMC's estimated output to be harvested at Harrow Plantation for the 2022 harvest. The productivity indicator ranges between 25–30 imperial tons per acre (i.e., approximately 56–67 metric tonnes of cane per hectare) for the farm using the methodology for establishing productivity potential for sugarcane in Barbados performance index developed by Thelma McCatty and Ranjit Singh (Barbados Cane Industry Corporation). Given the low rainfall of approximately 74.3 cm in 2020, the achievement of output of 22 imperial tons per acre (i.e., approximately 49 metric tonnes per hectare) during the 2022 harvest within the conventional plant cane (CPC) would indicate that other factors described under good management practices above are critically important to raising field productivity on a per hectare basis.

Table 7.5 Estimated Output at Harvest 2022

Sub Farm Unit	Harrow Plantation					
	Imperial Units of Measurement			Metric Units of Measurement*		
	Acres	Tons/Acre	Total Tons	Hectares	Tonnes / Hectare	Total Tonnes
Sugarcane Production						
CPC 2020/22	77.00	22.00	1,694.00	31.16	49.31	1,536.50
HWT CPC 2020/22	9.00	20.00	180.00	3.64	44.83	163.18
HWT 2020/22 R1	2.5			1.01		
HWT 2019/21 R2						
Force Back						
Ratoon 1	15.75	18.00	283.50	6.37	40.35	257.03
Ratoon 2						
Ratoon 3						
Ratoon 4						
Ratoon 5						
Sub Total	**104.25**		**2,157.50**			
TOTAL			**2,157.50**			**1,956.71**

Note:
* Original data was provided using imperial units of measurement (refer to the Agricultural Impact Assessment in Appendix C). Approximate conversions to metric units of measurement were calculated using the online Google Unit Converter.

7.2.2 Visual Environment

A Project-specific Visual Impact Assessment (VIA) was conducted by way of field reconnaissance to select vantage points to assess the future visibility of the solar PV power plant when constructed. Photographs from vantage points of concern were taken as part of the VIA. The vantage points of concern (i.e., the locations around PDA where photographs were taken for the VIA) are shown on Figure 7.8, and the photographs that were taken at each of these vantage points are provided in Appendix G. The results of the VIA are described below.

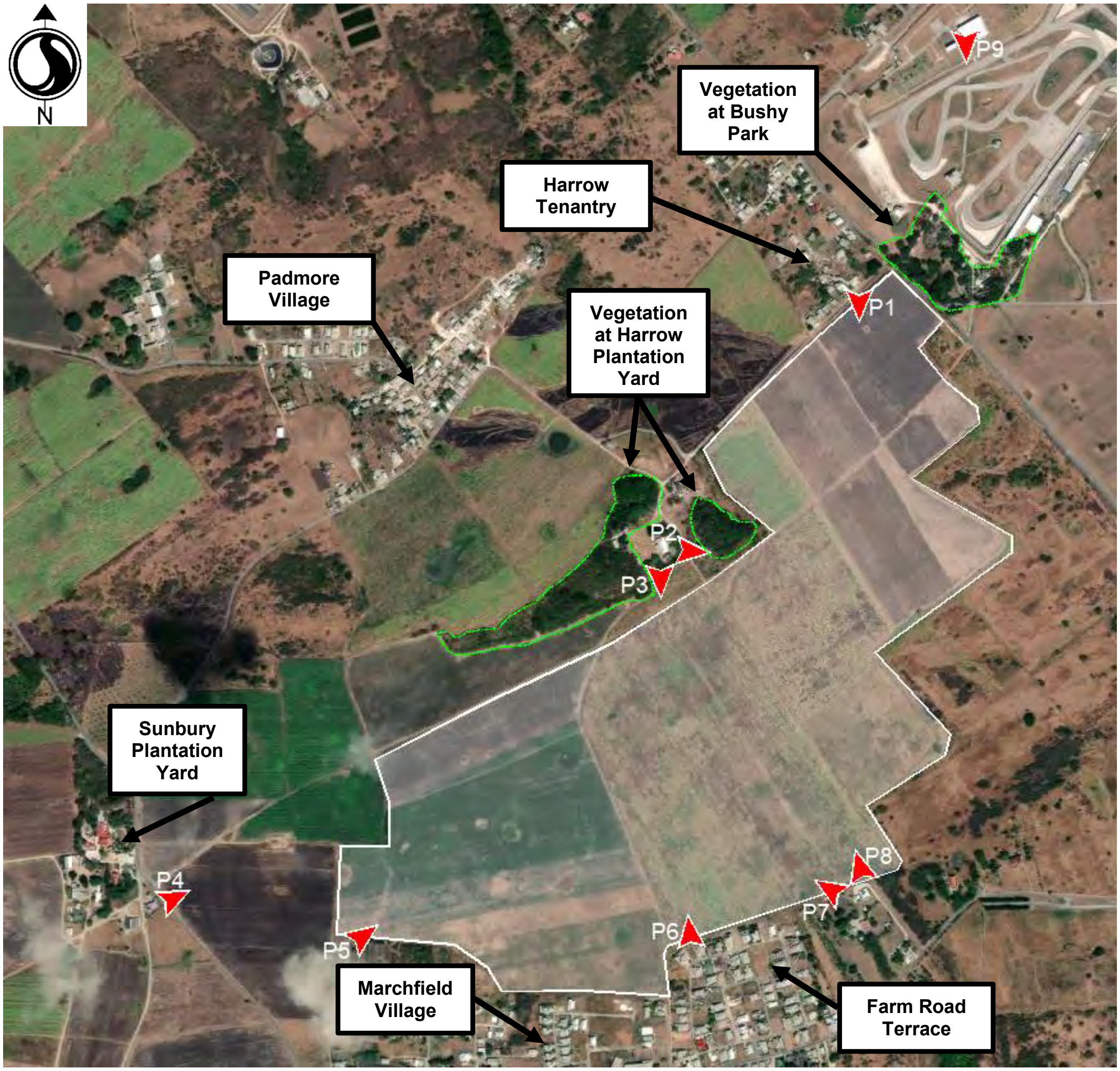

Figure 7.8 Locations Around PDA Where Photographs Were Taken for Visual Impact Assessment

The PDA is currently used for agricultural operations. The majority of the PDA consists of open land; however, portions of the PDA are currently used for sugarcane and other crop cultivation. The PDA slopes gently in a southern direction, with minor undulations throughout. Consequently, observers along the PDA boundaries generally have wide views of the areas that is unobstructed by terrain.

Six key locations were identified at or close to the PDA boundary that are most likely to experience visual impacts due to the proposed Project. These locations, and their current views of the site, are described below. Each of the following locations is shown in the satellite imagery on Figure 7.8, and photographs showing their respective views of the PDA are provided in Appendix G.

- **Harrow Tenantry –** Located to the northeast of the PDA. Views of the PDA are largely unobstructed to the south and south-southwest. Portions of the public road adjacent to the tenantry also provide a view of the PDA. Sections of the PDA to the far west are obstructed by a densely vegetated depression and other trees at Harrow Plantation Yard. Marchfield Village and Farm Road Terrace are clearly visible on the far side of the PDA.
- **Harrow Plantation Yard –** Located to the north of the PDA. Views of the PDA are largely unobstructed to the south. Vegetation to the east and west of the Yard prevents clear view of the PDA in those directions. Marchfield Village and Farm Road Terrace are clearly visible on the far side of the PDA.
- **Sunbury Plantation / Eastern Veterinary Clinic –** Located to the west of the PDA. Views of the PDA are obstructed by tall sugarcane growing between Sunbury and the PDA. Western sections of the PDA may become visible following crop harvest, or in the event that shorter root crops are grown on this land. The tall vegetation surrounding Harrow Plantation Yard can be seen in the distance.
- **Marchfield Village –** Located to the southwest of the PDA. Views of the PDA are largely unobstructed to the northeast. Other portions of the southern PDA border are visible. The tall vegetation surrounding Harrow Plantation can be seen across the PDA.
- **Farm Road Terrace –** Located to the south of the PDA. Views of the PDA are largely unobstructed to the northwest, north, and northeast. Harrow Plantation Yard and Harrow Tenantry are clearly visible on the far side of the PDA.
- **Bushy Park Raceway –** Located to the northeast of the site. The spectator stands – a tall structure situated on a small rise – faces the PDA. Views of the PDA are currently obstructed by mahogany trees and other vegetation. Portions of the PDA may become visible in the future if some or all of this vegetation is removed.

7.3 SOCIAL ENVIRONMENT

A baseline study of the existing social environment (including economic and cultural aspects) in which the Project is proposed to be carried out was conducted in support of the Social Impact Assessment (SIA) portion of the ESIA. Representatives from 155 households within a 1-km radius of the PDA were interviewed to collect data pertaining to local demographics, housing and community conditions, public perceptions of solar PV energy in general, public perceptions of the Project in particular, and local commercial enterprises. Section 9.1 provides further information regarding the survey methods that were employed, as well as detailed results of the baseline study.

8.0 ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION

This chapter is the Environmental Impact Assessment (EIA) portion of the ESIA, which focuses on the potential interactions between the Project and the biophysical/ecological and anthropogenic VCs identified in Section 6.2. The following types of impacts are assessed with respect to the biophysical/ecological and anthropogenic VCs:

- the residual environmental impacts of the Project on its own (refer to Section 8.2 to Section 8.6)
- the residual environmental impacts that have potential to occur in the event of an accident, malfunction, emergency, or disaster (refer to Section 8.7)

Chapter 10 assesses the residual environmental and social impacts of the Project in combination with the residual impacts of other past, present, or reasonably foreseeable future projects and activities.

8.1 ENVIRONMENTAL IMPACT ASSESSMENT METHODS

The following subsections describe the approach and methods used to conduct the assessment of potential Project-related impacts on the biophysical/ecological and anthropogenic VCs. Potential cumulative environmental impacts are assessed separately as described in Chapter 10, and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

8.1.1 Identification of Project Interactions with Valued Components

Table 8.1 identifies the potential for interaction between routine Project activities and components and the biophysical/ecological and anthropogenic VCs identified for the assessment (Section 6.2). Further discussion of the potential environmental changes and impacts associated with each of these identified interactions is provided in the assessment subsections for each VC (i.e., Section 8.2 to Section 8.6).

Table 8.1 Project-VC Interaction Matrix

Routine Project Activities and Components, by Project Phase	Valued Components				
	Atmospheric and Acoustic Environment	Surface Water and Groundwater Resources	Flora and Fauna	Visual Environment	Agriculture and Other Land Uses
Construction					
Site preparation, including vegetation clearing, levelling of soils, establishment of temporary construction laydown areas, and excavation of ditches and ponds	✓	✓	✓	✓	✓
Physical construction and equipment installation of the following Project components: • Solar PV power plant • HyPCe area facilities (i.e., BESS, HESS, and EMS) • Buildings associated with the agricultural facilities • Supporting infrastructure, facilities, and utilities (including other buildings and yards, access road and internal site roads, parking areas, security facilities, site lighting, on-site transmission lines and cables and associated on-site hook-ups, connection to existing public water main, package water treatment plant, water storage tanks, and drainage works)	✓	✓	–	✓	✓
Project-related vehicle traffic within the Parish of Saint Philip	✓	–	✓	✓	–
Presence and operation of Project vehicles, heavy equipment, and machinery on-site	✓	–	✓	✓	✓
On-site management (i.e., collection, storage, handling, and transportation) of Project-related wastes	✓	✓	✓	✓	–
Employment and presence of Project personnel	–	–	✓	✓	–
Finalization and commissioning	✓	–	–	–	–
Operation and Maintenance					
Presence and operation of the following Project components: • Solar PV power plant • HyPCe area facilities (i.e., BESS, HESS, and EMS) • Supporting infrastructure, facilities, and utilities (including related buildings and yards, access road and internal site roads, parking areas, security facilities, site lighting, on-site transmission lines and cables and associated on-site hook-ups, connection to existing public water main, package water treatment plant, water storage tanks, and drainage works)	✓	✓	✓	✓	✓

Table 8.1 Project-VC Interaction Matrix

Routine Project Activities and Components, by Project Phase	Valued Components				
	Atmospheric and Acoustic Environment	Surface Water and Groundwater Resources	Flora and Fauna	Visual Environment	Agriculture and Other Land Uses
Solar grazing of sheep between the solar panels of the power plant; vegetation management; and harvesting, bailing, and storage of grass from the fodder pasture	✓	✓	✓	✓	✓
Sheep husbandry and the provision of associated feeding, watering, and veterinary care	✓	–	✓	–	–
Re-use of mineralized by-product water from the water treatment plant for irrigation of the fodder pasture, washdown, and sanitation purposes	–	✓	–	–	✓
Project-related vehicle traffic within the Parish of Saint Philip	✓	–	✓	✓	–
Presence and operation of Project vehicles, heavy equipment, and machinery on-site	✓	–	✓	✓	✓
On-site management (i.e., collection, storage, handling, and transportation) of Project-related wastes	✓	✓	✓	✓	–
Employment and presence of Project personnel	–	–	✓	✓	–
Decommissioning					
Dismantling and removal of the following Project components: • Solar PV power plant • HyPCe area facilities (i.e., BESS, HESS, and EMS) • Buildings associated with the agricultural facilities • Supporting infrastructure, facilities, and utilities (including other buildings and yards, access road and internal site roads, parking areas, security facilities, site lighting, on-site transmission lines and cables and associated on-site hook-ups, connection to existing public water main, package water treatment plant, water storage tanks, and drainage works)	✓	✓	✓	✓	✓
Backfilling of ponds and ditches and re-establishment of natural drainage patterns	✓	✓	✓	✓	✓
Recontouring and revegetation of disturbed areas	✓	✓	✓	✓	✓
Project-related vehicle traffic within the Parish of Saint Philip	✓	–	✓	✓	✓
Presence and operation of Project vehicles, heavy equipment, and machinery on-site	✓	–	✓	–	✓
On-site management (i.e., collection, storage, handling, and transportation) of Project-related wastes	✓	✓	✓	✓	–

Table 8.1 Project-VC Interaction Matrix

Routine Project Activities and Components, by Project Phase	Valued Components				
	Atmospheric and Acoustic Environment	Surface Water and Groundwater Resources	Flora and Fauna	Visual Environment	Agriculture and Other Land Uses
Employment and presence of Project personnel	–	–	✓	✓	–
Notes: ✓ = Potential interaction – = No interaction					

8.1.2 Impact Analysis, Mitigation, and Environmental Impact Predictions

Project-related environmental impacts are assessed for each biophysical/ecological and anthropogenic VC during every phase of the Project (i.e., construction, operation and maintenance, and decommissioning). The focus of the assessment is on residual environmental impacts (i.e., the environmental impacts that remain after planned mitigation has been applied).

8.1.2.1 Potential Project-Related Impacts

Specific Project activities that may interact with the VC to result in an environmental impact (i.e., a measurable change that may affect the VC) are identified and the associated impact pathway(s) are described for each potential impact. Project components and activities that do not interact with the VC are also identified and the reason for the lack of interaction is explained. Each identified environmental impact is then analysed based on scientific knowledge, assessment tools such as quantitative modelling (where needed), and professional judgement.

8.1.2.2 Mitigation

Technically and economically feasible mitigation measures are proposed to eliminate, reduce, or control adverse environmental impacts, to address public concerns, and to optimize beneficial effects. Types of mitigation measures include:

- Project design mitigation measures, such as those identified in Section 3.7.1;
- Standard environmental protection procedures, such as those identified in Section 3.7.2;
- VC-specific mitigation measures to address the potential impacts on a particular VC, such as those identified in the assessment subsections for each VC (Section 8.2.2 to Section 8.6.2) and summarized in Section 3.7.2;

- Mitigation and contingency measures to address the possibility of accidents, malfunctions, emergencies, or disasters that could affect the environment, such as those identified in Section 8.7; and
- Measures proposed in monitoring and management plans as part of a process of adaptive management, such as those referred to in Chapter 11 and identified in the ESMP for the Project (Appendix I).

8.1.2.3 Residual Environmental Impact Characterization Criteria

Direct and indirect residual impacts are described and rated based on the characterization criteria defined in Table 8.2, which are standard across all VCs.

Table 8.2 Residual Environmental Impact Characterization Criteria

Criteria	Description	Definition of Possible Ratings
Direction	This rating denotes the long-term trend of the residual impact.	**P** **Positive:** A residual impact that moves the measurable parameter(s) in a direction beneficial to the VC relative to baseline conditions. **A** **Adverse:** A residual impact that moves the measurable parameter(s) in a direction detrimental to the VC relative to baseline conditions. **N** **Neutral:** No net change in the measurable parameter(s) for the VC relative to baseline conditions.
Magnitude	This rating denotes the expected degree or severity of the residual impact, in consideration of the proportion of the VC affected.	**N** **Negligible:** No measurable change from existing/baseline conditions. **L** **Low:** Measurable change from existing/baseline conditions that is within the range of natural variability and does not exceed applicable objectives, guidelines, or standards, nor does it pose a risk to the short-term viability of human health or wellbeing; surface water or groundwater resources; terrestrial habitats, populations, or biodiversity; the activities of agricultural or other land users; or the visual landscape. **M** **Moderate:** Measurable change from existing/baseline conditions that may exceed natural variability but does not exceed applicable objectives, guidelines, or standards, nor does it pose a risk to the long-term viability of human health or wellbeing; surface water or groundwater resources; terrestrial habitats, populations, or biodiversity; the activities of agricultural or other land users; or the visual landscape. **H** **High:** Measurable change from existing/baseline conditions that exceeds the limits of natural variability; may exceed applicable objectives, guidelines, or standards; and may affect the long-term viability of human health or wellbeing; surface water or groundwater resources; terrestrial habitats, populations, or biodiversity; the activities of agricultural or other land users; or the visual landscape.
Geographic Extent	This rating denotes the geographic area in which a residual environmental impact occurs.	**S** **Site:** Residual impact is spatially limited to within the PDA. **L** **Local:** Residual impact is spatially limited to within the AOI. **R** **Regional:** Residual impact is spatially limited to within the RSA. **R+** **Extra-Regional:** Residual impact extends beyond the RSA.

Table 8.2 Residual Environmental Impact Characterization Criteria

Criteria	Description	Definition of Possible Ratings
Duration	This rating denotes the length of time the residual impact is expected to persist, which may be longer than the duration of the Project activity or component that gave rise to the residual impact.	Quantitative measure; or **ST** **Short-term:** Residual impact occurs for a portion of the duration of the applicable phase(s) of the Project. **MT** **Medium-term:** Residual impact occurs for the entire duration of the applicable phase(s) of the Project. **LT** **Long-term:** Residual impact extends beyond the life of the Project.
Frequency	This rating denotes how often the residual environmental impact might occur within a specified time period.	Quantitative measure; or **O** **Occasional:** Residual impact occurs once per month or less. **S** **Sporadic:** Residual impact occurs sporadically at irregular intervals. **R** **Regular:** Residual impact occurs on a regular basis and at regular intervals. **C** **Continuous:** Residual impact occurs continuously.
Reversibility	This rating denotes whether or not the VC can recover to existing/baseline conditions once the activity causing the residual impact ceases.	**R** **Reversible:** Residual impact is likely to be reversed (i.e., VC will likely recover to existing/baseline conditions) before or after the completion of Project activities. **I** **Irreversible:** Residual impact is unlikely to be reversed, even after the completion of Project activities, and is likely permanent.
Probability	This rating denotes the likelihood of the residual impact occurring.	**L** **Likely:** Residual impact is considered likely to occur based on available information and professional judgement. **U** **Unlikely:** Residual Impact is considered unlikely to occur based on available information and professional judgement.

8.1.2.4 Significance Criteria

The predicted significance of residual Project-related environmental impacts is determined for each VC based on the VC-specific significance criteria (or thresholds) defined below.

- For the **Atmospheric and Acoustic Environment VC** (Section 8.2), a significant residual adverse impact is defined as a residual Project-related change to the atmospheric and/or acoustic environment that results in any of the following:
  - A reduction in air quality beyond the PDA such that the maximum ground-level air contaminant concentration associated with the Project, in combination with the conservative background concentration, frequently exceeds the applicable ambient air quality standard presented in Table 8.3. “Frequently” is defined as once per week for 1-hour and 8-hour objectives, and once per month for 24-hour objectives. Barbados’ ambient air quality standards (Table 8.3) are based on international standards such as the United States Environmental Protection Agency’s *National Ambient Air Quality Standards* for the following air contaminants: particulate matter, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide, and lead.

Table 8.3 Barbados' Ambient Air Quality Standards

<table>
<tr><th>Air Contaminant</th><th colspan="12">Standard
µg - micrograms (one-millionth of a gram)</th></tr>
<tr><td>Particulate Matter ($PM_{2.5}$)</td><td colspan="6">25 µg/m^3 24-hour mean</td><td colspan="6">10 µg/m^3 annual mean</td></tr>
<tr><td>Particulate Matter (PM_{10})</td><td colspan="6">50 µg/m^3 24-hour mean</td><td colspan="6">20 µg/m^3 annual mean</td></tr>
<tr><td>Ozone (O_3)</td><td colspan="12">100 µg/m^3 8-hour mean</td></tr>
<tr><td>Nitrogen Dioxide (NO_2)</td><td colspan="6">200 µg/m^3 1-hour mean</td><td colspan="6">40 µg/m^3 annual mean</td></tr>
<tr><td>Sulphur Dioxide (SO_2)</td><td colspan="4">500 µg/m^3 10-minute mean</td><td colspan="4">200 µg/m^3 1-hour mean</td><td colspan="4">20 µg/m^3 24-hour mean</td></tr>
<tr><td>Carbon Monoxide (CO)</td><td colspan="3">100 µg/m^3 15-minute mean</td><td colspan="3">60 µg/m^3 30-minute mean</td><td colspan="3">30 µg/m^3 1-hour mean</td><td colspan="3">10 µg/m^3 8-hour mean</td></tr>
<tr><td>Lead (Pb)</td><td colspan="12">0.5 µg/m^3 annual mean</td></tr>
<tr><td colspan="13">Source: Government of Barbados 2019f.</td></tr>
</table>

  - The release of more than 500,000 t CO_2e/year of GHG emissions to the atmosphere.
  - Noise emissions from routine activities that exceed background sound pressure levels by more than 5 dBA beyond the PDA.
- For the **Surface Water and Groundwater Resources VC** (Section 8.3), a significant residual adverse impact is defined as a residual Project-related change to surface water and/or groundwater resources that results in any of the following:
  - Alteration of the hydrological regime and/or sediment transport regime beyond the PDA such that it no longer meets established instream flow needs.
  - A reduction in surface water quality beyond the PDA that causes acute or chronic toxicity to aquatic life at the community or population level.
  - A reduction in groundwater quantity and/or quality to the point where the yield from an established groundwater supply aquifer or well is no longer suitable or adequate for its intended use.
  - Physical or chemical alteration of an aquifer to the extent that interaction with local surface water results in streamflow or chemistry changes that adversely affect aquatic life at the community or population level or surface water supply.
  - Contravention of an applicable watershed management target.

- For the **Flora and Fauna VC** (Section 8.4), a significant residual adverse impact is defined as a residual Project-related change to the environment that results in any of the following:
  - A decline in abundance and/or change in distribution of a species such that the integrity (i.e., long-term persistence or viability) of the species in the RSA is threatened to the extent that natural recruitment (i.e., reproduction and immigration from unaffected areas) is insufficient to return the population to its former level within several growing seasons (for flora) or generations (for fauna).
  - A change in terrestrial habitat that alters its status or integrity within the RSA.
  - A disruption in the achievement of self-sustaining population objectives or recovery goals for special status species.
  - An impact that is contrary to or inconsistent with the goals, objectives, or activities of an applicable plan, policy, or legislation.
- For the **Visual Environment VC** (Section 8.5), a significant residual adverse impact is defined as a residual Project-related change to the environment that results in high-intensity glare with the potential to cause permanent eye damage if observed by receptors beyond the PDA, or glint and glare impacts that otherwise represent a public health and safety hazard.
- For the **Agriculture and Other Land Uses VC** (Section 8.6), a significant residual adverse impact is defined as a residual Project-related change to the environment that results in either of the following:
  - A change or disruption that widely restricts or degrades present land use capability to a point where agricultural or other land use activities cannot continue at or near current levels in the RSA.
  - Non-compliance with established land use plans, policies, or by-laws, or incompatibility with adjacent or historical land use activities as designated through a regulatory land use process.

8.1.2.5 Prediction Confidence

Level of confidence is assigned to the residual impact predictions for each VC. A lower level of confidence may be indicative of deficiencies in available information (e.g., data gaps in baseline information or limitations in the availability of existing knowledge related to potential Project-environment interactions) or other challenges. VC-specific deficiencies or challenges associated with the EIA process are identified, where applicable.

8.1.2.6 Follow-up and Monitoring

Follow-up and monitoring programs are identified for each VC, where applicable, to verify the accuracy of key EIA predictions and the effectiveness of prescribed mitigation measures. Although not described in the EIA, compliance monitoring will also be undertaken as necessary to verify compliance with applicable regulatory requirements, potentially including the terms and conditions of any environmental permits, approvals, or authorizations that may be issued in support of the Project.

8.2 ATMOSPHERIC AND ACOUSTIC ENVIRONMENT

As described in Section 7.1.2 and Appendix E, baseline noise monitoring was conducted to quantify the existing acoustic environment in the vicinity of the PDA. An acoustic assessment was subsequently carried out (Appendix E) in which commercially available CADNA/A acoustic modelling software was used to predict Project-related sound emissions and estimate the Project-related change in baseline sound levels at nearby receptor locations (i.e., within 100 m of the PDA) during the operation and maintenance phase of the Project. The complete Acoustic Assessment report is provided in Appendix E, including detailed modelling methods and results. Key findings and proposed mitigation measures from the Acoustic Assessment report are considered where applicable in this assessment of potential Project-related environmental impacts on the atmospheric and acoustic environment.

8.2.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with the atmospheric and acoustic environment to adversely affect air quality and result in increased levels of GHG emissions, noise, and vibration. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on the atmospheric and acoustic environment is focused on the following potential changes to the environment:

- Change in air quality
- Change in GHG emissions
- Change in the acoustic environment (including noise and vibration)

During the **construction phase** of the Project, the atmospheric and acoustic environment could be impacted by the following:

- An adverse Project-related <u>change in air quality</u> due to
  - atmospheric emissions of combustion by-products and other air contaminants resulting from the operation of gasoline and diesel-powered Project construction vehicles heavy equipment, and machinery.
  - atmospheric emissions of particulate matter and fugitive dust emissions associated with site preparation (including the levelling of soils, establishment of temporary construction laydown areas, and excavation of ditches and ponds) and other ground-disturbing activities, the construction of site roads and parking areas, the handling of aggregate materials used in construction, the on-site management of Project-related construction wastes, and the movement of Project construction vehicles, heavy equipment, and machinery.
- An adverse Project-related <u>change in GHG emissions</u> due to atmospheric emissions of GHGs in combustion by-products resulting from the operation of gasoline and diesel-powered Project construction vehicles, heavy equipment, and machinery.

- An adverse Project-related change in the acoustic environment due to acoustic emissions resulting from the physical construction and installation of Project components and the operation of Project construction vehicles, heavy equipment, and machinery, including potential noise and vibration emissions associated with pile driving (if required).

  In addition to the Project vehicles, heavy equipment, and machinery that will be used on-site to carry out Project construction activities, it is estimated that approximately 450 trucks will be required to transport key Project components to the PDA to enable construction and equipment installation (refer to Section 3.3.1.2).

During the **operation and maintenance phase** of the Project, the atmospheric and acoustic environment could be impacted by the following:

- An adverse Project-related change in air quality due to
  - atmospheric emissions of combustion by-products and other air contaminants resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance.
  - atmospheric emissions of particulate matter and fugitive dust emissions associated with the movement of Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance; the presence and operation of the feed silo; the use of gravel site roads and parking areas; and the on-site management of Project-related wastes.
- An adverse Project-related change in GHG emissions due to
  - atmospheric emissions of GHGs in combustion by-products resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance.
  - atmospheric emissions of GHGs from various sources associated with operation of the sheep farm (e.g., the presence of sheep manure, the potential application of fertilizers).
- A positive (i.e., beneficial) Project-related change in air quality and GHG emissions due to the generation and delivery of renewable power from a non-polluting and carbon-free source, which will reduce the potential air contaminant and GHG emissions that would have otherwise been associated with the generation and delivery of non-renewable power from Barbados' existing large-scale power plants that primarily rely on imported petroleum products.
- An adverse Project-related change in the acoustic environment due to noise emissions resulting from the operation of electrical and electronic components associated with the Project energy facility, the presence of approximately 1,830 Blackbelly sheep, and the operation of Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance.

As described in Section 3.6.2, small amounts of pure oxygen, hydrogen gas, and water vapour will be emitted from the HESS during routine operation of the Project. However, these gaseous emissions are anticipated to be non-polluting and are therefore not considered further in the assessment of Project-related environmental impacts on the atmospheric and acoustic environment. Section 8.7 considers potential atmospheric and acoustic impacts that could occur in the event of accident or malfunction.

During the **decommissioning phase** of the Project, the atmospheric and acoustic environment could be impacted by the following:

- An adverse Project-related change in air quality due to
  - atmospheric emissions of combustion by-products and other air contaminants resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery.
  - atmospheric emissions of particulate matter and fugitive dust emissions associated with activities such as backfilling, recontouring, and other ground-disturbing site reclamation activities; the dismantling and removal of Project components; the on-site management of Project-related demolition wastes; and the movement of Project vehicles, heavy equipment, and machinery.
- An adverse Project-related change in GHG emissions due to atmospheric emissions of GHGs in combustion by-products resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery.
- An adverse Project-related change in the acoustic environment due to noise emissions resulting from the dismantling and removal of Project components and the operation of Project vehicles, heavy equipment, and machinery.

8.2.2 Mitigation

Potential Project-related adverse environmental impacts on the atmospheric and acoustic environment will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable.

The following VC-specific mitigation measures will also be implemented to reduce potential adverse impacts to the atmospheric and acoustic environment:

- Only areas required for construction will be cleared.
- Where practical, Project vehicles, heavy equipment, and machinery will be sized to the smallest needed to perform the work.
- Air and acoustic emissions from Project vehicles, heavy equipment, and machinery will be managed by conducting regular inspection, repair, and maintenance activities as required for operation in accordance with manufacturer's recommendations and to reduce instances of visible sooty emissions or abnormally high sound levels. Defective vehicles or equipment will be taken out of service and not permitted to resume operations until they are repaired.
- Project vehicles, heavy equipment, and machinery will be outfitted with mufflers (and/or other appropriate sound attenuation devices) that meet international design standards.
- Project vehicles, heavy equipment, machinery, and associated exhaust systems and mufflers (and/or other appropriate sound attenuation devices) will be regularly inspected and maintained so that they remain operating in accordance with manufacturer's recommendations.Project vehicles, heavy equipment, and machinery will be shut down when stationary for long periods of time. The idling of vehicles and equipment will be avoided whenever practical.
- Dust from Project activities will be controlled where required by using applications of water. Waste oil will not be used for dust control, but other agents, such as wood chips, calcium chloride, matting, and revegetation may be considered on a site-specific or as needed basis.

- Project-related fugitive road dust will be controlled through measures such as:
  - Establishing speed limits of less than 20 km/hour on Project-controlled gravel roads
  - Conducting road watering on an as-needed basis
  - Washing truck tires before leaving the construction area onto existing paved roads
  - Requiring trucks hauling material to have tarps to cover the load
- Dust emissions during Project activities will be further reduced by covers, screens, enclosures, or other similar methods, where necessary.
- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors, which will help to prevent the movement of dust onto surrounding areas.
- Cleared areas will be paved or revegetated, where possible.
- A cover of native grass will be planted and maintained under and between rows of solar PV panels and routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could produce dust emissions during dry conditions.
- Stockpiles of topsoil, overburden, and other potentially dust-generating materials will be kept covered and used as soon as practical.
- Waste materials will not be burned on-site.
- Haul distances to disposal sites will be reduced as much as possible.
- A construction fence will be retained along the perimeter of the site where feasible; this will act as a barrier to prevent the movement of dust onto surrounding areas.
- Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).
- Blasting will be avoided, where possible, during construction.
- If required and if feasible, augering will be conducted rather than pile driving. If pile driving cannot be avoided, it will be scheduled during daytime hours only and a vibratory hammer will be used since it is quieter and generates less vibration than an impact hammer.
- Nearby residents will be notified prior to potential pile driving (if required).
- Project vehicles will drive within the speed limit to reduce engine noises as vehicles travel on roadways within adjacent communities and horns will be used only as necessary for safety purposes.
- Acoustical barriers (e.g., engineered materials or stockpiled overburden) will be used near loud sources during construction, if feasible.
- Walled enclosures may be constructed around especially noisy activities, or clusters of noisy equipment or machinery.
- Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential impacts to various receptors, including flora and fauna, surface water resources, and surrounding agricultural and other land users, residents, and businesses.

The Acoustic Assessment report (Appendix E) recommends the following additional mitigation measures that will be implemented to further reduce Project-related sound pressure levels: the establishment of physical noise controls (e.g., an enclosure for the BESS and physical barriers for transformers and inverters) and the preferential selection of Project components with noise reduction capabilities, in cases where it is technically and economically feasible to do so.

8.2.3 Characterization of Residual Project-Related Impacts

Most of the potential emissions of air contaminants, GHGs, noise, and vibration associated with Project activities will be temporary and intermittent (i.e., occurring only during the course of transient activities such as the operation and movement of Project vehicles, heavy equipment, and machinery; the carrying out of ground-disturbing activities; the handling of aggregate materials; and the on-site management of Project-related wastes). The magnitude of Project-related atmospheric and acoustic emissions is predicted to be highest during the construction phase (which is anticipated to last approximately 24 months), followed by the decommissioning phase (which is anticipated to last approximately 12 months), due to the nature of the activities associated with those phases of the Project.

During the operation and maintenance phase of the Project (which is anticipated to last approximately 25 years or more), the potential use of heavy equipment and machinery will be limited to that required to support occasional to regular general facilities maintenance activities and sporadic to regular sheep farming activities. Other potential sources of atmospheric and acoustic emissions associated with operation of the sheep farm (e.g., emissions of particulate matter from the feed silo, GHG emissions from sheep manure and the potential application of fertilizers, and acoustic emissions from the bleating of sheep) may occur relatively more frequently. However, the residual impacts of Project farming-related emissions are not anticipated to differ substantially from the potential residual atmospheric and acoustic impacts that could conceivably occur at the site in the absence of the Project, since the PDA is currently designated for agricultural land use.

8.2.3.1 Characterization Residual Project-Related Changes in Air Quality and GHG Emissions

With the application of proposed mitigation, residual Project-related changes in air quality and GHG emissions during construction are predicted to be adverse in direction, low in magnitude, ranging in geographic extent from being spatially limited to the PDA or AOI (e.g., for emissions of particulate matter and fugitive dust) to extending beyond the RSA (i.e., due to the potential for certain types of air emissions, including GHG emissions, to disperse in the atmosphere), medium-term in duration, occurring sporadically at irregular intervals, and reversible. During the operation and maintenance phase and the decommissioning phase, residual Project-related changes in air quality and GHG emissions (i.e., from the operation of Project agricultural facilities, general facilities maintenance activities, the use of gravel site roads and parking areas, and the on-site management of Project-related wastes) are similarly predicted to be adverse in direction, low in magnitude, ranging in geographic extent from the PDA or AOI to beyond the RSA, medium-term in duration, and reversible. However, the residual impacts associated with the operation phase are predicted to occur occasionally to regularly, whereas the residual impacts associated with the decommissioning phase are predicted to occur sporadically at irregular intervals.

The Project energy facility (i.e., the solar PV power plant, BESS, HESS, and EMS) are not anticipated to produce any measurable emissions of air contaminants or GHGs during the operation phase. Furthermore, as indicated in Section 4.1.2, the Project is anticipated to reduce Barbados' total CO_2 emissions by approximately 48,000 tons annually through the generation of approximately 56,000 MWh of carbon-free electricity per year[7]. Generating that amount of electricity from a non-polluting source, rather than from Barbados' existing large-scale power plants that primarily rely on imported petroleum products, will also reduce Barbados' total annual emissions of air contaminants. Thus, the operation of the Project energy facility is predicted to result in a residual change in air quality and GHG emissions that is positive in direction (i.e., a beneficial reduction in air contaminant and GHG emissions), moderate in magnitude, medium-term in duration, continuous, and reversible.

8.2.3.2 Characterization of the Residual Project-Related Change in the Acoustic Environment

With the application of proposed mitigation, the residual Project-related change in the acoustic environment during construction is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible. If pile driving is required during construction, it would be expected to temporarily raise the magnitude of the residual impact to moderate. However, any potential pile driving activities (if required) will be short-term in duration (i.e., occurring for approximately 16 weeks out of the 24-month construction period). The characteristics of this residual impact are expected to be similar during the decommissioning phase, but exclusively low in magnitude (since no pile driving is anticipated) and likely relatively lower in frequency and duration than during construction.

The Project energy facility is anticipated to emit noise continuously during the operation and maintenance phase. As indicated earlier, an acoustic assessment was subsequently carried out (Appendix E) in which commercially available CADNA/A acoustic modelling software was used to predict sound emissions from the Project energy facility and estimate the change in baseline sound levels at nearby receptor locations. The noise sources that were included in the acoustic model were the electrolysers and fuel cells associated with the HESS, as well as their cooling fans; the inverters and transformers associated with operation of the solar PV panels, BESS, and HESS; the fan noise from the battery packs associated with the BESS; and the sheep pens. Noise levels at the nearest points of reception were estimated and then assessed for compliance using World Health Organization (WHO) and World Bank noise exposure guidelines (i.e., WHO 1999 and World Bank Group 2007b).

The results of the Acoustic Assessment (Appendix E) indicate that the noise contribution from the Project is not anticipated to exceed WHO criteria at the points of reception identified near the PDA during the daytime. During the nighttime, slight exceedances of the WHO guideline criteria of 45 dBA are predicted at the nearest receptors to the south of the PDA. However, the nighttime predictions are likely overly conservative, as they include noise from the operation of the inverters, which will likely not operate overnight when the solar PV plant is not generating power. Furthermore, these predictions are based on a modelling scenario that excludes the application of mitigation measures, and the model also did not

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[7] Calculation based on average specific CO_2 emissions of 0.87 tCO_2/MWh, as per BLPC figures.

consider the potential barrier effect that may result from the proposed positioning of ten rows of solar panels between Project-related noise generating sources and the receptors south of the PDA.

With the application of proposed mitigation, the residual Project-related change in the acoustic environment during the operation and maintenance phase is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, and reversible. The frequency of the residual impact is predicted to be continuous with respect to operation of the Project energy facility but is anticipated to range from occasional to regular for residual noise emissions associated with general facilities maintenance, and from sporadic to regular for residual noise emissions associated with sheep farming.

8.2.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of the Project on the atmospheric and acoustic environment (i.e., residual Project-related adverse changes in air quality, GHG emissions, and the acoustic environment, as well as residual Project-related positive changes in air quality and GHG emissions) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.4 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on the atmospheric and acoustic environment. These predictions have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities, the effectiveness of standard mitigation measures, and the use of BLPC figures to calculate the anticipated Project-related reduction in Barbados' total CO_2 emissions.

Table 8.4 Summary of Project Residual Environmental Impacts on the Atmospheric and Acoustic Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in Air Quality									
Construction	A	L	L–R+	MT	S	R	L	N	H
Operation and Maintenance	A	L	L–R+	MT	O–R	R	L	N	H
Operation and Maintenance	P	M	L	MT	C	R	L	N	H
Decommissioning	A	L	L–R+	MT	S	R	L	N	H

Table 8.4 Summary of Project Residual Environmental Impacts on the Atmospheric and Acoustic Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in GHG Emissions									
Construction	A	L	L–R+	MT	S	R	L	N	H
Operation and Maintenance	A	L	L–R+	MT	O–R	R	L	N	H
Operation and Maintenance	P	M	L	MT	C	R	L	N	H
Decommissioning	A	L	L–R+	MT	S	R	L	N	H
Residual Change in the Acoustic Environment									
Construction	A	L–M	L	ST–MT	S	R	L	N	H
Operation and Maintenance	A	L	L	MT	O–C	R	L	N	H
Decommissioning	A	L	L	MT	S	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:
- P Positive
- A Adverse
- N Neutral

Magnitude of Residual Impact:
- N Negligible
- L Low
- M Moderate
- H High

Geographic Extent of Residual Impact:
- S (Site): Within the PDA
- L (Local): within the AOI
- R (Regional): Within the RSA
- R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:
Quantitative measure; or
- ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
- MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
- LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:
Quantitative measure; or
- O (Occasional): Once per month or less
- S (Sporadic): Occurs sporadically at irregular intervals
- R (Regular): Occurs on a regular basis and at regular intervals
- C (Continuous): Occurs continuously

Reversibility of Residual Impact:
- R Reversible
- I Irreversible

Probability
- L Likely
- U Unlikely

Significance of Residual Impact:
- S Significant
- N Not Significant

Prediction Confidence:
- L Low level of confidence
- M Moderate level of confidence
- H High level of confidence

8.2.5 Deficiencies, Challenges, and Prediction Confidence

Due to the completion of a Project-specific baseline noise study (appended to the Acoustic Assessment report in Appendix E) and Project-specific acoustic modelling (Appendix E), the level of confidence regarding the predicted residual Project-related change in the atmospheric environment is relatively slightly higher than it is for the predictions that are based on qualitative assessment of Project-related changes in air quality and GHGs emissions. Project-specific air contaminant and GHG emissions were not estimated or modelled due to the lack of information at this stage in Project planning regarding the anticipated types and numbers of vehicles, heavy equipment, and machinery that will be employed to carry out Project activities. However, the level of confidence regarding predicted residual Project-related changes in air quality and GHG emissions remains high in consideration of the results of air quality and GHG assessments that have been previously conducted by the Study Team for other projects of a similar nature and/or scale. Follow-up monitoring for Project-related emissions of air contaminants and GHGs will be undertaken to confirm residual atmospheric impact predictions or identify the potential need for adaptive management, if applicable.

8.2.6 Follow-up and Monitoring

No VC-specific follow-up and monitoring plans are proposed.

8.3 SURFACE WATER AND GROUNDWATER RESOURCES

A Project-specific Drainage Assessment (Appendix B) was completed in support of the ESIA. As part of the Drainage Assessment, a stormwater runoff modelling exercise was carried out for the PDA to analyze drainage patterns and potential changes to drainage patterns following construction of the Project. The complete Drainage Assessment report is provided in Appendix B, including detailed modelling methods and results. Key findings and proposed mitigation measures from the Drainage Assessment report are considered where applicable in this assessment of potential Project-related environmental impacts on surface water and groundwater resources.

8.3.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with surface and groundwater resources. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on surface and groundwater resources is focused on the following potential changes to the environment:

- Change in surface water quantity / quality
- Change in groundwater quantity / quality

During the **construction phase** of the Project, surface water and groundwater resources could be impacted by an adverse Project-related change in surface water quantity / quality due to

- potential erosion and loss of topsoil associated with the disturbance and/or removal of existing vegetation by heavy machinery, which could result in drainage impacts (e.g., sedimentation) affecting downstream farmlands and communities.
- the introduction of new impermeable surfaces to the PDA (e.g., through the construction of concrete pads, roads and other paved areas, and arrays of solar PV panels), which could increase runoff to downstream areas and potentially cause or worsen flooding during extreme or prolonged rainfall events.
- dust generated from Project vehicles, heavy equipment, and machinery, which could be introduced to and affect the quality of surface water.

During the **operation and maintenance phase** of the Project, surface water resources could be impacted by an adverse Project-related change in surface water quantity / quality due to

- surface runoff from rainwater/stormwater and Project sources (including potential excess water from the washdown and sanitation of Project facilities and the irrigation of grazing and fodder pasture areas) – in combination with the continued presence of Project-related impermeable surfaces (e.g., concrete pads, roofs, roadways, hard pavements, solar PV panels) within the PDA – could increase runoff to downstream areas and potentially cause or worsen flooding during extreme or prolonged rainfall events.
- the potential for grassed solar grazing areas to develop bare patches (especially in between panels where routine traffic and maintenance will occur), which could result in increased surface runoff and the formation of erosion channels and pathways.

The planned re-use of mineralized by-product water from the water treatment plant during the operation and maintenance phase of the Project is not anticipated to adversely affect surface water quality. As described in Section 3.6.2, the mineralized by-product water from the water treatment plant is not anticipated to contain potential contaminants other than the minerals that were removed during reverse osmosis (e.g., salt, manganese, iron, fluoride, lead, and calcium), and the concentration of minerals in the by-product water is anticipated to be suitable for irrigation and washdown purposes. As described in Section 3.2.1.2, the fuel cells in the HESS will essentially reverse the the electrolysis process by transforming hydrogen and oxygen back into electricity and pure water vapour (i.e., gaseous H_2O) that is anticipated to be free of contaminants.

During the **operation and maintenance phase** of the Project, groundwater resources could be impacted by a Project-related change in groundwater quantity / quality associated with the infiltration and percolation of captured runoff to groundwater zones from Project-related drainage systems, including existing and proposed on-site infiltration wells (suckwells) and a runoff interceptor drainage system that is proposed along the entire southern boundary of the PDA (as described in the Project-specific Drainage Assessment in Appendix B). The resultant Project-related change may be adverse if the captured runoff contains sediment or other contaminants.

During the **decommissioning phase** of the Project, surface water and groundwater resources could be impacted by an adverse Project-related change in groundwater quantity / quality and an adverse Project-related change in surface water quantity / quality due to the vehicle and heavy equipment use associated with the dismantling and removal of Project components, the backfilling of ponds and ditches, the re-establishment of natural drainage patterns, and the recontouring and revegetation of disturbed areas.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, surface water and groundwater resources could be impacted by an adverse Project-related change in surface water quantity / quality and/or an adverse Project-related change in groundwater quantity / quality due to potential interactions with the emissions, discharges, and wastes identified in Section 3.6.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, surface water and groundwater resources could also be impacted by an adverse Project-related change in surface water quality and/or an adverse Project-related change in groundwater quality due to potential spills/leaks of petroleum products, hydraulic fluids, lubricants, or coolants from Project construction vehicles, heavy equipment, and machinery, and the potential leaching of these substances into groundwater zones beneath the PDA. These potential impacts are considered separately in Section 8.7 – in the context of potential accidents, malfunctions, emergencies, and disasters – and are not considered further here in the assessment of Project-related environmental impacts on surface water and groundwater resources.

8.3.2 Mitigation

Potential Project-related adverse environmental impacts on surface and groundwater resources will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable.

The following VC-specific mitigation measures will also be implemented to reduce potential adverse impacts to surface water and groundwater resources:

- Existing drainage systems within the PDA – including land slopes, watercourses, depressions, suckwells, and dry ponds – will be retained and maintained where possible.
- A cover of native grass will be planted and maintained under and between rows of solar PV panels to help slow the rate of runoff, control erosion, and reduce the transport of sediment/topsoil off-site.
- Routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could result in a change of the runoff characteristics in those areas.
- Paved roadways within the PDA will consist of kerb and slipper drains, with sets of catchbasins including gully grates to drain captured runoff to culverts leading to suckwells.
- Paved areas within the HyPCe area and administration areas will be drained by a system of catchment basins, drainpipes, and suckwells. The use of suckwells is intended to promote on-site drainage of runoff to groundwater, rather than to natural drainage courses that convey runoff south and off-site.

- A 9-m wide drainage reserve has been proposed along the entire southern boundary of the Project Property. This would involve construction of a runoff interceptor drainage system within the aforementioned drainage reserve. This system may consist of an earthen swale with sloped embankments or an infiltration trench with vertical side faces. Suckwells/infiltration wells may be added to the interceptor drain to assist with the sub-surface drainage of captured rainwater. A hydrological study will be performed during detailed design which will seek to finalise drainage mitigation measures, including final selection of any interceptor drainage system(s) that would be required.
- A vegetated buffer strip will be established at the downstream site boundary to control excess runoff.
- Silt screens and/or bales of hay will be installed where necessary to contain and prevent the erosion and loss of topsoil from localized areas.
- Temporary boulder barriers will be installed at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands.
- Temporary stockpiles of topsoil that are not required for re-instatement will be removed from site as soon as possible to avoid migration of topsoil into the natural drainage system.
- Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor.
- The drainage system for the site will be designed to limit stormflows from the site.
- The drainage system design for areas on-site where impermeable areas are to be added will focus on draining runoff to suckwells, and ultimately to groundwater, to reduce the amount of surface water runoff that could potentially impact communities downstream.
- During detailed design, the implementation of a dry pond will be studied. If needed, the dry pond will be constructed on land to the west of the area proposed for sheep grazing, north of the Old Train Line Road (i.e., at the location shown on Figure 17 in Appendix B), to capture a portion of runoff from the North Watershed, promote the infiltration and percolation of runoff to groundwater zones, and reduce to some extent the quantity of runoff that crosses the Old Train Line Road and enters the PDA. The dry pond shall have shallow slopes, be grassed to facilitate grazing by sheep, and include suckwells with top and side entry inlets along its perimeter.
- Septic tanks and soakaways will be routinely inspected at least once every six months and cleaned as necessary.
- The cleaning of PV panels will only be done with clean water. No detergents or cleaning chemicals will be used so that the water that runs off onto the ground does not have chemicals entrained.

8.3.3 Characterization of Residual Project-Related Impacts

8.3.3.1 Characterization Residual Project-Related Change in Surface Water Quantity / Quality

Construction

The topography of the PDA site is not proposed to be substantially modified by Project construction, and it is expected that the finished surface will be graded and planted with a native grass to control erosion of the surface soil. During construction, the use of Project vehicles, heavy equipment, and machinery may result in the disturbance and/or removal of existing vegetation, resulting in increased potential for erosion and washing of topsoil. Loss of topsoil could impact drainage and thus surface water on downstream farmlands and communities. However, the potential for this impact is temporary, as the PDA will be planted with native grass at the end of the construction phase. In addition, the implementation of proposed mitigation measures for erosion and sediment control (e.g., the installation of silt screens and/or bales of hay and temporary boulder barriers) will reduce potential residual impacts to surface water quality that could occur if sediment-laden runoff from the PDA results in the sedimentation/siltation of downstream surface water resources.

Based on the stormwater runoff model and associated assumptions in the Project-specific Drainage Assessment report (Appendix B), it is estimated that the addition of impermeable surfaces due to the development (excluding solar PV panel surfaces) will result in an approximately 9.5% increase in peak runoff from the South Watershed (versus the baseline scenario) for a 1:20-year 24-hour design storm criterion scenario and an approximately 8.4% peak runoff increase for a 1:50-year 24-hour design storm criterion scenario.

Taking into consideration runoff from the North Watershed and South Watershed (PDA), as well as the drainage provided by 29 infiltration wells in the North Watershed and 23 wells in the South Watershed (PDA), the runoff discharging along the southern boundary of the PDA towards the communities to the south of the site is estimated to increase (versus baseline flows) by 0.36% for the 1:20-year 24-hour design storm criterion and 0.3% for the 1:50-year 24-hour design storm criterion. Thus, the introduction of additional impermeable surfaces due to the development on site is not predicted to substantially increase runoff to downstream communities.

With the application of proposed mitigation, residual Project-related changes in surface water quantity / quality during construction are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, ranging in frequency from occurring sporadically at irregular intervals (for residual impacts associated with the disturbance and/or removal of existing vegetation) to continuous (for residual impacts associated with the introduction of impermeable surfaces to the PDA), and reversible.

Operation and Maintenance

As described in Section 7.1.5, runoff from the North Watershed to the PDA is predominantly via overland flow with shallow flow depths; there are a few watercourses where runoff occurs at deeper depth. Hydrological and hydraulic analyses conducted as part of the Project-specific Drainage Assessment (Appendix B) indicate shallow runoff depths predominantly throughout the site (post-development) and an increased percentage of impermeable areas in the catchment. As described above, this increase of impermeable surfaces within the PDA is expected to marginally increase runoff to downstream areas. Surface runoff from rainwater/stormwater and Project sources (including potential excess water from washdown and sanitation of Project facilities and irrigation of grazing and fodder pasture areas) will be managed through on-site drainage works (refer to Section 3.2.3.6). By way of analyses conducted in Appendix B, it was demonstrated that an infiltration trench along the southern boundary of the PDA could result in downstream runoff volumes from the PDA being slightly less than the baseline scenario. On-site rainwater harvesting, if implemented (Section 3.2.3.5), will also reduce runoff during precipitation events.

PV solar panels are impervious to rainfall; however, they are generally mounted on a steel support framework above the permeable land formation. A study by Cook and McCuen (2013) investigated the hydrologic effects of solar farms and examined whether or not stormwater management is needed to control runoff volumes and rates following the development of a farm. During the study, a model of a solar farm was created for simulating runoff conditions for pre- and post-PV panelled conditions. The study conducted sensitivity analyses taking into consideration varying conditions, including changing the storm duration and volume, soil type, ground slope, panel angle, and ground cover – all towards determining the effect that each of these factors would have on the volumes and peak discharge rates of the runoff.

Cook and McCuen (2013) concluded that the addition of solar PV panels over a grassy field does not have much of an effect on the volume of runoff, the peak discharge, nor the time to peak, given that lands beneath the panels are permeable. However, when land cover type is changed under the panels (e.g., the use of gravel or a hard pavement), and the space between is patchy ground or bare, the peak discharge in the model increased by 100% (Cook and McCuen 2013). The kinetic energy of water draining from a solar panel is 10 times greater than rainfall, resulting in the possibility that soil below panels could erode due to concentrated flow of water off the panel, and this scenario is heightened if there is bare earth and/or the panels are sloping in two directions (Cook and McCuen 2013).

Cook and McCuen (2013) ultimately recommend the use of consistent and well-maintained grass-covered soil beneath panels and in the pathway/space between panels. In situations where the use of gravel or hard pavements underneath and between panels is unavoidable, Cook and McCuen (2013) further recommend the use of a vegetated buffer strip at the downstream site boundary to control excess runoff.

With the application of proposed mitigation (Section 8.3.2), residual Project-related changes in surface water quantity / quality during operation and maintenance are predicted to be adverse, low in magnitude, spatially limited to the AOI, medium-term in duration, ranging in frequency from occurring sporadically at irregular intervals (for residual impacts associated with the development of bare patches in solar grazing areas) to continuous (for residual impacts associated with the continued presence of impermeable surfaces within the PDA), and reversible.

Decommissioning

Project decommissioning activities will ultimately serve to reduce and reverse the adverse Project-related impacts on surface water resources associated with Project construction and operation. The activities associated with decommissioning will, however, result in temporary adverse effects similar in nature to construction, although at a limited duration and scale. It will require the use of heavy machinery and equipment to dismantle and remove equipment and regrade and restore surfaces. Residual Project-related changes in surface water quantity / quality during decommissioning are therefore predicted to be adverse in direction, low in magnitude, spatially limited to the PDA, medium-term in duration, occurring continuously, and reversible.

8.3.3.2 Characterization Residual Project-Related Change in Groundwater Quantity / Quality

Construction

No pathways for potential Project-related changes in groundwater quantity / quality have been identified for the construction phase of the Project other than potential interactions with the emissions, discharges, and wastes identified in Section 3.6. With the application of proposed mitigation, residual Project-related changes in groundwater quantity / quality during construction are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible.

Operation and Maintenance

The runoff interceptor drainage system proposed in Section 8.3.2 above and in the Project-specific Drainage Assessment (Appendix B) will capture, attenuate, and promote the infiltration of runoff to groundwater zones. This increased infiltration could cause an adverse change in groundwater quality if the runoff contains sediment or other contaminants. During the operation and maintenance phase of the Project, groundwater resources could be impacted by a Project-related change in groundwater quality associated with the infiltration and percolation of captured runoff to groundwater zones from other Project-related drainage systems, including existing and proposed on-site infiltration wells (suckwells). However, standard mitigation measures and environmental protection procedures identified in Section 8.3.2 will be implemented to reduce potential adverse impacts on runoff quality and consequent adverse impacts on groundwater quality. Although an adverse Project-related change in groundwater quantity / quality could also conceivably occur due to the disposal of wastewater, if untreated wastewater is allowed to discharge directly to suckwells where it could impact groundwater quantity and quality beneath the site, such impacts are not anticipated for the Project since wastewater from sanitary uses within Project buildings will be discharged to the municipal sewage system.

With the application of proposed mitigation, the residual Project-related change in groundwater quantity / quality during the operation and maintenance phase is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible.

Decommissioning

Project decommissioning activities will ultimately serve to reduce and reverse the adverse Project-related impacts on groundwater resources associated with Project construction and operation. The activities associated with decommissioning will, however, result in temporary adverse effects similar in nature to construction, although at a limited duration and scale. It will require the use of heavy machinery and equipment to dismantle and remove equipment and regrade and restore surfaces. Residual Project-related changes in ground water quantity / quality during decommissioning are therefore predicted to be adverse in direction, low in magnitude, spatially limited to the PDA, medium-term in duration, occurring continuously, and reversible.

8.3.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual environmental impacts of the Project on surface water and groundwater resources are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Section 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.5 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on surface and groundwater resources.

Table 8.5 Summary of Project Residual Environmental Impacts on Surface Water and Groundwater Resources

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in Surface Water Quantity / Quality									
Construction	A	L	L	MT	S–C	R	L	N	H
Operation and Maintenance	A	L	L	MT	S–C	R	L	N	H
Decommissioning	A	L	S	MT	C	R	L	N	H
Residual Change in Groundwater Quantity / Quality									
Construction	A	L	L	MT	S	R	L	N	H
Operation and Maintenance	A	L	L	MT	S	R	L	N	H
Decommissioning	A	L	S	MT	C	R	L	N	H

Table 8.5 Summary of Project Residual Environmental Impacts on Surface Water and Groundwater Resources

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.3.5 Deficiencies, Challenges, and Prediction Confidence

Due to the completion of a Project-specific Drainage Assessment (Appendix B) that included stormwater runoff modelling, the level of confidence regarding the predicted residual Project-related change in surface water quantity / quality is slightly higher than it is for the predictions that are based on qualitative assessment of Project-related changes in groundwater quantity / quality. However, the predictions in Table 8.5 above have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

8.3.6 Follow-up and Monitoring

No VC-specific follow-up and monitoring plans are proposed.

8.4 FLORA AND FAUNA

8.4.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with flora and fauna species and their habitats. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on flora and fauna is focused on the following potential changes to the environment:

- Change in flora / flora habitat (as measured through the amount [m^2] of habitat directly or indirectly [qualitative] lost or altered)
- Change in flora health / survival (as measured through the change in species occurrence [i.e., number of species and/or number of individual plants])
- Change in fauna habitat quantity / quality / use (as measured through the amount [m^2] of habitat directly or indirectly [qualitative] lost or altered)
- Change in fauna mortality risk (as measured through interactions with Project infrastructure and equipment [number of incidents recorded])

During the **construction phase** of the Project, flora and fauna could be impacted by the following:

- An adverse Project-related <u>change in flora / flora habitat</u> due to the alteration or loss of flora habitat associated with site preparation activities (e.g., the clearing of vegetation and levelling of soils), which will also result in the direct mortality of flora; the planting of high-protein grasses for grazing; and the potential deposition of dust and emissions for vehicles and machinery.
- An adverse Project-related <u>change in flora health / survival</u> due to the potential deposition of dust and emissions from vehicles and machinery.
- An adverse Project-related <u>change in fauna habitat quantity / quality / use</u> due to the alteration or loss of fauna habitat associated with site preparation activities (e.g., the clearing of vegetation and levelling of soils), the planting of high-protein grasses for grazing, and potential sensory disturbances from dust, noise, light, and other emissions.
- An adverse Project-related <u>change in fauna mortality risk</u> due to site preparation and the risk of collisions with vehicles or other Project infrastructure.

During the construction phase, the physical construction and equipment installation for Project components and the finalization and commissioning of the Project are expected to have no interaction with flora or fauna and their habitats, as these activities would take place on sites already disturbed during site preparation.

During the **operation and maintenance phase** of the Project, flora and fauna could be impacted by the following:

- An adverse Project-related change in flora / flora habitat and an adverse Project-related change in flora health / survival due to
  - the alteration of flora habitat associated with activities such as the grazing of sheep between the solar panels of the power plant, vegetation management and harvesting, and the bailing and storage of grass from the fodder pasture.
  - the potential deposition of dust and emissions associated with vehicle traffic within the Parish, the presence and operation of vehicles and equipment on-site as well as the on-site management of wastes generated by Project operation activities.
- An adverse Project-related change in fauna habitat quantity / quality / use due to potential sensory disturbances that could repel or deter species. These sensory disturbances may be caused by Project-related emissions of dust and other air contaminants, noise, and light, as well as visual disturbances associated with the presence and operation of the solar PV power plant, HyPCe area facilities, and supporting infrastructure, facilities, and utilities; Project-related vehicle traffic within the Parish; the on-site management of Project-related wastes; and the presence and operation of Project vehicles, heavy equipment, and machinery on-site.
- An adverse Project-related change in fauna mortality risk due to the risk of collisions associated with the presence and operation of Project components such as the solar panel arrays and supporting infrastructure, facilities, and utilities; Project-related vehicle traffic; and the presence and operation of Project vehicles, heavy equipment, and machinery on-site.

During operation and maintenance, re-use of mineralized by-product water from the water treatment plant is not anticipated to affect the flora and fauna and their habitats, as this water will be conveyed as needed to the agricultural facilities.

During the **decommissioning phase** of the Project, flora and fauna could be impacted by the following:

- An adverse Project-related change in flora / flora habitat and an adverse Project-related change in flora health / survival due to the potential deposition of dust and emissions from vehicles and machinery as Project components are dismantled and removed, through the on-site management of wastes generated during decommissioning activities, and during the re-establishment of natural drainage patterns, the recontouring and revegetation of disturbed areas, and the backfilling of ponds and ditches.
- An adverse Project-related change in fauna habitat quantity / quality / use due to potential sensory disturbances that could repel or deter species. These sensory disturbances may be caused by the dismantling and removal of Project components, the backfilling of ponds and ditches and re-establishment of natural drainage patterns, the recontouring and revegetation of disturbed areas, the on-site management of wastes generated during decommissioning activities, and the presence of Project decommissioning personnel.
- An adverse Project-related change in fauna mortality risk is expected, as there will be a continued risk of collisions with vehicles or potentially other Project equipment. However, overall mortality risk will be reduced as Project components are dismantled and removed.

Following decommissioning, flora/flora habitats are expected to return to baseline conditions over time.

8.4.2 Mitigation

Potential Project-related adverse environmental impacts on flora and fauna will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable.

The following VC-specific measures will also be implemented to reduce adverse effects on flora and fauna and their habitats:

- The mitigation measures identified in Section 8.2.2 with respect to the Atmospheric and Acoustic Environment VC will be implemented to mitigate the potential impacts of air, noise, vibration, and dust emissions on flora and fauna. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna.
- Only areas required for construction will be cleared, and construction equipment and vehicles will only operate in previously disturbed areas, where possible. Sensitive areas and habitats (if identified) will be fenced off to prevent damage by Project vehicles, heavy equipment, and machinery.
- The vegetation/tree screens, which are proposed for reducing visual impacts (refer to Section 8.5.2), will also reduce sensory disturbance to fauna off-site.
- Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce the attraction of birds.
- To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels.
- Native plants will be used for landscaping.
- Cleared areas will be revegetated, where possible.
- To avoid attracting wildlife, wastes will be securely stored, frequently removed from site, and properly disposed of in an environmentally acceptable manner at an approved site.
- Erosion and sediment control measures will be established to reduce the potential for silty water runoff from construction areas to migrate off-site and/or into environmentally sensitive areas. Further details regarding proposed erosion and sediment control measures are provided in Section 8.3.2 in the context of the Surface Water and Groundwater Resources VC. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna.
- Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations.

8.4.3 Characterization of Residual Project-Related Impacts

The Project is anticipated to result in some adverse residual effects on flora and fauna; however, the risk to flora and fauna is expected to be negligible to low in magnitude given the relatively low number of species using the site and the absence of any species at risk. Adverse changes to flora / flora habitat; flora health / survival; fauna habitat quantity / quality / use; and fauna mortality risk will occur primarily during the construction phase during site preparation activities, while some habitat changes will occur continuously throughout the life of the Project (e.g., sensory disturbance) and a low but increased risk of mortality over baseline conditions will continue for birds during Project operation (e.g., potential for birds to collide with Project infrastructure during migration). With the proposed mitigation, these effects are anticipated to be negligible to low in magnitude, have a low likelihood of occurrence, and reversible. Project effects will be medium-term (construction phase) to long-term (operation and maintenance and decommissioning phases) in duration and occur continuously. All of the flora and fauna identified during a field survey conducted in support of a Project-specific Baseline Ecological Assessment (Appendix F) are common in Barbados and, following decommissioning, previously occupied habitats are expected to return to baseline conditions.

8.4.3.1 Characterization Residual Project-Related Changes in Flora / Flora Habitat and Flora Health / Survival

Construction

The PV power plant will occupy land formerly used for agriculture. The flora / flora habitat found within the PDA will be directly affected through the clearing of vegetation and levelling of soils, resulting in the loss or alteration of habitats present. Indirect effects on plant health and survival from dust and other emissions (e.g., vehicle exhausts) during site preparation activities may also occur and may extend into the AOI. However, none of the flora in the PDA or surrounding areas recorded during the baseline survey (Appendix F) are considered rare or at risk. The majority of the area to be cleared and levelled during construction consists of already cleared agricultural land and sugarcane fields (approximately 0.5 km^2, based on visual assessment during the baseline survey), and the remainder consists of sparse grass and shrubs (approximately 0.2 km^2), which are largely considered weeds. In addition, mitigation measures will be applied (e.g., dust suppression and emissions reduction) to reduce potential effects on the surrounding vegetation.

With the application of proposed mitigation, residual Project-related changes in flora / flora habitat and flora health / survival during construction are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, long-term in duration, occurring continuously, and reversible.

Operation and Maintenance

Vegetation clearing will occur during the construction phase, and therefore no additional loss of flora and flora habitat is expected to occur during operation and maintenance. However, the flora / flora habitat in will be altered from the solar grazing of sheep between the solar panels of the power plant, vegetation management, and the harvesting, bailing, and storage of grass from the fodder pasture. Solar grazing is an important part of the PV power plant's design, and there will be a higher proportion of high-protein grasses being grown, thus altering existing habitats in the PDA. The sheep may also graze on other grasses and shrubs that may be freely growing in the PDA. However, the growth of these other grasses and shrubs will occur in the area previously cleared during construction.

As during construction, Project-related vehicle traffic within the Parish, the presence and operation of vehicles and equipment on-site, on-site management of wastes generated by Project activities, and the presence of Project operation and maintenance personnel may have indirect effects on plant health and survival from dust and other emissions, that may extend into the AOI. Standard mitigation measures and environmental protection practices will be implemented to reduce potential effects on the flora in the AOI.

With the application of proposed mitigation, residual Project-related changes in flora / flora habitat and flora health / survival during operation and maintenance are predicted to be adverse in direction, negligible to low in magnitude, spatially limited to the AOI, long-term in duration, occurring continuously, and reversible.

Decommissioning

The decommissioning phase is anticipated to return previously occupied flora habitats to baseline conditions as Project components are dismantled and removed, ponds and ditches are backfilled, natural drainage patterns are re-established, and disturbed areas are recontoured and revegetated. Flora / flora habitats are expected to regrow over time. Potential effects on the flora in the AOI from dust or other emissions generated during decommissioning activities will be reduced using standard mitigation and environmental protection procedures. Overall, Project-related changes in flora / flora habitat and flora health / survival are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, long-term in duration, occurring continuously, and reversible.

8.4.3.2 Characterization of the Residual Project-Related Changes in Fauna Habitat Quantity / Quality / Use and Fauna Mortality Risk

Construction

Vegetation clearing, levelling of soils, and the establishment of temporary construction laydown areas will have a direct effect on habitat. As indicated, most of the area that will be cleared consists of already cleared agricultural land and sugarcane fields, with approximately 0.2 km^2 comprised of grass and shrubs. This latter area is the only location in the PDA where birds were found during the 2021 baseline survey (Appendix F). However, the bird species observed in the PDA during the baseline survey are considered common in Barbados and would be expected to move into similar adjacent available habitats. Further, prior to any clearing activities, the vegetation and ground will first be searched for bird nests or other evidence of nesting activity. One bird species, the cattle egret (*Bubulcus ibis*), may potentially benefit during site preparation, as this species is known to follow tractors and other machinery as they flush prey out by their movement while clearing vegetation and levelling soil.

Construction vehicle traffic to and from the site, the presence and operation of construction vehicles and equipment on-site, on-site management of wastes generated by Project construction activities, and the presence of Project construction personnel may result in sensory disturbance (e.g., visual, noise, light and dust) to birds and other fauna that may extend into the AOI. The AOI for the Project partly encompasses an Important Bird Area (IBA) used by migratory species. None of the IBA migratory bird species were observed in the PDA or adjacent sampled habitat during the baseline survey nor are they expected to occur, as they are attracted to swampy areas rather than cleared, dry land with minimal vegetation. Standard and VC-specific mitigation measures will be applied to reduce potential sensory disturbance effects on surrounding habitats that may be used by birds and other fauna. Therefore, Project activities during the construction phase are not anticipated to result in a measurable change in habitat or mortality risk of the birds in the neighboring IBA, which is located approximately 1.2 km to the south of the PDA.

Project-related traffic and other equipment may also have a residual effect on the mortality risk of fauna through an increased collision risk as vehicles move to and from the site and as infrastructure is installed. Standard and VC-specific mitigation measures, including speed limits, limiting the areal extent of activities and operating equipment in previously disturbed areas, and the use of deterrents, if necessary, will reduce the potential mortality risk to fauna.

With the application of proposed mitigation, the residual Project-related changes in fauna habitat quantity / quality / use and fauna mortality risk during construction are predicted to be adverse in direction, low in magnitude, occurring continuously, and reversible. The residual Project-related change in fauna habitat quantity / quality / use is anticipated to be spatially limited to the AOI and long-term in duration, whereas the residual change in fauna mortality risk is anticipated to be spatially limited to the PDA and short-term in duration.

Operation and Maintenance

Vegetation clearing will occur during the construction phase and therefore no additional loss of fauna habitat will occur during operation and maintenance. Project vehicle traffic (which will be limited during operation and maintenance of the Project), the presence and operation of Project equipment, on-site management of wastes generated by Project operation and maintenance activities, and the presence of Project operation and maintenance personnel may result in indirect sensory disturbances (i.e., visual, noise, light, and dust) that may extend into the AOI. These may indirectly affect the fauna and their habitat by repelling or deterring species throughout the life of the Project. Standard and VC-specific mitigation measures will be implemented to reduce potential sensory disturbances to fauna and their habitat.

The presence and operation of the Project components such as the PV arrays and supporting infrastructure may have a direct effect on fauna mortality risk. PV panels may attract migratory bird species through the “lake effect”, where some birds may perceive the reflective surfaces as bodies of water, which may lead to collisions as they try to land (ECO Consult 2020, Hathcock 2018, and Walston et al. 2016). There are nearby ponds that are already used as rest sites (within the Project AOI, as well as the IBA), and therefore this could be an issue for birds in the area. To date no empirical research has been identified that evaluates the attraction of PV facilities to migrating waterfowl or songbird species

(Hathcock 2018, Walston et al. 2016), though anecdotal events have been noted (Kagan et al. 2014). There may also be a collision risk for birds associated with certain Project infrastructure, potentially including power lines (depending on final Project design). Injuries or mortalities observed will be documented and additional mitigation considered (e.g., panel markings) should any high-risk areas be identified.

With the application of proposed mitigation, the residual Project-related changes in fauna habitat quantity / quality / use and fauna mortality risk during operation and maintenance are predicted to be adverse in direction, negligible to low in magnitude, long-term in duration, occurring continuously, and reversible. The residual Project-related changes in fauna habitat quantity / quality / use are predicted to be spatially limited to the AOI while the residual change in fauna mortality risk is predicted to be spatially limited to the PDA.

Decommissioning

The decommissioning phase is expected to return fauna habitats to their original baseline conditions as Project components are dismantled and removed, ponds and ditches are backfilled, natural drainage patterns are reestablished, and disturbed areas are recontoured and revegetated.

Sensory disturbances (e.g., noise, light, visual, dust) generated during decommissioning activities will be reduced using standard mitigation and environmental protection procedures.

An adverse Project-related change in fauna mortality risk is expected, as there will be a continued risk of collisions with vehicles. However, the overall mortality risk will be reduced as Project components (e.g., solar panels) are dismantled and removed.

With the application of proposed mitigation, the residual Project-related changes in fauna habitat quantity / quality / use and fauna mortality risk during decommissioning are predicted to be adverse in direction, low in magnitude, long-term in duration, occurring continuously, and reversible. The residual Project-related changes in fauna habitat quantity / quality / use are spatially limited to the AOI while the residual Project-related changes in fauna mortality risk are spatially limited to the PDA.

8.4.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of routine Project on flora and fauna (i.e., residual Project-related changes in flora / flora habitat; flora health / survival; fauna habitat quantity / quality / use; and fauna mortality risk) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.4 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on flora and fauna. These predictions have been made with a moderate level of confidence for change in fauna mortality risk during operation and maintenance based on a high level of confidence for all other changes based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

Table 8.6 Summary of Project Residual Environmental Impacts on Flora and Fauna

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in Flora / Flora Habitat									
Construction	A	L	L	LT	C	R	L	N	H
Operation and Maintenance	A	N–L	L	LT	C	R	L	N	H
Decommissioning	A	L	L	LT	C	R	L	N	H
Residual Change in Flora Health / Survival									
Construction	A	L	L	LT	C	R	L	N	H
Operation and Maintenance	A	N–L	L	LT	C	R	L	N	H
Decommissioning	A	L	L	LT	C	R	L	N	H
Residual Change in Fauna Habitat Quantity / Quality / Use									
Construction	A	L	L	LT	C	R	L	N	H
Operation and Maintenance	A	N–L	L	LT	C	R	L	N	H
Decommissioning	A	L	L	LT	C	R	L	N	H
Residual Change in Fauna Mortality Risk									
Construction	A	L	S	MT	C	R	L	N	H
Operation and Maintenance	A	N–L	S	LT	C	R	L	N	M
Decommissioning	A	L	S	LT	C	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:
P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:
N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:
S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:
Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:
Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:
R Reversible
I Irreversible

Probability
L Likely
U Unlikely

Significance of Residual Impact:
S Significant
N Not Significant

Prediction Confidence:
L Low level of confidence
M Moderate level of confidence
H High level of confidence

The Project is anticipated to result in adverse residual effects on the Flora and Fauna VC. Adverse changes to flora and flora habitat and flora health and survival and fauna and fauna habitat and their mortality risk will occur primarily during the construction phase during site preparation activities, while some habitat changes will occur continuously throughout the Project's lifetime (e.g., sensory disturbance). With the proposed mitigation, these effects are anticipated to be negligible to low in magnitude, have a low likelihood of occurrence, and reversible. Project effects will be medium-term (construction phase) to long-term (operation and maintenance and decommissioning phases) in duration and occur continuously. All of the flora and fauna identified during the field survey conducted in support of the Project-specific Baseline Ecological Assessment (Appendix F) are common in Barbados and, following decommissioning, previously occupied habitats are expected to return to baseline conditions.

Overall, the predicted residual environmental effects from the Project do not threaten the long-term persistence or viability of the flora or fauna within the AOI and are not contrary to or inconsistent with the goals, objectives and activities of action plans and management plans. As such, residual environmental effects from routine Project activities are predicted to be not significant.

8.4.5 Deficiencies, Challenges, and Prediction Confidence

The flora and fauna survey conducted in support of the Baseline Ecological Assessment (Appendix F) identified the different habitats and flora and fauna found in the PDA and adjacent areas surveyed. Although there is a lack of seasonal data since the baseline study was only conducted during the wet season, the timing of the study (in mid-September 2021) coincided with the annual period during which migratory birds stopover in Barbados on their way to South America. This is the annual period during which the greatest diversity of species has potential to occur in or around the PDA.

8.4.6 Follow-up and Monitoring

Follow-up and monitoring will include regular monitoring for evidence of avian mortalities/collisions with Project infrastructure during the operation and maintenance phase.

8.5 VISUAL ENVIRONMENT

A Project-specific Visual Impact Assessment (VIA) (Appendix G) and a Project-specific Glint and Glare Study (Appendix H) were conducted in support of the ESIA:

- The VIA was conducted by way of field reconnaissance to select vantage points to assess the future visibility of the solar PV power plant when constructed. Potential visual impacts and mitigation measures were also considered as part of the VIA. The complete VIA report is provided in Appendix E, including photographs that were taken at each of the six vantage points of concern identified in the VIA.

- For the Glint and Glare Study, glare modelling software – Solar Glare Hazard Analysis Tool (SGHAT) – was used to estimate glare at eleven observation points and four route receptors (i.e., public roadways). The selected observation points have the potential of being in direct line of sight of the solar PV power plant, depending on the state of the surrounding vegetation. Five different panel configurations were modelled, including smooth panels with/without anti-reflective coating, lightly textured panels with/without anti-reflective coating, and deeply textured panels without anti-reflective coating. Detailed methods and results for the Glint and Glare Study are provided in Appendix H.

  Key findings and proposed mitigation measures from the VIA and Glint and Glare Study are considered where applicable in this assessment of potential Project-related environmental impacts on the visual environment.

8.5.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with the visual environment by altering the visual landscape and aesthetics of the PDA and causing reflection (i.e., glint and glare) and lighting impacts that could cause sensory (visual) disturbance to adjacent and nearby land users. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on the visual environment is focused on the following potential changes to the environment:

- Change in visual landscape / aesthetics
- Change in reflection conditions (i.e., glint and glare[8])
- Change in lighting conditions

During the **construction phase** of the Project, the visual environment could be impacted by the following:

- An adverse Project-related change in visual landscape / aesthetics due to physical alteration of the PDA – which currently consists primarily of sugarcane and rotational crops – through site preparation activities and the physical construction and installation of Project components. There will also be an adverse Project-related change in visual landscape / aesthetics associated with the presence of Project-related vehicle traffic within the Parish; the presence of Project vehicles, heavy equipment, and machinery on-site; the on-site management of Project-related wastes (e.g., overburden stockpiles); and the presence of Project personnel.
- An adverse Project-related change in lighting conditions due to the use of artificial night lighting to illuminate work areas as needed to carry out Project construction activities safely and effectively.

[8] "Glint" refers to a momentary flash of light from a reflective surface, which can cause discomfort to those impacted, while "glare" is generally described as direct sunlight or reflected sunlight from a surface for an extended duration.

During the **operation and maintenance phase** of the Project, the visual environment could be impacted by the following:

- An adverse Project-related change in visual landscape / aesthetics due to the new presence of the Project energy facility (including a ground-mounted solar PV power plant and associated energy storage and management systems); Project agricultural facilities (including a fodder pasture, sheep pens, barn, feed silo, and other buildings) and solar grazing sheep; and supporting Project infrastructure, facilities, and utilities; as well as the continued presence of Project vehicles, heavy equipment, machinery, and personnel.
- An adverse Project-related change in reflection conditions due to the potential glint and glare impacts associated with the presence of an array of 96,154 solar panels.
- An adverse Project-related change in lighting conditions due to the use of artificial night lighting to illuminate the site as needed for security purposes and to carry out operation and maintenance activities safely and effectively.

During the **decommissioning phase** of the Project, the visual environment could be impacted by the following:

- An adverse Project-related change in visual landscape / aesthetics due to physical alteration of the PDA to return it to conditions that are consistent with the desired land use of the Project Property by the landowner, which will include the dismantling and removal of Project components, the backfilling of ponds and ditches and re-establishment of natural drainage patterns, and the recontouring and revegetation of disturbed areas. There will also be an adverse Project-related change in visual landscape / aesthetics associated with the presence of Project-related vehicle traffic within the Parish; the presence of Project vehicles, heavy equipment, and machinery on-site; the on-site management of Project-related wastes (e.g., demolition wastes, topsoil and overburden stockpiles); and the presence of Project personnel.
- An adverse Project-related change in lighting conditions due to the use of artificial night lighting to illuminate work areas as needed to carry out Project decommissioning activities safely and effectively.

8.5.2 Mitigation

Potential Project-related adverse environmental impacts on the visual environment will be mitigated through implementation of the standard environmental protection procedures discussed in Section 3.7.2, as applicable.

The following VC-specific measures will also be implemented to reduce adverse effects on the visual environment:

- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted in areas where potential off-site visual impacts are of such a nature and magnitude that warrants the introduction of vegetation/tree screens. During the growing-in period of the vegetation/tree screens, the perimeter fencing around the PDA will be fitted with an opaque privacy screen.

- Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce visual impacts.
- To reduce solar glare, lightly textured solar panels with anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels.
- An adaptive management approach will be employed if complaints regarding glint and glare are received from local residents or other surrounding land users, potentially including implementation of some or all of the following mitigation measures:
  - the establishment of additional and/or taller vegetation/tree screens and/or additional opaque privacy screens to further shield or obscure offending panels so that they cannot be seen
  - replacement of the offending solar panels with those that have a deeply textured surface, to reduce glare intensity
  - removal or reorientation of the offending solar panels

  More generally, if complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

8.5.3 Characterization of Residual Project-Related Impacts

8.5.3.1 Characterization of Residual Project-Related Changes in Visual Landscape / Aesthetics

The results of the VIA (Appendix G) indicate that the PDA is at least partially visible from all directions. Although there are some existing screens (e.g., vegetation at Bushy Park and Harrow Plantation Road), screens are not present along the entire length of the PDA boundary. Proposed mitigation measures include the establishment of additional screens to hide the solar PV power plant from ground-level receptors in all directions from the PDA. However, even with the establishment of additional screens, the solar PV power plant will remain visible to vantage points of upper floors of buildings and from tall structures. There are several two storey houses along the southern PDA boundary that may retain partial views of the site. Since the PDA boundaries are unobstructed by terrain, observers can have wide views of the area.

With the application of proposed mitigation, residual Project-related changes in visual landscape / aesthetics during the construction phase and the decommissioning phase are predicted to be adverse in direction, moderate in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible. During the operation and maintenance phase, residual Project-related changes in visual landscape / aesthetics are predicted to be similar but low in magnitude. Following the completion of decommissioning activities, it is anticipated that the PDA will return to physical and visual conditions that are similar to baseline and/or are consistent with the desired land use of the Project Property by the landowner.

8.5.3.2 Characterization of Residual Project-Related Changes in Reflection Conditions (i.e., Glint and Glare)

When glare was modelled for smooth or lightly textured solar panels, the results of the Glint and Glare Study (Appendix H) predict potential glint and glare impacts at 9 out of 11 observation points and 4 out of 4 route receptors. The entirety of the glare that is predicted to result from smooth and lightly textured solar panels is classified as a “moderate potential hazard”, meaning that glare will be present and will have potential to leave a temporary after-image of the glare (i.e., a lingering image of the glare in the field of view) but will not be strong enough to cause permanent eye damage. Smooth panels are predicted to generate less glare than lightly textured panels, and anti-reflective coating is predicted to have a detrimental effect when applied to smooth panels and a beneficial effect when applied to lightly textured panels. Several trends were observed from the model results regarding smooth and lightly textured panels. Receptors to the west of the PDA are predicted to experience glare during the morning hours (just after sunrise) while receptors to the east of the PDA are predicted to experience glare during the evening hours (just before sunset). The low angle of the sun at these hours provides an opportunity for sunlight to reflect off panels at a shallow angle and possibly affect receptors. It should be noted that the thick vegetation/tree screen, recommended as a mitigation measure, was not included in the model.

Deeply textured panels are predicted to produce far more glare-minutes than any other configuration, although at a lesser intensity. When glare was modelled for deeply textured panels, the results of the Glint and Glare Study predict extended periods of glare at 10 out of 11 observation points and 4 out of 4 route receptors. However, the glare from deeply textured panels is classified as a “low potential hazard” (i.e., glare will be present with a low potential for a temporary after-image).

The Glint and Glare Study notes that impacts to the receptors identified, where glare is predicted, may be less than predicted (or in some cases completely eliminated) due to existing partial to full obstructions within the vicinity of the receptors and the PDA which are not accounted for in the model. Several receptors had a clear line of sight to a portion of the proposed solar PV array and the rest were chosen based on their proximity to the PDA or due to the possibility of vegetation being cleared in the future.

The Glint and Glare Study further notes that, to attain maximum efficiency, solar panels are designed to absorb as much light/solar energy as possible (rather than reflect it); PV panels usually reflect 2% of incident sunlight. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow, and steel (e.g., metal sheeted roofs).

With the application of proposed mitigation (i.e., use of thick vegetation/tree screens and additional adaptive management measures should complaints be received), residual Project-related changes in reflection conditions during the operation and maintenance phase are predicted to be adverse in direction, moderate in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible. No pathways for potential Project-related changes in reflection conditions have been identified for the construction or decommissioning phases of the Project. Project construction and decommissioning activities are therefore not anticipated to result in a residual change in reflection conditions.

8.5.3.3 Characterization of Residual Project-Related Changes in Lighting Conditions

It is anticipated that several of the mitigation measures that are proposed in Section 8.5.2 to reduce potential adverse Project-related changes in visual landscape / aesthetics will also serve to reduce adverse Project-related changes in lighting, as they will help obscure views of the PDA for off-site receptors.

With the application of proposed mitigation, residual Project-related changes in lighting conditions during the construction, operation and maintenance, and decommissioning phases are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible.

8.5.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual environmental impacts of the Project on the visual environment (i.e., residual Project-related adverse changes in visual landscape / aesthetics, reflection conditions (i.e., glint and glare), and lighting conditions) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.6 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on the visual environment. These predictions have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

Table 8.6 Summary of Project Residual Environmental Impacts on The Visual Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Change in Visual Landscape / Aesthetics									
Construction	A	M	L	MT	C	R	L	N	H
Operation and Maintenance	A	L	L	MT	C	R	L	N	H
Decommissioning	A	M	L	LT	C	R	L	N	H
Change in Reflection Conditions (i.e., Glint and Glare)									
Construction	No pathways for potential Project-related changes in reflection conditions have been identified for the construction phase of the Project (refer to Section 8.5.1). Project construction activities are therefore not anticipated to result in a residual change in reflection conditions.								

Table 8.6 Summary of Project Residual Environmental Impacts on The Visual Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Operation and Maintenance	A	M	L	MT	C	R	L	N	H
Decommissioning	No pathways for potential Project-related changes in reflection conditions have been identified for the decommissioning phase of the Project (refer to Section 8.5.1). Project decommissioning activities are therefore not anticipated to result in a residual change in reflection conditions.								
Change in Lighting Conditions									
Construction	A	L	L	MT	C	R	L	N	H
Operation and Maintenance	A	L	L	MT	C	R	L	N	H
Decommissioning	A	L	L	MT	C	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:
P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:
N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:
S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:
Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:
Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:
R Reversible
I Irreversible

Probability
L Likely
U Unlikely

Significance of Residual Impact:
S Significant
N Not Significant

Prediction Confidence:
L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.5.5 Deficiencies, Challenges, and Prediction Confidence

Due to the completion of a Project-specific Glint and Glare Study (Appendix H), which included glare modelling, the level of confidence regarding the predicted residual Project-related change in reflection conditions (i.e., glint and glare) is relatively higher than it is for the predictions that are based on qualitative assessment of Project-related changes in visual landscape / aesthetics and lighting conditions. However, an important limitation of the SGHAT software that was used for the glare modelling is that it only applies to reflective surfaces on flat topography and does not account for the detailed geometry of a solar array system constructed on variable topography (e.g., gaps between modules, variable heights of PV arrays and support structures), which could impact glare results.

8.5.6 Follow-up and Monitoring

There are no follow-up and monitoring plans proposed.

8.6 AGRICULTURE AND OTHER LAND USES

A Project-specific Agricultural Impact Assessment (AIA) was completed in support of the ESIA, as an AIA is required for any development proposal that may result in alienation or fragmentation of food and agricultural land or when development is proposed adjacent to such lands. The AIA report, which evaluates the potential impacts of Project activities on existing agricultural operations and recommends ways to avoid or mitigate adverse impacts, is provided in Appendix C. Key findings and proposed VC-specific mitigation measures from the AIA report are considered where applicable in this assessment of potential Project-related environmental impacts on agriculture and other land uses. The AIA also outlines general (not VC-specific) measures for site management and the control of dust, noise, and sediment, as well as waste management; these measures have been incorporated where applicable in Section 3.7.2 and in the Project-specific ESMP (Appendix I).

8.6.1 Potential Project-Related Impacts

The Project will alter the existing agricultural land within the PDA, which is currently used for sugarcane farming, and introduce a new agricultural use (i.e., a commercial Blackbelly sheep farming operation). Other existing surrounding land uses that could be affected by the Project include residential and commercial developments as well as tourism/recreation and historical/cultural facilities (e.g., Bushy Park Raceway, Sunbury Greathouse, and Bushy Park Cemetery).

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with agriculture and other land uses. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on agriculture and other land uses is focused on the following potential changes to the environment:

- Change in the quantity / quality of agricultural land
- Change in other (non-agricultural) land use

During the **construction phase** of the Project, agricultural and other land uses could be impacted by the following:

- An adverse Project-related <u>change in the quantity / quality of agricultural land</u> due to
  - the loss of arable production within the PDA.
  - potential sensory disturbance and nuisance impacts from noise, vibration, and dust emissions associated with the operation of Project construction vehicles, heavy equipment, and machinery.

- An adverse Project-related change in other (non-agricultural) land use due to potential sensory disturbance and nuisance impacts from noise, vibration, and dust emissions associated with the operation of Project construction vehicles, heavy equipment, and machinery.

During the **operation and maintenance phase** of the Project, agricultural and other land uses could be impacted by the following:

- An adverse Project-related change in the quantity / quality of agricultural land due to the continued loss of arable production within the PDA.
- A positive (i.e., beneficial) Project-related change in the quantity / quality of agricultural land due to the introduction of a commercial Blackbelly sheep farming operation within the PDA.
- An adverse Project-related change in the quantity / quality of agricultural land and/or an adverse Project-related change in other (non-agricultural) land use due to potential sensory disturbance and nuisance impacts from Project-related noise, dust emissions, odours (e.g., from the operation of Project agricultural facilities), and visual impacts (e.g., from reflections [glint and glare] and site lighting).
- An adverse Project-related change in other (non-agricultural) land use due to the potential for the inverters associated with the solar PV power plant to produce radio frequency emissions, which is a form of electromagnetic interference that could impact radio receivers, communication devices, and navigational aids.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, agricultural and other land uses could be impacted by an adverse Project-related change in the quantity and quality of agricultural land and/or an adverse Project-related change in other (non-agricultural) land use due to potential interactions with the emissions, discharges, and wastes identified in Section 3.6.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, agricultural and other land uses could also be impacted by potential drainage and runoff impacts and associated changes to the quantity / quality of surface water and/or groundwater resources. These potential impacts are assessed separately in Section 8.3, in the context of potential Project-related environmental impacts on surface water and groundwater resources.

8.6.2 Mitigation

Potential Project-related adverse environmental impacts on agriculture and other land uses will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable, as well as implementation of the VC-specific mitigation measures proposed in Section 8.2.2, Section 8.3.2, and Section 8.5.2, for the Atmospheric and Acoustic Environment VC, the Surface Water and Groundwater Resources VC, and the Visual Environment VC, respectively.

The following VC-specific mitigation measures will also be implemented to reduce Project-related adverse effects on agriculture and other land uses:

- Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential sensory/nuisance impacts to nearby land users (e.g., agricultural workers on the site or on adjacent lands), residents, businesses, and other off-site receptors. The ESMP also includes details of how RSB will liaise with the local community before each phase of development.
- Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).
- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors and will act as a buffer to adjoining lands. RSB will consult with neighboring landowners and request that the spraying of herbicides on adjoining fields be limited to days that are not windy in order to reduce dispersion onto the operational renewable energy facility and the sheep farm.
- If complaints are received from agricultural or other land users regarding perceived Project-related impacts, RSB will work with the affected land users to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

With respect to the mitigation of potential Project-related impacts associated with electromagnetic interference, the inverters will be sited at least 46 m away from the EMS, since electromagnetic fields typically reach background levels at a distance of approximately 46 m (150 feet) away from inverters (REPO 2017). The U.S. Department of the Navy's Renewable Energy Program Office also recommends establishing a minimum setback distance of approximately 76 m (250 feet) between an airfield radar system and the leading edge of a PV array or any of its ancillary support equipment (REPO 2017).

8.6.3 Characterization of Residual Project-Related Impacts

The Project is generally anticipated to result in adverse residual impacts on agriculture and other land uses. However, the proposed use of the PDA for sheep farming will result in a positive (i.e., beneficial) Project-related change in the quantity / quality of agriculture land that will partially offset the residual adverse Project-related change in the quantity / quality of agricultural land associated with the loss of arable production at Harrow Plantation. Residual Project-related adverse changes to the quality and quantity of agricultural land and to other (non-agricultural) land use will occur primarily during the construction and operation and maintenance phases. Following decommissioning, the PDA is expected to return to baseline conditions.

The shift from solely arable production to sheep farming and renewable energy production will result in the loss of approximately 36 ha (90 acres) of arable land within the PDA, which occupies a total of approximately 73.2 ha of agricultural land within the larger (approximately 123.0 ha) Harrow Plantation. The approximately 49.8 ha of remaining Harrow Plantation lands are expected to continue to be used for agricultural purposes, with all of Harrow Plantation's productive land to the north of the PDA anticipated to remain in mainly sugarcane production, managed and operated by BAMC. There will be no fragmentation or alienation of the remaining plantation lands due to the simple manner in which the overall plantation is being divided to accommodate Project facilities. The viability of the continuation of sugarcane production at Harrow Plantation will depend on external factors unrelated to the Project, and there is also scope for other crops to potentially be introduced at Harrow Plantation in the future. While the lands of Harrow Plantation are flat and therefore suitable for mechanical sugarcane production, yields are affected by low rainfall and poorer quality soils.

Construction impacts on the PDA and surrounding area will occur over a relatively short period of time and can be managed. The most common impacts are dust and noise which can affect those employed on adjacent agricultural lands, and neighbouring residents. Adjoining agricultural lands of Harrow Plantation and other plantations could potentially experience dust and drainage impacts. The Project-specific AIA (Appendix C) that was carried out in support of the ESIA recommends mitigation measures aimed at reducing potential dust impacts and these are included in the ESMP (Appendix I). Noise impacts will be inevitable, and the contractor will implement mitigation measures to reduce this to the extent possible. Other construction mitigation measures will be implemented aimed at site management as outlined in Section 3.7.2.

The AIA (Appendix C) concludes that the Project will have a limited impact on the agricultural activities of the remaining lands of Harrow Plantation (i.e., outside of the PDA) by virtue of the benign nature of the proposed Project, together with the fact that agricultural activity (i.e., commercial sheep farming) will continue at the site.

With respect to the potential for electromagnetic interference to adversely impact other land users, the only Project components that are capable of producing radio frequency emissions are the inverters associated with the solar PV power plant. Although there is potential for radio frequency emissions from solar PV systems to block nearby radar emissions of the type that is typically used by airport control towers, ground-mounted solar PV systems (such as the Project) generally tend to have a low profile/height relative to radar surveillance equipment, which is typically located on elevated towers or platforms (NREL 2017). No airfields or airports are located within approximately 76 m of the PDA, which is the minimum recommended setback distance that should be established between an airfield radar system and the leading edge of a PV array or any of its ancillary support equipment (REPO 2017).

8.6.3.1 Characterization Residual Project-Related Changes in Quantity / Quality of Agricultural Lands

As discussed in Section 3.7.1, the introduction of the sheep farming operation as part of the Project is anticipated to partially offset the adverse change associated with the loss of arable production within the PDA.

With the application of proposed mitigation, residual Project-related changes in the quantity / quality of agricultural land during the construction phase and the operation and maintenance phase are generally predicted to be adverse in direction, moderate in magnitude, spatially limited to the AOI, medium-term in duration, ranging in frequency from occurring sporadically at irregular intervals (for sensory disturbance) to occurring continuously (for the loss of arable production within the PDA), and reversible.

Following decommissioning activities and the implementation of mitigation strategies, the PDA is expected to be viable for re-instatement to baseline conditions. For the decommissioning phase itself (i.e., the activities associated with removal of infrastructure and rehabilitation of the site), Project related changes in the quantity and/or quality of agricultural lands are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, continuous, and reversible.

8.6.3.2 Characterization of Residual Project-Related Changes in Other (Non-Agricultural) Land Use

With the application of proposed mitigation, residual Project-related changes in other (non-agricultural) land use during the construction phase are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible. If pile driving is required during construction, it would be expected to temporarily raise the magnitude of residual sensory disturbance and nuisance impacts to moderate. However, potential pile driving activities (if required) will be short-term in duration (i.e., occurring for approximately 16 weeks out of the 24-month construction period).

With the application of proposed mitigation, the residual Project-related change in other (non-agricultural) land use during the operation and maintenance phase is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, and reversible. The frequency of the residual impact is predicted to be continuous with respect to noise associated with operation of the Project energy facility, odours from the operation of Project agricultural facilities, and visual impacts, but is anticipated to range from occasional to regular for residual sensory disturbance and nuisance impacts associated with general facilities maintenance, and from sporadic to regular for residual sensory disturbance and nuisance impacts associated with sheep farming.

Similar to construction, the residual Project-related change in other (non-agricultural land use) as a result of decommissioning activities is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible.

8.6.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of the Project on agriculture and other land uses (i.e., a residual Project-related adverse change in the quantity / quality of agricultural land, a residual Project-related positive change in the quantity / quality of agricultural land, and a residual Project-related changes in other [non-agricultural] land use) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.7 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on agricultural and other land uses. These predictions have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

Table 8.7 Summary of Project Residual Environmental Impacts on Agricultural and Other Land Uses

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in the Quantity / Quality of Agricultural Land									
Construction	A	M	L	MT	S–C	R	L	N	H
Operation and Maintenance	A	M	L	MT	S–C	R	L	N	H
Decommissioning	A	L	L	MT	C	R	L	N	H
Residual Change in Other (Non-Agricultural) Land Use									
Construction	A	L–M	L	ST–MT	S	R	L	N	H
Operation and Maintenance	A	L	L	MT	C	R	L	N	H
Decommissioning	A	L	L	MT	C	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:
P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:
N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:
S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:
Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:
Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:
R Reversible
I Irreversible

Probability
L Likely
U Unlikely

Significance of Residual Impact:
S Significant
N Not Significant

Prediction Confidence:
L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.6.5 Deficiencies, Challenges, and Prediction Confidence

No deficiencies or challenges have been identified in relation to the environmental impact assessment for this VC.

8.6.6 Follow-up and Monitoring

No VC-specific follow-up and monitoring plans are proposed.

8.7 ACCIDENTS, MALFUNCTIONS, EMERGENCIES, AND DISASTERS

Subsection 8.7.1 below assesses the potential impacts of accidental events on the biophysical/ecological and anthropogenic environment (i.e., atmospheric and acoustic environment, surface water and groundwater resources, flora and fauna, visual environment, and agriculture and other land use). The potential impacts of accidental events on the social environment are considered separately in Section 9.2.

Subsection 8.7.2 below focuses on the potential impacts of climate change and natural disasters on the Project.

8.7.1 Accidents, Malfunctions, Emergencies, and Disasters

Table 8.8 identifies potential accidents, malfunctions, and emergencies that could occur during the construction, operation and maintenance, and decommissioning phases of the Project.

Table 8.8 Potential Project-Related Accidents, Malfunctions, Emergencies, and Disasters

Potential Accidents, Malfunctions, Emergencies, and Disasters	Potential Causes of Incident
Spills or leaks of petroleum products, hydraulic fluids, lubricants, or coolants during Project construction, operation and maintenance, or decommissioning	• Improper transportation, storage, handling, or use of petroleum products, hydraulic fluids, or lubricants • A malfunction or mechanical failure due to improper operation or maintenance of Project vehicles, heavy equipment, or machinery • A collision, roll-over, other accidental event, or natural disaster resulting in physical damage to Project vehicles, heavy equipment, or machinery
Spills or leaks of the KOH solution used as an electrolyte in the process of alkaline electrolysis during Project operation and maintenance	• Improper transportation, storage, handling, or use of KOH solution • A malfunction due to improper operation or maintenance of electrolyser equipment • A vehicle collision, other accidental event, or natural disaster resulting in physical damage to electrolyser equipment • Improper removal, handling or transportation of used KOH solution at the end of its useful life
Spills or leaks of oil from electrical transformers during Project operation and maintenance	• Improper transportation, storage, handling, or use of transformer oil • A malfunction due to improper operation or maintenance of electrical transformer equipment • A vehicle collision, other accidental event, or natural disaster resulting in physical damage to electrical transformer equipment • Improper handling of transformer oil during operational sampling and testing activities • Improper removal, handling or transportation of used transformer oil at the end of its useful life

Table 8.8 Potential Project-Related Accidents, Malfunctions, Emergencies, and Disasters

Potential Accidents, Malfunctions, Emergencies, and Disasters	Potential Causes of Incident
Loss of containment (LOC) of flammable vapours from battery modules within the BESS during Project operation and maintenance	• Ruptures or leaks from battery modules within the BESS, which could occur as a result of the following: – A malfunction due to improper operation or maintenance of battery modules – A vehicle collision, other accidental event, or natural disaster causing physical damage to battery modules • Upset conditions such as fires within the BESS, runaway chemical reactions, or other accidents or malfunctions
LOC of hydrogen gas (H_2) from the HESS during Project operation and maintenance	• Ruptures or leaks from H_2 storage tanks, process piping, electrolysers, or fuel cells, which could occur as a result of: – A malfunction due to improper operation or maintenance of these components – A vehicle collision, other accidental event, or natural disaster causing physical damage to these components • Upset conditions such as fires within the HESS, runaway chemical reactions, or other accidents or malfunctions

8.7.1.1 Potential Impacts of Accidents, Malfunctions, Emergencies, and Disasters on the Environment

An accident, malfunction, emergency, or disaster resulting in the release of hazardous materials (e.g., petroleum products, hydraulic fluids, lubricants, or coolants associated with Project vehicles, heavy equipment, or machinery; the KOH solution used as an electrolyte in the process of alkaline electrolysis; or the oil in electrical transformers) to the environment could result in the contamination of soil and/or water resources. Such an incident could potentially cause adverse changes to the quality and use of terrestrial habitat within the PDA, the quality and use of downstream aquatic habitat beyond the PDA, and the health and survival of affected terrestrial and aquatic biota. Birds are particularly vulnerable to potential injury or mortality when exposed to hydrocarbon contamination. The accidental release of hazardous materials could also conceivably adversely affect drinking water resources if contamination reaches the groundwater table, due to the presence of drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6) as well as several existing and proposed drainage systems within the PDA.

A Project-specific Quantitative Risk Assessment (QRA) was conducted to examine the potential consequences in the event of an accidental LOC of flammable vapours from the BESS or an accidental LOC of hydrogen gas from the HESS during the operation and maintenance phase of the Project. The full QRA report, including detailed methods and results, is provided in Appendix D. Completion of the QRA involved the following tasks:

- Source characterization of several LOC, including the following:
  - Estimated time-varying H_2 release rates in the event of storage, piping, electrolyser, or fuel cell ruptures or leaks
  - Flammable or toxic gas releases due to upset conditions associated with the BESS

- Consequence modelling to determine the extents of hazard zones for various combinations of release types, hazards, and meteorological conditions
- Risk modelling, which combines the results of the consequence modelling with the probability of a release occurring, to provide an estimate of the likelihood of harm on individual or societal bases

As described in Section 3.2.1.2, the Project energy facility will include a BESS and a HESS in the HyCPe area. The BESS will employ Li-ion batteries for the short-term storage of electricity. The HESS will produce gaseous hydrogen via water electrolysis and then store it in pressurized storage cylinders until it is eventually converted into electricity and water via fuel cells.

In the event of an accident, malfunction, emergency, or disaster that causes a rupture, leak, or other upset conditions, flammable vapours could potentially be released from the battery modules in the BESS or hydrogen gas could potentially be released from the H_2 storage cylinders, associated piping, electrolysers, or fuel cells in the HESS. The main hazards associated with the energy facility components in the HyCPe area are the potential fires or explosions that could result from ignition of the flammable vapours from the BESS or the hydrogen gas from the HESS, respectively.

Accidental releases of flammable vapours from the BESS or hydrogen gas from the HESS could result in the following hazardous events, which are assessed in the QRA (Appendix D):

- Flash fires
- Vapour cloud explosions
- Jet fires/fireballs
- Explosions from storage vessels or process containers

During an uncontrolled release within an enclosure (e.g., the electrolysers or battery storage enclosure), it is possible that combustible material could be vented from the enclosure and ignite outdoors, or that a fire could be initiated within the enclosure and potentially lead to thermal radiation exposure. However, based on the current design of the enclosed processes and the facility, the potential hazard extents from jet fires or explosions are anticipated to be much larger than the potential hazard extents from thermal radiation due to fires related to enclosure releases. Therefore, enclosure fires were not considered further in the QRA.

Hydrogen gas is not known to have toxic effects and the only expected hazard from H_2 inhalation is asphyxiation. Simple asphyxiation can occur if the concentration of a substance is sufficiently high enough that it displaces oxygen in the air. Based on NFPA 59a guidance (i.e., the National Fire Protection Association's S*tandard for the Production, Storage, and Handling of Liquefied Natural Gas*), the lethality limit is a 40% concentration of the contaminant (hydrogen), while irreversible harm occurs at a 23% concentration of the contaminant (NFPA 2019). Based on the current design of the HESS, concentrations that exceed these thresholds for asphyxiation are not expected to occur beyond the PDA boundary. The asphyxiation hazard was therefore not considered further in the QRA.

As part of the QRA, consequence modelling was completed for potential hazardous events – including consideration of a range of weather conditions, release scenarios, and configurations – to identify the maximum predicted distances to selected endpoints. The information obtained through this modelling exercise is included in Appendix D and can be used to inform emergency responders and assist in the development of emergency response plans.

The consequence modelling results were used as inputs to the subsequent risk modelling, which was conducted to evaluate the potential for harm at locations in the vicinity of the PDA. Risk modelling was completed with consideration of both the potential consequences and their likelihood of occurrence. The results of this risk modelling are included in Appendix D and considered in Section 8.7.1.3 below.

8.7.1.2 Mitigation

Mitigation measures related to the storage, handling, use, and end-of-life disposal/recycling of hazardous materials are described in Section 3.5 and Table 3.3 (in Section 3.7.2) of this ESIA. Table 3.3 also outlines relevant environmental protection procedures for spill prevention, control, and response in relation to these substances.

The BESS and HESS, as well as related utilities and auxiliary systems, will be centralized and contained within a secured and fenced HyPCe area that will be approximately 1.6 ha in size and located near the middle of the PDA (refer to Figure 3.2 and Figure 3.7). As described in Section 3.2.1.2, the HyPCe area will be specifically designed to mitigate the risks associated with the energy storage equipment (e.g., fire or explosion due to a battery malfunction or hydrogen leak), for the protection of Project personnel and the surrounding community:

- The BESS will be designed in accordance with applicable international standards, including NFPA 855 (NFPA's *Standard for the Installation of Stationary Energy Storage Systems*). Each unit will be individually sealed and separated to avoid fire propagation, with fusing and electrical protection adapted to shut-down each module individually if necessary. The units will have at least a 2-hour rating in accordance with ANSI/CAN/UL 9540A: 2019 (*Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*). The battery cells will be designed to withstand temperatures of up to 50°C. At the system level, HVAC and building management control systems will be able to shut the units down and put them in safe mode in the event that the range of safe operating conditions is exceeded. The ventilation system will also enable the safe evacuation of gases and flames through the top of the unit and passive deflagration venting to control the risk of fire and explosion. Fire detection systems will include integrated sensors and multi-spectrum infrared systems capable of detecting fire-related thermal or gas emissions.
- The HESS will similarly be designed in accordance with applicable international standards, including NFPA 2 (Hydrogen Technologies). The electrolysers and hydrogen fuel cells in the HESS will be housed in prefabricated and containerised enclosures that are actively ventilated to maintain a non-explosive atmosphere. The containers will be equipped with H_2 detectors (set to 20% of the lower explosive limit) and ventilation switch detectors.

The Project has been designed with a setback radius of more than 200 m between the HyPCe area fenceline and the PDA site boundary.

An Emergency and Disaster Management Plan has been prepared as part of the ESMP (Appendix I) to describe the recommended procedures and protocols to be carried out in the event of a natural, accidental, or human-induced emergency or disaster (e.g., explosion, fire, spill, or hurricane) at the Project facility. This Plan has been developed in consideration of the QRA (Appendix D), which identifies the maximum predicted distances to selected emergency planning endpoints based on the results of consequence modelling.

8.7.1.3 Characterization of Residual Impacts and Significance Determination

With the application of proposed mitigation, the residual Project-related environmental impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, coolants, KOH solution, or transformer oil are predicted to be adverse in direction and reversible. Depending on the volume and type of hazardous material that is spilled/leaked, residual impacts could range from low to high in magnitude, from the PDA to the AOI in geographic extent, and from short-term to medium-term in duration. The probability of occurrence is generally considered low for all volumes and types of potential hazardous material spills/leaks, but is relatively higher for smaller spills/leaks during activities such as refueling. Refueling will be conducted at designated sites furnished with spill containment equipment and will be sited away from watercourses and drainage works where possible. An accidental spill of a large volume of bulk hazardous materials (i.e., fuel, lubricant, or KOH solution) is considered unlikely due to the planned storage of these substances in secure areas equipped with bund walls and impervious flooring for additional spill containment. Other hazardous materials will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer. Spill response kits will also be available on-site.

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil could be significant for the Surface Water and Groundwater Resources VC and the Agriculture and Other Land Uses VC but are predicted to be not significant for the remaining biophysical/ecological and anthropogenic VCs. These significance determinations are based on the considerations outlined in Table 8.9.

Table 8.9 Potential Significance of the Residual Impacts of an Accidental Spill or Leak of Hazardous Materials on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Atmospheric and Acoustic Environment	• A residual Project-related reduction in air quality beyond the PDA such that the maximum ground-level air contaminant concentration associated with the Project, in combination with the conservative background concentration, frequently exceeds the applicable ambient air quality standard.	Although an accidental spill of a large volume of hazardous material could conceivably cause a one-time residual reduction in air quality (e.g., due to the volatilization of hydrocarbons), the associated air emissions would not be anticipated to frequently exceed the applicable ambient air quality standard(s).	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on the atmospheric and acoustic environment are predicted to be **not significant**.
Surface Water and Groundwater Resources	• A residual Project-related reduction in groundwater quality to the point where the yield from an established groundwater supply aquifer or well is no longer suitable or adequate for its intended use • A residual Project-related contravention of an applicable watershed management target	One or both of the identified significance criteria/thresholds could be exceeded in the event that an accidental spill of a large volume of hazardous materials infiltrates and percolates to groundwater zones via existing and proposed on-site infiltration wells (suckwells) and the runoff interceptor drainage system that is proposed along the entire southern boundary of the PDA (as described in Appendix B and Section 8.3). The accidental release of hazardous materials could conceivably adversely affect drinking water resources if contamination reaches the groundwater table, due to the presence of drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6) as well as several existing and proposed drainage systems within the PDA.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on surface water and groundwater resources **could be significant** (depending on the magnitude of the accidental spill or leak).

Table 8.9 Potential Significance of the Residual Impacts of an Accidental Spill or Leak of Hazardous Materials on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Flora and Fauna	• A residual Project-related change in terrestrial habitat that would alter its status or integrity within the RSA	There is an IBA located within the RSA, approximately 1.2 km to the south of the PDA, and birds are particularly vulnerable to potential injury or mortality when exposed to hydrocarbon contamination. Due to the proximity of the IBA and ponds in the area, there is potential for several species of birds to occur in the vicinity of the PDA, including restricted-range birds. However, they would not be expected to use the PDA as there is no water to attract them. Thus, even a large accidental spill of petroleum hydrocarbons would not be anticipated to alter the status or integrity of the PDA as terrestrial habitat for birds within the RSA.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on flora and fauna are predicted to be **not significant**.
Visual Environment	• A residual Project-related change to the environment that results in high-intensity glare with the potential to cause permanent eye damage if observed by receptors beyond the PDA, or glint and glare impacts that otherwise represent a public health and safety hazard	Potential accidental spills/leaks of hazardous materials would not be anticipated to result in glint or glare impacts, nor would they be anticipated to interact with the Visual Environment VC since they would likely not be visible to off-site receptors beyond the PDA.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on the visual environment are predicted to be **not significant**.

Table 8.9 Potential Significance of the Residual Impacts of an Accidental Spill or Leak of Hazardous Materials on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Agriculture and Other Land Uses	• A residual Project-related change to the environment that results in non-compliance with established land use plans, policies, or by-laws • A residual Project-related change to the environment that results in incompatibility with adjacent or historical land use activities as designated through a regulatory land use process.	Both the current PDP (Government of Barbados 2003) and the draft amended PDP (Government of Barbados 2017) designate Harrow Plantation (including the PDA) as agricultural land and contain policy requirements related to the conservation of designated agricultural lands. Harrow Plantation (including the PDA) also falls within the boundaries of a designated Soil Protection Overlay that is identified in the 2017 draft amended PDP and is intended to safeguard agricultural lands. It is therefore anticipated that the residual impacts of a large accidental spill of hazardous materials at Harrow Plantation could constitute non-compliance with the PDP or other established land use plans, policies, or by-laws, and/or could be otherwise incompatible with adjacent or historical land use activities as designated through a regulatory land use process.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on agriculture and other land uses **could be significant** (depending on the magnitude of the accidental spill or leak).

Note:

* This table presents only those significance criteria/thresholds that are considered to be the most relevant in the context of this assessment of potential residual environmental impacts that could arise as a result of Project-related accidents, malfunctions, emergencies, or disasters. The other VC-specific significance criteria/thresholds (i.e., those that are identified in Section 8.1.2.4 but not presented in this table) are considered less relevant for the purposes of this assessment, given the nature of the potential residual impacts and their pathways; it is assumed that none of those other significance criteria/thresholds will be exceeded for any VC in the event of a potential Project-related accident, malfunction, emergency, or disaster.

With respect to the potential consequences in the event of an accidental LOC of flammable vapours from the BESS or an accidental LOC of hydrogen gas from the HESS during the operation and maintenance phase of the Project, the results of the risk modelling conducted as part of the QRA (Appendix D) were compared to criteria published in NFPA 59a that are commonly used to assess risk acceptability throughout North America and the Caribbean. NFPA 59a recommends risk criteria based on the chances of a fatality or irreversible harm, otherwise known as individual risk. These risk criteria, or thresholds, are presented in Table 8.10.

Table 8.10 Risk Thresholds for Fatalities and Irreversible Harm

NFPA 59a Risk Zone	Permitted Developments	Individual Risk (Chances in a Million)	
		Fatalities	Irreversible Harm
1.	All land uses under the control of the plant operator or subject to an approved legal agreement	> 50	> 500
2.	General public areas excluding sensitive establishments	0.3–50	3–500
3.	No restrictions	< 0.3	< 3
Source: NFPA 2019.			

NFPA 59a Zone 3 applies to areas that have broadly acceptable risk levels without permitting restrictions; it is defined as the zone in which the individual risk of fatality is less than 0.3 chances in a million. Table 8.11 provides a comparison of common individual fatality risk levels for Barbados relative to the NFPA 59a Zone 3 individual fatality risk threshold. The fatality risk posed to the public in NFPA 59a Zone 3 is small in comparison to other risks.

Table 8.11 Comparison of Common Individual Fatality Risks in Barbados Relative to the NFPA 59a Zone 3 Individual Fatality Risk Threshold

Causes	Individual Risk of Fatality (Chances in a Million)
Motor Vehicle Accidents	77.7
Falls	14.4
Drowning	3.3
Fires	1.7
NFPA 59a Zone 3	< 0.3
Note: The individual risk data for motor vehicle accidents, falls, drowning, and fires is based on 2018 data for Barbados (WHO 2018).	

Individual incremental risk contour plots are presented in the QRA (Figures 7.2 and 7.3 in Appendix D). These modelled risk contours indicate that Project-related risk is predicted to be largely localized within the PDA, with risk levels for fatality or irreversible harm predicted to be less than the NFPA 59a Zone 3 risk thresholds at all locations beyond the PDA site boundary. Accordingly, the individual risk of fatality from the Project (i.e., in the event of an accident, malfunction, emergency, or disaster entailing LOC of flammable vapours from the BESS or LOC of hydrogen gas from the HESS) is estimated to be less than 0.3 chances per million outside of the PDA. The nearest permanent residence is located outside of the PDA boundary, at a distance of approximately 230 m from the HyPCe area fenceline. The Project is therefore considered to be appropriately sited for public safety.

With the application of proposed mitigation, the residual Project-related environmental impacts of a potential accidental LOC of flammable vapours from the BESS or a potential accidental LOC of hydrogen gas from the HESS are predicted to be adverse in direction, moderate to high in magnitude, ranging in geographic extent from the PDA to the AOI, short-term in duration, and reversible. The probability of occurrence is considered low.

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of a potential accidental LOC of flammable vapours from the BESS or a potential accidental LOC of hydrogen gas from the HESS could be significant for the Surface Water and Groundwater Resources VC and the Agriculture and Other Land Use VC but are predicted to be not significant for the remaining biophysical/ecological and anthropogenic VCs. These significance determinations are based on the considerations outlined in Table 8.12.

Table 8.12 Potential Significance of the Residual Impacts of an Accidental LOC of Flammable/Explosives Substances from the BESS or HESS on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Atmospheric and Acoustic Environment	• A residual Project-related reduction in air quality beyond the PDA such that the maximum ground-level air contaminant concentration associated with the Project, in combination with the conservative background concentration, frequently exceeds the applicable ambient air quality standard. • Noise emissions from routine activities that exceed background sound pressure levels by more than 5 dBA beyond the PDA.	Although an accidental LOC of flammable/explosive substances from the BESS or HESS could conceivably cause a one-time, temporary residual reduction in air quality if the incident results in a flash fire, jet fire/fireball, or explosion, the associated air emissions would not be anticipated to frequently exceed the applicable ambient air quality standard(s). Additionally, while an explosion could cause a one-time exceedance in sound pressure levels, it would be temporary and not a routine exceedance.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on the atmospheric and acoustic environment are predicted to be **not significant**.
Surface Water and Groundwater Resources	• A residual Project-related reduction in groundwater quality to the point where the yield from an established groundwater supply aquifer or well is no longer suitable or adequate for its intended use • A residual Project-related contravention of an applicable watershed management target	One or both of the identified significance criteria/thresholds could be exceeded in the event that a flash fire, jet fire/fireball, or explosion associated with an accidental LOC of flammable/explosive substances from the BESS or HESS directly or indirectly results in an accidental spill of a large volume of hazardous materials, or the release of large volumes of other contaminants, that infiltrate	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on surface water and groundwater resources **could be significant** (if it results in an accidental spill of hazardous materials, depending on the magnitude of the spill).

Table 8.12 Potential Significance of the Residual Impacts of an Accidental LOC of Flammable/Explosives Substances from the BESS or HESS on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
		and percolate to groundwater zones via existing and proposed on-site drainage systems. Such an accidental release of hazardous materials could conceivably adversely affect drinking water resources if contamination reaches the groundwater table, due to the presence of drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6) as well as several existing and proposed drainage systems within the PDA.	
Flora and Fauna	• A residual Project-related change in terrestrial habitat that would alter its status or integrity within the RSA	For the same reasons as discussed in Table 8.9 regarding the residual impacts of a large accidental spill of hazardous materials, the residual impacts of a flash fire, jet fire/fireball, or explosion associated with an accidental LOC of flammable/explosive substances from the BESS or HESS would similarly not be anticipated to alter the status or integrity of the PDA as terrestrial habitat for birds within the RSA.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on flora and fauna are predicted to be **not significant**.
Visual Environment	• A residual Project-related change to the environment that results in high-intensity glare with the potential to cause permanent eye damage if observed by receptors beyond the PDA, or glint and glare impacts that otherwise represent a public health and safety hazard	Although a flash fire, jet fire/fireball, or explosion associated with an accidental LOC of flammable/explosive substances from the BESS or HESS could be visible to off-site receptors beyond the PDA, such an incident would not be anticipated to result in off-site glint or glare impacts that could represent a public health and safety hazard.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on the visual environment are predicted to be **not significant**.

Table 8.12 Potential Significance of the Residual Impacts of an Accidental LOC of Flammable/Explosives Substances from the BESS or HESS on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Agriculture and Other Land Uses	• A residual Project-related change to the environment that results in non-compliance with established land use plans, policies, or by-laws • A residual Project-related change to the environment that results in incompatibility with adjacent or historical land use activities as designated through a regulatory land use process.	For the same reasons as discussed in Table 8.9 regarding the residual impacts of a large accidental spill of hazardous materials at Harrow Plantation, it is similarly anticipated that the residual impacts of a flash fire, jet fire/fireball, or explosion at Harrow Plantation associated with an accidental LOC of flammable/explosive substances from the BESS or HESS could constitute non-compliance with the PDP or other established land use plans, policies, or by-laws, and/or could be otherwise incompatible with adjacent or historical land use activities as designated through a regulatory land use process.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on agriculture and other land uses **could be significant**.

Note:
* This table presents only those significance criteria/thresholds that are considered to be the most relevant in the context of this assessment of potential residual environmental impacts that could arise as a result of Project-related accidents, malfunctions, emergencies, or disasters. The other VC-specific significance criteria/thresholds (i.e., those that are identified in Section 8.1.2.4 but not presented in this table) are considered less relevant for the purposes of this assessment, given the nature of the potential residual impacts and their pathways; it is assumed that none of those other significance criteria/thresholds will be exceeded for any VC in the event of a potential Project-related accident, malfunction, emergency, or disaster.

8.7.2 Climate Change and Natural Disasters

With Barbados proposing to move to 100% renewable energy production by 2030 (Government of Barbados 2019), it is critical that the Project and other proposed renewable energy systems are resilient to the potential impacts of climate change and natural disasters.

8.7.2.1 Climate Change

The Intergovernmental Panel on Climate Change defines climate change as “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC 2012). This definition differs from that of the *United Nations Framework Convention on Climate Change*, where climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (United Nations 1992). GHGs are known to contribute to human-induced climate change (IPCC 2021).

Due to their size and location, Caribbean small island developing states – including Barbados – are particularly susceptible to the potential adverse impacts of climate change (IADB 2016, in Government of Barbados 2019), such as increased temperatures; sea-level rise; and more frequent and/or severe extreme weather and climate events, potentially including heat waves, droughts, wildfires, heavy rainfall, and intense storms.

General Circulation Models (GCMs) are mathematical models of the physical and dynamic processes within and between the Earth's atmosphere, ocean, cryosphere, and land masses. Although they are accepted tools for projecting future climate information, GCMs are limited by their coarse resolution relative to the higher resolution detail found in specific regional scales and therefore may not fully describe interactions between physical processes and the local details that describe a specific location or region. Thus, for an island nation with a small geographical footprint such as Barbados, larger scale GCMs can be combined with Regional Climate Models (RCMs) to improve the model's mathematical representations of physical processes (IPCC 2007).

Relevant climate change information for Barbados was derived from a combination of recently observed climate data sources and climate model projections of future scenarios using an ensemble of 15 GCMs and the RCM known as PRECIS. RCM simulations from PRECIS were driven by two different GCMs (ECHAM4 and HadCM3) to project climate to the Barbados level (Simpson et al. 2012). This modelling represents future change under the following three different GHG emissions scenarios (Simpson et al. 2012):

- High Emission Scenario (A2)
- Medium Emissions Scenario (A1B)
- Lower Emissions Scenario (B1)

RCM projections indicate the potential for sea-level rise, temperature increases, and decreases in annual rainfall in Barbados. GCM projections predict a reduction in maximum one-day rainfall totals by the 2080s. Of particular relevance to the Project is the potential for increases in tropical storms and hurricanes, to which solar PV farms are generally vulnerable. Climate change models are deemed relatively primitive with respect to representing tropical storms and hurricanes, and by extension primitive in their ability to predict future changes in the frequency and intensity of such events. Recent studies indicate that the frequency of storms may decrease; however, in some of the same studies the intensity of hurricanes is expected to increase (despite reductions in frequency) (Simpson et al. 2012).

8.7.2.2 Natural Disasters

The United Nations Office for Disaster Risk Reduction defines a disaster as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic, [or] environmental losses and impacts" (UNDRR n.d.).

There are three broad categories of natural hazards that could result in a natural disaster:

- Hydrometeorological hazards (e.g., tropical storms and hurricanes, storm surges, droughts, floods, landslides/mudflows), which may be exacerbated by climate change
- Geological or seismic hazards (e.g., earthquakes, volcanic eruptions, tsunamis)
- Biological hazards (e.g., epidemics and wildfires), which may be exacerbated by climate change

Barbados is exposed to each of the natural hazards identified above. Although there are no volcanoes in Barbados, the ash flow from potential volcanic eruptions in surrounding Caribbean countries (e.g., St. Vincent and the Grenadines, Montserrat, Dominica, and St. Lucia) could adversely impact Barbados. Additionally, the potential eruption of "Kick 'em Jenny", the underwater volcano off the coast of Grenada, could cause a tsunami affecting Barbados (Government of Barbados n.d.).

8.7.2.3 Potential Impacts of Climate Change and Natural Disasters on the Project

Given that the PDA is located more than 3 km inland, at elevations ranging from 43 m to 56 m AMSL, potential sea-level rise associated with climate change is not anticipated to adversely affect the Project over its lifetime. However, the Project is susceptible to potential adverse impacts associated with climate-related and other natural hazards, such as tropical storms and hurricanes, droughts and floods, earthquakes, volcanic eruptions, tsunamis, and wildfires.

The Rocky Mountain Institute (RMI) conducted research related to the resilience of ground-mounted solar PV systems in the Eastern Caribbean against strong hurricanes during the 2017 hurricane season (Burgess and Goodman 2018). According to the World Meteorological Organization, the 2017 hurricane season in the Caribbean was "unprecedented" and included three "exceptionally destructive" hurricanes that occurred in rapid succession in late August and September: Hurricanes "Maria", "Harvey", and "Irma" (WMO 2018). Hurricanes Irma and Maria peaked at category five intensity, with Irma maintaining that intensity for 60 hours, which is longer than any North Atlantic hurricane in the satellite era (WMO 2018).

The RMI reported that, despite the record 180 mile/hour (approximately 290 km/hour) wind speeds, several ground-mounted solar PV systems in the Caribbean survived. However, there were others that did not, including some ground-mounted solar PV systems in Puerto Rico, the US Virgin Islands, and Barbuda that suffered major damage (e.g., airborne solar modules, broken equipment, and twisted metal racking) or complete failure (Burgess and Goodman 2018). Some similarities were identified among the ground-mounted solar PV systems that failed during the 2017 hurricane season, including the following weaknesses (Burgess and Goodman 2018):

- Top-down or T-clamp failure of modules
- Undersized rack or rack not designed for wind load

- Lack of lateral racking support (rack not properly designed for wind loading from the side)
- Undersized bolts
- Under-torqued bolts
- Lack of vibration-resistant connections
- PV module design pressure too low for environment
- Use of self-tapping screws instead of through bolting

Several common attributes were identified among the ground-mounted solar PV systems that survived the 2017 hurricane season, including the following (Burgess and Goodman 2018):

- Dual post piers
- Through-bolting of solar modules (no top-down or T-clamps)
- Lateral racking supports
- Structural calculations on record
- Oversight of construction by Engineer of Record with quality assurance and control program
- Vibration-resistant module-bolted connections such as Nylocs

Tropical storms, hurricanes, and other natural hazards (e.g., earthquakes, tsunamis, and wildfires) also have potential to cause damage to various other Project components, including equipment in the HyPCe area, Project agricultural facilities, and various supporting infrastructure, facilities, and utilities. Depending on the intensity of an extreme weather event or the severity of a natural disaster, the resultant damage could conceivably be substantial enough to cause an accident, malfunction, or emergency such as those assessed in Section 8.7.1 above.

A drought or a flood could also adversely affect Project, particularly with respect to water supply requirements for the Project energy facility and agricultural operations, while volcanic ash could adversely affect operation of the solar PV power plant by blocking incoming solar radiation.

8.7.2.4 Mitigation

The potential impacts of climate and natural disasters on the Project will be considered and incorporated into the planning and design of Project components and the scheduling of Project activities.

RMI's recommendations regarding the construction of resilient ground-mounted solar PV systems in the Caribbean included recommendations pertaining to proper specifications for systems and recommendations pertaining to design collaboration between developers and module suppliers. Below are some key recommendations from RMI regarding proper specifications for ground-mounted solar PV systems (Burgess and Goodman 2018):

- Specify high-load (up to 5,400 Pascal uplift) PV modules, based on structural calculations; these are currently available from a number of Tier-1 module manufacturers.
- Require structural engineering in accordance with ASCE 7 and site conditions, with sealed calculations for wind forces, reactions, and attachment design (ground-mount foundation).
- Specify through-bolting of modules as opposed to top-down or T clamps, or if top clamping is required, use clamps that hold modules individually or independently.

- Require structural engineer review of lateral loads due to racking and electrical hardware. Often lateral loads are missed, and recent failures have proven them to be a critical source of weakness (e.g., combiner boxes attached to end solar array posts caused increased loading and led to failure).
- Specify bolt quality assurance and quality control processes.
- Specify all hardware be sized based on 25 years (or project life) of corrosion.
- Do not recommend any self-tapping screws.
- Specify dual post fixed tilt ground mounts, which significantly reduce foundation failure risk.

The above recommendations will be considered during detailed design of the solar PV power plant for the Project. In addition, as indicated in Section 3.2.1, the solar panel structures for the Project will be designed in accordance with local and international standards and to withstand Category 4 hurricanes. A certified engineer will review the selected structures for compliance with applicable codes from ASCE.

The design of the BESS and HESS will incorporate several safety features, as described in Section 8.7.1.2 above. These safety features will help maintain the safe operation of the Project energy facility in the event of a climate-related or other natural disaster.

The risk of drought conditions adversely affecting the Project will be mitigated through the planned re-use of the mineralized water by-product of reverse osmosis, the planned recirculation of process water from the HESS to the electrolysers for re-use in the electrolysis process, and potential harvesting of rainwater via water tanks located beneath Project buildings/infrastructure (refer to Section 3.2.3.5), while the risk of flood conditions adversely affecting the Project will be mitigated through the planned establishment of drainage reserves for runoff management (refer to Section 3.2.3.6).

As described in Chapter 4, the Project EMS will enable RSB to calculate the solar irradiance forecast and notify the grid operator 24 hours in advance regarding the availability of power so that storage can be optimized as necessary to deliver the maximum amount of power to the grid and reduce energy losses.

An Emergency and Disaster Management Plan has been prepared as part of the ESMP (Appendix I) and identifies recommended procedures and protocols to be carried out in the event of a natural, accidental, or human-induced emergency or disaster (e.g., explosion, fire, spill, or hurricane) at the Project facility. This Plan will be developed in consideration of the QRA (Appendix D), which identifies the maximum predicted distances to selected emergency planning endpoints based on the results of consequence modelling.

8.7.2.5 Characterization of Residual Impacts and Significance Determination

As noted above, depending on the intensity of an extreme weather event or the severity of a natural disaster, the resultant damage could conceivably be substantial enough to cause an accident, malfunction, or emergency such as those assessed in Section 8.7.1. The potential residual impacts of such incidents on the environment are characterized, and associated determinations of significance are provided, in Section 8.7.1.3.

With application of the design considerations and proposed mitigation described above, climate change and natural disasters are not anticipated to result in substantial delays to the Project schedule, damage to

Project components, or disruption to Project activities that could compromise the long-term technical or economic viability of the Project. The residual impacts of climate change and natural disasters on the Project are therefore predicted to be not significant.

9.0 SOCIAL IMPACT ASSESSMENT AND MITIGATION

This chapter documents the approach, methods, and results of the Social Impact Assessment (SIA) portion of the ESIA, which focuses on potential interactions between the Project and the social VCs (including economic and cultural aspects) identified in Section 6.2.

9.1 BASELINE STUDY

9.1.1 Survey Methods and Spatial Boundaries

The baseline was established from interviews with samples of the residents within a 1-km radius of the Harrow site (Figure 9.1). The Bushy Park Barbados Racing Facility and the Sunbury Greathouse are the closest commercial facilities to the Harrow site. Contact was made and interviews conducted. There is a small corner shop in Harrow, but the proprietor was not available for the interview. There is also a shop attached to a home in Padmore Village, but the owner preferred to complete the residential interview. The development to the south of the PDA has a covenant that prohibits the operation of businesses. Just outside of the 1 km zone to the Northwest is the Government Industrial School, a residential rehabilitative facility for children and teens designed to support them and their families and to reintegrate the children into the community. It should be noted that this facility caters to a vulnerable community, defined as such because of their potentially diminished capacity to anticipate, cope with, resist, and/or recover from the impact of a natural or man-made hazard. However, it is not anticipated that there would be any contact between the Project and the residents at the school.

Bing Maps was used to obtain aerial views of the surrounding communities and estimate the number of buildings. Based on an estimate of 367 structures, the Raosoft sample size calculator was used to determine a statistically representative sample size of 188 households using a 5% margin of error at the 95% confidence level with a response distribution of 50%. Every household within the survey zone was approached. Considering several unoccupied buildings, homes where no one was present after multiple attempts, and households that declined to participate in the survey, ultimately, a final total sample of 155 households was achieved, comprising interviews with 82 females (52.9%) and 73 males (47.1%). Table 9.1 lists the road/communities captured within the 1-km radius of the PDA.

Figure 9.1 1-km Radius Surrounding the Harrow Site

Table 9.1 Names of Roads and Communities Included in the Survey

Name of Road/Community	Number of respondents		Percentage		Total %
	Female	Male	Female	Male	
Padmore Village	19	17	12.3%	11.0%	23.2%
Circular Road	14	17	9.0%	11.0%	20.0%
Marchfield Village Road	12	12	7.7%	7.7%	15.5%
Harrow Land	10	5	6.5%	3.2%	9.7%
Neil Kirk Gardens	6	5	3.9%	3.2%	7.1%
Farm Road	6	3	3.9%	1.9%	5.8%
Harrow Road	1	6	0.6%	3.9%	4.5%
Crescent Drive	5	2	3.2%	1.3%	4.5%
Farm Gardens	4	1	2.6%	0.6%	3.2%
Farm Road Terrace	2	1	1.3%	0.6%	1.9%
Harrow Park	2	1	1.3%	0.6%	1.9%
Green Way / Farm Gardens	1	1	0.6%	0.6%	1.3%
Bushy Park Road	0	1	0.0%	0.6%	0.6%
Neil Kirk Road	0	1	0.0%	0.6%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

More than 70% of the sample have lived in their respective communities for over ten years (Table 9.2). Therefore, these respondents were well placed to provide a long-term perspective on issues in their community.

Table 9.2 Length of Time Respondents Have Lived in Their Communities

Years of Residence	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Less than one year	0	1	0.0%	0.6%	0.6%
1 – 5 years	11	3	7.1%	1.9%	9.0%
6 – 10 years	9	15	5.8%	9.7%	15.5%
10 – 20 years	22	20	14.2%	12.9%	27.1%
Over 20 years	17	12	11.0%	7.7%	18.7%
Over 30 years	6	8	3.9%	5.2%	9.0%
Over 40 years	7	5	4.5%	3.2%	7.7%
Over 50 years	10	9	6.5%	5.8%	12.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

9.1.2 Demographic Profile

Interviews were conducted with the head of household or adult household members, with the head of household being defined as the adult who makes the decisions in the home and has primary responsibility for taking care of the household members and or finances[9]. Within the 155 households in the study, 70.3% were female-headed, 10.3% were male-headed, and 19.4% jointly managed (Table 9.3). This result is reflective of the national trend where female-headed households are predominant.

Table 9.3 Heads of Households

Head of Household	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Female-headed Household	56	53	36.1%	34.2%	70.3%
Joint responsibilities	14	16	9.0%	10.3%	19.4%
Male-headed Household	12	4	7.7%	2.6%	10.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

The 155 households in the survey represented a total population of 431 persons, 73.5% of whom live in one, two or three-person households (Table 9.4).

Table 9.4 Number of Persons Per Household

No. Persons Per Household	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
One person	29	15	18.7%	9.7%	28.4%
Two persons	16	22	10.3%	14.2%	24.5%
Three persons	15	17	9.7%	11.0%	20.6%
Four persons	7	9	4.5%	5.8%	10.3%
Five persons	7	5	4.5%	3.2%	7.7%
Six persons	3	3	1.9%	1.9%	3.9%
Seven persons	2	1	1.3%	0.6%	1.9%
Eight persons	2	1	1.3%	0.6%	1.9%
Nine persons	0	0	0.0%	0.0%	0.0%
Ten persons	1	0	0.6%	0.0%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.5 shows that, amongst the respondents, representation in the younger age groups between 18–34 was low. Across the higher age groups, representation was relatively evenly distributed, with the

[9] This definition was based on similar ones found online at https://sociologydictionary.org/head-of-household/ https://www.encyclopedia.com/social-sciences-and-law/law/law/head-household.

largest proportion in the 65+ range. This distribution is unsurprising since the latter represents the retirement age, and these individuals are more likely to be at home and accessible during a survey.

Table 9.6 shows the employment status of the respondents. Just over half, 56.1% are fully employed, 5.8% are in part-time employment, 27.7% are retired and 3.2% are unemployed. 27.7% of the respondents are retired. Older individuals represent one of the age groups most impacted by construction and operational activities at nearby project sites since they are more likely be at home during working hours.

Table 9.5 Respondents' Age Ranges

Age Group	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
18-24	3	3	1.9%	1.9%	3.9%
25-34	8	5	5.2%	3.2%	8.4%
35-44	16	12	10.3%	7.7%	18.1%
45-54	19	14	12.3%	9.0%	21.3%
55-64	13	25	8.4%	16.1%	24.5%
65+	23	14	14.8%	9.0%	23.9%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.6 Respondents' Current Employment Status

Employment Status	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Full-time employment					
Privately employed (full-time)	27	24	17.4%	15.5%	32.9%
Government employee (full-time)	9	13	5.8%	8.4%	14.2%
Self-employed (without paid employees)	4	9	2.6%	5.8%	8.4%
Self-employed (with paid employees)	1	0	0.6%	0.0%	0.6%
Part-time employment					
Privately employed (part-time)	5	4	3.2%	2.6%	5.8%
Retired					
Retired	24	19	15.5%	12.3%	27.7%
Unemployed					
Unemployed	4	1	2.6%	0.6%	3.2%

Table 9.6 Respondents' Current Employment Status

Employment Status	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Other					
Unable to work due to a disability	3	1	1.9%	0.6%	2.6%
Housewife/Househusband/Contributing Family Member/Unpaid Family Worker	3	0	1.9%	0.0%	1.9%
Other	0	2	0.0%	1.3%	1.3%
Student/In-training	2	0	1.3%	0.0%	1.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Figure 9.2 shows the employment status of the other persons living within the households that were surveyed. Just under half, 48.5% are fully employed, 30.1% are unemployed, and 21.4% are retired. This may be compared to the results from the Continuous Household Labour Force Survey, which show an overall national unemployment rate of 15.9% (14.1% for males, 17.8% for females) (BSS 2021). Currently, unemployment is high because of the extended negative economic effects of the Covid-19 pandemic. Amongst the children 17 years and younger, living within these households, 90% are attending school (Figure 9.3).

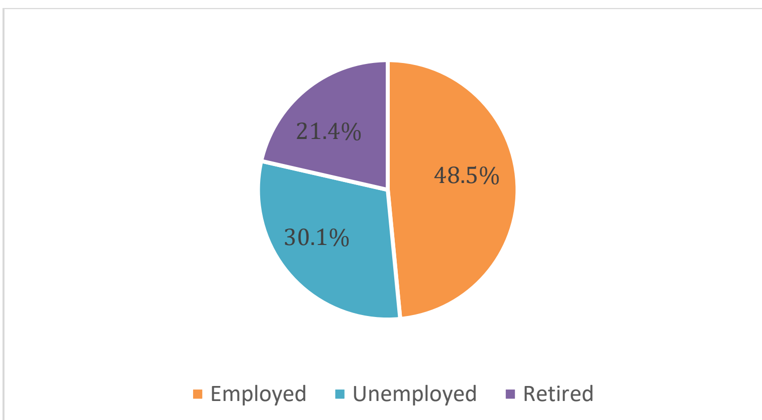

Figure 9.2 Employment Status of Other Household Members

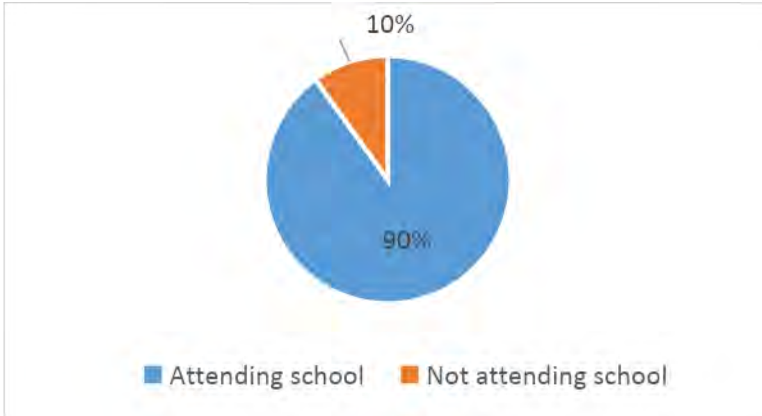

Figure 9.3 School Attendance

Amongst the 155 respondents, 41.9% had attained secondary education as their highest level of formal education (Table 9.7).

Table 9.7 The Highest Level of Education Attained by Respondents

Education	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Secondary education	30	35	19.4%	22.6%	41.9%
Vocational education (e.g., Polytechnic)	9	19	5.8%	12.3%	18.1%
Undergraduate degree	13	4	8.4%	2.6%	11.0%
Continuing Professional Development	10	4	6.5%	2.6%	9.0%
Post-graduate degree	7	4	4.5%	2.6%	7.1%
Primary education	7	3	4.5%	1.9%	6.5%
Associate degree	5	4	3.2%	2.6%	5.8%
No Response	1	0	0.6%	0.0%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

9.1.3 Housing and Community Information

The majority of the respondents, 91%, stated that they owned their homes (Table 9.8). Consequently, Table 9.9 shows that most of the sample, 92.9%, live in privately owned single-dwelling houses, compared to 4.5% who live in government units and 2.6% who live in apartments. In addition, 79.4% of the homes are constructed from concrete blocks and concrete (Table 9.10).

Table 9.8 Homeownership Status

Homeownership	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Owned	78	63	50.3%	40.6%	91.0%
Rental	3	6	1.9%	3.9%	5.8%
Using but not paying rent	1	3	0.6%	1.9%	2.6%
Prefer not to say	0	1	0.0%	0.6%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.9 Housing Types

Dwelling Type	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Private House	76	68	49.0%	43.9%	92.9%
Government Unit	5	2	3.2%	1.3%	4.5%
Flat/Apartment	1	3	0.6%	1.9%	2.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.10 Materials Used to Construct the Homes in the Sample

Dwelling Material	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Concrete block	41	43	26.5%	27.7%	54.2%
Concrete	20	19	12.9%	12.3%	25.2%
Wood	13	6	8.4%	3.9%	12.3%
Wood and Concrete block	7	4	4.5%	2.6%	7.1%
Wood and Concrete	1	1	0.6%	0.6%	1.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

The respondents were asked to indicate what attributes were desirable within their communities. This information identifies the characteristics within the surrounding areas that should be maintained throughout the construction and operation of the proposed Project. Table 9.11 shows that the peaceful and quiet nature of the communities is the primary feature valued by 64.5% of the respondents. Just over half, 54.2%, also like that their neighbours are friendly, and 40.6% appreciate the proximity to commercial, social and community services. Only 30.4% identified safety and security as a valued attribute in the area.

Table 9.11 Community Attributes Valued by Respondents

Attributes	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
It is peaceful and quiet	60	40	38.7%	25.8%	64.5%
The people who live in the area are friendly	48	36	31.0%	23.2%	54.2%
Proximity to commercial, social and community services (e.g., businesses, healthcare, schools, church, recreational spaces, social clubs)	34	29	21.9%	18.7%	40.6%
It is safe and secure	33	28	21.3%	18.1%	39.4%
It is an attractive area	16	20	10.3%	12.9%	23.2%
It is breezy	1	1	0.6%	0.6%	1.3%
Nothing	0	1	0.0%	0.6%	0.6%

Table 9.12 displays the results of the respondents' ratings of various services and amenities in their communities. Amongst the services and amenities that received a rating of "good" or "excellent" from a total of 50% or more of the respondents were the electricity supply (71.6% good, 9.7% excellent), the water supply (76.1%, 13.5% excellent), the telephone and internet service (67.7% good, 2.6% excellent), the garbage collection service (66.5% good, 11.0% excellent), street lighting (52.3% good, 26% excellent), access to commercial services (51% good, 20.6% excellent), access to health care services (49.7% good, 25.2% excellent), and proximity to schools (48.4% good, 13.5% excellent). Noticeably, amongst these are the primary utilities of electricity, water, and communication services, indicating that these communities enjoy convenient service most of the time.

On the other hand, services and amenities that were rated "poor" by 50% or more of the respondents were pedestrian walkways and bicycle paths (54.8%) and road conditions (51%). Unfortunately, bicycle paths are not common in Barbados, and sidewalks can typically be non-existent, too narrow or in a state of disrepair. Similarly, residents from across the island have noted their displeasure with the quality of the nation's roads in print, electronic, and social media regularly. A look at the remaining services and amenities shows the following:

- Public transport is deemed "good" by only 31.0% and "average" by 33.5%; an area for improvement.
- Employment opportunities scored as "poor" by 32.3% and "average" by 30.3%. With 30% unemployment within the households, this is an area for urgent attention.
- Recreational facilities scored as "poor" by 44.5% and "average" by 27.1%; an area for investment.
- Dining opportunities scored as "poor" by 35.5% and "average" by 26.5%; an area for improvement.

Table 9.12 Rating of Community Services and Amenities

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
The condition of the roads					
Poor	41	38	26.5%	24.5%	51.0%
Average	21	16	13.5%	10.3%	23.9%
Good	18	19	11.6%	12.3%	23.9%
Excellent	2	0	1.3%	0.0%	1.3%
Don’t know	0	0	0.0%	0.0%	0.0%
Public transportation					
Average	29	23	18.7%	14.8%	33.5%
Good	21	27	13.5%	17.4%	31.0%
Poor	20	13	12.9%	8.4%	21.3%
Don’t know	12	7	7.7%	4.5%	12.3%
Excellent	0	3	0.0%	1.9%	1.9%
Recreational facilities					
Poor	35	34	22.6%	21.9%	44.5%
Average	22	20	14.2%	12.9%	27.1%
Good	15	13	9.7%	8.4%	18.1%
Don’t know	9	5	5.8%	3.2%	9.0%
Excellent	1	1	0.6%	0.6%	1.3%
Garbage collection service					
Good	58	45	37.4%	29.0%	66.5%
Average	14	18	9.0%	11.6%	20.6%
Excellent	9	8	5.8%	5.2%	11.0%
Poor	1	1	0.6%	0.6%	1.3%
Don’t know	0	1	0.0%	0.6%	0.6%

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Employment opportunities					
Poor	30	20	19.4%	12.9%	32.3%
Average	25	22	16.1%	14.2%	30.3%
Don’t know	19	15	12.3%	9.7%	21.9%
Good	7	16	4.5%	10.3%	14.8%
Excellent	1	0	0.6%	0.0%	0.6%
Lighting of the streets					
Good	39	42	25.2%	27.1%	52.3%
Average	34	22	21.9%	14.2%	36.1%
Poor	5	7	3.2%	4.5%	7.7%
Excellent	3	1	1.9%	0.6%	2.6%
Don’t know	1	1	0.6%	0.6%	1.3%
Pedestrian walkways, bicycle paths					
Poor	45	40	29.0%	25.8%	54.8%
Average	22	14	14.2%	9.0%	23.2%
Good	14	14	9.0%	9.0%	18.1%
Don’t know	1	5	0.6%	3.2%	3.9%
Excellent	0	0	0.0%	0.0%	0.0%
Telephone and internet service					
Good	56	49	36.1%	31.6%	67.7%
Average	17	19	11.0%	12.3%	23.2%
Poor	4	4	2.6%	2.6%	5.2%
Excellent	4	0	2.6%	0.0%	2.6%
Don’t know	1	1	0.6%	0.6%	1.3%

Table 9.12 Rating of Community Services and Amenities

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Dining opportunities					
Poor	28	27	18.1%	17.4%	35.5%
Average	25	16	16.1%	10.3%	26.5%
Good	21	19	13.5%	12.3%	25.8%
Don't know	6	8	3.9%	5.2%	9.0%
Excellent	2	3	1.3%	1.9%	3.2%
Water supply					
Good	66	52	42.6%	33.5%	76.1%
Excellent	9	12	5.8%	7.7%	13.5%
Average	7	9	4.5%	5.8%	10.3%
Poor	0	0	0.0%	0.0%	0.0%
Don't know	0	0	0.0%	0.0%	0.0%
Electricity supply					
Good	59	52	38.1%	33.5%	71.6%
Average	14	12	9.0%	7.7%	16.8%
Excellent	8	7	5.2%	4.5%	9.7%
Poor	1	2	0.6%	1.3%	1.9%
Don't know	0	0	0.0%	0.0%	0.0%

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Proximity to schools and day-care facilities					
Good	42	33	27.1%	21.3%	48.4%
Average	18	21	11.6%	13.5%	25.2%
Excellent	10	11	6.5%	7.1%	13.5%
Poor	7	6	4.5%	3.9%	8.4%
Don't know	5	2	3.2%	1.3%	4.5%
Access to commercial services such as banks, supermarkets					
Good	43	36	27.7%	23.2%	51.0%
Average	19	15	12.3%	9.7%	21.9%
Excellent	15	17	9.7%	11.0%	20.6%
Poor	5	4	3.2%	2.6%	5.8%
Don't know	0	1	0.0%	0.6%	0.6%
Access to health care services, clinic, pharmacy, doctor's office					
Good	43	34	27.7%	21.9%	49.7%
Excellent	19	20	12.3%	12.9%	25.2%
Average	17	15	11.0%	9.7%	20.6%
Poor	3	4	1.9%	2.6%	4.5%
Don't know	0	0	0.0%	0.0%	0.0%

9.1.4 Perceptions of the Project Energy Facility

In this survey segment, an assessment was made of the respondents' knowledge and aptitude for renewable energy before discussing their awareness of and attitude towards the Project. The majority, 91%, indicated that they had heard the term "Renewable Energy". While 47.7% of respondents reported using solar water heaters, only 2.6% reported using solar lights, and 1.9% reported using solar PV, i.e., complete electrical home installation (Table 9.13).

Table 9.13 Respondents' Use of Renewable Energy Products

Renewable Energy	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
None	43	34	27.7%	21.9%	49.7%
Solar Water Heater	36	38	23.2%	24.5%	47.7%
Solar lights / security lights	2	2	1.3%	1.3%	2.6%
Solar PV (home electrical installation)	1	2	0.6%	1.3%	1.9%
Don't know	1	1	0.6%	0.6%	1.3%
Wind System	1	0	0.6%	0.0%	0.6%

The respondents also reported using energy-efficient devices and appliances in their homes. Table 9.14 shows that the majority, 87.7%, used LED bulbs, and 36.8% used Energy Star certified appliances.

Table 9.14 Energy-Efficient Devices and Appliances Used by Respondents

Energy-efficiency	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
LED bulbs	71	65	45.8%	41.9%	87.7%
Energy Star appliances	31	26	20.0%	16.8%	36.8%
Fluorescent bulbs	15	24	9.7%	15.5%	25.2%
Incandescent bulbs	11	11	7.1%	7.1%	14.2%
None	7	2	4.5%	1.3%	5.8%
Solar lights	3	2	1.9%	1.3%	3.2%
Don't know	3	1	1.9%	0.6%	2.6%

More than half of the respondents, 59.4%, knew about the Government's new energy policy to have Barbados using 100% renewable energy by 2030 (Table 9.15).

Table 9.15 Respondents' Knowledge of Government's New Energy Policy

Heard about Energy Policy	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Yes	41	51	26.5%	32.9%	59.4%
No	41	22	26.5%	14.2%	40.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

With specific reference to the Project, Table 9.16 shows that only 16.1% of the respondents had knowledge about it prior to the visit from the enumerators.

Table 9.16 Respondents' Knowledge of the Proposed Energy Facility at Harrow

Knowledge of Project	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Yes	11	14	7.1%	9.0%	16.1%
No	71	59	45.8%	38.1%	83.9%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Of those 25 respondents who knew of the proposed Project, Table 9.17 shows that 36% had heard about it from television, 32% by word of mouth, 32% by the newspaper, and 24% the radio.

Table 9.17 Source of Information About the Proposed Project

Medium	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
Television	6	3	24.0%	12.0%	36.0%
Word of mouth	4	4	16.0%	16.0%	32.0%
Newspaper	4	4	16.0%	16.0%	32.0%
Radio	3	3	12.0%	12.0%	24.0%
Social Media/Internet	2	2	8.0%	8.0%	16.0%

Respondents were provided with a flyer that offered a brief description of the Project. They were then asked to suggest positive benefits from the construction and operation of the Project. Table 9.18 shows that more than half of the sample, 52.3%, agreed that there could be positive benefits, and these are listed in Table 9.19. The two leading options were reduced or more competitive cost of electricity and employment opportunities during the construction phase. In addition, one resident called Stantec to enquire whether he could bring his sheep over to the facility when it is up and running.

Table 9.18 Number/Percentage of Respondents Who Believe that Benefits will Accrue from the Project

Positive Impact	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Yes	39	42	25.2%	27.1%	52.3%
Don't know	32	23	20.6%	14.8%	35.5%
No	11	8	7.1%	5.2%	12.3%
Total	82	73	52.9%	47.1%	100%

Table 9.19 Potential Benefits from the Project

Project Benefits	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
Reduced or more competitive cost of electricity	27	35	33.3%	43.2%	76.5%
Employment opportunities during the construction phase	22	23	27.2%	28.4%	55.6%
Energy independence	10	16	12.3%	19.8%	32.1%
Economic development for the island	13	12	16.0%	14.8%	30.9%
Protection for the environment	12	10	14.8%	12.3%	27.2%
Reduced greenhouse gases	11	10	13.6%	12.3%	25.9%
Don't know	1	2	1.2%	2.5%	3.7%
N=81					

The respondents were also asked to indicate whether they felt that there could be adverse effects from the construction and operation of the facility at Harrow, and Table 9.20 shows that only 7.1% said yes. Table 9.21 shows that the main concerns were noise and dust pollution during construction. One respondent followed up with a call to Stantec to specifically ask for more detailed information about the Project. He was especially interested in the use of agricultural lands, the proposed layout for the Project identifying the planned location and dimensions of the areas for the PV panels placement, the black belly sheep and the hydrogen generators, storage, and the planned safety management system for such storage. He expressed concern about the risk and dangers posed by hydrogen storage both in gas and in liquefied form. It should be noted that there will be no storage of liquid hydrogen on-site.

Table 9.20 Number/Percentage of Respondents Who Believe that there will be Adverse Effects from the Project

Negative Impact	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
No	41	41	26.5%	26.5%	52.9%
Don't know	36	26	23.2%	16.8%	40.0%
Yes	5	6	3.2%	3.9%	7.1%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.21 Potential Adverse Effects of the Project

Project Concerns	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
Noise pollution during construction	4	4	36.4%	36.4%	72.7%
Dust pollution during the construction phase	2	4	18.2%	36.4%	54.5%
Removal of trees and other vegetation during the during construction phase	1	1	9.1%	9.1%	18.2%
Unsafe/hazardous work sites	1	1	9.1%	9.1%	18.2%
Don't know	0	2	0.0%	18.2%	18.2%
Noise from livestock during the operational phase	0	1	0.0%	9.1%	9.1%
Vibration damage to structures nearby during construction phase	0	1	0.0%	9.1%	9.1%
Lower water pressure in area due to water usage by the power plant during the operational phase	0	1	0.0%	9.1%	9.1%
Odours from the animals during the operational phase	1	0	9.1%	0.0%	9%
Release of hazardous emissions and products from the power plant during the operational phase	1	0	9.1%	0.0%	9.1%
N=11					

In closing the interview, respondents were asked whether they currently use the lands at Harrow Plantation, and only five respondents, or 3.2% of the total, said yes. Table 9.22 shows that these activities are growing vegetables and fruits and livestock rearing, and houses situated on past plantation land.

Table 9.22 Activities Currently Done at Harrow Plantation by Respondents

Type of Land Use	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Growing vegetables or fruits	1	0	20.0%	0.0%	20.0%
House is situated on past plantation land	0	2	0.0%	40.0%	40.0%
Livestock rearing	0	2	0.0%	40.0%	40.0%
Total	**1**	**4**	**20.0%**	**80.0%**	**100%**

Thirty-six or 23.2% of the respondents indicated that they would like to participate in the Public Consultation and provided their contact details for follow-up.

9.1.5 The Commercial Enterprises

Interviews were conducted with representatives of the Bushy Park Racetrack and Sunbury Greathouse. One was a male supervisor and the other a female manager. Both confirmed that neither property currently uses renewable energy. Bushy Park Barbados had heard of the RSB Barbados Project because a representative from the Project had informed them. However, the Sunbury Greathouse had not heard of the Project. The Supervisor at Bushy Park Racetrack was unable to state whether the Project would create any positive or negative impacts on the business. However, he indicated that they are willing to participate by renting the roof of their facility to house PV panels. It should be noted that it is outside of the scope of the Project to install PV panels on third-parties' roofs. The Manager at Sunbury raised concerns about the potential for dust and noise impacts during the construction phase and the possibility of effects from glare during the operational phase.

9.2 IMPACT ANALYSIS

Section 3.7 outlines the design mitigation and environmental protection measures that would be in place for the Project. The SIA that follows considers these measures in predicting residual impacts of the Project. Further information on proposed mitigation measures specific to the social environment are described in Section 9.2.3

The potential emissions, discharges and wastes that could affect the social components, are presented in Table 9.23. Refer to Section 3.6 for additional details regarding anticipated Project-related emissions, discharges, and wastes.

Table 9.23 Potential Emissions, Discharges, and Wastes

Project Components	Potential emissions discharges and wastes
Construction phase	• Clearing of lands for construction could create dust, noise, and vibrations • Construction debris • Garbage and sewage from workers on site
Operational phase	• Sheep grazing and grass harvesting could cause odours and dust • Glint and glare from the panels could affect the well-being and safety of residents and road users in the vicinity of the site • Garbage and sewage from workers on site
Accidental (non-routine) events	• Spills, leakages, fires, or explosions from the long-term use and/or storage of various hazardous products

Determination of the valued social components that could be affected by the Project was based on three factors: the Project activities likely to impact social features, reports reviewed, and data collected during the surveys. The valued social components are explained in Table 9.24.

Table 9.24 Valued Social Components

Valued Social Components	Justification
Health and safety	The development of the site and the operation of the Project could directly or indirectly affect human health.
Human capital	Construction and operation of the Project can provide opportunities for human capital development.
Economy	The Project may provide new economic and employment opportunities.
Cultural values	The Project will alter the aesthetic of the area.
Infrastructure and services	The Project could affect local infrastructure and services.
Social dynamics	In-migration of temporary workers could affect social networks and dynamics in nearby communities.

Impacts have been evaluated based on the following criteria:

- Nature
  - Positive – the action will result in benefits to the community or the country
  - Negative – the action will have undesirable consequences to the community or the country
- Geographic extent
  - Site – contained within PDA
  - Local – extends to at least a 1-km radius of the PDA
  - Parish – extends to the wider Parish of Saint Philip
  - Island-wide – extends to the entire island
- Duration
  - Intermittent – occurring sporadically
  - Short-term – within the two-year construction period
  - Medium-term = > two years and up to five years
  - Long-term = > five years
  - Irreversible

- Significant
  - No mitigation required
  - Can be mitigated – can be compliant with standards or laws through mitigation measures
  - Significant – will not be compliant with standards or laws even if mitigation measures are implemented
- Likelihood
  - Likely to occur
  - Unlikely to occur
  - Uncertain of its occurrence due to insufficient information

9.2.1 Potential Social Impacts During Construction of the Project

The proposed Project can facilitate employment as well as economic opportunities and benefits for local businesses. It is estimated that there could be a maximum of 150 construction jobs over two years. There could also be opportunities for capacity-building and skills development for local workers, particularly youth, since training will be offered. In addition, collaboration and working relationships with foreign companies involved in the Project's construction could increase the technological capacity of local businesses. These are all benefits that should accrue during the construction phase and require no mitigation measures.

However, the influx of many temporary workers during the construction phase could affect social networks and dynamics in nearby communities, should there be negative interactions with residents. Moreover, care must be taken to establish fair employment and decent work conditions to prevent perceptions of unequal employment benefits and conditions between local workers and equivalent foreign personnel. These potential adverse effects can be readily mitigated and made compliant with local labour laws and regulations. To enhance the employment benefits of the Project, the hiring process will be transparent and allow eligible locals to apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas. Further mitigation, including gender sensitization training for workers, is described in Section 9.2.3. There is no expectation of significant residual impacts.

The Project could support local businesses that provide supplies for the construction and renewable energy sectors. The construction phase is typically a boost to local entrepreneurs operating small retail businesses near the Project, especially food and beverage, because the construction workers will provide additional customers. In addition, accommodation and rental car companies could also gain business from foreign personnel working on the Project. The construction phase could therefore boost the economy and have a positive effect on local livelihoods. The provision of employment is a particularly positive impact given that 30% of the residents in the sampled householders were reported as unemployed. Moreover, the economic opportunities would be a considerable benefit in the current economic context, where the prolonged Covid-19 pandemic has resulted in a decline in tourism arrivals, the closure of many businesses and the loss of several jobs. These benefits require no mitigation measures. To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas.

However, the noise, dust, and vibration during the construction of the Project may have adverse effects on the physical and psychological well-being of people in surrounding communities, especially individuals with a sensitivity to dust and noise. In this regard, 21% of the residents in the sample households were retired and would likely be at home during the construction activities. In addition, the peaceful and quiet nature of the communities is the primary feature valued by 64.5% of the respondents. There was also a concern raised about the removal of trees and other vegetation. Construction sites also tend to reduce visual amenity. There is typically debris such as concrete and scrap iron, and human activities on-site will generate garbage. However, a well designed and implemented construction management plan that includes a waste handling component (refer to Section 3.7.2 and 9.2.3), should mitigate these adverse effects and keep emissions within the required local standards for health and safety. Refer to Section 8.2 for the assessment of Project effects on the atmospheric and acoustic environment, including the planned mitigation and monitoring procedures. With these mitigation measures in place, there is no expectation of significant residual impacts.

The potential impacts from the construction vehicles and equipment are also a concern. There is potential for further damage to the roads, already rated as “poor” by 51% of the respondents. In addition, the absence of adequate sidewalks or bicycle paths place these users at risk if construction drivers do not drive with due care and within the required speed limit. Road restoration and the implementation of traffic management measures should address these potential adverse effects and protect health and safety. Traffic management measures would address on-site traffic, as well as the practices of construction drivers to and from the construction site. With mitigation in place, there is no expectation of significant residual impacts.

A further potential concern is that of persons accessing the PDA without authorization. They could be both subject to and the possible cause of health and safety risks. In addition, there will be health and safety risks to workers, including falls and injuries that might arise from the inappropriate use of machinery or improper handling of chemicals or flammable substances. Implementation of appropriate safety measures on-site should reduce or eliminate these occurrences (refer to Sections 3.7.2, 3.8, and 9.2.3 for measures to mitigate impacts on worker and public health and safety). During construction and operation, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. With mitigation measures in place, there is no expectation of significant residual impacts.

Finally, appropriate preservation measures will be taken if archaeological and cultural heritage features are encountered during Project activities. These measures could delay the construction timeline of the Project. Timely involvement of local heritage specialists would reduce delays and assist the construction with staying on time. Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the PDA. In this event, the Contractor will work with the Museum to develop and implement a plan to protect the artefacts.

Table 9.25 provides a characterization of the potential benefits and adverse effects that could occur during the construction phase.

Table 9.25 Characterization of Social Impacts During the Construction Phase

Potential Impacts	Phase	Nature	Geographic Extent	Duration	Significant	Likelihood
Construction-related jobs	Construction	Positive	Site specific	Short-term	No mitigation required	Likely
Capacity-building and skills development for local workers	Construction	Positive	Site specific	Long-term	No mitigation required	Likely
Increased technological capacity of local businesses	Construction	Positive	Site specific	Long-term	No mitigation required	Likely
Support for local suppliers in the construction and renewable energy sectors	Construction	Positive	Local	Short-term	No mitigation required	Likely
Increased retail business, primarily food-related from construction workers	Construction	Positive	Local	Short-term	No mitigation required	Likely
Business for accommodation and car rental companies	Construction	Positive	Island wide	Short-term	No mitigation required	Likely
Noise and vibrations from construction vehicles and equipment	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Impaired air quality from dust and other emissions from construction vehicles and equipment	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Reduced visual amenity due to construction activity	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Damage to roads from construction vehicles and equipment	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Health and safety risks to on-site workers	Construction	Negative	Site	Short-term	Can be mitigated	Unlikely
Health and safety risks to adjacent communities and general public	Construction	Negative	Local	Short-term	Can be mitigated	Unlikely
Influx of temporary workers affect social dynamics	Construction	Negative	Local	Short-term	Can be mitigated	Unlikely
Perceptions of inequitable labour conditions	Construction	Negative	Site	Short-term	Can be mitigated	Unlikely
Delays to construction if any archaeological and cultural heritage features are found within the PDA	Construction	Negative	Site	Short-term	Can be mitigated	Uncertain
Accidental spill or leak	Construction and operational phase	Negative	Local	Long-term or irreversible	Can be mitigated but could be significant if it occurs	Unlikely

9.2.2 Potential Social Impacts During the Operational Phase

The Project provides the opportunity to produce a clean, reliable, environmentally friendly source of energy in comparison to traditional fossil fuels. It can therefore contribute to an increase in national energy independence and promote the diversification and security of the energy supply. Thus, it is consistent with the goal of the *Barbados National Energy Policy 2019–2030*, which is to transition the island to 100% renewable energy and carbon-neutral by 2030. In addition, the added value of the sheep facility addresses the issue of replacing productive agricultural lands with an industrial use and will be a benefit to the national agricultural productive capacity. There will also be a corresponding positive effect on food and nutrition security and the sustainability of the national food system. These benefits should accrue during the construction phase and require no mitigation measures.

The energy facility will provide an estimated twenty permanent jobs when fully operational, and the sheep facility is expected to employ ten people. Thus, it will provide employment opportunities to the community. These benefits require no mitigation. As indicated in Section 9.2.1, however, the hiring process will be transparent and allow eligible locals to apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas.

However, the transformation of the rural landscape with a large-scale solar PV power plant could have a negative visual impact if persons or groups perceive the arrays to affect the existing landscape's aesthetic negatively. In addition, the potential impact of "glint and glare" from the panels could adversely affect the well-being and safety of neighbouring residents and roads users in the vicinity of the site. Judicious use of thick vegetation (e.g., hedges) and/or trees with heights of at least 3 m (10 feet) should reduce the visual impact and address the reflection from the panels. Refer to Section 8.5 for the assessment of the Project's impacts on the visual environment and proposed mitigation. With proposed mitigation in place, there is no expectation of significant residual impacts.

A variety of hazardous products will be stored at the site. These include potassium hydroxide, pressurised gaseous hydrogen, lithium-ion batteries, and transformer oils. The presence of these substances was raised as a concern by one resident. Storage of the products according to industrial specifications and strict site security should reduce the likelihood of negative impacts, including potential health and safety impacts on workers and adjacent communities. Refer to Section 3.5 for further information on the safe handling, use, storage, and disposal of hazardous materials associated with the Project.

A Project-specific Quantitative Risk Assessment (Appendix D) was conducted to examine the potential consequences in the event of an accidental LOC of flammable vapours from the BESS or an accidental LOC of hydrogen gas from the HESS during the operation and maintenance phase of the Project. As explained in Section 8.7.1.3, the individual risk of fatality from the Project (i.e., in the event of an accident, malfunction, emergency, or disaster entailing LOC of flammable vapours from the BESS or LOC of hydrogen gas from the HESS) is estimated to be less than 0.3 chances per million outside of the PDA. The nearest permanent residence is located outside of the PDA boundary, at a distance of approximately 230 m from the HyPCe area fenceline. The Project is therefore considered to be appropriately sited for public safety.

A further potential concern is that of persons accessing the PDA without authorization. They could be both subject to and the possible cause of health and safety risks. In addition, there will be health and safety risks to workers, including falls and injuries that might arise from the inappropriate use of machinery or improper handling of chemicals or flammable substances. Implementation of appropriate safety measures on-site should reduce or eliminate these occurrences (refer to Sections 3.7.2, 3.8, and 9.2.3 for measures to mitigate impacts on worker and public health and safety). During construction and operation, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. With mitigation measures in place, there is no expectation of significant residual impacts.

Although the water supply was rated as good or excellent by a total of 89.6% of the respondents, a concern was raised about the potential for lower water pressure in the area due to water usage by the Project during the operational phase. It is unlikely that the Project will impact on the water pressure. As described in Section 3.2.3.5, standard Project-related operational water consumption requirements are estimated to be 64.5 m^3 per day. Although it is anticipated that the Project water supply will primarily be sourced from existing public water main pipelines that are owned and operated by BWA, on-site water storage tanks for operations water will smooth out the flow of withdrawal from BWA's public water mains during the day. The water in these storage tanks can be drawn upon as needed during Project operations to supplement the water supply from BWA, thereby reducing the Project's reliance on that external resource, and/or as a contingency reserve in the event of interruption to water service from BWA. The planned re-use of the mineralized water by-product from the water treatment plant for irrigation and washdown, and the planned recirculation of the process water from the HESS to the electrolysers for re-use in the electrolysis process, will reduce Project-related consumption of potable water. An evaluation of the viability of rainwater harvesting as a mechanism for reducing Project-related potable water use will be performed. Water from this storage would be captured during the rainy season for use throughout the year, thus offsetting the quantity of potable water that may be required from the public mains.

There was also a concern about the odours from the animals during the operational phase. The odours from the sheep would have to be controlled by regular cleaning of the farm. Sheep manure from the pens will be collected in skips and sold to soil mix and landscape companies as needed. Sheep manure typically dries out and breaks down quickly without producing strong odours, unlike chicken and pig waste.

If complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare, reduced water pressure, odour, noise), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

There is also the possibility that the Project could have an impact the values of surrounding property. There are no local studies on property value impacts in the Barbadian setting and international studies offer conflicting perspectives. For example, economists at the University of Rhode Island have concluded that solar development is having a negative impact on nearby home values (Vasundhara and Lang 2020). However, a survey by the University of Texas at Austin was much less conclusive and the National Director of CohnReznick Advisory's Valuation Practice, said that based on property value impact studies involving solar studies, no consistent negative impact was found on residential property value that could be attributed to nearby solar farms (ASFMRA 2021). In a Policy Research Project paper published in 2018 by the LBJ School of Public Affairs at the University of Texas at Austin, Leila Al-Hamoodah et al. concluded that "*while a majority of survey respondents estimated a value impact of zero, some estimated a negative impact associated with close distances between the home and the facility, and larger facility size. Regardless of these perceptions, geospatial analysis shows that relatively few homes are likely to be impacted. Though only one component of a larger analysis, these property value impacts are likely to be of growing interest as more solar facilities are built*" (Al-Hamoodah 2018). Therefore, it is too early to make a judgement on the potential impact of the Project on the property values of the neighbouring properties.

Table 9.26 provides a characterization of the potential benefits and adverse effects that could occur during the construction phase.

Table 9.26 Characterization of Social Impacts During the Operational Phase

Potential Impacts	Phase	Nature	Geographic Extent	Duration	Significant	Likelihood
The generation of clean, renewable energy	Operation	Positive	Island-wide	Long-term	No mitigation required	Likely
Employment at the energy facility	Operation	Positive	Local/parish	Long-term	No mitigation required	Likely
Employment at the sheep farm	Operation	Positive	Local/parish	Long-term	No mitigation required	Likely
Improvement in national agricultural productive capacity	Operation	Positive	Island-wide	Long-term	No mitigation required	Likely
Reduced visual amenity due to the presence of Project components and perceived negative aesthetic impacts	Operation	Negative	Local	Long-term	Can be mitigated	Uncertain
Potential health and safety impacts on workers	Operation	Negative	Site	Long-term	Can be mitigated	Unlikely
Potential health and safety impacts on adjacent communities	Operation	Negative	Local	Long-term	Can be mitigated	Unlikely
Decreased water pressure due to Project-related water usage	Operation	Negative	Local	Intermittent	Can be mitigated	Uncertain
Odours from the sheep farm	Operation	Negative	Local	Intermittent	Can be mitigated	Likely
A change in property values	Operation	Unknown	Local	Long-term	Cannot be determined based on available information	Uncertain
Accidents (non-routine) events from hazardous products	Operation	Negative	Site	Long-term	Could be significant if they occur	Unlikely

9.2.3 Mitigation Measures

As indicated in Sections 9.2.1 and 9.2.2, there are a number of mitigation measures proposed to reduce the impacts of the Project on the social environment. These are summarized below. In addition, many of the mitigation measures identified in Section 3.7 and Chapter 8 will serve to indirectly reduce Project impacts on the social environment.

The Project is intended to provide jobs for at least 150 persons during construction and up to 20 full-time-equivalents during its operational phase. In addition, the sheep facility is expected to employ ten persons. To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas.

The Project will be a new addition to a previously agricultural location in a rural community. Concerns about the potential change to the aesthetics of the area will be addressed through a carefully planned and implemented public awareness campaign to address the typical concerns raised about the construction of solar facilities on the scale of the Project. An important component of this campaign will be to clearly explain the design of the energy facility and the potential benefits that could accrue to Barbados.

To reduce negative impacts on neighbouring residents, action will be taken to reduce and mitigate potentially adverse effects from the construction of the Project. The Project must also be compliant with the legal and statutory labour requirements, to safeguard community and worker safety and health. Construction will therefore be based on an approved construction management plan (i.e., a component of the ESMP for the Project) that includes measures to reduce the impacts of noise, dust, vibration, wastes, and traffic (refer to Chapter 11 and Appendix I). Standard environmental protection procedures and mitigation measures that will be implemented for the management of noise, dust, vibration, wastes, and traffic are also outlined in Section 3.7.2, as are measures to mitigate potential impacts on the use of public roadways.

OHS plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans. All personnel will be required to use protective gear to guard against on-the-job injuries. Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers. Only trained and/or certified persons will use specialised equipment and handle dangerous chemicals. There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site. Daily OHS meetings will occur.

There will be adequate 24-hour security to prevent unauthorized entry into restricted Project areas, through CCTV or equivalent monitoring systems. Additional provisions that will be made to enforce safety in and around construction areas include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meet the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways. Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorised personnel. An emergency and disaster management plan (Section 11.3) will be developed, with emergency drills regularly conducted so that Project personnel are able to respond swiftly and appropriately in the event of an incident. Additional measures to mitigate potential impacts to public health and safety are identified in Section 3.7.2.

Public service announcements will be provided so that commercial operators, residents, and the public are updated on and given appropriate advance notice of the construction activities, especially those, such as construction activities planned outside of typical work hours, such as late evening or night, that could be disruptive.

In addition to regular OHS training and the proposed capacity-building and skills development, Contractors will be required to provide gender sensitization training to address critical on-the-job issues and facilitate positive interactions between workers and the surrounding residents. Topics to be included in the training include gender-responsive behaviour and interactions, avoiding sexual harassment, and conflict resolution skills. In addition, there will be transparent disclosure of the requirements for adequate work facilities and decent work, to allow employees to be apprised of their worker rights and benefits.

Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the PDA. In this event, the Contractor will work with the Museum to develop and implement a plan to protect the artefacts.

When operational, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. In addition to addressing the impacts of noise, air quality, vibrations, worker health and safety, and public health and safety, the ESMP (Appendix I) includes a SMP that comprises both a stakeholder engagement plan and a grievance redress mechanism, which are designed to allow the best interests of relevant stakeholders to be considered during the Project. The ESMP also includes a Social Monitoring Plan.

10.0 CUMULATIVE IMPACT ASSESSMENT AND MITIGATION

This chapter is the cumulative impact assessment (CIA) portion of the ESIA. The CIA identifies other past, present, and likely (i.e., certain or reasonably foreseeable) future developments within the AOI whose residual environmental impacts could interact cumulatively with the residual environmental impacts of the Project, and assesses the significance of those potential cumulative impacts on relevant VCs.

10.1 CUMULATIVE IMPACT ASSESSMENT SCOPING CONSIDERATIONS AND APPROACH

Where applicable, a CIA is conducted to identify and evaluate the potential cumulative impacts of the Project in combination with other identified developments in the AOI and determine if those cumulative impacts could be significant.

The spatial and temporal boundaries that are presented in Section 6.3 remain applicable for the CIA. As the area in which Project-related impacts will be experienced and can be predicted or measured with a level of confidence that allows for assessment, the AOI is also the area in which residual Project-related residual impacts have potential to interact with residual impacts from other (non-Project) developments and in which Project contributions to cumulative environmental impacts are likely to be measurable.

A CIA scoping exercise was conducted to identify other past, present, and future developments that:

- Are outside the scope of the Project
- Have been, are being, or are likely to be carried out in the AOI
- Have potential to result in residual environmental and/or social impacts that may interact cumulatively with (i.e., overlap spatially and temporally with) the residual environmental and/or social impacts of the Project

The PDD's statutory map register was reviewed on January 20, 2022 to identify relevant development proposals within the AOI, based on the Applications for Planning Permission (Planning Applications) that have been submitted to the PDD. The search revealed that the PDD has received several hundred Planning Applications for developments proposed within the AOI over the past approximately 20 years. The majority of those Planning Applications pertain to proposed residential and commercial developments within Six Roads and other settlements that are consistent with local land use designations. It was determined that considering hundreds of Planning Applications would be impractical, and in all likelihood would not benefit the purpose of the exercise to identify those developments that could interact cumulatively with the Project. Accordingly, the approach taken was to interview an experienced and knowledgeable Planning Officer (R. Grant, personal communication, 2022), who is familiar with the AOI and the developments therein, regarding the most relevant existing and proposed developments that should be considered in the CIA. The interview was conducted with reference to the PDD's electronic map register to facilitate the identification of specific developments of interest (Table 10.1), the approximate locations of which are shown on Figure 10.1. However, because the PDD does not generally provide third parties with access to submitted Planning Applications, the ESIA Study Team was unable to review planning or other details associated with these existing and proposed developments.

Table 10.1 Developments of Interest for the Cumulative Impact Assessment

Planning Application Number	Application Submission Date (mm/yyyy)	Proposed Development	Location	Project Status
Undetermined Applications				
1857/12/2016D	12/2016	Subdivision of Land into Lots for Residential, Commercial, and Recreational Purposes	Bushy Park (Satellite reference point #1 on Figure 10.1)	Under Review
0159/02/2019D	02/2019	Two Wind Turbines	Sunbury Plantation (Satellite reference point #2 on Figure 10.1)	Under Review
0042/01/2020D	01/2020	1-MW Solar Farm	Sunbury (Satellite reference point #3 on Figure 10.1)	Under Review

Table 10.1 Developments of Interest for the Cumulative Impact Assessment

Planning Application Number	Application Submission Date (mm/yyyy)	Proposed Development	Location	Project Status
1737/11/2020D	11/2020	495-kW Solar Farm	Grove Plantation (Satellite reference point #4 on Figure 10.1)	Under Review
1932/12/2020E	12/2020	495-kW Solar Farm	Congo Road (Satellite reference point #5 on Figure 10.1)	Under Review
0184/03/2021D	03/2021	Change of Use and Subdivision of Land for Residential and Commercial Purposes	Oughterson Plantation (Satellite reference point #6 on Figure 10.1)	Under Review
1574/09/2021E	09/2021	Solar Farm	Sterling Plantation (Satellite reference point #7 on Figure 10.1)	Under Review
Approved Applications				
2091/12/2012	12/2012	Quarry	Padmore (Satellite reference point #8 on Figure 10.1)	Implemented
1171/08/2018D	08/2018	Solar PV Panels	St. Philip Parish Church (Satellite reference point #9 on Figure 10.1)	Not Yet Implemented
1586/11/2018E	11/2018	Solar Farm	Grove Plantation (Satellite reference point #10 on Figure 10.1)	Implemented
0789/06/2019D	06/2019	Biomass Power Generating Facility	Sunbury Plantation (Satellite reference point #11 on Figure 10.1)	Not Yet Implemented

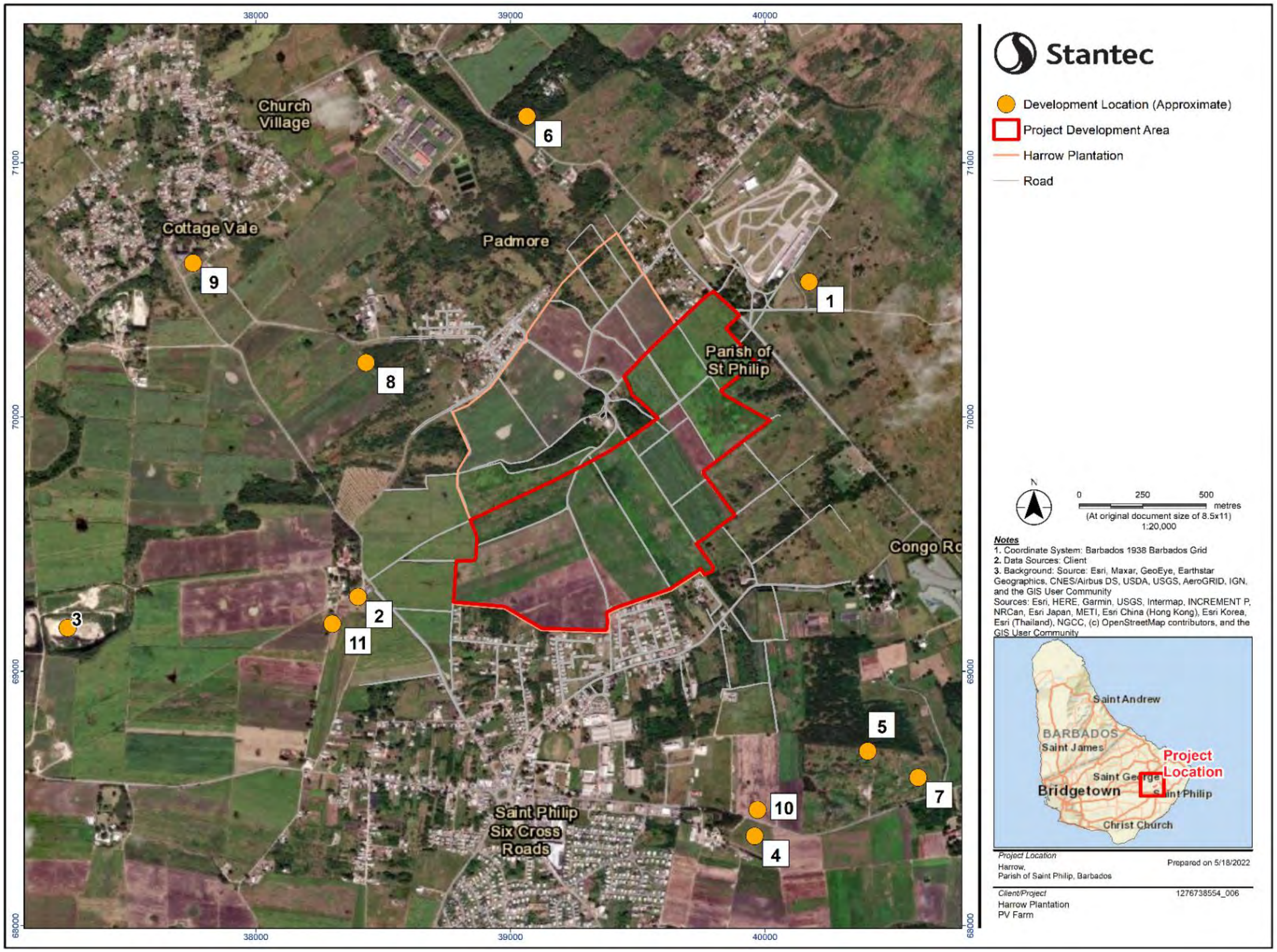

Figure 10.1 Locations of Other Developments of Interest in the AOI, Relative to the Project Development Area

Table 10.1 indicates the statuses of the relevant Planning Applications associated with the developments of interest that have been identified in the AOI, and is broken down into undetermined applications (i.e., applications that are currently under review) and approved applications. Two of the developments that received Planning Permission have already been implemented (i.e., a quarry at Padmore Village and a solar farm at Grove Plantation). Table 10.1 excludes those Planning Applications for which Planning Permission was refused, and for which no appeal against the refusal has been lodged; such developments are excluded from the scope of the CIA.

Existing conditions for each of the VCs in the AOI have been, and continue to be, shaped by the cumulative impacts of historical developments and physical activities previously carried out, as well as ongoing developments and physical activities presently being carried out, in the AOI. Likewise, future developments and physical activities will influence future environmental and social conditions in the AOI. Table 10.1 excludes various agricultural, residential, commercial, recreational, and institutional developments that have historically influenced, and continue to influence, the area. The description of existing conditions that is presented in Chapter 7 characterizes the setting for the Project, supports an understanding of the receiving environment, and provides context for the CIA. It is assumed that the existing status or baseline conditions of each VC reflect the past and present influence of other past and present developments and physical activities within the AOI – including associated cumulative residual environmental and social impacts. Accordingly, the past and present agricultural, residential, commercial, recreational, and institutional developments that have been omitted from Table 10.1 are not considered further in the CIA.

10.2 POTENTIAL CUMULATIVE IMPACTS

For the purposes of this assessment, the potential residual impacts associated with construction, operation and maintenance, and eventual decommissioning (where applicable) of the developments of interest identified in Table 10.1 are generally assumed to be similar to those considered in Chapter 8 and Chapter 9 with respect to the construction, operation and maintenance, and decommissioning phases of the Project. This is expected to be particularly true regarding the construction, operation and maintenance, and eventual decommissioning (if applicable) of other solar PV power projects within the AOI. As is the case for the Project, it is generally assumed that activities associated with other proposed developments in the AOI (where applicable) will be as outlined in Table 10.2.

Table 10.2 Likely Activities Associated with Other Proposed Developments

Phase	Activities
Construction	• Site preparation (e.g., clearing, grubbing, excavation and other ground-disturbing activities), including potential alteration of site topography, vegetation, terrestrial habitat, and drainage conditions • Physical construction and/or installation of various components (e.g., buildings, facilities, equipment, and/or infrastructure) • Construction-related vehicle traffic within the Parish of Saint Philip • Presence and operation of construction-related vehicles, heavy equipment, and machinery on-site, including associated noise, vibration, dust, GHGs, and other air emissions • Generation and management of construction-related emissions, discharges, and/or wastes • Employment and presence of construction personnel
Operation and Maintenance	• Presence and operation of various components (e.g., buildings, facilities, equipment, and/or infrastructure) • Operational vehicle traffic within the Parish of Saint Philip • Presence and operation of maintenance vehicles, heavy equipment, and machinery on-site, including associated noise, vibration, dust, GHGs, and other air emissions • Generation and management of operational emissions, discharges, and wastes • Employment and presence of operational and maintenance personnel
Decommissioning (Where Applicable)	• Dismantling and removal of various components (e.g., buildings, facilities, equipment, and/or infrastructure) • Restoration of disturbed areas as necessary to facilitate the desired end land use of the development site by the landowner • Decommissioning-related vehicle traffic within the Parish of Saint Philip • Presence and operation of vehicles, heavy equipment, and machinery on-site, including associated noise, vibration, dust, GHGs, and other air emissions • Generation and management of decommissioning-related emissions, discharges, and waste • Employment and presence of decommissioning personnel

Ways in which the construction, operation and maintenance, and eventual decommissioning (where applicable) of the other developments of interest in the AOI could vary from the construction, operation and maintenance, and eventual decommissioning of the Project include potential differences in the following:

- The nature and extent of site preparation activities
- The nature and extent of activities associated with the construction / installation, and/or eventual dismantling / removal (where applicable), of various components
- The volume of vehicle traffic within the Parish of Saint Philip and the sizes / types of vehicles used
- The sizes / types and numbers of vehicles, equipment, and machinery required on-site
- The quantities / volumes and types of emissions, discharges, and wastes
- The number of people employed and their demographics

Despite these potential differences, the mechanisms / pathways for residual impacts associated with the other developments of interest in the AOI are generally anticipated to be similar to the mechanisms / pathways for residual Project-related impacts. The other developments of interest in the AOI are therefore anticipated to interact with the biophysical / ecological, anthropogenic, and social VCs identified in Section 6.2 in such a way that results the same residual environmental and social impacts that are predicted for the Project in Chapter 8 and Chapter 9.

Table 10.3 summarizes the predicted residual impacts of the Project, which are generally anticipated to also be applicable for the other developments of interest in the AOI. However, the characteristics (i.e., direction, magnitude, geographic extent, duration, frequency, reversibility, and probability) of some or all of the residual impacts of the other developments of interest in the AOI may vary – and in some cases may vary considerably – from the characteristics of Project-related residual impacts, as demonstrated by the following examples:

- It is assumed that several of the residual impacts associated with the proposed residential, commercial, and recreational developments at Bushy Park and Oughterson Plantation will be relatively greater in magnitude and/or geographic extent than the corresponding Project-related residual impacts.
- It is assumed that the magnitude, frequency, duration, and/or probability of several potential residual impacts associated with quarry operations at Padmore Village (e.g., residual changes in air quality, the acoustic environment, surface water quantity / quality, groundwater quantity / quality, flora / flora habitat, flora health / survival, flora habitat quantity / quality / use, and non-agricultural land use) will be relatively greater than the magnitude, frequency, duration, and/or probability of those Project-related residual impacts. This is because quarrying operations may entail activities such as blasting, the extraction and crushing rock, the presence of overburden and aggregate stockpiles, potential excavation below the groundwater table and the pumping of water to maintain a dry quarry floor, and the complete removal of vegetation and terrestrial habitat within the quarry footprint.
- It is assumed that operation of the proposed biomass power generation facility at Sunbury Plantation will produce stack emissions and that the resultant residual changes in air quality, and GHG emissions will therefore have a relatively greater magnitude than the residual changes in air quality and GHG emissions that are predicted for the Project in Chapter 8.

It is generally assumed that the residual impacts of the existing and proposed solar PV power projects identified in Table 10.1 will be the most directly comparable to Project-related residual impacts and will have the most similar characteristics.

Table 10.3 Residual Impacts of the Project and Other Developments of Interest in the AOI

Potential Residual Environmental Impacts	Potential Residual Social Impacts
Construction Phase and Potential Decommissioning Phase (Where Applicable)	
• Change in air quality • Change in GHG emissions • Change in acoustic environment • Change in surface water quantity / quality • Change in groundwater quantity / quality • Change in flora / flora habitat • Change in flora health / survival • Change in fauna habitat quantity / quality / use • Change in visual landscape / aesthetics • Change in reflection conditions (i.e., glint and glare)[1] • Change in lighting conditions • Change in quantity / quality of agricultural land • Change in other (non-agricultural) land use	• Construction-related jobs • Capacity-building and skills development for local workers • Increased technological capacity of local businesses • Support for local suppliers in the construction and other relevant sectors[2] • Increased retail business, primarily food-related from construction workers • Business for accommodation and car rental companies • Noise and vibrations from construction vehicles and equipment • Impaired air quality from dust and other emissions from construction vehicles and equipment • Reduced visual amenity due to construction activity • Damage to roads from construction vehicles and equipment • Health and safety risks to on-site workers • Health and safety risks to adjacent communities and general public • Influx of temporary workers affect social dynamics • Perceptions of inequitable labour conditions • Delays to construction if any archaeological and cultural heritage features are found on-site
Operation and Maintenance Phase	
• Change in air quality • Change in GHG emissions • Change in acoustic environment • Change in surface water quantity / quality • Change in groundwater quantity / quality • Change in flora / flora habitat • Change in flora health / survival • Change in fauna habitat quantity / quality / use • Change in visual landscape / aesthetics • Change in reflection conditions (i.e., glint and glare)[1] • Change in lighting conditions • Change in quantity / quality of agricultural land • Change in other (non-agricultural) land use	• The generation of clean, renewable energy[3]Employment • Improvement in national agricultural productive capacity[4] • Reduced visual amenity due to the presence of Project components and perceived negative aesthetic impacts • Potential health and safety impacts on workers • Potential health and safety impacts on adjacent communities • Decreased water pressure due to operational water usage • A change in property values

Notes:

1 A residual change in reflection conditions (i.e., glint and glare) is only anticipated to be applicable with respect to the proposed solar farms at Sunbury Planation, Grove Plantation, Congo Road, and Sterling Plantation, as well as the existing solar PV panels at St. Philip Parish Church and the existing solar farm at Grove Plantation.

2 This residual social impact is identified in Chapter 9 as "support for local suppliers in construction and renewable energy sectors", but has been generalized here, for the purposes of the CIA, to be more broadly applicable to the other developments of interest in the AOI.

Table 10.3 Residual Impacts of the Project and Other Developments of Interest in the AOI

Potential Residual Environmental Impacts	Potential Residual Social Impacts
[3] This residual social impact (i.e., the generation of clean and/or renewable energy) is only applicable to the Project, the various other existing and proposed solar PV power projects in the AOI, and the proposed wind turbines and biomass power generation facility at Sunbury Plantation. [4] Although the Project and the other developments of interest in the AOI are generally anticipated to result in adverse residual impacts on agricultural land use, the proposed use of the PDA for sheep farming will result in a positive (i.e., beneficial) Project-related change in the quantity / quality of agriculture land that will partially offset the residual adverse Project-related change in the quantity / quality of agricultural land associated with the loss of arable production at Harrow Plantation. Similarly, there is potential for the other developments of interest in the AOI to be designed in such a way that partially offsets their residual impacts on agricultural land use and helps improve national agricultural productive capacity.	

The main potential cumulative impacts that could arise due to interactions between the residual impacts of the Project and the residual impacts of other developments of interest in the AOI are as follows.

- The **Atmospheric and Acoustic Environment VC** could be affected by cumulative changes in air quality, GHG emissions, and the acoustic environment if residual Project-related atmospheric and acoustic emissions (i.e., noise, vibration, dust, GHGs, and other air contaminants) interact cumulatively with:
  - residual atmospheric and acoustic emissions from the construction, operation and maintenance, and/or decommissioning (where applicable) of the other developments of interest in the AOI.
  - residual dust, vibration, and other residual atmospheric and acoustic emissions from current quarrying operations at Padmore Village.
  - residual stack emissions and other residual atmospheric and acoustic emissions from future operation of the proposed biomass power generation facility at Sunbury Plantation.

  The residual impacts of the Project on the atmospheric and acoustic environment have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on the atmospheric and acoustic environment due to:
  - the proximity of the other developments of interest to the PDA.
  - the potential for Project and non-Project residual air emissions to disperse in the atmosphere.
  - the potential for Project and non-Project residual acoustic emissions to be perceptible at a distance from the source.
- The **Surface Water and Groundwater Resources VC** could be affected by cumulative changes in surface water quantity / quality and groundwater quantity / quality if residual Project-related impacts on surface water and groundwater resources interact cumulatively with residual drainage and water balance impacts associated with current quarrying operations in Padmore Village.

  The residual impacts of the Project on surface water and groundwater resources have potential to overlap spatially with the residual impacts of the quarry at Padmore Village on surface water and groundwater resources due to:
  - the proximity of the quarry to the PDA and the drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6).
  - the location of the quarry within the North Watershed, which drains into the PDA (as described in Section 7.1.5.1).

- The **Flora and Fauna VC** could be affected by cumulative changes in flora / flora habitat, flora health / survival, fauna habitat quantity / quality / use, and fauna mortality risk due to the cumulative loss/alteration of terrestrial habitat within the AOI in general as well as the potential for residual Project-related impacts on flora and fauna to interact cumulatively with:
  - residual sensory disturbance to fauna from the construction, operation and maintenance, and eventual decommissioning (where applicable) of other developments of interest in the AOI.
  - residual risks of collisions between birds / fauna and the vehicles, heavy equipment, machinery, and/or infrastructure (including solar panels and wind turbines) associated with the other developments of interest in the AOI.

  The residual impacts of the Project on flora and fauna have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on flora and fauna due to:
  - the proximity of the other developments of interest to the PDA.
  - the potential for Project and non-Project residual air emissions to disperse in the atmosphere.
  - the potential for Project and non-Project residual acoustic emissions to be perceptible at a distance from the source.
  - the potential for birds / fauna that travel around the AOI throughout their life histories to repeatedly encounter or become exposed to residual sensory disturbance and/or residual collision risk from multiple Project and non-Project sources.
- The **Visual Environment VC** could be affected by <u>cumulative changes in visual landscape / aesthetics, reflection conditions (i.e., glint and glare), and lighting conditions</u> if residual Project-related impacts on the visual environment interact cumulatively with:
  - residual visual impacts from the presence of buildings, facilities, equipment, and/or infrastructure associated with the other developments of interest in the AOI, including residential and commercial buildings and associated infrastructure, solar panels at several sites, wind turbines at Sunbury Plantation, the operational area of the quarry at Padmore Village, and the biomass power generation facility at Sunbury Plantation.
  - residual glint and glare from other solar PV power projects in the AOI.
  - residual artificial night lighting from the other developments of interest in the AOI.

  The residual impacts of the Project on the visual environment have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on the visual environment due to:
  - the proximity of the other developments of interest to the PDA.
  - the possibility that some of the same off-site receptors may be subject to residual visual impacts from both Project and non-Project sources.

- The **Agriculture and Other Land Use VC** could be affected by a cumulative change in quantity / quality of agricultural land due to the cumulative loss / alteration of agricultural land within the AOI in general, as many of the other existing and proposed developments in the AOI are located on agricultural lands, including at Sunbury Plantation, Grove Plantation, Oughterson Plantation, and Sterling Plantation.

  The **Agriculture and Other Land Use VC** could also be affected by a cumulative change in other (non-agricultural) land use if residual Project-related impacts on other (non-agricultural) land use interact cumulatively with residual sensory disturbance and nuisance impacts from the other existing and proposed developments in the AOI.

  The residual impacts of the Project on agriculture and other land use have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on agriculture and other land use due to:
  - the proximity of the other developments of interest to the PDA.
  - the designation of Harrow Plantation (including the PDA) and other lands within the AOI as agricultural lands in the current PDP (Government of Barbados 2003) and the draft amended PDP (Government of Barbados 2017). These lands also fall within the boundaries of a designated Soil Protection Overlay that is identified in the 2017 draft amended PDP and is intended to safeguard agricultural lands.
- The **Social VCs** could be affected by cumulative changes in health and safety, human capital, economy, cultural values, infrastructure and services, and social dynamics if Project-related residual social impacts interact cumulatively with the residual social impacts of the other developments of interest in the AOI.

  The residual impacts of the Project on agriculture and other land use have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on agriculture and other land use due to:
  - the proximity of the other developments of interest to the PDA.
  - the possibility that some of the same off-site receptors may be subject to residual social impacts from both Project and non-Project sources.
  - the likelihood that the Project and some or all the other developments of interest in the AOI may draw from the same local workforce; interact with the same local infrastructure and services; and/or affect the local economy, local human capital, local cultural values, and/or local social dynamics within the same area.

The residual impacts of the Project on all VCs have potential to overlap temporally with the residual impacts of the other developments of interest in the AOI on all VCs if the timing of Project construction, operation and maintenance, and/or decommissioning activities coincides with the timing of construction, operation and maintenance, and/or decommissioning (where applicable) activities associated with the other developments of interest in the AOI.

10.3 MITIGATION

Section 3.3 summarizes the design mitigation measures, general standard environmental protection procedures, and VC-specific mitigation measures that will be implemented to mitigate potential Project-related environmental and social impacts. VC-specific mitigation measures are also described in Chapters 8 and 9.

Where applicable, it is assumed that each of the other developments of interest in the AOI will be carried out in accordance with the requirements of the PDP and other relevant plans, policies, and legislation pertaining to land use and environmental / social considerations, including in accordance with requirements related to the assessment of potential environmental, social, and/or agricultural impacts associated with each respective development. It is also anticipated that each of the other developments of interest in the AOI will be required to have the following in place:

- measures to manage their emissions, discharges, and wastes, including mitigation measures to reduce the noise, vibration, dust, GHGs, and other air emissions potentially generated from their activities
- measures to mitigate potential erosion and sedimentation, surface water runoff and other drainage and water balance impacts, impacts to flora and fauna, visual impacts, agricultural impacts, and social impacts.

If complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related residual impacts or the Project's perceived contribution to cumulative impacts, RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

10.4 CHARACTERIZATION OF RESIDUAL CUMULATIVE IMPACTS AND SIGNIFICANCE DETERMINATION

In general, with application of the mitigation considered in Section 10.3, the potential cumulative environmental impacts of the Project in combination with the other developments of interest in the AOI are predicted to be adverse in direction, low to moderate in magnitude, to range in geographic extent from the PDA to the RSA, to occur occasionally to continuously in frequency over a medium-term duration, and to be reversible. However, residual cumulative changes in air quality and GHG emissions have potential to extend beyond the RSA due to the potential for certain types of air emissions, including GHG emissions, to disperse in the atmosphere.

The residual impacts of the proposed residential, commercial, and recreational developments at Bushy Park and Oughterson Plantation may interact cumulatively with the residual impacts of the Project on various VCs. As is generally anticipated to be the case for the various developments of interest identified in Table 10.1, their construction will likely entail atmospheric and acoustic emissions, physical disturbances and associated drainage impacts and alteration / loss of terrestrial habitat, risk of wildlife collisions with construction vehicles and equipment, alteration of the visual landscape, artificial night lighting, potential sensory disturbance and nuisance impacts to surrounding receptors, and the alteration/loss of agricultural land. Following their construction, they may contribute to cumulative adverse impacts due to the increased presence of traffic, artificial night lighting, and infrastructure within the AOI. (The potential cumulative adverse change in fauna mortality risk associated with the increased presence of infrastructure within the AOI is considered in the following paragraph.) However, these proposed developments are consistent with local land use designations and may also contribute a residual positive change in non-agricultural land use within the AOI, as well as other residual social and economic benefits (e.g., an increase in property values), once their construction is complete.

As described in Section 8.4.3.2, solar PV panels may attract migratory bird species through the “lake effect”, where some birds may perceive the reflective surfaces as bodies of water, which may lead to collisions as they try to land (ECO Consult 2020, Hathcock 2018, and Walston et al. 2016). There are nearby ponds that are already used as rest sites (within the Project AOI, as well as the IBA), and therefore this could be an issue for birds in the area. There may also be a collision risk for birds associated with certain infrastructure, potentially including power lines. Accordingly, when the Project and the other existing and proposed solar PV power projects identified in Table 10.1 are operational, the presence of their PV arrays and supporting infrastructure is anticipated to result in a cumulative adverse change in fauna mortality risk. The two wind turbines that are proposed at Sunbury Plantation are also anticipated to pose a potential collision risk for birds, as well as bats, that will contribute to this cumulative adverse change in fauna mortality risk, as is the infrastructure associated with several of the other proposed developments identified in Table 10.1. The presence and operation of Project components, such as the PV arrays and supporting infrastructure, may have a direct effect on fauna mortality risk that contributes incrementally to the residual cumulative change in fauna mortality risk in the AOI. Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations.

As is the case for the Project, the other existing and proposed solar PV power projects in the AOI are also anticipated to result in residual changes in the visual landscape / aesthetics and reflection (i.e., glint and glare). Although some of the same off-site receptors may be subject to residual visual impacts from both Project and non-Project sources, it is considered unlikely that any receptors would be simultaneously exposed to potential glint and glare from multiple solar PV power projects.

The Project may interact cumulatively with operation of the quarry at Padmore Village to result in residual cumulative adverse changes in surface water quantity / quality and groundwater quantity / quality. However, the potential contribution of the Project to any such residual cumulative impacts is anticipated to be negligible since the PDA is located downstream of the quarry and is also located downstream of the drinking water wells that are in the vicinity of the quarry (i.e., to the north of the PDA) (refer to Figure 7.5 in Section 7.1.6). Furthermore, by way of analyses conducted in the Project-specific Drainage Impact Assessment (Appendix B), it was demonstrated that the infiltration trench that is proposed along the southern boundary of the PDA could result in downstream runoff volumes from the PDA being slightly less than the baseline scenario during the operational phase of the Project.

The Project and the other developments of interest in the AOI are generally anticipated to result in cumulative residual adverse impacts on agriculture land use due to the occupation, alteration, and use of existing or historical agricultural lands for non-agricultural purposes (i.e., for the purposes of carrying out the Project as well as for the purposes of carrying out most of the other existing and proposed developments in the AOI that are identified in Table 10.1). However, the proposed use of the PDA for sheep farming will partially offset the residual adverse Project-related change in the quantity / quality of agricultural land associated with the loss of arable production at Harrow Plantation. Since the ESIA Study Team was unable to review the proposed planning details associated with the other developments of interest in the AOI, it is unknown whether Sunbury Plantation will continue to support agricultural land use following construction of the proposed wind turbines and the proposed biomass power generation facility identified in Table 10.1, or the extent to which the other developments of interest identified in Table 10.1 may be designed to mitigate or partially offset residual changes in the quantity / quality of agricultural land in the AOI. In the absence of this information, the residual cumulative change in quantity / quality of agricultural land is conservatively estimated to range from moderate to high in magnitude.

The predicted residual cumulative adverse change in the quantity / quality of agricultural land could be significant if the residual impacts of the Project combine with the residual impacts of the other developments of interest in the RSA to result in a cumulative change or disruption that widely restricts or degrades present land use capability to a point where agricultural or other land use activities cannot continue at or near current levels in the RSA. However, this is not expected to occur since, as indicated in Section 10.3, it is assumed that each of the other developments of interest in the AOI will be carried out in accordance with the requirements of the PDP and other relevant plans, policies, and legislation pertaining to land use and environmental / social considerations, including in accordance with requirements related to the assessment of potential environmental, social, and/or agricultural impacts associated with the development (where applicable). The current PDP (Government of Barbados 2003) requires that, under exceptional circumstances, non-agricultural development may be considered on agricultural land (subject to an ESIA and amendment to the current PDP in instances where the land area is greater than 10 ha), but only if the proposal provides significant economic, social, or environmental benefits, and if suitable sites are not available in urban areas or rural settlements. Where there are no alternatives to development on agricultural land, development will be directed to lower quality agricultural land. The draft amended PDP (Government of Barbados 2017) states that a change of use or subdivision of agricultural land for a site greater than two acres (approximately 0.8 ha) or more than five residential lots will require an Agricultural Impact Assessment to determine impacts on or incompatibilities with agricultural use. It is also anticipated that each of the other developments of interest in the AOI will be required to have mitigation in place to reduce potential agricultural impacts.

In general, with application of the mitigation considered in Section 10.3, the potential cumulative social impacts of the Project in combination with the other developments of interest in the AOI are predicted to range from positive to adverse in direction, from low to moderate in magnitude, from the PDA to the RSA in geographic extent, and from occasionally to continuously in frequency. These residual cumulative social impacts are also generally predicted to be medium-term in duration and reversible.

As is the case for the Project, it is similarly anticipated that each of the other developments of interest in the AOI will be required to have mitigation in place to reduce the noise, vibration, dust, GHGs, and other air emissions potentially generated from their activities. These measures will help mitigate the potential cumulative adverse changes in air quality, GHGs, and the acoustic environment; potential cumulative adverse changes in flora / flora health and fauna habitat quantity / quality / use; potential cumulative adverse changes in the quantity / quality of agricultural land; potential cumulative adverse changes in other (non-agricultural) land use; and potential adverse cumulative changes to the health and safety of the residents in the adjacent communities that might otherwise occur at a greater magnitude due to the cumulative noise, vibration, dust, GHGs, and other air emissions that could result from the simultaneous construction of multiple projects. However, as several of the Planning Applications identified in Table 10.1 are still under review and there is no indication of the schedule for construction of the proposed developments that have already received approval, it is assumed to be unlikely that all of the other proposed developments in the AOI will be under construction simultaneously with each other and/or with the Project.

The positive residual cumulative social impacts that may be associated with the construction and decommissioning phases of the Project in combination with construction, operation and maintenance, and/or decommissioning (where applicable) of the other developments of interest in the AOI include beneficial cumulative changes related to jobs, capacity-building and skills development for local workers, technological capacity of local businesses, support for local suppliers in the construction and renewable energy sectors, retail business, and business for accommodation and car rental companies. The positive residual cumulative social impacts that may be associated with the operation and maintenance phase of the Project in combination with construction, operation and maintenance, and/or decommissioning (where applicable) of the other developments of interest in the AOI include beneficial cumulative changes related to the generation of clean, renewable energy and employment.

When they are all constructed, the Project and the other solar PV power projects in the AOI will cumulatively represent a substantial change in the existing visual character of the AOI from agricultural, residential, and minimal commercial, to an increase in solar generating use and transmission infrastructure. Some residents could perceive the increased arrays as negatively affecting the landscape's aesthetic.

As is the case for the Project, several of the other developments of interest in the AOI (i.e., the existing and proposed solar PV power projects throughout the AOI, the proposed wind turbines at Sunbury Plantation, and the proposed biomass power generation facility at Sunbury Plantation) are anticipated to contribute towards positive cumulative social impacts related to the generation of clean and/or renewable energy; these positive residual cumulative social impacts are predicted to extend beyond the RSA to result in island-wide benefits. In addition to representing an enhancement in the production of reliable energy for the island, the cumulative increase in renewable energy developments will further the national goal of transitioning to 100% renewable energy and carbon-neutrality by 2030. There will also be an attendant increase in employment in the local renewable energy industry.

In conclusion, with the application of the mitigation considered in Section 10.3, residual cumulative environmental and social impacts on the atmospheric and acoustic environment, surface water and groundwater resources, flora and fauna, the visual environment, agriculture and other land uses, health and safety, human capital, cultural values, infrastructure and services, and social dynamics are predicted to be not significant. Table 10.4 characterizes the predicted residual cumulative impacts of the Project in combination with the residual impacts of the other developments of interest in the AOI (as identified in Table 10.1). No additional mitigation measures are considered necessary to address potential cumulative impacts on those VCs – beyond the general standard environmental protection procedures and VC-specific measures that have been proposed to mitigate Project-related impacts, as well as the standard mitigation measures that are assumed to be required for the other developments of interest in the AOI (as described in Section 10.3).

The residual cumulative impact predictions summarized in Table 10.4 have been made with a moderate level of confidence based on a good understanding of the general environmental and social impacts of Project activities, the general environmental and social impacts of the main activities that are likely to be associated with the other developments of interest in the AOI, and the effectiveness of standard mitigation measures, but in the absence of details regarding the timing, scale, or specific activities associated with the other developments of interest in the AOI.

The potential environmental and social impacts of various Project-related accident, malfunction, emergency, or disaster scenarios are assessed in Section 8.7 and Section 9.2. All of the scenarios are considered unlikely to occur. Of the identified scenarios, the most likely Project-related accidental events that could occur are small spills or leaks of petroleum products, hydraulic fluids, lubricants, or coolants from Project vehicles, heavy equipment, or machinery. Spill prevention and response procedures will be in place to reduce the risk of spills, including small spills, and associated environmental impacts (refer to Section 8.7 and Section 3.3 for additional information). It is assumed that the proponents of other developments of interest in the AOI will also implement spill prevention and response measures. A small Project-related spill within the PDA would not be expected to interact cumulatively with the other developments of interest in the AOI because the residual impacts of the spill would not be expected to overlap spatially and temporally with the residual impacts of the other developments of interest in the AOI. As described in Section 8.7 and Section 9.2, the residual adverse impacts of a potential accidental spill or leak of a large volume of hazardous substances could be significant, depending on the magnitude of the accidental spill or leak. However, given the low likelihood of a major spill event occurring for the Project, the likelihood of spills occurring from multiple projects in the AOI in such a way that residual environmental impacts have potential to overlap spatially and temporally is even more remote.

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Atmospheric and Acoustic Environment									
Residual Change in Air Quality and Residual Change in GHG Emissions									
Construction	A	L–M	L–R+	MT	S–C	R	L	N	M
Operation and Maintenance	A	L–M	L–R+	MT	O–C	R	L	N	M
Operation and Maintenance	P	M	L	MT	C	R	L	N	M
Decommissioning	A	L–M	L–R+	MT	S–C	R	L	N	M
Residual Change in Acoustic Environment									
Construction	A	L–M	L	ST–MT	S–C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	O–C	R	L	N	M
Decommissioning	A	L–M	L	MT	S–C	R	L	N	M
Surface Water and Groundwater Resources									
Residual Change in Surface Water Quantity / Quality and Groundwater Quantity / Quality									
Construction	A	L–M	L	MT	S–C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	S–C	R	L	N	M
Decommissioning	A	L–M	S–L	MT	C	R	L	N	M
Flora and Fauna									
Residual Change in Flora / Flora Habitat									
Construction	A	L–M	L	LT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	LT	C	R	L	N	M
Decommissioning	A	L–M	L	LT	C	R	L	N	M
Residual Change in Flora Health / Survival and Fauna Habitat Quantity / Quality / Use									
Construction	A	L–M	L	LT	C	R	L	N	M
Operation and Maintenance	A	L	L	LT	C	R	L	N	M
Decommissioning	A	L–M	L	LT	C	R	L	N	M
Residual Change in Fauna Mortality Risk									
Construction	A	L–M	S–L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	S–L	LT	C	R	L	N	M
Decommissioning	A	L–M	S–L	LT	C	R	L	N	M

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Visual Environment									
Residual Change in Visual Landscape / Aesthetics									
Construction	A	M	L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	L	N	M
Decommissioning	A	M	L	LT	C	R	L	N	M
Residual Change in Reflection Conditions (i.e., Glint and Glare)									
Construction	No pathways for potential Project-related changes in reflection conditions have been identified for the construction phase of the Project (refer to Section 8.5.1). Project construction activities are therefore not anticipated to result in a residual change in reflection conditions, nor to contribute to a residual cumulative change in reflection conditions.								
Operation and Maintenance	A	M	L	MT	C	R	L	N	M
Decommissioning	No pathways for potential Project-related changes in reflection conditions have been identified for the decommissioning phase of the Project (refer to Section 8.5.1). Project decommissioning activities are therefore not anticipated to result in a residual change in reflection conditions, nor to contribute to a residual cumulative change in reflection conditions.								
Residual Change in Lighting Conditions									
Construction	A	L–M	L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	L	N	M
Decommissioning	A	L–M	L	MT	C	R	L	N	M
Agriculture and Other Land Use									
Residual Change in Quantity / Quality of Agricultural Land									
Construction	A	M–H	L	MT	S–C	R	L	N	M
Operation and Maintenance	A	M–H	L	MT	S–C	R	L	N	M
Decommissioning	A	M	L	MT	C	R	L	N	M
Residual Change in Other (Non-Agricultural) Land Use									
Construction	A	M	L	ST–MT	S–C	R	L	N	M
Operation and Maintenance	A	M	L	MT	C	R	L	N	M
Decommissioning	A	M	L	MT	C	R	L	N	M

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Social VCs									
Residual Change in Health and Safety									
Construction	A	L– M	S–L	MT	C	R	U	N	M
Operation and Maintenance	A	L– M	S–L	MT	C	R	U	N	M
Decommissioning	A	L– M	S–L	MT	C	R	U	N	M
Residual Change in Human Capital									
Construction	P	L–M	S–L	MT	C	R	L	N	M
Operation and Maintenance	P	L–M	S–L	MT	C	R	L	N	M
Decommissioning	P	L–M	S–L	MT	C	R	L	N	M
Residual Change in Economy									
Construction	P	L–M	L	MT	C	R	L	N	M
Operation and Maintenance	P	L–M	L	MT	C	R	L	N	M
Decommissioning	P	L–M	L	MT	C	R	L	N	M
Residual Change in Cultural Values									
Construction	A	L–M	S–L	MT	O–C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	L	N	M
Decommissioning	A	L–M	S–L	MT	O–C	R	L	N	M
Residual Change in Infrastructure and Services									
Construction	A	L–M	L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	S–C	R	L	N	M
Operation and Maintenance	P	M	R+	MT	C	R	L	N	M
Decommissioning	A	L–M	L	MT	C	R	L	N	M

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Residual Change in Social Dynamics									
Construction	A	L–M	L	MT	C	R	U	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	U	N	M
Decommissioning	A	L–M	L	MT	C	R	U	N	M

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:
P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:
N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:
S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:
Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:
Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:
R Reversible
I Irreversible

Probability
L Likely
U Unlikely
? Uncertain

Significance of Residual Impact:
S Significant
N Not Significant

Prediction Confidence:
L Low level of confidence
M Moderate level of confidence
H High level of confidence

11.0 MONITORING AND MANAGEMENT PLANS

11.1 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The Environmental and Social Management Plan (ESMP) for the Project (Appendix I) is intended to be a "living" document that is revised as necessary to remain relevant to the applicable stage of Project planning, design, and execution. The ESMP defines mitigation, management, and monitoring requirements for the Project by phase (i.e., construction, operation and maintenance, and decommissioning) and provides a framework for the specific responsibilities, tasks, and schedule for implementing, supervising, monitoring, and reporting the prescribed environmental and social impact mitigation and management measures. It is based on the results of the ESIA and provides practical guidance on how commitments made in the ESIA will be implemented during Project execution. As identified in the TOR, additional consideration has been given to environmental concerns from the use of hydrogen manufacturing, hydrogen storage and utility-scale batteries including disposal, recycling and fire / explosion mitigation.

11.2 CONSTRUCTION MANAGEMENT PLAN

As per the TOR, the purpose of the Construction Management plan is to outline the approach to be taken for managing construction works. A comprehensive description of expected activities, techniques, laydown yard location, hours of operation and timeframes for different phases has been presented. The purpose of the plan is to appropriately identify, manage, and mitigate potential impacts that may arise due to the Project. The impacts addressed include construction-related noise, vibrations, dust, storm-water run-off, safety, traffic flows and any other relevant matters.

The Construction Management Plan is included within the overall ESMP (Appendix I).

11.3 EMERGENCY AND DISASTER MANAGEMENT PLAN

As per the TOR, the Emergency and Disaster Management Plan has been prepared to identify recommended procedures and protocols to be carried out in the event of a natural, accidental, or human-made disaster at the Project energy facility. The plan includes protocols for emergencies and disasters such as explosions, fire, spills, and hurricanes. It has been developed in consideration of the results of the Project-specific Hazard Study and Quantitative Risk Assessment (Appendix D).

The Emergency and Disaster Management Plan is included within the overall ESMP (Appendix I).

12.0 CONCLUSION AND RECOMMENDATIONS

RSB is proposing to construct and operate a hybrid solar PV energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados. The Project will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas. The Project will generate approximately 56,000 megawatt-hours (MWh) per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually[10].

With the release of the BNEP (Government of Barbados 2019a), the Government of Barbados officially announced its intention for the island to achieve 100% renewable energy and carbon neutral transformational goals by 2030. As a baseload clean asset, the Project will help Barbados achieve its renewable energy and carbon neutrality targets. Where other solar PV approaches provide intermittent power with little or no storage, the Project offers a baseload solution that combines solar power with hydrogen and lithium technologies.

The electricity generated by the Project will be purchased by BLPC at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. The tentative Project schedule is for construction to occur between June 2023 and June 2025. Operation and maintenance would begin in July 2025 with the designed operational lifetime of the Project being at least 25 years. The decommissioning phase of the Project will commence following the conclusion of Project operations and is anticipated to last approximately 12 months.

Project construction will be managed by an international engineering, procurement, and construction contractor that will subcontract with the local workforce. It is estimated that the construction phase of the Project will provide temporary employment for up to approximately 150 local people. Following construction, it is estimated that approximately 20 full-time-equivalent permanent local jobs will be created to support Project operation, maintenance, and security requirements. The sheep farming aspect of the Project is expected to employ an additional 10 local people as farmers and farm staff. In addition to their pay, Project personnel will also gain valuable experience and training.

This ESIA has been prepared to support the Proponent’s application to Barbados’ Planning and Development Department for Planning Permission to proceed with the Project. It has been developed in consideration of the TOR for the ESIA (Appendix A) and relies on several Project-specific studies that have been conducted in support of the impact assessment:

- Baseline Ecological Assessment (Appendix F)
- Baseline Noise Assessment (appended to the Acoustic Assessment in Appendix E)
- Acoustic Assessment (Appendix E)
- Drainage Assessment (Appendix B)

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[10] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

- Visual Impact Assessment (Appendix G)
- Glint and Glare Study (Appendix H)
- Agricultural Impact Assessment (Appendix C)
- Social Impact Assessment Baseline Study (Section 9.1)
- Quantitative Risk Assessment (Appendix D)

The ESIA describes the planned activities and components of the Project, the existing baseline conditions at the Project Property, the potential physical, biological and social impacts associated with routine Project activities, and mitigation measures and controls to reduce the potential for adverse environmental impacts during each phase of the Project. In addition, the ESIA assesses potential impacts that could occur as a result of accidents, malfunctions and disasters, as well as the potential cumulative impacts of the Project in combination with other past, present and reasonably foreseeable activities. Further, the ESIA identifies the proposed management and monitoring plans (including emergency response procedures) that would be in place to protect the environment and human health and safety.

Specifically, the ESIA assesses potential Project impacts for the following VCs:

- Atmospheric and Acoustic Environment
- Surface Water and Groundwater Resources
- Flora and Fauna
- Visual Environment
- Agriculture and Other Land Uses
- Health and Safety
- Human Capital
- Economy
- Cultural Values
- Infrastructure and Services
- Social Dynamics

Table 12.1 summarizes the results of the impact assessment for each VC, in consideration of the design mitigation and environmental protection procedures identified in 3.7.

Table 12.1 Summary of VC Impact Assessment in Consideration of Identified Mitigation

VC	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters	Cumulative Effects
Atmospheric and Acoustic Environment	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.

Table 12.1 Summary of VC Impact Assessment in Consideration of Identified Mitigation

VC	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters	Cumulative Effects
Surface Water and Groundwater Resources	Residual adverse impacts are predicted to be low in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of a worst-case accidental spill, leak or LOC could be **significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Flora and Fauna	Residual adverse impacts are predicted to be neutral to low in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Visual Environment	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Agriculture and Other Land Uses	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of a worst-case accidental spill, leak or LOC could be **significant**.	Residual cumulative impacts are predicted to be moderate to high in magnitude, reversible and **not significant** with a moderate degree of confidence.
Health and Safety	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impact of a worst-case accidental spill, leak or LOC could be **significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Human Capital	Positive impacts are predicted.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.

Table 12.1 Summary of VC Impact Assessment in Consideration of Identified Mitigation

VC	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters	Cumulative Effects
Economy	Positive impacts are predicted.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Cultural Values	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Infrastructure and Services	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Social Dynamics	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.

Follow-up and monitoring is proposed only for the Flora and Fauna VC and will include regular monitoring for evidence of avian mortalities / collisions with Project infrastructure during the operation and maintenance phase.

No VC-specific follow-up and monitoring plans are proposed for Surface Water and Groundwater Resources, Visual Environment, and Agriculture and Other Land Uses. A Social Monitoring Plan has been proposed as described in the ESMP (Appendix I).

The implementation of the design mitigation and environmental protection procedures identified in Section 3.7 are formalized through the ESMP, which is intended to be a "living" document that is revised as necessary to remain relevant to the applicable stage of Project planning, design, and execution. The ESMP includes a Construction Management Plan and an Emergency and Disaster Management Plan. Through these plans, RSB will manage and reduce the potential adverse environmental and social impacts of the Project and enhance benefits to the community and Barbados as a whole. RSB is committed to developing and operating this Project in keeping with best practices and in a manner that is protective of the environment and public health and safety.

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13.2 PERSONAL COMMUNICATIONS

Carrington, Sean – Retired professor specialized in plant Biology at UWI Cave Hill Campus. Personal Communication, October 2021. Contact: sean.carrington@cavehill.uwi.edu

Grant, Ron – Senior Planning Assistant, Government of Barbados (Planning and Development Department). Personal Communication, January 20, 2022.

APPENDIX A

Terms of Reference

Erection of a Solar Photovoltaic Energy Facility at Harrow Plantation, St. Philip

Project Description & Terms of Reference for an EIA

-- 12 October, 2021 -

REV A – 4 November, 2021

RENEWSTABLE BARBADOS (RSB)

HDF ENERGY

Table of Contents

I) PROJECT PRESENTATION

A) PROJECT DEFINITION

Renewstable® Barbados ("RSB") - carried out by Renewstable (Barbados) Inc. (hereinafter "RSB"), a Special Purpose Vehicle (SPV) company fully owned by HDF Energy - is an innovative, non-intermittent electrical power plant solution. It will deliver 13 MW firm of carbon-free and renewable electrical power from 8AM to 5PM and 7PM to 9PM, 2-hours-dispatch flexible to meet the end-of-the-day-peak (when the marginal cost of generation in Barbados is the highest) and 3 MW firm power the rest of the time.

RSB is a Dual Land Use project as it will accommodate a large-scale Blackbelly sheep farming facility with both direct sheep grazing and grass harvesting within the solar power plant and surrounding green areas.

The Renewstable® power plant will be composed of the following key components:

- a ground mounted solar photovoltaic plant that generates power for storage and direct usage
- a long-term energy storage solution using hydrogen that includes electrolyzers, a gaseous hydrogen storage tank farm and a fuel cell system
- a short-term energy storage solution using Lithium-ion batteries
- a comprehensive commercial Blackbelly sheep farm specifically designed to be financially viable and environmentally sustainable in the long term, and proposed to be the largest in Barbados, focusing on the local and export market

This project represents a Capex of around 115 million US dollars that will be raised through a project finance scheme with equity financing and external lenders.

The electricity generated by RSB will be purchased by the privately-owned utility Barbados Light & Power Company (BLPC) at an agreed rate through a Power Purchase Agreement (PPA) for 25 years from the commissioning of the power plant (expected to be in 2024).

B) PROJECT ENVIRONMENT

Barbados electricity dispatch profile

The total annual electricity demand for Barbados is in the range of 900 GWh, with a maximum load of around 170 MW. The installed dispatchable thermal power capacity is 239.1 MW allowing a reserve margin for unscheduled downtimes and scheduled equipment maintenance. The production units are based on mineral oil products in the form of heavy fuel oil (HFO), diesel or kerosene (jet fuel). The steam turbines are ageing assets that need to be decommissioned.

TYPE OF POWER PLANT	POWER INSTALLED	TYPE OF FUEL	SPECIFIC CONSUMPTION	CO_2 EMISSIONS
2 steam turbines	40 MW	HFO	3,78 kWh/L	1,39 tCO2/MWh
6 low speed diesel	113,5 MW	HFO	4,93 kWh/L	0,69 tCO2/MWh
5 gas turbines	86 MW	Diesel and jet fuel	2,82 kWh/L - 2,94 kWh/L	0,95 tCO2/MWh
1 Large-Scale Power Plant	10 MW	Solar	-	-

Figure 1: Large-scale power plants in Barbados

The daily load is around 155 MW during the day and 100 MW during the night with an end-of-the-day consumption peaking at around 130 MW at 7:30 PM.

RSB has been designed to deliver 13 MW baseload power when the power consumption is most needed and the generation price is the highest due to the use of expensive gas turbines. The 13MW-power capacity at the end-of-the-day-peak meets the power capacity of the peaking Gas Turbine that needs to be decommissioned according to BLPC retirement schedule (GT02)

SERVICE

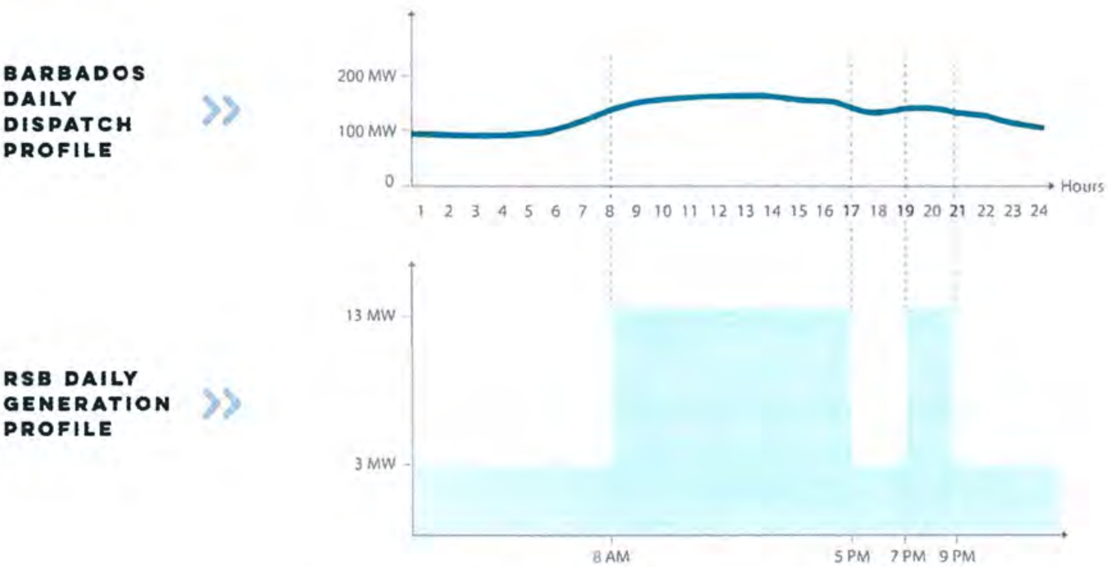

Figure 2: Barbados typical daily grid dispatch profile and RSB generation profile

C) PROJECT JUSTIFICATION AND NEED

Barbados has set a goal of 100% renewable energy usage by 2030. BLPC and Barbados Renewable Energy Association (BREA) have highlighted that this goal will not be achievable without **baseload** renewable power implementation.

Numerous small-scale to commercial-scale solar projects are expected to be developed in the upcoming years. Some large-scale solar projects (5 to 10 MW intermittent power plant) are in development as well. The deployed small-scale photovoltaic systems on the island were installed under the Renewable Energy Rider 'RER' Program with a Feed-In Tariff. The Fair Trading Commission **'FTC'** has released in September 2019, new feed in tariffs for renewable energy projects with a power under 1MW, providing a regulatory framework for such size projects.

These future power systems will all provide non-dispatchable electricity only during the day time and will be subject to the same intermittency. BLPC will need to curtail power, and/or invest massively in storage to dispatch this large amount of intermittent power while ensuring energy security. This stand-alone storage investment is likely to be recovered through the FTC process and eventually transferred to the customer through the price of electricity.

As a baseload clean asset, RSB will help reaching the renewable energy target while sustaining the stability of the grid at a competitive cost with no hidden costs. RSB is a **baseload solution** which is very different to other photovoltaic systems that provide intermittent power with minimal or no storage. By combining hydrogen and lithium storage technologies, a clean, viable baseload solution is achieved that stabilises the grid rather than stressing it.

RSB will transfer part of the operational risk of renewable energy integration and operation from BLPC to Renewstable (Barbados) Inc. Through its contractual structure, RSB includes a built-in business model for energy storage (i.e. quantified and qualified use of the storage for 25 years).

D) SITE DESCRIPTION

RSB has secured via lease a 182-acre plot at Harrow Plantation in the parish in the parish of Saint Philip. The contract will cover a 28-years-period, enough to build the power plant and ensure at least 25 years of operation. A lease extension will also be negotiable.

Figure 3 - Harrow location

Figure 4: The Site and its surrounds


Figure 5: Photography of successful dual use with renewable energy and sheep farming at Trents solar facility (BLPC)

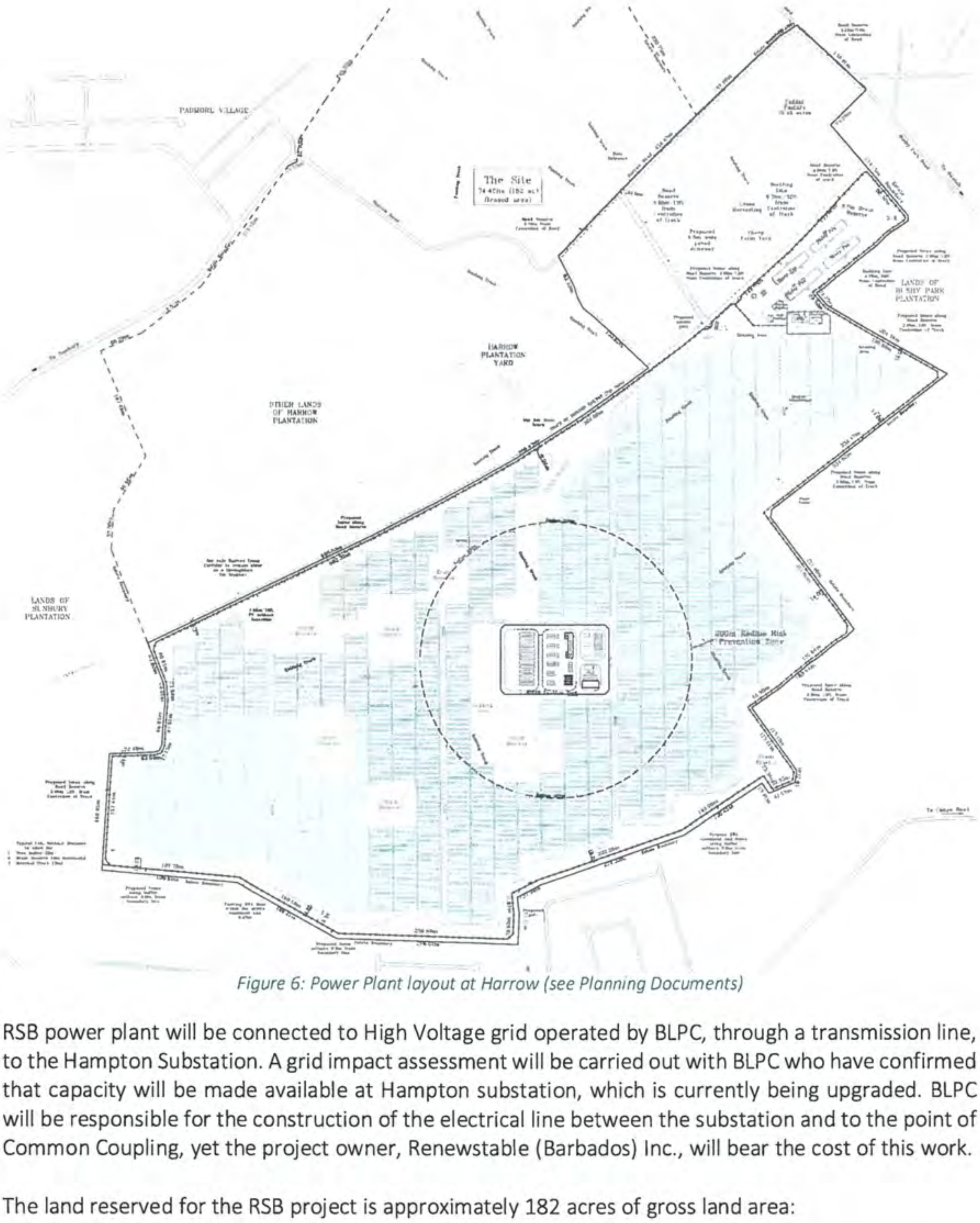

Figure 6: Power Plant layout at Harrow (see Planning Documents)

RSB power plant will be connected to High Voltage grid operated by BLPC, through a transmission line, to the Hampton Substation. A grid impact assessment will be carried out with BLPC who have confirmed that capacity will be made available at Hampton substation, which is currently being upgraded. BLPC will be responsible for the construction of the electrical line between the substation and to the point of Common Coupling, yet the project owner, Renewstable (Barbados) Inc., will bear the cost of this work.

The land reserved for the RSB project is approximately 182 acres of gross land area:

- 6 acres are used to implement Sheep Farming Buildings and Facilities
- 25 acres are used for grass harvesting and bailing. This grassed area is free from construction
- 146 acres are used to implement the solar power plant together with solar grazing, including right of ways and various restrictions such as drain reserves
- 4 acres are used to implement the energy management and storage systems, the "HyCPE area"

Agricultural Areas Breakdown

Fodder Pasture = 25.45 acres
Agricultural, Office and Storage Facility = 5.63 ac
HyCPE Facility Area = 3.92 ac
Solar Grazing Area = 141.73 ac (Covered & Uncovered)
Sailover Area = 73.40 acres (Covered by panels)
Percentage Covered (Sailover) : Uncovered (Grassed) = 43%

Figure 7: Agricultural Breakdown Details

Drain reserves have been anticipated in the implementation of the power plant, those areas are left free from construction. They will be eventually shaped to accommodate a sufficient volume of runoff and equipped with suckwells. The accurate positioning and sizing of the drainage reserves will be confirmed in the EIA hydrological assessment.

Figure 8 - Similar rainwater drainage reserves as proposed

Cultivation of the existing sugar cane fields will continue at Harrow until the start of the construction.

Sheep husbandry will be introduced on the site by an experienced farmer who has a solid track record of raising sheep in dual land use facilities. A farmer has already been pre-selected and expressed a strong desire to expand his operations, and included is his letter of preliminary commitment.

The facilities will be designed to accommodate at least 1,830 blackbelly sheep. On-site sheep farming facilities include pens, a hay barn, a platform for a silo, potable and rainwater tanks, and a staff facility. In addition, a 25-acre area is left as a grass harvesting area, enabling the farmer to feed the sheep through the dry season. The soil quality at the site is good (Class IIb) and in line with what is required to successfully grow high-protein grass and hay for the animals. No irrigation supply wells are available, but excess rainwater and process water will be available for the irrigation of struggling grass areas as needed.

E) CONTRACTUAL STRUCTURE

Project finance

The project CAPEX is estimated at around US 115 m$. Renewstable (Barbados) Inc. will be financed through a conventional project finance scheme with an anticipated ratio of equity/debt of 30/70%.

Project finance is a commonly used financing structure for large-scale renewable energy projects, and investors are used to dealing with Power Purchase Agreements.

RSB has started the discussions with potential local equity investors (including Sagicor, Fortress Fund, Rubis Group, Group Sol, Amphora), international investors with experience in the region (including MPC Capital, Contour Global), international lenders (including IDB invest, IFC, EIB, CDB) and local commercial banks (Republic Banks, CIBC).

Rubis Energie (French energy giant) and HDF Energy, have entered into a strategic partnership as part of HDF Energy's public listing operation done in June 2021. Rubis Energie is committed through this partnership to support HDF Energy's development:

- by participating by to €78.6 million in the capital increase to be carried out as part of HDF Energy's listing on the regulated Euronext Paris market, and by having a position of director and a position of censor within the Board of Directors of HDF Energy;
- by benefiting, during five years, from a priority to become a majority investor in the projects that HDF Energy plans to develop in Africa/Indian Ocean, the Caribbean and Europe, allowing Rubis Energie to position itself as a major direct investor in renewable electricity generation projects. Rubis Energie will also be offered the opportunity to invest in projects in other parts of the world, without requiring majority status in any given project. The Group will bring its insight into local markets and provide HDF Energy with technical, logistical, administrative, and legal support for projects that will be developed in the countries where Rubis operates. Following HDF Energy Initial Public Offering on the regulated Euronext Paris market, on June 24th 2021, Rubis became the second shareholder of HDF with a participation of 18.5% in HDF Energy's capital.

Under this strategic Partnership, Rubis Group is currently evaluating a potential investment decision before the end of the year 2021.

The IDB Invest has provided technical assistance to Renewstable Barbados Inc. and a letter of intent was signed confirming the interest of the IDB invest to finance up to 60% of the debt of the project. The IFC is also evaluating the project from a lender's perspective and can provide up to 36% of the project debt.

Procurement

RSB will procure each main component of the Renewstable® power plant through a competitive process. HDF has built an expertise in the very dynamic markets of hydrogen, battery and solar power, with constant benchmarking of the main suppliers. HDF has signed a technology transfer with Ballard Power Systems, world leader in fuel cell stacks manufacturing.

RSB plans to establish a turnkey contract between the SPV and an EPC firm (Engineering, Procurement, Construction) at a fixed-cost and fixed term. EPC contracts are commonly used in large-scale energy projects, the EPC firm being selected to bring a maximum of guarantees to the investors. RSB intends to maximize the share of local workforce for the implementation of the project.

HDF has built a strong experience in EPC tender negotiations for hybrid power plants with international references such as Siemens, Sener, Bouygues, GranSolar, TSK. The contractual and technical structure of the EPC Contract will derive from CEOG project, which has been successfully closed in September 2021, with Siemens Energy as EPC and O&M contractor. The EPC will build strong relationships with local contractors to maximise the local content of the works: civil works, logistics, mechanical and electrical erection, for example.

HDF is already procuring services to multiple local Barbadian companies in order to support the development of RSB project:

- Richard Gill Associates Limited: planning application consultant
- Stantec: Environmental and Social consultant
- ENSMART: Electrical grid consultancy
- Vita Sharde Chambers: Real Estate
- Aidan Rogers: Legal Services

Power Purchase Agreement

RSB will derive its remuneration from a **long-term contract with BLPC** (25-years Power Purchase Agreement), to be validated by the Fair Trading Commission. BLPC is supportive of this project that helps increase the penetration of renewables without causing any intermittency issues.

After several discussions with the utility, RSB proposes a power generation of 13 MW firm from 8 AM-5 PM and 7PM to 9PM with 3MW the rest of the time an availability above 85% for 25 years.

The design of the power plant can be slightly adjusted during the negotiations of the contract. RSB has started negotiating the commercial terms of the PPA with BLPC and participates in the stakeholders PPA draft review process led by the FTC. BLPC has signed a letter of support for the RSB project (enclosed in the Planning Application).

The Ministry of Energy Small Businesses and Entrepreneurship (MESBE) and the FTC are aware of the RSB power plant project being developed by HDF energy. The MESBE is ready to receive the IPP License which is to be submitted early November 2021 and engage with HDF Energy to properly evaluate this generation asset.

Due Diligence

RSB will contract with engineering offices and advisors to share expertise on the financial, legal, insurance, technical, and environmental aspects of the project. In order to obtain a positive due diligence investigation and review, they will interact with the lenders' advisors, providing all the requested information, covering all project expenses and risks assessment. HDF has experience working with the following advisors: Eight Advisory; Get Invest; Willkie Farr & Gallagher; DNV; Linklaters ; Asrtis Finance; Clifford Chance; Apave.

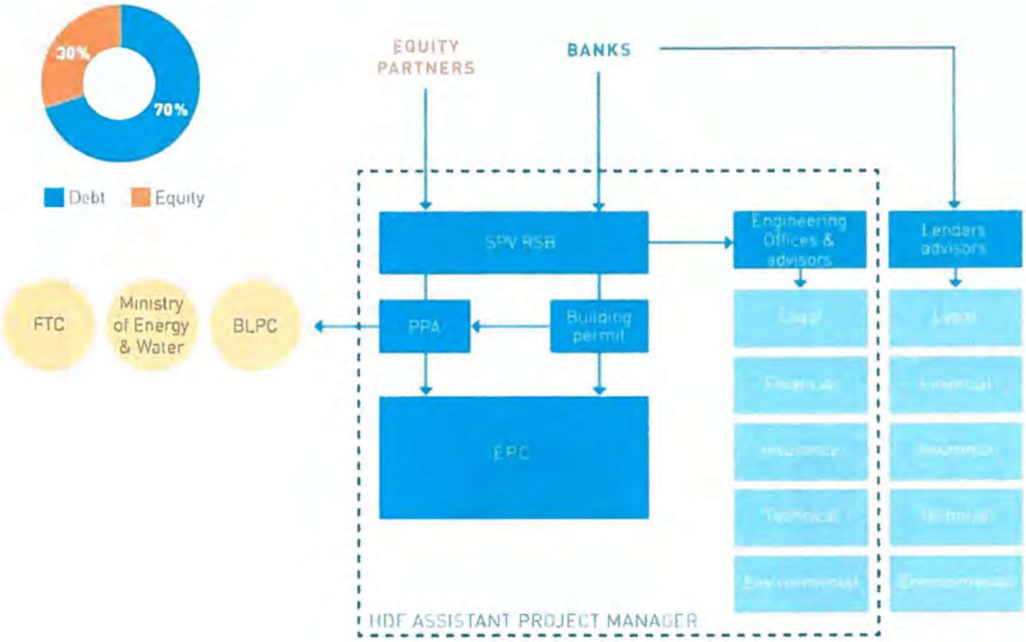

Figure 9: Renewstable (Barbados) Inc. due diligence process

Operation and Maintenance:

RSB will contract with the EPC to take responsibility for operations and maintenance for the first two (2) years. The EPC will also rely on local subcontractors. Transfer of operations and maintenance will be re-evaluated after two (2) years, and the long-term vision is to enable to develop new skills for the local economy.

Example of O&M Organization :

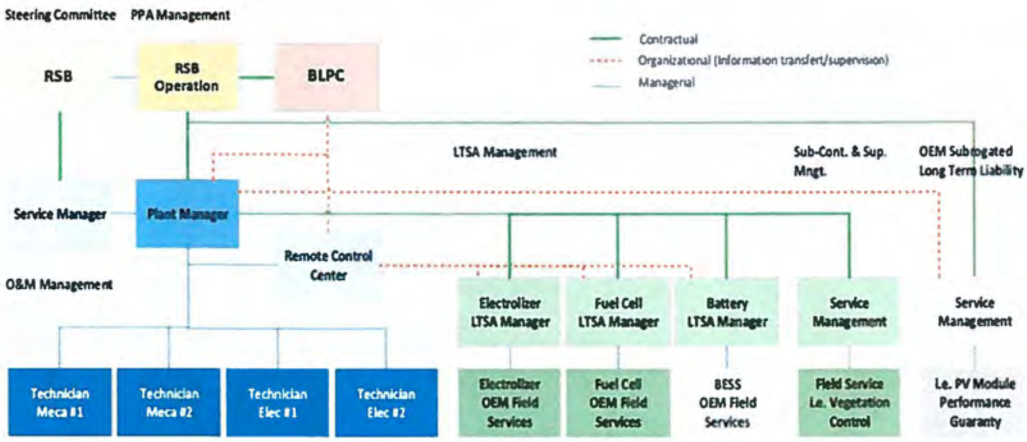

Figure 10: Operation and maintenance possible organisation

F) TIMELINE

Financial close and project commencement is envisaged for the middle of 2023. The permitting process, including the authorization to launch the EIA, the EIA approval and the IPP license are on the critical path and must be achieved prior to commencement. After financial close, construction is expected to last 24 months.

G) HDF PROJECT TEAM

HDF has structured a dedicated team for RSB project but also have contracted with local consultants for development, legal advisory and environmental advisory at this stage.

RSB team: HDF

Figure 11: HDF team for RSB

RSB team: Local Advisors

Figure 12: Local advisory team for RSB

HDF has successfully registered "HDF Caribbean" in Barbados in early October 2021 and is hiring for this skill profile to cover development in the Caribbean based in Barbados. The team is to be composed of an even mix of young individuals who will be trained plus experienced individuals with experience in the Caribbean energy sector.

II) TECHNICAL DEFINITION

A) ENERGY SERVICE

RSB is a Renewstable® power plant, it will generate firm and clean renewable power from an intermittent source of energy.

The selection and the sizing of each equipment of this hybrid power plant have been optimised to deliver 13 MW firm power from 8 AM to 5PM and 7PM to 9PM when it is the most needed, and 3 MW firm power the rest of the time with a high reliability.

The capacity factor will vary with each equipment performance degradation over their lifetime and their respective replacement. But the overall capacity factor (or energy target compliance) will remain greater than 85% over the lifetime of the project.

B) OPERATING PRINCIPLE

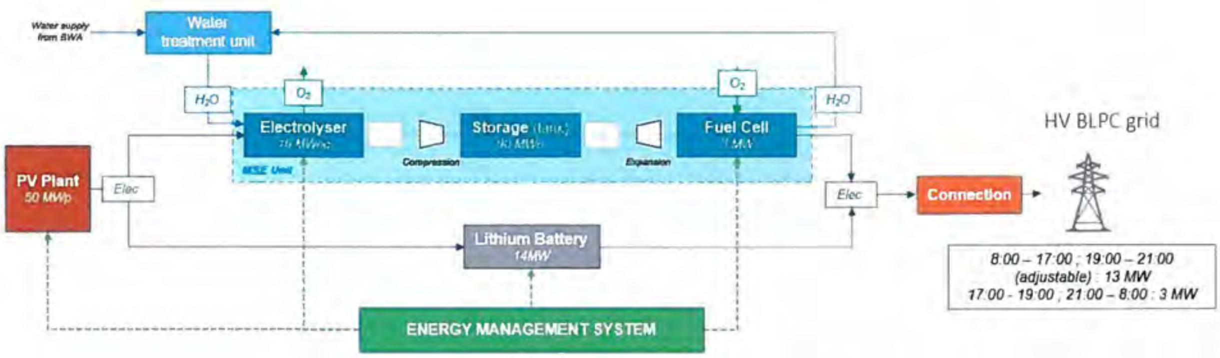

Figure 13: RSB operating diagram

The power plant will incorporate:

- a 50 MWp photovoltaic generation plant,
- an Electrolyzer system with a total capacity equivalent to 16 MW,
- a Hydrogen Storage of 7.3 Tons, equivalent to 90 MWh, in gaseous form in pressurized cylinders at 30 barg,
- a 14 MW Battery Energy Storage System, with 3-hours capacity,
- a high-powered Fuel Cell system with a capacity of 3 MW,
- a Water treatment plant
- Diverse utilities and auxiliary system for power plant management

The system converts electricity from the photovoltaic plant into hydrogen using an electrolyzer system, stores the hydrogen in horizontal cylinders and then produces electricity whenever needed from stored hydrogen using a fuel cell.

These technologies are based on the water cycle: they consist in breaking a water molecule (H_2O) down and then recomposing it. The hydrogen storage contains no chemicals and emits no harmful emissions, only oxygen and water.

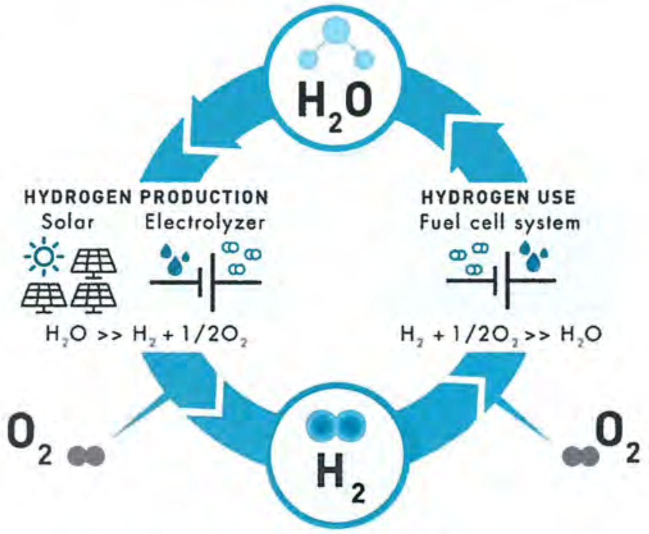

Figure 14: Hydrogen storage based on the water cycle

C) ENERGY CHAIN COMPONENTS

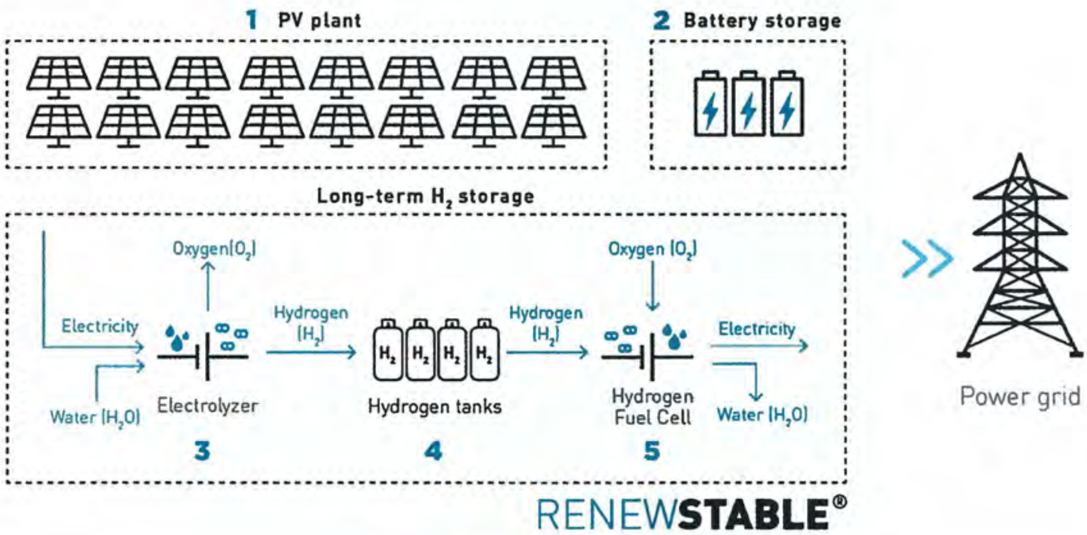

Figure 15: Renewstable power plant principle

1) The solar power plant

The primary source of energy of RSB will be a 50 MWp photovoltaic solar power plant in fixed-tilt configuration. The configuration is chosen to be well-adapted to solar grazing, to maximise the energy generation and to minimise the land used. The PV structures are designed to meet the local building codes, in particular withstand strong winds and hurricanes (Cat. 3 minimum).

2) The Battery Energy Storage System

RSB will include a 14 MW short-term energy storage: the battery energy storage system. The role of this battery is to:

- Deliver a 2-hour dispatchable block to meet the end-of-the-day-peak (anticipated 7PM to 9PM but that can vary according to the needs of the grid) of firm power at 13 MW to cover the end-of-the-day peak when the energy generation is the most expensive (open cycle gas turbine running at a cost of between 250 and 600 USD/MWh)
- Provide quick energy response within RSB in order to ensure a stable and optimized energy service during the day (i.e. to mitigate cloud cover and other intermittencies).
- Provide additional power for absorbing peak power during the day when the electrolysers are running at maximum power and solar power is available in excess.

Each battery will be integrated in prefabricated enclosures, including the battery cells but also management systems, auxiliaries, cooling, fire safety and security systems.

3) The Hydrogen Energy Storage System

The hydrogen storage allows the Renewstable® power plant to supply energy 24/7. It enables the storage a large quantity of energy for long-term service, thus enabling baseload generation over extended time periods. The similar use of a storage in CEOG project, in French Guiana has proven to be bankable.

It will be composed of:

- **16 MW** of electrolysers (Alkaline technology) that will be contained in containers and prefabricated enclosures. The role of the electrolyser is to absorb a significant part of the energy output of the solar power plant to generate hydrogen for storage.

- Compressors and multiple racks of pressurized bottles of hydrogen at 30 bars able to store **90 MWh** of energy. This represents approximately **7.3 tons of hydrogen** to be stored.

- **3 MW** of hydrogen fuel cells using PEM (Proton Exchange Membrane) technology to transform the stored hydrogen and the oxygen available in the surrounding air into electricity and water. The fuel cells will be in **containerised enclosures** as well.

The BESS (battery) and HESS (hydrogen) systems, as well as utilities and auxiliary systems are implemented on a centralised area located at the centre of the power plant. This area is called the "HyCPE area", it's specifically designed to mitigate the risk represented by the energy storage equipment in order to protect the workers and the surrounding community. A large setback from the nearest receptors is proposed in excess of the minimum recommended safety limit.

4) The EMS (Energy Management System)

The EMS is the software that will compute the solar irradiance forecast in advance and optimize the use of both the hydrogen and battery storages in order to deliver the maximum amount of power to the grid and minimize the energy losses. In case of low solar resources, it can maximize the energy supply and adapt the generation profile to comply best with the contractual obligations.

III) INPUTS AND OUTPUTS

A) NATURAL RESOURCES REQUIRED

Both the Power Plant and the sheep farm require a supply of water. The water consumption is estimated at:

- **60 m^3/day** for a standard day of operation: this water will be demineralized. Half of it will serve for hydrogen production, and the other half will serve for irrigation and wash-down purposes for farming
- **4.5 m^3/day** for sheep farming and staff operations

A water storage tank for operations water will smooth out the flow during the day and allow RSB power plant to run for 5 days at full load without water access. The maximum flow of water required by RSB will be 5 m^3/hour (electrolysis at maximum load during 12 hours).

Both rainwater and potable water tanks will be located within the office area and sheep farming facilities to store water and ensure 5 days of potable water for offices and sheep, and 15 days of rainwater storage for sheep drinking and pen wash-down.

Rainwater harvesting will be studied in the EIA in order to reduce potable water use during the year. Drainage reserves are already considered on-site, to manage water run-off. A hydrological/hydraulic study shall be done to assess rainwater harvesting via ponds or water tanks located beneath power plant buildings. Water from this storage shall be captured during the rainy season for use throughout the year towards, thus offsetting the quantity of potable water that may be required from the public mains. The EIA shall examine options to minimize the dependence of the facility on the public water mains.

B) HAZARDOUS PRODUCTS ON SITE

The hazards and risks related to the project will be studied qualitatively and quantitatively in a Hazard study. The main hazardous products that will be used on site are the following:

The potassium hydroxide solution for the electrolysers

A potassium hydroxide solution at 25% (up to 100 m^3) is used for the alkaline electrolysers. The potassium is not a consumable since it works in a closed loop in the electrolysis process. It is normally changed every 10 years, and in this case the project owner (RSB) will manage the safe evacuation and proper recycling of the product.

The accidental spillage of the potassium hydroxide solution can cause soil and water pollution. This risk will be assessed in the hazard study, yet the following mitigation measures are anticipated: the electrolysis process equipment to be in sealed enclosures (a container), and additional protection is applied to avoid spillage or catch the leaks through containments.

The pressurized gaseous hydrogen

Gaseous hydrogen is to be produced and stored on site. The maximum amount of hydrogen stored on site is 7,300 kg. The hydrogen is compressed at 30 bars and stored in 115 m3 cylinders.

Bottles of pressurized gas could theoretically cause a blast due to a hydrogen leak. Worst-case scenarios will be assessed in the hazard study to determine the security perimeter around the hydrogen containers. The hazard study for HDF's project "CEOG" in French Guiana equipped with 115 MWh (7000 kg) of hydrogen storage assesses a 130m-radius security zone around the storage facility.

RSB has defined, as an anticipated mitigation measure, a 200m radius security zone around the storage area that is fully contained within RSB's land reserve and with no human habitation within it (already anticipated in the layout provided). The power plant is designed so that the consequences of the worst scenario - the hydrogen explosion - are included within the site boundaries and there is no risk to the surroundings. Moreover, a hydrogen explosion would not release any pollutant or harmful products into the soil or atmosphere.

This proposed 200m setback is clearly illustrated on the Site Plans.

The Lithium-Ion used in the batteries

Li-ion batteries are used for the storage of electricity. They are integrated in pre-assembled enclosures, and include cooling, fire detection, automatic fire extinguisher, and comprehensive fault detection in charge/discharge cycles. Batteries are susceptible to fire, and this hazard will be assessed in the hazard study. In particular, batteries shall be compliant with NFPA 855 (Standard for the Installation of Stationary Energy Storage Systems) which is a widely used norm for battery installation in the USA.

Strong consideration will be given to Lithium-Iron batteries and whether this technology is suitable for the project at time of procurement.

The used batteries will be sent back to the manufacturer for end-of-life disposal.

The Oil in the electrical transformers

Standard transformer oils represent a potential danger to third parties and the environment since they can cause soil pollution in the event of accidental spillage. Recommendations will be made to minimize this risk.

Incompatibilities of hazardous products

There are no products on the site with particular incompatibilities.

C) MAIN OUTPUTS

Gaseous outputs

The Hydrogen Storage does not emit any gaseous pollutant. It releases the following:

- Pure oxygen from the water electrolysis process when operating
- Hydrogen can be released in small quantities during operation or maintenance phases, out of the electrolyzer and the fuel cell.
- Air-enriched in Nitrogen: Air with low O_2 rate will be released from the fuel cell
- Water in gaseous form will be released (pure H_2O) from the fuel cell when operating

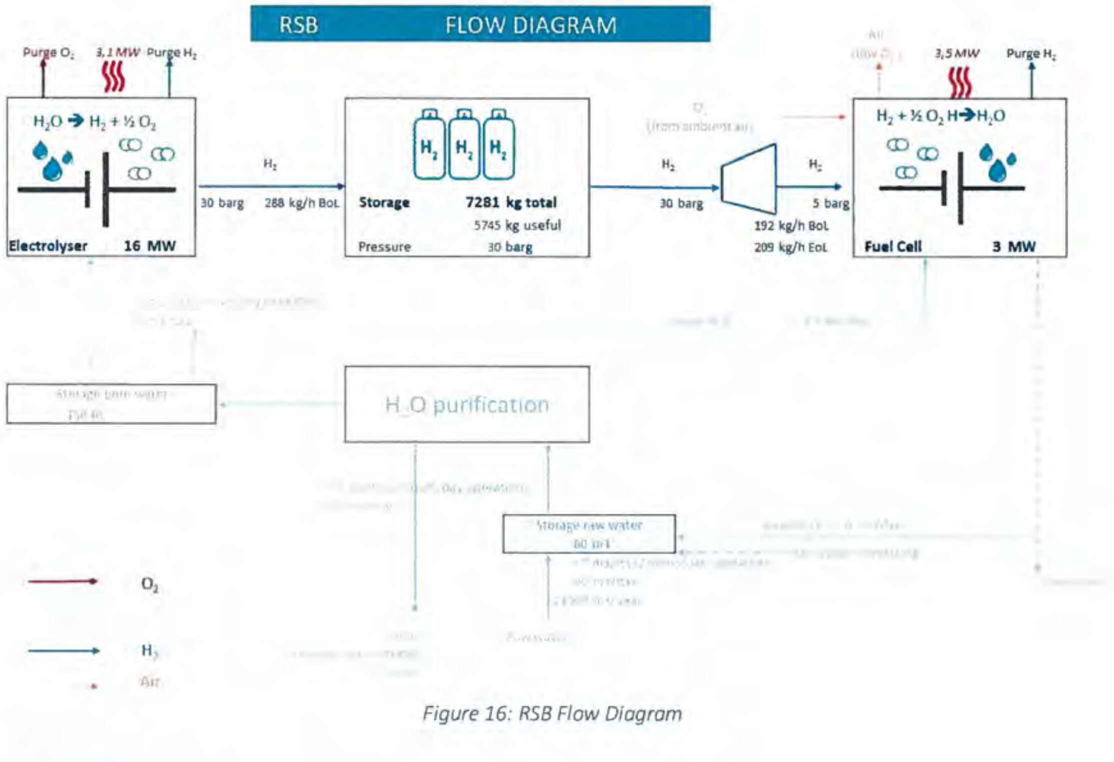

Figure 16: RSB Flow Diagram

Liquid/Solid output

A volume of 30 m³/day of **water concentrated in minerals** (no pollutants) will be released on site during normal days of operation: this water is the by-product of the water treatment (purification) process which aims at producing pure, demineralized water for the power plant process. This by-product water can be used to irrigate the grazing areas as it is concentrated in minerals. See table below for the tolerance of different forages to Electrical Conductivity and Total Dissolved Solids, according to research performed in California, USA (Canadian Council of Ministers of the Environment, 1987).

Table 1 - Tolerance of Selected Crops to TDS in Irrigation Water, as determined by research in California, USA (Canadian Council of Ministers of the Environment, 1987)

Degree of Tolerance	Forages
Electrical Conductivity < 3600 µS/cm Total Dissolved Solids <2500 mg/L	Oat hay, Wheat hay, Brome, mountain, Tall fescue, Sweet clover, Reed, Canarygrass,Birdsfoot, Trefoil, Perennial, Ryegrass
Electrical Conductivity <5000 µS/cm Total Dissolved Solids <3500 mg/L	Barley hay Tall wheatgrass

According to their nature, wastes will be stored on site in rubbish bins, containers, or water-tight barrels. These will be qualified and quantified in the EIA.

Sheep manure from the pens will collected in skips and sold to soil mix and landscape companies as needed. Sheep manure dries out and breaks down quickly without significant odours, unlike chicken and pig waste. Some will also be spread across the site as fertilizer to assist with healthy grass growth.

No butchering will take place on site, and any dead animals will be removed and disposed of at approved facilities.

IV) BENEFITS

A) ECONOMIC BENEFIT

Fixed and competitive pricing

RSB will deliver non-intermittent and renewable power for at least 20 years. Compared to other renewable, "firm" power solutions, the tariff is competitive and benefits from economies of scale. The price of generation will be set and known for at least 20 years in the Power Purchase Agreement. It will lower the impact of the variable and unpredictable "fuel cost adjustment" for the end-consumer.

Reduced fuel and mutton/lamb imports

RSB's average generation of 56,000 MWh/year over 20 years will save 13 million litres [1]of heavy fuel oil per year, representing 13.6 million BDS \$/year[2]. Furthermore, lamb meat imports will be reduced, hence saving foreign exchange of over 1 million BDS \$/year.

Agriculture

RSB is committed to promoting the dual use of solar energy plus agriculture on the site. The sheep farm will be operated by an established, experienced farmer who is adamant that a secure, fenced environment such as a solar facility is the only way for a sheep farm to succeed in our environment where praedial larceny and wild dog attacks are a major contributor to failure. The sheep farm facilities included are designed to accommodate at least 1,830 sheep, with local lamb meat production saving vital foreign exchange, and local skin production set to take off in the export market.

Additionally, the power plant and extra fodder area are designed to ease the impact of the dry season on sheep farming. With fodder area will allow the growth and bailing of grass for storage, and the water by-product from the electrolysis process will allow continued use for irrigation and wash-down.

Local return on investment

RSB is financed through a project finance scheme with a 30/70 equity/debt ratio by international and local lenders. HDF energy will remain a long-term investor. It has been proposed to potential local shareholders to participate up to 60% to the equity shares. The local commercial banks and credit unions are also consulted to participate to the debt. Furthermore, all farmers and farm staff are expected to be local. The Energy Co-op has expressed a strong interest in de-risked equity investment prior to financial close. It would be the ideal vehicle for local investment as it benefits to a large community of Barbadian.

Employment

[1] *Calculation based on an average specific consumption of HFO of 0,23 L/kWh, based on BLPC figures*

[2] *Calculation based on a price of 25 \$BBD/MBTu, data from Barbados IRPP (Mott Macdonald) Average price projected between 2020 and 2030*

RSB will be built by an international EPC which will need to subcontract with the local workforce. The number of jobs during the construction (one to two years) is estimated at a maximum of 150. The number of permanent jobs for the operation, maintenance and security is estimated at 20. All persons involved will gain in experience and training. The sheep farm will employ a further 10 persons.

Model for the Future

The dual usage of land (agriculture and stable energy) is a perfect example in sustainability. Not only is Barbados achieving baseload renewable energy production, but it does so while preserving agricultural activities and saving foreign exchange. Since agricultural land will inevitably be impacted in order to achieve our renewable energy goals, then at least we should be re-purposing it for other agricultural activities that can co-exist with solar energy production. Because high quality grass for fodder requires good soils, this site is ideal for a sheep farm. The estate does not have a working groundwater well, and therefore irrigation is not available on the site.

HDF Energy has started similar power plant development in the region and RSB example of dual usage of Land is extremely well seen. Suriname has an interest in duplicating this approach for example.

B) ENVIRONMENTAL BENEFITS

Reduced GHG Emissions

RSB will deliver power without emitting any greenhouse gases. The hydrogen storage runs on the water cycle and only emits pure water steam. 99 % of the hydrogen infrastructure is recyclable. RSB average electricity generation of 56,000 MWh/year will cut Barbados CO_2 emissions by 48 000 tons per year[3].

RSB will generate clean and renewable electricity for 16,000 inhabitants[4].

Optimized land usage

RSB project is a dual land use project designed to accommodate both power generation and sheep farming. Sheep farming facilities are included on-site, 1,830 sheep can be accommodated to graze on the power plant, along with 56,000 MWh/year baseload power generation that is fully renewable.

C) TECHNOLOGY BENEFITS

Simplified operation

RSB Power Plant will deliver baseload power to the grid operator 24/7 with an availability higher than 85%, RSB will give notice of the availability of the power plant 24-hrs in advance to the grid operator.

[3] *Calculation based on an average specific CO_2 emissions of 0,87 tCO_2/MWh, based on BLPC figures*

[4] *Calculation based on an average electricity consumption of 3480 kWh/inhabitant/year*

This predictable firm power will eliminate for BLPC additional operating costs and infrastructure upgrade usually necessary when implementing classic renewable energy (intermittent wind and solar).

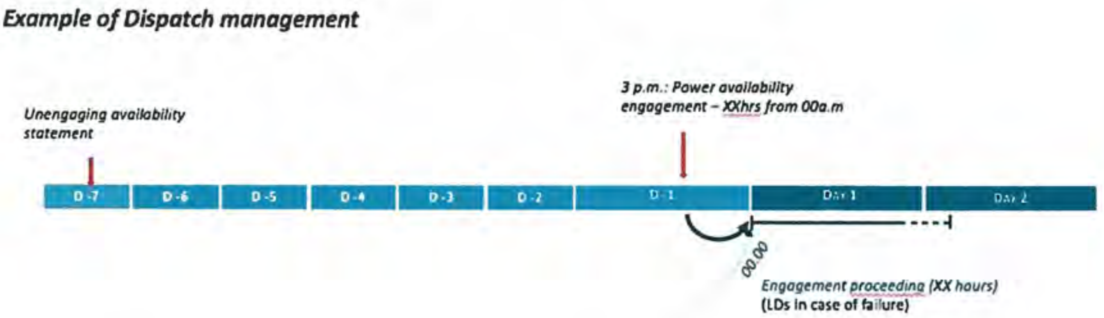

Figure 17: Example of dispatch management

Resilience

RSB will comply with the local and international norms to withstand 150+ miles/hour wind. The East-West configuration of the solar panel tables has been highly recommended by infrastructure suppliers for hurricane zones. The selected structure will be checked according to the ASCE code by a certified engineer.

RSB power plant will participate in distributing the generating assets to the national grid. It will spread the risk of a general power outage.

After an extreme weather event, RSB could still deliver stable electricity to the grid, not being affected by fuel supply issues.

RSB will be energy self-sufficient, and will power the national grid with underground cables as agreed with BLPC.

Technology know-how and knowledge transfer

RSB will host the first large-scale hydrogen industrial application in Barbados. This project is an opportunity for the country to develop local know-how in this new industry, leading the way for other projects of this nature. HDF Energy is hoping to collaborate on other Renewstable® power plants, hydrogen mobility projects, desalination power plants running on solar power and hydrogen, and waste recovery through hydrogen.
The University of the West Indies has signed an LOI with HDF Energy over transfer knowledge collaboration on the green hydrogen deployment in the region. A relevant application in the Caribbean region would be the energy independence of territories and clean regional ferries running on hydrogen. The case is being considered for Aruba-Curacao and Trinidad-Tobago. The Renewstable power plants can provide the extra hydrogen to power the future hydrogen mobility.

HDF is also in discussion with the University of Trinidad to collaborate in classes related to hydrogen power. With RSB, HDF Caribbean will position Barbados as an expert in the field and allow Barbados to export its knowledge throughout the Caribbean region. o

TERMS OF REFERENCE OF EIA

The following tasks will be performed as per departmental guidance in order to ensure a thorough EIA process and resulting EIA report:

DESCRIPTION OF THE PROPOSED PROJECT

A comprehensive description of the project will be provided, noting areas to be reserved for construction, areas to be preserved in their existing state as well as activities and features which will introduce risks or generate impact (negative and positive) on the environment. This will involve the use of maps, site plans, aerial photographs and other graphic aids and images, as appropriate, and include information on location, general layout and size, ancillary buildings, as well as pre-construction, construction, and post construction plans.

The design, construction, and operations stages of the development will be fully described.

The description shall include: location of all development components; raw materials required (including power, water supply and other utilities); general layout; capacity; size; process description where relevant; Best Available Technologies (BAT) in use where relevant; any by-products, and any waste flows.

LEGISLATIVE AND REGULATORY CONSIDERATIONS

A description will be provided of the pertinent regulations, standards and policies at the local and national levels governing environmental quality, health and safety, infrastructural development and land use control that may have an impact on the proposed development.

In the absence of local standards, appropriate internationally-recognised standards shall be recommended. The examination of the legislation shall include appropriate international convention/protocol/treaty commitments where applicable. The National Energy Policy shall also be considered.

The standards retained for each section of the EIA, including the hazard study; should be acceptable to the International Financial Institutions (IFI) such as the Inter-American Development Bank (IADB).

PROJECT ALTERNATIVES

Examine alternatives to the project including the no-action alternative. The main reasons for choosing the site will be indicated, taking into account environmental effects. Also, different battery types including Lithium-Iron technology will be assessed to ensure that the most appropriate technology is specified.

DESCRIPTION OF THE ENVIRONMENT

A description of all aspects of the physical, biological and social environment likely to be significantly affected by the development will be provided.

Baseline data will include:

A. Physical

i. A description of the soil and geology, landscape and hydrology
ii. A detailed description of storm water run-off and drainage patterns.
iii. General climatic conditions for the area.
iv. Existing land use patterns in the area.
v. Existing visual characteristics and views of and from the site.
vi. Existing baseline noise at nearby receptors.
vii. Existing agricultural history, constraints, activities and management.
viii. Surrounding Infrastructure and required upgrades (potable water, power and any other requirements)

B. Biological

Based on initial assessments, low biodiversity and sensitive flora or fauna is expected to be found at the development site since it consists of active cane fields, tracks and sour grass patches.

The existing fields are regularly ploughed, sprayed with insecticides, weed killers and fertilisers, and the future finished project will be seeded with high-protein grass and is expected to support similar levels of biodiversity.

Although minimal biological impacts are expected, a flora and fauna baseline study for the development site is proposed. The Ecological inventory will determine:

- Description of habitats and species,
- The delineation of the area of environments and species (obstacles to movement, disturbances, disappearance or amputation or splitting of vital spaces ...),
- The ecological functionality of the various components of the natural environment present,
- Project sensitivity of species and environments,
- The evolutionary dynamics of natural habitats.

C. Social & Cultural

A Social Impact Assessment will be undertaken that includes questionnaires and community engagement. A representative sample of residents and commercial entities within a defined study area is to be interviewed (within 1km of site boundaries). In addition to identifying any potential concerns, this baseline data - including current and expected trends – is to be used as the basis against which the potential benefits and adverse effects are projected.

Cultural peculiarities, aspirations and attitudes will be explored together with an assessment of public perception of the proposed development. Potential impacts on the surrounding community as well as displaced activities (if any) will be explored. The historical significance of the area will be examined. Socio-economic data will be collected where possible.

POTENTIAL IMPACTS TO BE STUDIED

A description of all likely significant effects of the development on the environment will be provided, which should cover the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the development, resulting from:

- The existence of the development;
- The use of natural resources; and
- The emission of potential pollutants, the creation of nuisances and the elimination of waste, and the description by the applicant of the forecasting methods used to assess the effects on the environment.

Analyses should result in a projection of the significant issues, i.e., the potential benefits as well as the adverse impacts. These issues are to be characterized to determine factors, including, but not limited to, duration, magnitude, timing, extent and location. Estimations of the significance of these issues are to be made against established legal standards, as well as levels of public concern. An evaluation is also to be done of the significance of any residual impacts. The potential benefits or adverse effects are to be evaluated and prioritized to focus on the information that is critical for decision making.

For all potential impacts identified below the associated mitigation measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment will be presented.

The study area will be defined as a 1km offset from the boundary of the site unless otherwise stated.

The following assessments are deemed relevant to the proposed development and shall exhaustively studied:

- **Land Use Impacts:**
  - A land use policy review will be included, and the suitability of the proposal will be investigated while taking into account surrounding land uses including the existing residential properties located near to the site;
  - The social and economic impacts of utilising the land for electricity generation will be assessed.

- **Social Impacts:**
  - Impact on the adjoining uses and residential settlements will be assessed;
  - Potential impacts, both positive and negative, as perceived by both the consultants and nearby residents and businesses will be documented via questionnaire surveys;
  - One public meeting will be held on the completion of the study once the EIA has been reviewed by the agencies and the CTP has confirmed in writing that it can proceed. The EIA Report will be made available for viewing by the general public for a minimum

of 28 days prior to the public meeting. A Public Meeting Report will be prepared and submitted to the CTP on conclusion of the meeting.

- **Visual Impacts:**
  - The change in the aesthetic of the concerned area shall be assessed
  - The visual impact of the proposal on its surroundings will be assessed from various vantage points and sensitive receptors in the vicinity of the site;
  - Photographic techniques will be used to demonstrate the significance of any potential visual impacts.
  - Mitigation measures will be recommended for any identified potential impacts.

- **Reflection (Glint & Glare) Impacts:**
  - Glint and glare impacts to nearby sensitive receptors will be investigated using computer modelling software. Levels of significance will be analysed.
  - Lighting options will be assessed and presented.
  - Mitigation measures will be recommended for any identified potential impacts.

- **Ecological Impacts:**
  - Baseline study will be performed as described in previous section.
  - Proposed mitigation measures will consist of avoidance measures in areas of ecological interest or areas with protected species, and impact reduction measures which allow the project design to change in order to better accommodate any biological concerns.

- **Agricultural Impacts:**
  - Baseline study will be performed as described in previous section, with soil classes, characteristics and agricultural policies outlined.
  - An assessment of viability (including capital investment and farm economics) of the site and how the proposed development might impact the surrounding community shall be done;
  - Description of impacts on existing and future agricultural operations, water usage, character and fragmentation (if any) shall be presented.
  - Waste management will be assessed for construction, operational and decommissioning stages of the project;
  - Mitigation measures will be recommended for any identified potential impacts.

- **Noise Impacts:**
  - Information from manufacturers will be used to describe the equipment noise signatures.
  - Noise generation levels will be estimated from all significant equipment including hydrogen compressors, battery enclosures, transformers and control equipment.
  - Generated noise levels will be compared with ambient baseline levels and applicable recommended day-time and night-time noise limits in order to determine the significance of impacts on surrounding receptors.
  - Mitigation measures will be recommended for any identified potential impacts.

- **Storm Water Drainage:**
  - Rainwater catchments responsible for runoff onto and through the site shall be mapped.

- Hydrological analyses focused on storm events with a 1 in 25-yr. return period, potential drainage impacts to the proposed developments and any downstream receptors shall be done.
- Hydrological analyses taking into plant water use demand, irrigation demands and demands for sheep farming shall be taken into consideration in sizing a rainwater harvesting pond for the site. An objective of the pond sizing exercise will be to reduce the demand for potable water from the public mains.
- Site-specific drainage solutions will be proposed along with measures to mitigate any identified impacts.
- Mitigation measures will be recommended for any identified potential impacts.

- **Hydrogeological Impacts:**
  - Potential impact of rainwater harvesting on groundwater recharge in the groundwater unit within which the site lies shall be investigated. Measures to mitigate any impacts shall be recommended
  - Potential impacts to groundwater quality due to the facility's operation - PV, hydrogen storage, battery usage etc. shall be examined. Potential groundwater quality impacts due to remaining agricultural practices including sheep farming shall also be assessed.
  - Mitigation and monitoring will be recommended as needed.

- **Potable Water Impacts:**
  - Impacts on the existing BWA infrastructure will be investigated. Taking into consideration the net potable water requirement of the facility, there shall be consultation with the BWA to determine the current supply capability and existing distribution infrastructure.
  - Infrastructure upgrades required to enable the supply of potable water to the site shall be determined. The potential environment impact of the upgrades shall be assessed and the cost of upgrades investigated. It is expected that a financial or other arrangement will be reached between parties to enable an adequate supply of water to the facility.
  - Mitigation measures and preferred potential upgrades will be presented.

- **Waste disposal Impacts:**
  - The sources and quantities of solid and liquid waste streams will be presented
  - Measures proposed by the Developer to dispose of all solid and liquid wastes shall be presented. Recommendation where necessary to improve the environmental performance of disposal measures shall be given.
  - Potential Impacts shall be identified, and mitigation measures proposed as needed.

- **Construction, Site Management and End-of-Life:**
  - Impacts due to construction activities will be investigated, and mitigation measures will be proposed together with a Construction Management Plan.
  - End-of-life site remediation and equipment replacement options will be discussed.

- **Energy Production & Potential Benefits**
  - Energy-related impacts resulting from the proposal will be Presented and assessed.
  - Positive national economic and long-term environmental benefits expected from the proposal shall be presented in this section of the EIA

HAZARD STUDY

Using internationally accepted codes and standards, the hazard study will present a Detailed Risk Analysis that will assess the inherent hazards of the project.

These are the worst-case and most critical risks that the proposed installation can expose to the environment and third parties, either directly or indirectly. These include but (are not limited to) hydrogen leakages, explosions, fires, chemical spills, natural hazards and other emergency situations.

We will also discuss measures to reduce the likelihood and impact, in relation to the magnitude of the risks posed by the facility.

Based on each of the factors taken into account (materials, processes, equipment, fluids, personnel, environment), the study will include:

- An identification and characterization of potential hazards;
- An estimation of the consequences of these potential hazards;
- A risk analysis, identification of major accident scenarios;
- An assessment of the consequences of dangerous phenomena, taking into account the effectiveness of internal preventive and protective measures;
- The description of the method of calculation used;
- A description of the means of prevention, protection and intervention;

Safety setbacks and hazard zones will be justified and established based on the results. Additionally, any recommended fire-fighting requirements and infrastructure will be proposed.

ENVIRONMENTAL MANAGEMENT AND MONITORING

An Environmental Management Plan (EMP) to mitigate any negative impacts will be included, and the applicant will propose realistic, feasible and cost-effective measures to avoid, reduce, mitigate or remedy impacts identified to acceptable levels. These measures will aim to satisfy local environmental, health and safety standards/regulations/guidelines/policies and where these are not available, internationally accepted standards/guidelines should be used.

Appropriate mitigation measures are to be recommended to enhance the social and economic benefits, and to avoid, minimize or remedy adverse impacts. These measures are to be designed to ensure that residual impacts remain within acceptable levels.

An impact management framework is to be developed to provide guidance on the monitoring requirements and indicators. This framework must indicate the agencies/stakeholders responsible for monitoring, the schedule of required actions, and contingency measures for greater than expected impacts.

Additional consideration will be given to environmental concerns from the use of hydrogen manufacturing, hydrogen storage and utility-scale batteries including disposal, recycling and fire/explosion mitigation.

Impacts will be categorised and illustrated in matrix form and a Mitigation Management Plan (MMP) will be formulated. The MMP should be prepared in the form of a framework management plan for the development to comprehensively manage existing health, safety and environmental issues as well as expected impacts as a result of the proposed project.

The MMP should be formulated in a manner which clearly sets out the various phases of activity e.g. site preparation, pre-construction, construction and operation etc. Finally, the cost of implementing and maintaining the MMP will be considered.

EMERGENCY (DISASTER) MANAGEMENT PLAN

An Emergency Management Plan will be prepared to identify all recommended procedures and protocols to be carried out in the event of a natural, accidental or man-made disaster at the facility. These will include protocols for explosions, fire, spills, hurricanes, etc.

CONSTRUCTION MANAGEMENT PLAN

The purpose of a Construction Management plan is to outline the approach to be taken for managing construction works. A comprehensive description of expected activities, techniques, laydown yard location, hours of operation and time-frames for different phases will be presented.

The statement ensures that possible impacts that may arise from the works have been appropriately identified, managed and minimised. The impacts addressed include construction-related noise, vibrations, dust, storm-water run-off, safety, traffic flows and any other relevant matters.

DEFICIENCIES AND CHALLENGES

An indication of any difficulties (technical deficiencies or lack of know-how) encountered (if any) by the applicant in compiling the required information will be provided.

THE EIA REPORT

The EIA report will be clear, concise and limited to significant environmental issues. The main text will focus on findings, conclusions and recommended actions, supported by summaries of data collected and analysed and citations for any references used in their interpretation. The report should include an appendix with items such as maps, site plans, the study team, photographs and other relevant information. The following EIA format (or similar) is proposed:

Introductory Section

- Executive Summary
- Table of Contents
- List of Figures and tables
- Glossary of terms/abbreviations/acronyms

Main Report

- Introduction
  - Project Introduction
  - Regulatory Process
  - Analysis of Alternatives
- Policy, Legislative and Regulatory Framework
- Approach and Methodology
- Detailed Project Description
- Description of Existing Environment
- Valued Ecosystem Components (VECs)
- Environmental Impacts & Proposed Mitigation
  - Construction Impacts
  - Operation Impacts
  - Deficiencies & Challenges
- Social Impact Assessment & Mitigation
- Hazard Risk Assessment & Mitigation
- Cumulative Effects Assessment
- Monitoring and Management Plans
  - Construction Management Plan
  - Environmental Management Plan
  - Emergency (Disaster) Management Plan
- Conclusions & Recommendations
  - Summary of Mitigation Measures
  - Final Conclusions
- List of References

Appendices

- Terms of Reference
- List of author/s who prepared the Environmental Impact Assessment
- Survey Questionnaires (Sample Copy)
- Schematic drawings, site plans, elevations, photographs, etc.

- Detailed Baseline Data, Analysis, Calculations and Reports
- Inter-Agency, Public and any other involvement

NOTE: **All pages are to be numbered and one convention of units is to be used consistently, preferably the metric system.**

APPENDIX B

Drainage Assessment

Environmental Impact Assessment for Erection of a Solar Photovoltaic Energy Facility at Harrow Plantation, St. Philip.

Drainage Assessment

Prepared for:
Renewstable (Barbados) Inc
20 rue Jean Jaures
Lormont, France

Prepared by:
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St Michael, Barbados

Project Number: 128019054

February 25, 2022

Sign-off Sheet

This document entitled **Environmental Impact Assessment for Erection of a Solar Photovoltaic Energy Facility at Harrow Plantation, St. Philip.** was prepared by **Stantec Consulting Caribbean Ltd.** ("Stantec") for the account of Renewstable (Barbados) Inc (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Digitally signed by Jennings-Wray, Justin
Date: 2022.02.25 14:57:00 -04'00'

Prepared by ______________________________

(signature)

Justin Jennings-Wray, P. Eng.

Table of Contents

Stantec

1.0 INTRODUCTION

1.1 BACKGROUND

Renewstable (Barbados) Inc – hereafter termed the "Developer" – proposes the construction of a non-intermittent electrical power plant on lands located at Harrow, St. Philip, Barbados. The Photo Voltaic (PV) array will provide power during daylight hours, with other processes including the use of hydrogen as a fuel in a generator and batteries providing power during night hours.

An application was made to the Town & Country Development Planning Office (TCDPO) for permission to develop the proposed project. The TCDPO application requires an Environmental Impact Assessment (EIA)to support the evaluation of the application. The Environmental Impact Assessment includes, among other items, the preparation of a drainage assessment – focussed on the impact of the development on baseline drainage conditions; in particular, the potential for flooding of the development site and areas downstream of the site in the event of prolonged and intense rainfall.

This report presents the findings of the drainage assessment for the EIA.

1.2 PROPOSED DEVELOPMENT

The proposed facility shall provide approximately 60,000 MWH/y of power. The facility shall consist of the following components:

- A 50 MWp ground-mounted photovoltaic array
- A 16 MWp electrolyser system
- Hydrogen storage of 90 MWh in gaseous form in pressurized cylinders
- A Battery Energy Storage System; 14 MW max power, 3 hours capacity
- A high-power fuel cell system with a capacity of 3MW
- Operation facilities and utilities; electrical room, water treatment, water supply, etc.
- A black-belly sheep farming facility, including fodder pasture and pens

The project area slated for development occupies a total footprint of 734,000m^2 (181.38 acres). Sheep farming facilities – pens, storage, and fodder pastures – shall utilize the North easternmost sections of the development. Office buildings and general storage are proposed to the immediate Southwest of the sheep pens; the balance of the development towards the Southwest shall be occupied by the PV array system. Centrally located within the array shall be the HYPCE facility, housing the electrolyser system, battery banks, hydrogen storage, water treatment plant, and fire suppression systems.

The 73.4 ha greenfield site will require infrastructure works to receive the PV panels, their support system, and the other facility components. Site infrastructure shall include the construction of a 5m wide paved entrance road; a 4m internal service road – traversing panel perimeter and in between rows of panels - will enable access to the various facility components to facilitate maintenance. The site shall be enclosed within a security fence.

While the site's topography is not proposed for significant modification, it is expected that the finished surface will be graded and planted with a native grass to control erosion of the surface soil. Sheep will be deployed within the array portion of the site to control the growth of native grasses around and under the elevated PV panels- all to preserve the existing agricultural land use designation of the site.

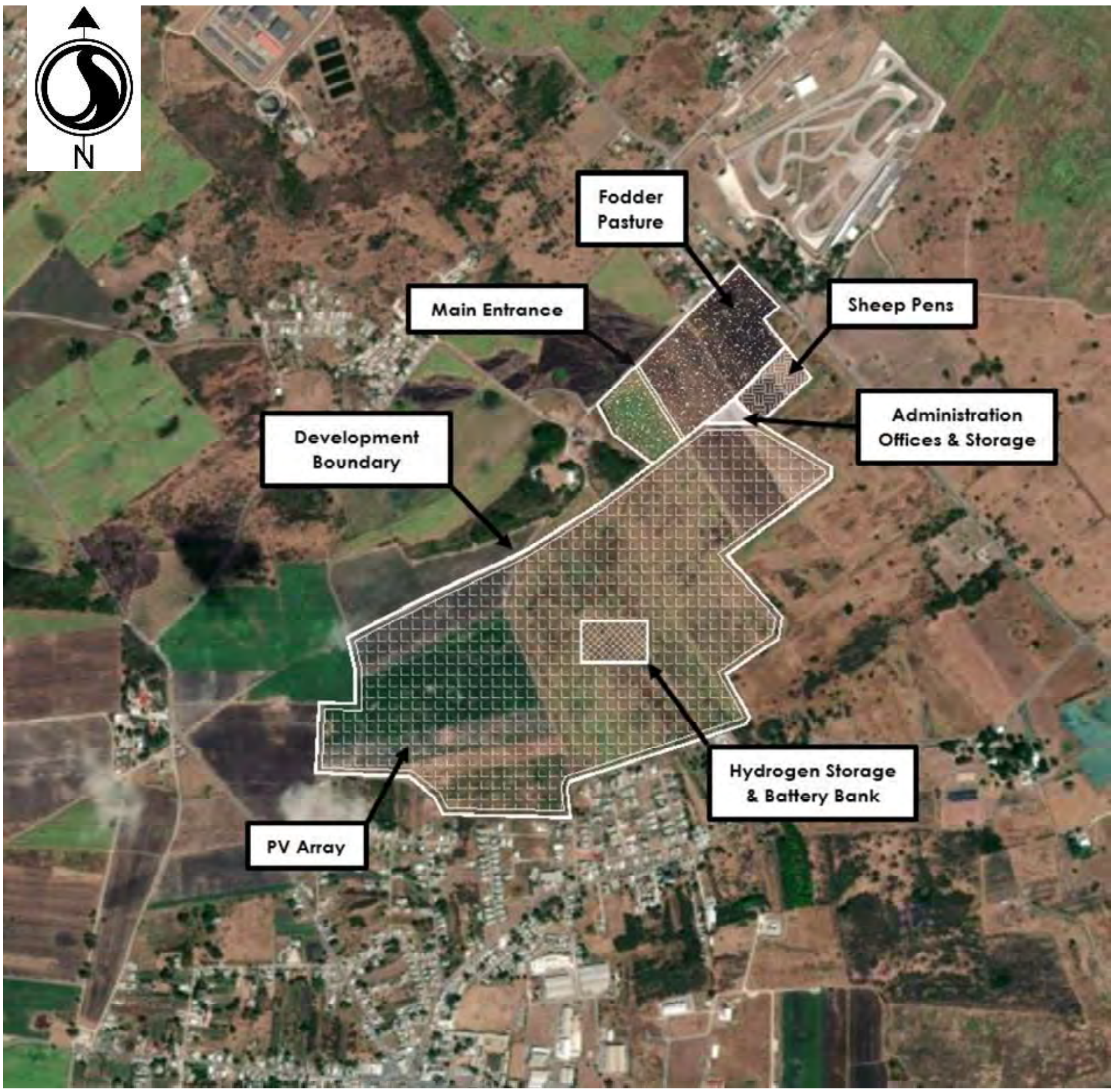

Figure 1 – Harrow Facility Simplified Layout

1.3 PERTINENT LEGISLATION

CAP 283: Underground Water Control Act. This Act makes provision for the establishment of a Water Board and the granting of licenses for abstraction of ground water. The Act also prescribes against contamination of groundwater sources. The Barbados Water Authority (BWA), established under the **Barbados Water Authority Act, CAP.274A**, 1980, through its Board of Directors, has assumed the role of the Water Board. The BWA has been mandated to manage the island's water resources. One effective management policy is the **National Groundwater Protection Zoning Policy**, 1963 (updated 2010), which delineates the island into 5 zones. Public supply wells are located in the most restricted Zone 1 areas (see development control zones below).

Table 1: Development Control Zones

Zone	Definition of Zone Boundary	Soak-away Pit Max. depth	Domestic Controls	Industrial Controls
1	300 day travel time	None allowed	No new housing or water connections, No change to existing wastewater disposal except BWA secures improvements.	No new industrial development.
2	600 day travel time	6.5m	Septic Tank + soak-away pit required, No storm runoff to soak-away pit, No new petrol or fuel oil tanks.	All liquid industrial waste to be disposed as specified by BWA. Max soak-away pit depths as for domestic waste.
3	5 – 6 Yrs travel time	13m	As above for domestic wastewater, petrol or fuel oil tanks to approved leak proof design.	As for Zone (2) above
4	Extends to all high land	No limit	No restrictions on domestic wastewater disposal. Petrol or fuel oil tanks to approved leak proof design.	As for Zone (2) above.
5	Coastline	No limit	No restrictions on domestic wastewater disposal. Siting of new fuel storage tanks subject to BWA approval.	As for Zone (2) above

1.4 GREEN PAPER FOR REVISED GROUNDWATER PROTECTION ZONING

Though not set in law currently, it is proposed that the groundwater protection zones – introduced above - be re-configured to boost groundwater water quality protection due to the presence of more recalcitrant persistent pollutants and also to release more lands in the current Zone 1 protection areas for development.

The 2020 Water Protection and Land use Zoning Policy – Green Paper[1] – produced by the Ministry of Energy and Water Resources, Government of Barbados, and the BWA states the following:

- The existing policy – over 50 years old – does not protect against persistent chemical pollutants.
- Proposed that the existing Zones 1 to 5 are replaced with Zones A to E, with Zone A termed a *strict exclusion zone* smaller than the existing Zone 1.
- Only agriculture Class Two will be permitted within Zone A; this type of agriculture includes *"horticulture, fruit growing, seed growing, use of lands for farmers markets, bursary grounds, woodland or forestry"*.
- Solar PV farms and wind farms – deemed to have low environmental impact – may also be allowed in Zone A areas under specific permitting conditions.

2.0 SITE CHARACTERISTICS

2.1 LOCATION AND ACCESS

The PV site is located at Harrow Plantation, St. Philip. Access to the site will be via Harrow Road, branching off Bushy Park Road to the East and Sunbury Road to the West. The site itself is situated on agricultural land, with the environs predominantly consisting of residential and agricultural land. Residential communities exist adjacent to the Northern and Southern project boundaries. Harrow Plantation Yard is located immediately North of the array – West of the sheep grazing area. A small community is located immediately North of the sheep fodder pasture, and a larger community – Marchfield Village – is located along much of the Southern boundary. A veterinary clinic is located at Sunbury Plantation some 400m West of the site. Bushy Park Raceway is located approximately 250m Northeast of the array and Bushy Park Cemetery approximately 300m to the Southeast.

[1] Tentative government consultation document of policy proposals for debate and discussion.

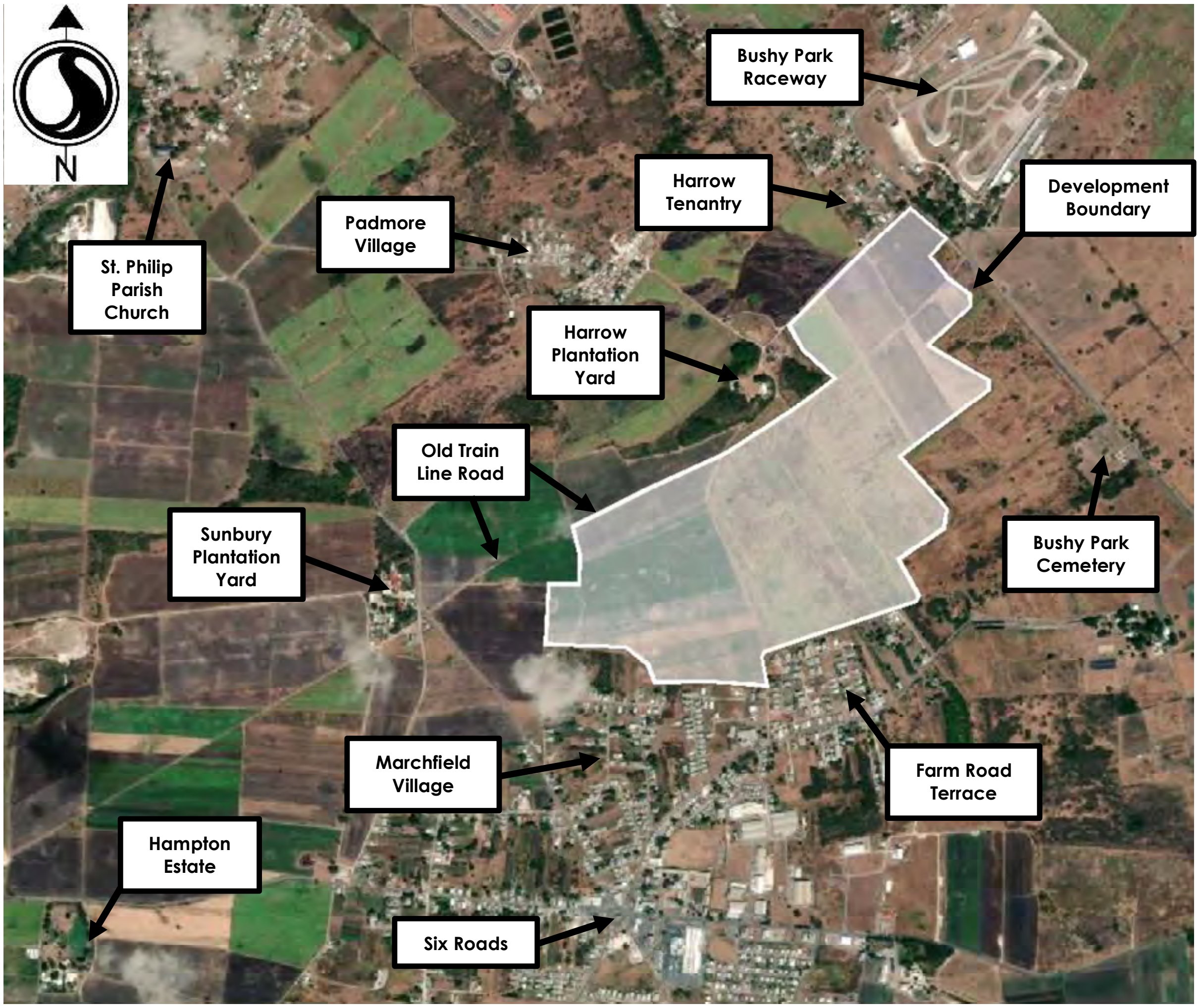

Figure 2 – Site Surroundings

2.2 TOPOGRAPHY

Information on site topography was obtained: via site reconnaissance; by reviewing 1:10000 and 1:5000 topographical mapping available from the Lands and Surveys Department of the Government of Barbados, and a higher resolution topographical survey of the site made available by the Developer.

- Along the site's northern boundary, adjacent to the Old Train line road, ground elevations range from 52m Above Mean Sea Level (AMSL) in the West to 56m in the East.
- Along the site's southern boundary, land elevations range from 46.0m AMSL in the West to 43m, 47.0m, and 48m going eastwards; at the eastern end of the southern boundary land elevations are in the region of 50m AMSL.

- In between northern and southern site boundaries, the land is relatively flat with site slopes from North to South in the region of 1.5%.
- There are several small *(compared to overall site area)* natural depressions – possibly past collapsed caves. Natural drainage watercourses lead to these depressed areas.

2.3 SOILS

The site is in the Coral Region of Barbados – characterised by shallow topsoil followed by limestone rock of significant depth. The site's surficial geology predominantly consists of a 'St. Philip Plain Association' soil cover layer – over 900mm in thickness (Vernon and Carrol, 1966). Southwestern sections of the site consist of a 'Grey-Brown Association' soil – under 450mm in thickness. A Coral Limestone rock layer underlies the site (30m-55m in depth); the deeper depth being towards the Southern site boundary. The limestone layer is underlain by the impermeable Oceanics layer – known to have a Westerly dip towards the sea and to be several hundred metres in depth (Poole & Barker, 1983).

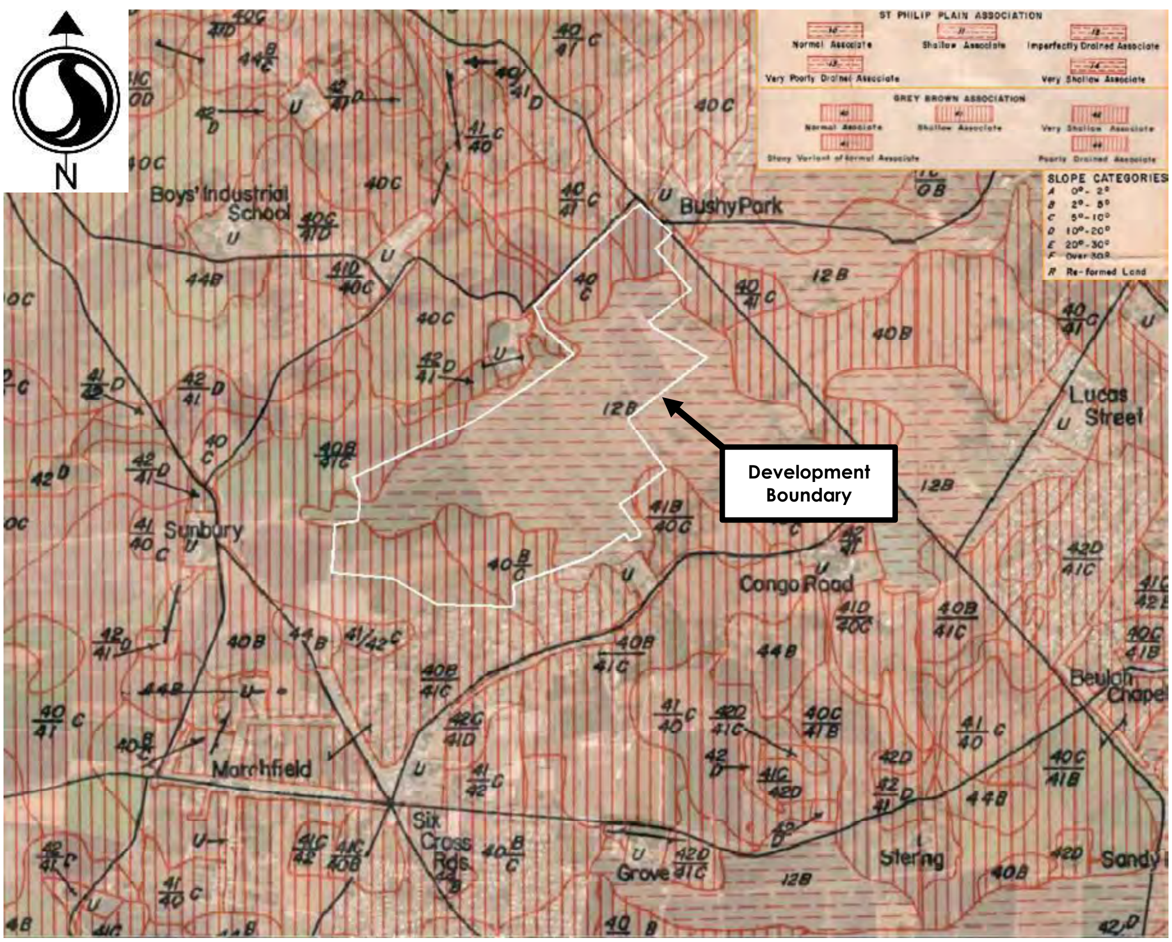

Figure 3 – Site Location on Soils Map (Vernon and Carrol, 1966)

The 'Grey Brown Association' soil layer is composed of approximately 65% clay, 10% sand, and 18% silt; the balance of the composition being calcium carbonate and moisture. The St. Philip Plain Association generally resembles the Grey-Brown Association however has a different parent material. Both soil covers are slated to have slow to moderate permeability.

The limestone rock layer has a very high effective porosity. This porosity coupled with the extensively cracked and fissured nature of the rock makes it an extremely permeable stratum. The permeable coral limestone rock and impermeable Oceanics geological structure – described above, collectively form an 'unconfined' aquifer through which groundwater flows.

2.4 GROUNDWATER

The level of the surface of the Oceanics layer with respect to mean sea level (MSL) defines whether groundwater in the unconfined aquifer exists as 'streamwater' or 'sheetwater'. Oceanic levels below mean sea level (BMSL) indicate that groundwater may exist as sheetwater, whilst levels above MSL indicate the possible existence of streamwater. Streamwater, found in the higher land elevations of Barbados, is defined as groundwater flowing at the interface of coral rock and the Oceanic clay layer towards the sea, after having percolated through overlying coral rock and its fissures. Sheetwater, found at lower elevations, is a thin layered reservoir of freshwater resting above saline water, in the coral rock medium, at the interface with the sea level.

Based on the *Geology of Barbados (Poole et Barker, 1983)* , the elevation of the Oceanics layer beneath the site ranges from approximately 35m AMSL in the Northeast to -15m AMSL in the South; consequently, groundwater beneath the development exists predominantly as streamwater, with some sheetwater present in Southern sections of the site. An examination of the Oceanic contours implies that groundwater flows are in a Southerly direction.

To validate the interpolated limestone-oceanic contouring included in the Geology of Barbados Map, a review of nearby water wells surveyed by Alfred Senn was conducted. *The Geological Investigations of the Groundwater Resources of Barbados (Senn, 1946)* includes physical surveys of water wells in the environs of the site. Well data within the report confirms depths to oceanics as previously described and indicates groundwater depths at the site in the region of 1.8m.

Table 2: Well Survey in Proximity of Site (Senn, 1946)

Location	Surface Elev.	Well Depth	Elev. of Base	Water Depth	Water Elev.	Approx. Interface Elev.	Aquifer Type
	(m AMSL)	(m)	(m AMSL)	(m)	(m AMSL)	(m AMSL)	
Sunbury	46.9	48.2	-1.2	1.2	0.0	< 0	*Sheetwater*
Harrow	**62.2**	**37.5**	**24.7**	**1.8**	**26.5**	**27**	**Streamwater**
Chapel	77.1	60.7	16.5	1.8	18.3	18	*Streamwater*
Marchfield	40.4	41.5	-1.1	1.1	0.0	< 0	*Sheetwater*
Summervale	102.4	68.9	33.5	0.6	34.1	34	*Streamwater*

Farm No. 1	43.6	41.8	1.8	0.0	-	-	-
Farm No. 2	37.2	34.1	3.1	0.0	-	-	-
Bushy Park #1	61.0	22.3	38.7	0.9	39.6	40	*Streamwater*
Fairfield	78.9	29.0	50.0	2.4	52.4	52	*Streamwater*

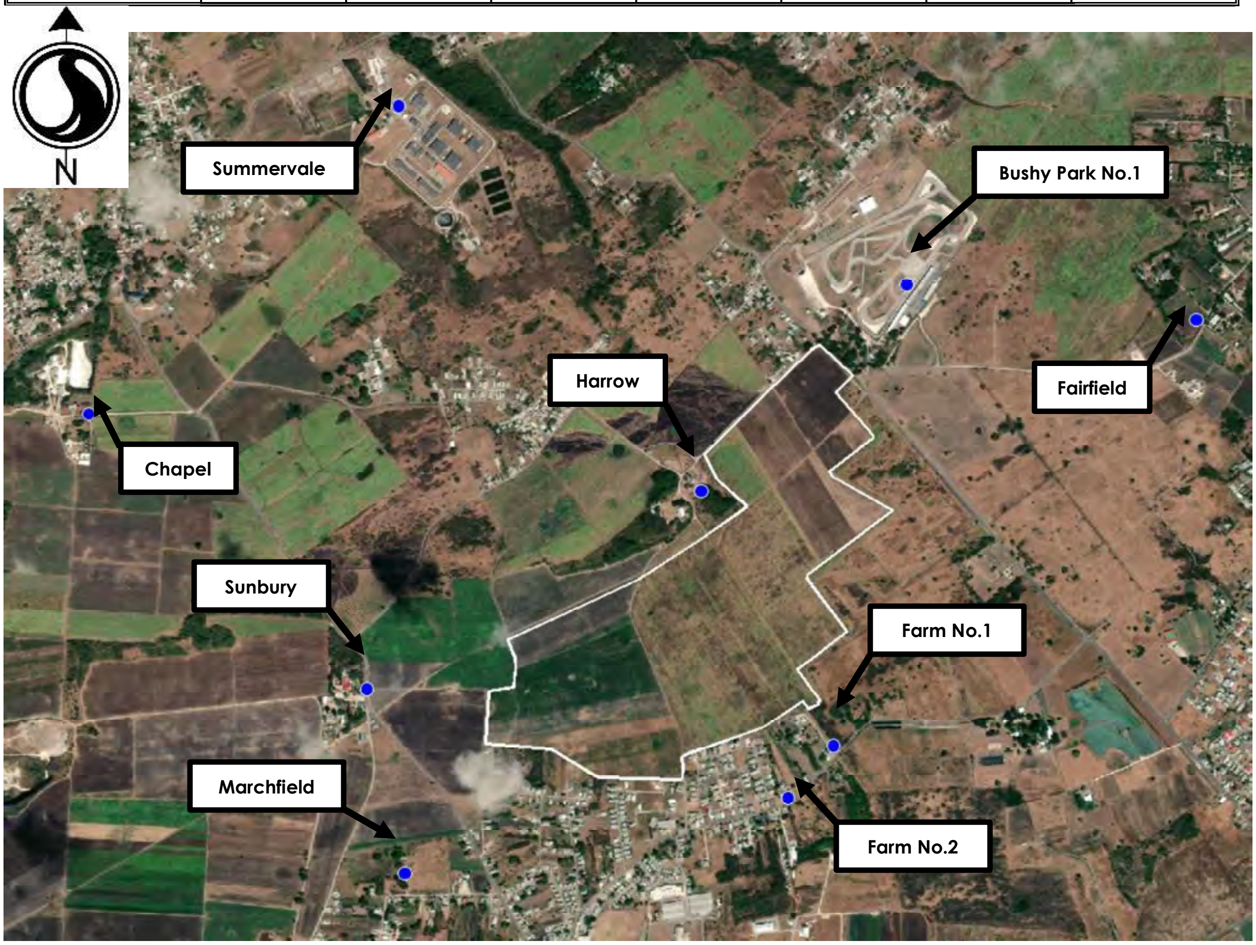

Figure 4 – Well Locations as per Senn, 1946

The site for development is located within a *Zone 3* groundwater protection zone per Barbados Water Authority Act, CAP.274A (See Figure 5).

When the revised zoning policy is made into law, the site will be in a *Zone D* groundwater protection zone (See Figure 6).

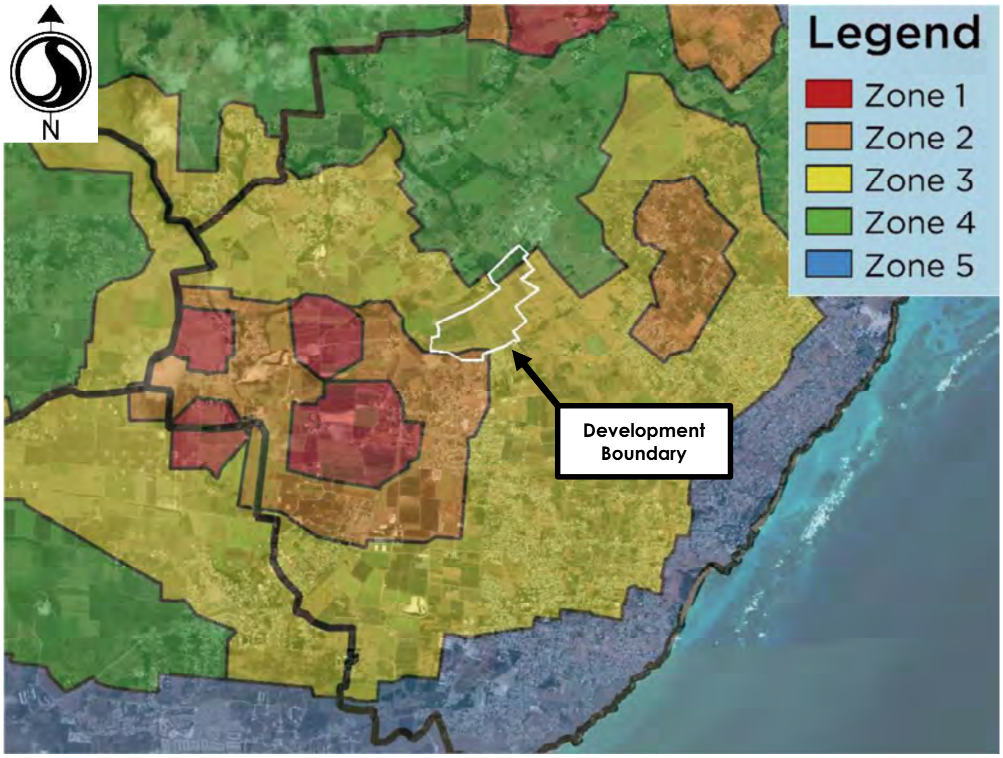

Figure 5 – BWA Groundwater Protection Zones

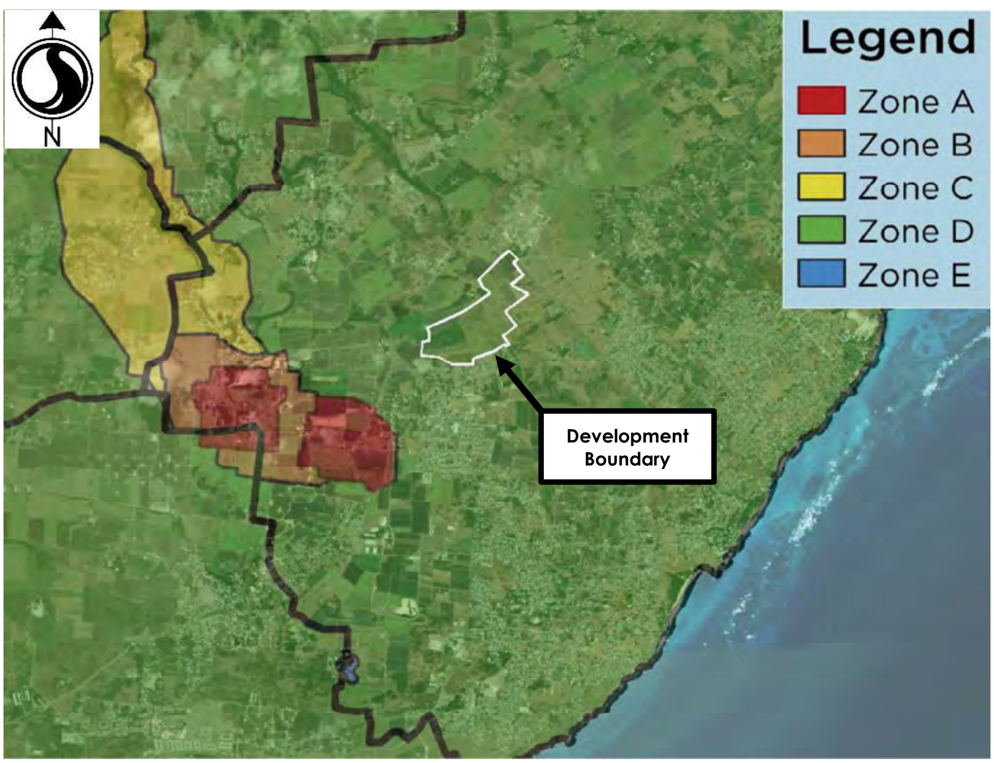

Figure 6 – Revised BWA Groundwater Protection Zones

3.0 DRAINAGE ASSESSMENT

3.1 RAINFALL & RUNOFF

'Rainfall Intensity-Duration-Frequency Maps for Barbados' as published by the Caribbean Meteorological Institute in 1972 provide excellent data on rainfall events of various duration and return periods. Based on rainfall records for the period 1887-1986, the average annual rainfall that can be expected across the site area is in the region of 1300mm/year.

The topography of an area defines the rainwater watershed within which rain falls and is converted to runoff. Runoff follows water paths from regions of higher elevation to regions of lower elevation. The rate at which stormwater leaves the several areas of a catchment and enters a main drainage (gully/watercourse) system is dependent on a number of factors: soil type, gradient, land use, rainfall intensity, losses and drainage channel characteristics. 'Losses' reduce the amount of surface runoff resultant from a rainfall event. The losses occur as primarily depression storage (water stored in localized surface depressions), interception (water trapped by tree leaves, vegetation etc), and infiltration (vertical flows towards groundwater zones). Impermeable surfaces within a catchment – roofs, roadways, hard pavements etc – prevent infiltration and promote the generation of runoff; generally, the higher the percentage of impermeable areas within a catchment, the greater the volumes of runoff.

3.2 EXISTING DRAINAGE

3.2.1 Site Environs

The lands to the North of the site have higher elevations than lands on the development site; lands to the South of the site have lower elevations than those on site. The net result is runoff from rainfall flows from lands to the North onto the site; this runoff combines with runoff generated from rainfall directly on the site resulting in cumulative runoff than discharges South of the site to the adjacent community and towards the town of Six Roads. Given the highly vegetated nature of both the North watershed and the catchment on site – hereafter termed the South watershed, significant interception and depression storage are expected to occur, with infiltration and percolation of captured runoff to groundwater zones.

The North watershed resulting in runoff towards the site is quite large extending from the site's northern boundary in a north westerly direction to the general vicinity of Guinea, Victoria, and Colleton plantations. The watershed contains several catchments and drainage watercourses that lead in some instances to natural depressions, which are commonplace throughout the watershed; these depressions help to promote depression storage and the percolation of captured water to groundwater zones attenuating or lessening the amount of runoff that is conveyed to the site. Via scrutiny of the 1:10000 topographical map of the area, the North watershed has 29 infiltration wells (suckwells) within its boundary. The watershed is depicted in Figure 3.0 below. The hydrological characteristics of the catchment are depicted in Table 1.

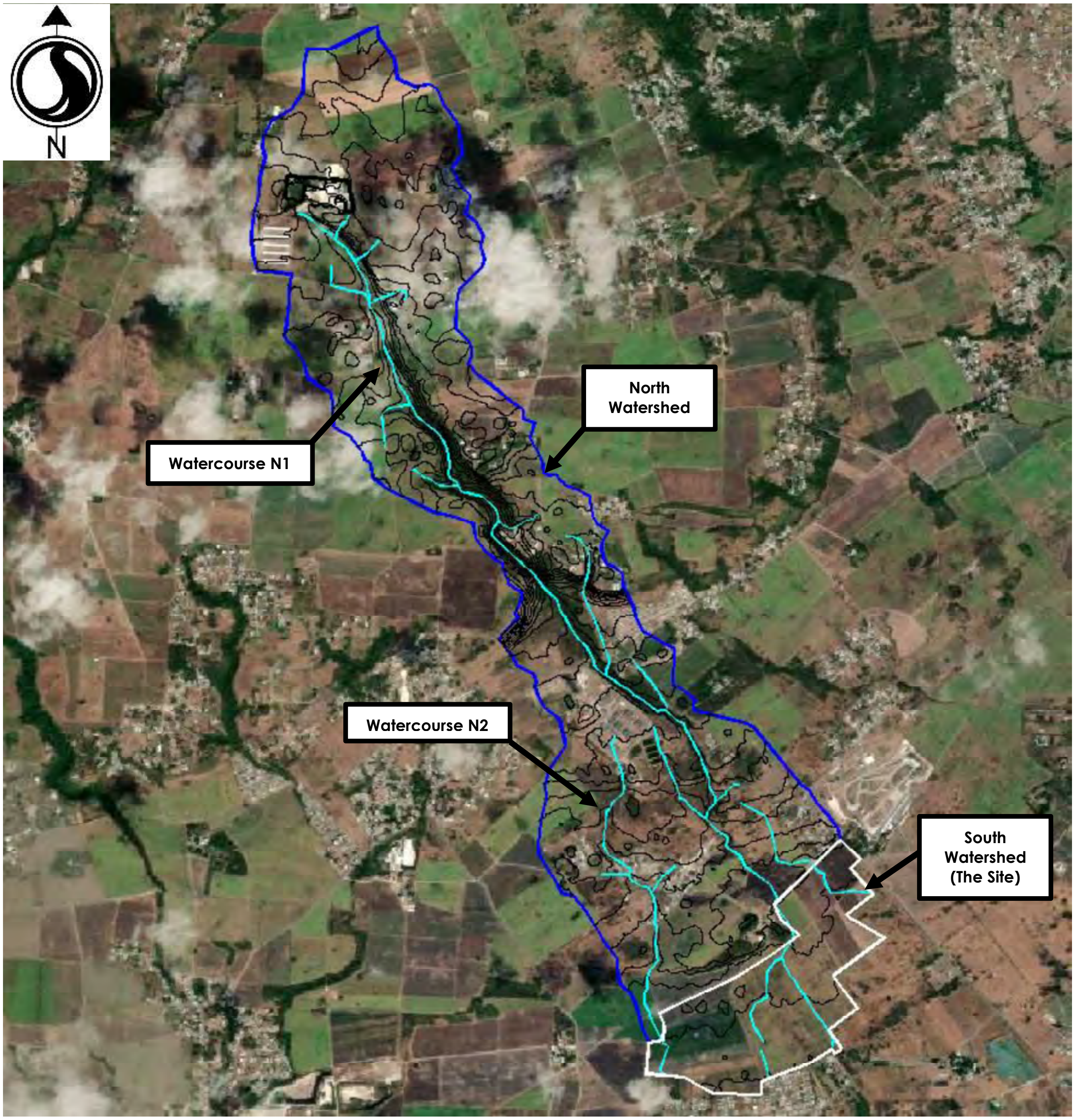

Figure 7 – Watersheds Under Study

Table 3: Hydrological Characteristics of North Watershed

Description	Parameter
Watershed Area	474.22 Ha
Vegetation Area (grass)	457.62Ha
Impermeable Area (roads, pavements, buildings etc)	16.6Ha
Longest drainage path	4.74km
Average slope of longest watercourse	2.53%
Average Annual Rainfall	1300mm

Though there are several sub-catchments with associated watercourses within the North watershed, there are two prominent watercourses that traverse significant distances within the watershed in northern to southern directions; these watercourses – termed watercourse #N1 and #N2 – are highlighted in Figure 7.0 above. Both watercourses result in runoff entering the site.

The Old Train Line road – an unpaved "cart" road - effectively represents the southern boundary of the North watershed; this road generally slopes with reducing elevation in a westerly direction implying that any captured runoff could be conveyed in westerly directions away from the site. However, there are several points where sags in the road direct runoff captured from the North watershed onto the site.

South of the site are the densely populated residential/commercial areas of Farm Garden and Marchfield Village. An examination of contour information in that area – further confirmed by field reconnaissance – reveals that there is a drainage watercourse that follows a north to south roadway through the village and which further traverses in a southward direction through the Six Roads Industrial Park and the Six Roads town centre. There have been instances in the past where prolonged and intense rainfall has resulted in runoff from the North and South watersheds flowing to the mentioned areas to the South of the site causing flooding. Several years ago a cannery within the industrial park was completely flooded causing equipment damage during a prolonged rainfall event. Field reconnaissance of this area revealed the construction of culverts and several infiltration wells as means to improve drainage within this southern zone.

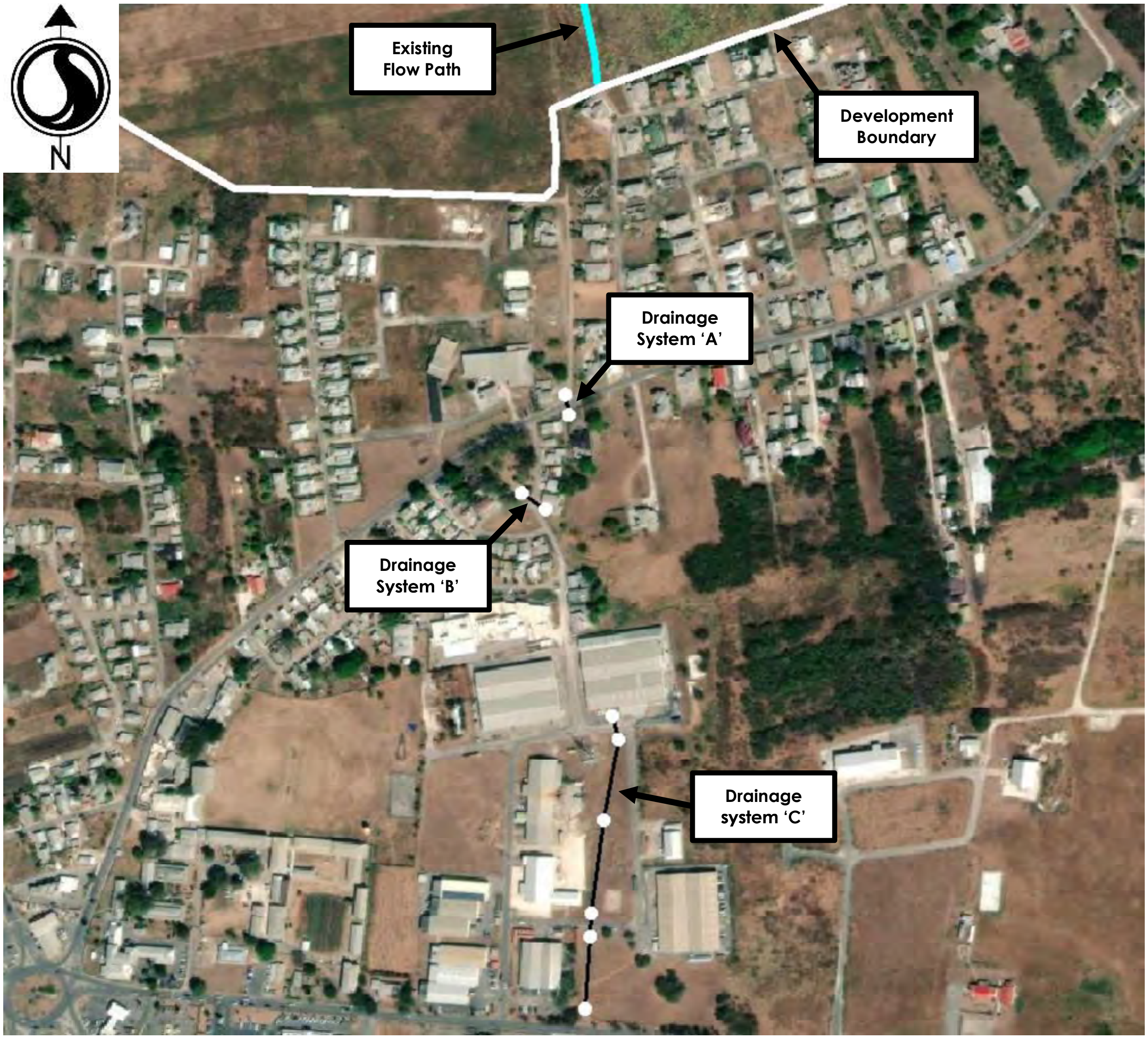

Figure 8 – Schematic Showing Existing Drainage Systems Downstream of the Site

- Drainage System 'A' – A simple catch basin connected to a roadway culvert directing flow from the North side of the road to a suckwell on the South side of the road
- Drainage System 'B' – A simple roadway culvert directing flow from a small park on the Northwest side of the road to a suckwell on the Southeast side of the road
- Drainage System 'C' – A series of suckwells, culverts, and weirs positioned along a grassy swale directing flow from industrial warehouses in the North towards Highway 5 in the South. The weirs promote the ponding of runoff upstream improving stormwater entry conditions to the upstream suckwell.

Figure 9 – Drainage System 'A'

Figure 10 – Drainage System 'A'

Figure 11 – Drainage System 'B'

Figure 12 – Drainage System 'C'

Figure 13 – Drainage System 'C'

Figure 14 – Drainage System 'C'

3.2.2 The Site

The site for development is relatively flat and when under agriculture totally vegetated. In addition to runoff from the North watershed, the site itself also forms a rainwater catchment (South watershed) onto which runoff is generated when rain falls. There are 23 infiltration wells on site to augment surface water drainage.

Drainage of runoff on site is predominantly via overland flows in a Southward direction with infiltration and percolation of runoff to groundwater zones. The furrows and rows of cultivated lands aid in retarding runoff and promoting infiltration. The several infiltration wells on site also promote the drainage of captured runoff to groundwater zones.

There are five (5) well defined drainage paths/watercourses within the site – these are labelled watercourses A to E in Figure 15 below. Four (4) watercourses are connected to upstream watercourses within the Northern watershed introduced above. Watercourse 'C' originates within the site and possibly connects to watercourse 'B' during significant rainfall events. Watercourses B, D, and E terminate within existing natural depressions within in the site; watercourses A and C extend past the southern site boundary. The existing watercourses that channel runoff to natural depressions promote the storage and percolation of runoff to groundwater zones; those watercourses that pass through the site convey captured runoff downstream of the site.

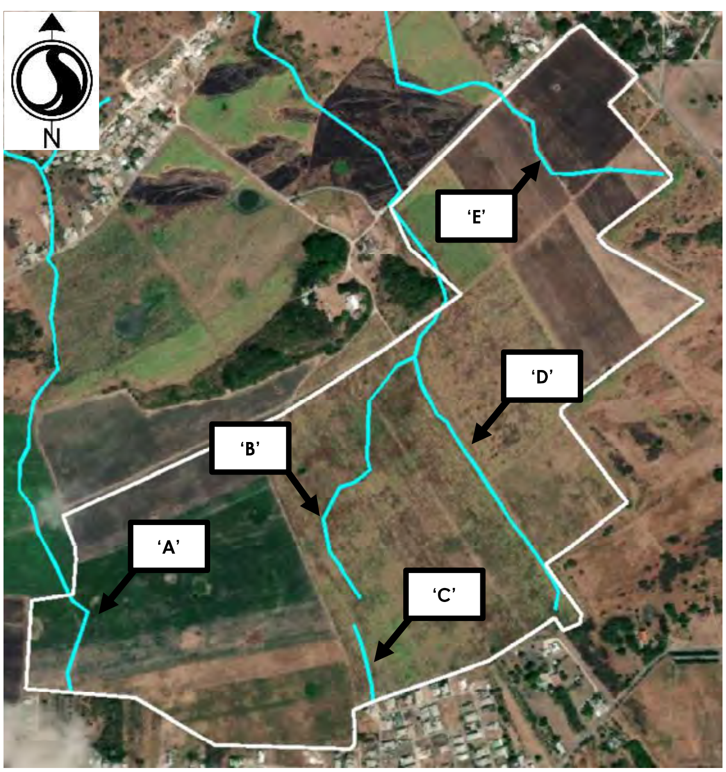

Figure 15 – Existing Flow Paths Within the Site

Table 4: Hydrological Characteristics of South Watershed

Description	Parameter
Watershed Area	73.00 ha
Vegetation Area (grass)	69.44 ha
Impermeable Area (roads, pavements, buildings etc)	3.64 ha
Longest drainage path	1.1km
Average slope of longest watercourse	1.37%
Average Annual Rainfall	1300mm

During a prolonged rainfall event, runoff enters the site from the North watershed predominately following the natural watercourses within the watershed and those introduced above within the site. Rainfall onto the lands of the site also adds to the volume of runoff on site. Some watercourses on site direct runoff to natural depressions. The 23# infiltration wells/suckwells on site assist with draining surface runoff. When depressions are filled runoff overflows the banks of the depressions and flows southwards predominantly via overland flow. As the site becomes flooded the roadways/cart paths within the site become watercourses conveying runoff in southwards directions towards the site's boundary. Once the site is flooded and suckwells are at their drainage capacity runoff effectively passes through the site to downstream areas.

3.3 PROPOSED DRAINAGE SYSTEM

3.3.1 Site Infrastructure

It is understood that the existing site grades will generally be retained as well as the existing watercourses and depressions. The PV panels will be mounted and supported above grade on a network of steel frames anchored to the ground. The PV panels will be installed in rows with adequate space between rows for maintenance access – there will be roads in between banks of panels and along the perimeter to provide access for servicing. The administration area of the facility at the north-eastern end of the site and the centrally located hydrogen and battery storage area will introduce impermeable services that will generate runoff when it rains.

It is understood that the portion of the development site on which panels shall be installed will be provided with a cover of native grass – under and between the rows of panels. This grass cover will retard the rate of runoff, control erosion and transport of sediment/topsoil off the site.

Paved roadways within the site shall consist of kerb and slipper drains, with sets of catchbasins with gully grates to drain captured runoff to culverts leading to suckwells. Paved areas within the administration and the hydrogen and battery storage area shall be drained by a system of catchment basins, drainpipes and suckwells. The intent of the use of suckwells is to promote on site drainage of runoff to groundwater rather than to natural drainage courses that convey runoff South and off site.

Where possible the existing 23# suckwells shall be retained. Also, to be retained are the seven existing dry ponds, each of which are proposed as drainage reserves. A nine (9)m wide drainage reserve along the entire Southern boundary of the site is also proposed. The Developer proposes the construction of a runoff interceptor drainage system along the site's Southern boundary; this may consist of an earthen swale with sloped embankments or infiltration trench with vertical side faces – within the mentioned reserve. The drain shall capture, attenuate, and promote the infiltration of runoff. Suckwells/infiltration wells may be added to the interceptor drain to boost the sub-surface drainage of captured rainwater. The final selection of type of interceptor drainage system – swale vs infiltration trench - shall be the subject of a detailed drainage design effort by the Developer.

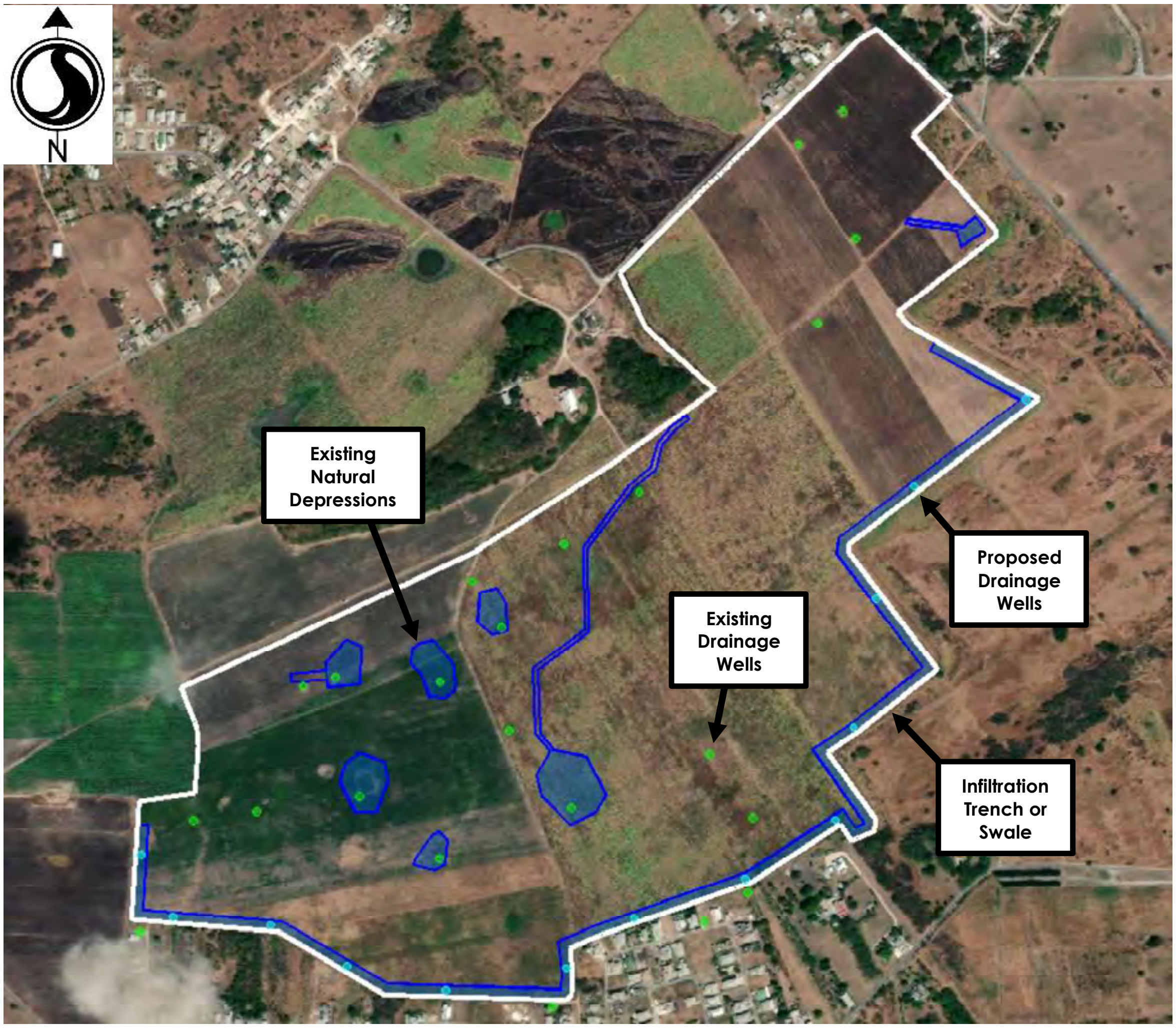

Figure 16 – Proposed Drainage System

4.0 DRAINAGE ANALYSES

4.1 HYDRAULIC RESPONSE OF PV SOLAR FARMS

PV solar panels are impervious to rainfall; however, they are generally mounted on a steel support framework above the permeable land formation. The study (Cook et. al., 2013) investigated the hydrologic effects of solar farms and examined whether or not stormwater management is needed to control runoff volumes and rates – post the development of a farm. During the study a model of a solar farm was created for simulating runoff conditions for pre and post PV panelled conditions. The study conducted sensitivity analyses taking into consideration varying conditions including changing the storm duration and volume, soil type, ground slope, panel angle, and ground cover; all towards determining the effect that each of these factors would have on the volumes and peak discharge rates of the runoff.

The study concluded the following:

- The addition of solar PV panels over a grassy field does not have much of an effect on the volume of runoff, the peak discharge nor the time to peak; given that lands beneath the panels are permeable.
- However, when land cover type is changed under the panels – such as the use of gravel or a hard pavement – (and the space between is patchy ground or bare), the peak discharge in the model increased by 100%
- The kinetic energy of water draining from a solar panel is 10 times greater than rainfall resulting in the possibility that soil below panels could erode due to concentrated flow of water off the panel; a scenario which is heightened if there is bare earth and/or the panels are sloping in two directions.

The study (Cook et. al., 2013) ultimately recommended that a grass covered soil beneath panels and in the pathway/space between panels be consistent and well maintained. Where use of gravel and hard pavements underneath and between panels is unavoidable, the study recommended the use of a vegetated buffer strip at the downstream site boundary - to control excess runoff and ensure adequate losses.

4.2 MODELLING STORMWATER RUNOFF

The Soil Conservation Service (SCS) Synthetic Unit Hydrograph (UH) method {Soil Conservation Service: Technical Release Number 55 (TR-55), 1986} was used to estimate peak runoff flows (Qp) from the development site. Peak flow from 24 hour duration storms from the watershed were estimated for the following design storm return periods - 1:20yr and 1:50yr.

The Time of Concentration Tc - the time it takes for water from the furthest reaches of a catchment to appear at a watercourse's mouth – is integral for the calculation of peak flows by the SCS UH method. The "Lag/CN" and "Upland" methods (HydroCAD Technical Reference, 2001) were used to calculate the Tc of the watershed. The longest flow path within watersheds – crucial for the determination of Times of Concentrations - was determined using topographical mapping for the site and the North watershed.

Depths of rainfall for each extreme storm and duration were obtained from extreme precipitation (isoline) maps from appendices to the 1996 Stormwater Drainage Study for Barbados (Cummings Cockburn et. al, 1996). One in twenty year (1:20Yr) and1:50 Yr data were obtained from the precipitation maps in the appendices of the study. Isoline maps created as part of the 1996 Barbados Stormwater Drainage Study utilised additional rainfall data recorded between 1971 and 1996. These data, in addition to those collected prior to 1971 (Lirious, 1972), were found to be statistically adequate for extreme value analysis. The results of the analysis were utilised to ultimately produce updated Intensity Duration Frequency (IDF) isoline maps for Barbados. The 1996-Drainage Study states that the new maps are a vast improvement upon the previous maps.

Curve Numbers (CNs) indicate the fraction of rainfall depth that may occur as runoff; they are a function of the type of soil and ground cover. The CN for a particular sub-catchment is dependent on the percentage areas of permeable, semi-permeable and impermeable areas within the catchment. A composite CN value for each catchment was calculated on the basis of the aforementioned percentage areas. The CN is also utilized in the SCS UH method to determine peak runoff.

Hydraulic and hydrological analyses were executed using HydroCAD, the computer modelling software.

4.3 BASELINE STORMFLOWS

4.3.1 Assumptions

The following were assumed in the calculation of baseline stormflows from the North watershed and South watershed (the site):

- Suckwells identified via topographical mapping and those on site have average dimensions of 1.8m diameter x 12m deep with a corresponding exfiltration rate[2] of 0.0339m^3/sec. Suckwells were modelled as an exfiltration outlet device within HydroCAD.
- The storage provided by the several small localised depressions within the North and South watersheds were ignored due to their small size relative to the watersheds. It is expected that during prolonged rainfall that they will fill quickly resulting in the overflow of runoff.
- Old train line road was modelled as a broad crested weir outlet structure with a crest width of 6m and a length of 1km (maximum allowed within HydroCAD); the elevation of the road was set at 55m AMSL.
- The southern boundary of the site was also modelled as a broad crested weir outlet to a maximum length of 1km with a crest width of 6m.

4.3.2 Additional hydrological characteristics & HydroCAD results

Additional hydrological characteristics entered in HydroCAD for both watersheds are as follows. Also included in table are the resultant estimated baseline peak flows due to 1:20 and 1:50yr 24hr duration design storms; HydroCAD calculations are shown in Appendix A.

[2] Based on exfiltration rate of 0.5 L/s per m2 of wetted area (Stantec, 2002)

Table 5: Additional Hydrological Characteristics (Baseline Scenario)

Hydrological Characteristic	North WS	South WS
Average Land Slope	9.69%	3.27%
Curve Number (CN)	62.29	61.00
Time of Concentration (T_c)	149 mins	64mins
Inflow Loss due to suckwells	0.983 m^3/sec	0.78 m^3/sec
Type II 24 Hr Rainfall: 1:20Yr	190mm	
Type II 24 hr Rainfall: 1:50Yr	220mm	
Peak Flow: 1:20Yr storm from watershed	26.91 m^3/sec	7.65 m^3/sec
Peak Flow: 1:20Yr storm (discharge to South WS)	26.91 m^3/sec	n/a
Peak Flow: 1:50Yr storm from watershed	35.30 m^3/sec	10.08 m^3/sec
Peak Flow: 1:50Yr storm (discharge to South WS)	35.30 m^3/sec	n/a
Peak Flow: 1:20Yr storm (discharge South of Site)	n/a	27.69 m^3/sec
Peak Flow: 1:50Yr storm (discharge South of Site)	n/a	36.88 m^3/sec

Estimated depths of overland flow ranged from 80mm in the North watershed to 100mm in the South watershed.

Maximum depth of flow of water over broad crested weirs was estimated at 0.042m (1.5”).

4.3.3 Results

Note the following observations from the results of baseline HydroCAD analyses.

- The presence of suckwells in the North and South watersheds has a negligible impact on peak storm flows estimated for both the 1:20yr and 1:50yr scenarios. This observation implies that for an extended duration storm the impact of suckwells on draining surface runoff is negligible.

- Excess peak runoff – South and downstream – of the site is estimated at 27.69 m^3/s for the 1:20yr design storm criterion and 36.84 m^3/s for the 1:50yr design storm criterion. Given the negligible impact of suckwells on drainage, these figures are deemed to represent the combined stormflows from both catchments with negligible losses due to suckwells and dry pond attenuation. These flows are deemed the baseline peak flows for the purpose of this study.

4.4 POST DEVELOPMENT STORMFLOWS

4.4.1 Assumptions

The following were assumed in the calculation of post development stormflows from the North and South watershed (the site):

- No change in the hydrological characteristics of the North watershed.
- Increase in Curve Number for watershed #2 due to the construction of roads, buildings and paved areas.
- The storage provided by several small localised depressions within the North and South watershed were ignored due to their smaller size relative to the areas of the watersheds.
- Assumed that presence of panels has no impact on runoff magnitude (per section 4.1 of this report).
- Assumed that 7# Suckwells (1.8m x 12m deep) added for the drainage of roads and paved areas of the administration area and hydrogen and battery storage area.
- Retention of the existing 23# suckwells on site.
- A 2.0 m deep x 9m wide x 1.2km long infiltration trench within drainage reserve along southern site boundary. Provision for 13# suckwells with top and side inlet entry for runoff equidistantly spaced within trench. Provision for captured runoff in trench to exfiltrate at a rate of 10mm/hr (Tullstrom, 1964).

4.4.2 Post development hydrological characteristics & HydroCAD results

Inputs into HydroCAD and modelled results for both watersheds based on the post development scenario were as follows:

Table 6: Hydrological Characteristics (Post Development Scenario)

Hydrological Characteristic	North WS	South WS	Remarks
Average Land Slope	9.69%	3.27%	
Curve Number (CN)	62.29	62.84	3% increase in CN for South WS due to addition of hard surfaces of development.
Time of Concentration (T_c)	149 mins	63mins	1.5% reduction in T_c for South WS due to introduction of impermeable surfaces.
Inflow Loss due to suckwells	0.983 m^3/sec	0.78 m^3/sec	
Type II 24 Hr Rainfall: 1:20Yr	190mm		
Type II 24 hr Rainfall: 1:50Yr	220mm		
Peak Flow: 1:20Yr storm from watershed	No change from baseline	8.38 m^3/sec	9.5% increase over the baseline peak flow due to introduction of impermeable surfaces
Peak Flow: 1:20Yr storm (discharge to South WS)	No change from baseline	n/a	
Peak Flow: 1:50Yr storm from watershed	No change from baseline	10.93 m^3/sec	8.4% increase over the baseline peak flow due to the introduction of impermeable surfaces
Peak Flow: 1:50Yr storm (discharge to South WS)	No change from baseline	n/a	
Peak Flow: 1:20Yr storm (discharge South of Site)	n/a	27.79 m^3/sec	0.36% increase over the baseline peak flow due to the introduction of impermeable surfaces

Hydrological Characteristic	North WS	South WS	Remarks
Average Land Slope	9.69%	3.27%	
Peak Flow: 1:50Yr storm (discharge South of Site)	n/a	36.99 m^3/sec	0.3% increase over the baseline peak flow due to the introduction of impermeable surfaces

Estimated depth of overland flow in the South watershed – post development – was 104mm.

With the proposed infiltration trench introduced along the southern site boundary as a mitigation measure the reduction in runoff from the site southwards was estimated as follows:

Table 7: Infiltration Trench Runoff Rates

Hydrological Characteristic	South WS (Baseline)	South WS (Post Development)	Remarks
Peak Flow: 1:20Yr storm (discharge South of Site)	27.69 m^3/sec	27.07 m^3/sec	2.2% less than baseline peak flow
Peak Flow: 1:50Yr storm (discharge South of Site)	36.88 m^3/sec	36.25 m^3/sec	1.7% less than baseline peak flow

4.5 DISCUSSION

Drainage analyses were done to assess whether the proposed development and its introduction of impermeable surfaces have the potential to cause on-site flooding or worsen flooding conditions in areas South of the site during extreme and prolonged rainfall events.

Based on the model and associated assumptions, the addition of impermeable surfaces due to the development (excluding PV panel surfaces) results in an estimated 9.5% increase in peak runoff from the South watershed (versus the baseline scenario) for the 1:20yr 24hr design storm criterion and an 8.4% peak runoff increase for the 1:50yr 24hr design storm criterion.

Taking into consideration runoff from the North and South watershed and drainage provided by 29 infiltration wells in the North watershed and 23 wells in the South watershed, the runoff discharging along the site's southern boundary towards the communities to the South of the site was estimated to increase (versus baseline flows) by 0.36% for the 1:20yr 24hr design storm criterion and 0.3% for the 1:50yr 24hr design storm criterion. Thus, the impact of the additional impermeable surfaces due to the development on site is not estimated to significantly increase runoff to downstream communities. As discussed in the prior section, given the magnitude – especially - of the North watershed and its associated runoff, the drainage capabilities of infiltration wells in the system modelled are deemed insignificant, having what appears to be no impact on reducing stormflows from catchments.

The construction of a 2m deep, 1.2km long, and 9m wide trench along the southern site boundary would capture and hold portions of runoff from the site and promote infiltration and percolation of runoff to groundwater zones. This trench was modelled in HydroCAD; to assist with drainage, 13# suckwells were added to the trench. It was also assumed that between the roadways and other paved areas that seven (7) new infiltration wells would be built to provide drainage to these areas. Running this post-development model in HydroCAD estimated a 2.2% reduction in runoff (versus the baseline scenario) from the site for the 1in20yr 24hr design storm criterion and a likewise 1.7% reduction for the 1in 50yr 24hr design storm criterion.

Scrutiny of the above-described model reveals that infiltration wells have a negligible impact on reducing runoff quantities; the storage provided by the trench along with its exfiltration capabilities are primarily responsible for the minor drainage mitigation provided by the trench – in the model.

Significant earthworks and costs would be required to build such a trench; the model assumed the ability to construct the trench with vertical walls. If rock is located at depth, consideration would have to be given to sloping the trench embankments which would further widen the footprint.

The runoff from the two watersheds is expected – based on site topography - to be predominantly via overland flow; shallow depths of runoff were estimated from HydroCAD ranging from 80mm to 104mm. Thus, provided site infrastructure is built on lands of higher elevation – not within depressed areas - then the flooding of the site is not expected.

It is clear that the communities and Six Roads township to the South of the development site have been developed downstream of a significant watershed system. An infiltration trench or swale with sloped embankments along the site's Southern boundary would – if built – provide very little relief from flooding for longer duration rainfall events, which tends to occur during the passage of Tropical Storms or hurricanes. Significant measures to capture, attenuate, and drain runoff upstream of the development site would be required to mitigate flooding problems downstream of the site; these measures could include the development of quarries (with runoff diversion to quarries) and the construction of dry ponds. These measures would reduce runoff to the site and to the communities downstream of the site; these measures would possibly have to be implemented as part of an areawide Government led municipal drainage improvement and groundwater augmentation project.

5.0 POTENTIAL IMPACTS & MITIGATION MEASURES

The following drainage related impacts were identified with the potential to occur because of the proposed development. Mitigation measures are recommended for each impact so that these measures can be incorporated into the construction, operation, and management of the PV solar farm.

5.1 CONSTRUCTION STAGE

a) The construction stage will require the use of heavy equipment, which may result in the disturbance and/or removal of the existing vegetation resulting in the increased potential for erosion and the washing of top soil. Such a scenario could result in the loss of topsoil that may impact drainage on downstream farmlands and communities.

This is a transient potential impact, the possibility of which ceases after the completion of the construction stage and the planting of native grass on the development site.

Mitigation Measures

- Silt screens and/or bales of hay should be used where necessary to contain and retard the erosion and loss of topsoil from localised areas.
- Temporary boulder barriers should be provided at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands.
- Temporary stockpiles of topsoil not required for re-instatement should be removed from site as soon as possible; to avoid migration of topsoil into the natural drainage system.

b) Spillages of fuel, lubricants, coolants, etc. from construction equipment have the potential to be leached by rainfall or intense water use activities to the groundwater zone beneath the site.

Mitigation Measures

- Best practices for the proper handling, storage and disposal of spilled hazardous chemicals and fuels should be referenced and included in the contractor's environmental management plan; these measures should be implemented by the contractor.

5.2 OPERATIONS STAGE

a) The development site currently receives stormwater runoff from a large watershed to the immediate North of the site. This runoff may flood portions of the site, especially those in the vicinity of existing depressions. Runoff generated from rainfall on the site and from the North watershed has the potential to impact communities downstream of the site.

Runoff from the North watershed to the site is predominantly via overland flow with shallow flow depths; there are a few watercourses where runoff occurs at deeper depth. Hydrological and hydraulic analyses conducted in Section 4.0 indicate shallow runoff depths predominantly throughout the site - post development and the increase of the percentage of impermeable areas in the catchment. This increase of impermeable surfaces within the site is expected to marginally increase runoff to downstream areas. By way of analyses conducted in section 4.4 of this report, it was demonstrated that an infiltration trench along the southern boundary of the site could result in runoff volumes from the site downstream being slightly less than the baseline scenario.

Mitigation Measures:

- The drainage system for the site should be designed to limit stormflows from the site to baseline levels.

- Drainage system design for areas on site where impermeable areas are to be added – roofs, roads etc - should focus on draining runoff to suckwells and ultimately groundwater, to reduce the potential for higher surface runoff that could impact communities downstream.

- Drainage system design could consider the construction of an interceptor drainage system along the southern boundary of the site. Further consideration could be given to including suckwells in the interceptor drainage system to assist with the subsurface drainage of captured runoff.

- Consideration could be given to designing and constructing a dry pond on land to the West of the area proposed for sheep grazing, north of the Old Train line road. The dry pond could have shallow slopes and have a few suckwells with top and side entry inlets along its perimeter. With shallow slopes the pond could be grassed and foraged by sheep. The dry pond (see Figure 17 below) would capture a portion of runoff from the North watershed, promote the infiltration and percolation of runoff to groundwater zones and reduce to some extent the quantity of runoff that crosses the Old Train line road and enters the site.

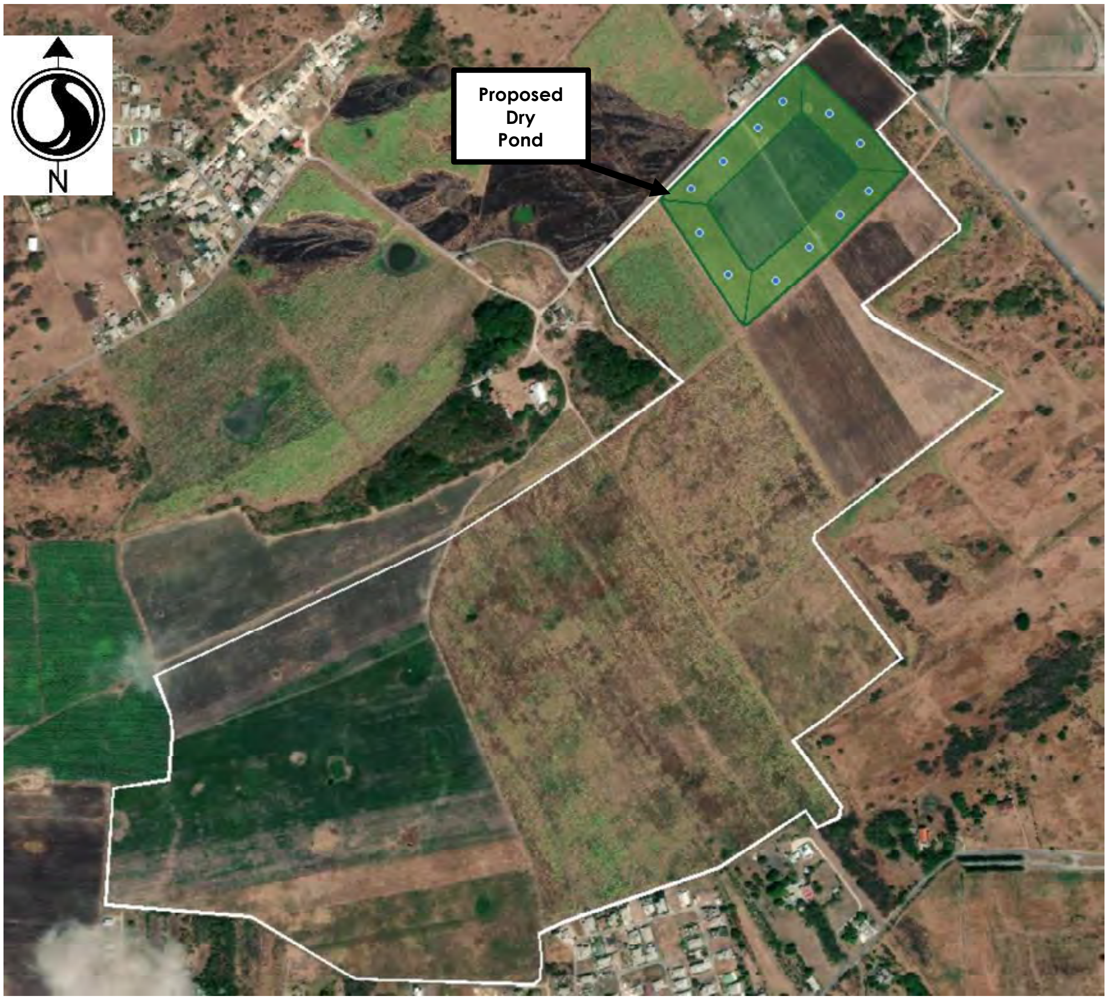

Figure 17 – Potential Dry Pond Location

b) The construction of arrays of PV panels may result in a significant increase in impermeable surface areas on the site and runoff quantities, which in turn may result in flooding of downstream areas.

As discussed in Section 4.1, provided ground conditions beneath solar panels are suitably grassed and maintained, the presence of PV panels is not expected to produce a net increase in runoff or materially alter the drainage characteristics of the site.

<u>Mitigation Measures</u>

- Beneath panels and on the pathway/space between panels, the ground surface should be prepared, planted and maintained with a surface cover of a sustainable native grass.

c) The improper maintenance of the grassed surface at the PV farm could result in bare patches in areas- especially in between panels where routine traffic and maintenance will occur. These bare patches could result in increased runoff, which could result in the formation of erosion channels/pathways that may destabilize the main service road between panels.

Mitigation Measures

- There should be routine maintenance of the grassed surface to ensure that there are no bare patches or inconsistencies, which could result in a change of the runoff characteristics in those areas.

d) The disposal of foul wastewater without treatment – directly to suckwells – has the potential to impact groundwater quality beneath the site; the site is in a Zone 3 groundwater protection zone.

Mitigation Measures:

- The Developer should develop an operations management plan, which schedules the routine inspection and cleaning – if necessary – of septic tanks and soakaways; these units should be inspected at least once every six (6) months.

- The cleaning of PV panels should only be done with clean water; no detergents or cleaning chemicals should be used; this way water that runs off onto the ground will not have any chemicals entrained.

6.0 REFERENCES

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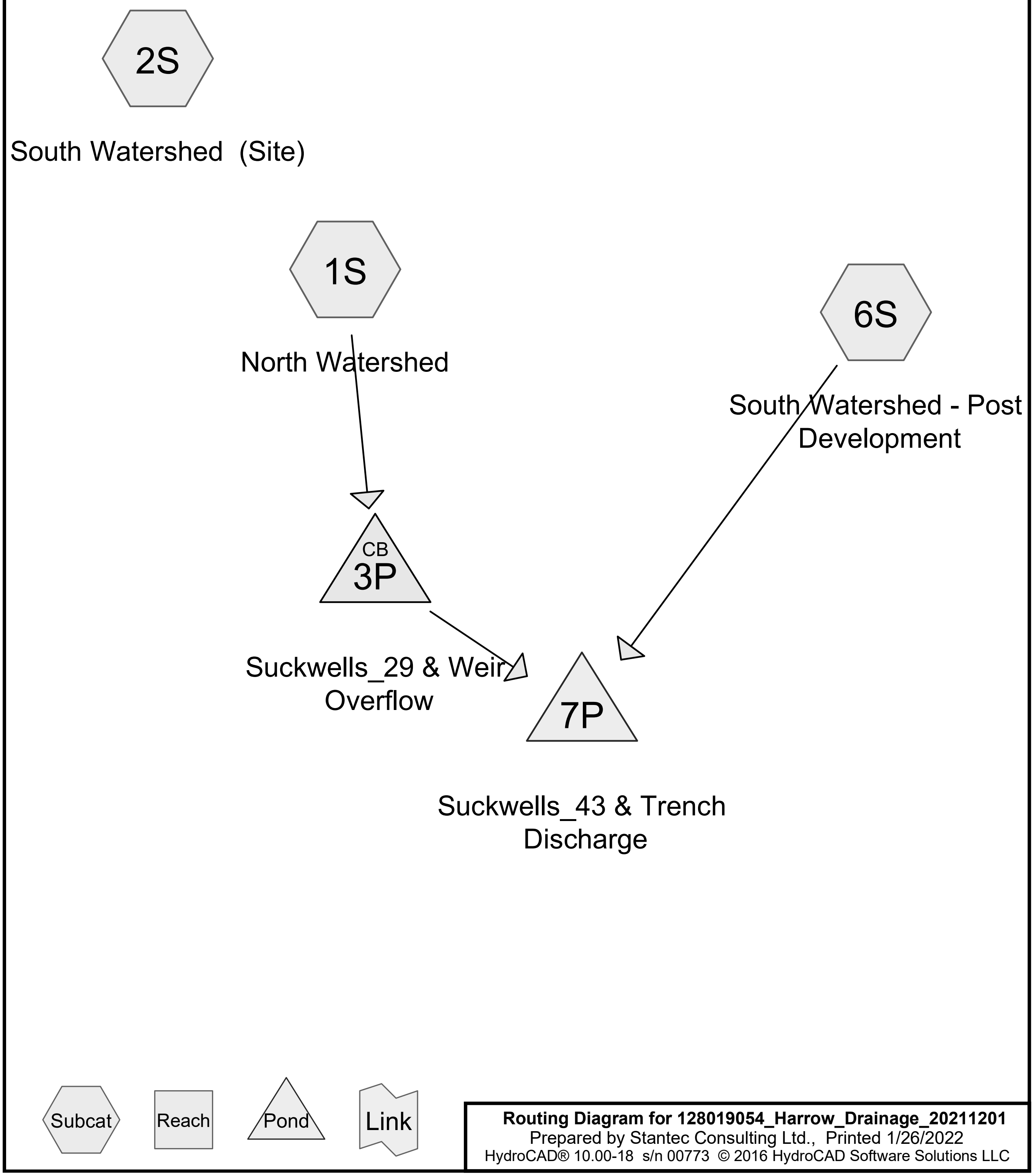
APPENDIX A

HydroCAD Modelling Results



Routing Diagram for 128019054_Harrow_Drainage_20211201
Prepared by Stantec Consulting Ltd., Printed 1/26/2022
HydroCAD® 10.00-18 s/n 00773 © 2016 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: North Watershed

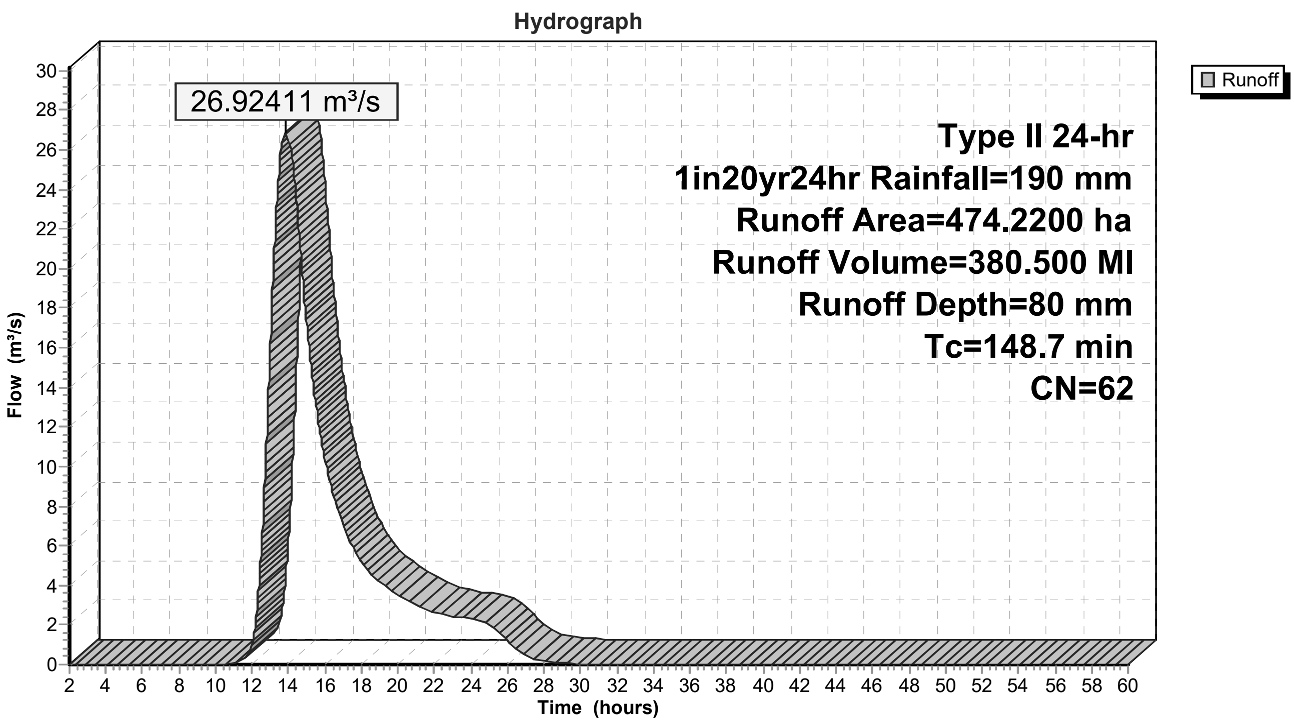
Runoff = 26.92411 m³/s @ 13.88 hrs, Volume= 380.500 Ml, Depth= 80 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1in20yr24hr Rainfall=190 mm

	Area (ha)	CN	Description
*	474.2200	62	
	474.2200		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
148.7					**Direct Entry,**

Subcatchment 1S: North Watershed



Summary for Subcatchment 2S: South Watershed (Site)

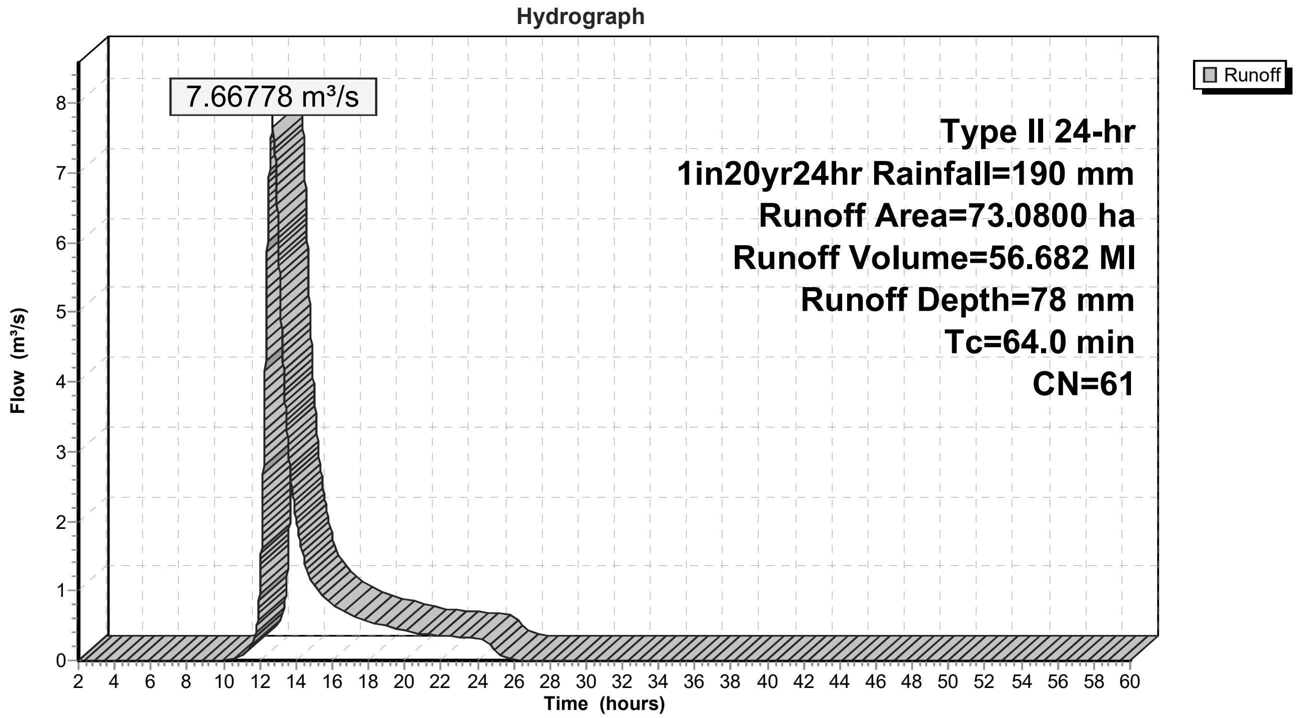
Runoff = 7.66778 m³/s @ 12.73 hrs, Volume= 56.682 Ml, Depth= 78 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1in20yr24hr Rainfall=190 mm

	Area (ha)	CN	Description
*	73.0800	61	
	73.0800		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
64.0					**Direct Entry,**

Subcatchment 2S: South Watershed (Site)



Summary for Subcatchment 6S: South Watershed - Post Development

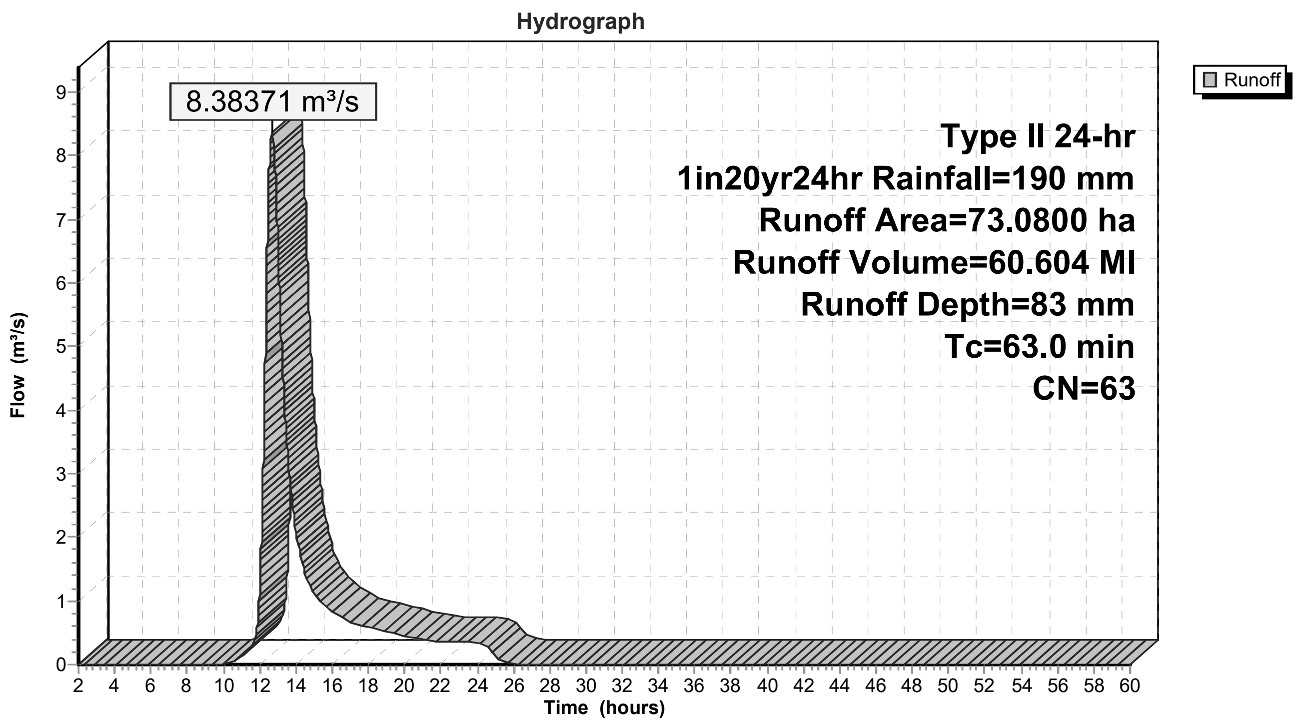
Runoff = 8.38371 m³/s @ 12.67 hrs, Volume= 60.604 Ml, Depth= 83 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1in20yr24hr Rainfall=190 mm

	Area (ha)	CN	Description
*	73.0800	63	
	73.0800		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
63.0					**Direct Entry,**

Subcatchment 6S: South Watershed - Post Development



Summary for Pond 3P: Suckwells_29 & Weir Overflow

Inflow Area = 474.2200 ha, 0.00% Impervious, Inflow Depth = 80 mm for 1in20yr24hr event
Inflow = 26.92411 m³/s @ 13.88 hrs, Volume= 380.500 Ml
Outflow = 26.92445 m³/s @ 13.88 hrs, Volume= 530.748 Ml, Atten= 0%, Lag= 0.0 min
Discarded = 0.98397 m³/s @ 2.00 hrs, Volume= 205.488 Ml
Primary = 25.94048 m³/s @ 13.88 hrs, Volume= 325.260 Ml

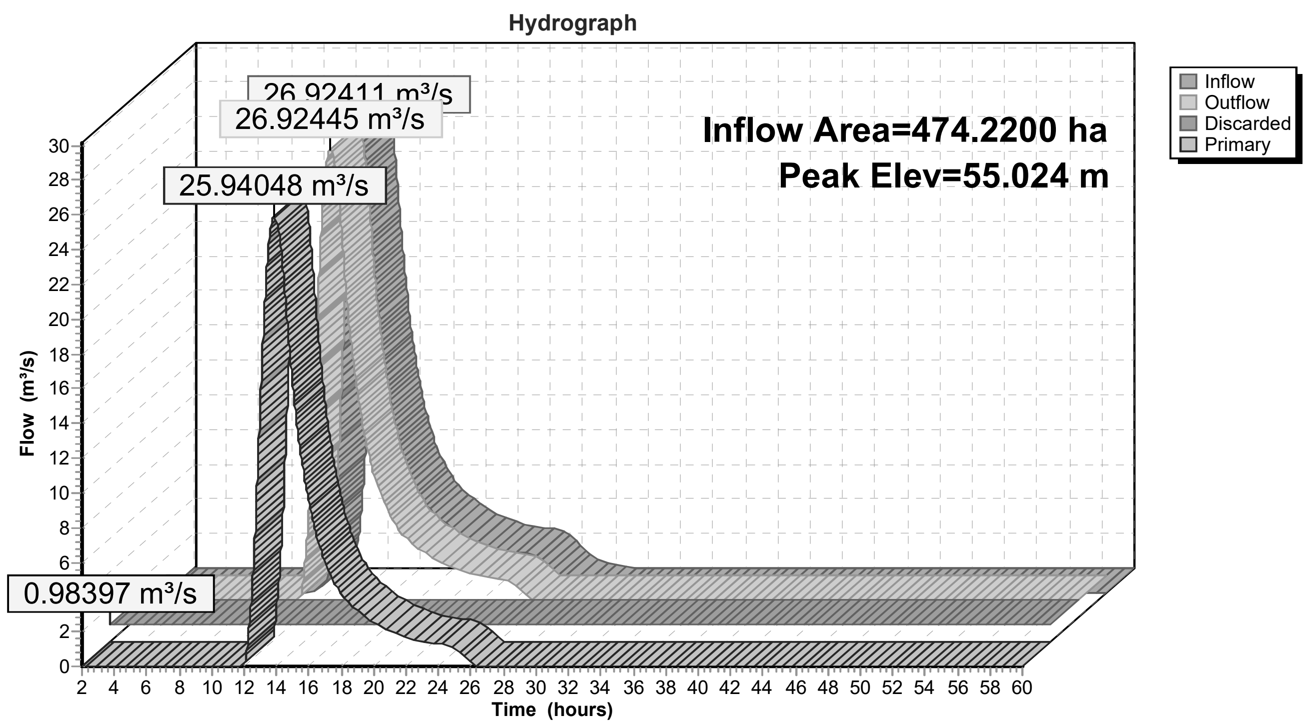
Routing by Stor-Ind method, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs / 9
Peak Elev= 55.024 m @ 13.88 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	55.000 m	**999.00 m long x 6.00 m breadth Broad-Crested Rectangular Weir** Head (meters) 0.061 0.122 0.183 0.244 0.305 0.366 0.427 0.488 Coef. (Metric) 1.48 1.49 1.49 1.46 1.45 1.46 1.46 1.45
#2	Discarded	0.000 m	**0.03393 m³/s Suckwells X 29.00 at all elevations**

Discarded OutFlow Max=0.98397 m³/s @ 2.00 hrs HW=0.000 m (Free Discharge)
└─**2=Suckwells** (Exfiltration Controls 0.98397 m³/s)

Primary OutFlow Max=5.54704 m³/s @ 13.88 hrs HW=55.024 m (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 5.54704 m³/s @ 0.23 m/s)

Pond 3P: Suckwells_29 & Weir Overflow



Summary for Pond 7P: Suckwells_43 & Trench Discharge

Inflow Area = 547.3000 ha, 0.00% Impervious, Inflow Depth = 71 mm for 1in20yr24hr event
Inflow = 28.57633 m³/s @ 13.72 hrs, Volume= 385.863 Ml
Outflow = 28.57005 m³/s @ 13.72 hrs, Volume= 385.851 Ml, Atten= 0%, Lag= 0.4 min
Discarded = 1.50289 m³/s @ 13.72 hrs, Volume= 95.563 Ml
Primary = 27.06716 m³/s @ 13.72 hrs, Volume= 290.288 Ml

Routing by Stor-Ind method, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs / 9
Peak Elev= 47.069 m @ 13.72 hrs Surf.Area= 10,800.0 m² Storage= 22,348.9 m³
Flood Elev= 48.000 m Surf.Area= 10,800.0 m² Storage= 22,680.0 m³

Plug-Flow detention time= 50.5 min calculated for 385.785 Ml (100% of inflow)
Center-of-Mass det. time= 50.5 min (984.4 - 933.9)

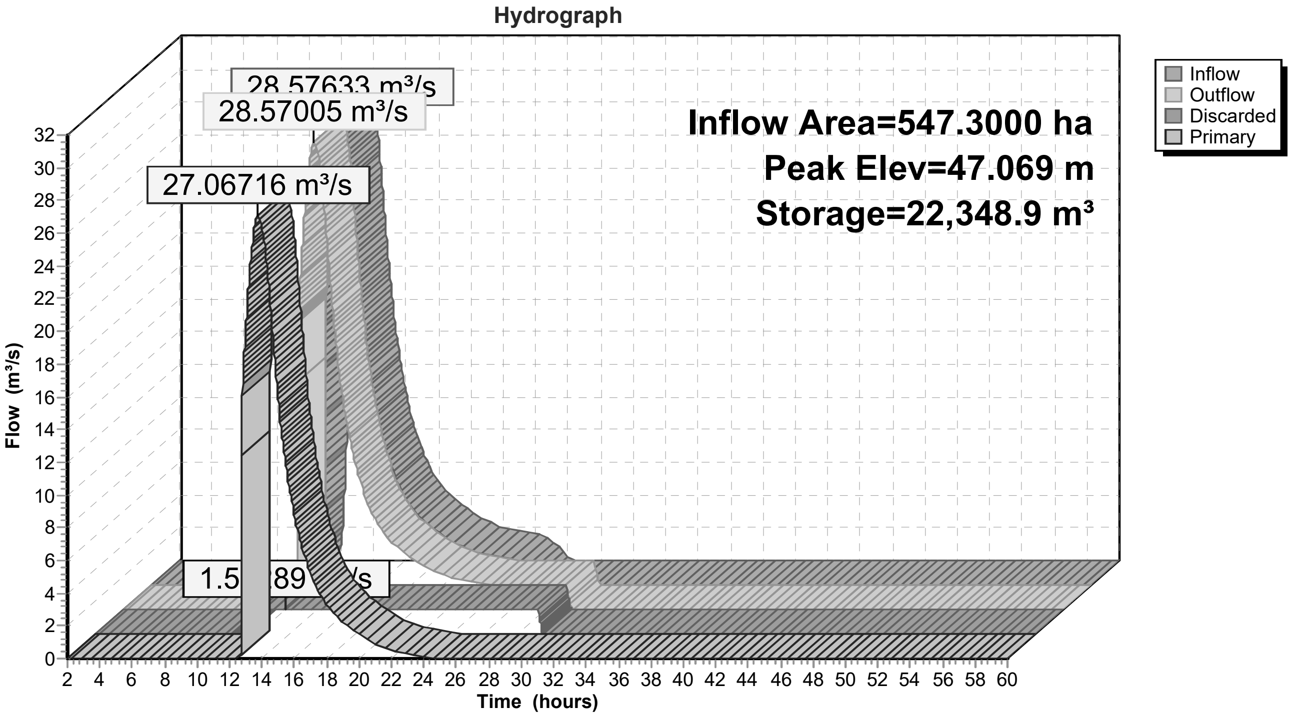
Volume	Invert	Avail.Storage	Storage Description
#1	45.000 m	22,680.0 m³	**9.00 mW x 1,200.00 mL x 2.10 mH Southern boundary trench**

Device	Routing	Invert	Outlet Devices
#1	Primary	47.000 m	**999.00 m long x 6.00 m breadth Broad-Crested Rectangular Weir** Head (meters) 0.061 0.122 0.183 0.244 0.305 0.366 0.427 0.488 Coef. (Metric) 1.48 1.49 1.49 1.46 1.45 1.46 1.46 1.45
#2	Discarded	45.000 m	**10.00 mm/hr Exfiltration over Wetted area**
#3	Discarded	45.000 m	**0.03393 m³/s Suckwells X 43.00 at all elevations**

Discarded OutFlow Max=1.50289 m³/s @ 13.72 hrs HW=47.069 m (Free Discharge)
—**2=Exfiltration** (Exfiltration Controls 0.04390 m³/s)
—**3=Suckwells** (Exfiltration Controls 1.45899 m³/s)

Primary OutFlow Max=27.01872 m³/s @ 13.72 hrs HW=47.069 m (Free Discharge)
—**1=Broad-Crested Rectangular Weir** (Weir Controls 27.01872 m³/s @ 0.39 m/s)

Pond 7P: Suckwells_43 & Trench Discharge



Summary for Subcatchment 1S: North Watershed

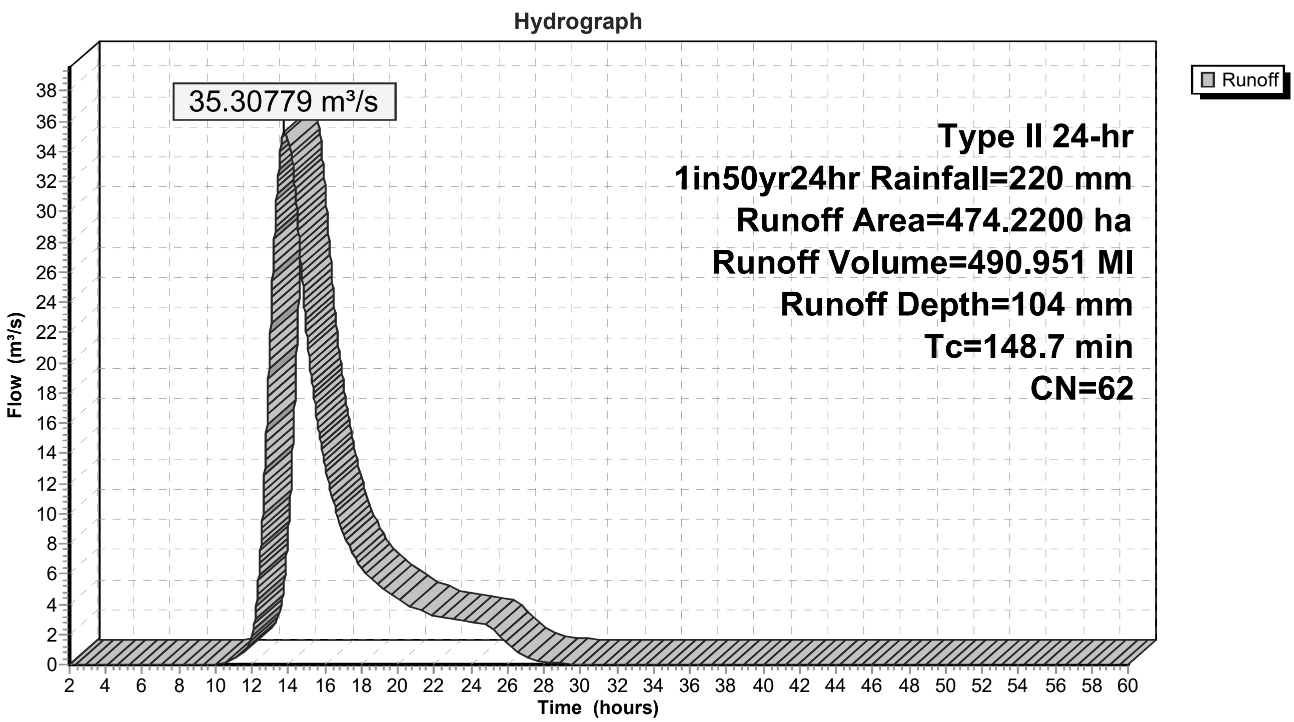
Runoff = 35.30779 m³/s @ 13.72 hrs, Volume= 490.951 Ml, Depth= 104 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1in50yr24hr Rainfall=220 mm

	Area (ha)	CN	Description
*	474.2200	62	
	474.2200		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
148.7					**Direct Entry,**

Subcatchment 1S: North Watershed



Summary for Subcatchment 2S: South Watershed (Site)

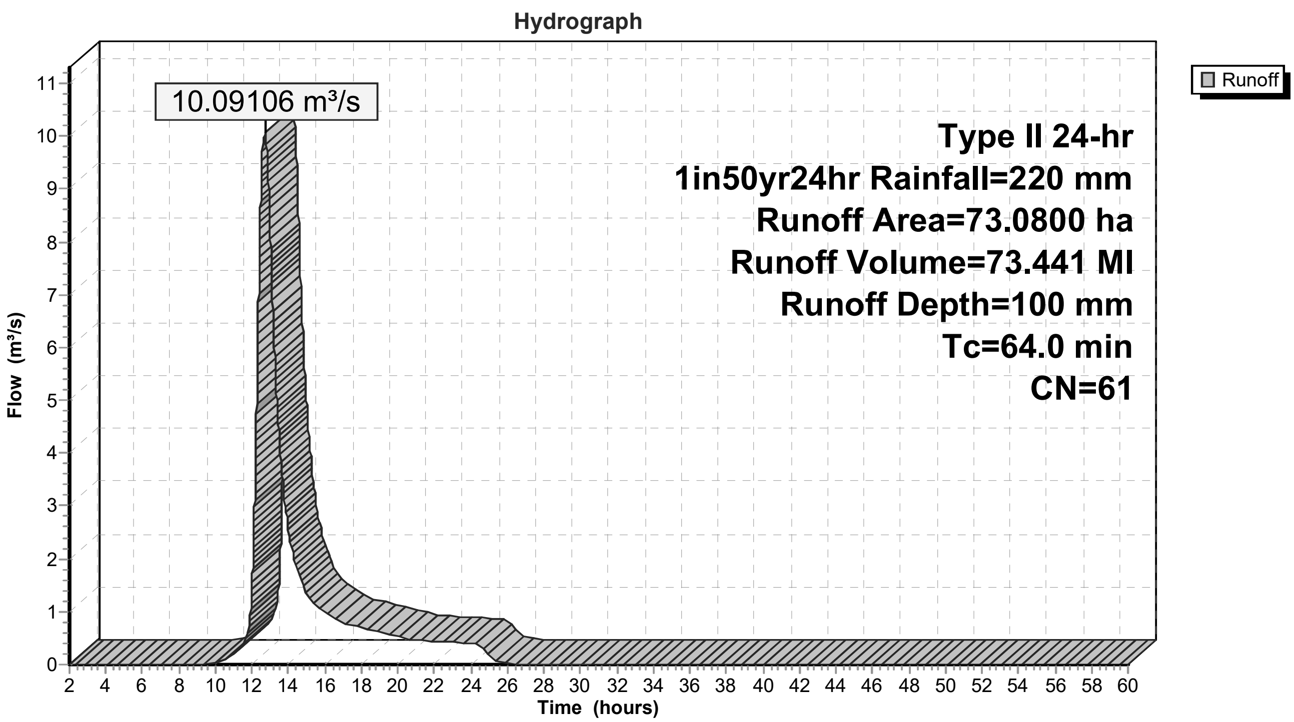
Runoff = 10.09106 m³/s @ 12.72 hrs, Volume= 73.441 Ml, Depth= 100 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1in50yr24hr Rainfall=220 mm

	Area (ha)	CN	Description
*	73.0800	61	
	73.0800		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
64.0					**Direct Entry,**

Subcatchment 2S: South Watershed (Site)



Summary for Subcatchment 6S: South Watershed - Post Development

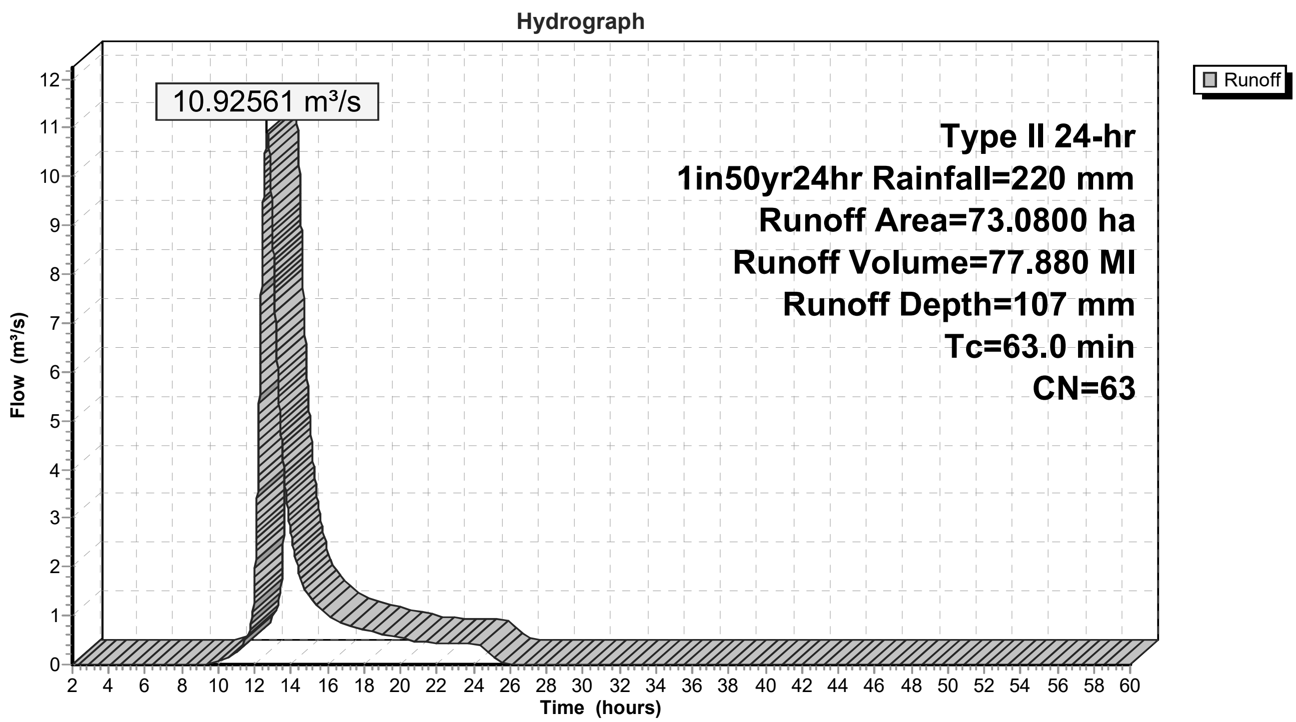
Runoff = 10.92561 m³/s @ 12.67 hrs, Volume= 77.880 Ml, Depth= 107 mm

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 1in50yr24hr Rainfall=220 mm

	Area (ha)	CN	Description
*	73.0800	63	
	73.0800		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
63.0					**Direct Entry,**

Subcatchment 6S: South Watershed - Post Development



Summary for Pond 3P: Suckwells_29 & Weir Overflow

Inflow Area = 474.2200 ha, 0.00% Impervious, Inflow Depth = 104 mm for 1in50yr24hr event
Inflow = 35.30779 m³/s @ 13.72 hrs, Volume= 490.951 Ml
Outflow = 35.30835 m³/s @ 13.72 hrs, Volume= 638.686 Ml, Atten= 0%, Lag= 0.0 min
Discarded = 0.98397 m³/s @ 2.00 hrs, Volume= 205.488 Ml
Primary = 34.32438 m³/s @ 13.72 hrs, Volume= 433.197 Ml

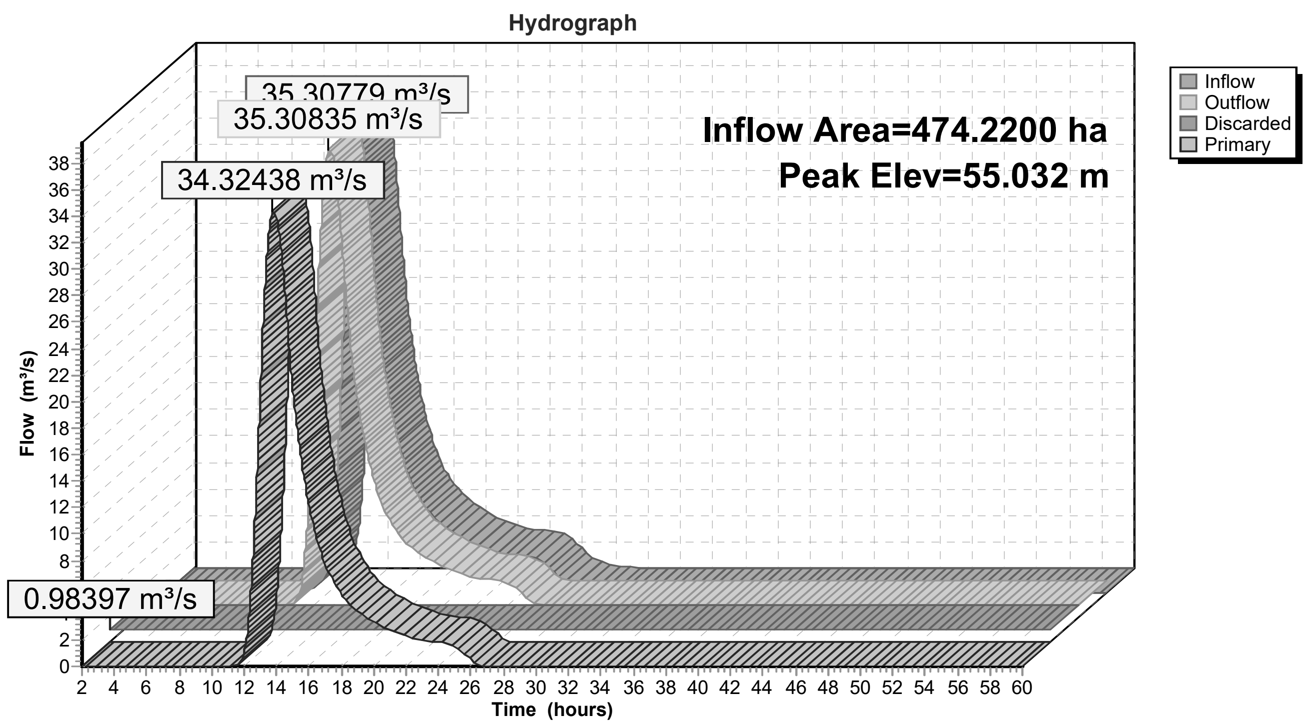
Routing by Stor-Ind method, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs / 9
Peak Elev= 55.032 m @ 13.72 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	55.000 m	**999.00 m long x 6.00 m breadth Broad-Crested Rectangular Weir** Head (meters) 0.061 0.122 0.183 0.244 0.305 0.366 0.427 0.488 Coef. (Metric) 1.48 1.49 1.49 1.46 1.45 1.46 1.46 1.45
#2	Discarded	0.000 m	**0.03393 m³/s Suckwells X 29.00 at all elevations**

Discarded OutFlow Max=0.98397 m³/s @ 2.00 hrs HW=0.000 m (Free Discharge)
└─**2=Suckwells** (Exfiltration Controls 0.98397 m³/s)

Primary OutFlow Max=8.44421 m³/s @ 13.72 hrs HW=55.032 m (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 8.44421 m³/s @ 0.26 m/s)

Pond 3P: Suckwells_29 & Weir Overflow



Summary for Pond 7P: Suckwells_43 & Trench Discharge

Inflow Area = 547.3000 ha, 0.00% Impervious, Inflow Depth = 93 mm for 1in50yr24hr event
Inflow = 37.76308 m³/s @ 13.71 hrs, Volume= 511.077 Ml
Outflow = 37.75322 m³/s @ 13.72 hrs, Volume= 511.051 Ml, Atten= 0%, Lag= 0.3 min
Discarded = 1.50298 m³/s @ 13.72 hrs, Volume= 98.840 Ml
Primary = 36.25024 m³/s @ 13.72 hrs, Volume= 412.211 Ml

Routing by Stor-Ind method, Time Span= 2.00-60.00 hrs, dt= 0.01 hrs / 9
Peak Elev= 47.084 m @ 13.72 hrs Surf.Area= 10,800.0 m² Storage= 22,502.5 m³
Flood Elev= 48.000 m Surf.Area= 10,800.0 m² Storage= 22,680.0 m³

Plug-Flow detention time= 39.4 min calculated for 510.962 Ml (100% of inflow)
Center-of-Mass det. time= 39.4 min (972.4 - 932.9)

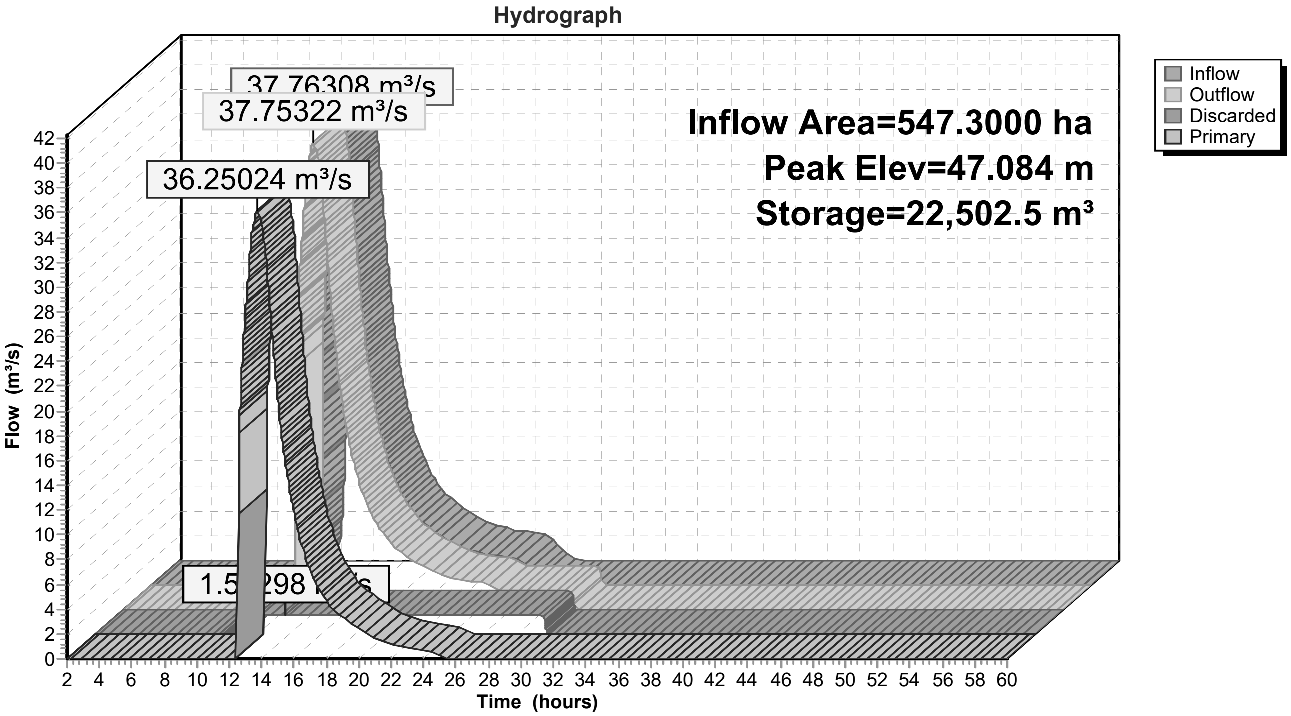
Volume	Invert	Avail.Storage	Storage Description
#1	45.000 m	22,680.0 m³	**9.00 mW x 1,200.00 mL x 2.10 mH Southern boundary trench**

Device	Routing	Invert	Outlet Devices
#1	Primary	47.000 m	**999.00 m long x 6.00 m breadth Broad-Crested Rectangular Weir** Head (meters) 0.061 0.122 0.183 0.244 0.305 0.366 0.427 0.488 Coef. (Metric) 1.48 1.49 1.49 1.46 1.45 1.46 1.46 1.45
#2	Discarded	45.000 m	**10.00 mm/hr Exfiltration over Wetted area**
#3	Discarded	45.000 m	**0.03393 m³/s Suckwells X 43.00 at all elevations**

Discarded OutFlow Max=1.50298 m³/s @ 13.72 hrs HW=47.084 m (Free Discharge)
├─**2=Exfiltration** (Exfiltration Controls 0.04399 m³/s)
└─**3=Suckwells** (Exfiltration Controls 1.45899 m³/s)

Primary OutFlow Max=35.80530 m³/s @ 13.72 hrs HW=47.084 m (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 35.80530 m³/s @ 0.43 m/s)

Pond 7P: Suckwells_43 & Trench Discharge



APPENDIX C

Agricultural Impact Assessment

INSTALLATION OF SOLAR PHOTOVOLTAIC ENERGY GENERATION AND STORAGE FACILITY WITH SHEEP FARM

AT

HARROW PLANTATION, ST. PHILIP

AGRICULTURAL IMPACT ASSESSMENT.

PLANNING APPLICATION NO. 1735/10/2021D.

December 2021

Prepared by:

bain planning + development

William F. Bain

Executive Summary

Introduction

A Planning Application (ref 1735/10/2021D) was submitted for the *Installation of Solar Photovoltaic Energy Generation and Storage Facility with Sheep Farm* at Harrow Plantation, St. Philip

Harrow Plantation has an area of 304 acres of which 252.5 acres are in arable production. The proposed energy generation and storage facility with sheep farming facility will utilise 184 acres. The balance of the land 120 acres will remain as operational plantation lands.

Agricultural Impact Assessment

An Agricultural Impact Assessment (AIA) is required for any development proposal that may result in alienation or fragmentation of food and agricultural land or when development is proposed adjacent to such lands.

This Agricultural Impact Assessment forms part of an overall Environmental and Social Impact Assessment for the proposal. The following is a summary of the report's main findings.

Site Description and Baseline Conditions

Harrow Plantation is bounded by Padmore Village to the north, Bushy Park Tenantry and Bushy Park Road (Highway M) to the east, agricultural lands of Bushy Park Plantation and the Six Cross Roads settlement to the south, and lands of Sunbury Plantation to the west.

The Plantation has traditionally been in sugar cane cultivation which has been augmented by rotational crops, currently cotton. The Plantation has an area of 304 acres with most of the productive lands having been traditionally in sugar cane. There are currently 252.5 acres in arable production.

The proposed Solar Photovoltaic Energy Generation and Storage Facility will occupy an overall lease area of 184 acres south and east of the plantation yard.

The application site is located within a generally flat and expansive agricultural area typical of rural St. Philip. There are no major water courses or drainage features within the site other than a series of low areas or small depressions located throughout.

Impacts on Lands of Harrow Plantation

The application site has traditionally been used for the cultivation of sugar cane and rotational crops, mainly cotton. It will now be used for renewable energy purposes combined with sheep farming.

The proposed Solar Photovoltaic Energy Generation and Storage Facility will occupy an overall lease area of 184 acres south and east of the plantation yard. The facility will incorporate a sheep farm with a total of 1830 Black Belly sheep, hence the proposal is for the dual agriculture and renewable energy use of the site.

The shift from solely arable production to arable combined with sheep farming and renewable energy will result in the loss of approximately 90 acres of arable land.

Operational Impacts

The proposed solar photovoltaic energy generation and storage facility will not adversely impact continued agricultural activity (mainly sugar cane production) on the remaining plantation lands.

There will be no fragmentation or alienation of any of the remaining planation lands due to the simple manner in which the overall planation is being divided to accommodate the proposed facility.

Impacts of Agriculture in Development

Post development, agricultural activity will continue on all of these lands and it is considered that any such activity will have minimal impact, if any on the proposed facility. Indeed, the introduction of sheep grazing within the facility will have the positive impact of limiting vegetation growth on the land occupied by the solar farm.

Agricultural Viability

The Plantation will remain in agricultural use. All the productive lands to the north of the proposed facility will remain in mainly sugar cane production, managed and operated by the Barbados Agricultural Management Company (BAMC). The viability of the continuation of sugar cane production will depend on external factors unrelated to site specifics. There is also scope for other crops to be introduced in the future.

The lands included within the proposed facility will be utilised for the sheep farm project.

Construction Impacts

Construction impacts on the site and surrounding area will occur over a relatively short period of time and can be managed. The most common impacts are dust and noise which can affect both construction workers, those employed on adjacent agricultural lands and neighbouring residents.

Adjoining agricultural lands of the plantation and other plantations could potentially experience dust and drainage impacts during the construction process.

While this report is focussed on the Agricultural Impacts of the proposed development, it is nevertheless important to consider the impacts of construction on the wider community. In view of this, the main report recommends mitigation measures aimed at minimising any dust impacts.

Noise impacts will be inevitable, and the contractor should ensure that any inconvenience is kept to a minimum.

Other construction mitigation measures will be implemented aimed at site management as outlined in the main report.

The report also outlines waste management measures for both construction and operational phases and considers the options for decommissioning.

Conclusions

The loss of arable production at the plantation, mainly sugar cane, will be offset by the introduction of sheep livestock farming as part of the renewable energy project. While the lands of the plantation are flat and thereby suitable for mechanical sugar cane production, yields are impacted by low rainfall and poorer quality soils.

The loss of approximately 90 acres of arable land must be seen in the above context together with the benefits resulting from the level of investment in the renewable energy generation and storage facility. These factors provide sufficient justification for a departure from policy as facilitated by Section 5.2.2 of the Draft Physical Development Plan 2017. These policies are outlined in the main report.

It is considered that the proposal will have a limited impact on the agricultural activities of the remaining lands of the Plantation by virtue of the benign nature of the proposed development, together with the fact that agricultural activity (sheep farming) will continue at the site.

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1 Introduction and Report Structure

A Planning Application (ref 1735/10/2021D) was submitted for the *Installation of Solar Photovoltaic Energy Generation and Storage Facility with Sheep Farm* at Harrow Plantation, St. Philip

Harrow Plantation has an area of 304 acres of which 252.5 acres are in arable production. The proposed energy generation and storage facility with sheep farming facility will utilise 184 acres. The balance of the land 120 acres will remain as operational plantation lands.

This Agricultural Impact Assessment forms part of an overall Environmental and Social Impact Assessment for the proposal and has been prepared by Bain Planning and Development.

2 Background to Agricultural Impact Assessment

2.1 Site Description

The project area and remaining lands of Harrow Plantation are shown in Figure 2.1 below. Harrow Plantation is bounded by Padmore Village to the north, Bushy Park Tenantry and Bushy Park Road (Highway M) to the east, agricultural lands of Bushy Park Plantation and the Six Cross Roads settlement to the south, and lands of Sunbury Plantation to the west.

Figure 2-1 Satellite Image of Site

Harrow Plantation has traditionally been in sugar cane cultivation which has been augmented by rotational crops, currently cotton.

2.2 Regulatory and Policy Framework

This Agricultural Impact Assessment (AIA) forms part of the Environmental and Social Impact Assessment (ESIA) which is being undertaken in respect of the project.

An Agricultural Impact Assessment is a study that evaluates the potential impacts of non-agricultural development on agricultural operations and the agricultural system and recommends ways to avoid or, if avoidance is not possible, minimise and mitigate adverse impacts.

An Agricultural Impact Assessment:

- Identifies and assesses potential impacts from the proposed development on agriculture including impacts to farmland, farm operations and the surrounding area.
- Recommends measures or strategies to avoid impacts.
- Recommends measures to minimize or mitigate impacts e.g. through design, use of buffers, etc.

2.3 Agricultural Policy

Harrow Plantation is identified as agricultural in both the current Physical Development Plan, Amended 2003 and Draft Physical Development Plan, 2017. In each case, the lands of the plantation are classified primarily as IIa Prime A in the Agricultural Land Classification Map. The Plantation also falls within a Soil Protection Overlay area in the Draft Physical Development Plan 2017.

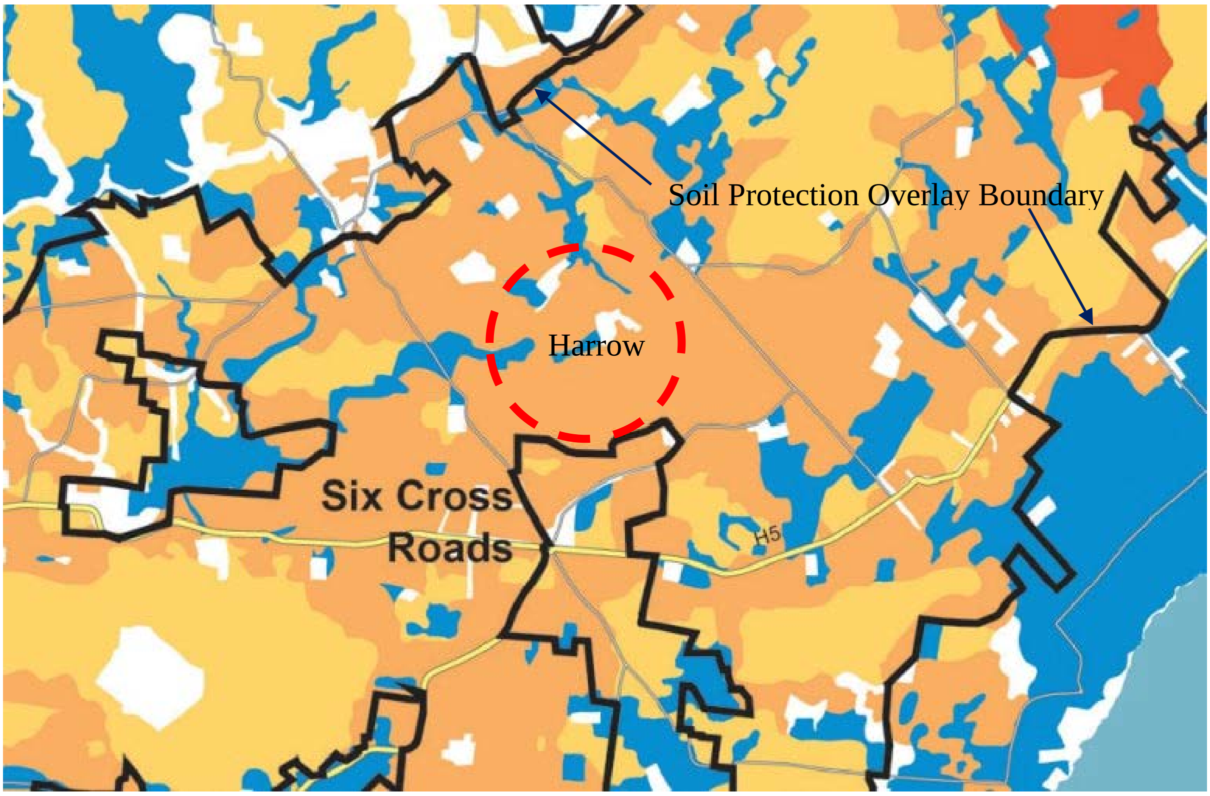

Figure 2-2 Extract from Map 4 Agricultural Land Classification - Draft Physical Development Plan 2017

2.3.1 Physical Development Plan, Amended 2003

Section 3.13.3 of the Plan states that: the lands designated Agricultural are intended to be conserved for agricultural purposes. Only very limited non-agricultural development will be permitted in agricultural areas, such as agriculture-related dwellings, limited infilling adjacent to settlements and small-scale tourism or recreational uses in surplus plantation yards. Urban development is to be directed to the designated Urban Corridor and Rural Settlements with Growth Potential, where sufficient land has been designated to accommodate projected urban growth within the Physical Development Plan Amended 2003 period and beyond,

Under exceptional circumstances, non-agricultural development may be considered on agricultural land (subject to an Environmental Impact Assessment and amendment to the Physical Development Plan Amended 2003 in instances where the land area is greater than 10 hectares), but only if the proposal provides significant economic, social or environmental benefits, and if suitable sites are not available in urban areas or rural settlements. Where there are no alternatives to development on agricultural land, development will be directed to lower quality agricultural land.

With regard to this study, it should be noted that the Physical Development Plan, Amended 2003 did not contain any provisions for the carrying out of Agricultural Impact Assessments.

Paragraph 3.13.3.5 states that: It is recognized, however, that it may be necessary, under exceptional circumstances, to permit non-agricultural land uses in the Agricultural area. Land uses not identified in Section 3.12.2 shall only be permitted in accordance with the following policies:

a) there are over-riding social environmental and economic benefits associated with the proposal;

b) there are no alternative locations for the proposal within the Urban Corridor, in Rural Settlements with Growth Potential, or in the National Park Villages;

c) if there are no alternatives to development on agricultural land, the proposal shall be directed to the land of the lowest Class, provided that alternative sites in lower Classes do not have an environmental, cultural or economic value which outweighs the agricultural considerations, and that development of these alternative locations does not contravene other applicable policies of the Physical Development Plan Amended 2003.

d) satisfactory completion of an Environmental Impact Assessment, which addresses the issues set out in Policies 3.13.3.5 a), b) and c), plus any other issues considered relevant by the Environmental Impact Assessment Panel;

e) an amendment to the Physical Development Plan Amended 2003 where the land area is greater than 10 hectares, in accordance with the policies of Section 12.4.

2.3.2 Draft Physical Development Plan 2017

The agricultural policies of the Draft Physical Development Plan 2017 are contained in Sections 2.2.1 and 3.1.2.

Paragraph 2.2.1.1 states that: the Government will promote a viable food and agricultural sector, recognizing its important role in food security, climate change resilience, the national economy and healthy communities. This will include (*inter alia*):

a) Protecting the agricultural land base from alienation and fragmentation.

Paragraph 2.2.1.4 seeks to ensure that an adequate supply of viable agricultural land will be protected to ensure the food security of Barbados. Two of the four types of protection that work together to support food and agricultural production are applicable to the application site:

a) The Food and Agriculture land use designation;

b) The Soil Protection Overlay.

Paragraph 2.2.1.5 states that: Agricultural uses will be protected on lands within **The Food and Agriculture Land Use Designation**, in accordance with Section 3.13. The intent of the Food and Agriculture land use designation is to:

a) Accommodate food production and other agricultural uses with a priority on growing local food and food security.

b) Protect large, contiguous agricultural areas to enable efficient agricultural protection and support the food and agricultural sector.

c) Restrict the alienation of land to any other use unless the criteria set out in Section 3.13 are met.

Paragraph 2.2.1.6 states that: Lands within **The Soil Protection Overlay** represent an irreplaceable resource and will be protected over the long term for food production and other agricultural uses. The Soil Protection Overlay has been identified based on the following criteria: the availability of the best agricultural land, suitability under projected climatic conditions, access to or potential for irrigation water and the provision of the support services necessary for the efficient production of food crops. Within the Soil Protection Overlay:

a) Alienation of land to non-agricultural uses will not be permitted.

b) The Government will encourage the return of idle lands to agricultural production including, but not limited to, exploring incentives for farmers and landowners to do so.

With regard to development on or adjacent to agricultural lands, **Paragraph 2.2.1.10** sets out the procedures and requirements for consideration of such proposals:

Agricultural Impact Statements will be required for new major development proposed on or adjacent to lands designated for agricultural use.

a) A change of use or subdivision of agricultural land for a site greater than two acres or more than 5 residential lots will require an Agricultural Impact Assessment to determine impacts on or incompatibilities with agricultural use.

b) Agricultural Impact Statements will be prepared in accordance with Section 5.

Paragraph 2.2.1.11 goes on to state that: new development adjacent to Food and Agricultural land will only be permitted if it can be demonstrated that surrounding agricultural operations have the ability to carry on normal farm practices and development will not adversely impact farming practices.

Paragraph 2.2.1.12 further states that: new development adjacent to Food and Agricultural land will provide sufficient buffers to mitigate land use conflicts with farming operations to the extent feasible. This would depend on the size and nature of the proposed use, the existing agricultural uses, and on any buffering factors between them. For example, gulleys, roadways and other prominent features would be helpful in defining and screening a non-agricultural use from surrounding farms.

Section 5.2 of the Draft Plan seeks to explain the Development Approval Process:

Paragraph 5.2.2 states that: where development applications do not, in the opinion of the Chief Town Planner, conform to the policies of the PDP:

a) The applicant may be refused, without further consideration, or

b) Where the Chief Town Planner deems further consideration of the application is warranted, they may:

i) Undertake a detailed planning review of the merits of the application;

ii) Require the proponent to prepare one or more of the following to identify and address impacts arising from the potential development:

• An Environmental and Social Impact Assssment (ESIA) where it is required or where the Chief Town considers that there may be environmental impacts and/or impacts to Core Assets on this island or the development is within a floodplain, natural hazard or risk prone area.

• An Agricultural Impact Statement (AIS) where it is required or where the Chief Town Planner considers that there may be an impact on the Food and agricultural zone and food production.

Section 5.3 states that Impact Assessments are a key tool to assess proposed development and infrastructure projects. There are four types of impact assessment contemplated in the PDP Amended: **Environmental and Social Impact Assessments**; Heritage Impact Assessments; **Agricultural Impact Assessments** and; Traffic Impact Assessments.

Where Impact Assessments are required, they shall be completed to the satisfaction of the Chief Town Planner (or Minister), prior to approval being given. Approvals of development subject to Impact Assessments may contain certain conditions of approval to ensure that adverse impacts of such development are mitigated.

Agricultural Impact Assessments

Of specific relevance to this application, an Agricultural Impact Assessment will be required to consider any development proposal that would result in alienation or fragmentation of Food and Agricultural Land or when development is proposed adjacent to Food and Agricultural Land. The AIA will:

a) Describe the proposed development and contextual factors

b) Determine potential adverse impacts on Food and Agricultural lands and active agricultural operations on-site and adjacent to the site in the surrounding area; and

c) Recommend measures to buffer, mitigate and minimize potential land use conflicts.

In this context, the Draft Physical Development Plan recognises (Section 5.2.2) that some development applications do not conform to the policies of the plan but nevertheless warrant further consideration. This proposal is an example of such a development and its merits should be given due consideration.

2.4 Baseline Conditions

2.4.1 Harrow Plantation

Harrow Plantation has an area of 304 acres with most of the productive lands having been traditionally in sugar cane. There are currently 252.5 acres in arable production. The application site will utilise 184 acres.

Figures 2.3 – 2.7 below show current baseline conditions within and close to the Plantation.

Figure 2-3 View of Plantation from Northern Boundary

Figure 2-4 Sugar Cane Cultivation at Harrow

Figure 2-5 View south-west over Harrow Plantation

Figure 2-6 Harrow Plantation Yard

Figure 2-7 Housing at Padmore Village

2.4.2 Agro-ecological Context

Harrow Plantation falls within in the Agro-ecological Group C. Agro-ecological group is defined by soil type, land capability i.e., slope, fertility, drainage and effective rainfall-annual total and distribution within the growing season that meets the need for a specific crop during its growth cycle.

Group C is regarded as a less productive zone because of the above factors with effective rainfall ranked highest as the most binding constraint to crop development within the area.

2.4.3 Rainfall

Total rainfall distribution throughout the growing cycle is a very important variable. Table 2.1 below shows the measured rainfall totals at Harrow for the period 2011-2020. For sugarcane growth approximately 56 inches of rainfall is required for optimum growth during the growing period and output at harvest.

Given that total rainfall in some years fell below the maximum amount required (56 inches) for optimum sugar cane output the plantation would not have met its optimum growth during production.

Year	Inches
2020	29.27
2019	35.97
2018	43.40
2017	54.75
2016	61.59
2015	36.69
2014	40.92
2013	62.69
2012	57.70
2011	71.50

Table 2-1 Rainfall at Harrow Plantation 2011-2020

2.4.4 Soils

The Soils and Land-Use Surveys (Vernon and Carroll) published by The Regional Research Centre, Imperial College of Tropical Agriculture, March 1966 classifies the soils of the coral region of Barbados into nine associations, an association being a group of soils developed from the same parent material within one climatic area and representing the range of profile types produced as a result of differences in drainage. In these soils, the range of profile types is closely associated with depth characters and the depth of coral rock has been used to define the various associates.

The report identifies the northern portion of Harrow Plantation as St. Philip Plain Association Soil (imperfectly drained associate) which is further described as clay soils developed from lagoonal or other clay deposits. The report identifies this type of soil as ‘Poorly drained marly soils’ that occur in a region of erratic rainfall. They are considered to be relatively poor cane producers, but the report acknowledges that the parts of St. Philip where these soils occur are moderately flat and suitable for mechanisation. The southern portion is identified as Grey Brown Association – more mature soils. These are further identified as normal associate (deeper than 18 inches) and shallow associate (a depth of 10 to 20 inches). The report states that cane is likely to give the best return.

2.4.5 Cropping systems

Traditionally mono-cropping of sugarcane with rotation of secondary crops has been the production pattern at Harrow. At present Sugarcane accounts for 193.75 acres under various rotations with 17.5 acres of cotton grown as a rotation enterprise, while 89.25 acres are fallowed/rested.

The irrigation well at Harrow requires extensive refurbishment and this can facilitate year round growth of cash crops once it is renovated.

2.4.6 Historic Performance

Within the recent past, all farms managed by the BAMC have underperformed given cash-flow constraints of the parent company to provide field inputs in a timely manner aligned to crop growth/biological requirements. Substandard management practices at the farm level have also contributed to low production. Given the above conditions, actual productivity indicators suggest underperformance within crop production at Harrow.

2.4.7 Present performance

Given good management practices, (effective weed control, high plant population, varieties suitable for the area) within the present crops an estimate of potential output can be made for the area. Table 2.2 below shows the estimated output to be harvested at Harrow for the 2022 harvest. The productivity indicator ranges between 25-30 tons of cane per acre for the farm using the, “Methodology for establishing productivity potential for sugarcane in Barbados” which is a performance index developed by Thelma McCatty and Ranjit Singh (Barbados Cane Industry Corporation). Given the low rainfall of 29.27 inches in 2020, the achievement of output of 22 tons per acre during the harvest 2022 within the Conventional Plant Cane (CPC) would indicate that other factors described under good management practices above are critically important to raising field productivity on a per acre basis.

Sub Farm Unit	**Harrow**		
	Acres	**Tons/Acre**	**Total**
Sugarcane Production			
CPC 2020/22	77.00	22.000	1694.000
HWT CPC 2020/22	9.00	20.000	180.000
HWT 2020/22 R1	2.50		
HWT 2019/21 R2			
Force Back			
Ratoon 1	15.75	18.000	283.500
Ratoon 2			
Ratoon 3			
Ratoon 4			
Ratoon 5			
Sub Total	**104.25**		**2157.500**
TOTAL TONS			**2157.500**

Table 2-2 Estimated Output at Harvest 2022 (source: BAMC)

2.4.8 Site Drainage

There are no major water courses or drainage features within the site other than a series of low areas or small depressions located throughout. Typically, low lying areas are drained via suckwells of which there are 23 located throughout the site.

2.4.9 Land Use in Vicinity of Site

The application site is located within an area that has traditionally been rural in character. The dominant land use has been agriculture with mainly sugar cane cultivation taking place within the application site and surrounding agricultural lands. Any residential development would have been located within the existing tenantries. The main changes within the immediate environs have related to the:

- Planned expansion of the Six Cross Roads Regional Centre to the south.
- Development of Bushy Park race track facility to north-east.

2.4.10 Topography

The application site is located within a generally flat and expansive agricultural area typical of rural St. Philip see Figures 2.3 and 2.5 above.

Figure 2.8 below shows the site's topography. There is a 23 metres variation in elevation from the northern boundary to the southern boundary of the Plantation. This represents an average gradient of around 1:50. Within the site there are a few depressions and elevated areas. There is an east-west ridge to the south of the plantation yard which separates the north-west quadrant of the planation from the south-west quadrant with a 10 metres variation in elevation between the higher land to the north and lower land to the south.

Other than the cluster of buildings within and around the plantation yard, there are no other buildings within the plantation. The agricultural lands are separated into individual fields, often separated by cart tracks. The main areas of non-arable lands lie to the east of the plantation and to the west along the above mentioned ridge.

Figure 2-8 Topographical Survey of Site – Heights are in Metres

3 Evaluation of Impacts

3.1 Impacts on Lands of Harrow Plantation

3.1.1 Current and Proposed Agricultural Activity

The application site has traditionally been used for the cultivation of sugar cane and rotational crops, mainly cotton. It will now be used for renewable energy purposes combined with sheep farming (see Table 3.1 below).

The proposed Solar Photovoltaic Energy Generation and Storage Facility will occupy an overall lease area of 182 acres south and east of the plantation yard. The facility will incorporate a sheep farm with a total of 1830 Black Belly sheep, hence the proposal is for the dual agriculture and renewable energy use of the site. This agricultural component will comprise the following:

- Fodder pasture – 25.45 acres located to the north-east of the solar farm.
- Agricultural, office and Storage Facility – 5.63 acres located to the south of the fodder pasture and occupied by 4 no. sheep pens, hay storage building, staff building and office/storage building.
- Solar Grazing Area – 141.73 acres taking up the bulk of the application site and providing covered (under solar panels) and uncovered grazing area. It should be noted that there will be no sheep grazing/access to the 3.92 acres HyCPE facility containing equipment and system for energy storage.

Sheep grazing takes place at other solar facilities on the island including Barbados Light and Power's photovoltaic farm at Trents, St. Lucy (see Figure 3.1 below).

Figure 3-1 Sheep Grazing at Trents PV Farm, St. Lucy

Table 3.1 below shows **agricultural use** within the plantation for 2021 and for the post development operational phase. The 2021 totals are based on data provided by the BAMC as is the 2022 estimate for sugar cane production.

Harrow Plantation yard remains part of the plantation but is not used for management purposes, which takes place from Mount Pleasant Plantation in St. John.

Agricultural Production (acres)		
Period	**2021**	**Post Development**
Sugar Cane	193.75	104.50 (2022 estimate)
Sugar Cane (prepared – not planted)	41.25	
Cotton	17.50	
Sheep Grazing Combined with Solar		141.73
Fodder Pasture		25.45
Sheep Pens		5.63
Total Acres	**252.50**	**277.77**

Table 3-1 Harrow Plantation - Agricultural Use

3.1.1.1 Impact on Agricultural Production

The figures in Table 3.1 demonstrate the shift from solely arable production to arable combined with sheep farming and renewable energy. If we are to look at the reduction in sugar cane production alone, it is estimated to be 89.25 acres.

3.1.2 Operational Impacts

The proposed solar photovoltaic energy generation and storage facility will not adversely impact continued agricultural activity (mainly sugar cane production) on the remaining plantation lands. The facility will have its own dedicated access off Harrow Road to the north and it will be separated from the remaining lands of the plantation by a fence and approximate 10 metre buffer zone between the solar panels and fence. There will inevitably be some inconvenience caused during the construction phase, but the agricultural operations of the plantation will not be unduly interrupted during this phase.

There will be no fragmentation or alienation of any of the remaining planation lands due to the simple manner in which the overall planation is being divided to accommodate the proposed facility.

3.1.3 Impact of Agriculture on Development

The potential for agricultural activity to have an impact on the proposed development also has to be considered. In this regard, it should be noted that the overall plantation is bounded by agricultural activity mainly to the east, west and north-west. Post development, agricultural activity will continue on all of these lands and it is considered that any such activity will have minimal impact, if any on the proposed facility. Indeed, the introduction of sheep grazing within the facility will have the positive impact of limiting vegetation growth on the land occupied by the solar farm.

The only potential negative impact that agriculture would have on the proposed facility would be through the use of herbicides which can potentially impact workers at the site. Spraying does take place periodically using herbicides approved by the Pesticide Control Board. It is expected that any post development impact on the site from the remaining plantation lands would be minimal due to the prevailing wind direction being from the south-east, east and north-east. There is always the potential for impacts from adjoining plantations to the east and west. These lands are outside the control of the applicant.

3.2 Agricultural Viability

The Plantation will remain in agricultural use. All the productive lands to the north of the proposed facility will remain in mainly sugar cane production, managed and operated by the Barbados Agricultural Management Company (BAMC). The viability of the continuation of sugar cane production will depend on external factors unrelated to site specifics. There is also scope for other crops to be introduced in the future.

The lands included within the proposed facility will be utilised for the sheep farm project. A total of 1830 sheep will graze throughout the facility with land also being allocated as a fodder pasture. Four sheep pens are also proposed. The combination of sheep grazing and ground mounted solar photovoltaics is a viable and practical option that has been widely implemented elsewhere.

3.3 Drainage Impacts

Drainage impacts have been reviewed elsewhere in the EISA document. Given that the main drainage flows are from north to south, there are unlikely to be any post-development impacts on the other lands of Harrow Plantation which are north of the proposed facility.

3.4 Construction Impacts

Construction impacts on the site and surrounding area will occur over a relatively short period of time and can be managed. The most common impacts are dust and noise which can affect both construction workers, those employed on adjacent agricultural lands and neighbouring residents. Drainage issues can also arise during the construction of roads, car parks and buildings as systems and structures are typically not in place as work proceeds.

Adjoining agricultural lands of the plantation and other plantations could potentially experience dust and drainage impacts during the construction process.

3.4.1 Description of Construction Activities

Construction work will involve the following:

a. Site preparation:

   i. Road access construction.

   ii. Vegetation removal (only light vegetation), levelling of the soils.

   iii. Installation of temporary installation for works.

   iv. Platform levelling for HyCPE area, and other buildings.

   v. Internal road construction and drainage system for management of runoffs.

   vi. Trench digging.

b. PV Construction
    i. PV structure foundation construction.
    ii. PV structure assembling.
    iii. PV modules installation.
    iv. Power station foundation construction.
    v. Power station installation.
    vi. Installation of cabling, boxes and auxiliaries from PV modules to power station, and power station to HyCPE.

c. HyCPE Construction
    i. Foundation construction.
    ii. Electrical building construction.
    iii. Installation of integrated systems (electrolyser, fuel cell containers, battery, etc).
    iv. Erection of Electrical and Mechanical Balance of Plant (BOP) - cabling, piping, auxiliaries.

d. Construction of Buildings (Guardhouse, Operation, Sheep pens).

e. Finalisation
    i. Pre-commissioning of sub-systems (PV, batteries, etc).
    ii. Connection of all the power plant.
    iii. Connection to the grid.
    iv. Commissioning of the entire.

3.4.2 Construction Mitigation Measures:

- Any imported marl shall be placed, spread, and compacted in place with a minimum of stockpiling and in a linear programme of completion. Any marled surfaces shall be watered on a regular basis to reduce dust dispersion.
- A water vessel should be available and used when needed to suppress dust generation during windy periods.
- Concrete mixing shall be undertaken in such a way to prevent the run-off of slurry into adjacent properties or public road.
- Site workers will be required to wear hard hats within the construction zone.
- Mechanical equipment shall use noise reduction measures.
- Generally, working hours shall be 0700 to 1800, Mondays to Fridays and 0730 to 1230 on Saturdays for all work at the site. The only exception to this will be when instances arise where is it will be necessary for overtime work due to schedule management. Such work may take place on Sundays.

3.4.3 Sediment Dust Control and Site Management Plan

A Sediment, Dust Control and Site Management Plan is often required as a condition of permission granted for construction projects. Its purpose is to ensure that impacts on nearby receptors, including, in this case, agricultural workers, is minimised as far as possible, given that most construction work inevitably involves some level of inconvenience. Preparation of such a plan ensures that the developer considers the wider impacts of the construction process outside the immediate site boundaries.

3.4.4 Site Management

The following relates to the works described in Section 3.2.2.1 above:

3.4.4.1 Supervision

- Site management and supervisory staff will be responsible for daily assessments of conditions with respect to dust generation, noise, material storage and sediment run off.
- The site supervisor will be briefed on the site management plan. The brief will convey the need to avoid activities and works which create nuisance.
- Should any situation arise resulting in nuisance or pollution, the supervisor shall immediately access the activity and, if deemed necessary, cease operations until the response to the problem can be implemented.

3.4.5 Control of Dust

Potential sources of dust may arise from:

- Site clearing.
- Excavation.
- Spreading of marl fill.
- Delivery and tipping of sand and stone and marl fill.
- Storage of sand and cement on site.
- Vehicular traffic and construction plant.

The most effective method of dust control is the wetting of surfaces when the problem arises. This will take place particularly when vehicular movements are the cause of the problem. Site burning of materials will be prohibited and loading/tipping from trucks will be monitored and material sprayed with water should the need arise.

Given that the prevailing wind direction is from the north-east to the south-east, dust impacts may be experienced by residents of Padmore Village and the northern extremity of Six Cross Roads. While this report is focussed on the Agricultural Impacts of the proposed development, it is nevertheless important to consider the impacts of construction on the wider community and the following measures are recommended:

- Stockpiles of topsoil and building materials should be covered in order to reduce dust generation.

- A water vessel should be available and used when needed to suppress dust generation during windy periods.
- Within the site, all vehicles should be encouraged to drive at speeds no greater than 10mph in-order to reduce dust generation.

Site workers also need to be protected from dust impacts and it is recommended that dust masks be made available for all workers.

3.4.6 Control of Noise

Potential sources of noise are identified as follows:

- Excavation and any resulting rock breaking – limited to foundations work.
- Compaction and spreading of marl fill.
- Cement mixers and other equipment. Tipping from trucks. To mitigate noise nuisance, working hours will be restricted to 0700 to 1800, Mondays to Fridays and 0730 to 1230 on Saturdays for all work at the site.

3.4.7 Control of Sediment

The main issue here is the accumulation of sediment caused by surface water run-off. At the site access every effort will be made to ensure that no sediment is discharged on to the public road.

3.4.8 Control of Construction Waste and Materials

Waste generation is addressed with respect to the following:

- General construction debris -
  This waste will be collected daily and transported to the skip location on site. When full, each skip will be collected and taken to a licensed tip.
- Reinforcement ends and cutting/metals -
  Re-bar and metal cuttings will be stockpiled neatly on site in a designated area. When the stockpile is deemed to be redundant and unusable, all off-cuts and steel cuttings will be placed in a skip and taken to a licensed tip.
- Light weight debris susceptible to blowing about site –
  Debris which is liable to blow around the site will be secured, bundled, and placed in the general construction skip and taken to a licensed tip. The skip will be covered during transportation.

Construction waste is discussed further in Section 3.3 below (Waste Management Plan).

3.4.9 Operational Phase

Potential sources of dust nuisance during the operational phase:

- Wind generated dust dispersal from between and underneath the panels.
- Wind generated dust dispersal from vehicles traversing over marled access roads within the site.

3.4.9.1 Operational Phase Dust Mitigation Measures

The following mitigation measures are recommended for the operational phase:

- Grass should be planted between and underneath panels. Any bare patches should be replanted as quickly as possible.
- Maintenance vehicles, with the exception of safety response/emergency response and urgent project related matters, should drive at a speed of no more than 10 mph over the marled access track within the site to avoid dust dispersal during dry periods.
- Vegetation screens can be planted along any portion of the site boundary close to any residential receptors that may be impacted by dust.

3.5 Waste Management Plan

3.5.1 Construction Phase

During construction, the contractor will ensure that all surplus waste materials are dealt with responsibly. Relevant waste and resource management procedures will be communicated to all operatives during the initial site induction. This will include procedures on segregation, handling, recycling, re-use and return methods to be used. A specific area will be set out to facilitate separation of the various types of waste.

Potential waste streams during the construction process are:

- Packaging material. PV modules typically arrive in wooden pallets which will be forwarded to a pallet management company for re-use. These pallets are often encased in either wood crates or cardboard boxes which will be segregated and removed from site on a regular basis.
- Packing materials for other components, such as screws, cabling and mounting frames will be segregated and transported to a suitable land fill.
- Food waste from workers. This will also be taken to a suitable land fill.
- Portable toilet waste. Removed from site by supplier.
- In order to prevent any silt runoff and dust creation, any waste soils that have been excavated from the site will be reused as backfill materials, or re-distributed around the site and used for remediation and biodiversity enhancement features.

3.5.2 Operational Phase

It is expected that the operational phase will result in the production of general waste consisting mostly of cardboard, paper, plastic, metals and a variety of synthetic compounds. Limited hazardous wastes (grease, oils) may also be generated during maintenance activities. All waste generated will be required to be temporarily stored at the facility in appropriate sealed containers prior to disposal at a permitted landfill site. Sheep waste will also be generated.

The following waste management principles should apply during the operational phase:

- The Site Manager must develop, implement, and maintain a waste inventory reflecting all waste generated during operation for both general and hazardous waste streams.
- Adequate waste collection bins at site must be supplied. Separate bins should be provided for general and hazardous waste.
- Recyclable waste must be removed from the waste stream and stored separately.
- Waste storage shall be in accordance with all best-practice guidelines and under no circumstances may waste be burnt on site.
- Vegetation removed from the site must be chipped, removed from the site and disposed of at an appropriate waste disposal facility or used as mulch on site.
- Waste generated on site must be removed on a regular basis throughout the operational phase.
- Waste must be removed by a suitably qualified contractor and disposed at an appropriately licensed landfill site. Proof of appropriate disposal must be provided by the contractor.
- Sheep waste will be removed daily to avoid flies and insect infestation and will be used as fertiliser elsewhere on the plantation or donated to local farmers.

3.5.3 End of Life – Decommissioning

3.5.3.1 Overview

Solar photovoltaic panels degrade slowly over time, their viable lifetime is estimated at a minimum 25 year. The International Renewable Energy Agency estimated that there were about 250,000 metric tons of solar panel waste in the world at the end of 2016 and that the figure could reach 78 million metric tons by 2050. Solar panels contain lead, cadmium, and other toxic chemicals that cannot be removed without breaking apart the entire panel. While disposal of solar panels has taken place in regular landfills, it is not recommended because like any other waste, it carries the potential for pollution leakage. Solar panels can be recycled but adequate industrial facilities need to scale up in order to make it economically viable. Regardless, solar panel waste disposal is a problem that needs to be addressed.

Washington State is the only U.S. state that requires the manufacturer to develop a recycle plan, but the state requirement does not address the cost of recycling.

Natural events such as hurricanes and earthquakes can cause damage to the panels. For example, the second largest solar farm in Puerto Rico, generating 40 percent of the island's electricity, was severely damaged during Hurricane Maria.

A state-of-the-art recycling network for PV panels will have to be developed over the coming years to ensure responsible end of life disposal for an ever-growing volume of PV panels, and is a key element of a responsible transition to a clean energy economy.

3.5.3.2 Course of Action

Currently, less than 1% of PV panels in existence needs to be disposed of annually. In contrast to the more mature and saturated consumer electronics market, the PV industry is still in a relatively early stage.

There are presently no suitable mechanisms in place to monitor the disposal of used PV panels within Barbados. The two options that are available appear to be landfill and export for recycling. In the case of landfill, there are clearly risks involved due to the possibility of toxic materials leaching. The best option may be to export used panels for recycling. In this respect, pilot recycling facilities are already operational in Europe. However, this will depend on economic viability as well as the willingness of other countries to accept the panels.

There is no definitive plan in place for the island to deal with disposal of used PV panels and it is clear that government and the solar industry need to develop a workable strategy for their safe disposal. In this respect, it is fortunate that PV waste volume will remain relatively low for many years to come which should allow sufficient time to establish a proactive waste management infrastructure.

Decommissioning of the operation is expected to last approximately twelve months for dismantling of the power plant, expedition of equipment and material to recycling and treatment facilities as well as clearing of the site

Following the decommission phase the site can be re-instated or used for another purpose subject to any requirement for planning permission.

The design lifetime of the installation is thirty years, although the contractual duration will be twenty-five years at least. Any possible extension of operation will depend on degradation status on the installation and environment factors such as power demand in Barbados.

4 Summary of Mitigation Measures

The following is a summary of the mitigation measures recommended for both the construction and operational phase of the project:

a) Construction activity should be carried in a manner that limits any negative impacts on nearby residents. It is recommended that a condition should be attached to any planning permission granted which requires the submission and approval of a Sediment, Dust Control and Site Management Plan for the construction phase of the project. This should include details of how the developer will liaise with the local community before each phase of development.
b) A tree screen should be planted along the western and southern boundaries of the site to act as a buffer to adjoining agricultural lands. The details of this screen can be submitted under condition of any permission granted.
c) The plantation should limit the spraying of herbicides on adjoining fields to days that are not windy in order to prevent any dispersion onto the operational renewable energy facility and sheep farm.

5 Conclusions

This Agricultural Impact Assessment has sought to address the main agricultural considerations relating to the proposal with reference to current and proposed policy.

The loss of arable production at the plantation, mainly sugar cane, will be offset by the introduction of sheep livestock farming as part of the renewable energy project.

While the lands of the plantation are flat and thereby suitable for mechanical sugar cane production, yields are impacted by low rainfall and poorer quality soils. The loss of approximately 90 acres of arable land must be seen in the above context together with the benefits from the resulting level of investment in the renewable energy generation and storage facility. These factors provide sufficient justification for a departure from policy as facilitated by Section 5.2.2 of the Draft Physical Development Plan 2017.

It is considered that the proposal will have a limited impact on the agricultural activities of the remaining lands of the Plantation by virtue of the benign nature of the proposed development, together with the fact that agricultural activity (sheep farming) will continue at the site.

The economic and social benefits of the proposal provide further justification for the proposed renewable energy generation and storage facility. This will provide lasting benefits to the local community and the entire country.

6 References

- Government of Barbados' Town & Country Planning Development Planning Office, – *Physical Development Plan Amended 2003.*
- Government of Barbados' Town & Country Planning Development Planning Office, – *Draft Physical Development Plan 2017.*
- Barbados Agricultural Management Company, Agronomy Research and Variety Testing Unit, Ltd. – *Sugar Cane Growers Manual, Second Edition.*
- Vernon and Carroll - The Regional Research Centre of the British Caribbean, - *Soils and Land-Use Surveys, March, 1966.*

7 List of Persons Contacted During Study

- Mr. Anderson Eversley – Barbados Agricultural Development Management Company.

8 Study Team Members

William Robert Bain BA (Hons), BTP, MRTPI is Principal of Bain Planning and Development, a Barbados based Town Planning consultancy. He holds a Bachelor of Arts Honours degree in Urban and Regional Planning (upper second class), together with a

Bachelor of Town Planning degree (commendation) and is a full Member of the Royal Town Planning Institute. He is also a member of the Barbados Town Planning Society and has previously served as their representative to the Government's Planning Advisory Committee. He has over 26 years' experience in private planning practice representing a broad range of clients in the residential, tourism, medical, agricultural, retail, quarrying and industrial sectors. He also has experience in the preparation of Environmental Impact Assessments and Environmental Scoping Studies for a broad range of projects including resort, quarrying, renewable energy, hospital and educational developments. Prior to relocating to Barbados in 1995, William was employed in public sector planning in the UK for 7 years.

APPENDIX D

Quantitative Risk Assessment

Quantitative Risk Assessment of the Proposed Renewstable® Barbados Hybrid Renewable Power Plant with Hydrogen Storage

FINAL REPORT

February 4, 2022

Prepared for:

Renewstable® Barbados

Prepared by:

Stantec Consulting Caribbean Ltd.

Project Number: 128019045

Revision: 1

Limitations and Sign-off

This document entitled Quantitative Risk Assessment of the Proposed Renewstable® Barbados Hybrid Renewable Power Plant with Hydrogen Storage was prepared by Stantec Consulting Caribbean Ltd. ("Stantec") for the account of Renewstable® Barbados (the "Client") to support the regulatory review process for its Environmental Impact Assessment (the "Application") for the Renewstable® Barbados Hybrid Renewable Power Plant with Hydrogen Storage (the "Project"). In connection therewith, this document may be reviewed and used by the Town & Country Planning Development Office participating in the review process in the normal course of its duties. Except as set forth in the previous sentence, any reliance on this document by any other party or use of it for any other purpose is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The information and conclusions in the document are based on the conditions existing at the time the document was published and does not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by the Client or others, unless expressly stated otherwise in the document. Any use which another party makes of this document is the responsibility and risk of such party. Such party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other party as a result of decisions made or actions taken based on this document.

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Principal, Environmental Services

Executive Summary

Renewstable® Barbados (RSB) retained Stantec Consulting Caribbean Ltd. (Stantec) to perform a consequence assessment and a Quantitative Risk Assessment (QRA) associated with accidental releases from the proposed Harrow hybrid renewable power plant with hydrogen storage (the Project). The Project will be a photovoltaic plant combined with an energy storage system using hydrogen technologies for long-term storage and a battery system for short-term storage. Utilizing multiple electricity generation and storage technologies allows the Project to deliver stable power to the grid 24 hours per day. The plant will include:

- A 50 MWp photovoltaic plant
- An electrolyzer system with a total capacity equivalent to 16 MW
- Gaseous hydrogen storage in pressurized cylinders, with a maximum of 8 tons of H_2 stored on-site
- A Battery Energy Storage System (BESS) with 14 MW maximum power capacity (3 hour)
- A high-power fuel cell system with a capacity of 3 MW
- Operation facilities and utilities including an electrical room, water treatment, water supply, etc.
- A sheep farming facility

The Project will generate up to 13 MW of power for the grid during the daytime/evening and up to 3 MW during the night.

The QRA for the Project involved the following tasks:

1. Source characterization of several loss of containment (LOC) scenarios, including:
   a. Estimated time-varying H_2 release rates in the event of storage, piping, electrolyzer or fuel cell ruptures or leaks
   b. Flammable or toxic gas releases due to upset conditions associated with the BESS.
2. Consequence modeling to determine the extents of hazard zones for various combinations of release types, hazards and meteorological conditions
3. Risk modeling, which combines the results of the consequence modelling with the probability of a release occurring, to provide an estimate of the likelihood of harm on individual or societal bases

The primary hazard associated with accidental releases from the Project is the flammability of the gas. Accidental releases of H_2 may result in hazardous events including:

- Flash Fires (impingement of a moving flame front);
- Vapour Cloud explosions (overpressure resulting from a flame front moving rapidly through a congested area);
- Jet Fires/Fireballs (exposure to thermal radiation); and

- Explosions from storage vessels or process containers (overpressure, shrapnel and thermal radiation).

Consequence modelling was completed for potential hazardous events to provide the distances to selected endpoints. This modelling was completed for a range of weather conditions, release scenarios and configurations. The results of this modelling can be used to inform emergency responders and assist in the development of emergency response plans. Additionally, the consequence modelling was used as input to the subsequent risk modelling. The maximum predicted distance to selected emergency planning end points include:

- Flash Fire: Distance of 306 m to 50% of the lower flammability limit (LFL) and 193 m to the LFL resulting from the catastrophic failure of a H_2 storage cylinder;
- Fireball/Jet Fire: Distance of 47 m to 2nd degree burns (5 kW/m^2 over 40 seconds) as a result of a catastrophic failure of a H_2 storge cylinder;
- Explosion: Distance of 149 m to 6.9 kPa overpressure from a vessel explosion of a H_2 storage cylinder; and
- Explosion: Distance of 272 m to 6.9 kPa overpressure from a vapour cloud explosion.

The flash fire extents as defined by the LFL/2 concentration, as well as overpressure extents, as defined by the distance to 6.9 kPa overpressure, are not predicted to reach permanent residences in the vicinity of the facility. The remaining emergency planning and response consequence endpoints considered are also not predicted to reach permanent residences in the vicinity of the facility.

Risk modelling was completed to evaluate the potential for harm at locations in the vicinity of the facility. The modelling was completed with consideration of both the potential consequences and their likelihood of occurrence. The failure frequencies were obtained from published United Kingdom Health and Safety Executive (UK HSE) data (HSE 2017). Meteorological data from the Grantley Adams International airport was used to estimate the frequencies of selected meteorological conditions. The results of the risk modelling were compared to criteria published by the National Fire Protection Association (NFPA). The NFPA criteria are commonly used to assess risk acceptability throughout North America and the Caribbean.

Based on Stantec's current understanding of the facility and from the perspective of public safety, the risk modeling predictions indicate that the siting of the Project is acceptable.

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1.0 INTRODUCTION

Renewstable® Barbados (RSB) retained Stantec Consulting Ltd. (Stantec) to perform a Quantitative Risk Assessment (QRA) associated with accidental releases from a proposed photovoltaic (PV) power plant with hydrogen (H_2) generation and storage facilities for night-time power generation. The project also includes a Battery Energy Storage System (BESS) to complement power delivery when needed.

The primary hazard s associated with H_2 releases include the potential for a flash fire, jet fire, enclosure explosion or a vapor cloud explosion. Hazards associated with the BESS are thermal radiation or explosions from ignition of flammable substance releases. The potential release scenarios for the Project include ruptures and leaks from the H_2 storage cylinders, piping, electrolyzers, fuel cells, and battery fires/explosions.

This report outlines the modelling methodology and assumptions used to conduct the QRA. The report also provides estimates of the distances to selected hazard endpoints.

This report is divided into the following main components:

- System Description (Section 2.0);
- Hazard Identification (Section 3.0);
- Source Characterization (Section 4.0);
- Dispersion and Consequence Modelling (Section 5.0);
- Risk Modelling (Section 6.0);
- Results (Section 7.0); and
- Conclusions (Section 8.0).

2.0 SYSTEM DESCRIPTION

2.1 OVERVIEW

The Project includes a photovoltaic plant combined with an energy storage system using hydrogen technologies for long-term storage and a battery system for short-term storage. Utilizing multiple electricity generation and storage technologies allows the Project to deliver stable power to the grid 24 hours per day. The plant will include:

- A 50 MWp photovoltaic plant
- An electrolyzer system with a total capacity equivalent to 16 MW
- Gaseous Hydrogen storage of 90 MWh in pressurized cylinders, with a maximum of 8 tons of H_2 stored on-site
- A Battery Energy Storage System with 14 MW maximum power capacity (3 hours)
- A high-power fuel cell system with a capacity of 3 MW
- Operation facilities and utilities including an electrical room, water treatment, water supply, etc.
- A sheep farming facility

The Project will generate 13 MW of power for the grid during the daytime/evening and 3 MW during the night. The plant is to be sited at Harrow, Barbados. The majority of the Project site will be used for the implementation of the PV power plant and will also accommodate sheep farming and grazing.

A satellite view of the Harrow Plantation site, locating the Project relative to the surrounding land use is provided in Figure 2.1. The PV infrastructure within the site is shown in Figure 2.2 and a close-up view of the process area is shown in Figure 2.3. A simplified process flow diagram for the Project is presented in Figure 2.4.

The following sections provide details of the Project components.

Figure 2.1 Project Location

Figure 2.2 Plan View of the Project

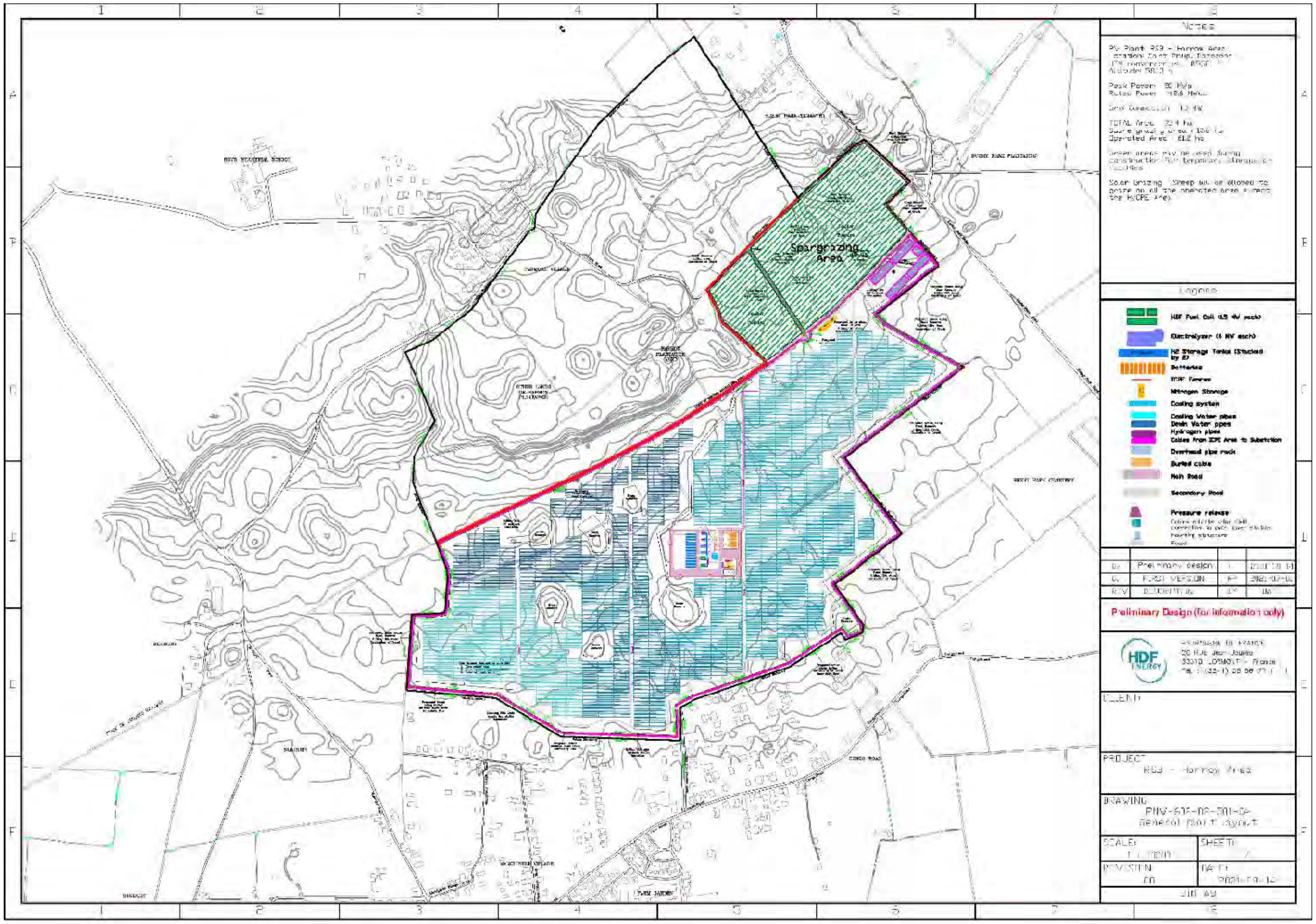


Figure 2.3 Plan View of the Process Area

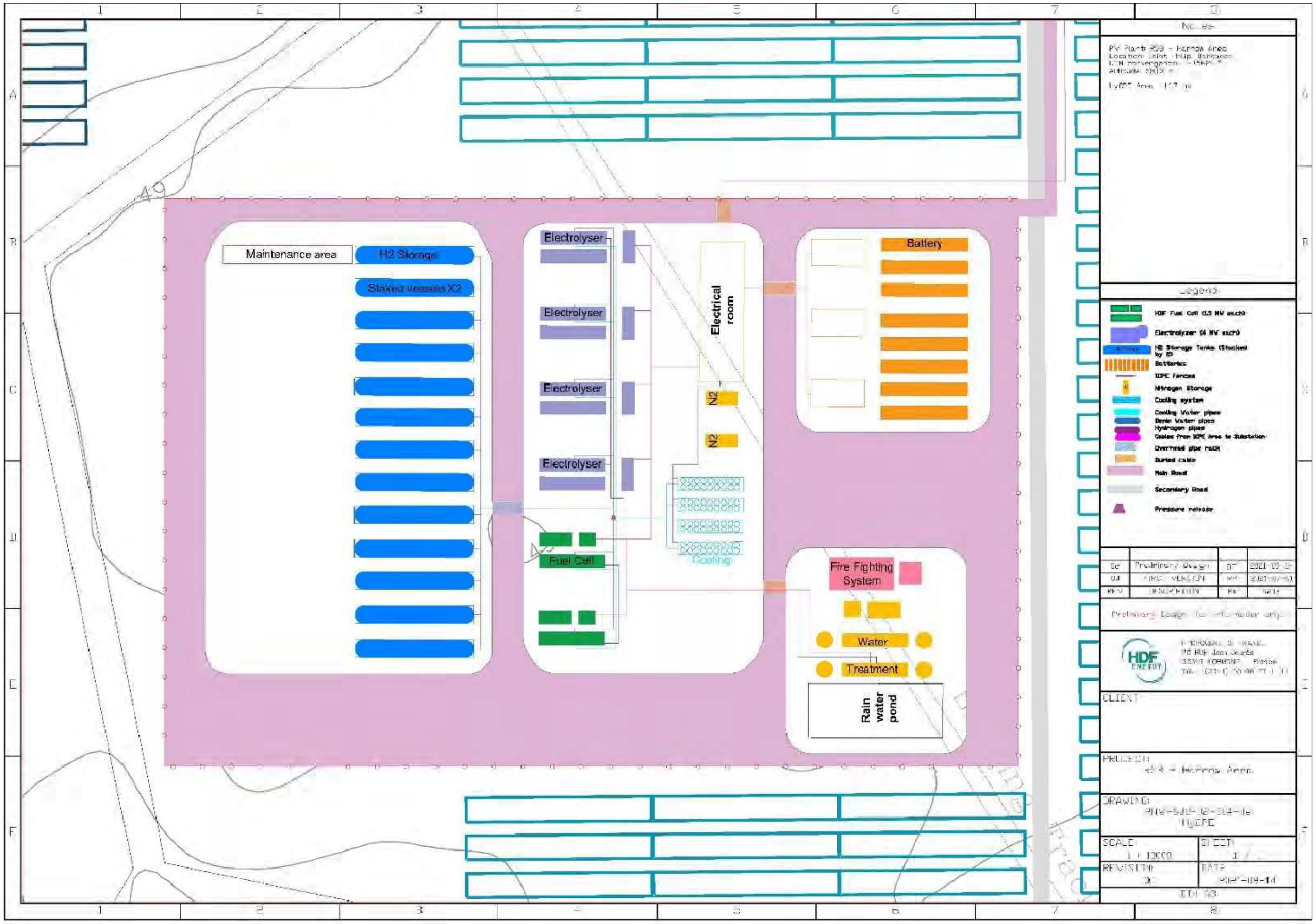
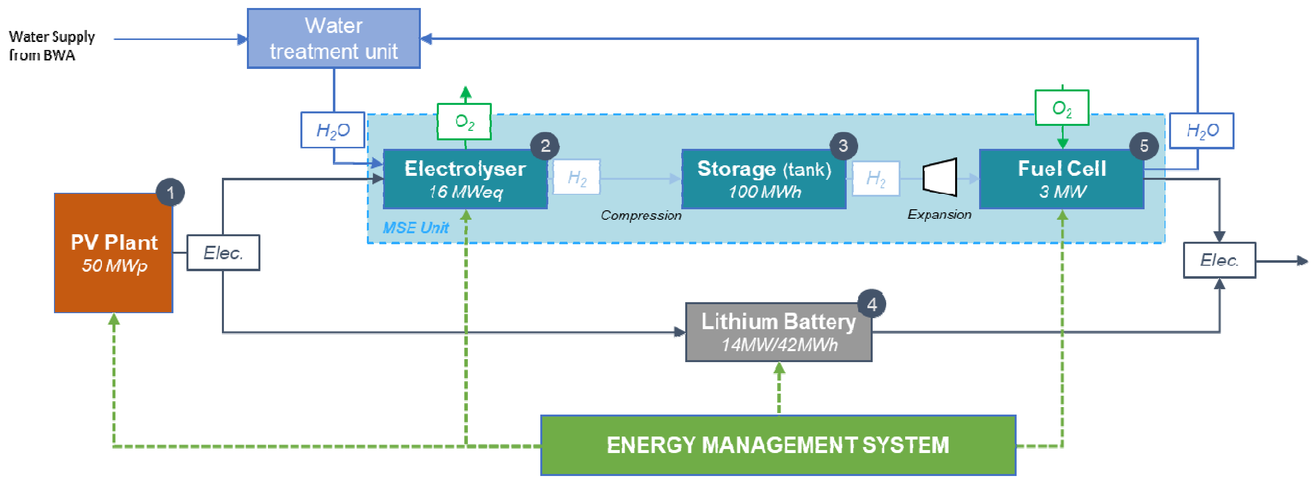


Figure 2.4 Simplified Project Process Flow Diagram



2.1.1 PV Power Plant

The primary source of energy of the RSB will be a 50 MWp photovoltaic solar power plant in fixed-tilt configuration. The PV structures are designed to meet the local building codes and to withstand strong winds and a minimum Category 3 hurricane.

2.1.2 Hydrogen Energy Storage System

The hydrogen energy storage system (HESS) allows the power plant to supply energy 24/7. It is comprised of:

- Four modules of 4-MW electrolyzers with each module capable of generating 70 kg/h of hydrogen for storage. Each electrolyzer will be containerized in a prefabricated enclosure.
- A hydrogen storage system including 26 horizontal steel cylinders, with each cylinder capable of storing 115 m^3 of H_2 at ambient temperature and 30 barg. The cylinders will be configured in a 2 stack configuration with each cylinder being approximately 22 m long and 2.8 m in diameter. This represents approximately 7.3 tons of hydrogen.
- Two 1.5-MW modules of hydrogen fuel cells using Proton Exchange Membrane (PEM) technology to generate electricity. Each module will consume hydrogen at a rate of 150 kg/h and 5 barg. Each fuel cell will be containerized in a prefabricated enclosure.

A summary of the H_2 storage properties used for source characterization is presented in Table 2.1.

Table 2-1 Summary of H_2 Storage Properties used for Source Characterization

Parameter	Units	Value
Pressure	bar(g)	30
Temperature	°C	30
Quantity	m^3	115

H_2 is transferred to each cylinder from the electrolyzers via 2-inch piping. H_2 is transferred from the storage system via 3” piping to the fuel cell. The pressure in each H_2 cylinder was assumed to be 3000 kPa(a) at the start of a release event, with all tanks being interconnected and the valve on each tank being remotely closed 10 minutes after the start of a release. A 10-minute closure time is expected to be conservative and representative of a manual (rather than automated) time. The dimensions of the fuel cell and electrolyzer enclosures were assumed to be 2 m high by 3 m wide and 13 m in length.

2.1.3 Lithium-Ion Battery Energy Storage System

The Project will include a 14 MW battery energy storage system. Batteries will be contained in 8 prefabricated enclosures, including the battery cells and management systems, auxiliaries, cooling, fire safety and security systems. Each enclosure will have approximately 5 MWh capacity consisting of 20 stacks of 250 kWh, each stack having 12 modules of 20.8 kWh and each module containing 24 cells of 874 Wh.

Each enclosure contains a HVAC system sized to regulate heating and cooling to avoid battery over-heating. Air conduits are connected to each HVAC unit with direct ducts to each stack. Each stack has an individually powered 600 CFM ventilation system that is automatically activated for normal cooling operation, but is also activated if a single cell temperature in the stack exceeds a threshold value.

The dimensions of each BESS enclosure were assumed to be 2 m high by 3 m wide and 16.5 m in length.

2.1.4 HyCPE Area

The BESS (battery) and HESS (hydrogen) systems, as well as utilities and auxiliary systems will be contained in a centralized area located at the center of the site called the HyCPE area. The siting of this area is designed to mitigate the risk represented by the energy storage equipment in order to protect the workers and the surrounding community by providing a setback of more than 200 m from the nearest residential area.

3.0 Hazard Identification

Gaseous hydrogen will be produced and stored on site in pressurized storage cylinders at 30 bar. The primary hazards associated with an accidental release from the hydrogen system will result from the flammability of H_2 along with the potential for a subsequent explosion. Asphyxiation due to oxygen displacement is also a potential hazard reviewed within the assessment. Leaks or ruptures could occur for the H_2 storage cylinders, associated piping, or from the fuel cells or electrolyzers.

Lithium-ion batteries will also be used to store electricity on site. The batteries are integrated in pre-assembled enclosures, and include cooling, fire detection, automatic fire extinguisher, and comprehensive fault detection in charge/discharge cycles. The intrinsic hazard associated with the battery modules is the flammability of the vapours associated with the electrolyte solvent used. Uncontrolled releases of these vapours may result in fires or explosions.

The potential primary hazardous events are summarized in Table 3.1.

Table 3-1 Hazard Summary

Hazard Event	Cause	Consequence
Fireball/Jet Fire	Immediate ignition of the H_2.	Exposure to thermal radiation.
Flash Fire	Delayed ignition of the dispersing vapor cloud.	Exposure to the travelling flame front and associated thermal radiation exposure.
Inhalation	Displacement of oxygen by the released fluid.	Asphyxiation of the individual.
Vapor Cloud Explosion	Significant structural congestion in the flammable region of the H_2 vapor cloud, which causes flame speeds high enough to result in the formation of a pressure wave as the flame propagates through the region.	Exposure to thermal radiation, direct impingement of the travelling flame front, and exposure to damaging overpressure (both directly and through its impact on structures).
Vessel Explosion	Jet Fire impinging on second storage cylinder, causing the liquid inside to boil and the pressure to increase beyond the maximum allowable for the cylinder.	Overpressure as a result of the vessel rupturing, thermal radiation due to a fireball, and potential shrapnel.
Process Enclosure Explosion	Sufficient vapours released from the battery storage system, hydrolyzer, or fuel cells into their enclosures can lead to an explosion.	Overpressure as a result of an explosion of the enclosure.

3.1 FIREBALLS/JET FIRES

The consequences of the thermal radiation hazard associated with fireballs and jet fires are often defined using either the thermal radiation intensity level or a thermal radiation dose level. Thermal radiation intensity is a direct measure of the thermal radiation received at a target. The effects associated with selected thermal radiation intensities are shown in Table 3.2.

The dose is a function of the intensity level and duration of exposure and can be used to define the anticipated effects on a receptor. For example, researchers have defined the dose required to produce first, second, and third degree burns to an unprotected human receptor. Typically, thermal radiation hazards are expressed in Thermal Dose Units (TDU = 1 $(kW/m^2)^{4/3}s$), Table 3.3 shows the TDU range associated with the harm caused to a human receptor.

For the current assessment, the following three thermal radiation endpoints were chosen:

- A thermal radiation intensity of 5 kW/m^2 for 40 seconds (342 TDU), which represents second degree burns (NFPA, 2019)
- A thermal dose endpoint of 240 $(kW/m^2)^{4/3}$ s, which represents a lower boundary for second-degree burns to individual due to exposure to thermal radiation (O'Sullivan and Jagger, 2004)
- A thermal dose endpoint of 1060 $(kW/m^2)^{4/3}$ s, which represents third-degree burns to individual due to exposure to thermal radiation, as well as approximately 1% probability of lethality (O'Sullivan and Jagger, 2004)

Table 3-2 Effects of Thermal Radiation Intensity

Radiation Intensity (kW/m^2)	Effect
1.2	Received from the sun at noon in summer.
2	Minimum to cause pain after 1 minute.
Less than 5	Will cause pain in 15-20 seconds and injury after 30 seconds exposure.
Greater than 6	Pain within approximately 10 seconds.
12.5	Significant chance of fatality for medium duration exposure. Thin steel insulation on the side away from the fire may reach thermal stress level high enough to cause structural failure.
25	Likely fatality for extended exposure and significant chance of fatality for instantaneous exposure. Spontaneous ignition of wood after long exposure. Unprotected steel will reach thermal stress temperature that can cause failures.
35	Cellulosic material will pilot ignite within one minute's exposure. Significant chance of fatality for people exposed instantaneously.

NOTE:
SOURCE: UK HSE (2013)

Table 3-3 Burn vs. Thermal Dose Relationship

Harm Caused	Infrared Radiation Thermal Dose (TDU), $(kW/m^2)^{4/3}s$	
	Mean (Observations)	Range (Observations)
Pain	92	86-103
Threshold first degree burn	105	80-130
Threshold second degree burn	290	240-350
Threshold third degree burn	1,000	870-2,600

NOTE:
SOURCE: O'Sullivan & Jagger (2004)

3.2 FLASH FIRES AND VAPOR CLOUD EXPLOSIONS

Flash fire and vapour cloud explosion hazards result from the delayed ignition of a dispersing vapour cloud. The flammable extents of a release can be assessed by estimating the concentration of the fuel in the air as it is transported and dispersed away from the release. The Lower Flammable Limit (LFL) is the lowest concentration at which the released fuel will support combustion in the presence of an ignition source. This endpoint is identified in the National Fire Prevention Association's guidelines (NFPA, 2019). This endpoint is also identified in the United States Environmental Protection Agency (U.S. EPA) Risk Management Program (RMP) Guidance documentation as one of the endpoints used for an alternate assessment of flammable hazards (U.S. EPA, 2009).

Dispersion models typically used to assess the dispersion of vapour clouds calculate time and ensemble average concentrations downwind of the release location. These models do not directly account for atmospheric concentration fluctuations that can occur during a release event. These models predict the expected time-averaged concentration based on many similar events (referred to as an ensemble average). As a result, some jurisdictions consider a fraction of the LFL concentration to account for the variability about the ensemble mean. For instance, the United Kingdom Health and Safety Executive (U.K. HSE) considers the extents of the LFL/2 (50% of the LFL) to be the footprint of a potential flash fire but will consider arguments and data put forward to support the use of model algorithms to address concentration fluctuations in defining the extents of a potential flash fire (Webber, 2002). The current assessment provides the downwind extents to LFL/2 concentrations in addition to those for the LFL.

A vapour cloud explosion occurs when the flame speeds within a flash fire are high enough to generate a damaging overpressure wave. The primary consequence of a vapour cloud explosion is the overpressure (the pressure above atmospheric pressure) to which a receiver or structure is subjected due to the rapidly advancing flame front. At high levels, the overpressure can cause direct damage to an individual such as rupturing of eardrums or hemorrhaging of the lungs. At lower levels, the overpressure may cause significant damage to buildings and structures that contain an individual, such as shattering of glass and structural failure. Overpressure effects are summarized in Table 3.4.

A vapour cloud explosion requires significant congestion to generate the flame speeds necessary to generate damaging overpressures. For example, a complex three-dimensional network of piping and vessels found at a congested facility may result in flame speeds high enough to develop a vapour cloud explosion. In addition, it is generally accepted that only the vapour in the congested region contributes to the overpressure.

For the purposes of this study, overpressure endpoints were chosen to be 6.89 kPa(g) and 20.7 kPa(g) (NFPA 68, 2019).

Table 3-4 Overpressure Effects

Pressure		Damage
(psi)	(kPa)	
0.02	0.14	Annoying noise (137 dB), if of low frequency (10-15 Hz)
0.03	0.21	Occasional breaking of large glass windows already under strain
0.04	0.28	Loud noise (143 dB), sonic boom glass failure
0.1	0.69	Breakage of small windows under strain
0.15	1.03	Typical pressure for glass breakage
0.3	2.07	"Safe distance" (probability 0.95 no serious damage beyond this value); projectile limit; some damage to house ceilings; 10% window glass broken
0.4	2.76	Limited minor structural damage
0.5-1.0	3.45-6.89	Large and small windows usually shattered; occasional damage to window frames
0.7	4.83	Minor damage to house structures
1.0	6.89	Partial demolition of houses, made uninhabitable
1-2	6.89-13.8	Corrugated asbestos shattered; corrugated steel or aluminum panels, fastenings fail, followed by buckling; wood panels (standard housing) fastenings fail, panels blowing
1.3	8.96	Steel frame of clad building slightly distorted
2	13.8	Partial collapse of walls and roofs of houses
2-3	13.8-20.7	Concrete or cinder block walls, not reinforced, shattered
2.3	15.9	Lower limit of serious structural damage
2.5	17.2	50% destruction of brickwork of houses
3	20.7	Heavy machines (3,000 lb) in industrial buildings suffered little damage; steel frame building distorted and pulled away from foundations
3-4	20.7-27.6	Frameless, self-framing steel panel building demolished; rupture of oil storage tanks
4	27.6	Cladding of light industrial buildings ruptured
5	34.5	Wooden utility poles snapped; tall hydraulic press (40,000 lb) in building slightly damaged
5-7	34.5-48.3	Nearly complete destruction of houses
7	48.3	Loaded train wagons overturned
10	68.9	Probable total destruction of buildings; heavy machine tools (7000 lb) moved and badly damaged, very heavy machine tools (12,000 lb) survived

Pressure		Damage
(psi)	(kPa)	
300	2068	Limit of crater lip
NOTE: Based on Canadian Society for Chemical Engineering (2004)		

3.3 VESSEL OR ENCLOSURE EXPLOSION

A vessel explosion can occur when the walls of a pressurized vessel are compromised. This can occur through external heating of the vessel, which can both weaken the structure and also raise the internal pressure of the vessel. Explosions can also occur though overfilling pressure vessels beyond their rated capacity. The explosion can cause several physical effects including overpressure and fragmentation, all of which may cause damage. Additionally, if the material is flammable there is the potential for exposure to thermal radiation.

Accidental releases could lead to an explosion of a BESS, fuel cell, or hydrolyzer storage enclosures. Should flammable gases be released in these enclosures, the concentration of these materials could build over time if ventilation systems fail and lead to an explosion if an ignition source is introduced.

For the current assessment, the following endpoints were reviewed for vessel and enclosure explosions:

- Overpressure endpoint of 6.9 kPa(g), NFPA endpoint for irreversible harm (NFPA, 2019)
- Overpressure endpoint of 20.7 kPa(g) NFPA endpoint for fatality (NFPA, 2019)

3.4 ENCLOSURE FIRES

During an uncontrolled release within an enclosure, there is also the possibility that combustible material is vented from the enclosure and ignites outdoors, or that a fire is initiated within the enclosure and potentially leads to thermal radiation exposure. Based on the current design of the enclosed processes and the facility, the hazard extents from jet fires or explosions are anticipated to be much larger than hazard extents from thermal radiation due to fires related to enclosure releases. Therefore, these fires have not been included as part of this QRA.

3.5 INHALATION

H_2 is not known to have toxic effects and the only expected hazard from inhalation is asphyxiation. Simple asphyxiation can occur if the concentration of a substance is sufficiently high enough that it displaces oxygen in the air, causing asphyxiation. Common health effects of reduced oxygen levels are shown in Table 3.5. Based on the NFPA 59a guidance, the lethality limit is 40% concentration of the contaminant (hydrogen), while irreversible harm occurs at 23% concentration of the contaminant (NFPA 59a, 2019).

Based on the current design of the hydrogen production and storage system, concentrations that exceed the above thresholds for asphyxiation are not expected to occur beyond the site boundary. The asphyxiation hazard has therefore not been included as part of this QRA.

Table 3-5 Common Health Effects of Exposure to Reduced Oxygen Levels

Oxygen Concentration (Volume %)	Simple Asphyxiant Concentration[1] (ppmv)	Effects
19.5	71,400	Minimum safe level (OSHA)
15 – 19	95,000 - 286,000	Decreased ability to work strenuously
12 – 14	333,000 - 429,000	Respiration increases with exertion; pulse increases; impaired muscular coordination, perception and judgment
10 – 12	429,000 - 524,000	Respiration increases in rate and depth, poor judgment, blue lips
8 – 10	524,000 - 620,000	Mental failure, fainting, unconsciousness, ashen face, nausea vomiting, inability to move freely
6 – 8	620,000 - 714,000	6 minutes exposure results in 50% probability of death, 8 minutes exposure results in 100% probability of death
4 – 6	714,000 - 810,000	Coma in 40s respiration ceases, death

NOTE:
[1] Asphyxiant concentration in air that results in the associated reduction in O_2 concentration.
SOURCE: Based on Perry et al. (2008).

4.0 SOURCE CHARACTERIZATION AND MODELLING

Source characterization was completed to estimate the release rate and characteristics of the release (e.g., release temperature) that would then be used for estimating the hazardous end points of concern. A list of loss of containment (LOC) scenarios considered in this consequence and risk analysis are listed in Table 4.1. The hydrogen storage system included a range of potential release scenarios, from large ruptures to small leaks, as well as a vessel explosion. Scenarios assessed for the containerized processes for hydrogen production and consumption (i.e., the hydrolyzer and fuel cell) were a release within the container filling the container, which is then ignited creating an explosion. Similarly, an explosion scenario involving a release of flammable material in a BESS container was also included in the assessment.

Table 4-1 Failure Scenarios Included in the QRA

Scenario	LOC Scenario Description	Release Diameter (mm)	Initial Pressure (barg)
Hydrogen Storage System			
1	Catastrophic rupture from a H_2 storage vessel	203	30
2	Large rupture from H_2 storage vessel	102	30
3	Rupture from H_2 storage vessel	50.8	30
4	Small rupture from H_2 storage vessel	25.4	30
5	Full Rupture from H_2 process 2-inch piping	50.8	30
6	Rupture from H_2 process 2-inch piping	25.4	30
7	Leak from H_2 storage vessel	12.5	30
8	Small leak from H_2 storage vessel	6	30
9	Small leak from H_2 process 2-inch piping	6	30
10	Explosion due to H_2 storage vessel failure	-	75
Fuel Cell and Hydrolyzer Enclosure			
11	Explosion due to a H_2 leak within the enclosure system	-	5
Battery Energy Storage System (BESS)			
12	Explosion due to a release of flammable material from battery modules within a BESS enclosure	-	-

4.1 HYDROGEN RELEASE MODELLING

Source characterization modelling was completed to estimate the source properties occurring during a pressurized hydrogen release. Inputs to the source characterization model include the storage temperature, the size of the storage vessel, and the size of the rupture. These inputs are used to estimate the time-varying properties of the release, including the mass release rate, liquid mass fraction, and temperature.

These source conditions in combination with the physical properties of the fluid are direct inputs used to predict the consequence extents during an accidental release event. The properties of hydrogen were estimated using the Peng-Robinson equation of state, which provides a reasonable estimate of hydrogen properties occurring for this Project.

The exit conditions as a function of time for the hydrogen processes can be estimated by solving the time-varying mass, momentum and energy conservation equations for the fluid flowing from the storage vessels. A compressible fluid flow model with consideration of friction and heat transfer was used to estimate the source conditions during a release. The following assumptions were made:

- The fluid is real and compressible (compressible flow terms are included in the analysis);
- The vapor and liquid phases are in thermodynamic equilibrium;
- The vapor and liquid phases are assumed to travel at the same velocity (i.e., there is no slip between the vapor and liquid phases); and,
- The fluid properties are estimated using the Peng-Robinson equation of state (Peng & Robinson, 1976).

Based on the operating conditions provided by RSB, the storage vessels will contain the majority of the hydrogen in the system and will therefore contribute more to an uncontrolled release than inlet flow from the hydrolyzers.

The source conditions used in the consequence modelling were estimated through mass, momentum and energy balances from the exit plane (located at the failure point) to the source plane (located at the point where the fluid has expanded to atmospheric pressure). As the fluid moves between the exit plane and the source plane, it was assumed that there is no heat transfer between the fluid and its surroundings, and the fluid does not work on its surroundings. If the flow is choked at the exit plane (i.e., the exit plane pressure is higher than the ambient pressure), an estimate of the expanded conditions was made. Additionally, obstruction drag coefficients of 0, 1 and 2 were used, these correspond to removing 0%, 40% and 66% of the momentum from the release.

4.2 VESSEL AND CONTAINER EXPLOSION MODELLING

Modelling was also undertaken to estimate the extent to damaging overpressures associated with an uncontrolled release of hydrogen within the hydrolyzer or fuel cell enclosures, a gas mixture in the BESS enclosures, or structural failure of the hydrogen storage vessels. Explosions related to fuel storage vessels are generally understood to be more powerful in the event of accidental overfilling, rather than due to structural weakening from a fire or other causes (TNO, 2005). Therefore, hydrogen storage vessel explosions were assumed to occur when filled to 7,500 kPa (2.5 times the rated container capacity), as recommended by NFPA guidance.

For enclosure explosions associated with the hydrolyzers, fuel cells, and BESS enclosures, it was assumed that an uncontrolled release of flammable material would fill the enclosure up to the stoichiometric ratio of the fuel in air. Use of the stoichiometric ratio results in the maximum amount of fuel within the enclosure volume being consumed during an explosion event. This is the recommended approach for estimating fuel availability for explosion hazards (NFPA, 2018).

Explosions from the hydrolyzers, fuel cells and hydrogen storage assumed pure hydrogen as the fuel gas. There are a variety of flammable mixtures than can be released from batteries within a BESS during upset conditions such as fires within the containers, runaway chemical reactions, other accidents and malfunctions (DNV GL 2019; Johnsplass et al. 2017). The flammable mixture composition also depends on the type of batteries used and their charge level. A range of mixtures was considered in this QRA for BESS container explosions based on the proportion of the mixture that included both combustible (e.g., methane, hydrogen) and incombustible (CO_2) gases. A summary of the compositions and stoichiometric ratios used for the BESS enclosure explosion is provided below in Table 4.2.

The composition with the highest fuel and air heating value would typically lead to the largest hazard extents for overpressure, since this composition would contain the most energy available for an explosion. The high-flammability composition shown in Table 4.2 had the highest fuel and air heating value, and so was used for BESS explosion consequence modelling.

A summary of the volumes of combustible gas used for enclosure explosion consequence modelling is provided in Table 4.3.

Table 4-2 Flammable Mixture Compositions Considered for BESS Explosion Modelling

Parameter	Units	Average Combustible Mixture	High-CO_2 Composition	High-Flammability Composition
H_2	Molar fraction	0.3	0.31	0.3
CO_2	Molar fraction	0.3	0.52	0.19
CO	Molar fraction	0.09	0.05	0.12
Methane	Molar fraction	0.15	0.04	0.06
Ethane	Molar fraction	0.09	0.08	0.21
Propane	Molar fraction	0.07	0	0.12
Fuel Heating Value	MJ/m^3	20.72	9.96	29.60
Fuel and Air Heating Value	MJ/m^3	3.14	2.76	3.27
Stoichiometric Volume Fraction	(%)	15.13	27.69	11.05

References for Compositions: DNV GL 2019; Johnsplass et al. 2017.

Table 4-3 Container Dimensions and Flammable Mixture Volumes used for Enclosure Explosion Modelling

System	Dimensions (m)			Container Volume [1] (m^3)	Estimated Oxygen in Container		Combustion Gas	Combustion Gas Quantity (moles)
	Height	Width	Length		Volume (m^3)	moles		
Fuel Cell & Electrolyzer	2	3	13	78	16.4	713	H_2	744
BESS	2	3	16.5	99	20.8	905	High Flammability BESS Mixture	944

1 – Volumes were conservatively calculated based on the enclosure dimensions and don't consider the presence of equipment within the enclosure reducing the available volume.

5.0 CONSEQUENCE MODELLING METHODOLOGY

Consequence modelling estimates the physical effects of a hazardous event. The consequences associated with the release of a flammable fuel can be influenced by factors including the manner in which the plume disperses downwind, the release rate profile, storage conditions and the physical and thermodynamic properties of the fluid.

5.1 METEOROLOGY

For delayed ignition (flash fire) and unignited events (asphyxiation) the weather conditions during the time of the release will affect the location and size of the hazard zones. The dilution capability of the atmosphere depends on the meteorological conditions at the time of the release. The Pasquil-Gifford classification scheme with six categories ranging from A (very unstable) to F (moderately stable) to characterize the atmosphere is often used. The occurrence of these stability conditions can be summarized as follows:

- Unstable conditions A through C are characterized by strong to moderate incoming solar radiation and low to moderate wind speeds. Unstable conditions typically occur on calm, warm and sunny days when ground heating results in vertical motion of air within the layer of the atmosphere close to the surface. This vertical motion results in increased turbulence. Unstable conditions are restricted to daylight hours.
- Neutral stability, D, often occurs during overcast conditions or conditions with moderate to high wind speeds. Neutral stability can occur at any time during the day or night.
- Stable conditions E and F typically occur on calm, cool clear nights when radiation cooling of the ground relative to the layer of air above it results in a stable temperature gradient (temperature increasing with altitude). This stable gradient dampens vertical motion and results in a reduction in the level of turbulence. Stable conditions generally occur during night-time.

Table 5.1 provides the meteorological conditions used in the consequence modelling. Modelling the release over this range of possible conditions is an attempt to ensure that a reasonable worst-case meteorology is represented thereby providing a conservative estimate of the hazard extents for a given release event. A larger number of Stability Class F conditions are evaluated as the largest extents are typically associated with these conditions due to the associated low turbulence conditions.

Table 5-1 Meteorological Conditions Used in the Consequence Modelling

Meteorology Code	Stability Class	Wind Speed		Description
		(m/s)	(kmph)	
A	1	1	3.6	Typically occurs on warm, sunny days, late morning to mid-afternoon when the sun is at its peak.
B2	B	2	7.2	
D2	D	2	7.2	Overcast conditions, day or night, anytime of the year

Meteorology Code	Stability Class	Wind Speed		Description
		(m/s)	(kmph)	
D5	D	5	18	Moderate to high wind speed conditions, any time of day
D10	D	10	36	
E2	E	2	7.2	Nighttime conditions, slightly overcast
E5	E	5	18	
F2	F	1.5	5.4	Clear nights
F4	F	4	14.4	

Other important factors for the dispersion modelling are as follows:

- An ambient temperature of 25°C was used, as recommended by the NFPA 59a guidelines (NFPA 59a, 2019). This temperature is similar to the mean temperature (27°C) observed in the meteorological data from Grantley Adams Airport.
- A surface roughness of 100 cm, representative of the ground cover in the area surrounding the facility.

5.2 DISPERSION MODELLING

Dispersion modelling is performed to determine the concentration of pollutants at ground level, downwind of a release. The US EPA SLAB dispersion model, which can estimate the dispersion of releases with a density equal to or greater than that of air (in addition to buoyant releases), was used in the assessment. The SLAB dispersion model was developed at the Lawrence Livermore Labs and contains algorithms that can model the physics of these releases including gravity slumping, reduced air entrainment resulting from stable density gradients (i.e., density within the plume is larger than that of the ambient air) and the thermodynamics of phase change within the plume. The SLAB model finds regular use in meeting dispersion modelling requirements in the US EPA Risk Management Plan (RMP).

SLAB is a widely used dispersion model and is listed by the US EPA as an alternative model that can be used with case-by-case justification for dispersion assessments. Validation studies of consequence models are generally limited due to the relative scarcity of full-scale measurement data against which to make comparisons. In a review study by Gudivakaa and Kumara (1990) they noted “In predicting ground level concentrations, the SLAB model performed well in all atmospheric conditions and calm conditions.” Another study by Ermak et al. (1982) noted that the SLAB model generally predicted the maximum distance to the lower flammability limit (LFL) and cloud width quite well and that the SLAB model accurately predicted the length of time required for the cloud to disperse to a level below the LFL, even in a low wind speed test.

The SLAB model was applied for a range of meteorological conditions. This provides a reasonable estimate of an extreme case for use in emergency planning and an indication of the range of potential outcomes for use in estimating the risk associated with the facility.

To address the transient behavior of the predicted mass release rate, additional post processing was done on the SLAB model output. The post processor implements the method of observers as is done in the Degadis (Spicer and Havens 1989) and HGSYSTEM models. A separate SLAB model run was conducted at each of a set of discrete time steps. The individual SLAB runs were interpreted as releases of successive planar puffs. The source input parameters for each puff; including the liquid mass fraction, temperature, and release rate were obtained from the RELEASE model output for the considered time step. The concentration at a downwind location is then estimated by summing the contribution of all available planar puffs with the consideration of “along wind” diffusion.

5.3 FLAMMABILITY AND VAPOUR CLOUD EXPLOSION

The flammable extents of the dispersing plume were calculated using the dispersion model, with considered concentration endpoints of the LFL and LFL/2. The NFPA considers the LFL concentration as a region within which fatalities are possible (NFPA 59a, 2019).

Hazard extents resulting from a vapour cloud explosion were calculated using the Multi-Energy Method (MEM) (TNO, 2005). The calculation of overpressure using this method is based partly on the level of obstruction and confinement as defined in MEM - the greater the congestion and confinement, the farther the hazard extent for a given overpressure. Typically, the blast is classified by the level of congestion and those areas of the plume in a congested area have a greater contribution to the overpressure than those that are outside of the congested area. The immediate vicinity of the hydrogen system is not considered congested, but for the purpose of this assessment and to provide a conservative estimate of the consequences (i.e., overstates the vapour cloud explosion extents), it was assumed:

- That the area congested, and
- The entire plume within the flammable envelope contributed to the explosion.

The NFPA considers overpressure endpoints of 6.9 kPa(g) (potential for irreversible harm) and 20.7 kPa(g) (potential for fatalities) (NFPA 59a, 2019).

5.4 THERMAL RADIATION

The thermal radiation consequence is estimated using thermal dose units (TDU). The release rate and thermal radiation intensity are time varying, so the thermal radiation dose can be estimated using:

$$D = \int_0^T I^{4/3} dt$$

Where D is the dose (1 Thermal Dose Unit (TDU) = 1 $(kW/m^2)^{(4/3)}s$), I is the thermal radiation intensity (kW/m^2) and T is the exposure duration (seconds). The thermal dose unit accounts for the duration and exposure level. The probability of lethality can be estimated using the following equation and assuming probit parameters of a = -19.9 and b = 2.56 (CCPS 1989).

$$P(D) = \frac{1}{2}\left[1 + erf\left(\frac{b\ln(D) + a - 5}{\sqrt{2}}\right)\right]$$

For the current assessment, the thermal radiation consequence was estimated using algorithms presented by Cook et al. (Cook, 1987) which characterizes a jet fire as a line source with a user specified degree of anisotropy. The time varying burning rate was obtained from the source characterization modelling. Two scenarios were considered for each release:

- Early Ignition: Immediate ignition of the release; and,
- Late Ignition: Delayed ignition of the release.

The following additional assumptions were made relating to the thermal dose estimation for an individual in the vicinity of an ignited release:

- At the onset of the release, the individual is assumed to remain stationary “stunned” for 5 seconds;
- The individual will move directly away from the release at a speed of 2.5 m/s (9.0 km/h); and,
- The individual is assumed to be oriented to receive the maximum thermal radiation from the source.

An individual will accumulate a thermal dose over the duration of the release that is dependent on the time varying intensity level of thermal radiation emitted from the source and the time varying distance between the individual and the release point. For the current assessment, the distance to a thermal dose of 5 kW/m^2 over 40 seconds, 240 TDU for second degree burns and a 1% probability of lethality were used to assess the thermal radiation extents for jet fires. The distance to second degree burns was used when assessing maximum hazard distances for emergency planning purposes.

Additionally, the NFPA considers that there is potential for fatalities if an individual is exposed to a maximum heat flux of 9 kW/m^2 and potential for irreversible harm if an individual is exposed to a maximum heat flux of 5 kW/m^2. Based on the NFPA guidance, these values were used in the subsequent risk modelling (Section 6.0).

5.5 VESSEL AND ENCLOSURE EXPLOSIONS

Vessel explosions can occur as a result of initiating events including external heating, fires, overfilling, and fast chemical reactions such as combustion. For the current assessment, it was assumed that the initiating event for the hydrogen vessels was overfilling and for the considered enclosures it was assumed to be ignition and combustion of fuel accidentally released within the enclosure.

The overpressure was calculated following the guidance from TNO (2005), in which the hazard extent was estimated using the available expansion energy and empirical relationship for pentolite. For the hydrogen storage vessels, the peak (rupture) pressure was taken as 7500 kPa(g) (i.e., 2.5 times the maximum allowable working pressure of 3000 kPa(g) (TNO, 2005; Crowl and Tipler, 2013)). For the enclosures, it was assumed that all the safety mechanisms associated with venting of the combustion materials failed. If ignited, the increase in expansion energy within the enclosure was based on the resulting increasing temperature and the generation of combustion products. The overpressure endpoints considered were the same as those used for a vapour cloud explosion.

6.0 RISK MODELLING METHODOLOGY

Risk assessment provides a means of evaluating the safety of a proposed industrial activity by comparing the risk associated with the activity to accepted guidelines. It is important to note, that while knowledge of a credible worst-case hazard extent is useful for emergency planning purposes, this information does not necessarily provide a complete measure of safety and, as a result, is difficult to use for land use planning purposes. The identification of the extents of a hazard is not traditionally nor solely used to determine the acceptability of a development. Safety refers to the acceptability of the risk. Safety considers the likelihood that an accident will occur and produce an adverse outcome. For example, while the consequences associated with an uncontrolled release may be large, if the frequency of occurrence is low or not measurable, then the facility may in fact be considered safe, since the risk is low.

6.1 QUANTITATIVE RISK ANALYSIS

Quantitative risk analysis provides a means of generating numerical estimates of risk by combining the consequences associated with a range of accidental release events with their expected frequency. Simply defined, risk provides an estimate of the likelihood of harm: either to an individual or to society as a whole. For this assessment, both individual and societal risks were considered. Individual risk estimates have been given as “an annual chance of fatality” at specific locations in the vicinity of the proposed facility. A common and convenient expression for individual risk is:

$$Risk = Frequency \times Consequence$$

Where: Frequency = an approximation of the annual probability of an event; and

Consequence = the probability of lethality for a specified event.

Results of the risk analysis provide a numerical measure of the incremental individual risk associated with an accidental release from the facility. This information can be used to compare and assess land use and development activities near a proposed facility.

Individual risk at any point in the study area will be dependent on a number of parameters including, wind direction and wind speed/atmospheric stability probabilities, release location within the facility, and the probability of lethality for a particular hazard at the point being assessed. The following equation is used to estimate individual risk for point sources such as vessels or facility piping:

$$R_{ind}(x,y) = \sum_{j}^{J} f_j \sum_{i}^{I} f_i \int_{0}^{2\pi} f(\theta) P_{ij}\,(\theta, x, y) d\theta$$

Where:

R_{ind}	=	The individual risk estimated at a location (x,y),
θ	=	The wind direction,
$f(\theta)$	=	The wind direction probability distribution as a function,
I	=	The index of the weather case,
j	=	The index of the release scenario and geometry,
f_i	=	The frequency of the weather case (weather probability distribution),
f_j	=	The frequency of the release scenario and geometry,
P_{ij}	=	The probability of lethality or irreversible harm for a given release scenario and weather condition and as a function of the wind direction and location along the pipeline

For a particular hazard (e.g., flash fire, jet fire or un-ignited cloud), the probability P_{ij} includes consideration of the probability of the release size, probability of release orientation (horizontal or vertical), probability of ignition (instantaneous or delayed), and the probability of an individual (at the location being assessed) being indoors/outdoors. The NFPA 59a guidelines indicate the thresholds for lethality and irreversible harm as presented in Table 6.1. In this assessment we have used the provided thresholds, as they will provide conservative results for the individual risk. For the purposes of this study, only outdoor risk was considered.

Table 6-1 Summary of NFPA Guidance on Consequence Thresholds used in Risk Assessment

Event Type	Threshold for Fatality	Threshold for Irreversible Harm
Flash Fire	LFL	LFL
Vapour Cloud Explosion/BLEVE	20.7 kPa overpressure	6.9 kPa overpressure
Fireball	562 TDU	562 TDU
Jet Fire	9 kW/m^2 (outdoors)	5 kW/m^2 (outdoors)

6.2 PROBABILITY AND FREQUENCY INFORMATION

A variety of probability and frequency information is needed to evaluate risk. Details of these data are provided in the following sections.

6.2.1 Failure Frequency Analysis

Frequency analysis is used to quantify the occurrence of accidental release events such as an uncontrolled release. Accident frequency information provides a historical measure of how often similar events have occurred in the past. The frequency of a Project release was adopted from rates put forward by the United Kingdom Health and Safety Executive (UK HSE) (HSE 2012) along with failure frequencies provided in recent publications (DNV GL, 2019). Table 6.2 provides a summary of the failure frequency. The electrolyzer and fuel cell event frequencies were estimated based on the frequency of releases from hydrogen storage (excluding the vessel explosion) modified by the probability of ignition as presented in Section 6.2.2.

Table 6-2 Failure Frequencies used in the QRA

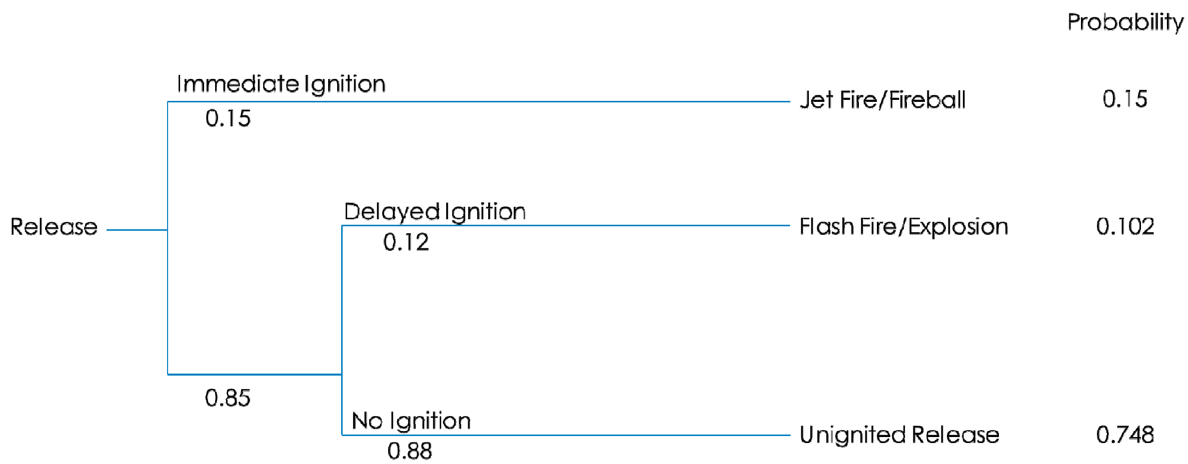
Component	Failure	Frequency	Units	Additional Information
Piping[1]	Full Bore	1.00E-06	failures/m/yr	2” Hole
	Rupture	5.00E-06	failures/m/yr	1” Hole
	Leak	1.00E-05	failures/m/yr	0.25” Hole
Hydrogen Storage[1]	Catastrophic	4.00E-06	failures/vessel/yr	Represented as 8" Hole
	2" Hole	5.00E-06	failures/vessel/yr	
	1" Hole	5.00E-06	failures/vessel/yr	
	Leak (13 mm)	1.00E-05	failures/vessel/yr	
	Leak (6 mm)	4.00E-05	failures/vessel/yr	
	Vessel Explosion	1.00E-05	failures/vessel/yr	Frequency for a boiling liquid expanding vapour explosion of a liquified petroleum gas vessel used, which is expected to be conservative
Electrolyzer[1]	Building Explosion	1.61E-05	failures/vessel/yr	Vessel failure modified by Ignition probability
Fuel Cell[1]	Building Explosion	1.61E-05	failures/vessel/yr	Vessel failure modified by Ignition probability
Battery Building[2]	Building Explosion	1.75E-05	failures/vessel/yr	Assumed enclosure safeguards fail

[1] UK Health and Safety Executive (2017)
[2] DNV GL (2019)

6.2.2 Hazard Frequency

Event trees are often used to assist in the development, and quantification of probabilities of possible hazard outcomes following an accidental release. Figure 6.1 shows a simplified event tree used in the current assessment for vessel and piping releases. As indicated in the event tree, immediate ignition was assumed to occur 15% of the time and delayed ignition was assumed to occur 12% (Muhlbauer, 2004) of the time, resulting in an overall estimated ignition probability of 25.2%.

Figure 6.1 Event Tree to Estimate the Outcome Probability for Considered Hazard Events



6.2.3 Site-Specific Meteorology

The frequency of occurrence of the weather conditions including atmospheric stability, wind speed and wind direction are required for the risk assessment. A description of the methodology used to obtain the weather frequency information is provided within this section.

6.2.3.1 Meteorological Observation Site

Surface meteorological data (2008-2012) for the Grantley Adams Airport meteorological station (USAF ID# 11501) was obtained from the United States National Climactic Data Centre (NCDC). A summary of the meteorological data provided at the station is shown in Table 6.3.

Table 6-3 Meteorological Station Parameter Summary

	Description
Station Name	Grantley Adams Airport
Station Location	13.07°N, -59.50°E
Years	Jan 1, 2008 to Dec 30, 2012
Data Type	Hourly

	Description
Parameters	Wind Speed Wind Direction Temperature Dew Point Relative Humidity Cloud Cover (Tenths) Cloud Opacity Ceiling Height Pasquil-Gifford Stability Class

6.2.4 Summary of Meteorological Data Review

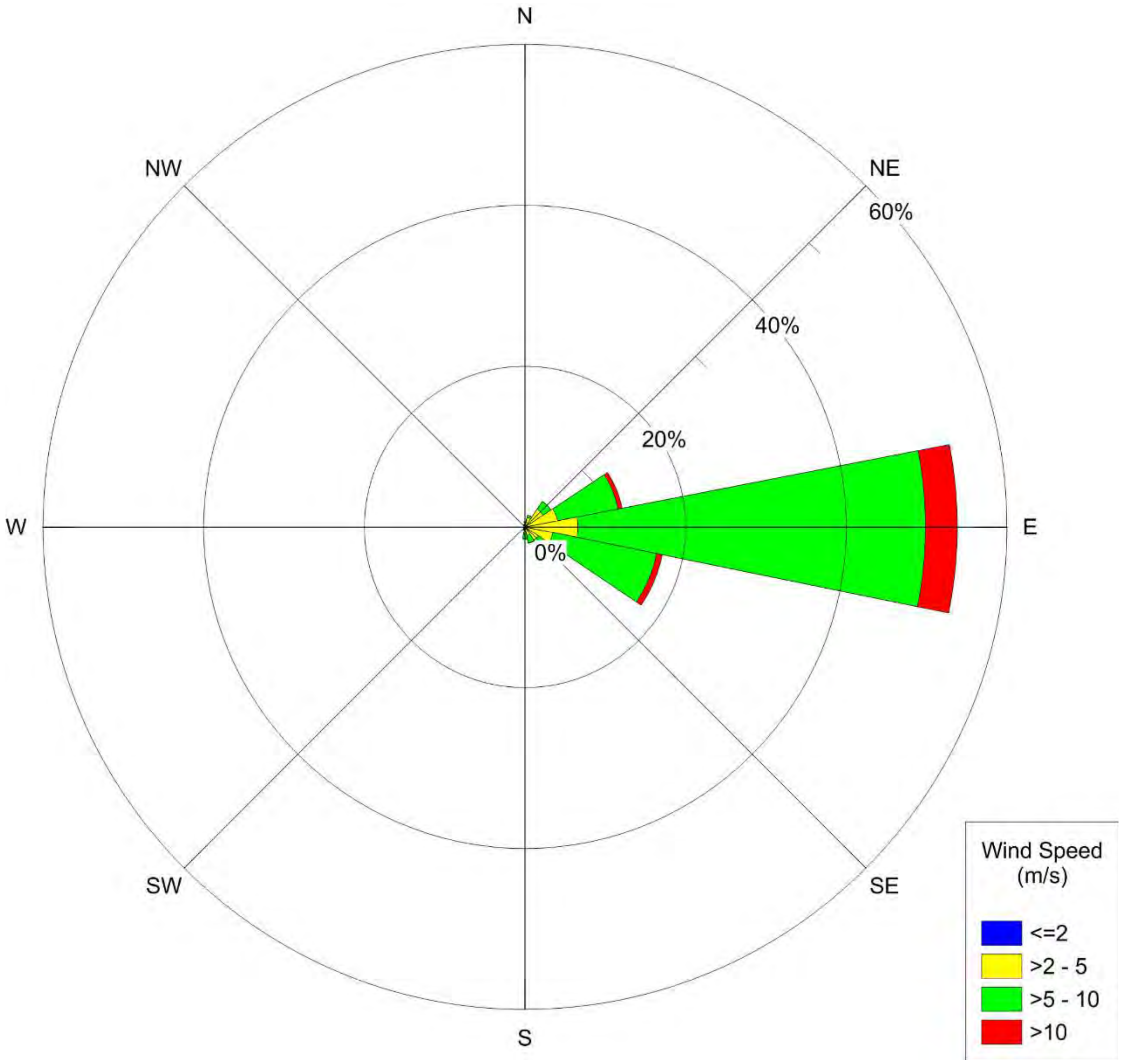
The windspeed and atmospheric stability classes were used to calculate the frequency of meteorological conditions at the Project site. These frequencies are summarized in Table 6.4. A wind speed and wind direction frequency distribution (commonly known as a windrose) is shown in Figure 6.2.

Table 6-4 Frequency of Meteorological Conditions

Meteorology Code	Stability Class	Wind Speed		Frequency of Occurrence
		(m/s)	(km/h)	
A1	A	1	3.6	0.7%
B2	B	2	7.2	1.8%
D2	D	2	7.2	1.2%
D5	D	5	18	28.7%
D10	D	10	36	31.9%
E2	E	2	7.2	0.1%
E5	E	5	18	22.2
F2	F	1.5	5,4	4.0%
F4	F	4	14.4	9.5%

NOTE: The meteorological data were binned to the nearest meteorological code. For example, meteorological code D10 would include meteorological conditions that are more similar to D10 (such as D8, D9, D11) than to other meteorological codes.

Figure 6.2 Wind Rose Plot Showing Wind Direction and Wind Speed Frequencies



Note – Direction is for "wind blowing from"

6.3 RISK ACCEPTABILITY CRITERIA

Risk acceptability criteria can be defined for off-site and on-site activities. "Offsite" refers to risk levels to the public beyond the boundaries of the risk source. "On-site" refers to the risk to workers at the facility. "On-site" risks are the direct responsibility of the duty holder and were not considered in this assessment.

6.3.1 Individual Risk

Annual individual risk thresholds are presented in Table 6.5. Under NFPA 59a guidelines, $5x10^{-5}$ and $5x10^{-4}$ are considered intolerable risk for the public for fatalities and irreversible harm, respectively.

Table 6-5 Risk Thresholds for Fatalities and Irreversible Harm

Risk Zone	Permitted Developments	Individual Risk (Chances in a million)	
		Fatalities	**Irreversible Harm**
1	All land uses under the control of the plant operator or subject to an approved legal agreement	> 50	> 500
2	General public areas excluding sensitive establishments	0.3 - 50	3 - 500
3	No restrictions	< 0.3	< 3

6.4 SOCIETAL RISK

Societal risk is a measure of the risk to groups of people or a segment of the population. Societal risk is commonly used in risk assessments to estimate the chance that a specified number of people may be harmed by an accident. As in the case of individual risk, the likelihood of the event is an important consideration, but the risk quantification considers the number of individuals affected.

One method of assessing societal risk is the cumulative frequency distribution of N or more fatalities commonly known as an F-N (Frequency Number) curve. In a F-N plot, the horizontal axis provides an indication of the scale of a particular accident in terms of the number individuals affected (N). The vertical axis provides the frequency (F). The event data is tabulated and plotted such that the y-axis represents a frequency of N or more affected (fatalities or irreversible harm).

Societal risk criteria are not as well established as individual risk criteria. Though many jurisdictions agree that it is intolerable to expose any individual member of the public to an annual fatality risk of greater than 100 in a million, there does not appear to be a similar level of consensus for specified societal risk criteria.

The NFPA 59a guidelines propose upper and lower comparison F-N curves (NFPA, 2019), which are shown in Figure 6.3 and Figure 6.4 for fatalities and irreversible harm, respectively. The upper comparison curve is a straight line that passes through a point that suggests that society is not tolerant of an accident that adversely affects one or more individuals occurring at a frequency of more than once every 100 years (irreversible harm) and once every 1000 years (fatalities). The lower comparison line passes through the point that indicates an accident of the same scale (one or more individuals affected) occurs once every 10,000 years (irreversible harm) and once every 100,000 years (fatalities). Both the Upper and Lower comparison lines have slopes such that a 10-fold increase in the number of individuals affected, by an accident, should be accompanied by a 10-fold decrease in the frequency of an accident of that scale occurring.

For the current assessment, the upper and lower comparison lines bound the regions of intolerable and negligible risk, respectively. The NFPA, along with other jurisdictions, recommend that if societal risk levels fall between these two regions, the risk should be mitigated such that it is As Low as Reasonably Practicable (ALARP).

Figure 6.3 Tolerability Regions of Societal Fatality Risk in the F-N Domain

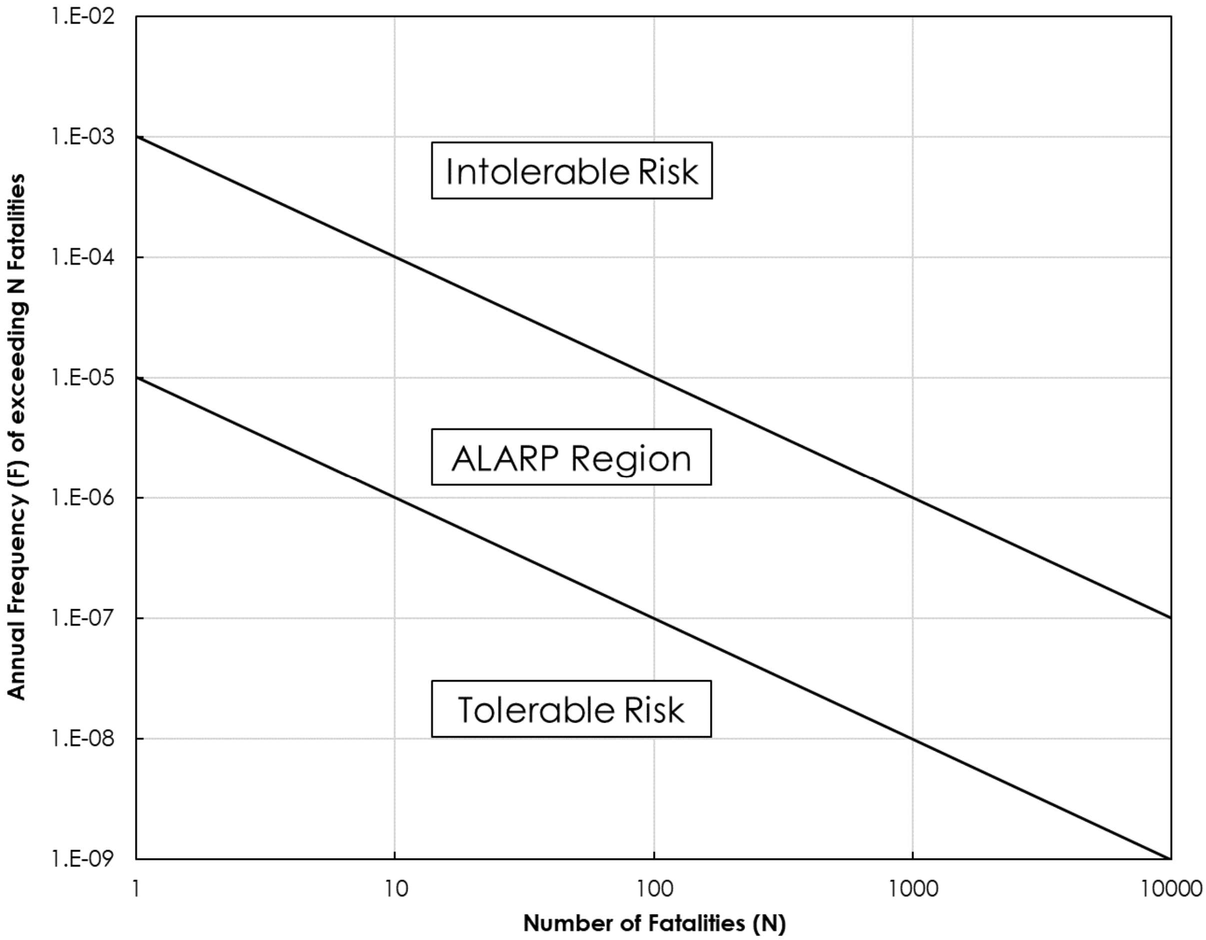
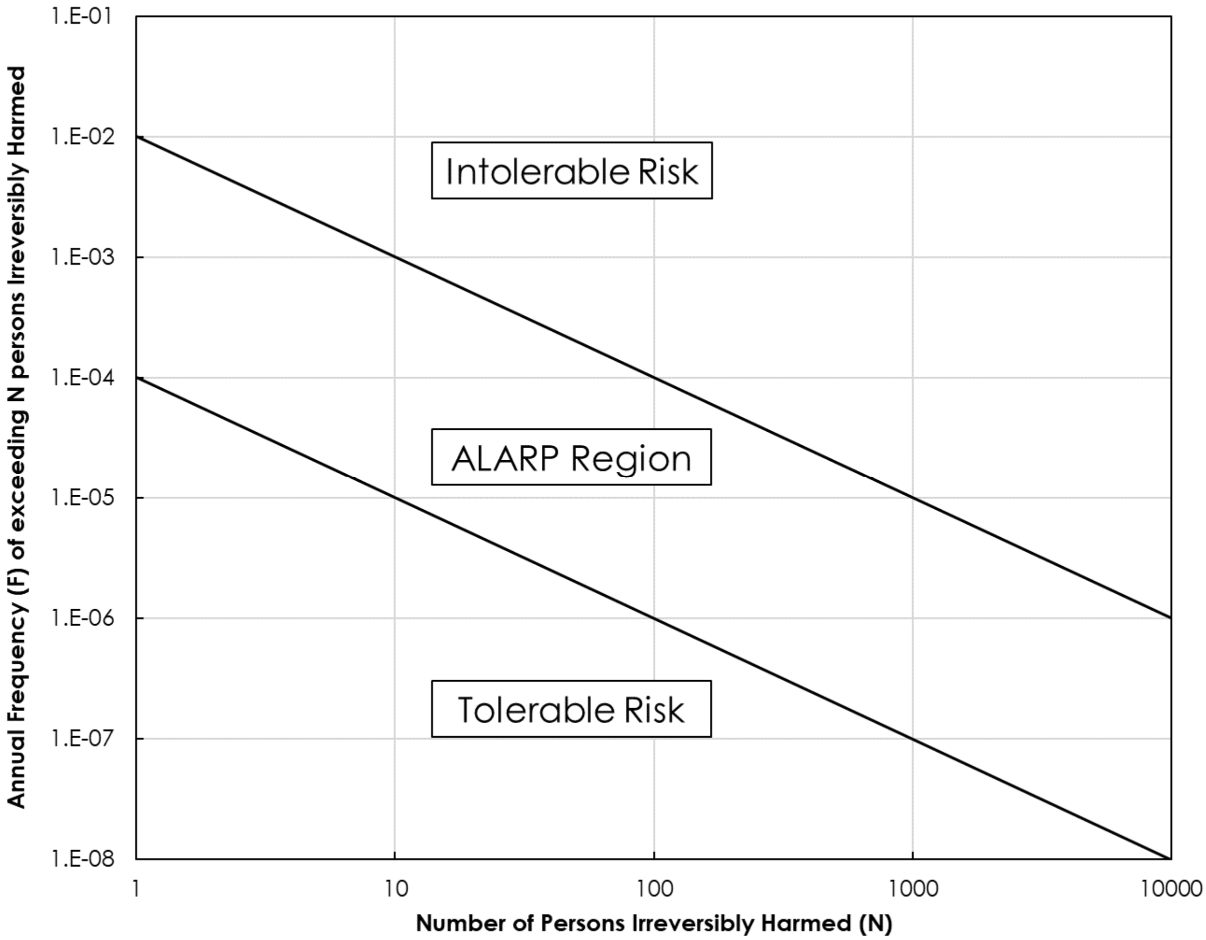


Figure 6.4 Tolerability Regions of Societal Irreversible Harm Risk in the F-N Domain



7.0 RESULTS

7.1 CONSEQUENCE MODELLING

Source characterization and consequence modelling were used to evaluate the downwind extents to selected end-point criteria associated with accidental releases from the facility. The extents to selected endpoint criteria (flammable extents, thermal radiation extents and overpressure consequences) are presented in Table 7.1 to Table 7.5.

The predicted distances to the flammable extents of a dispersing vapour cloud are provided in Table 7.1 for the LFL and Table 7.2 for the LFL/2. The maximum distances to the LFL and LFL/2 concentrations were predicted to be 193 m and 306 m, respectively and resulted from a catastrophic release from the H_2 storage vessel.

The distances to thermal radiation endpoints for the considered scenarios are provided in Table 7.3. The maximum predicted distances to the thermal radiation consequences were:

- Instantaneous exposure to 5 kW/m^2 - 147 m
- Instantaneous exposure to 9 kW/m^2 - 105
- 5 kW/m^2 over 40 seconds - 47 m

The predicted distance to the overpressure levels of 6.9 kPa(g) and 20.7 kPa(g) for vapour cloud explosions are provided in Table 7.4 and Table 7.5 for delayed ignition of a H_2 release. The maximum predicted distances to overpressure levels of 6.9 kPa and 20.7 kPa were 272 and 158 m, respectively, and occurred for a large rupture in a hydrogen storage vessel.

It is acknowledged that hydrogen is highly reactive and has a high laminar flame speed, both helping to promote the likelihood of a vapour cloud explosion. Based on the un-ignited vapor cloud extents presented in Table 7.1 and a review of the surrounding area, the potential for a vapor cloud explosion to occur was assessed. Since the HyCPE and surrounding area are not what would be typically considered highly congested regions, it is anticipated that assuming the entire cloud above the LFL would be involved would overstate the vapour cloud explosion consequences.

The predicted distances to overpressure levels for enclosure explosions (hydrogen storage vessel, fuel cell, hydrolyzers, and BESS container) are provided in Table 7.6. The maximum predicted distance to overpressure levels of 6.9 kPa(g) and 20.7 kPa(g) are 149 m and 69 m and result from a hydrogen storage vessel explosion.

Table 7-1 Downwind Hazard Extents to LFL for each Scenario

Atmospheric Stability	Wind Speed (m/s)	Downwind Distance to LFL (m)									
		Scenario									
		1	2	3	4	5	6	7	8	9	Maximum
A	1	71	52	32	14	34	14	11	3	3	71
B	2	77	56	41	17	37	18	13	3	3	77
D	2	86	62	38	17	41	17	23	3	3	86
D	5	112	156	99	22	112	24	17	3	3	156
D	10	193	149	78	28	84	28	13	3	3	193
E	2	92	71	42	11	43	11	16	0	0	92
E	5	103	123	122	11	148	16	23	0	0	148
F	2	98	74	44	13	47	13	12	0	0	98
F	4	106	78	51	14	49	14	34	0	0	106
Maximum		193	156	122	28	148	28	34	3	3	193

Table 7-2 Downwind Hazard Extents to LFL/2 for each Scenario

Atmospheric Stability	Wind Speed (m/s)	Downwind Distance to LFL/2 (m)									
		Scenario									
		1	2	3	4	5	6	7	8	9	Maximum
A	1	79	61	41	22	43	22	13	5	5	79
B	2	87	67	68	28	46	47	23	7	7	87
D	2	97	75	74	27	52	29	51	5	5	97
D	5	186	257	173	47	199	81	33	7	7	257
D	10	306	243	133	61	143	63	23	9	9	306
E	2	108	91	59	21	62	23	43	0	0	108
E	5	141	217	221	38	278	92	48	0	0	278
F	2	114	96	63	29	67	29	18	0	0	114
F	4	122	99	113	33	68	32	89	0	0	122
Maximum		306	257	221	61	278	92	89	9	9	306

Table 7-3 Downwind Hazard Extents to 20.7 kPa Overpressure for each Scenario

Atmospheric Stability	Wind Speed (m/s)	Downwind Distance (m)									
		Scenario									
		1	2	3	4	5	6	7	8	9	Maximum
A	1	72	96	71	48	78	49	29	13	13	96
B	2	72	97	76	52	77	52	28	13	13	97
D	2	77	101	74	51	79	51	32	13	13	101
D	5	143	158	104	58	113	58	28	12	12	158
D	10	133	143	89	48	81	49	24	11	11	143
E	2	77	98	74	49	79	49	32	12	12	98
E	5	113	136	113	64	121	64	31	11	11	136
F	2	79	103	77	48	78	49	31	13	13	103
F	4	84	103	78	51	78	51	34	12	12	103
Maximum		143	158	113	64	121	64	34	13	13	158

Table 7-4 Downwind Hazard Extents to 6.9 kPa Overpressure for each Scenario

Atmospheric Stability	Wind Speed (m/s)	Downwind Distance (m)									
		Scenario									
		1	2	3	4	5	6	7	8	9	Maximum
A	1	144	189	146	99	156	101	63	28	28	189
B	2	143	188	152	107	156	108	59	27	27	188
D	2	148	191	149	103	159	103	66	28	28	191
D	5	243	272	191	116	197	114	58	26	26	272
D	10	227	246	167	96	158	99	52	23	23	246
E	2	148	191	147	98	157	99	66	24	24	191
E	5	204	241	199	124	206	124	63	21	21	241
F	2	148	196	151	98	154	101	63	26	26	196
F	4	154	194	151	99	154	101	69	24	24	194
Maximum		243	272	199	124	206	124	69	28	28	272

Table 7-5 Maximum Predicted Downwind Hazard Extents to Thermal Radiation Endpoints for each Scenario

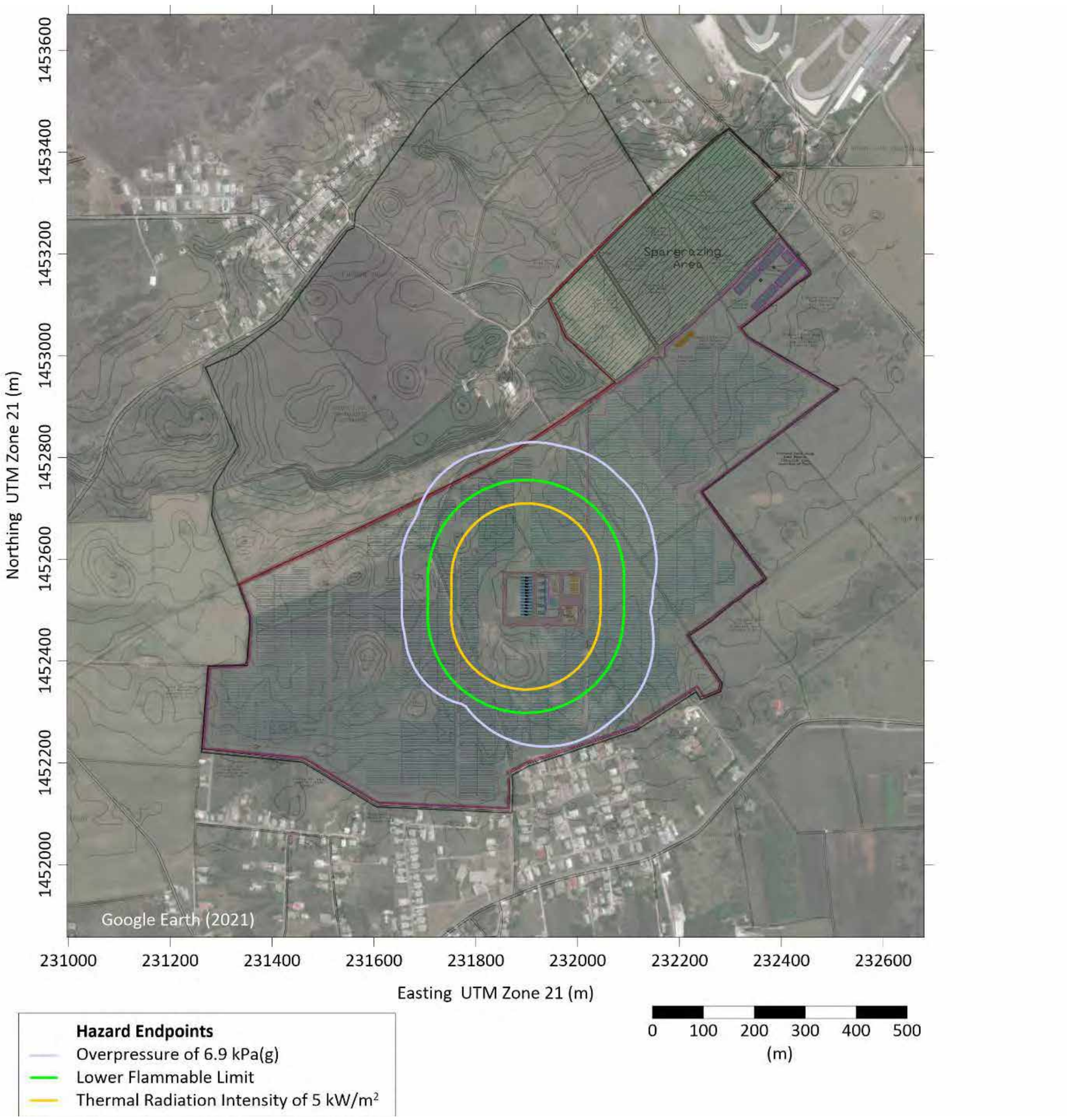
Release Scenario	Downwind Distance to Hazard Extent (m)		
	5 kW/m^2	9 kW/m^2	342 TDU
1	147	105	47
2	82	59	24
3	43	31	10
4	22	16	4
5	43	31	10
6	22	16	4
7	11	8	1
8	6	4	0
9	6	4	0
Maximum	147	105	47

Table 7-6 Maximum Predicted Distances to Selected Overpressure Endpoints for Vessel and Container Explosion Scenarios

Scenario Number	Facility Element	Distance (m) to Selected Criteria	
		NFPA Irreversible Harm 6.9 kPa(g)	NFPA Fatality 20.7 kPa(g)
10	Hydrogen Storage Vessel	149	69
11	Electrolyzer or Fuel Cell Container	54	25
12	Battery Enclosure (BESS)	61	29

The maximum predicted extents to selected end points, without consideration of the likelihood of the event and associated meteorology, is often used in emergency response planning. These predicted extents are provided in Figure 7.1. The hazard extent contours indicate an area in which emergency response could be prioritized in the event of an accident. As noted previously, the hazard predictions for vapour cloud explosions assume that the portion of the cloud in the assumed congested regions that is at greater concentrations than the LFL is involved in the explosion, where the congested regions include the solar panel array, hydrogen storage modules, and battery modules. The results provided in Figure 7.1 can help prioritize emergency response and allocate resources but are not directly used to assist in the siting of the facility relative to the public infrastructure.

Figure 7.1 Predicted Maximum Downwind Distances to Considered Hazard Endpoints



7.2 INDIVIDUAL RISK RESULTS

Individual risk was assessed based on the chance of fatality and irreversible harm using the risk levels presented by the NFPA (NFPA, 2019), and shown in Table 6.5. The factors influencing the risk calculations include the failure frequencies presented in Table 6.2, the additional conditional probabilities (probability of release being ignited) presented in Figure 6.1 and the frequencies of wind directionality and speed presented in Figure 6.2. Maps of the risk frequency contours around the facility are shown in Figure 7.2 for fatalities and Figure 7.3 for irreversible harm. These shapes of the contours in these figures reflect wind directionality/speed probabilities as well as the probabilities associated with the different release scenarios and their locations within the facility.

The predicted extents of the NFPA Zone 1 level (green contour) and Zone 2 level (yellow contour) fall within the property boundary of the facility, with all areas outside of the property boundary predicted to fall into Zone 3. When considering fatalities, Zone 3 is defined as having risk levels less than 0.3 chances in a million of a fatality occurring on an annual basis. The NFPA 59a guidelines indicate that individual risk levels in Zone 3 are considered tolerable to the public, with no restrictions on land use in this zone. Therefore, the proposed facility is predicted to present acceptable risks to the public.

Table 7-7 provides a comparison of common individual risk levels for Barbados relative to the Zone 3 criteria. As can be seen in this table, the risk posed to the public due to the proposed facility is small in comparison to common causes.

Table 7-7 Comparison of Common Individual Risks in Barbados to the NFPA Zone 3 Criterion

Cause	Individual Risk (Chances in a Million of a Fatality)
Motor Vehicle Accident [1]	77.7
Falls [1]	14.4
Drowning [1]	3.3
Fires [1]	1.7
NFPA Zone 3	<0.3

1 – Data for Barbados in 2018 (World Health Rankings, 2020)

Figure 7.2 Predicted Individual Fatality Risk Contours

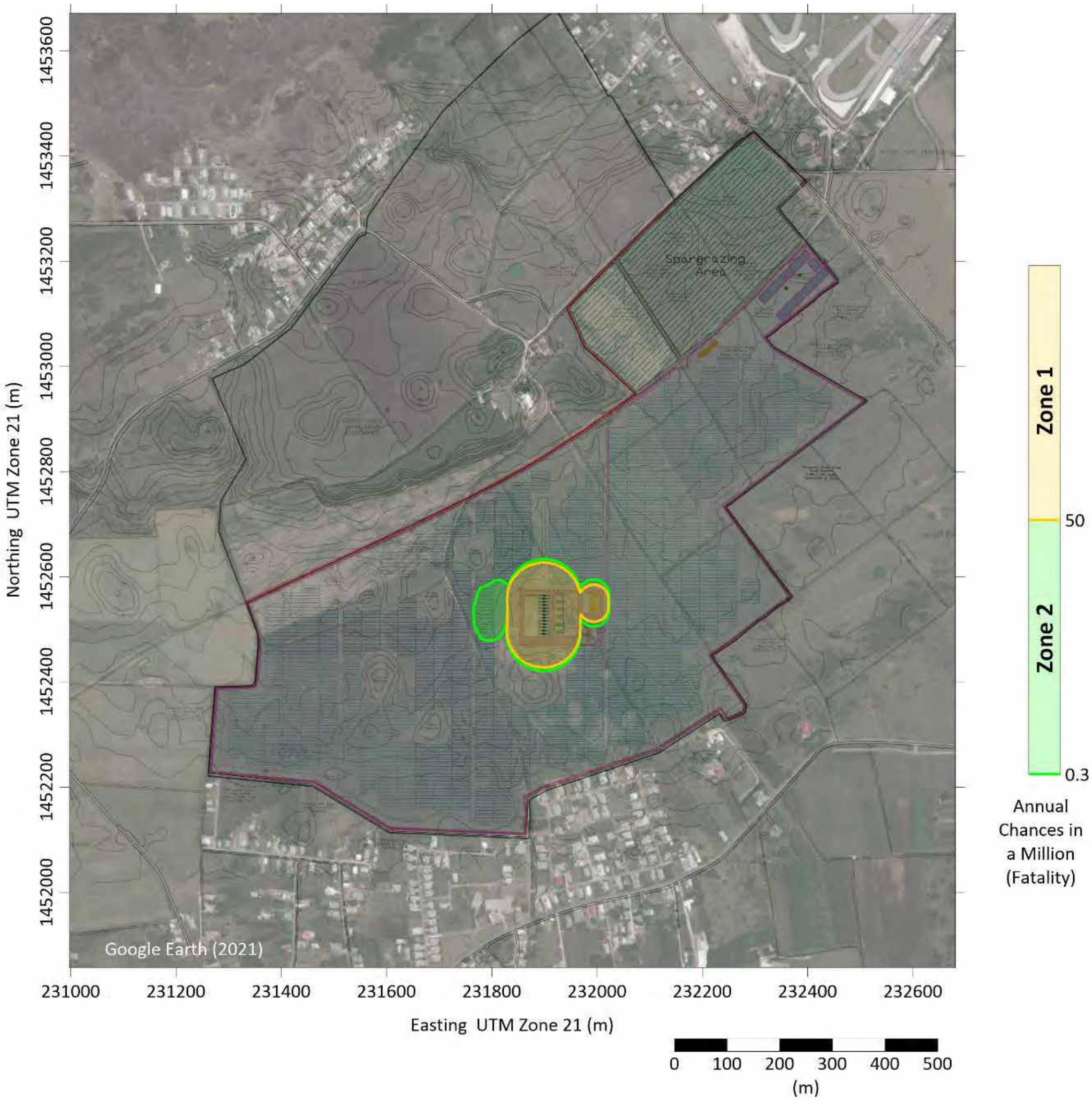
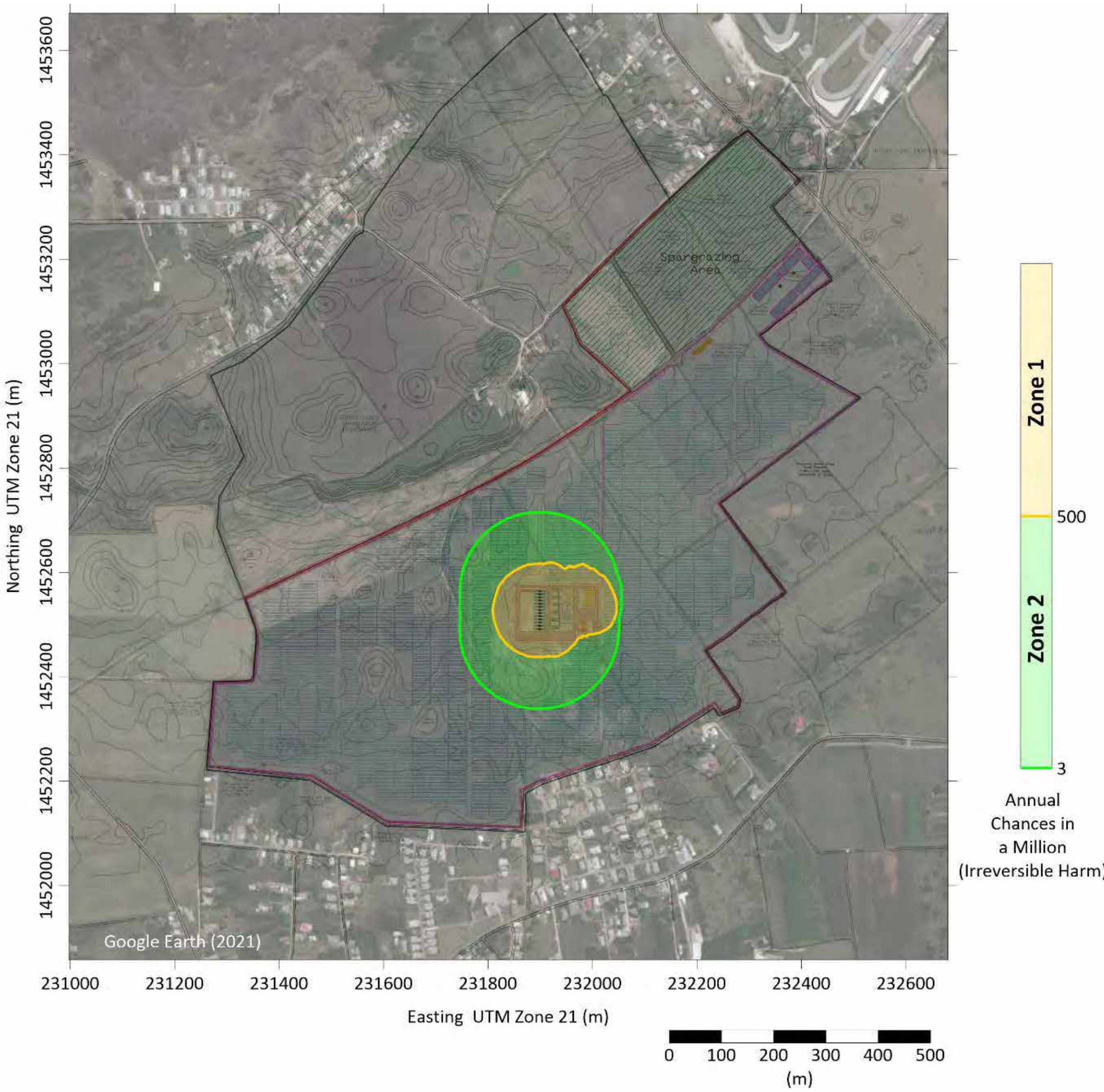


Figure 7.3 Predicted Individual Irreversible Harm Risk Contours



7.3 SOCIETAL RISK

An important factor in the estimate of Societal risk is the population density in the area surrounding the risk source. The individual risk results indicate that there are no permanent residences in either Zone 1 or Zone 2, which fall within the facility boundary. As a result, the societal risk curve will fall in the tolerable zone.

7.4 MODEL SENSITIVITY AND UNCERTAINTY

Uncertainty associated with risk assessment predictions could stem from the following areas:

- Uncertainty in emissions estimation;
- Uncertainty in consequence modeling (including limitations of the model physics and formulations and meteorology); and,
- Uncertainty with frequency data.

Facility releases were estimated using the RELEASE model which has been validated against measured data from several actual releases of different fluids, pipeline configurations and pressures. The model has validated well versus these data. In the release modeling the drag coefficient was varied and the maximum release rate over a range of drag coefficients was conservatively used. Thus, the RELEASE modeling is expected to produce conservative emissions estimates.

Consequence modeling was conducted using the SLAB model which has also undergone considerable validation and been shown to perform well versus actual measurement data. Therefore, the uncertainty associated with the consequence modeling is expected to be low.

Overall, the consequence and risk assessment analysis provided in this report are expected to provide conservative estimates of the actual hazard extents and risk levels associated with the proposed project.

8.0 CONCLUSIONS

Source characterization and consequence modelling were completed to estimate the consequence extents in the vicinity of the Project. The source modelling considered time varying releases from pressurized storage. Consequence modelling considered the impacts of hazardous events including flash fires, vapour cloud explosions, jet fires and vessel and container explosions.

The primary hazards associated with an H_2 release are the flammability of the fluid and the potential for a flash fire, jet fire, storage vessel explosion, enclosure explosion, or a vapor cloud explosion. The potential release scenarios from the Project were assessed from both catastrophic ruptures (less likely) and leaks (more likely).

Dispersion and thermal radiation consequence modeling were conducted over a range of weather conditions, obstruction drag assumptions, and release scenarios. The following conclusions were made related to the consequence modelling results:

- The maximum predicted distance to the lower flammability limit (LFL) was 193 m, and occurred because of a catastrophic release from the H_2 storage vessel;
- The maximum predicted distance to 50% of the lower flammability limit (LFL/2) was 306 m and occurred as a result of a catastrophic release from an H_2 storage vessel;
- The maximum predicted distance to a thermal radiation endpoint equivalent to an exposure of 5 kW/m^2 (for 40 seconds) associated with the jet fire hazard event was 47 m and occurred because of a catastrophic release from an H_2 storage vessel;
- The maximum predicted distance to overpressures of 6.9 kPa(g) and 20.7 kPa(g) for an explosion of a H_2 storage vessel were 149 and 69 m, respectively;
- The maximum predicted distance to overpressures of 6.9 kPa(g) and 20.7 kPa(g) for an explosion of a fuel cell or hydrolyzer container were 54 and 25 m, respectively;
- The maximum predicted distance to overpressures of 6.9 kPa(g) and 20.7 kPa(g) for an explosion of a BESS container were 61 and 29 m, respectively; and
- The maximum predicted distances to overpressure endpoints of 6.9 kPa(g) and 20.7 kPa(g) were 272 m and 158 m, respectively and occurred for a large rupture from the H_2 storage vessel.

Risk calculations were performed to evaluate the potential for harm associated with the Project with consideration of both the potential consequences and their likelihood of occurrence.

Individual incremental risk contour plots are presented in Figure 7.2 and Figure 7.3. The risk contours indicate that the risk is largely localized to the Project site, with risk levels for fatality or irreversible harm being less than the NFPA 59a Guideline Zone 3 values (no restrictions) at all locations outside the facility boundary. The individual risk results indicate that from a public safety perspective the facility is sited appropriately, and the risk posed to the public due to the facility is small in comparison to common causes in Barbados.

Additionally, the individual risk predictions indicate that societal risk will fall in the region considered by the NFPA to be tolerable.

9.0 CLOSURE

This report has been prepared for the sole benefit of Renewstable® Barbados, and their representatives. The report may not be used or relied upon by any other person or entity without the express written consent of Stantec and Renewstable® Barbados.

Any use which a third party makes of this report, or any reliance on decisions made based on it, is the responsibilities of such third parties. Stantec accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Should additional information become available which differs significantly from our understanding of conditions presented in this report, we request that this information be brought to our attention so that we may reassess the conclusions provided herein.

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APPENDIX E

Acoustic Assessment

Acoustic Assessment Report – Harrow Photovoltaic (PV) Project

Final Report

January 20, 2022

Prepared for:
Renewstable (Barbados) Inc., a HDF Energy Company

Prepared by:
Stantec Consulting Caribbean Ltd.

File: 1276738554

ACOUSTIC ASSESSMENT REPORT – HARROW PHOTOVOLTAIC (PV) PROJECT

This document entitled Acoustic Assessment Report – Harrow Photovoltaic (PV) Project was prepared by Stantec Consulting Caribbean Ltd. for Barbados Light and Power Corporation. The material in it reflects Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Caribbean Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

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Justin Jennings-Wray

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Executive Summary

HDF Energy is proposing to construct and operate Renewstable® Barbados (RSB), a non-intermittent electrical power plant solution (the Project) at Harrow Plantation in the parish of Saint Philip, Barbados. The plant will produce 13 MW firm of renewable electrical power between 8 AM to 5 PM and 7 PM to 9 PM and 3 MW firm power the rest of the time. The Project is also a dual land use project and will include a Blackbelly sheep farming facility with direct grazing and grass harvesting within the solar power plant and surrounding green areas (HDF Energy 2021). Baseline noise monitoring was conducted to quantify the existing acoustical environment near the Project. The measurement program consisted of taking discrete measurements at seven locations. The baseline noise levels averaged between 46 and 55 dBA during the daytime. Dominant noise sources included road noise, human activity, and sounds of nature (i.e. dogs and wind).

Sound emissions from the proposed facility were predicted with acoustical modelling software to estimate the change in sound levels at nearby receptor locations. Acoustic modelling was completed using the commercially available CADNA/A software. The main Project noise sources include transformers, inverters, electrolyzers and battery packs used for energy storage. Noise levels at the nearest points of reception were estimated and then assessed for compliance using World Health Organization and World Bank noise exposure guidelines.

The assessment indicated that the noise contribution from the Project would not exceed World Health Organization criteria at the points of reception identified near the Project during the daytime. During the nighttime slight exceedances of the WHO guideline criteria of 45 dBA were predicted at the nearest receptors to the south of the Facility. As these predictions are likely overly conservative, mitigation has not been recommended. While not required, if additional mitigation is desired, it could be achieved through physical controls (i.e., a noise enclosure for the battery storage facility) or specification of quieter equipment.

Abbreviations

ASA	Acoustic Study Area
dB	Decibel
dBA	Decibel, A-weighted
Hz	Hertz
ISO	International Organisation for Standardisation
Km	Kilometre
L_{eq}	Energy Equivalent Sound Level
L_p	Sound Pressure Level
LSA	Local Study Area
L_w	Sound Power Level
m	metre
POR	Point of Reception
PWL	Sound Power Level
SPL	Sound Pressure Level
WHO	World Health Organization

Glossary

Acoustic Study Area	Study area for the purposes of the Acoustics Assessment Technical Study. Generally, within 1,000 m of the Project property boundaries, with receptors considered in each cardinal direction.
Airborne Sound	Sound that reaches the point of interest by propagation through air.
Ambient Sound Level or Ambient Noise	All-encompassing sound that is associated with a given environment, usually a composite of sounds from many sources near and far. Includes noise from all sources other than the sound of interest (i.e., sound other than that being measured), such as sound from other industrial noise, transportation sources, animals and nature.
Attenuation	The reduction of sound intensity by various means (e.g., air, humidity and porous materials).
A-Weighting	The weighting network used to account for changes in level sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (i.e., 6.3 kHz and above) and low (i.e., below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of the human ear. See also frequency weighting.
Background Sound Level or Background Noise	Same as the ambient sound level.
Calibration	Procedure used to adjust a sound level meter using a reference source of a known sound pressure level and frequency. Calibration must take place before and after the sound level measurements.
Daytime	Defined as the hours from 07:00h to 22:00h; aligned with the WHO Noise Level Guidelines.
Decibel	A logarithmic measure of any measured physical quantity and commonly used in the measurement of sound. The decibel (dB) provides the possibility of representing a large span of signal levels in a simple manner. The difference between the sound pressure for silence versus a loud sound is a factor of 1,000,000:1 or more, therefore it is less cumbersome to use a small range of equivalent values: 0 to 130 dB. A tenfold increase in sound power is equal to +10 dB; a tenfold increase in sound amplitude is equal to +20 dB.
Decibel, A-weighted	A-weighted decibels (dBA). Most common units for expressing sound levels since they approximate the response of the human ear.

Decibel, Linear	Unweighted decibels (dBL). Logarithmic units associated with a sound pressure level, where the sound pressure signal is unfiltered and represents the full spectrum of incoming noise.
Energy Equivalent Sound Level	An energy-average sound level (L_{eq}) over a specified period that would have the same sound energy as the actual (i.e., unsteady) sound over the same period. It represents the average sound pressure encountered for the period. The period is often added as a suffix to the label (i.e., L_{eq}(24) for the 24-hour equivalent sound level). An L_{eq} value expressed in dBA is a good, single-value descriptor of the annoyance of noise.
Existing Ambient	All sounds in a given area (i.e., includes all natural sounds as well as all mechanical, electrical and other human-caused sounds).
Frequency	The number of times per second that the sine wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz). Frequency equals Speed of Sound / Wavelength.
Frequency Weighting	A method used to account for changes in sensitivity as a function of frequency. Three standard weighting networks, A, B, and C, are used to account for different responses to sound pressure levels. Note: The absence of frequency weighting is referred to as "flat" response, generally noted Z. See also A-weighting.
Ground Effect	The change in sound level, either positive or negative, due to intervening ground between source and receiver. Ground effect is a relatively complex acoustic phenomenon, which is a function of ground characteristics, source-to-receiver geometry, and the spectral characteristics of the source. A commonly used rule-of-thumb for propagation over soft ground (e.g., grass) is that ground effects will account for about 1.5 dB per doubling of distance. This relationship is empirical and tends to break down for distances greater than about 30 to 61 metres.
Hertz (Hz)	The unit of frequency also expressed as cycles per second.
Intensity	The sound energy flow through a unit area in a unit time.
International Organisation for Standardisation	An international body that provides scientific standards and guidelines related to various technical subjects and disciplines.
Mitigation	Measures taken to reduce, eliminate, or control impacts on the environment.
Monitoring and Protection Plan	A plan that outlines the conditions necessary to maintain adequate sound or vibration levels at area receptors. Components of such a plan may include monitoring protocols, complaint responses, and mitigation alternatives.
Natural Ambient	All natural sounds in a given area, excluding all non-natural sounds. “Natural ambient” is considered synonymous with the term “natural quiet,” although natural ambient is more appropriate because nature is often not quiet.

Nighttime	Defined as the hours from 22:00h to 07:00h; aligned with the WHO Noise Level Guidelines.
Noise	Any unwanted sound. "Noise" and "sound" are used interchangeably in this document.
Noise level	Same as sound level.
Octave	The interval between two frequencies having a ratio of two to one. For acoustic measurements, the octaves start a 1,000 Hz centre frequency and go up or down from that point, at the 2:1 ratio. From 1,000 Hz, the next filter's centre frequency is 2,000 Hz, the next is 4,000 Hz, or 500 Hz, 250 Hz, etc. Octave filtering is usually referred to as the class of octave filters typically 1, 3 or 12, thus creating full octaves, one-third octaves, or one-twelfth octaves.
Point of Reception	A representative point considered for the purpose of assessment within noise-sensitive receptor such as a residence, campground, daycare, school, church, or hospital.
Point Source	Source that radiates sound spherically (i.e., equally in all directions). Sound levels from a point source decrease at an ideal rate of 6 dB per doubling of distance.
Sound	A wave motion in air, water, or other media. It is the rapid oscillatory compression changes in a medium that propagate to distant points. It is characterized by changes in density, pressure, motion, and temperature as well as other physical properties. Not all rapid changes in the medium are due to sound (e.g., wind distortion on a microphone diaphragm).
Sound Level	Generally, sound level refers to the weighted sound pressure level obtained by frequency weighting, usually A- or C-weighted, and expressed in decibels
Sound Level Meter	An instrument consisting of a microphone, amplifier, output meter and frequency-weighting networks that is used to measure noise and sound levels.
Sound Power Level	The total sound energy radiated by a source per unit time. The unit of measurement is the Watt. The acoustic power radiated from a given sound source as related to a reference power level (i.e., typically 1E-12 watts, or 1 picowatt) and expressed as decibels. A sound power level of 1 watt = 120 decibels relative to a reference level of 1 picowatt.
Sound Pressure	The root-mean-square of the instantaneous sound pressures during a specified time interval in a stated frequency band.
Sound Pressure Level	Logarithmic ratio of the root mean square sound pressure to the sound pressure at the threshold of human hearing (i.e., 20 micropascals).
Sound Speed	The speed of sound in air is about 344 metres per second at 21°C and sea level. It varies depending on temperature and type of medium.

Spectrum (Frequency Spectrum)	The amplitude of sound at various frequencies. It is given by a set of numbers that describe the amplitude at each frequency or band of frequencies.
Wave	A particular type of disturbance that travels through a medium by virtue of the elastic properties of that medium.
Weighting	Adjustment of sound level data to achieve a desired measurement. A-weighting is used to account for changes in human hearing sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (i.e., 6,300 Hz and above) and low (i.e., below 1,000 Hz) frequencies, and emphasizes the frequencies between 1,000 Hz and 6,300 Hz, in an effort to simulate the relative response of human hearing. C-Weighting is linear over the mid frequency range from 200 Hz to 1,600 Hz, and de-emphasizes the low (i.e., below 200 Hz) and high (i.e., above 1,600 Hz) frequencies.
Windscreen	A porous device used to cover the microphone of a sound level measurement system. Windscreens are designed to minimize the effects of wind disturbance on the sound levels being measured while minimizing the attenuation (i.e., less than 0.5 dB) of the signal.

1.0 INTRODUCTION

HDF Energy is proposing to construct and operate Renewstable® Barbados (RSB), a non-intermittent electrical power plant solution (the Project) at Harrow Plantation in the parish of Saint Philip, Barbados. The plant will produce 13 MW firm of renewable electrical power between 8 AM to 5 PM and 7 PM to 9 PM and 3 MW firm power the rest of the time. The Project is also a dual land use project and will include a Blackbelly sheep farming facility with direct grazing and grass harvesting within the solar power plant and surrounding green areas (HDF Energy 2021).

The Project will consist of the following components (HDF Energy 2021):

- a ground mounted solar photovoltaic plant that generates power for storage and direct usage
- a long-term energy storage solution using hydrogen that includes electrolyzers, a gaseous hydrogen storage tank farm and a fuel cell system
- a short-term energy storage solution using Lithium-ion batteries
- a commercial Blackbelly sheep farm

Noise emissions from the proposed facility have the potential to change existing noise levels. Stantec Consulting Caribbean Ltd. (Stantec) was therefore retained to conduct an acoustic assessment of the proposed facility.

The proposed Project will be constructed in a lightly populated area approximately 15 km east of Bridgetown, in the southeast part of the island. Several potentially noise sensitive receptors are located within 1,000 m of the Project to the south, west and north. The purpose of this acoustic assessment was to estimate the potential increase in sound levels at the nearby receptor locations due to the operation of the Project.

2.0 STUDY AREA

A study area was chosen to address the sphere of influence of noise around the facility and is referred to as the Acoustics Study Area (ASA). The ASA includes the proposed plant site and the adjacent lands within 100 m of the Project property boundaries.

The Acoustic Study Area and location of the Project are shown in Figure 2.1.

2.1 LOCAL INDUSTRIAL SITES

The photovoltaic power plant site is located at Harrow Plantation, St. Philip. Access to the site will be provided via Harrow Road, branching off Bushy Park Road to the East and Sunbury Road to the West. The site itself is situated on agricultural land, with the immediate and expanded surroundings predominantly consisting of residential and agricultural land. Residential communities exist adjacent to the Northern and Southern project boundaries. Harrow Plantation Yard is located immediately adjacent and North of the array – West of the sheep grazing area. A small community is located adjacent and North of the sheep grazing area, and a larger community – Marchfield Village – is situated along much of the Southern boundary. A veterinary clinic is located at Sunbury Plantation some 400m West of the site. Bushy Park Raceway is located approximately 250m Northeast of the array, and Bush Park Cemetery approximately 300m to the Southeast

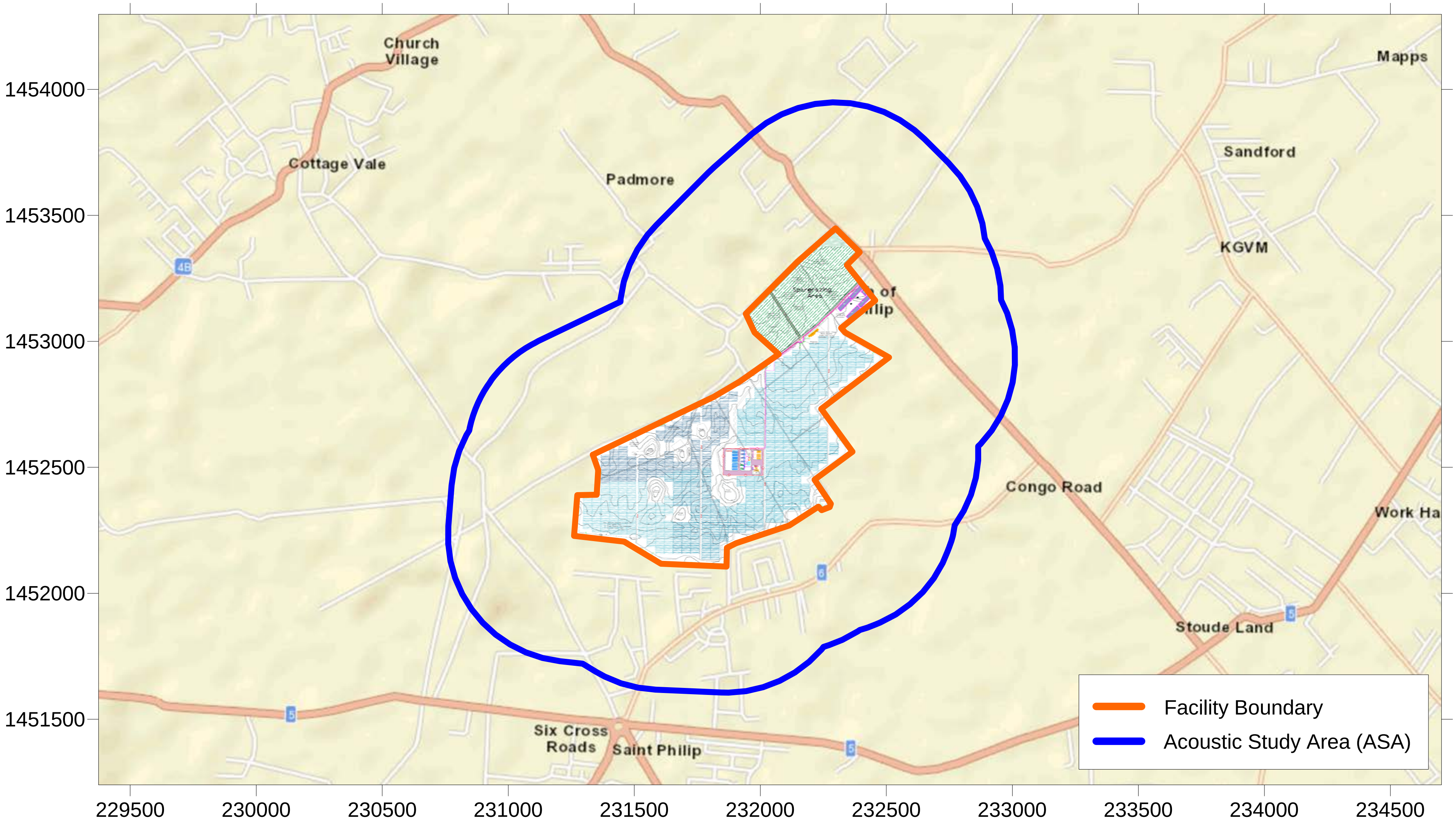

Figure 2 1 Acoustic Study Area (UTM Coordinates Zone 21)

2.2 TRANSPORTATION CORRIDORS

The Project would be located north of Highway 5 and Congo Road with Sunbury Road to the west and Highway M to the east. Road traffic from these roads has the potential to also contribute to the acoustic environment near the Project.

2.3 TOPOGRAPHY

Satellite topographic data was retrieved for the region for this acoustics assessment. The Shuttle Radar Topography Mission (SRTM) collected topography worldwide on a 1-arcsecond resolution (Farr et al., 2007). The surrounding topography is shown in Figure 2-2. Elevation changes between the Project and nearby receptors were estimated to be between 3 and 6 m lower to the south, with gently sloping terrain. Receptors located to the west are positioned at an elevation similar to the Project site, and those located to the north are approximately 9 – 12 m higher.

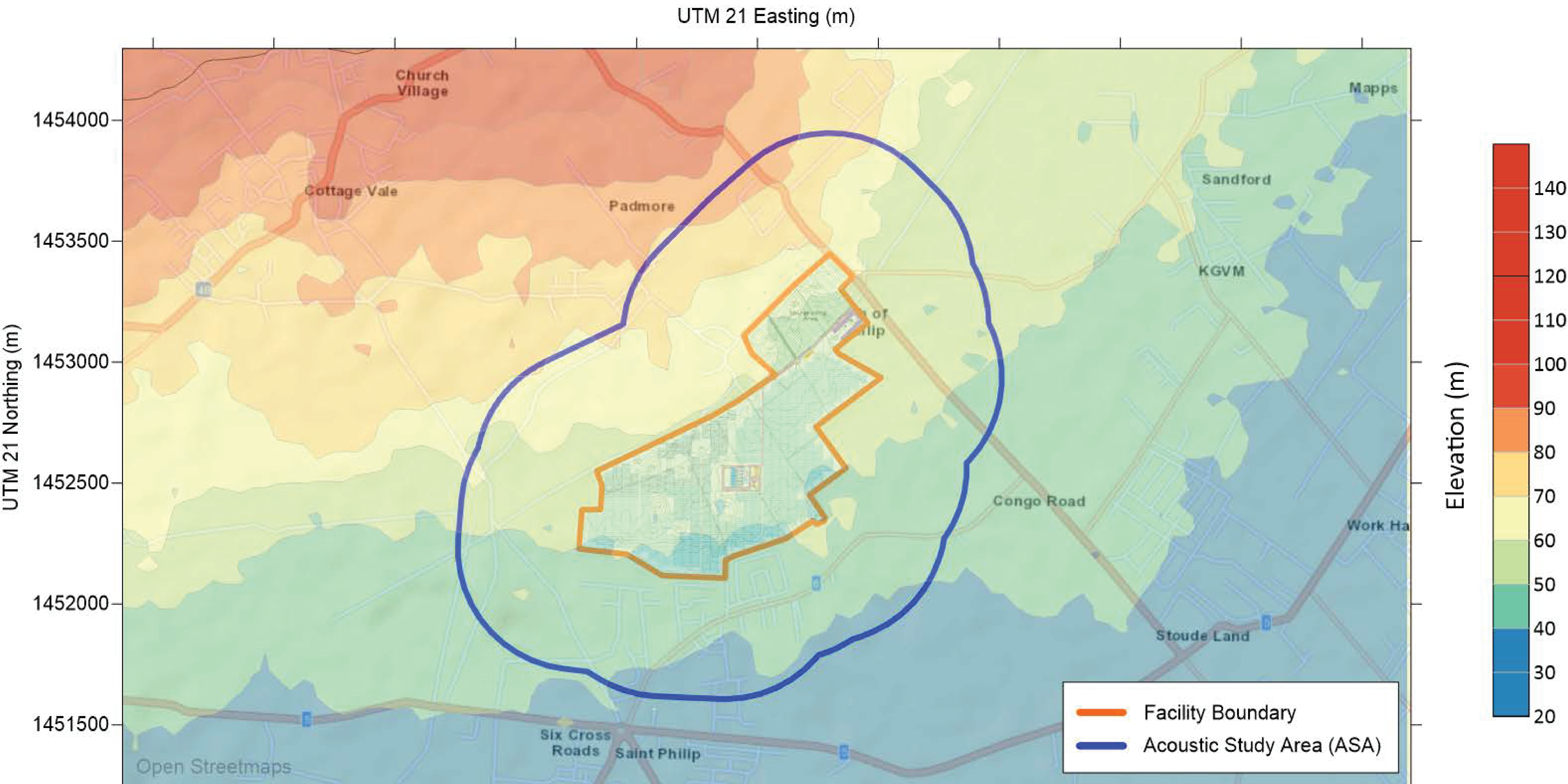

Figure 2 2 Topography near Project Location (UTM Coordinates Zone 21)

3.0 APPLICABLE REGULATIONS AND GUIDELINES

The Environmental Protection Division (EPD) of the Ministry of Housing, Lands and Environment does not specify acceptable noise levels from industrial facilities but does regulate the conditions for noise abatement and also investigates noise complaints. The World Health Organization (WHO) has published guidance on suitable noise thresholds for industrial applications (WHO 1999). Acceptable noise levels for residential areas are presented in Table 3-1

In addition to the WHO guidelines, the World Bank has published guidance indicating that if baseline sound levels are already above the guideline levels, the combined sound level from the proposed facility and baseline should be no more than 3 dBA above the baseline level (World Bank Group 2007).

Table 3-1 World Health Organization Noise Level Guidelines

Area (Outside Property Boundary)	One Hour L_{eq} (dBA)[1]	
	Day: 07:00 to 22:00 (dBA)	Night: 22:00 to 07:00 (dBA)
Residential	55[2]	45[2]

Notes:
[1]In cases where baseline sound levels are greater than the guideline level Leq, the World Bank recommends that the combined sound level for the project and baseline be no more than 3 dBA above baseline sound levels (World Bank Group 2007).
[2]From (WHO, 1999)

4.0 EXISTING ACOUSTICAL ENVIRONMENT

4.1 BASELINE NOISE MONITORING METHODOLOGY

Baseline noise monitoring was conducted to quantify the existing acoustical environment in the ASA. The measurement program consisted of taking discrete measurements at potential receptor locations near the Project during the day. Upon review of aerial imagery, residential locations were noted to the south, west, north, and northeast of the Project, with the closest receptors located to the south. Monitoring locations were chosen near identified sensitive receptors. The locations of the noise monitoring locations are presented in Figure 4.1. Locations were selected in all directions away from the facility except for the east, as the extent of the undeveloped agricultural lands in this direction implies no impact to human receptors. Monitoring location M1 was selected to represent the location that will house much of the power production infrastructure. Monitoring locations M2, M5 and M6 represent private residences located to the southeast, west and north of the Project site, respectively. Monitoring locations M3, M4 and M7 represent residential communities' location along the southern, southwestern and northeastern boundaries of the proposed facility.

The baseline noise monitoring was conducted using a Quest/3M SoundPro Type 2 sound level meter. The meter was calibrated according to manufacturer recommendations (refer to Appendix A) and were field calibrated before and after collecting data. Foam windscreens were used to reduce extraneous noise from wind.

Ten-minute noise measurements were taken over several hours throughout the day on August 31, 2021, September 1, 2021, and September 2, 2021 at the seven monitoring locations. Sound pressure levels were stored as energy averaged values, or L_{eq}, as A-weighted decibels (dBA), to capture the average sound pressure level present at each location over the measurement period. Summaries of noise levels in the bottom 90th percentile (called L_{90}, or the sound level that is not exceeded 90% of the time over the measurement period) were also included in the sound monitoring.

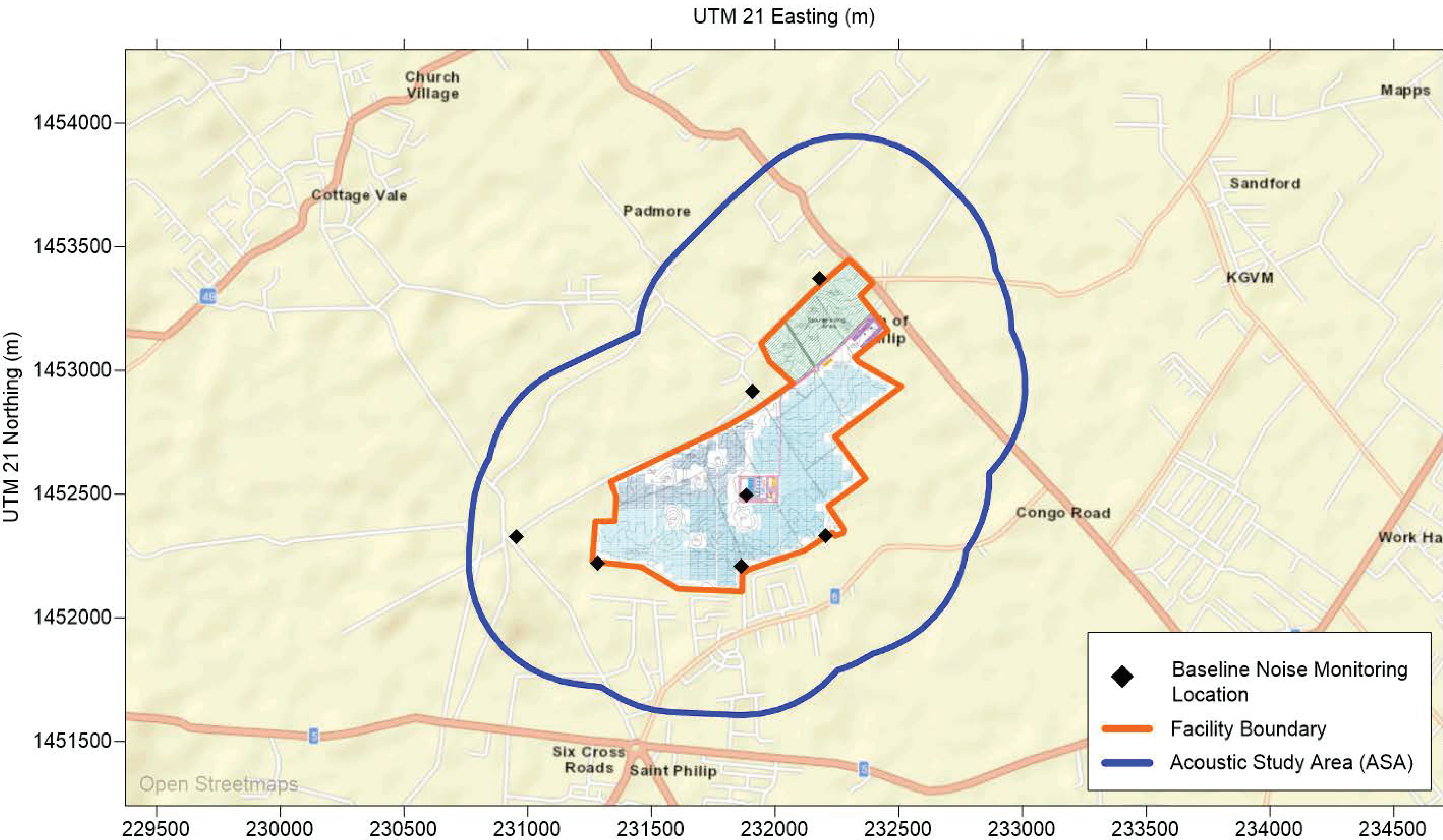

Figure 4 1 Baseline Noise Monitoring Locations (UTM Coordinates Zone 21)

4.2 BASELINE NOISE MONITORING RESULTS

The baseline noise monitoring results for each monitoring site, along with meteorological data and general comments collected during the monitoring are provided in detailed in the “Baseline Noise Assessment for the Harrow PV Project” (Stantec Consulting Caribbean Ltd. 2021) (refer to Appendix A). A summary of the average sound pressure and L_{90} levels at each monitoring location is provided in Table 4.1. Sound levels measured during times of extraneous activity (e.g., nearby vehicle pass-bys and animal calls) were omitted from the data presented in Table 4.1.

Table 4-1 Summary of Baseline Noise Monitoring Results

Sound Monitoring Location	Coordinates (UTM Zone 21)		1-hour L_{eq} Daytime Sound Pressure Level (dBA)	1-hour L_{90} Daytime Sound Pressure Level (dBA)
	Easting (m)	Northing (m)		
M1	231,882	1,452,495	47	46
M2	232,205	1,452,331	47	46
M3	231,865	1,452,209	48	47
M4	231,285	1,452,220	51	48
M5	230,955	1,452,326	53	48
M6	231,910	1,452,915	46	46
M7	232,179	1,453,371	55	47

The dominant noise sources included traffic noise and sounds of nature (i.e., wind and wind through cane, and dogs). For the daytime period, sound pressure levels averaged between 46 dBA and 55 dBA. The L_{90} values ranged from 46 dBA to 48 dBA during the day.

The monitoring results indicate that daytime noise levels are mainly a result of vehicle traffic and other human activities and sounds of nature.

Further details with respect to the baseline noise monitoring can be found in the “Baseline Noise Assessment for the Harrow PV Project” (Stantec Consulting Caribbean Ltd. 2021).

5.0 ACOUSTICS MODELLING ASSESSMENT

Acoustic modelling was conducted to predict sound pressure levels in the ASA from the operation of the Project. Modelling was completed using CADNA/A, a commercially available environmental acoustic model that complies with the algorithms described in the ISO 9613-1 and 9613-2 standards for acoustic modelling. CADNA/A includes geometrical divergence (distance attenuation), barrier effects due to intervening structures, ground effects, atmospheric absorption, and topography. Wind direction can change noise attenuation through the air, and therefore wind direction is always assumed to be blowing from each source location to each point of reception.

The main sources of noise consist of:

- air coolers associated with the electrolyzer and fuel cell,
- electrolyzers and fuel cells associated with the energy storage area,
- inverters and transformers linked to the operation of the photovoltaic solar panels,
- inverters and transformers related to the operation of the energy storage area,
- fan noise from the battery backs at the energy storage area, and
- sheep pens

Sound power levels for major equipment units associated with the Project were estimated based on noise level data provided by HDF Energy where available, and acoustic technical literature corresponding to appropriate equipment specifications (Bies and Hansen 2009 and Malen 2013). Sound levels associated with the sheep farm were acquired from available literature. According to Weeks et al. (2009), the sound level within a sheep pen containing approximately 100 sheep ranges from 57 dBA to 62 dBA.

Octave band sound power levels for the identified noise sources that were included in the acoustic model are summarized in Table 5-1. The sheep pens were modelled as a single band source and an average sound power level of 60 dBA was assumed (Weeks et al. 2009).

Table 5-1 Sound Power Levels used for the Acoustic Model of Project Noise Sources

Source	Sound Power Level (dB) by Octave Band (Hz)									Total Sound Power Level	
	31.5	63	125	250	500	1000	2000	4000	8000	dB	dB(A)
Air Cooler (cooling fans)	94.0	100.0	98.0	97.0	96.0	95.0	96.0	91.0	84	105.6	101.1
Transformer	87.8	93.8	95.8	90.5	90.8	84.8	79.8	74.8	67.8	99.8	91.2
Inverter	-	68.2	58.2	66.6	65.2	68.0	66.8	74.0	75.1	79.2	78.5
Battery Pack Back	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	92.5	90.0
Battery Pack Module	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	96.0	105.5	103.0
Electrolyzer	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	108.5	106.0
Fuel Cell	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	108.5	106.0

A map of the noise sources used in the acoustic model is presented in Figure 5-1.

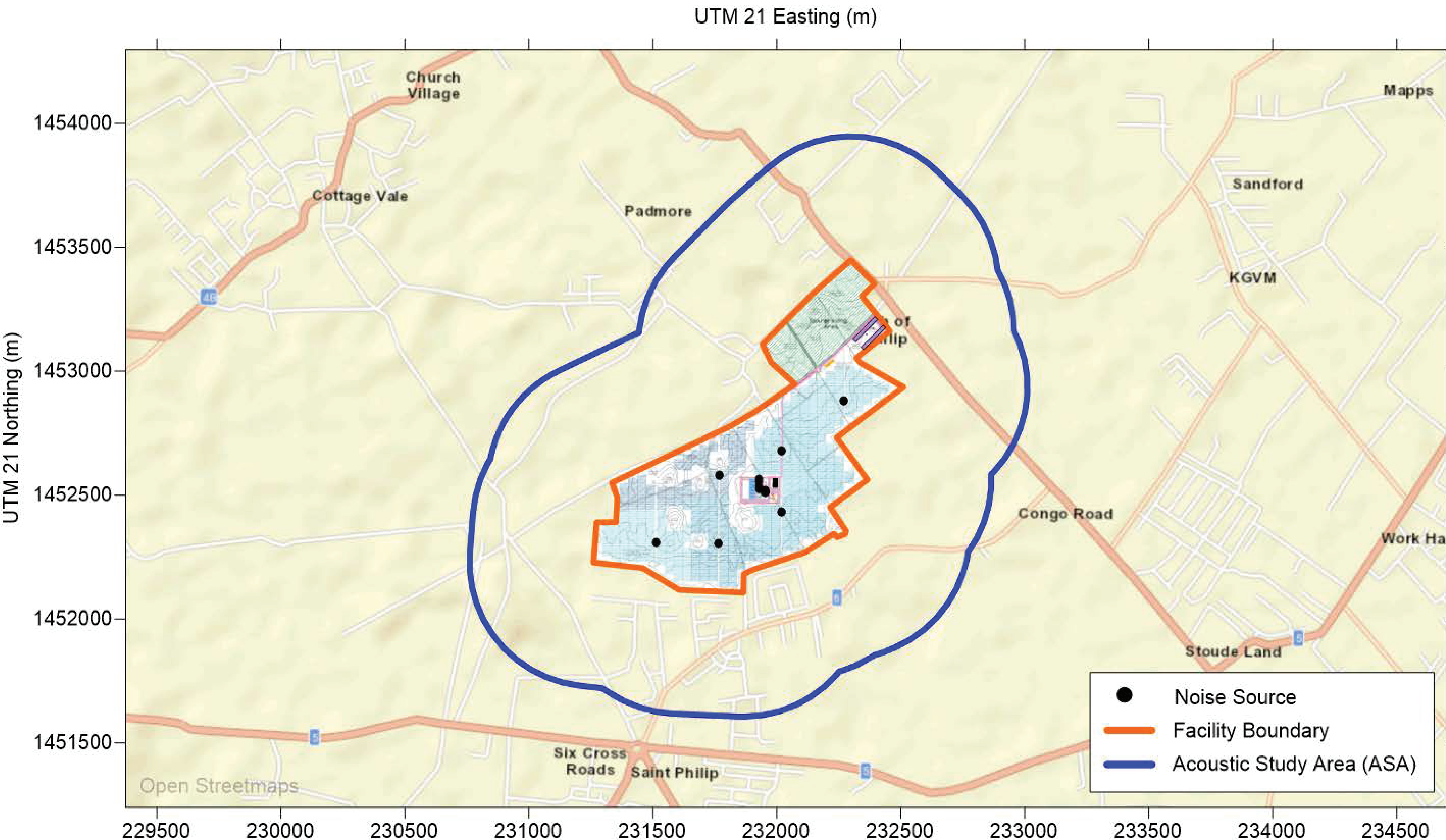

Figure 5 1 **Location of Noise Sources used in Acoustic Model (UTM Coordinates Zone 21)**

5.1 POINTS OF RECEPTION

Points of Reception (POR) are noise-sensitive locations, such as homes, located outside the Facility fence line. Industrial and commercial locations were not considered as part of the POR list since those locations are subject to less stringent noise guidelines. The most sensitive PORs within the ASA were identified from site plans and aerial photos. A total of 23 PORs were considered in the acoustic model and are listed in Table 5-2, and graphically presented in Figure 5-2. The PORs are located to the south, west, and northeast of the Facility.

Table 5-2 Points of Reception within the Acoustic Assessment Area

POR Number	UTM Coordinates (Zone 21)		POR Elevation Above Sea Level (m)
	Easting (m)	Northing (m)	
1	232,032	1,452,226	51
2	232,012	1,452,221	51
3	231,981	1,452,213	50
4	231,966	1,452,206	50
5	231,951	1,452,201	50
6	231,932	1,452,200	50
7	231,898	1,452,183	50
8	231,855	1,452,089	49
9	231,695	1,452,106	50
10	231,271	1,452,172	49
11	231,584	1,452,082	50
12	230,925	1,452,290	52
13	231,884	1,452,913	63
14	231,907	1,453,026	67
15	231,430	1,453,122	71
16	231,354	1,453,053	71
17	231,511	1,453,230	77
18	232,172	1,453,348	65
19	232,218	1,453,390	66
20	232,159	1,453,335	64
21	232,196	1,453,371	66
22	232,232	1,453,405	67
23	232,453	1,453,384	62

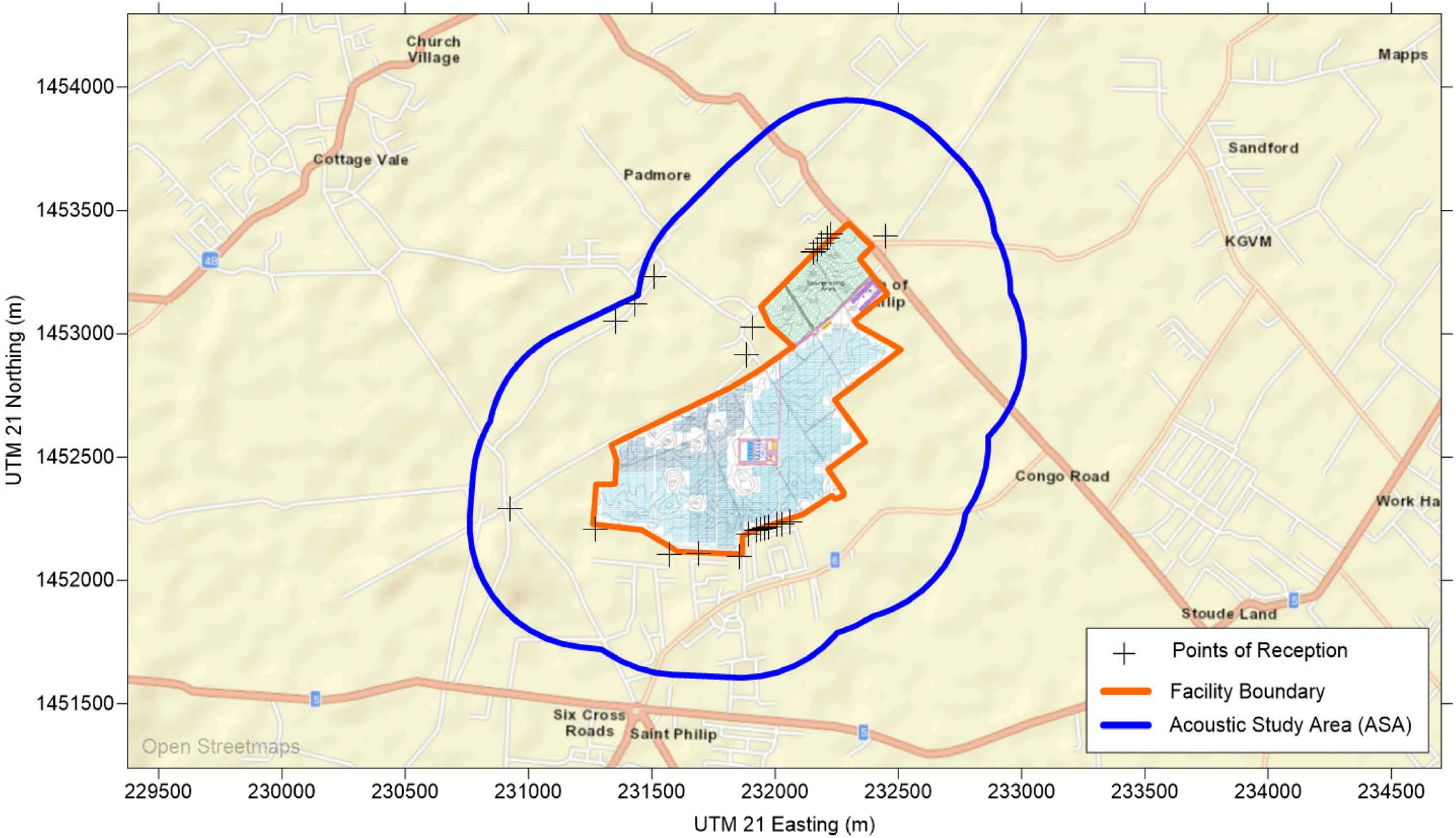

Figure 5 2 Points of Reception within the Acoustic Study Area (ASA) (UTM Coordinates Zone 21)

5.2 ACOUSTIC MODELLING SCENARIO

Once operational, the Facility is expected to operate continuously, 24 hours per day, 7 days per week, except during planned maintenance periods and unplanned outages.

Ground absorption was based on site drawings that delineated zones of higher absorption (e.g., vegetated or soils) and lower absorption (e.g., paved surfaces). A global ground absorption coefficient of 0.80 was used for modelling.

Two operating scenarios were reviewed:

1. **Daytime operations:** A worst-case scenario where the inverters, transformers, electrolyzers and battery storage units operate simultaneously at full capacity. The fuel cells will not operate during the daytime.
2. **Nighttime operations:** The same as scenario 1, except that the electrolyzers will not be operating and the fuel cells will be operating.

One-hour L_{eq} values were then computed and compared against the WHO and World Bank Guideline thresholds summarized in Section 3.

6.0 ACOUSTIC MODELLING RESULTS

Predicted hourly L_{eq} daytime and nightime sound pressure levels from the Project are shown in Table 6-1. The primary noise sources from the Project were the fuel cells, air coolers, battery packs, and electrolyzers. The predicted noise levels were well below the WHO guidelines criteria for daytime and at all points of reception. The predicted sound levels for the nighttime at PORs 1 through 6 were just above the WHO guideline criteria of 45 dBA. The predicted sound levels for the other PORs during the nighttime were below the WHO guideline criteria. Note the model currently does not consider the potential barrier effects due to the ten rows of solar panels between the noise generating sources and the receptors south of the facility.

Based on the existing noise generating activities near the Project, the Project is expected to result in a slight increase to ambient sound levels during the daytime.

As the baseline daytime sound levels are not above the WHO guideline levels, the World Bank guidance is not applicable.

Figures 6-1 and 6-2 shows the sound pressure level isopleths predicted for the operation of the Facility during the daytime and nighttime.

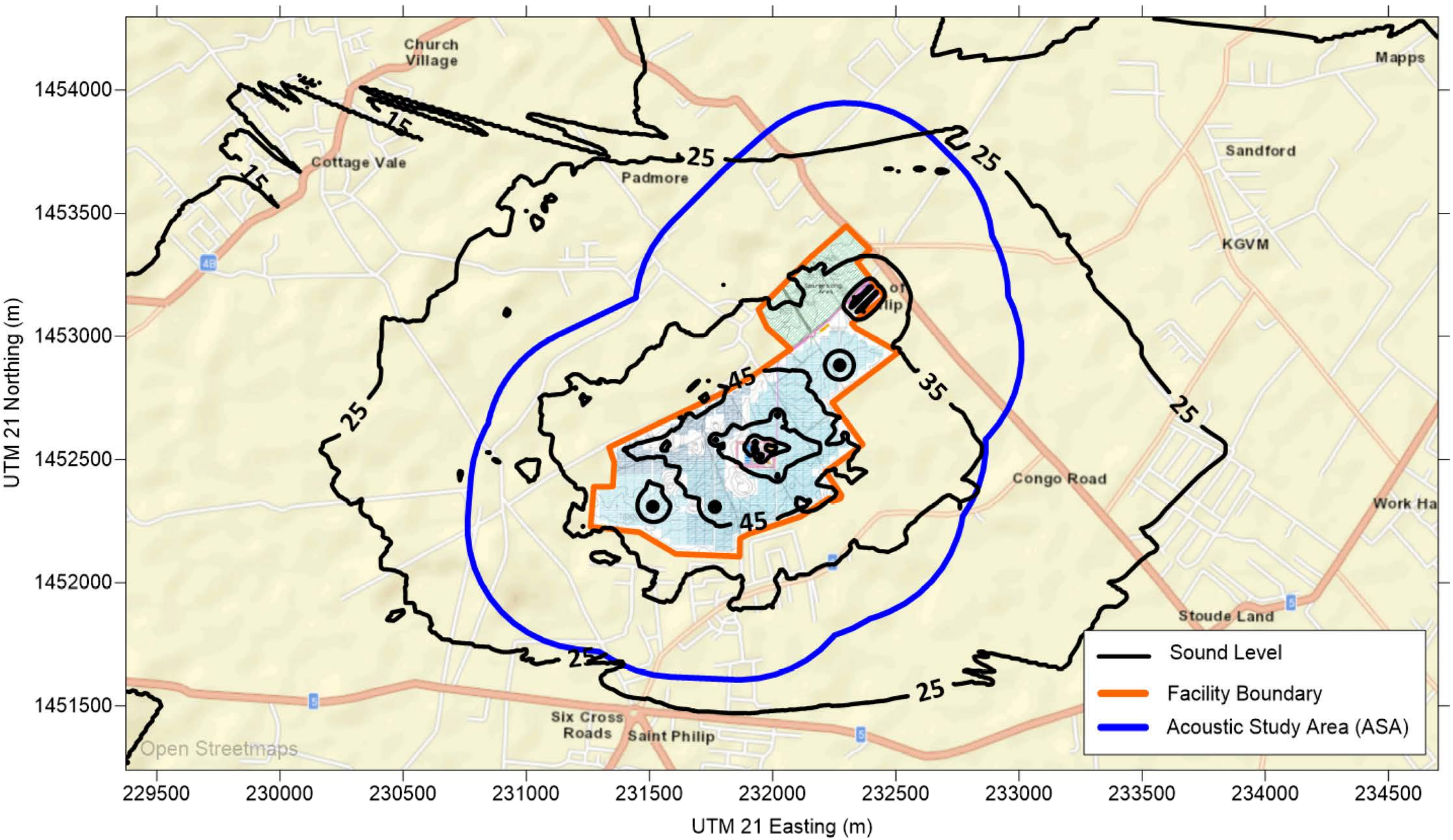

Figure 6 1 Predicted Sound Pressure Level Isopleths (dBA) from Project Operations during Daytime (UTM Coordinates Zone 21)

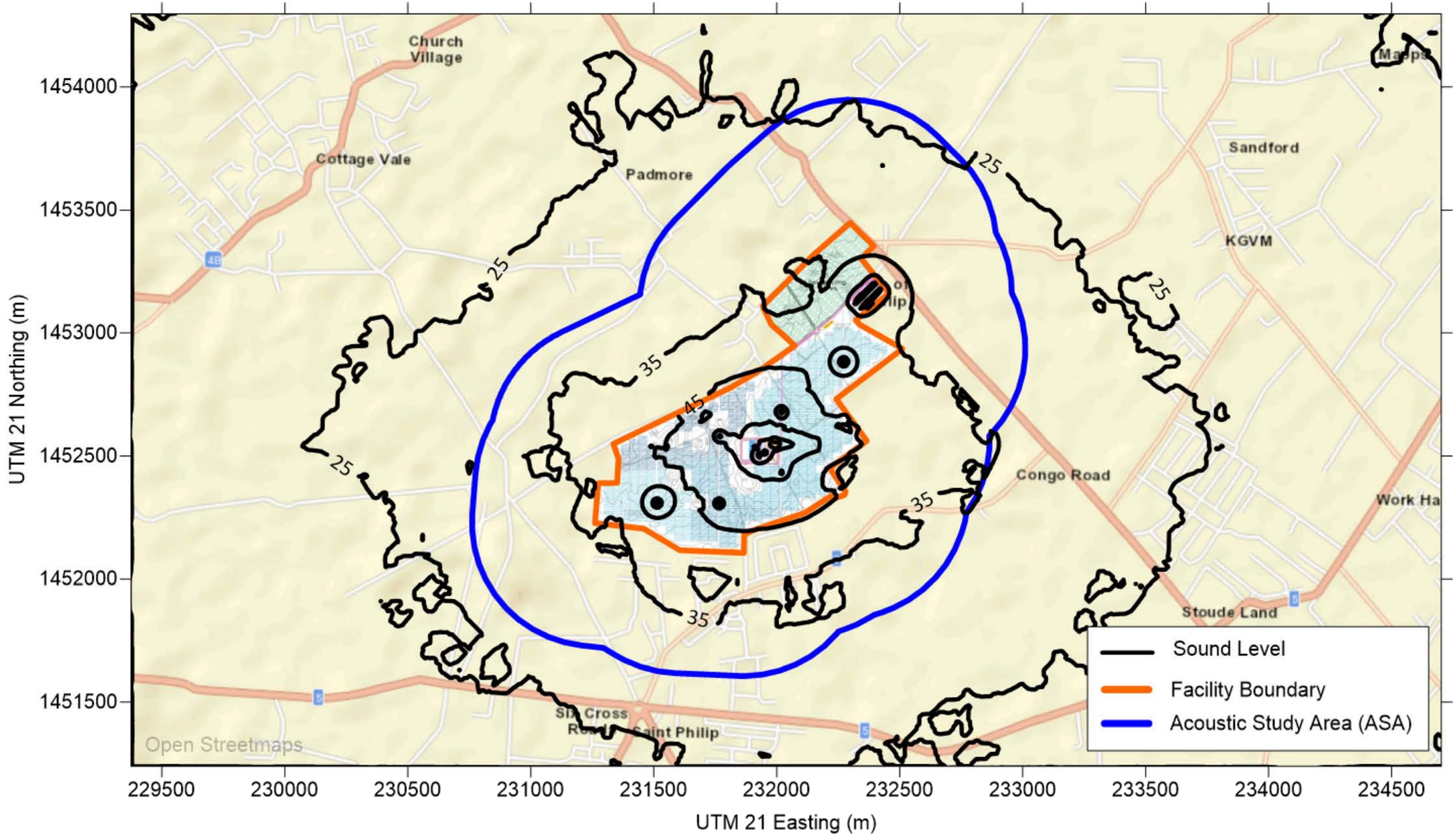

Figure 6 2 Predicted Sound Pressure Level Isopleths (dBA) from Project Operations during Nighttime (UTM Coordinates Zone 21)

Table 6-1 Predicted Sound Pressure Levels at Points of Reception

Receptor Location	Predicted Sound Pressure Level (dBA)		WHO 1-hour L_{eq} Guideline (dBA)	
	Daytime	Nighttime	Daytime	Nighttime
1	44	46	55	45
2	44	46		
3	43	46		
4	43	45		
5	43	45		
6	43	45		
7	43	45		
8	40	42		
9	40	42		
10	34	34		
11	38	39		
12	30	30		
13	43	43		
14	40	41		
15	32	31		
16	32	32		
17	32	31		
18	32	32		
19	32	32		
20	32	32		
21	32	32		
22	33	33		
23	33	32		

7.0 NOISE MITIGATION OPTIONS

The Project is predicted to comply with the WHO noise guidelines during the daytime, and no mitigation measures are required, however reductions to sound pressure levels could be achieved if desired. A few slight exceedances of the WHO guidelines were predicted during the nighttime at the nearest receptors, however it is likely that the nighttime predictions are overly conservative as they include noise from the operation of the inverters, which will likely not operate overnight when the facility is not generating power. Additionally, the model currently does not consider the potential barrier effects due to the ten rows of solar panels between the noise generating sources and the receptors south of the facility.

Physical noise controls, including consideration of an enclosure for the battery storage facility or physical barriers for transformers or inverters could be included. Some noise generation components may be available with additional noise reduction capabilities that may further reduce sound levels.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Stantec Consulting Caribbean Ltd. was retained by Barbados Light and Power Company to prepare an acoustic assessment for the proposed Lower Estates Solar Farm and Energy Storage project northeast of Bridgetown, Barbados. Stantec's assessment predicted that noise emissions during the operation of the proposed Facility would not likely exceed WHO acceptable noise levels at the Points of Reception identified within the Acoustic Study Area during the daytime. During the nighttime slight exceedances of the WHO guideline criteria of 45 dBA were predicted at the nearest receptors to the south of the Facility. As these predictions are likely overly conservative, mitigation has not been recommended. While not required, if additional mitigation is desired, it could be achieved through physical controls (i.e., a noise enclosure for the battery storage facility) or specification of quieter equipment.

9.0 CLOSURE

This report has been prepared on behalf of HDF Energy The acoustic analysis highlighted in this report is based on information obtained from HDF Energy and field observations. The assessment represents the conditions for the Project at the time of the assessment, and the conclusions are the best judgment of the assessor based on current environmental standards. Stantec Consulting Caribbean Ltd. attests that to the best of our knowledge, the information presented in this report is accurate.

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APPENDIX A

Baseline Assessment for the Harrow PV Project

Baseline Noise Assessment for Harrow PV Project

FINAL REPORT

September 16, 2021

Prepared for:

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Justin Jennings-Wray

Approved by ______________________________
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Justin Jennings-Wray

Table of Contents

Executive Summary

HDF Energy – hereafter termed the "Developer" – proposes the construction of a non-intermittent electrical power plant at Harrow, St. Philip, Barbados. The plant shall provide total power supplies of approximately 60,000 MWh/y. Much of the land slated for development will be used for the implementation of a PV power plant – intended to provide power during daylight hours. Additional plant components will be responsible for the non-intermittent supply of power during the night.

Due to the industrial nature of the proposed development, TCDPO requires the submission of an EIA to support the application for permission to proceed with the development. One component of said EIA is a noise assessment of the facility. In order to support an acoustic modelling exercise, an assessment of baseline noise levels originating from current site conditions site is required.

Baseline noise and climate measurements for seven (7) points were taken over three separate weekdays between 7:00AM and 5:00PM. Six of the seven monitoring points were arrayed North, West, and South of the project area – along the project border. One point within the development boundaries was also included. Each point was monitored for one hour during the morning period and for one hour in the afternoon period.

Five of the seven points were shown to experience average ambient sound levels below WHO guidelines; two points exhibited average ambient sound levels slightly above the guideline. Maximum noise levels (momentary instances of sound) were consistently above WHO guidelines. Generally, noise sources observed at each point were limited to wind interacting with vegetation and various noises originating from nearby communities, such as power tools, animals, and vehicles.

1.0 INTRODUCTION

HDF Energy – hereafter termed the "Developer" – proposes the construction of a non-intermittent electrical power plant at Harrow, St. Philip, Barbados. The plant shall provide total power supplies of approximately 60,000 MWh/y. Much of the land slated for development will be used for the implementation of a PV power plant – intended to provide power during daylight hours. Additional plant components will be responsible for the non-intermittent supply of power during the night. The plant shall consist of the following components:

- A 50 MWp photovoltaic plant
- A 20 MWp electrolyser system
- Hydrogen storage of 90 MWh in gaseous form in pressurized cylinders
- A Battery Energy Storage System; 14 MW max power, 3 hours capacity
- A high-power fuel cell system with capacity of 3MW
- Operation facilities and utilities; electrical room, water treatment, water supply, etc.
- A black-belly sheep farming facility

Due to the industrial nature of the proposed development, TCDPO requires the submission of an EIA to support the application for permission to proceed with the development. One component of said EIA is a noise assessment of the facility.

In order to support an acoustic modelling exercise, an assessment of baseline noise levels originating from current site conditions site is required. This report presents the findings of said baseline noise study.

2.0 NOISE

2.1.1 Noise

Noise is unwanted or undesired sound. Sound/noise waves are propagated in a spherical manner *(in all directions)* from point sources (see section 1.2.4). Sound is caused by the vibration of air molecules. When vibrated air molecules reach the ear, sound is heard. The frequency of vibration (of air molecules) is expressed in Hertz (Hz) – the number of vibrations per second. Audible sound ranges from 20Hz to 20,000Hz; frequencies below 20Hz are termed "infrasound" and those above 20,000Hz are termed "ultrasound". The magnitude of a sound, however, is expressed as a "sound pressure level" (SPL) in logarithmic decibel units (dB).

The human ear is not uniformly sensitive to all frequencies of sound. Several weighting scales have consequently been developed to simulate the various sensitivities. These weightings are known as A, B, C, or D weightings. Measurements of SPLs with a weighted response are referred to as 'sound levels with the appropriate suffix'; that is - dB(A), dB(B), dB(C) or dB(D).

The "A" weighting approximates the way that an average person hears high- and low-pitched sounds. With the "A" weighting, two sounds of a similar loudness have similar dBA, although unweighted dB values may vary.

With regard to reporting on noise as part of the assessment, environmental noise exposure refers to noise exposure to receptors located outside of the site's boundaries.

2.1.2 Noise Measurement Parameters

Table 1: Noise Measurement Parameters

Exchange rate	Number of decibels that noise has to increase by to be considered as being twice the harmful risk to hearing – typically, exchange rate values are 3, 4, or 5
Sound Pressure level	Instantaneous changing sound level with a selected frequency weighting and time response
Decibel	Dimensionless unit of acoustic measurement in sound level meters; 0dB is the threshold of normal hearing and 130 dB is the threshold of pain
L_{avg}	Average noise level over a period of time that uses an exchange rate of 4, 5 or 6 in the calculation of the final value. L_{avg} is a root mean square (*rms)* sound pressure level.
L_{eq}	Equivalent continuous noise level that contains the same amount of noise energy as the actual varying noise, the L_{eq} is a special case of the L_{avg} with the Q=3 exchange rate. L_{eq} is a root mean square (*rms)* sound pressure level.
L_{max}	Highest reading with a specified frequency weighting and time response in a sound level meter; also defined as highest *rms* sound pressure level within the measuring period.
L_{peak}	Absolute highest sound pressure of the noise signal of either the positive or negative part of the sound wave. *L_{peak} is not a rms level.* Also defined as being the crest of the sound pressure wave within the measuring period.
Time Weighted Average (TWA)	Total amount of noise exposure expressed as an equivalent standard 8 hour working day
Sound Exposure Level (SEL)	Average of measured sound levels over a 1s period
Threshold level	Sound pressure level below which an instrument will ignore any readings to include in noise dose measurements

2.1.3 Types of Noise

The key noise types of concern are as follows:

- Continuous noise – constant noise levels over extended periods such as from processing equipment, blowers, ventilation equipment etc.

- Intermittent noise – noise erupts on cyclical basis such as via single vehicles or airplanes passing. Noise increases rapidly then decreases.
- Impulsive noise – impacts from explosions, gunshots etc. Events are brief and abrupt.

2.1.4 Factors Affecting Noise Propagation

The following are key factors that affect noise propagation:

- Type of source (point or line): for point sources sound energy spreads equally and spherically; for line sources sound levels spread out cylindrically
- Atmospheric attenuation: noise magnitude reduces through air as a function of: distance from source, frequency, temperature, relative humidity and ambient pressure
- Wind: creates a “focus” effect on the downwind side increasing the noise effect whereas on the upwind side a “shadow” effect is created, which reduces noise levels. Measurement downwind is preferred as the result tends to be conservative
- Temperature: inversions at night; that is, increasing temperature with altitude can cause a focus effect focusing noise levels to ground levels – causing a general increase in noise effect; the converse occurs on a sunny day with no wind
- Barriers such as buildings and berms: can have an attenuating effect on noise. A barrier is most effective when placed close to the noise source or the receiver.
- Ground absorption: hardness and texture of the ground can have an attenuating effect on noise during propagation.
- Reflection: when sound waves impact on a surface, part of the acoustic energy is reflected

2.1.5 Noise Measurement to International Guidelines

2.1.5.1 Noise Measurement Parameters

Section 2.8 of the World Health Organization (WHO) guidelines for community noise recommends that L_{Aeq} measurements with an A-weighting be used to evaluate more or less continuous environmental noises. The guideline states that L_{Aeq} should also be used for assessing ongoing noises that may be composed of individual events with randomly varying sound pressure levels (SPLs). The guideline also states that where noise is principally composed of discrete events, measurements of L_{Amax}[1] or SEL are recommended.

---

[1] L_{max} with an A-Weighting

More specifically, L_{Amax} should be used to measure continuous sounds such as road traffic noise, many types of industrial noises, noise from ventilation systems in buildings etc. Where there are transient and distinct noise events such as aircraft or railway noise, noise measurement should be done using the parameters of L_{Amax} or SEL.

2.1.5.2 Sampling

With regard to sampling, section 2.4.4 of the WHO guidelines states that it is usually not possible to measure sound pressure levels continuously over a long enough period to completely define the environmental noise exposure. The guidelines conclude that when making environmental noise measurements, it is important that the measurement sample is representative of all variations of noise – including variations of the source of noise and variations in the propagation of sound – the latter variation possibly due to varying atmospheric conditions for example.

Generally, measurement of continuous noise for a short period is all that is required. For intermittent noise, measurement should be done over the period of the event, the SEL is preferred descriptor. More intricate sound measurement and analyses are required for impulsive noises.

2.1.5.3 Measurement Locations

Section 2.4.3 of the WHO guidelines for community noise recommends that noise measurements are made close to the point of reception of the noise. The guidelines go on to state that measurement locations should be selected such that there is a clear view of the sound source so that there are no barriers that reduce incident sound pressure levels received at the microphone of the noise meter. The guidelines also speak to the distance that the meter should be placed in front of solid surface, given that the process of reflection can result in an increase in noise levels received at a microphone of a noise meter.

2.1.6 Noise Abatement Standards

Table 2: Guideline Values (WHO) for Community Noise in Specific Environments

Specific Environment	Critical health effect(s)	L_{Aeq} [dB(A)]	Time base [hours]	L_{Amax} fast [dB]
Outdoor Living Area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors	Speech intelligibility & moderate annoyance, daytime &evening	35	16	45
Inside bedrooms	Sleep disturbance, night-time	30	8	45

Specific Environment	Critical health effect(s)	L_{Aeq} [dB(A)]	Time base [hours]	L_{Amax} fast [dB]
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School classrooms & pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	During class	-
Pre-school bedrooms, indoor	Sleep disturbance	30	sleeping time	45
School, playground outdoor	Annoyance (external source)	55	During play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time; Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music and other sounds through headphones/ earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -	- -	140 #2 120 #2
Outdoors in parkland and conservation	Disruption of tranquility	#3		

#1: as low as possible;

#2: peak sound pressure {not L_{Amax}, fast}, measured 100 mm from the ear;

#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low;

#4: under headphones, adapted to free-field values

2.1.7 Noise Measurement Equipment

A sound level meter is the instrument used for measuring sound.

For noise monitoring in connection with the Harrow baseline monitoring event, the Quest Technologies SoundPro SE SLM data-logging Type 2 electronic noise meter was used to measure noise/sound levels. The device conforms to all applicable IEC, ANSI and SI standards. The meter was used to measure the following pertinent noise parameters: L_{Aeq}, LAV, L_{Amax}, L_{Amin}, L_{Peak}, TWA, L_{10}, and L_{90}.

The device has two internal noise meters: Meter 1 was set to a Slow Response and Meter 2 was set to a Fast Response.

Best practices for environmental noise measurement - taking into consideration the WHO guidelines and other information mentioned earlier - are as follows

- The microphone of the noise meter should be 1.2 to 1.5m above ground level during measurement
- Conditions should be dry when taking noise measurements; noise measurements should be avoided when it is raining or when temperatures are less than 3 degrees Celsius
- Noise measurements should be done away from facades and barriers to eliminate barrier or reflection effects
- Noise measurements should be done downwind of the noise source
- An average wind speed of less than 5m/s is the preferred limit when noise measurements are being taken, with 7m/s being an upper limit.
- Typical “intervals” or “averaging times” should be 15 to 30 minutes during daytime and 15 minutes during nighttime
- Ideally, sampling over different days and at different times during the day should be done to help ensure that the survey is statistically representative
- When noise emissions are steady, a series of measurements should be taken over a typical period of 4 hours during the daytime time base and a minimum period of 2 hours during the nighttime time base.

Noise from the facility may come primarily from: inverters and transformers linked to the operation of the facility and fan noise from the battery backs at the energy storage area. There may also be some noise originating from the sheep raising component of the operation. The noises produced from the operation are therefore deemed to be more continuous in nature. Thus, it is proposed as part of the monitoring programme to focus on L_{Aeq} and L_{Amax} *(parameters for WHO standards)* and best practices – introduced earlier – to obtain results for comparison with WHO guideline values in table 2.0 above.

2.1.8 Climate Measurement Equipment

Climate measurements were taken with a Kestrel 4500 electronic weather measurement device which has, amongst other features, the ability to measure wind speed, wind direction, temperature, relative humidity, and atmospheric pressure. The device has a compass feature that permits the measurement of true and magnetic north.

Climate readings were taken alongside noise measurements, recorded at 10-minute intervals.

Noise and climate readings were taken roughly 1.5m from ground level.

3.0 NOISE MONITORING EVENT

3.1 MEASUREMENT LOCATIONS

The selection of the monitoring locations was based on proximity to the site as well as the potential impact receptors at those locations may experience. With winds predominantly emerging from the Northeast, locations to the West and Southwest may experience higher sound levels than those upwind. Locations were selected in all directions away from the facility except for East; the extent of the undeveloped agricultural lands in this direction implies no impact to human receptors.

Table 3: Monitoring Locations

Site	Description	Remarks
M1	Open agricultural field	Situated at the location proposed to house much of the power production infrastructure of the facility
M2	Private residence	Located on Southeastern border of proposed facility, adjacent to two houses
M3	Residential community	Located on Southern border of proposed facility, adjacent to residential community
M4	Residential community	Located on Southwestern border of proposed facility, adjacent to residential community
M5	Private business, residence	Located 400m to the West of the proposed facility, adjacent to a veterinary clinic and private residence

M6	Private residence	Located on Northern border of proposed facility, adjacent to two private residences
M7	Residential community	Located on Northeastern border of proposed facility, adjacent to a major road and residential community

Figure 1: Monitoring Locations

3.2 FIELD MEASUREMENT METHODOLOGY

3.2.1 General

The noise and climate measurements were taken over three separate weekdays between 7:00AM and 5:00PM (see Table 4 below). Each point was monitored for one hour during the morning period and for one hour in the afternoon period.

3.2.2 Noise Measurements

Measurements of noise levels were taken at each measurement locations – stated in Table 3 above – using the Quest/3M SoundPro Type 2 (calibration certificate in Appendix C) electronic noise meter introduced earlier. As per manufacturer's instructions, the noise meter was calibrated before each day's series of tests.

4.0 MEASUREMENT RESULTS

4.1 SAMPLING DATES AND TIMES

Table 4: Sampling Dates and Times

Location	Dates	Time
M1	September 1st, 2021 September 2nd, 2021	7:17 to 8:17 12:05 to 13:05
M2	September 1st, 2021 September 2nd, 2021	10:52 to 11:52 15:35 to 16:35
M3	September 1st, 2021 September 2nd, 2021	8:29 to 9:29 13:13 to 14:13
M4	September 1st, 2021 September 2nd, 2021	9:41 to 10:41 14:27 to 13:27
M5	August 31st, 2021 September 1st, 2021	11:07 to 12:07 14:44 to 15:44
M6	August 31st, 2021 September 1st, 2021	8:53 to 9:53 13:36 to 14:36
M7	August 31st, 2021 September 1st, 2021	7:45 to 8:45 12:29 to 13:29

Raw Field Data is shown in Appendix D.

4.2 NOISE DATA

Tabulated results of noise measurements on the days of monitoring are shown in Appendix B. Noise levels from the Fast Response meter of the Quest SoundPro are presented below, given the general steady/continuous noise levels observed.

Table 5: Baseline Results

Site	Results	Analysis
M1	The average ambient L_{Eq} noise level over the two hours of monitoring was 46.3 dBA. The average L_{max} value was 68.2 dBa. The highest Peak value was 98.1 dBA. The average TWA value was 37.4 dBA. Noise levels exceeded 48.3 dBA 10% of the time and 46 dBA 90% of the time.	Monitoring point M1 was located in the center of the open field slated for project development. There was very little ambient noise other than the wind through the grass. On one occasion a truck transporting field workers passed within 5m of the sound meter, resulting in the 98.1 dBA peak value recorded. Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. L_{max} values at this location exceeded the WHO residential guidance threshold.
M2	The average ambient L_{Eq} noise level over the two hours of monitoring was 46 dBA. The average L_{max} value was 63.3 dBa. The highest Peak value was 88.0 dBA. The average TWA value was 36.9 dBA. Noise levels exceeded 47.5 dBA 10% of the time and 46.3 dBA 90% of the time.	Monitoring point M2 was located on the edge of an open field adjacent to two private residences – Southeast of the project area. The occasional dog bark and other noises were heard from the nearby residence. Cars could be heard in the distance driving along the main road to the Southeast. Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. L_{max} values at this location exceeded the WHO residential guidance threshold.
M3	The average ambient L_{Eq} noise level over the two hours of monitoring was 47.4 dBA. The average L_{max} value was 66.8 dBa. The highest Peak value was 86.7 dBA. The average TWA value was 38.4 dBA. Noise levels exceeded 49.4 dBA 10% of the time and 46.6 dBA 90% of the time.	Monitoring point M3 was located on the edge of an open field, adjacent to a cane field and a private community – South of the project area. The occasional noise could be heard from the nearby houses. There was also noise resulting from the wind passing through the sugarcane. Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas.

		L_{max} values at this location exceeded the WHO residential guidance threshold.
M4	The average ambient L_{Eq} noise level over the two hours of monitoring was 49.7 dBA. The average L_{max} value was 66.1 dBa. The highest Peak value was 92.1 dBA. The average TWA value was 40.7 dBA. Noise levels exceeded 52.1 dBA 10% of the time and 47.7 dBA 90% of the time.	Monitoring point M4 was located on the edge of an open field adjacent to a residential community – Southwest of the project area. Consistent noise could be heard from the community, including a weedwhacker, power tools, dog barks, and vehicles. The highest peak value of 92.1 dBA resulted from a loud vehicle exiting a nearby driveway. Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. L_{max} values at this location exceeded the WHO residential guidance threshold.
M5	The average ambient L_{Eq} noise level over the two hours of monitoring was 53.2 dBA. The average L_{max} value was 70.2 dBa. The highest Peak value was 88.9 dBA. The average TWA value was 44.1 dBA. Noise levels exceeded 56 dBA 10% of the time and 48.3 dBA 90% of the time.	Monitoring point M5 was located on a cart road connected to Sunbury Road – West of the project area. Tall sugarcane flanks the cart road on either side. Most of the ambient noise could be attributed to cars constantly passing on the main road nearby and to the wind passing through the cane. Ambient sound levels at this location exceeded the WHO residential guidance threshold for outdoor living areas. L_{max} values at this location exceeded the WHO residential guidance threshold.
M6	The average ambient L_{Eq} noise level over the two hours of monitoring was 45.9 dBA. The average L_{max} value was 63.9 dBa. The highest Peak value was 84 dBA. The average TWA value was 36.8 dBA. Noise levels exceeded 47.3 dBA 10% of the time and 46.1 dBA 90% of the time.	Point M6 was located on the edge of an open field adjacent to a residence – North of the project area. Thick vegetation sheltered the monitoring point to the East. Some noise could be attributed to wind passing through the vegetation. Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. L_{max} values at this location exceeded the WHO residential guidance threshold.
M7	The average ambient L_{Eq} noise level over the two hours of monitoring was 54.3 dBA. The average L_{max} value was 72.3 dBa. The highest Peak value was 95.7 dBA.	Point M7 was located on the edge of an open field adjacent to a major road and residential community – Northeast of the project area. Ambient noise can be attributed to cars passing on the road

	The average TWA value was 45.2 dBA. Noise levels exceeded 53.2 dBA 10% of the time and 46.5 dBA 90% of the time.	nearby and from the community. Dogs were heard barking frequently and loud music was playing for some time. Ambient sound levels at this location exceeded the WHO residential guidance threshold for outdoor living areas. L_{max} values at this location exceeded the WHO residential guidance threshold.

5.0 DISCUSSION

Each monitoring point was selected on the basis of potential impacts to nearby receptors; those points along the boundary indicate existing noise levels for comparison with WHO guidelines. Monitoring point M1 was placed at the main infrastructure hub of the farm, which contains the H2 storage, electrolyser system, and battery bank. This area will be the primary source of noise from the facility and comparing post-development noise levels to baseline data will provide some insight as to the potential elevated noise levels that may result from operation of the facility. The following three points – M2, M3, and M4 – were all placed along the Southern boundary of the facility adjacent to residential properties; noise levels at these locations are expected to depict existing ambient levels at these residences. Point M5 was set at a veterinary clinic and private residences located to the West of the development. The final two points – M6 and M7 – are positioned to the East of the power production components of the facility. Point M6 is located due West of the proposed spare grazing area for the black-belly sheep; point M7 is located immediately North of and adjacent to the same area. Both points are also adjacent to residential properties and baseline data can be used to assess ambient noise levels in these areas.

Qualitative observations at the monitoring points reveal consistent sources of noise: wind interacting with vegetation and typical residential community noise. Much of the project area is open agricultural field; there is nothing to obstruct wind flow and a strong, steady breeze persisted throughout measurements. The two points with the lowest recorded ambient levels – M2 and M6 – were the two points furthest away from a major residential community or public road.

Ambient noise levels at five of the seven points were below the WHO guideline threshold for outdoor residential areas. The only exceptions were points M5 and M7, both of which slightly exceeded WHO guidelines. L_{max} readings exceeded WHO guidelines at all seven points. The trend of L_{eq} readings falling below the threshold and L_{max} readings exceeding the threshold describes a baseline environment where extended sound levels were reasonably low – interrupted sporadically by momentary instances of loudness.

6.0 CONCLUSION AND RECOMMENDATIONS

Baseline noise levels for seven (7) points located both within and surrounding project boundaries for a proposed power production facility located at Harrow, St. Philip, Barbados were recorded over the course of three separate days.

Six of the seven monitoring points were arrayed North, West, and South of the project area – along the project border. One point within the development boundaries was also included.

Five of the seven points were shown to experience average ambient sound levels below WHO guidelines; two points exhibited average ambient sound levels slightly above the guideline. Maximum noise levels (momentary instances of sound) were consistently above WHO guidelines.

Generally, noise sources observed at each point were limited to wind interacting with vegetation and various noises originating from nearby communities, such as power tools, animals, and vehicles.

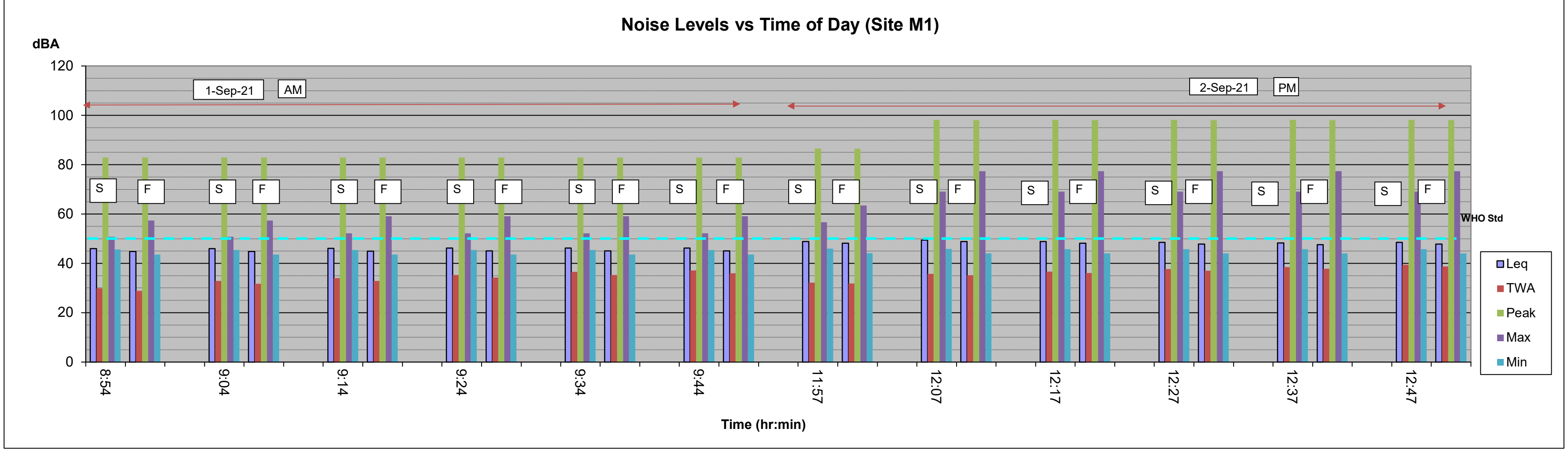
APPENDICES

Appendix A

TABULATED NOISE DATA

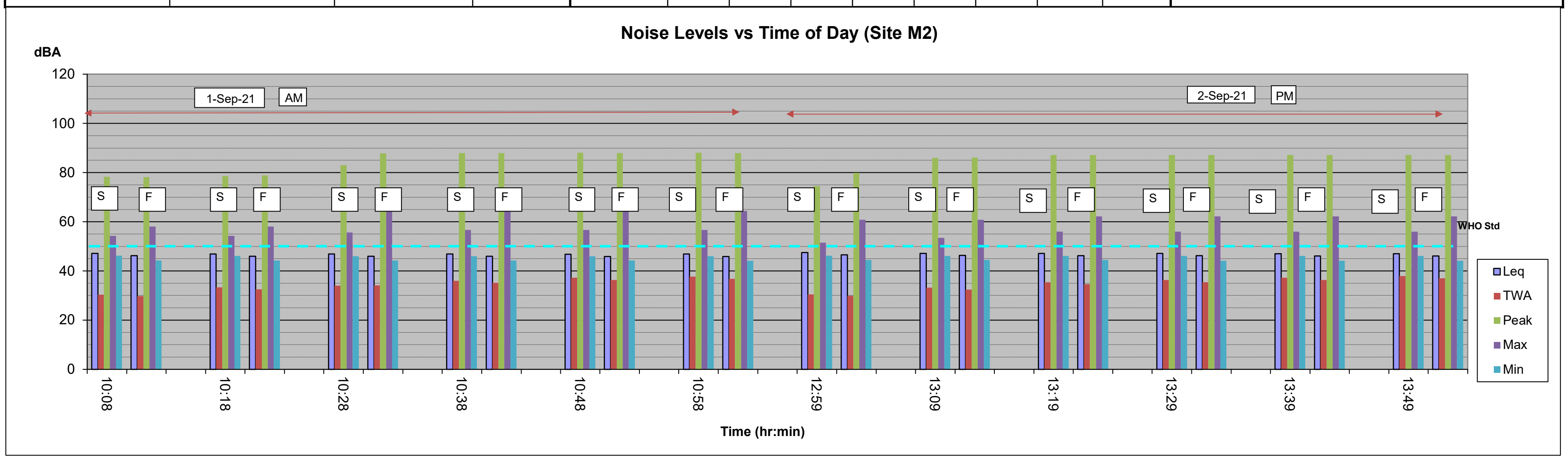
SITE NO. M1 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	Remarks
M1	1 S	8:54 AM	1-Sep-21	46	46.1	45.6	50.8	82.9	29.9	74.5	46.1	45.8	Center of open field. Very little significant noise other than wind.
M1	2 F		1-Sep-21	44.8	44.6	43.6	57.3	82.9	28.8	73.4			
M1	1 S	9:04 AM	1-Sep-21	46	46.4	45.4	50.8	82.9	32.8	77.4	46.1	45.8	
M1	2 F		1-Sep-21	44.8	45.8	43.6	57.3	82.9	31.7	76.3			
M1	1 S	9:14 AM	1-Sep-21	46.1	47	45.4	52.2	82.9	34	78.6	46.2	45.8	
M1	2 F		1-Sep-21	44.9	45.9	43.6	59.1	82.9	32.9	77.5			
M1	1 S	9:24 AM	1-Sep-21	46.2	46	45.4	52.2	82.9	35.3	79.9	46.4	45.8	
M1	2 F		1-Sep-21	45	45.4	43.6	59.1	82.9	34.2	78.8			
M1	1 S	9:34 AM	1-Sep-21	46.2	46.5	45.4	52.2	82.9	36.5	81.1	46.3	45.8	
M1	2 F		1-Sep-21	45	44.9	43.6	59.1	82.9	35.3	79.9			
M1	1 S	9:44 AM	1-Sep-21	46.2	46.1	45.4	52.2	82.9	37.1	81.7	46.3	45.8	
M1	2 F		1-Sep-21	45	44.4	43.6	59.1	82.9	36	80.6			
M1	1 S	11:57 AM	2-Sep-21	48.9	49.7	46	56.7	86.5	32.2	76.8	50.8	46.5	Center of open field. Very little significant noise other than wind.
M1	2 F		2-Sep-21	48.2	48.6	44.2	63.4	86.4	31.8	76.4			
M1	1 S	12:07 PM	2-Sep-21	49.4	47	45.9	69.1	98.2	35.7	80.3	51.1	46.4	Truck with workers drives past.
M1	2 F		2-Sep-21	48.8	46.6	44	77.3	98.1	35.2	79.8			
M1	1 S	12:17 PM	2-Sep-21	48.8	46.5	45.8	69.1	98.2	36.7	81.3	50.3	46.2	
M1	2 F		2-Sep-21	48.1	48.4	44	77.3	98.1	36.1	80.7			
M1	1 S	12:27 PM	2-Sep-21	48.5	46.5	45.8	69.1	98.2	37.7	82.3	50.1	46.2	
M1	2 F		2-Sep-21	47.8	48.4	44	77.3	98.1	37	81.6			
M1	1 S	12:37 PM	2-Sep-21	48.3	46.7	45.7	69.1	98.2	38.5	83.1	49.8	46.2	
M1	2 F		2-Sep-21	47.6	48.1	44	77.3	98.1	37.8	82.4			
M1	1 S	12:47 PM	2-Sep-21	48.5	47.6	45.7	69.1	98.2	39.4	84	50.3	46.2	
M1	2 F		2-Sep-21	47.8	48	44	77.3	98.1	38.7	83.3			



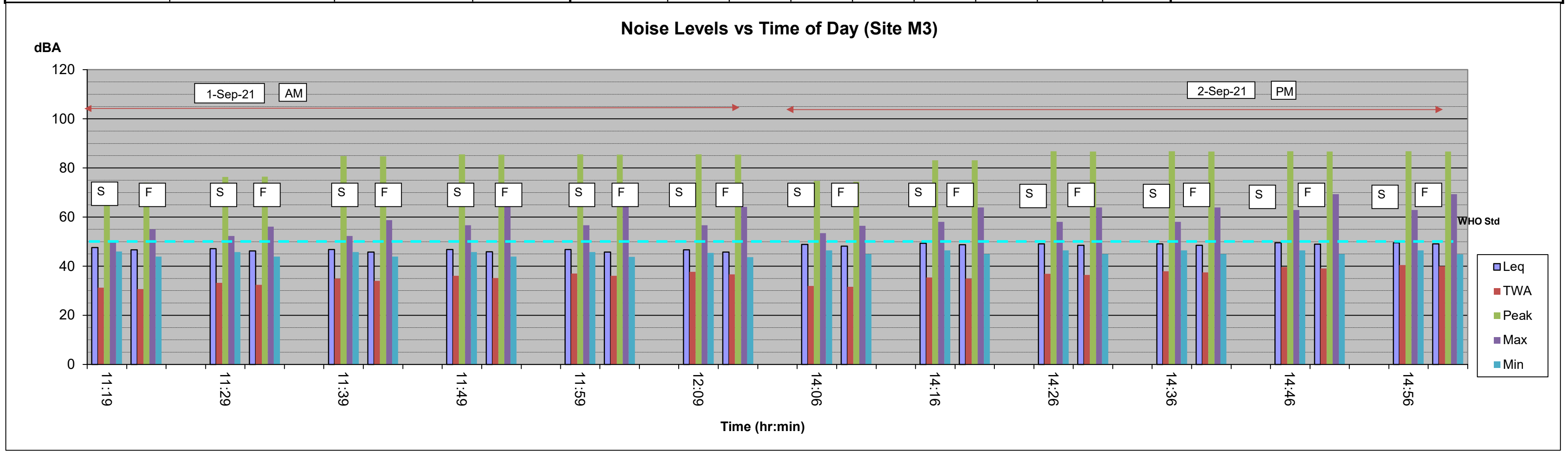
SITE NO. M2 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	Remarks
M2	1 S	10:08 AM	1-Sep-21	47.1	48	46.2	54.3	78.3	30.3	74.9	47.5	46.4	Edge of agricultural field adjacent to one house. Cars heard in distance. Occasional noise from the property.
M2	2 F		1-Sep-21	46.2	46.4	44.3	58	78.2	29.7	74.3			
M2	1 S	10:18 AM	1-Sep-21	46.9	46.5	46.1	54.3	78.6	33.3	77.9	47.4	46.3	
M2	2 F		1-Sep-21	46	45.6	44.3	58	78.9	32.5	77.1			
M2	1 S	10:28 AM	1-Sep-21	46.9	46.8	46	55.6	83	34	79.6	47.3	46.3	
M2	2 F		1-Sep-21	46	47.6	44.3	64.4	87.9	34.1	78.7			
M2	1 S	10:38 AM	1-Sep-21	46.9	48.1	46	56.7	88	36	80.6	47.3	46.2	
M2	2 F		1-Sep-21	46	46.5	44.3	64.4	88	35.2	79.8			
M2	1 S	10:48 AM	1-Sep-21	46.8	48.1	46	56.7	88.1	37.2	81.8	47.3	46.2	
M2	2 F		1-Sep-21	45.9	46.7	44.3	64.4	88	36.3	80.9			
M2	1 S	10:58 AM	1-Sep-21	46.9	46.3	46	56.7	88.1	37.7	82.3	47.3	46.2	
M2	2 F		1-Sep-21	45.9	44.9	44.2	64.4	88	36.8	81.4			
M2	1 S	12:59 PM	2-Sep-21	47.5	46.8	46.2	51.5	74.5	30.4	75	48.5	46.5	Edge of open field next to residential property. Cars sometimes heard in the distance.
M2	2 F		2-Sep-21	46.6	47.6	44.4	60.8	79.9	29.8	74.4			
M2	1 S	1:09 PM	2-Sep-21	47.2	46.7	46.1	53.4	86	33.2	77.8	48	46.3	
M2	2 F		2-Sep-21	46.3	46	44.4	60.8	86.1	32.4	77.1			
M2	1 S	1:19 PM	2-Sep-21	47.1	47.3	46.1	56	87.2	35.4	80	47.8	46.4	
M2	2 F		2-Sep-21	46.2	47.2	44.4	62.2	87.1	34.6	79.2			
M2	1 S	1:29 PM	2-Sep-21	47.1	46.7	46.1	56	87.2	36.3	80.9	47.8	46.3	
M2	2 F		2-Sep-21	46.2	45.7	44.2	62.2	87.1	35.4	80			
M2	1 S	1:39 PM	2-Sep-21	47	46.6	46.1	56	87.2	37.2	81.8	47.7	46.3	
M2	2 F		2-Sep-21	46.1	46	44.2	62.2	87.1	36.3	80.9			
M2	1 S	1:49 PM	2-Sep-21	47	46.8	46.1	56	87.2	37.9	82.5	47.6	46.3	
M2	2 F		2-Sep-21	46.1	45.7	44.2	62.2	87.1	37	81.6			



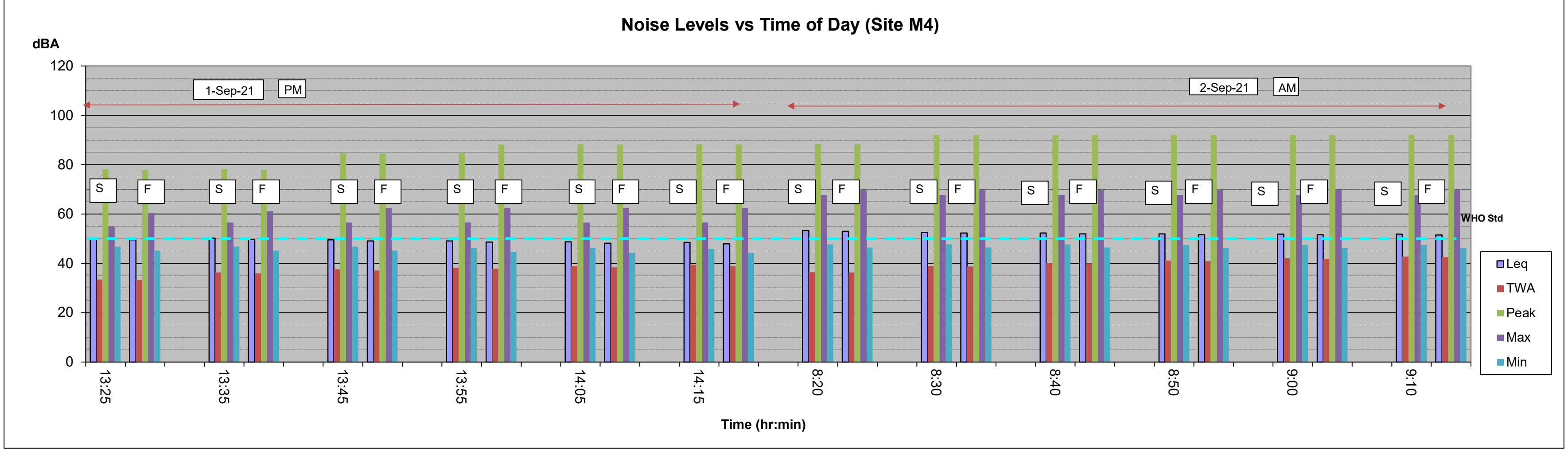
SITE NO. M3 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Noise Levels Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	Remarks
M3	1 S	11:19 AM	1-Sep-21	47.6	46.2	46	50	73.7	31.3	75.9	47.9	46.6	Open field to the North, residential community to the South. Some noise from community and from wind in grass.
M3	2 F		1-Sep-21	46.7	45.6	43.9	55.1	74	30.7	75.3			
M3	1 S	11:29 AM	1-Sep-21	47.1	46.5	45.7	52.3	76.4	33.2	77.8	47.8	46	
M3	2 F		1-Sep-21	46.2	45.3	43.9	56.1	76.5	32.4	77			
M3	1 S	11:39 AM	1-Sep-21	46.8	46.2	45.7	52.3	84.8	34.9	79.5	47.7	45.9	
M3	2 F		1-Sep-21	45.8	46.7	43.9	58.8	84.7	34	78.6			
M3	1 S	11:49 AM	1-Sep-21	46.8	47	45.7	56.6	85.5	36.1	80.7	47.7	45.9	
M3	2 F		1-Sep-21	45.9	47	43.9	64.2	85.4	35.2	79.8			
M3	1 S	11:59 AM	1-Sep-21	46.8	46.6	45.7	56.6	85.5	37	81.6	47.6	45.9	
M3	2 F		1-Sep-21	45.8	46.2	43.8	64.2	85.4	36.1	80.7			
M3	1 S	12:09 PM	1-Sep-21	46.7	47	45.4	56.6	85.5	37.7	82.3	47.6	45.9	
M3	2 F		1-Sep-21	45.7	46	43.7	64.2	85.4	36.7	81.3			
M3	1 S	2:06 PM	2-Sep-21	48.9	48.9	46.5	53.4	74.7	32	76.6	50.4	47	Point on edge of open field adjacent to residential community. Some noise from the community and from the wind in grass.
M3	2 F		2-Sep-21	48.2	50.2	44.9	56.4	74.4	31.6	76.2			
M3	1 S	2:16 PM	2-Sep-21	49.3	48	46.5	58.1	83.1	35.4	80	50.7	47.1	
M3	2 F		2-Sep-21	48.7	47.4	44.9	63.9	83.1	35	79.6			
M3	1 S	2:26 PM	2-Sep-21	49.1	48.8	46.5	58.1	86.8	36.9	81.5	50.6	47.2	
M3	2 F		2-Sep-21	48.5	49	44.9	63.9	86.7	36.4	81			
M3	1 S	2:36 PM	2-Sep-21	49.1	47.8	46.5	58.1	86.8	38	82.6	50.6	47.1	
M3	2 F		2-Sep-21	48.5	51	44.9	63.9	86.7	37.5	82.1			
M3	1 S	2:46 PM	2-Sep-21	49.5	52	46.5	62.9	86.8	39.6	84.2	51.2	47.2	
M3	2 F		2-Sep-21	49	49.3	44.9	69.3	86.7	39.1	83.7			
M3	1 S	2:56 PM	2-Sep-21	49.6	48.5	46.4	62.9	86.8	40.5	85.1	51.2	47.2	
M3	2 F		2-Sep-21	49.1	47.8	44.8	69.3	86.7	40	84.6			



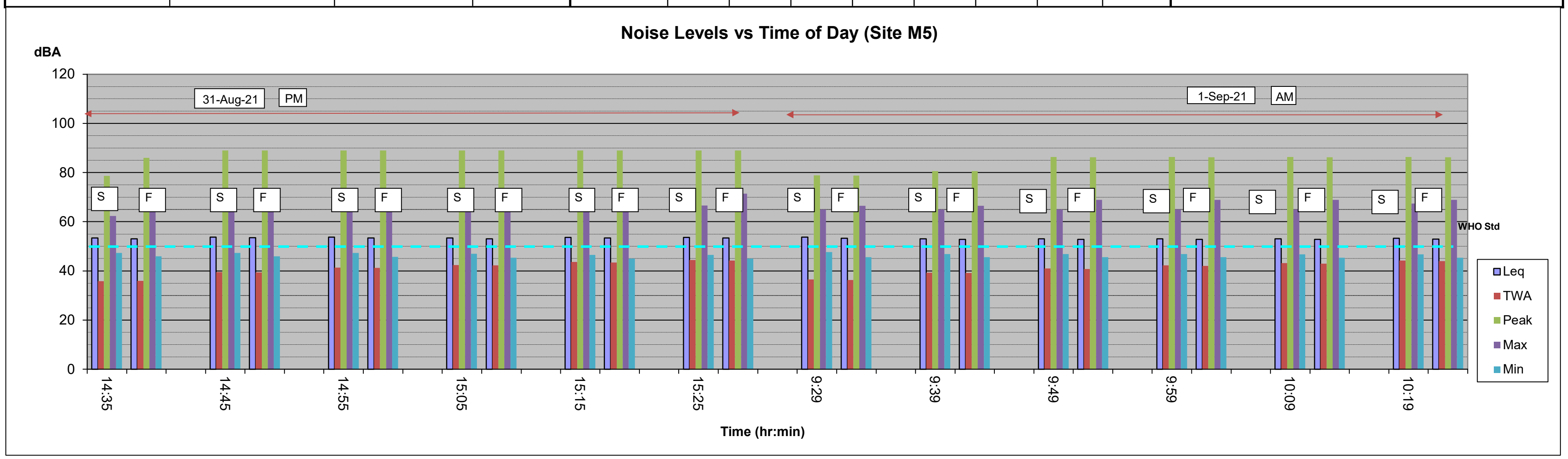
SITE NO. M4 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Noise Levels: Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	Remarks
M4	1 S	1:25 PM	1-Sep-21	49.9	49.2	46.8	54.9	78.2	33.4	78	52.1	47.6	Edge of open field adjacent to residential community, occasional
M4	2 F		1-Sep-21	49.5	49.1	45.2	60.5	77.8	33.2	77.8			weedwacker, dogs barking, etc.
M4	1 S	1:35 PM	1-Sep-21	50.2	48.1	46.8	56.5	78.2	36.3	80.9	52.3	47.5	
M4	2 F		1-Sep-21	49.7	47.2	45.2	61.2	77.8	36	80.6			
M4	1 S	1:45 PM	1-Sep-21	49.6	48.7	46.8	56.5	84.6	37.6	82.2	51.9	47.3	
M4	2 F		1-Sep-21	49.1	47.8	45.2	62.5	84.5	37.1	81.7			
M4	1 S	1:55 PM	1-Sep-21	49.1	47.6	46.2	56.5	84.6	38.3	82.8	51.6	46.6	
M4	2 F		1-Sep-21	48.6	48.5	44.7	62.5	88.2	37.8	82.4			
M4	1 S	2:05 PM	1-Sep-21	48.7	47	46.2	56.5	88.3	38.9	83.5	51.2	46.4	
M4	2 F		1-Sep-21	48.1	46.4	44.3	62.5	88.2	38.4	83			
M4	1 S	2:15 PM	1-Sep-21	48.5	46.5	45.9	56.5	88.3	39.4	84	50.9	46.4	
M4	2 F		1-Sep-21	47.9	45.8	44.3	62.5	88.2	38.8	83.4			
M4	1 S	8:20 AM	2-Sep-21	53.3	51.9	47.7	67.7	88.4	36.4	81	53.3	48.9	Edge of agricultural field adjacent to community. Occasional noise,
M4	2 F		2-Sep-21	53	52.4	46.5	69.7	88.4	36.3	81			dogs barking etc. Some noise from wind in grass
M4	1 S	8:30 AM	2-Sep-21	52.6	49.2	47.7	67.7	92.1	38.9	83.6	53.6	49.2	Car exits driveway nearby.
M4	2 F		2-Sep-21	52.3	49.3	46.5	69.7	92.1	38.7	83.3			
M4	1 S	8:40 AM	2-Sep-21	52.3	54.1	47.7	67.7	92.1	40.2	84.8	53.7	49.1	
M4	2 F		2-Sep-21	52	50	46.5	69.7	92.1	40	84.6			
M4	1 S	8:50 AM	2-Sep-21	52	51.4	47.5	67.7	92.1	41.2	85.8	53.3	48.9	
M4	2 F		2-Sep-21	51.6	49.8	46.2	69.7	92.1	40.9	85.5			
M4	1 S	9:00 AM	2-Sep-21	51.9	51.5	47.5	67.7	92.1	42.1	86.7	53.4	48.8	
M4	2 F		2-Sep-21	51.6	50.1	46.2	69.7	92.1	41.8	86.4			
M4	1 S	9:10 AM	2-Sep-21	51.9	52.2	47.5	67.7	92.1	42.8	87.4	53.3	49	
M4	2 F		2-Sep-21	51.5	49.4	46.2	69.7	92.1	42.5	87.1			



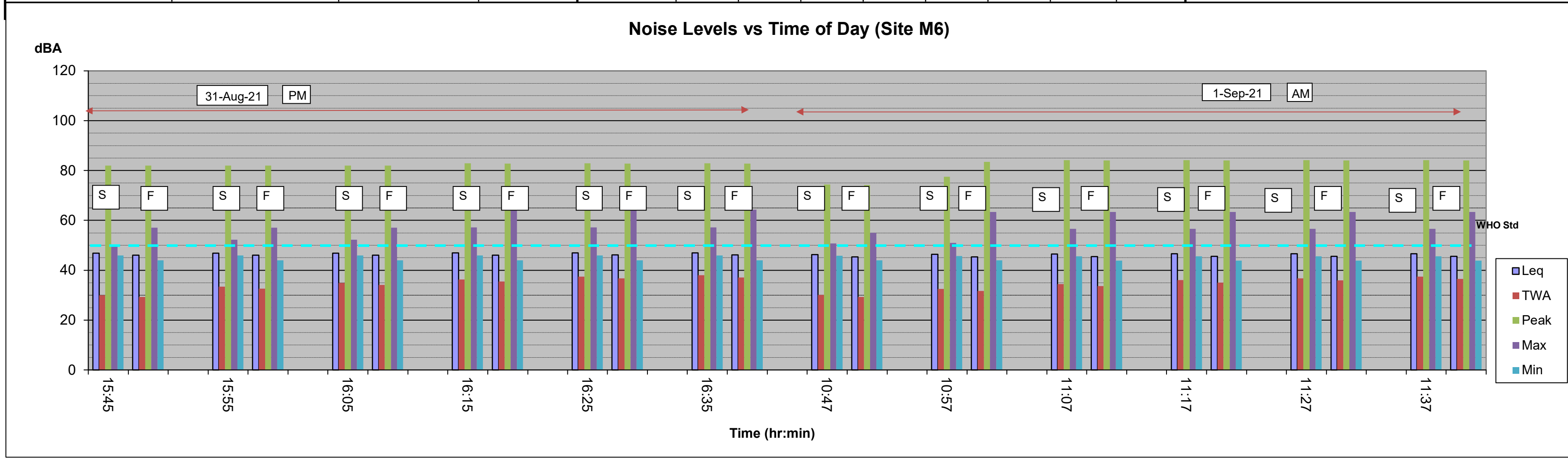
SITE NO. M5 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Noise Levels Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	Remarks
M5	1 S	2:35 PM	31-Aug-21	53.4	52.1	47.3	62.3	78.7	35.8	80.4	55.8	48.3	Cart road connecting to major road to the west. Tall sugarcane either side of the cart road. Cars constantly passing on the main road. Loud wind through cane.
M5	2 F		31-Aug-21	53.1	52.3	45.9	69	86	35.9	80.5			
M5	1 S	2:45 PM	31-Aug-21	53.7	57.4	47.3	66.2	89	39.5	84.1	56.2	48.4	
M5	2 F		31-Aug-21	53.5	51.7	45.9	69.1	88.9	39.4	84			
M5	1 S	2:55 PM	31-Aug-21	53.7	48.3	47.3	66.2	89	41.4	86	56	48.7	
M5	2 F		31-Aug-21	53.4	46.7	45.7	69.1	88.9	41.2	85.7			
M5	1 S	3:05 PM	31-Aug-21	53.4	51	47	66.2	89	42.4	87	55.9	48.4	
M5	2 F		31-Aug-21	53.1	49.7	45.4	69.1	88.9	42.2	86.8			
M5	1 S	3:15 PM	31-Aug-21	53.6	56.7	46.5	66.6	89	43.6	88.2	56.2	48.3	
M5	2 F		31-Aug-21	53.4	47.5	45	71.4	88.9	43.4	88			
M5	1 S	3:25 PM	31-Aug-21	53.6	51.2	46.5	66.6	89	44.5	89.1	56.2	48.4	
M5	2 F		31-Aug-21	53.4	51.7	45	71.4	88.9	44.2	88			
M5	1 S	9:29 AM	1-Sep-21	53.7	48.4	47.6	65	78.9	36.5	81	56.2	48.2	Cart road connected to major road in the West. Cars constantly pass, wind rattles through cane.
M5	2 F		1-Sep-21	53.3	47.3	45.6	66.5	78.8	36.3	80.8			
M5	1 S	9:39 AM	1-Sep-21	53.1	51.7	46.9	65	80.6	39.3	83.9	55.7	48.2	
M5	2 F		1-Sep-21	52.9	53.5	45.6	66.5	80.6	39.2	83.8			
M5	1 S	9:49 AM	1-Sep-21	53.1	55.3	46.9	65	86.3	41	85.6	55.6	48.3	
M5	2 F		1-Sep-21	52.8	49.9	45.6	68.9	86.2	40.8	85.4			
M5	1 S	9:59 AM	1-Sep-21	53.1	52.5	46.9	65	86.3	42.2	86.8	55.7	48.4	
M5	2 F		1-Sep-21	52.9	51.7	45.6	68.9	86.2	42	86.6			
M5	1 S	10:09 AM	1-Sep-21	53.1	52.1	46.8	65	86.3	43.2	87.8	55.8	48.3	
M5	2 F		1-Sep-21	52.9	48.3	45.4	68.9	86.2	43	87.6			
M5	1 S	10:19 AM	1-Sep-21	53.3	51.5	46.8	67.4	86.3	44.2	88.8	55.8	48.2	
M5	2 F		1-Sep-21	53	52.5	45.4	68.9	86.2	44	88.6			



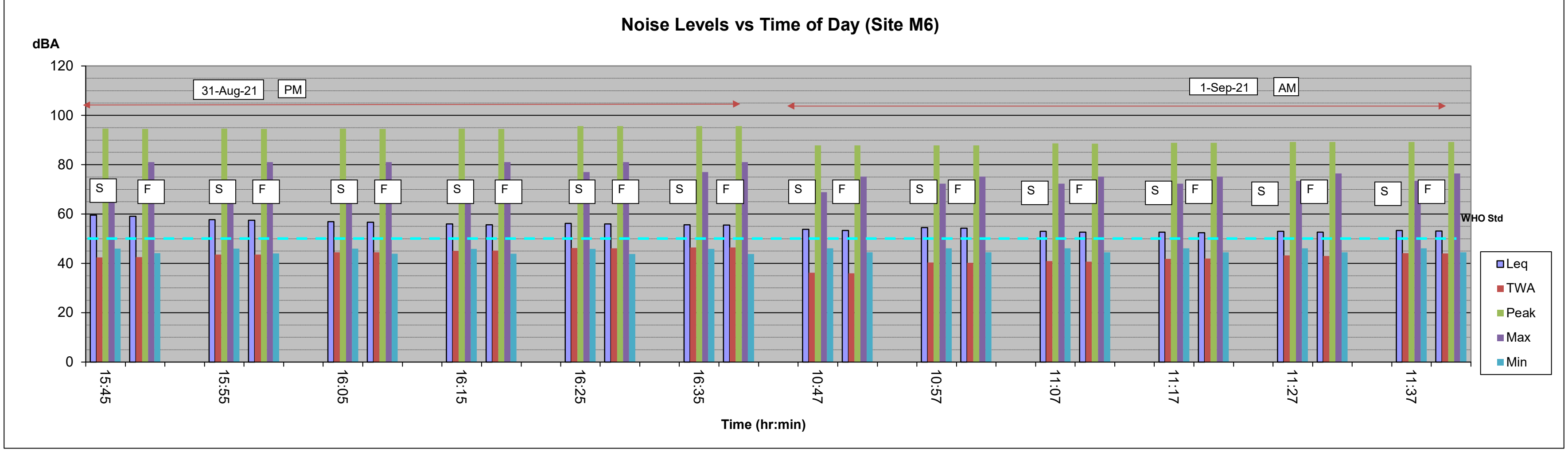
SITE NO. M6 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Noise Levels									Remarks
				Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	
M6	1 S	3:45 PM	31-Aug-21	46.9	46.7	45.9	50.3	82	29.9	74.5	47.5	46.1	Dense vegetation immediately East, agricultural fields to the South and West. Two houses to the North. Little consistent loud noise.
M6	2 F		31-Aug-21	46	46.7	44	57.1	82	29.3	73.9			
M6	1 S	3:55 PM	31-Aug-21	46.9	46.7	45.9	52.3	82	33.4	78	47.4	46.3	
M6	2 F		31-Aug-21	46	46.3	44	57.1	82	32.7	77.3			
M6	1 S	4:05 PM	31-Aug-21	46.9	47.2	45.9	52.3	82	34.9	79.5	47.4	46.3	
M6	2 F		31-Aug-21	46	45.2	44	57.1	82	34.1	78.7			
M6	1 S	4:15 PM	31-Aug-21	47	47.2	45.9	57.2	82.9	36.3	80.9	47.5	46.4	
M6	2 F		31-Aug-21	46.1	46.5	44	64.3	82.8	35.5	80.1			
M6	1 S	4:25 PM	31-Aug-21	47	47.8	45.9	57.2	82.9	37.5	82.1	47.5	46.4	
M6	2 F		31-Aug-21	46.2	47.5	44	64.3	82.8	36.7	81.3			
M6	1 S	4:35 PM	31-Aug-21	47	47.2	45.9	57.2	82.9	38	82.6	47.5	46.3	
M6	2 F		31-Aug-21	46.2	47.1	44	64.3	82.8	37.1	81.7			
M6	1 S	10:47 AM	1-Sep-21	46.3	49.5	45.8	50.7	74.4	30.1	74.7	46.6	45.9	Dense vegetation to the North and East, open fields to the South and West. Two houses to the North. Very little consistent significant noise.
M6	2 F		1-Sep-21	45.3	46.1	44	55	74.1	29.3	73.9			
M6	1 S	10:57 AM	1-Sep-21	46.4	46.4	45.7	51	77.5	32.5	77.1	46.6	45.9	
M6	2 F		1-Sep-21	45.3	46	44	63.4	83.5	31.7	76.3			
M6	1 S	11:07 AM	1-Sep-21	46.5	48.6	45.6	56.6	84.1	34.5	79.1	47	45.9	
M6	2 F		1-Sep-21	45.5	46	43.9	63.4	84	33.7	78.3			
M6	1 S	11:17 AM	1-Sep-21	46.6	46.2	45.6	56.6	84.1	36	80.6	47.1	45.9	
M6	2 F		1-Sep-21	45.6	47	43.9	63.4	84	35.1	79.7			
M6	1 S	11:27 AM	1-Sep-21	46.6	46.3	45.6	56.6	84.1	36.8	81.4	47.1	45.9	
M6	2 F		1-Sep-21	45.6	45.5	43.9	63.4	84	35.9	80.5			
M6	1 S	11:37 AM	1-Sep-21	46.6	46.7	45.6	56.6	84.1	37.5	82.1	47.1	45.9	
M6	2 F		1-Sep-21	45.6	49.1	43.9	63.4	84	36.5	81.1			



SITE NO. M7 - NOISE MEASUREMENTS

Sampling Location	Meter	Time	Date	Noise Levels Leq	LAV (dBA)	Min (dBA)	Max (dBA)	Peak (dBA)	TWA (dBA)	SEL	L10	L90	Remarks
M7	1 S	3:45 PM	31-Aug-21	59.5	48.3	46	74	94.6	42.4	87	64.1	46.6	Agricultural fields to the South, small community to the North adjacent to a main road. Cars frequently pass. Some noise infrequently from the community.
M7	2 F		31-Aug-21	59.1	46.4	44.2	81.1	94.5	42.5	87.1			
M7	1 S	3:55 PM	31-Aug-21	57.7	47.2	46	74	94.6	43.6	88.2	59	46.4	
M7	2 F		31-Aug-21	57.5	46.5	44.1	81.1	94.5	43.6	88.1			
M7	1 S	4:05 PM	31-Aug-21	56.9	50.3	46	74	94.6	44.5	89.1	56.1	46.5	
M7	2 F		31-Aug-21	56.7	47.6	43.9	81.1	94.5	44.4	89			
M7	1 S	4:15 PM	31-Aug-21	56	47	45.9	74	94.6	45	89.6	53.7	46.4	
M7	2 F		31-Aug-21	55.7	45.8	43.9	81.1	94.5	45.2	89.8			
M7	1 S	4:25 PM	31-Aug-21	56.2	46.7	45.9	77	95.7	46.2	90.8	53.6	46.4	
M7	2 F		31-Aug-21	56	46.8	43.8	81.1	95.7	46.1	90.7			
M7	1 S	4:35 PM	31-Aug-21	55.7	47.3	45.9	77	95.7	46.5	91.1	52.7	46.4	
M7	2 F		31-Aug-21	55.5	49.7	43.8	81.1	95.7	46.4	91			
M7	1 S	10:47 AM	1-Sep-21	53.8	49.2	46.1	68.8	87.9	36.2	80.8	54.1	46.4	Edge of agricultural field and adjacent to major road and small community. Cars frequently pass. Dogs barking, music playing.
M7	2 F		1-Sep-21	53.3	46	44.5	75.2	87.9	36	80.5			
M7	1 S	10:57 AM	1-Sep-21	54.5	50.6	46.1	72.3	87.9	40.4	85	56.5	46.5	
M7	2 F		1-Sep-21	54.2	47.3	44.5	75.2	87.9	40.2	84.8			
M7	1 S	11:07 AM	1-Sep-21	53	47.1	46.1	72.3	88.6	40.9	84.5	52.8	46.5	
M7	2 F		1-Sep-21	52.7	48	44.5	75.2	88.5	40.7	85.3			
M7	1 S	11:17 AM	1-Sep-21	52.7	46.9	46.1	72.3	88.9	41.8	86.4	52	46.5	
M7	2 F		1-Sep-21	52.4	47.5	44.5	75.2	88.9	41.9	86.5			
M7	1 S	11:27 AM	1-Sep-21	53	47.5	46.1	73.5	89.2	43.2	87.8	51.8	46.5	
M7	2 F		1-Sep-21	52.7	47	44.4	76.5	89.2	43	87.6			
M7	1 S	11:37 AM	1-Sep-21	53.3	49.1	46.1	73.5	89.2	44.2	88.8	53.6	46.5	
M7	2 F		1-Sep-21	53.1	46.5	44.4	76.5	89.2	44	88.6			



Appendix B

PHOTOGRAPHS

Apppendix B

Image 1: Equipment setup at M1, facing East

Image 2: Equipment setup at M2, facing North towards the site

Image 3: Equipment setup at M3, facing East towards the site

Image 4: Equipment setup at M4, facing Northeast towards the site

Image 5: Equipment setup at M5, facing East towards the site

Image 6: Equipment setup at M6, facing South towards the site

Image 7: Equipment setup at M7, facing South towards the site

Appendix C

MONITORING EQUIPMENT CALIBRATION CERTIFICATES

4983

TSI INCORPORATED – OCONOMOWOC
1060 Corporate Center Drive, Oconomowoc, WI 53066 USA
tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

An ISO 9001
Registered Company

Certificate of Calibration

Certificate Number:2106070335BGV060001

Date Issued: 07-Jun-2021

Model: SoundPro SP DL-2
S/N: BGV060001

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the performance requirements of the following acoustic standard(s):

ANSI S1.4 1983 (R 2006) - Specification for Sound Level Meters / Type 2

ANSI S1.43 1997 (R 2007) - Specification for Integrating - Averaging Sound Level Meters / Type 2

IEC 61672-1 (2002) - Electro acoustics – Sound Level Meters – Part 1: Specifications / Class 2

Test Conditions: Temp: 18-25°C Humidity: 20-80% R.H. Barometric Pressure: 950-1050 mBar
Test Procedure: S053-899

Subassemblies:

QE7052	53116
SPro Preamp	02214961

Reference Standard(s):

Device	Ref Standard Cal Due	Uncertainty - Estimated at 95% Confidence Level (k=2)
B&K Ensemble	22-May-2022	+/- 0.19dB Acoustic
Fluke 45	23-Feb-2023	+/- 1.4% AC Voltage, +/-0.1% DC Voltage

Calibrated By: Michele Hust
Michele Hust - Assembler

In order to maintain best instrument performance over time, and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration to drift before the recommended interval has expired. See user manual for more information.

All equipment used in the test and calibration of this instrument is traceable to NIST, and applies only to the unit identified above. This report must not be reproduced, except in its entirety, without the written approval of TSI, Inc.

TSI INCORPORATED — OCONOMOWOC
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tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

An ISO 9001
Registered Company

EU Declaration of Conformity

Certificate Number:2106070335BGV060001

Product Line: Sound Level Meter **Model:** SoundPro SP DL-2 **S/N:** BGV060001

Directives Covered:

> EMC / Council Directive 2014/30/EU on Electromagnetic Compatibility
> Safety / Council Directive 2014/35/EU on Low Voltage Equipment Safety
> RoHS / Council Directive 2011/65/EU on the restriction and use of certain hazardous substances
> WEEE / Council Directive 2012/19/EU Waste electrical and electronic equipment

The basis on which conformity is being declared:

EN 61326-1 (2005) Electrical equipment for measurement, control and laboratory use – EMC requirements, Group 1, Class B Equipment (emissions).

EN 61326-1 (2005) Electrical equipment for measurement, control and laboratory use – EMC requirements, Industrial Location Immunity.

IEC61010-1 (2010) Safety requirements for electrical equipment for measurement, control, and laboratory use Part 1: General requirements.

CFR:47 (2008) Code of Federal Regulations: Part 15 Subpart B - Radio Frequency Devices - Unintentional Radiators.

ANSI S1.4 1983 (R 2006) - Specification for Sound level Meters / Type 2

ANSI S1.43 1997(R 2007) - Specification for Integrating-Averaging Sound Level Meters / Type 2

IEC 61672-1 (2002)) - Electro acoustics – Sound level meters – Part 1: Specifications / Class 2

EN 50581 (2012) Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Note: This certification applies to all standard options and accessories supplied with the instrument.

At the end of its life cycle, this product, and any internal power cell, must be sent to a WEEE recycling center, and is marked accordingly.

The technical construction file required by this directive is maintained in Oconomowoc, WI USA

Tom Jacobson - Vice President - Engineering, TSI, Inc.

7936

TSI INCORPORATED — OCONOMOWOC
1060 Corporate Center Drive, Oconomowoc, WI 53066 USA
tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

An ISO 9001
Registered Company

Certificate of Calibration

Certificate Number: 2106080242AC300014964

Model: AC-300 Acoustic Calibrator

Date Issued: 08-Jun-2021

S/N: AC300014964

On this day of manufacture and calibration, TSI certifies that the above listed product meets or exceeds the performance requirements of the following acoustic standard(s):

ANSI S1.40-2006 (R2011) - Specifications and Verification Procedures for Sound Calibrators
IEC 60942:2003 / EN60942-2003 Electroacoustics Sound Calibrators / Class 1

Test Conditions: Temp: 18-25ºC   Humidity: 20-80% R.H.   Barometric Pressure: 950-1050 mBar

Test Procedure: S057-879

Reference Standard(s):

Device	Ref Standard Cal Due	Uncertainty - Estimated at 95% Confidence Level (k=2)
B&K Ensemble	22-May-2022	+/- 0.19dB Acoustic
Fluke 45	23-Feb-2023	+/- 1.4% AC Voltage, +/-0.1% DC Voltage

Calibrated By: Michele Hust

Michele Hust - Assembler

In order to maintain best instrument performance over time and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration to drift before the recommended interval has expired. See user manual for more information.

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1060 Corporate Center Drive, Oconomowoc, WI 53066 USA
tel 651 490 2811 + toll free 800 245 0779 + web www.tsi.com

An ISO 9001
Registered Company

EU Declaration of Conformity

Certificate Number:2106080242AC300014964

Product Line: Acoustic Calibrator **Model:** AC-300 Acoustic Calibrator **S/N:** AC300014964

Directives Covered:

> EMC/ Council Directive 2014/30/EU on Electromagnetic Compatibility
> Safety / Council Directive 2014/35/EU on Low Voltage Equipment Safety
> RoHS / Council Directive 2011/65/EU on the restriction and use of certain hazardous substances
> WEEE / Council Directive 2012/19/EU on Waste Electrical and Electronic Equipment

The basis on which conformity is being declared:

EN 61326-1 (2005) Electrical equipment for measurement, control and laboratory use - EMC requirements
Group 1, Class B Equipment (emissions)

EN 61326-1 (2005) Electrical equipment fo measurement control and laboratory use - EMC requirements
Industrial location immunity

IEC 61010-1 (2010) Safety requirements for electrical equipment for measurement, control and laboratory use
Part 1: General Requirements

CFR:47 (2008) Code of Federal Regulations: Part 15 Subpart B - Radio Frequency Devices - Unintentional Radiators

ANSI S1.40-2006 (R2011) - Specifications and Verification Procedures for Sound Calibrators

IEC 60942:2003 / EN60942-2003 Electroacoustics Sound Calibrators / Class 1

EN 50581 (2012) Technical documentation for the assessment of electrical and electronic products with respect
to the restriction of hazardous substances

Note: This certification applies to all standard options and accessories supplied with the instrument.
At the end of its life cycle, this product, and any internal lithium cell, must be sent to a WEEE recycling center, and is marked accordingly.

The technical construction file required by this directive is maintained in Oconomowoc, WI USA

Tom Jacobson - Vice President - Engineering, TSI, Inc.

Appendix D

RAW FIELD DATA

Stantec
Stantec Consulting Caribbean Ltd.
Winslow House
Black Rock, St. Michael, BB12056

Tel: 246-425-8505
Fax: 246-417-9560
E-mail: sccl@stantec.com

Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/08/01

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	Remarks
M1	717										CENTER OF OPEN FIELD. VERY LITTLE
											SIGNIFICANT NOISE OTHER THAN
	727	46.0	46.1	45.6	50.8	82.9	29.9	74.5	46.1	45.8	WIND
		44.8	44.6	43.6	57.3	82.9	28.8	73.4			
	737	46.0	46.4	45.4	50.8	82.9	32.8	77.4	46.1	45.8	
		44.8	45.8	43.6	57.3	82.9	31.7	76.3			
	747	46.1	47.0	45.4	52.2	82.9	34.0	78.6	46.2	45.8	
		44.9	45.9	43.6	59.1	82.9	32.9	77.5			
	757	46.2	46.0	45.4	52.2	82.9	35.3	79.9	46.4	45.8	
		45.0	45.4	43.6	59.1	82.9	34.2	78.8			
	807	46.2	46.5	45.4	52.2	82.9	36.5	81.1	46.3	45.8	
		45.0	44.9	43.6	59.1	82.9	35.3	79.9			
	817	46.2	46.1	45.4	52.2	82.9	37.1	81.7	46.3	45.8	
		45.0	44.4	43.6	59.1	82.9	36.0	80.6			

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Tel: 246-425-8505
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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/09/01

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data: Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	Remarks
M1	717						CENTER OF OPEN FIELD. MODERATE BREEZE
	727	115ESE	2.0	30.2	75.7	1009.1	
	737	124SE	1.8	30.0	80.2	1009.1	
	747	122SE	2.0	30.3	77.6	1009.3	
	757	108ESE	2.4	29.8	78.0	1009.3	
	807	111ESE	1.8	29.9	77.8	1009.5	
	817	85E	2.8	31.2	71.4	1009.7	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/2

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M1	1205										CENTER OF OPEN FIELD. VERY LITTLE
											SIGNIFICANT NOISE OTHER THAN
	1215	48.9	49.7	46.0	56.7	86.5	32.2	768	50.8	46.5	WIND
		48.2	48.6	44.2	63.4	86.4	31.8	76.4			
	1225	49.4	47.0	45.9	69.1	98.2	35.7	80.3	51.1	46.4	TRUCK WITH WORKERS DRIVES
		48.8	46.6	44.0	77.3	98.1	35.2	79.8			PAST
	1235	48.8	46.5	45.8	69.1	98.2	36.7	81.3	50.3	46.2	
		48.1	48.4	44.0	77.3	98.1	36.1	80.7			
	1245	48.5	46.5	45.8	69.1	98.2	37.7	82.3	50.1	46.2	
		47.8	45.9	44.0	77.3	98.1	37.0	81.6			
	1255	48.3	46.7	45.7	69.1	98.2	38.5	83.1	49.8	46.2	
		47.6	48.1	44.0	77.3	98.1	37.8	82.4			
	1305	48.5	47.6	45.7	69.1	98.2	39.4	84.0	50.3	46.2	
		47.8	48.0	44.0	77.3	98.1	38.7	83.3			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/2

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M1	1205						CENTER OF OPEN FIELD. STRONG STEADY
							BREEZE
	1215	116 ESE	4.3	29.2	79.8	1009.2	
	1225	72ENE	4.5	29.6	78.4	1009.0	
	1235	091E	3.5	31.2	73.9	1008.8	
	1245	060 ENE	3.7	32.0	70.3	1008.7	
	1255	062 ENE	4.1	31.7	71.3	1008.8	
	1305	068 ENE	5.0	31.3	69.7	1008.7	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M2	1052										EDGE OF AGRICULTURAL FIELD
											ADJACENT TO ONE HOUSE. CARS
	1102	47.1	48.0	46.2	54.3	78.3	30.3	74.9	47.5	46.4	HEARD IN DISTANCE. OCCASIONAL
		46.2	46.4	44.3	58.0	78.2	29.7	74.3			NOISE FROM THE PROPERTY
	1112	46.9	46.5	46.1	54.3	78.6	33.3	77.9	47.4	46.3	
		46.0	45.6	44.3	58.0	78.9	32.5	77.1			
							34.0				
	1122	46.9	46.8	46.0	55.6	83.0	~~46.9~~	79.6	47.3	46.3	
		46.0	47.6	44.3	64.4	87.9	34.1	78.7			
	1132	46.9	48.1	46.0	56.7	88.0	36.0	80.6	47.3	46.2	
		46.0	46.5	44.3	64.4	88.0	35.2	79.8			
	1142	46.8	48.1	46.0	56.7	88.1	37.2	81.8	47.3	46.2	
		45.9	46.7	44.3	64.4	88.0	36.3	80.9			
	1152	46.9	46.3	46.0	56.7	88.1	37.7	82.3	47.3	46.2	
		45.9	44.9	44.2	64.4	88.0	36.8	81.4			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. ˚C	Relative Humidity %	Barometric Pressure mb	
M2	1052						EDGE OF AGRICULTURAL FIELD. STEADY
							BREEZE COMING ACROSS FIELD
	1102	071 ENE	3.9	29.7	75.2	1010.2	
	1112	084E	3.3	30.4	72.9	1010.2	
	1122	084E	3.1	30.5	71.3	1010.0	
	1132	067 ENE	1.4	30.2	76.6	1010.1	
	1142	094 E	2.0	29.8	77.9	1010.0	
	1152	089E	2.3	30.3	78.2	1009.9	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/2

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M2	1535										EDGE OF OPEN FIELD NEXT TO
											RESIDENTIAL ~~COMMUNITY. OCCASIONAL~~
	1545	47.5	46.8	46.2	51.5	74.5	30.4	75.0	48.5	46.5	~~NOISE FROM NEIGHBORHOOD~~ PROPERTY.
		46.6	47.6	44.4	60.8	79.9	29.8	74.4			CARS SOMETIMES HEARD IN DISTANCE
	1555	47.2	46.7	46.1	53.4	86.0	33.2 ~~[illegible]~~	77.8	48.0	46.3	
		46.3	46.0	44.4	60.8	86.1	32.4	77.1			
	1605	47.1	47.3	46.1	56.0	87.2	35.4	80.0	47.8	46.4	
		46.2	47.2	44.4	62.2	87.1	34.6	79.2			
	1615	47.1	46.7	46.1	56.0	87.2	36.3	80.9	47.8	46.3	
		46.2	45.7	44.2	62.2	87.1	35.4	80.0			
	1625	47.0	46.6	46.1	56.0	87.2	37.2	81.8	47.7	46.3	
		46.1	46.0	44.2	62.2	87.1	36.3	80.9			
	1635	47.0	46.8	46.1	56.0	87.2	37.9	82.5	47.6	46.3	
		46.1	45.7	44.2	62.2	87.1	37.0	81.6			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/2

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M2	1535						STEADY BREEZE COMING ACROSS OPEN FIELD TO THE NORTH
	1545	087E	2.4	29.6	78.4	1007.2	
	1555	080E	4.9	28.9	78.1	1007.3	
	1605	081E	3.3	29.2	83.1	1007.2	
	1615	075ENE	3.5	28.4	83.5	1007.1	
	1625	036NE	2.5	28.4	83.6	1007.1	
	1635	080E	2.8	28.7	85.4	1007.1	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/01

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M3	829										OPEN FIELD TO NORTH, RESIDENTIAL
											COMMUNITY TO THE SOUTH. SOME NOISE
	839	47.6	46.2	46.0	50.0	73.7	31.3	75.9	47.9	46.6	FROM COMMUNITY AND FROM WIND
		46.7	45.6	43.9	55.1	74.0	30.7	75.3			IN GRASS
	849	47.1	46.5	45.7	52.3	76.4	33.2	77.8	47.8	46.0	
		46.2	45.3	43.9	56.1	76.5	32.4	77.0			
	859	46.8	46.2	45.7	52.3	84.8	34.9	79.5	47.7	45.9	
		45.8	46.7	43.9	58.8	84.7	34.0	78.6			
	909	46.8	47.0	45.7	56.6	85.5	36.1	80.7	47.7	45.9	
		45.9	47.0	43.9	69.2	85.4	35.2	79.8			
	919	46.8	46.6	45.7	56.6	85.5	37.0	81.6	47.6	45.9	
		45.8	46.2	43.8	64.2	85.4	36.1	80.7			
	929	46.7	47.0	45.4	56.6	85.5	37.7	82.3	47.6	45.9	
		45.7	46.0	43.7	64.2	85.4	36.7	81.3			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M3	829						EDGE OF OPEN FIELD TO THE NORTH-LIGHT BREEZE.
	839	114ESE	1.8	30.2	74.4	1010.1	
	849	102ESE	0.7	32.2	73.3	1010.2	
	859	111ESE	1.3	31.3	72.0	1010.1	
	909	115ESE	0.4	33.8	67.1	1009.9	
	919	137SE	1.5	30.4	73.1	1010.3	
	929	110 ESE	1.4	30.9	72.5	1010.3	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/09/02

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels: LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	Remarks
M3	~~1303~~										POINT ON EDGE OF OPEN FIELD
	1313										ADJACENT TO RESIDENTIAL COMMUNITY.
											SOME NOISE FROM THE COMMUNITY
	1323	48.9	48.9	46.5	53.4	74.7	32.0	76.6	50.4	47.0	AND FROM WIND IN GRASS
		48.2	50.2	44.9	56.4	74.4	31.6	76.2			
	1333	49.3	48.0	46.5	58.1	83.1	35.4	80.0	50.7	47.1	
		48.7	47.4	44.9	63.9	83.1	35.0	79.6			
	1343	49.1	48.8	46.5	58.1	86.8	36.9	81.5	50.6	47.2	
		48.5	49.0	44.9	63.9	86.7	36.4	81.0			
	1353	49.1	47.8	46.5	58.1	86.8	38.0	82.6	50.6	47.1	
		48.5	51.0	44.9	63.9	86.7	~~48.5~~	82.1			
							37.5	[illegible]			
	1403	49.5	52.0	46.5	62.9	86.8	39.6	84.2	51.2	47.2	
		49.0	49.3	44.9	69.3	86.7	39.1	83.7			
	1413	49.6	48.5	46.4	62.9	86.8	40.5	85.1	51.2	47.2	
		49.1	47.8	44.8	69.3	86.7	40.0	84.6			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/09/02

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data: Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	Remarks
M3	1313						OPEN FIELD TO THE NORTH. STEADY
							BREEZE ACROSS THE FIELD
	1323	64ENE	2.3	30.7	71.6	1008.8	
	1333	054NE	3.5	31.2	70.5	1008.6	
	1343	048NE	2.8	30.7	70.9	1008.4	
	1353	061ENE	4.2	30.6	73.8	1008.2	
	1403	050NE	3.9	30.9	71.0	1008.1	
	1413	069ENE	3.7	31.2	70.0	1008.2	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M4	941										EDGE OF OPEN FIELD ADJACENT
		49.9	49.2	46.8							TO RESIDENTIAL COMMUNITY, OCCASIONAL
	951	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	54.9	78.2	33.4	78.0	52.1	47.6	WEEDWACKER ETC., DOGS BARKING
		49.5	49.1	45.2	60.5	77.8	33.2	77.8			
	1001	50.2	48.1	46.8	56.5	78.2	36.3	80.9	52.3	47.5	
		49.7	47.2	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	36.0	80.6			
				45.2	61.2	77.8					
	1011	49.6	48.7	46.8	56.5	84.6	~~4~~37.6	82.2	51.9	47.3	
		49.1	47.8	45.2	62.5	84.5	37.1	81.7			
	1021	49.1	47.6	46.2	56.5	84.6	38.3	82.8	51.6	46.6	
		48.6	46.5	44.7	62.5	88.2	37.8	82.4			
	1031	48.7	47.0	46.2	56.5	88.3	38.9	83.5	51.2	46.4	
		48.1	46.4	44.3	62.5	88.2	38.4	83.0			
	1041	48.5	46.5	459	56.5	88.3	39.4	84.0	50.9	46.4	
		47.9	45.8	44.3	62.5	88.2	38.8	83.4			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M4	941						OPEN FIELD TO THE NORTH. LIGHT
							STEADY BREEZE
	951	083 E	1.9	30.7	72.9	1010.1	
	1001	119ESE	1.9	31.9	70.1	1010.2	
	1011	084E	2.2	30.2	70.6	1010.2	
	1021	077ENE	2.5	31.6	69.1	1010.2	
	1031	116ESE	1.8	32.6	69.3	1010.2	
	1041	110ESE	1.6	32.5	63.7	1010.1	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/2

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M4	1427										EDGE OF AGRICULTURAL FIELD ADJACENT
											TO COMMUNITY. OCCASIONAL NOISE, DOGS
	1437	53.3	51.9	47.7	67.7	88.4	364	81.0	53.3	48.9	BARKING ETC. SOME NOISE IN GRASS
		53.0	52.4	46.5	69.7	88.4	36.3	81.0			
											CAR EXITS DRIVEWAY NEARBY
	1447	52.6	49.2	47.7	67.7	92.1	38.9	83.6	53.6	49.2	
		52.3	49.3	46.5	69.7	92.1	38.7	83.3			
	1457	52.3	54.1	47.7	67.7	92.1	40.2	84.8	53.7	49.1	
		52.0	50.0	46.5	69.7	92.1	40.0	84.6			
		52.0									
	1507	~~[illegible]~~	51.4	47.5	67.7	92.1	41.2	85.8	53.3	48.9	
		51.6	49.8	46.2	69.7	92.1	40.9	85.5			
	1517	51.9	51.5	47.5	67.7	92.1	42.1	86.7	53.4	48.8	
		51.6	50.1	46.2	69.7	92.1	41.8	86.4			
	1527	51.9	52.2	47.5	67.7	92.1	42.8	87.4	53.3	49.0	
		51.5	49.4	46.2	69.7	92.1	42.5	87.1			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/2

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M4	1427						EDGE OF OPEN FIELD. STRONG STEADY
							BREEZE FROM ACROSS THE FIELD.
	1437	075 ENE	4.0	31.7	69.6	1007.7	
	1447	086E	4.5	32.6	65.5	1007.7	
	1457	063ENE	4.1	31.9	68.6	1007.6	
	1507	079 E	4.7	31.1	689	1007.4	
	1517	068ENE	4.8	31.4	71.8	1007.5	
	1527	84 E	4.4	30.4	74.3	1007.5	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/08/31

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M5	1107										CART ROAD CONNECTING TO
											MAJOR ROAD TO THE WEST. TALL
	1117	53.4	52.1	47.3	62.3	78.7	35.8	80.4	55.8	48.3	SUGARCANE EITHER SIDE OF
		53.1	52.3	45.9	69.0	86.0	35.9	80.5			CART ROAD. CARS CONSTANTLY
											PASSING ON MAIN ROAD. LOUD WIND
											THROUGH CANE
	1127	53.7	57.4	47.3	66.2	89.0	39.5	84.1	56.2	48.4	
		53.5	51.7	45.9	69.1	88.9	39.4	84.0			
	1137	53.7	48.3	47.3	66.2	89.0	41.4	86.0	56.0	48.7	
		53.4	46.7	45.7	69.1	88.9	41.2	85.7			
	1147	53.4	51.0	47.0	66.2	89.0	42.4	87.0	55.4	48.4	
		53.1	49.7	45.4	69.1	88.9	42.2	86.8			
	1157	53.6	56.7	46.5	66.6	89.0	43.6	88.2	56.2	48.3	
		53.4	47.5	45.0	71.4	88.9	43.4	86.0			
	1207	53.6	51.2	46.5	66.6	89.0	44.5	89.1	56.2	48.4	
		53.4	51.7	45.0	71.4	88.9	44.2	88.[illegible]			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/8/31

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M5	1107						CART ROAD FLANKED BY SUGARCANE
							EITHER SIDE. LIGHT BREEZE
	1117	133 SE	1.4	32.3	69.2	1009.4	
	1127	169 S	0.9	33.2	65.0	1009.4	
	1137	130 SE	0.9	33.1	69.4	1009.2	
	1147	163 SSE	1.1	33.0	66.1	1009.2	
	1157	126 SE	0.8	34.5	63.0	1009.0	
	1207	136 SE	0.4	34.1	63.3	1008.9	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M5	1444										CART ROAD CONNECTED TO MAJOR
											ROAD IN THE WEST. CARS CONSTANTLY
	1454	53.7	48.4	47.6	65.0	78.9	36.5	81.0	56.2	48.2	PASS, WIND RATTLES THROUGH
		53.3	47.3	45.6	66.5	78.8	36.3	80.8			CANE
	1504	53.1	51.7	46.9	65.0	80.6	39.3	83.9	55.7	48.2	
		52.9	53.5	45.6	66.5	80.6	39.2	83.8			
	1514	53.1	55.3	46.9	65.0	86.3	41.0	85.6	55.6	48.3	
		52.8	49.9	45.6	68.9	86.2	40.8	85.4			
	1524	53.1	52.5	46.9	65.0	86.3	42.2	86.8	55.7	48.4	
		52.9	51.7	45.6	68.9	86.2	42.0	86.6			
	1534	53.1	52.1	46.8	65.0	86.3	43.2	87.8	55.8	48.3	
		52.9	48.3	45.4	68.9	86.2	43.0	87.6			
	1544	53.3	51.5	46.8	67.4	86.3	44.2	88.8	55.8	48.2	
		53.0	52.5	45.4	68.4	86.2	44.0	88.6			

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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M5	1444						CART ROAD FLANKED BY TALL SUGAR CANE
							LIGHT STEADY BREEZE
	1454	072ENE	1.2	30.5	77	1008.6	
	1504	080E	1.4	30.4	73.9	1008.6	
	1514	072ENE	1.0	31.8	69.3	1008.4	
	1524	054NE	1.0	31.5	72	10084	
	1534	097E	0.7	31.5	70.0	1008.5	
	1544	058ENE	2.3	30.3	72.9	1008.5	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/08/31

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M6	853										DENSE VEGETATION IMMEDIATELY
											EAST, AGRICULTURAL FIELDS TO
	903	46.9	46.7	45.9	50.3	82.0	29.9	74.5	47.5	46.1	~~THE~~ SOUTH AND WEST. TWO HOUSES
		46.0	46.7	44.0	57.1	82.0	29.3	73.9			TO THE NORTH. LITTLE CONSISTENT
											LOUD NOISE.
	913	46.9	46.7	45.9	52.3	82.0	33.4	78.0	47.4	46.3	
		46.0	46.3	44.0	57.1	82.0	32.7	77.3			
	923	46.9	47.2	45.9	52.3	82.0	34.9	79.5	47.4	46.3	
		46.0	45.2	44.0	57.1	82.0	34.1	78.7			
	933	47.0	47.2	45.9	57.2	82.9	36.3	80.9	47.5	46.4	
		46.1	46.5	44.0	64.3	82.8	35.5	80.1			
	943	47.0	47.8	45.9	57.2	82.9	37.5	82.1	47.5	46.4	
		46.2	47.5	44.0	64.3	82.8	36.7	81.3			
	953	47.0	47.2	45.9	57.2	82.9	38.0	82.6	47.5	46.3	
		46.2	47.1	44.0	64.3	82.8	37.1	81.7			

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Black Rock, St. Michael, BB12056
Tel: 246-425-8505
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Measurement of Wind Speed & Climate Data

PROJECT: 19054 Harrow PV Farm

DATE: 2021/8/31

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M6	853						SHELTERED TO THE NORTH/EAST BY DENSE VEGETATION. VERY LIGHT BREEZE
	903	149S	1.0	31.0	75.6	1008.1	
	913	162SSE	0.7	31.5	71.8	1008.2	
	923	150SSE	0.7	33.2	69.5	1008.2	
	933	163S	1.0	31.3	70.5	1008.3	
	943	189S	1.9	30.9	76.8	1008.3	
	953	152SSE	1.7	31.9	70.9	1008.3	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M6	1336										DENSE VEGETATION TO THE NORTH/
											EAST, OPEN FIELDS TO THE SOUTH
	1346	46.3	49.5	45.8	50.7	74.4	30.1	74.7	46.6	45.9	AND WEST. TWO HOUSES TO THE
		45.3	46.1	44.0	55.0	74.1	29.3	73.9			NORTH. VERY LITTLE CONSISTENT
											SIGNIFICANIT NOISE
	1356	46.4	46.4	45.7	51.0	77.5	32.5	77.1	46.6	45.9	
		45.3	46.0	44.0	63.4	83.5	31.7	76.3			
									47.0		
	1406	46.5	48.6	45.6	56.6	84.1	34.5	79.1	~~49.~~	45.9	
		45.5	46.0	43.9	63.4	84.0	33.7	78.3			
	1416	46.6	46.2	45.6	56.6	84.1	36.0	80.6	47.1	45.9	
		45.6	47.0	43.9	63.4	84.0	35.1	79.7			
	1426	46.6	46.3	45.6	56.6	84.1	36.8	81.4	47.1	45.9	
		45.6	45.5	43.9	63.4	84.0	35.9	80.5			
	1486	46.6	46.7	45.6	56.6	84.1	37.5	82.1	47.1	45.9	
		45.6	49.1	43.9	63.4	84.0	36.5	81.1			

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DATE: 2021/9/1

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INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M6	1336						SHELTERED TO THE NORTH & EAST BY DENSE VEGETATION. VERY LIGHT BREEZE
	1346	011N	0.5	31.7	68.5	1007.7	
	1356	333NW	0.7	32.5	71.3	1007.7	
	1406	000N	0.8	32.1	73.9	1007.7	
	1416	—	0.0	31.6	76.5	1007.7	
	1426	002N	1.3	30.3	80.1	1007.6	
	1436	328NNW	0.4	30.3	80.3	1007.6	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/08/31

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M7	745										AGRICULTURAL FIELDS TO THE
											SOUTH, SMALL COMMUNITY TO THE
	755	59.5	48.3	46.0	74.0	94.6	42.4	87.0	64.1	46.6	NORTH. ON THE SIDE OF A MAIN ROAD
		59.1	46.4	44.2	81.1	94.5	42.5	87.1			CARS FREQUENTLY PASS. SOME
											NOISE INFREQUENTLY FROM THE
											COMMUNITY
	805	57.7	47.2	46.0	74.0	94.6	43.6	88.2	59.0	46.4	
		57.5	46.5	44.1	81.1	94.5	43.6	88.1			
	815	56.9	50.3	46.0	74.0	94.6	44.5	89.1	56.1	46.5	
		56.7	47.6	43.9	81.1	94.5	44.4	89.0			
	825	56.0	47.0	45.9	74.0	94.6	45.0	89.6	53.7	46.4	
		55.7	45.8	43.9	81.1	94.5	45.2	89.8			
	835	56.2	46.7	45.9	77.0	95.7	46.2	90.8	53.6	46.4	
		56.0	46.8	43.8	81.1	95.7	46.1	90.7			
	845	55.7	47.3	45.9	77.0	95.7	46.5	91.1	52.7	46.4	
		55.5	49.7	43.8	81.1	95.7	46.4	91.0			

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DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. ˚C	Relative Humidity %	Barometric Pressure mb	
M7	745						NEXT TO MAIN ROAD BETWEEN AGRICULTURAL
							FIELDS AND RESIDENTIAL COMMUNITY.
	755	128SE	1.0	30.8	76.5	1007.7	LIGHT BREEZE
	805	135SE	0.8	30.0	74.5	1007.7	
	815	118 ESE	0.6	31.3	73.8	1007.3	
	825	131SE	1.8	30.1	74.2	1007.6	
	835	170 S	1.3	30.2	71.6	1007.6	
	845	156SSE	1.1	30.2	74.0	1007.6	

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Measurement of Noise Levels

PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Quest SoundPro DL Type II

Sampling Location	Time	Noise Levels									Remarks
		LEq	LA	Min	Max	Peak	TWA	SEL	L10	L90	
M7	1229										EDGE OF AGRICULTURAL FIELD &
											ADJACENT TO MAJOR ROAD AND
	1239	53.8	49.2	46.1	68.8	87.9	36.2	80.8	54.1	46.4	SMALL COMMUNITY. CARS FREQUENTLY
		53.3	46.0	44.5	75.2	87.9	36.0	80.5			PASS, DOGS BARKING, MUSIC PLAYING
	1249	54.5	50.6	46.1	72.3	87.9	40.4	85.0	56.5	46.5	
		54.2	47.3	44.5	75.2	87.9	40.2	84.8			
	1259	53.0	47.1	46.1	72.3	88.6	40.9	85.5	52.8	46.5	
		52.7	48.0	44.5	75.2	88.5	40.7	85.3			
	1309	52.7	46.9	46.1	72.3	88.9	41.8	86.4	52.0	46.5	
		52.4	47.5	44.5	75.2	88.9	41.9	86.5			
	1319	53.0	47.5	46.1	73.5	89.2	43.2	87.8	51.8	46.5	
		52.7	47.0	44.4	76.5	89.2	43.0	87.6			
	1329	53.3	49.1	46.1	73.5	89.2	44.2	88.8	53.6	46.5	
		53.1	46.5	44.4	76.5	89.2	44.0	88.6			

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PROJECT: 19054 Harrow PV Farm

DATE: 2021/9/1

WEATHER: PARTLY CLOUDY

DATA COLLECTION TEAM: Jacob Davis

INSTRUMENT: Kestrel Pocket Climate

Sampling Location	Time	Climate Data					Remarks
		Avg. Wind Direction m/s	Avg. Wind Speed m/s	Temp. °C	Relative Humidity %	Barometric Pressure mb	
M7	1229						OPEN FIELDS TO THE SOUTH. STEADY BREEZE
	1239	100 E	3.2	30.8	75.7	1008.0	
	1249	109 ESE	2.8	30.9	73.0	1007.9	
	1259	084E	1.9	32.2	73.7	1007.8	
	1309	082E	2.4	30.5	75.6	1007.7	
	1319	109ESE	3.0	30.4	74.4	1007.8	
	1329	073ENE	1.3	30.9	72.8	1007.7	

APPENDIX F

Baseline Ecological Assessment

Harrow Plantation PV Project Baseline Ecological Assessment Report

Results of the 2021 Field Reconnaissance

May 3, 2022

Prepared for:

Renewstable (Barbados) Inc

Prepared by:

Stantec Consulting Caribbean Ltd.
Winslow House
Black Rock
St. Michael
Barbados BB12056

File: 1276738554

Prepared by: ______________________
Signature

Karen Rashleigh
Printed Name

Reviewed by: ______________________
Digitally signed by Justin Jennings-Wray
Date: 2022.05.20 13:40:55 -04'00'
Signature

Justin Jennings-Wray
Printed Name

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Executive Summary

Renewstable (Barbados) Inc. is proposing to construct and operate a hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation in the parish of Saint Philip, Barbados. A series of baseline studies were proposed to support the Environmental and Social Impact Assessment for the Project. This Baseline Ecological Assessment was designed to collect information on the availability and distribution of habitat and the potential for the occurrence of rare or endangered flora and fauna species in the vicinity of the Project.

Baseline information was collected through a field reconnaissance survey combined with a review of existing literature and databases related to rare species. The field survey consisted of walking along a series of Transect Lines on the Project Property and recording observations (e.g., flora, evidence of fauna, landscape features).

Transect lines where similar habitat features were observed were grouped together, resulting in three main habitat types on the Project Property: cleared agricultural land, grassy areas, and sugarcane fields. Fauna recorded on the property and in the vicinity consisted of mammals, birds, and arthropods, none of which were considered a rare or endangered species. Similarly, the flora found on the property were common species found around Barbados and not considered rare or endangered.

1.0 INTRODUCTION

Renewstable (Barbados) Inc. is proposing to construct and operate a hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation (Figure 1-1) in the parish of Saint Philip, Barbados (the Project). The Project will generate approximately 56,000 megawatt-hours per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 Barbadians annually. The site will also accommodate a commercial Blackbelly sheep farm that is specifically designed to be financially viable and environmentally sustainable in the long-term.

A series of baseline studies were proposed to support the Environmental and Social Impact Assessment for the Project. This report is a baseline ecological assessment of the flora and fauna in the vicinity of the Project, based on the findings of a field reconnaissance and a review of existing literature and databases related to rare species.

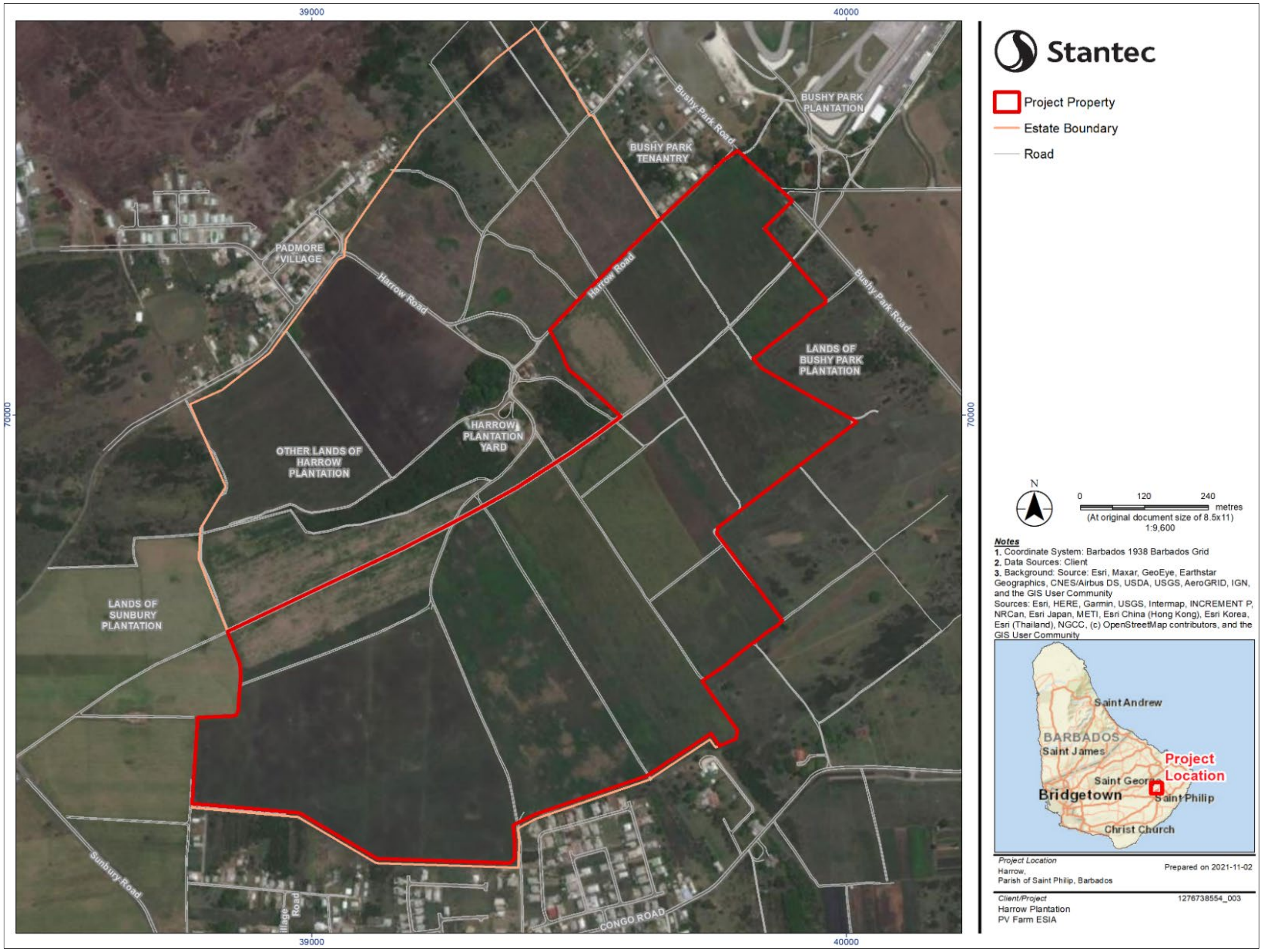

Figure 1-1 Project Location

2.0 RARE SPECIES AND REGULATORY OVERVIEW

2.1 RARE SPECIES OVERVIEW

A species can be considered rare because it has relatively few individuals, it is uncommon or scarce, and/or it occurs within a limited geographical range. The rarest species are those with small geographic ranges, few occurrences, and few individuals in each occurrence. For the purpose of this report, a species is considered rare if it is listed in or by the following:

- The IUCN (International Union for the Conservation of Nature) Red List of Threatened Species
- Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

2.2 RELEVANT LEGISLATION

Currently, Barbados has not enacted legislation specific to the protection of biodiversity in response to ratifying the 1992 Convention on Biological Diversity. Instead, the environment-related legislation in force in Barbados is dispersed over numerous statutes charging various government bodies with the management of the environment (NBSAP 2002). The legislation listed in Sections 2.2.1, 2.2.2, and 2.2.3 are the most relevant to protecting the flora and fauna of Barbados.

2.2.1 Wild Birds Protection Act

Under the Wild Birds Protection Act, CAP. 398, “Any person who knowingly kills or wounds or attempts to kill or wound a wild bird shall be liable to a penalty […] for each wild bird killed or wounded or attempted to be killed or wounded…” This includes bird species native to the Barbados as well as any birds migrating through the area (MENB 2021). A list of species protected by the Wild Birds Protection Act is provided in Table 2.1.

Table 2.1 Bird Species in Barbados Protected under the *Wild Birds Protection Act*

Pied-billed Grebe (*Podilymbus podiceps*)	Audubon's Shearwater (*Puffinus lherminieri*)
Brown Pelican (*Pelecanus occidentalis*)	Magnificent Frigate Bird/Cobber (*Fregata magnificens*)
Great Blue Heron/Grey Gaulin (*Ardea herodias*)	Little Green Heron; Gaulin (*Butorides virescens*)
Little Blue Heron (*Florida caerulea*)	Cattle Egret (*Bubulcus ibis*)
Great Egret (*Casmerodius alba*)	Snowy Egret (*Egretta thula*)
Tricoloured Heron/Louisiana Heron (*Hydranassa tricolour*)	Black-crowned Night Heron (*Nycticorax nyxticorax*)
Yellow-crowned Night Heron (*Nyctanassa violacea*)	Osprey/Fish Hawk (*Pandion haliaetus*)
Sora Craka/Duck-me-chick (*Porzana carolina*)	Common Gallinule/Red-seal Coot (*Gallinula chloropus*)
Caribbean Coot/White-seal Coot (*Fulica caribaea*)	Upland Sandpiper/Cotton Tree Plover (*Bartramia longicauda*)
Buff-Breasted Sandpiper (*Tryngites subruficollis*)	Hudsonian Godwit/Godwit (*Limosa haemastica*)
Ruff philomachus pugnax (*Philomachus pugnax*)	Red-necked pigeon/Ramier (*Columba squamosa*)
Zenaida Dove/Wood Dove (*Zenaida aurita*)	Ground Dove (*Columbina passerina*)
Guyana Parrotlet/Parakeet (*Forpus passerinus*)	Common Nighthawk (*Chordeiles minor*)
Green-throated Carib; Large Hummingbird (*Sericotes holosericeus*)	Antillean Crested Hummingbird (*Orthorhyncus cristatus*)
Belted Kingfisher/Kingfisher (*Halcyon ceryle*)	Grey Kingbird/Rain Bird/Dr. Morris (*Tyrannus dominicensis*)
Caribbean Eiaenia Flycatcher/Peewittler/Pee-whistler (*Elaenia martinica*)	Caribbean Purple Martin/Large Swallow (*Progne subis*)
Barn Swallow/Swallow (*Hirundo rustica*)	Scaly-breasted Thrasher/Thrush (*Margarops fuscus*)
Black-whiskered Vireo (*Viero altiloquus*)	Prothonotary Warbler (*Protnotaria citrea*)
Parula Warbler (*Parula americana*)	Yellow Warbler/Yellow bird (*Dendroica petechia*)
Blackpoll Warbler (*Dendroica striata*)	Northern Waterthrush (*Seiurus noveboracensis*)
American Redstart/Gold Finch/Christmas Bird (*Setophaga ruticilla*)	Scarlet Tanager (*Piranga olivacea*)
Glossy Cowbird/Brazilian Rice Bird (*Molothrus bonariensis*)	Carib Grackle/Blackbird (*Quiscalus lugubris*)
Yellow Grass Finch/Grass Canary (*Siscalis luteola*)	Black-faced Grassquit/Cane Sparrow (*Tiaris bicolor*)
Source: MENB 2021	

2.2.2 Trees (Preservation) Act

The Trees (Preservation) Act states that unless a permit is obtained from the Chief Town Planner, killing any tree with a circumference of which is one meter or more at a point half a meter or more from the ground is an offence.

The Act also gives the Chief Town Planner the power to require the owner of any vacant land, or any land on which a new road is to be made or any land abutting upon, adjoining or near a public road to do the following:

- plant or replant any tree of such size and species to the location stated in the notice.
- provide for the maintenance and protection of any tree.
- clear the land of weeds or overgrown grass
- take such other measures that are reasonably necessary for the purpose of preserving or enhancing the amenity of the vacant land

2.2.3 Other Acts, Strategies and Management Plans

Other strategies and management plans, policies, and legislation related to the protection of flora and fauna in the vicinity of the Project include (but are not limited to) the following:

- Barbados Physical Development Plan Amendment 2017 (Draft)
- Barbados Sustainable Development Policy 2004
- National Biodiversity Strategy and Action Plan
- National Strategic Plan 2006-2025
- Protection of New Plant Varieties Act

3.0 METHODS

A field reconnaissance survey was conducted at the Project Property and its environs to gather information on the availability and distribution of habitat for various species, including for rare or protected species. The specific objectives of the survey were to:

- Document habitats and species encountered
- Record observations of plants and wildlife, especially any rare or sensitive species and their habitats
- Delineate areas of distinct habitat types (e.g., wetlands or watercourses) or of a species occurrence
- Identify and map habitat features of potential importance to wildlife
- Identify obstacles to movement, disturbances, or the splitting of vital spaces
- Identify specific locations that would require additional surveys during the dry season

3.1 FIELD RECONNAISSANCE

3.1.1 Project Property

A series of survey transects (50m spacing) and the perimeter were walked, covering the Project Property (Figure 3-1). Along the Transect Lines photos were taken of:

- Representative habitat types encountered
- Wildlife or evidence of wildlife encountered (e.g., characteristic noises, paw prints and burrows)
- Potential wildlife habitat features (e.g., settled water and forested areas)

Observations were documented on prepared datasheets.

3.1.2 Adjacent Areas

Forested areas adjacent to the Project Property and dark spots (i.e., potential waterbodies) were identified via Google Earth and surveyed, where accessible (Figure 3-1). Additionally, the roads/tracks used to access the Project Property and the residential area to the south of the Project Property were also travelled/surveyed. In these areas photos were taken of fauna and landmarks.

3.2 ADDITIONAL INFORMATION SOURCES

Other sources of information used to gather information on habitats and species in the area were readily available (public) primary and secondary literature and government databases, including:

- Barbados National Biodiversity Strategy and Action Plan 2020 (Government of Barbados 2021)
- Important Bird Areas Americas - Priority sites for biodiversity conservation (Burke 2008)
- BirdLife International Country profile: Barbados (BirdLife International 2021)
- Plants of Saint Lucia (Graveson 2019)

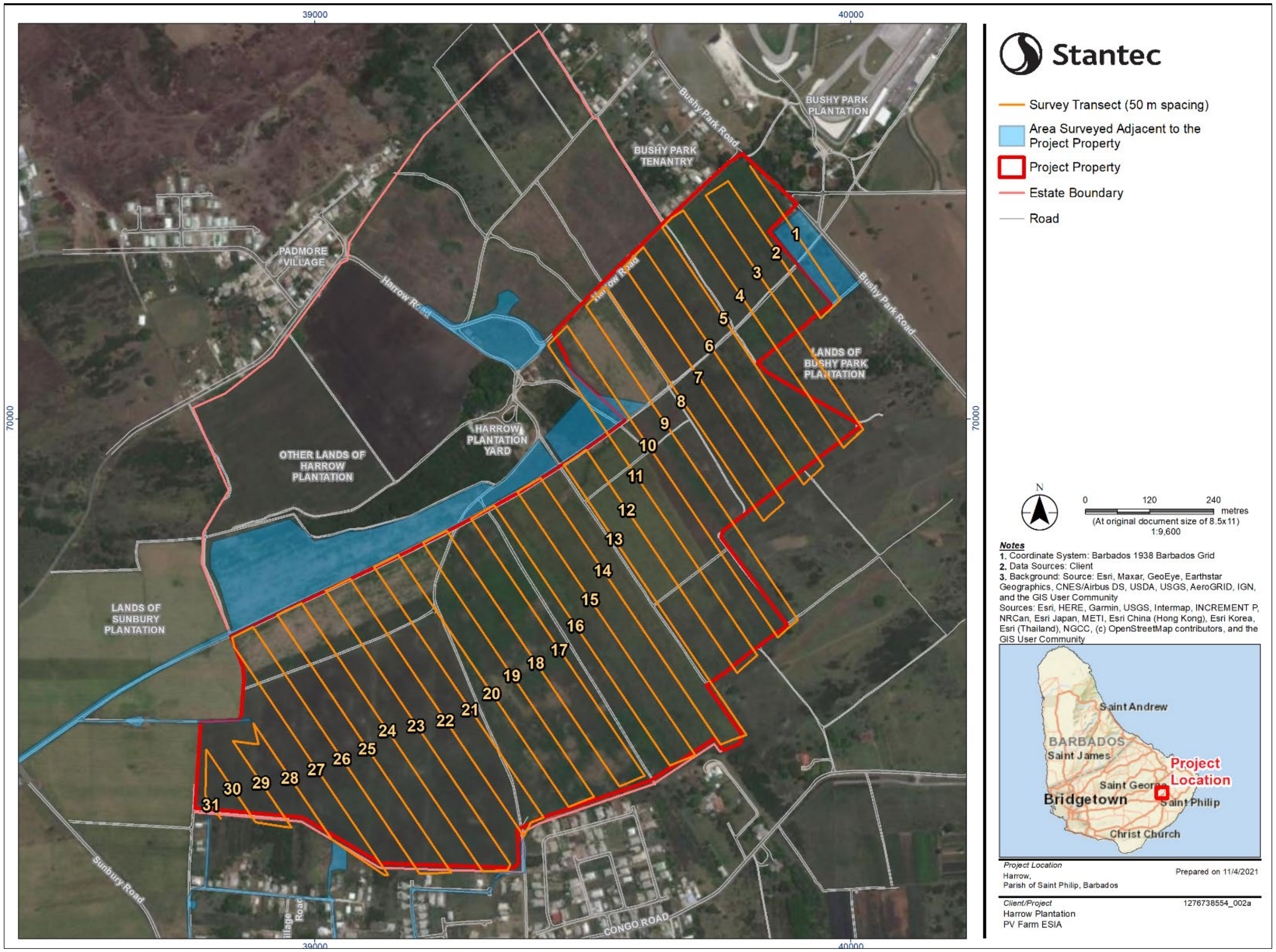

Figure 3-1 Transects and Adjacent Habitats Surveyed during the 2021 Field Reconnaissance

4.0 RESULTS

Completed datasheets from the 2021 field reconnaissance are provided in Appendix A and representative photos are provided in Appendix B.

4.1 PHYSICAL DESCRIPTION OF THE AREA

4.1.1 Project Property

The Project Property generally consists of areas of cleared agricultural land, grassy areas and sugar cane fields. Throughout the property there was little wildlife beyond a few species of birds which were seen more frequently and more abundantly in areas with greater vegetation. Another notable feature was the number of wells found (see Photos 28 & 29 in Appendix B). In general, habitat features were common among groups of transects.

Transect Lines 1 to 8 consisted of cleared agricultural land with very little habitat change noted (Figure 4 1) (see Photo 30 in Appendix B). This area was divided by paths/tracks and showed little signs of wildlife. There were ant nests (see Photo 27 in Appendix B) scattered throughout this area and occasionally wood doves and blackbirds were observed. The plant known locally as wild cucumber was found sporadically in this area. Four drainage wells were observed (Figure 4-1).

The upper area of Transect Lines 8 to 11 was a grassy area (Figure 4-1) with ant nests scattered throughout. An isolated rain tree exists near the center of the area and three coconut trees border the northern property boundary by the roadside. Between Transect Lines 10 and 11 a small ditch was observed outside of the Project Property boundary. The ditch, overgrown with vegetation, appears to follow the outline of the Project boundary in that area. South of the main track that runs perpendicular to Transect Lines 8 to 11 is one of two cane fields found on the property (Figure 4-1).

Transect Lines 10 to 15 consisted of land that was mostly grassy (Figure 4-1), with grass and elephant grass growing freely. Birds were seen more frequently and in bigger groups in this area. Toward the end of Line 7 there was settled water where water beetles, dragon flies, flies and an unidentified paw print (possibly canine) were observed. Three drainage wells were identified (Figure 4-1).

Transect Lines 15 to 20 consisted of cleared agricultural land with little wildlife observed (Figure 4-1). However, this area showed a greater level of vegetation regrowth (i.e., weeds and grass) compared to Lines 1 through 8. Seven drainage wells were observed (Figure 4-1).

Transect Lines 21 to 31 was more cleared agricultural land with a sugar cane field toward the southern part of the Transect Lines (Figure 4-1). Nine drainage wells were identified in the accessible areas (Figure 4-1).

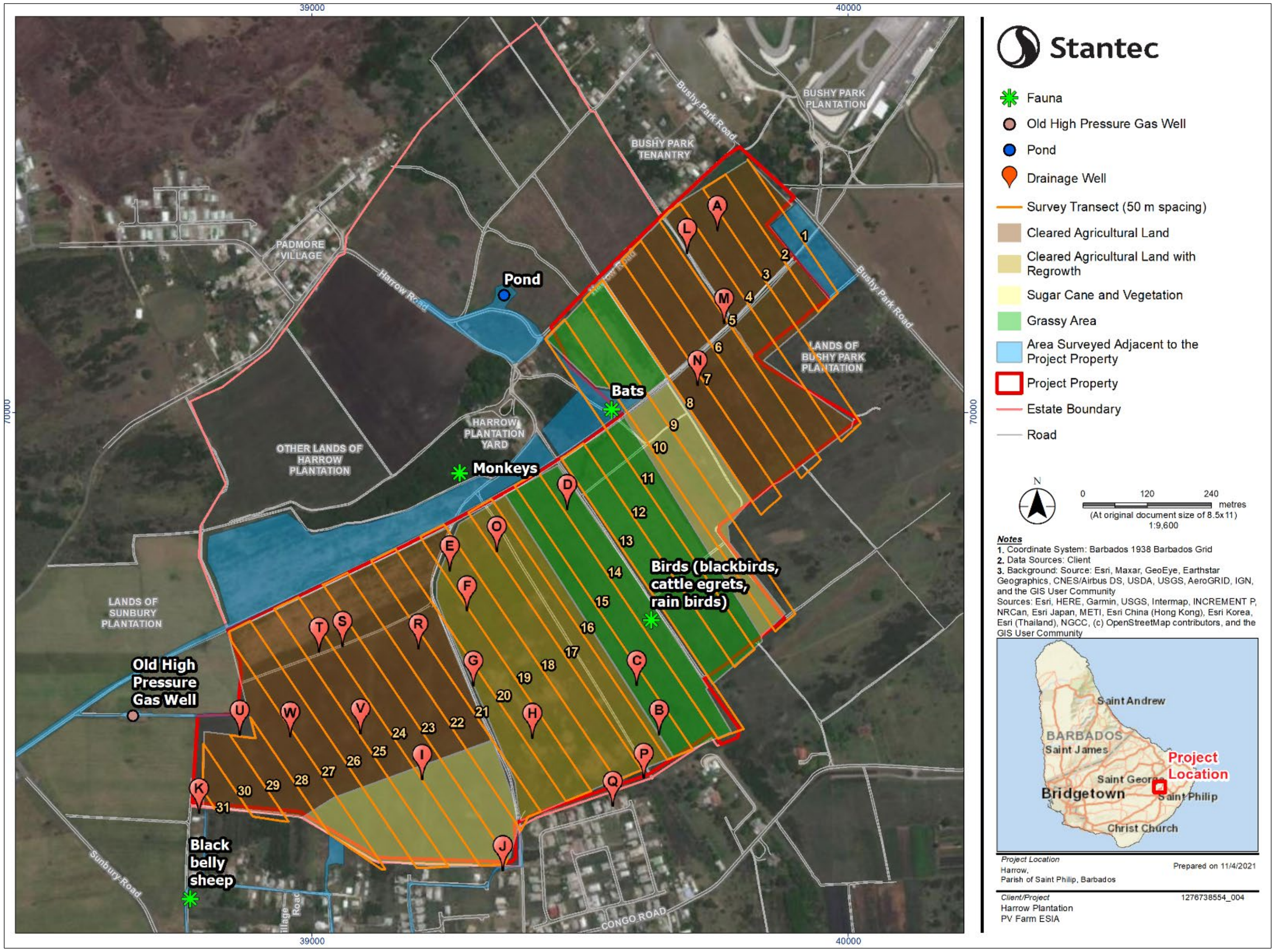

Figure 4-1 Observations during the 2021 Field Reconnaissance and the General Layout of Habitats on the Project Property

4.1.2 Adjacent Habitats

Outside of the Project Property the forested areas identified were mostly rain trees (see Photo 12 in Appendix B) and river tamarind trees. These areas were along Transect Line 1 and north of Transect Lines 16 and 17. Of the three dark circles on the satellite image to the north of the Project Property, one was accessible and was confirmed to be a relatively large pond (Figure 4-1) (see Photo 35 in Appendix B). The residential area to the south had three sheep being reared on an empty lot (Figure 4-1) (see Photo 15 in Appendix B). To the west of the Project Property an old high-pressure gas well was found (Figure 4-1) (see Photos 36 & 37 in Appendix B).

4.2 FLORA AND FAUNA

The flora in the Project Property consisted mostly of grass and shrub regrowth after the land had been left unattended, and there were sugarcane rows in some areas (as described in Section 4.1.1). The "forested" areas identified on the outside of the Project Property mostly consist of river tamarind trees and rain trees (Section 4.1.2). There was limited wildlife and evidence of wildlife found in the area. Most of the animals seen were birds.

4.2.1 Flora

There are roughly 700 species of flowering plants found in Barbados, two which are endemic to the island*, a* gully shrub *(Phyllanthus andersonii)* and slender climber (*Metastelma barbadense*). These endemic species are neither rare or endangered and are found in wooded areas (Government of Barbados 2021), making it unlikely they would occur on the Project Property, which is predominantly agricultural land.

Twenty-three plants on the island have been identified as needing protection, fifteen of which are found in one location, Turner's Hall Woods (Carrington pers. comm.) in northern Barbados, with eight of them being considered rare or endangered. These species were not observed on the Project Property and are not likely to be in the vicinity as they are found mostly in moist more sheltered regions.

Flora encountered during the field reconnaissance is listed in Table 4.1. The cleared agricultural land mostly consisted of plants like grasses, vines and the occasional tree. The vine known locally as wild cucumber (see Photos 10 & 11 in Appendix B) could be found sporadically throughout the cleared land and along the edges of property. Grasses could also be found along the paths/tracks cut through the cleared agricultural land. A lightning rod plant (see Photo 5 in Appendix B) was found along one of these paths. On the southern borders of the Transect Lines 1 to 9 elephant grass could be found. Amongst them were castor oil plants (see Photo 2 in Appendix B). Sugarcane (*Saccharum officinarum*) also occurs on the Project Property. Shrubby false buttonweed and cupid's shaving brush (*Emilia fosbergii*) (see Photo 4 in Appendix B) were found in the area of cleared agricultural land with more substantial regrowth.

Table 4.1 Flora Encountered during the Field Reconnaissance

Flora	Photo #
Butterfly pea vine (*Clitoria ternatea*)	1
Castor oil plant (*Ricinus communis*)	2
Clammy cherry tree (*Cordia obliqua*)	3
Cupids shaving brush (*Emilia fosbergii*)	4
Elephant grass (*Pennisetum purpureum*)	13
Khus khus grass (*Chrysopogon zizanioides*)	14
Lightning rod plant (*Leonotis nepetifolia*)	5
Tridax procumbens	6
Rain tree (*Albizia sp.*)	12
River tamarind (*Leucaena leucocephala*)	7
Shrubby false buttonweed (*Spermacoce verticillata*)	-
Sugarcane (*Saccharum officinarum*)	9
Vine from the sweet potato family (*Merremia dissecta* (Jacquin) Hallier f.)	8
Wild cucumber (*Cucumis melo var. dudaim (L.) Naudin)*	10, 11

Butterfly pea vines (Clitoria ternatea) (see Photo 1 in Appendix B) and other vines from the sweet potato family were found in the bushy areas outside of the Project Property. The areas that could be identified as possibly forested from satellite images were predominantly occupied by rain trees (Albizia sp.) and river tamarind trees (Leucaena leucocephala). On the ground around them were coarse grass and plants from the daisy family, which are normally considered weeds.

4.2.2 Fauna

An overview of the fauna of Barbados and observations during the field reconnaissance is provided below for Mammals (Section 4.2.2.1), Birds (Section 4.2.2.2) and Insects and Allied Arthropods (Section 4.2.2.3). The fauna encountered in and around the Project Property is listed in Table 4.2. The diversity of species encountered was limited, which is expected as the area is mostly agricultural land.

Table 4.2 Fauna Encountered during Field Reconnaissance

Fauna	Photo #
Antillean crested hummingbird (*Orthorhyncus cristatus*)	-
Ants	-
Bats	-
Blackbelly sheep (*Ovies aries*)	15
Blackbirds (*Quiscalus lugubris*)	16
Butterflies	22, 23
Cattle egret (*Bubulcus ibis*)	-
Centipede	-
Dragonflies	24
Giant African snail (*Lissachatina fulica*)	-
Grasshopper	-
Grassland yellow finch (*Sicalis luteola*)	-
Green monkey (*Chlorocebus sabaeus*)	-
Green heron (*Butorides virescens*)	18
Honeybee (*Apis mellifera*)	17
Millipede	-
Mosquitoes	-
Rain bird (*Tyrannus dominicensis*)	19, 20
Silver argiope spider (*Argiope argentata*)	21
Water beetles	-
Wood doves (*Zenaida aurita*)	25
Worm	-

4.2.2.1 Mammals

The mammalian fauna of Barbados is dominated by introduced species including rats, green monkeys and mongooses. Barbados has six extant indigenous mammals, which are all species of bats. None of the mammals found in Barbados are considered rare or endangered and the population of the six bat species are “in good condition” (Genoways et al. 2012).

The only mammals observed within the boundary of the Project Property were bats (Table 4.2). Bats were observed around the trees found north of Transect Line 10 in the evening; however, the species could not be identified.

In the residential area to the south of the Project Property, three black belly sheep were observed grazing and green monkeys were heard in the forested areas north of Transect Lines 14 to 17. In addition, a paw print was found in an area of settled water located at southern end of Transect Lines 6 and 7.

4.2.2.2 Birds

The island’s bird fauna is much more diverse compared to the mammalian fauna. Much of this diversity is a result of migratory species travelling to South America towards the end of the year. These birds are attracted to swamp areas in Barbados, such Graeme Hall Swamp, Chancery Lane Swamp, Green Pond, and Long Pond. Approximately 1.2 km to the south of the Project Property there is an Important Bird Area (IBA), BB006 St. Philip Shooting Swamps. This IBA attracts Neotropical migratory species which are heading south between the months of July and October. It also provides a habitat for other wetland birds, including populations of three (of the four) Lesser Antilles Endemic Bird Area (EBA) restricted-range birds (Burke 2008).

They are approximately 36 resident species of birds nesting on the island, the majority of which have. adapted well to human-altered habitats and are considered common. None of the birds observed during the field reconnaissance (Table 4.2) are considered rare or at risk, however they are all protected by the *Wild Birds Protection Act*.

Rain bird (*Tyrannus dominicensis)*, blackbirds (*Quiscalus lugubris*), and cattle egrets (*Bubulcus ibis)* were observed on the Project Property and were primarily located in areas with higher vegetation such as the grassy areas between Transect Lines 10 to 15 (Figure 4-1). A heron (*Butorides virescens*) was spotted standing in settled water which collected in a tractor tire mark (see Photo in 18 Appendix B) left on the ground just south of the Project Property border between Transect Lines 9 and 10. In addition, a group of approximately six grassland yellow finches (*Sicalis luteola*) was spotted west of the Project Property in mostly cleared agricultural land (the area had a green patch of grass in the center). A hummingbird (*Orthorhyncus cristatus*) was also observed at the flowers of a rain tree at the top of Transect Line 13.

4.2.2.3 Insects and Allied Arthropods

They are roughly 1,300 species of insects and allied arthropods that have been described in Barbados, the most common being odonates (dragonflies), hemipterans (bugs), coleopterans (beetles), and dipterans (flies) (Government of Barbados 2021).

Arthropods such as arachnids, myriapods, and insects were found on the Project Property and the adjacent forested areas. The most abundant insect on the Project Property were ants, as evidenced by the numerous nests found throughout the survey. Millipedes were also observed above ground around the Project Property and a centipede was found under a rock. Small spiderwebs were documented in areas with elephant grass and the silver argiope spider (*Argiope argentata*) (see Photo 21 in Appendix B) was found in areas outside of the Project Property in bushy areas among the river tamarind and rain trees. In addition, numerous insects such as flies, dragonflies, water beetles, and mosquitoes were found on the Project Property, mostly close to settled water or bushy areas, and there was a termite nest found among fallen cane and black worms in the same vicinity.

5.0 SUMMARY

This report summarizes the known and potential flora and fauna that may occur within or near the Project Property and its habitats, based on information collected via the field reconnaissance survey and published sources of information.

The Project Property can largely be divided into sections of cleared agricultural land, sugar cane fields and grassy fields, with forested areas and ponds on the outskirts.

The biodiversity found on the Project Property was limited. This was expected given that the area is mostly cleared agricultural land. Existing flora consists of wild shrubs, vines, grasses and trees commonly found in dry areas. None of the flora recorded during the reconnaissance survey are considered rare or endangered and the habitats in the area are unlikely to support such species.

Similarly, none of the fauna observed is considered to be rare or endangered. There were seven species of birds seen on the Project Property. However, due to the proximity of one IBA and ponds in the area there is potential to see more species of birds in the vicinity of the Project Property, including restricted range birds. However, these restricted-range species would be expected to preferentially use wetlands/swamps rather than agricultural habitats and are therefore unlikely to use the Project Property.

The only mammals encountered on the during the field reconnaissance were bats (flying overhead) and green monkeys, the latter of which were heard in the trees outside of the Project Property. The introduced green monkey is known to be adaptable and thrives in the human-disturbed environments of Barbados (Government of Barbados 2002) and are considered an agricultural pest (Government of Barbados 2021).

Other fauna observed during the field reconnaissance consists of insects and allied arthropods, all of which are common in Barbados.

6.0 REFERENCES

6.1 PERSONAL COMMUNICATIONS

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APPENDIX A

Datasheets

Project Name: *Harrow Plantation PV Farm* **Project Number:** *128019054*

Name: JAG **Date:** 18/09/2021 **Transect #:** 1 to 8 **Start time:** ________ **End time:** ________

Temp: ________ **Wind:** ________ **Precipitation:** ________ **Cloud cover:** ________ %

General Habitat: *(e.g., dominant trees or shrubs, tree cover (open / closed canopy), agricultural land / crops, etc.)*

Cleared agricultural land.

Observation / Species	Coordinates		Notes – *key features, # observed, evidence (e.g., nests, burrows, or other residences), etc.*	Photo #
	Latitude	Longitude		
Transect Start				
Plants			Grasses growing in the beds.	
Ants			Numerous at colonies in this section.	
Cucurbit			Vine known locally as wild cucumber found sporadically through area.	
Bird			Wood dove seen walking around.	
Millipede			Millipede remains found.	
Drainage well A	13° 8'4.31"N	59°28'11.09"W	Water drainage for field.	
Drainage well L	13° 8'2.91"N	59°28'12.98"W	Water drainage for field.	
Drainage well M	13° 7'58.68"N	59°28'10.67"W	Water drainage for field.	
Drainage well N	13° 7'54.92"N	59°28'12.33"W	Water drainage for field.	
Mint family			A single lightning rod plant seen along path that splits the agricultural land.	
Grass family			Khus khus grass was seen along path that splits the agricultural land.	
Spider			Unknown species. Spider found in bushy area.	
Sweet potato family			Unknown species. Found in forested area on transect line 1 beyond the project area.	
Legume family			River tamarind tree found in forested area on transect 1.	
Bird			Unknown species heard in rain trees. Most likely blackbirds.	
Legume family			Rain trees growing on the outside of the project area.	

Additional Notes: *(important habitat features, existing disturbances, access limitations, adjacent habitat / land uses, etc.)*

Not much change in habitat along transect. This area was overlooking the roadside. Beyond the area of interest further along the transect line there was an overgrown / bushy area. This area consisted of various plants and animals.

Project Name: *Harrow Plantation PV Farm* **Project Number:** *128019054*

Name: JAG **Date:** ______ **Transect #:** 8 to 11 **Start time:** ______ **End time:** ______

Temp: ______ **Wind:** ______ **Precipitation:** ______ **Cloud cover:** ______%

General Habitat: *(e.g., dominant trees or shrubs, tree cover (open / closed canopy), agricultural land / crops, etc.)*

Grassy area in the northern section of the transects lines. Across the path / track there is a sugarcane field. Toward the southern project area boundary there is settled water where insects are found.

Observation / Species	Coordinates		Notes – *key features, # observed, evidence (e.g., nests, burrows, or other residences), etc.*	Photo #
	Latitude	Longitude		
Transect Start				
Ant Colony			Ant colony seen in the grass.	
Legume family			Isolated rain tree in the center of grassy area.	
Palm family			Three coconut trees on the boundary of property next to roadside.	
Grass family			Rows of sugar cane.	
Dog			Paw print. Possibly dog from the residential area or stray.	
Insect			Water beetles found in open water.	
Insect			Dragonflies flying over open water.	
Insect			Unknown species. Small flies around the open water.	
Bird			Two wood doves seen walking.	
Bird			Heron seen in settled water.	

Additional Notes: *(important habitat features, existing disturbances, access limitations, adjacent habitat / land uses, etc.)*

Habitat changes from grassy area to cane field and then settled water can be found toward the end of transects.

Project Name: *Harrow Plantation PV Farm* **Project Number:** *128019054*

Name: JAG **Date:** ________ **Transect #:** 10 to 15 **Start time:** ________ **End time:** ________

Temp: ________ **Wind:** ________ **Precipitation:** ________ **Cloud cover:** ________ %

General Habitat: *(e.g., dominant trees or shrubs, tree cover (open / closed canopy), agricultural land / crops, etc.)*

Grassy area. Area is predominantly elephant grass.

Observation / Species	Coordinates		Notes – *key features, # observed, evidence (e.g., nests, burrows, or other residences), etc.*	Photo #
	Latitude	Longitude		
Transect Start				
Ant colony			Multiple ant nests found along the transect lines in the cleared agricultural land portion of the project area.	
Millipede			Carcass of millipede found.	
Bird			Rain bird seen in the area.	
Bird			Cattle egrets seen in the area.	
Bird			Group of blackbirds seen in the area.	
Termites			Termites' nest seen amongst fallen cane.	
Grass family			Elephant grass growing freely in this area.	
Grass family			Sugar cane found on the ground.	
Animal			Unknown species. Worm like creatures found on sugarcane.	
Drainage well B	13° 7'33.73"N	59°28'14.71"W	Water drainage for field.	
Drainage well C	13° 7'36.71"N	59°28'16.10"W	Water drainage for field.	
Drainage well D	13° 7'47.39"N	59°28'20.40"W	Water drainage for field.	

Additional Notes: *(important habitat features, existing disturbances, access limitations, adjacent habitat / land uses, etc.)*

No change in habitat along transects. Birds were spotted more frequently.

Project Name: Harrow Plantation PV Farm **Project Number:** 128019054

Name: JAG **Date:** 19/09/2021 **Transect #:** 15 to 20 **Start time:** ________ **End time:** ________

Temp:________ **Wind:** ________ **Precipitation:** ________ **Cloud cover:**________%

General Habitat: *(e.g., dominant trees or shrubs, tree cover (open / closed canopy), agricultural land / crops, etc.)*

Cleared agricultural land with a higher level of vegetation regrowth than the other areas of cleared land.

Observation / Species	Coordinates		Notes – *key features, # observed, evidence (e.g., nests, burrows, or other residences), etc.*	Photo #
	Latitude	Longitude		
Transect Start				
Millipede			Millipede remains seen on surface.	
Rubiaceae			Whitehead broom growing in the area.	
Insect			Bee seen on the flowers of the whitehead broom plant.	
Burrow			Unknown species.	
Drainage well E	13° 7'43.67"N	59°28'27.66"W	Water drainage for field.	
Drainage well F	13° 7'41.25"N	59°28'26.61"W	Water drainage for field.	
Drainage well G	13° 7'36.70"N	59°28'26.20"W	Water drainage for field.	
Drainage well H	13° 7'33.52"N	59°28'22.56"W	Water drainage for field.	
Drainage well O	13° 7'44.86"N	59°28'24.75"W	Water drainage for field.	
Drainage well P	13° 7'31.09"N	59°28'15.67"W	Water drainage for field.	
Drainage well Q	13° 7'29.39"N	59°28'17.59"W	Water drainage for field.	
Cucurbit			Vine known locally as wild cucumber found in area.	

Additional Notes: *(important habitat features, existing disturbances, access limitations, adjacent habitat / land uses, etc.)*

Not much change in habitat along transect lines. To the south there is not much division between the project area and residential area.

Project Name: *Harrow Plantation PV Farm* **Project Number:** *128019054*

Name: JAG **Date:** 19/09/2021 **Transect #:** 21 to 31 **Start time:** ______ **End time:** ______

Temp: ______ **Wind:** ______ **Precipitation:** ______ **Cloud cover:** ______ %

General Habitat: *(e.g., dominant trees or shrubs, tree cover (open / closed canopy), agricultural land / crops, etc.)*

Cleared agricultural land

Observation / Species	Coordinates		Notes – *key features, # observed, evidence (e.g., nests, burrows, or other residences), etc.*	Photo #
	Latitude	Longitude		
Transect Start				
Ant Colony			Ant nest seen.	
Millipede			Millipedes seen at damp drainage well.	
Grass			Elephant grass around drainage well.	
Bird			Grassland yellow finches were seen in the grass area of this section.	
Grass			Sugarcane field to the south of the transect lines.	
Drainage well I	13° 7'31.02"N	59°28'29.37"W	Water drainage for the field.	
Drainage well J	13° 7'25.49"N	59°28'24.38"W	Water drainage for the field.	
Drainage well K	13° 7'28.98"N	59°28'43.18"W	Water drainage for the field.	
Drainage well R	13° 7'38.93"N	59°28'29.61"W	Water drainage for the field.	
Drainage well S	13° 7'39.09"N	59°28'34.31"W	Water drainage for the field.	
Drainage well T	13° 7'38.74"N	59°28'35.77"W	Water drainage for the field.	
Drainage well U	13° 7'33.71"N	59°28'40.67"W	Water drainage for the field.	
Drainage well V	13° 7'33.78"N	59°28'33.19"W	Water drainage for the field.	
Drainage well W	13° 7'33.62"N	59°28'37.54"W	Water drainage for the field.	
Snail			Snail shell found in the area.	

Additional Notes: *(important habitat features, existing disturbances, access limitations, adjacent habitat / land uses, etc.)*

Mostly cleared agricultural land but they were some areas of grass and plant (weed) growth. There was a track cut to the west that led to an old high-pressure gas well.

APPENDIX B

Site Photos

Photo 1 **Butterfly pea vine (*Clitoria ternatea*)**

Photo 2 **Castor oil plant (*Ricinus communis*)**

Photo 3 **Clammy cherry tree (*Cordia obliqua*)**

Photo 4 **Cupids shaving brush (*Emilia fosbergii*)**

Photo 5　　Lightning rod plant (*Leonotis nepetifolia*)

Photo 6 ***Tridax procumbens*** **Linnaeus**

Photo 7 River tamarind (*Leucaena leucocephala*)

Photo 8 Merremia *dissecta* (Jacquin) Hallier f.

Photo 9 **Sugarcane (*Saccharum officinarum*)**

Photo 10 **Wild cucumber (*Cucumis melo var. dudaim* (L.) Naudin)**

Photo 11 Wild cucumber (*Cucumis melo var. dudaim* (L.) Naudin)

Photo 12 **Rain tree (*Albizia sp.*)**

Photo 13 **Elephant grass (*Pennisetum purpureum*)**

Photo 14 **Khus khus grass (*Chrysopogon zizanioides*)**

Photo 15 Barbados Blackbelly Sheep (*Ovies aries*)

Photo 16 Blackbirds (*Quiscalus lugubris*)

Photo 17 **Honeybee (*Apis mellifera*)**

Photo 18 **Green heron (*Butorides virescens*) and two wood doves (*Zenaida aurita*) in background.**

Photo 19 Rain bird (*Tyrannus dominicensis*)

Photo 20 **Rain bird (*Tyrannus dominicensis*)**

Photo 21 Silver argiope spider (*Argiope argentata*)

Photo 22 **Orange butterfly**

Photo 23 White butterfly

Photo 24 Dragonfly

Photo 25 **Wood dove (*Zenaida aurita*)**

Photo 26 **Termite nest**

Photo 27 Ant colony

Photo 28 **Drainage well H**

Photo 29 Drainage well A

Photo 30 Cleared agricultural land

Photo 31 Cleared agricultural land and sugar cane field

Photo 32 **Transect line 1 forested area's track toward the main road**

Photo 33 **Forested area of transect line 1 from main road looking southeast**

Photo 34 Forested area of transect line 1 from main road looking northeast

Photo 35 Pond outside Project Property

Photo 36 **High pressure gas well**

Photo 37 **High pressure gas well**

APPENDIX G

Visual Impact Assessment

Harrow Solar Photovoltaic Farm

Visual Impact Assessment

March 20, 2022

Prepared for:

Renewstable (Barbados) Inc.

Prepared by:

Stantec Consulting Caribbean Ltd.
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Sign-off Sheet

This document entitled "Harrow Solar Photovoltaic Farm – Visual Impact Assessment" was prepared by Stantec Consulting Caribbean Ltd. ("Stantec") for the account of Renewstable (Barbados) Inc (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Digitally signed by Justin Jennings-Wray
Date: 2022.05.16 14:54:55 -04'00'

Prepared by ______________________________

(signature)

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LIST OF FIGURES

1.0 INTRODUCTION

Renewstable Barbados Inc. – hereafter termed "the Developer" – proposes the construction of a non-intermittent electrical power plant on lands located at Harrow, St. Phillip. One major component of the power plant – occupying the majority of the total project area – is a photovoltaic solar farm. The array will provide power during daylight hours; other plant components will be responsible for non-intermittent electricity supply during night-time hours. The project area slated for the array occupies a total footprint of approximately 630,000m^2 (155.7 acres).

The specific location and site surroundings of the PV farm are shown below:

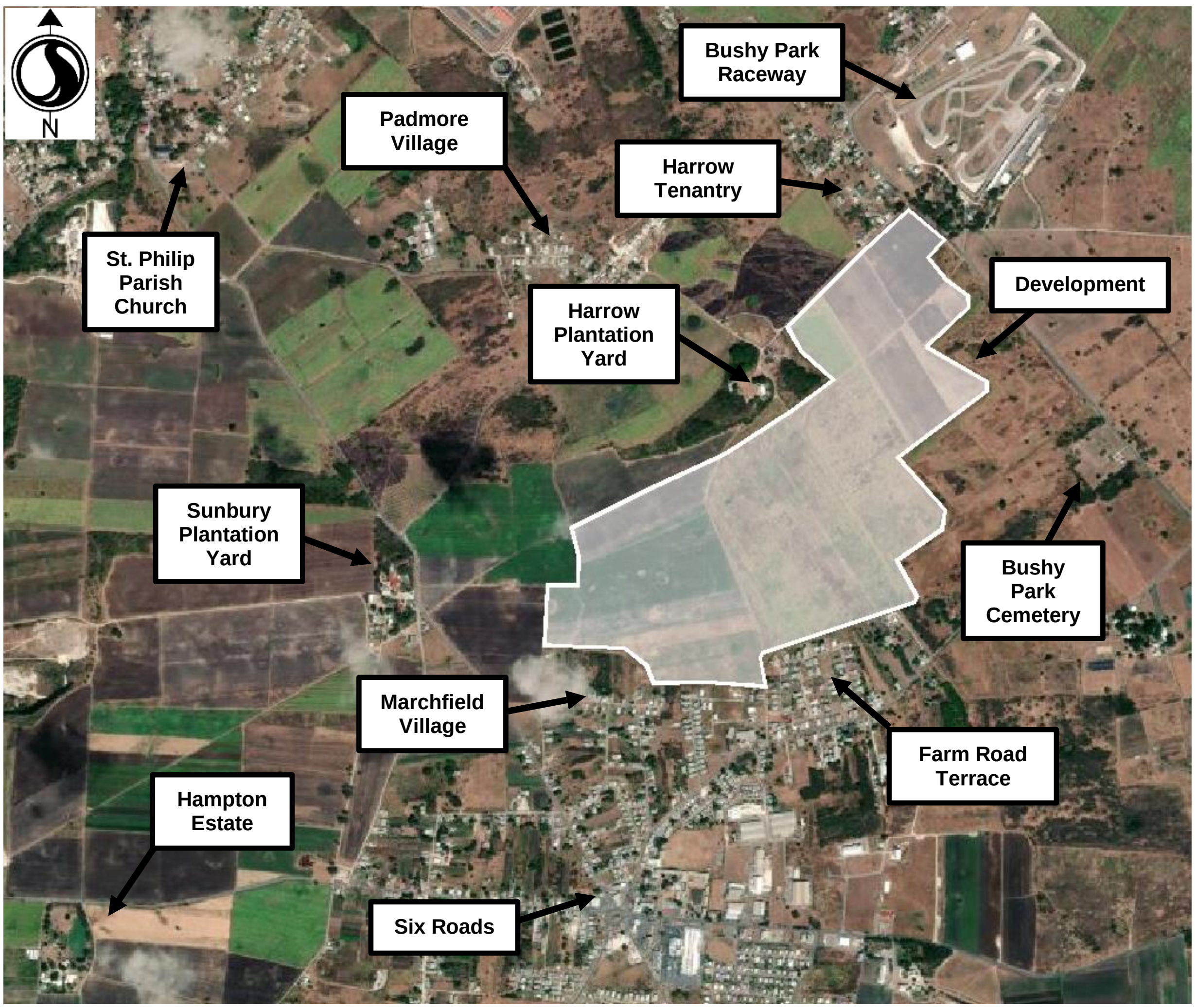

Figure 1 – Development Location and Surroundings

The PV site is located at Harrow Plantation, St. Philip. Access to the site will be provided via Harrow Road, branching off Bushy Park Road to the East and Sunbury Road to the West. The site itself is situated on agricultural land, with the environs predominantly consisting of residential and agricultural land. Residential communities exist adjacent to the Northern and Southern project boundaries. Harrow Plantation Yard is located immediately adjacent and North of the array – West of the sheep grazing area. A small community is located adjacent and North of the sheep grazing area, and a larger community – Marchfield Village – is situated along much of the Southern boundary. A veterinary clinic is located at Sunbury Plantation some 400m West of the site. Bushy Park Raceway is located approximately 250m Northeast of the array, and Bushy Park Cemetery approximately 300m to the Southeast.

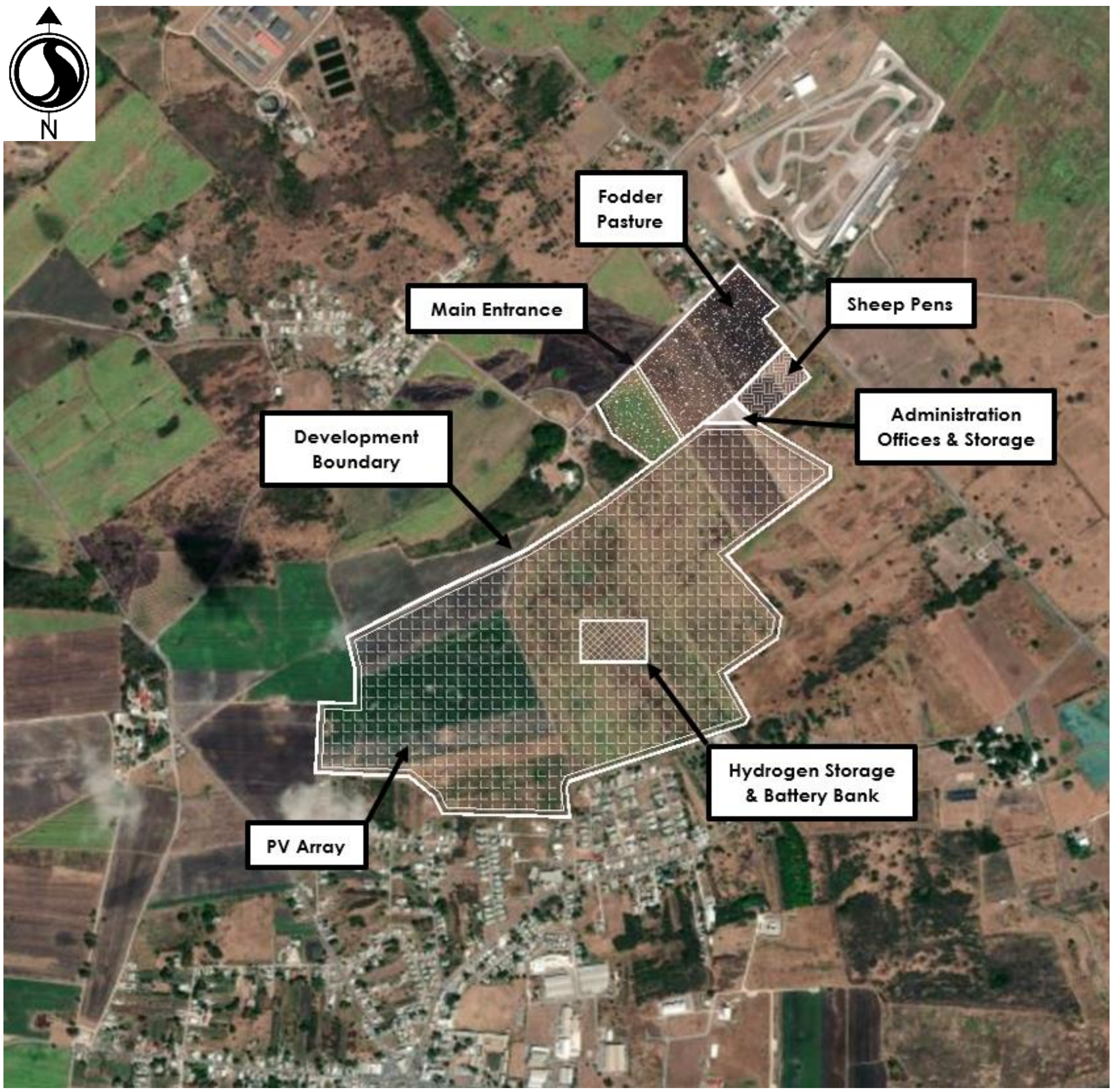

Figure 2 – Site Layout

2.0 VISUAL IMPACT ASSESSMENT

2.1 GENERAL

The visual impact assessment (VIA) was conducted by way of field reconnaissance to select vantage points to assess the future visibility of the PV farm when constructed. Photographs from vantage points of concern were taken for presentation as part of the VIA; the following presents the findings of the VIA along with the identification of potential negative impacts and mitigation measures.

2.2 FIELD RECONNAISSANCE

The site for development is currently used for agricultural operations. The majority of the site is open land, however portions are currently used for sugarcane and other crop cultivation. The site slopes gently in a Southern direction, with minor undulations throughout. Consequently, observers along the site boundaries generally have wide views of the areas, unobstructed by terrain.

Six key locations were identified at or close to the project boundary that are most likely to experience visual impacts due to the proposed development. Those locations, and their current views of the site, are described below:

1) **Harrow Tenantry –** Located to the Northeast of the site. Views of the site are largely unobstructed to the South and South-Southwest. Portions of the public road adjacent to the tenantry also provide a view of the site. Sections of the site to the far West are obstructed by a densely vegetated depression and other trees at Harrow Plantation Yard. Marchfield Village and Farm Road Terrace are clearly visible to the South of the site – in the distance.

2) **Harrow Plantation Yard –** Located to the North of the site. Views of the site are largely unobstructed to the South. Vegetation to the East and West of the Yard prevents clear view of the development in those directions. Marchfield Village and Farm Road Terrace are clearly visible to the South of the site.

3) **Sunbury Plantation / Eastern Veterinary Clinic –** Located to the West of the site. Views of the site are obstructed by tall sugarcane growing between Sunbury and the site. Western sections of the project development may become visible following crop harvest, or in the event that shorter root crops are grown on this land. The tall vegetation surrounding Harrow Plantation Yard can be seen in the distance.

4) **Marchfield Village –** Located to the Southwest of the site. Views of the site are largely unobstructed to the Northeast. Other portions of the Southern border are visible. The tall vegetation surrounding Harrow Plantation can be seen across the site.

5) **Farm Road Terrace –** Located to the South of the site. Views of the site are largely unobstructed to the Northwest, North, and Northeast. Harrow Plantation Yard and Harrow Tenantry are clearly visible to the North of the site – in the distance.

6) **Bushy Park Raceway –** Located to the Northeast of the site. The spectator stands - a tall structure situated on a small rise of land – faces the site for development. Views of the site are currently obstructed by mahogany trees and other vegetation. Portions of the site may become visible in the future if some or all of this vegetation is removed.

Each location is shown in the satellite imagery below, and their respective views of the site are displayed in the following photos.

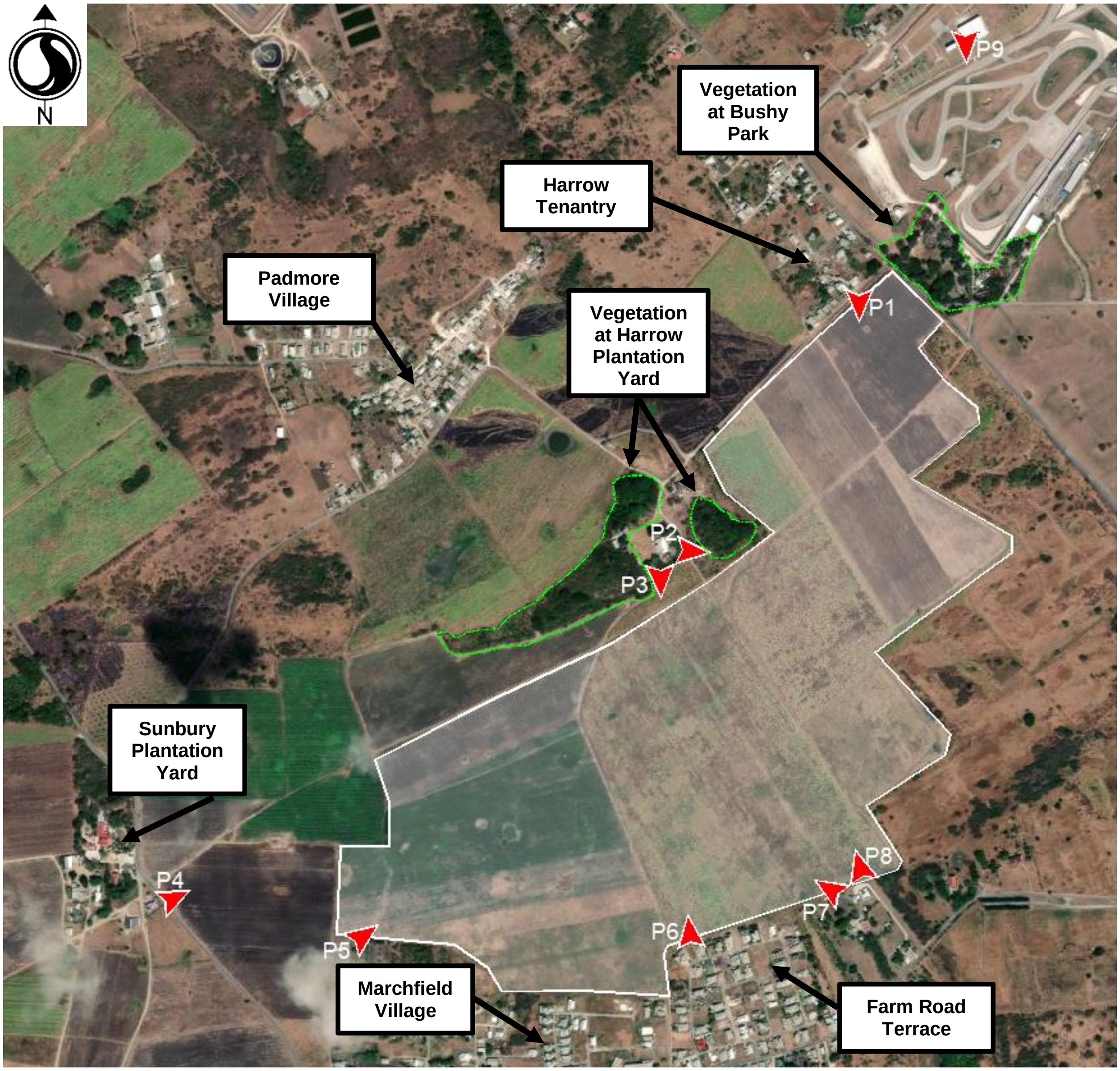

Figure 3 – Site Boundary and Locations where Photographs were Taken

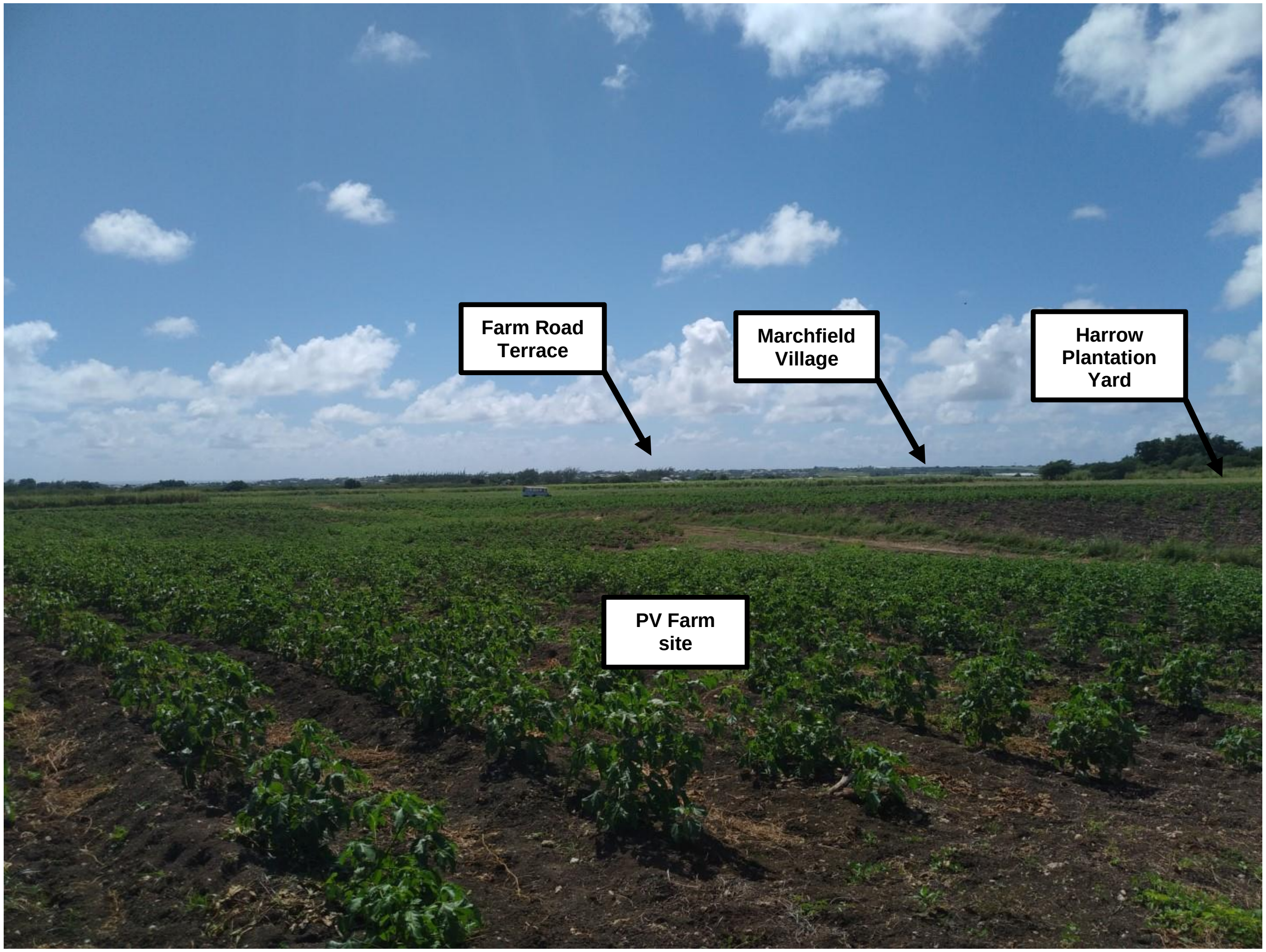

Photo 1 (P1): View from Harrow Tenantry to the Northeast of the site – looking South. *(Public road and tenantry areas will have an unobstructed view of the site)*

Photo 2 (P2): View from Harrow Plantation House to the North of the site – looking East-Southeast. *(Heavily vegetated depression partially obstructs view from this vantage point. Views to the South – right in photo - are largely unobstructed.)*

Photo 3 (P3): View from Harrow Plantation House to the North of the site – looking South. *(Views to the South to the PV farm site are unobstructed)*

Photo 4 (P4): View from Sunbury Plantation to the West of the site – looking East. *(View towards PV farm site is unobstructed.)*

Photo 5 (P5): View from Marchfield Village to the Southwest of the site – looking Northeast. *(View towards PV farm site is unobstructed.)*

Photo 6 (P6): View from Marchfield Village to the South of the site – looking North. *(View towards PV farm site is unobstructed.)*

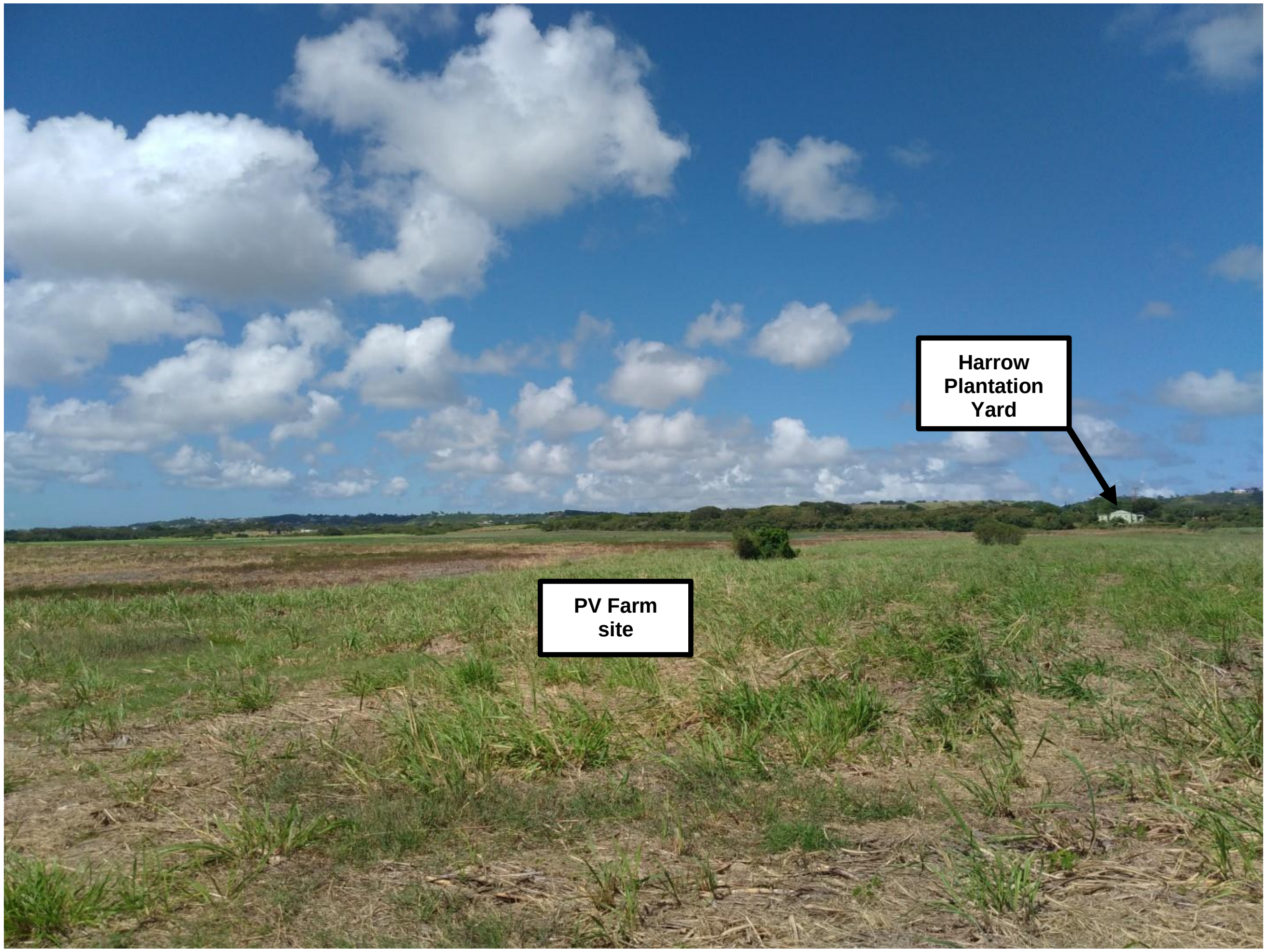

Photo 7 (P7): View from Farm Road Terrace to the Southeast of the site – looking Northwest. *(View towards PV farm site is unobstructed.)*

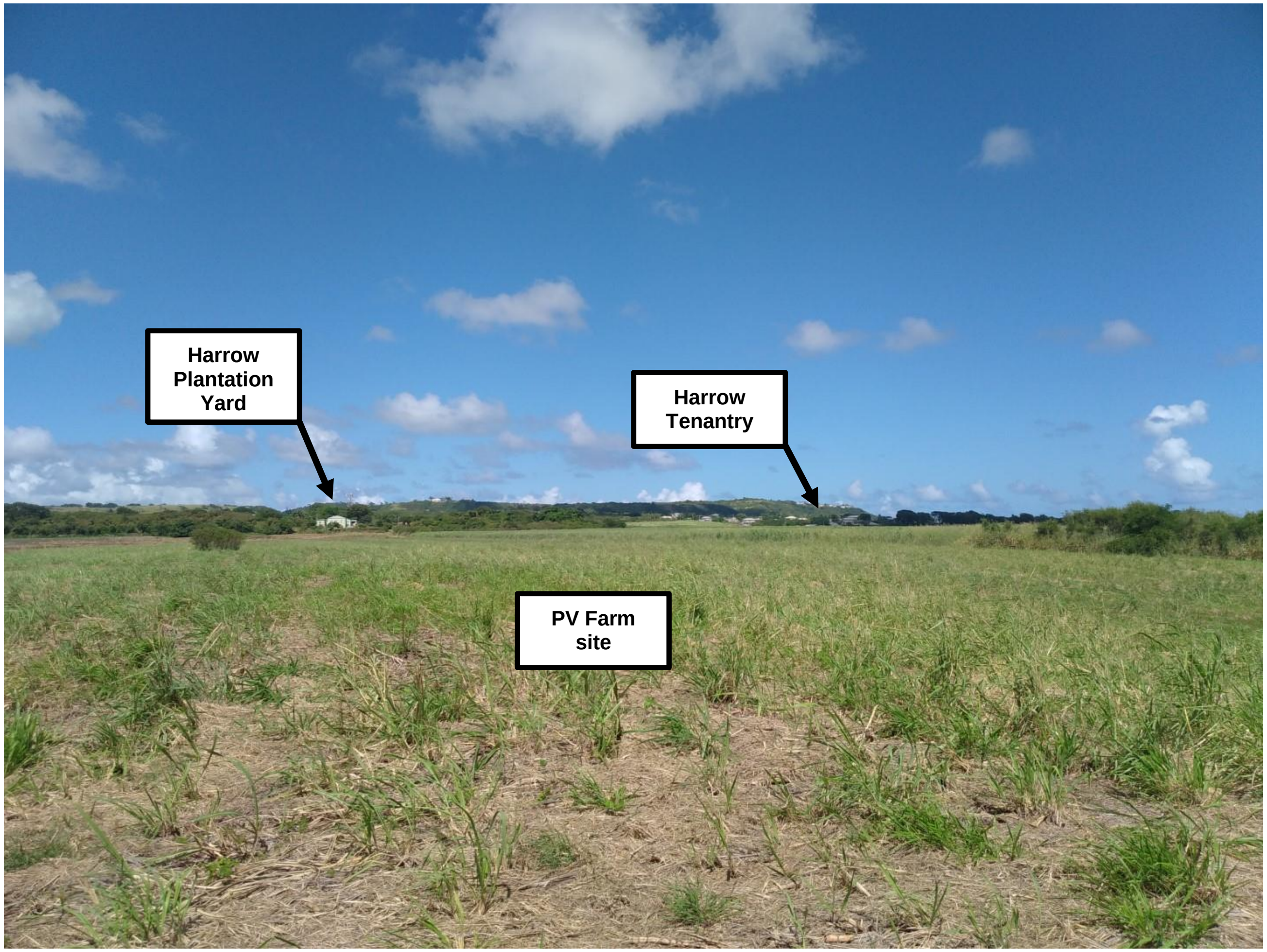

Photo 8 (P8): View from Farm Road Terrace to the Southeast of the site – looking North. *(View towards PV farm site is unobstructed.)*

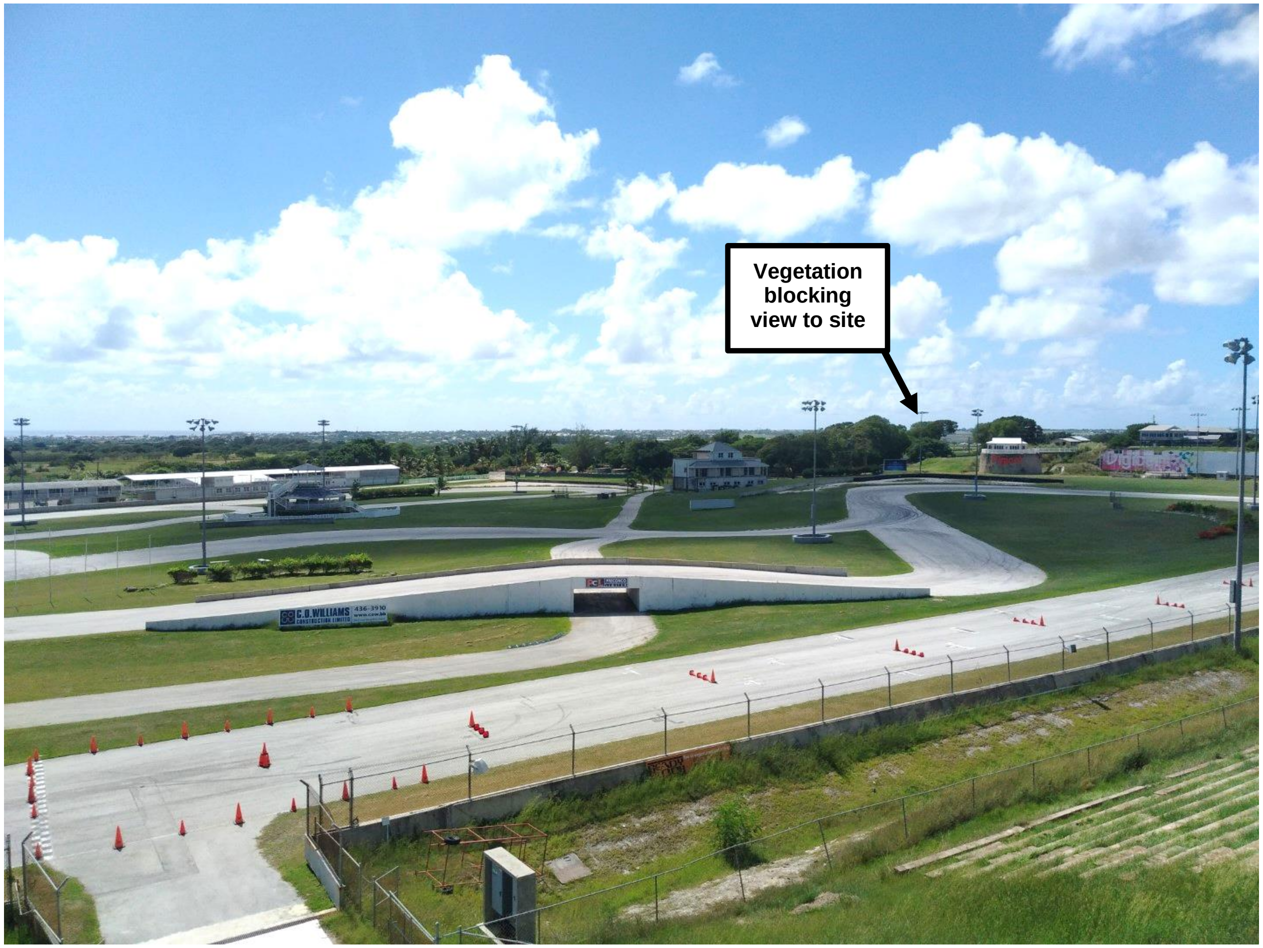

Photo 8 (P8): View from Bushy Park Spectator Stands to the Northeast of the site – looking Southwest. (*(View towards PV farm site is obstructed by an existing stand of mahogany tress and other vegetation.)*

3.0 POTENTIAL IMPACTS AND MITIGATION MEASURES

Scenario: The construction of the PV farm may result in visual impacts to nearby land users – post its construction.

Discussion

The site for the PV farm is at least partially visible from all directions. Though there are some existing screens by way of vegetation at Bushy Park and Harrow Plantation Road, these screens do not act along the entire length of boundary.

Mitigation Measures

It is recommended that a tall (minimum 3m high) and thick vegetated screen be planted (see Figure 4.0 below):

- Along the Southern boundary of the site.
- Along the Western boundary of the site.
- Along the northern site boundary from the Western edge to Harrow Plantation Yard.
- Along the site boundary from Harrow Plantation Yard to the Eastern edge.

Once erected these screens shall hide the PV farm site from ground level receptors in all directions from the site. Notwithstanding the presence of the screens the PV site will remain visible to vantage points of upper floors of buildings and from tall structures. There are several two-storey houses along the Southern boundary that may retain partial views of the site. Similarly, the spectator stands may have views of substantial areas of the site should the vegetation currently blocking those views be removed; consideration could be given to growing even taller vegetated screens.

Figure 4 – Recommended Vegetated Screening Mitigation Measures

APPENDIX H

Glint and Glare Study

Harrow Solar Photovoltaic Farm

Glint and Glare Study

January 14, 2022

Prepared for:

Renewstable (Barbados) Inc.

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Sign-off Sheet

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Prepared by ______________________________

(signature)

Reviewed by ______________________________

(signature)

Approved by ______________________________

(signature)

Table of Contents

Executive Summary

The Developer proposes the construction of a non-intermittent power plant – with power sourced from a solar array, batteries, and a hydrogen generator – all on lands located at Harrow, St. Philip. Power generated at the facility shall be sold to Barbados Light & Power Co. Ltd. The area slated for PV array development occupies a total footprint of approximately 630,000m^2 (155.7 acres). The solar farm will consist of 100,620 ground mounted panels. These 100,620 panels are expected to produce approximately 50MWp AC of renewable energy. A portion of this energy shall be used to provide electricity during the day for integration into the national power grid; another portion shall be stored and used to break down the water molecule to produce a hydrogen fuel for storage on site and use in a hydrogen power generator. A portion of the 50 MWp AC of renewable energy shall be stored in batteries; the hydrogen generator and batteries shall provide electricity to the grid during night-time hours.

Glare is generally described as direct sunlight or reflected sunlight from a surface for an extended duration. Glint is a momentary flash of light from a reflective surface, which can cause discomfort to those impacted. Solar panels are designed to absorb as much light/solar energy as possible to attain maximum efficiency; they are designed to absorb light and not reflect it. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow and steel (metal sheeted roofs, etc.). PV panels usually reflect 2% of incident sunlight.

SGHAT – a glare modelling software – was used to estimate glare at eleven (11) observation/receptor points (OPs) and four (4) route receptors (public roadways). All the selected observation points have the potential of being in direct line of sight of the solar farm depending on the state of the surrounding vegetation. The SGHAT model defines and models glare as follows:

Green	**Low Potential Hazard**: Glare present with a low potential for a temporary after-image (a lingering image of the glare in the field of view). This hazard is shown green on the glare potential plots.
Yellow	**Moderate Potential Hazard**: Glare present with the potential to leave a temporary after-image of the glare. This hazard is shown yellow on the glare potential plots.
Red	**High Potential Hazard**: Glare present with the potential for permanent eye damage if observed. This hazard is shown red on the glare potential plots.

An important limitation of the SGHAT software is that it does not take into consideration natural or artificial obstructions buildings, trees etc. between a receptor (OP) and the potential source of glare.

The results of the glint and glare study when modelled with smooth or lightly textured panels indicated potential glint and glare impacts at 9 out of 11 observation points, and 4 out of 4 observation routes. The entirety of glare predicted to result from smooth and lightly texture panels was classified as ‘yellow level’ glare. Modelling the array with deeply textured panels predicts extended periods of glare at 10 out of 11 observation points and 4 out of 4 observation routes, although at a lower intensity – ‘green level’ glare.

The configuration which predicted the least number of glare-minutes was smooth panels without ARC.

Glare is predicted to occur in the early morning after sunrise for receptors West of the array, and in the early evening before sunset for receptors East of the array.

Impacts to the receptors identified, where glare is predicted, may be less than predicted or in some cases completely eliminated due to existing partial to full obstructions within the vicinity of the receptors and site. Several receptors had a clear line of sight to a portion of the PV array, the rest were chosen based on their proximity to the proposed array or on the possibility of vegetation being cleared in the future.

The following measures are recommended to mitigate potential glare impacts where they may occur:

Pre-construction

- A tree screen of height not less than 3m (10 feet) should be constructed along the site boundaries. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors in all directions, and by extension mitigate – if not eliminate – the potential for glare impacts. The implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm.

Post construction

- Replacing offending panels with a deep textured panel – to reduce glare intensity.
- Removing the offending solar panels.

1.0 INTRODUCTION

1.1 DEVELOPMENT PROPOSAL

Renewstable (Barbados) Inc. – hereafter termed "the Developer" – proposes the construction of a non-intermittent power plant – with power sourced from a solar array, batteries, and a hydrogen generator – all on lands located at Harrow, St. Philip. Power generated at the facility shall be sold to Barbados Light & Power Co. Ltd. The area slated for PV array development occupies a total footprint of approximately 630,000m^2 (155.7 acres). The solar farm will consist of 100,620 ground mounted panels. These 100,620 panels are expected to produce approximately 50MWp AC of renewable energy. A portion of this energy shall be used to provide electricity during the day for integration into the national power grid; another portion shall be stored and used to break down the water molecule to produce a hydrogen fuel for storage on site and use in a hydrogen power generator. A portion of the 50 MWp AC of renewable energy shall be stored in batteries; the hydrogen generator and batteries shall provide electricity to the grid during night-time hours.

The specific location and site surroundings of the PV farm are shown below:

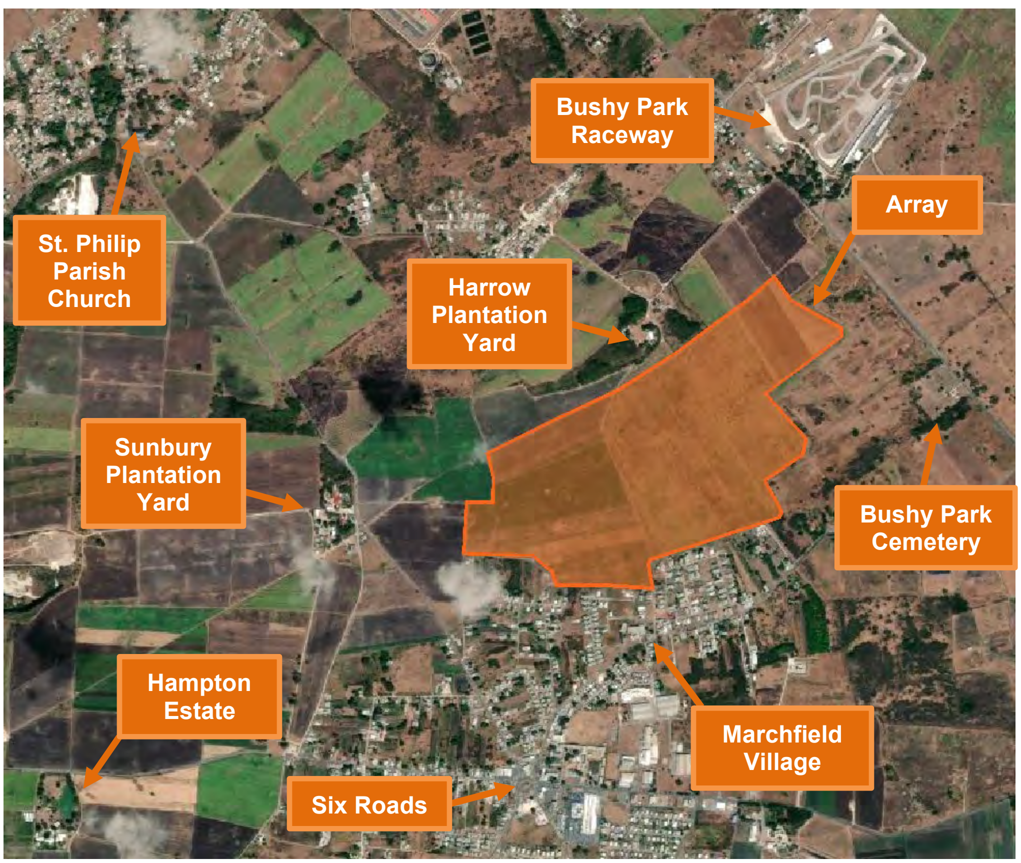


Figure 1 – Array Location and Surroundings

The PV site is located at Harrow Plantation, St. Philip. Access to the site will be provided via Harrow Road, branching off Bushy Park Road to the East and Sunbury Road to the West. The site itself is situated on agricultural land, with the immediate and expanded surroundings predominantly consisting of residential and agricultural land. Residential communities exist adjacent to the Northern and Southern project boundaries. Harrow Plantation Yard is located immediately adjacent and North of the array – West of the sheep grazing area. A small community is located adjacent and North of the sheep grazing area, and a larger community – Marchfield Village – is situated along much of the Southern boundary. A veterinary clinic is located at Sunbury Plantation some 400m West of the site. Bushy Park Raceway is located approximately 250m Northeast of the array, and Bush Park Cemetery approximately 300m to the Southeast.

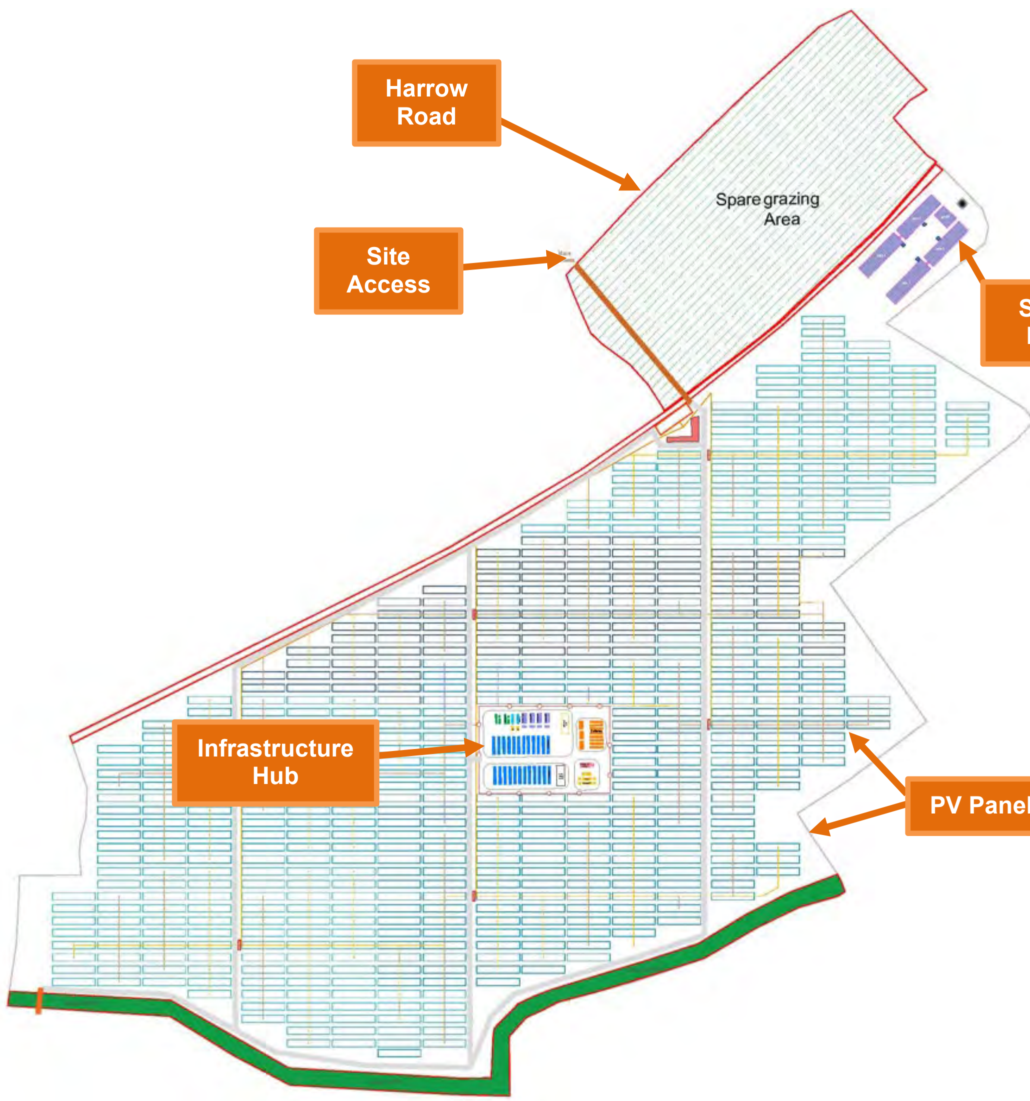


Figure 2 – Site Layout

1.2 STUDY PURPOSE

There is a concern that the development of the solar farm may result in glint and glare impacts to other adjacent and nearby land users. The purpose of this report is to assess the potential for glint and glare impacts to nearby land users, and to recommend measure(s) to mitigate these impacts.

The report continues with a description of glint and glare, its potential impacts, methodology for assessment, the presentation of results, and conclusions and recommendations.

1.3 PV PANELS

Photovoltaic panels usually consist of several layers. The top layer is typically glass with a high transmissivity and low reflectance[1] values. The glass layer is typically followed by a structural layer – usually the back sheet. The solar cells along with electrical circuitry are usually between the glass and the back sheet; they are normally bound together by encapsulating materials on the front and back of the PV cell layer. To further stabilize and protect the edges of a panel, a frame – usually made from aluminium – is used.

With respect to the top glass layer, this layer can be specially treated to lower the reflectance of the panel and improve its efficiency. An Anti-Reflective Coating (ARC) can be applied to the glass layer to increase the amount of light absorbed into the cell; the ARC can be applied to smooth or textured glass of a panel. The vast majority of glare observed by human receptors is produced when the sun is low in the sky; ARC does not appear to significantly reduce glare produced at these low angles.

Textured glass was predominantly used to reduce the reflectivity of solar panels before ARCs became more affordable. On clean surfaces textured glass improves the efficiencies of solar devices; incoming light is reflected off the raised surface of textured glass and is re-directed to other portions of the surface improving the solar energy capture efficiency. Another benefit of textured glass surfaces is that they may reduce PV panel glare intensity. Drawbacks with textured solar PV glass structures are:

- Higher cost due to the additional material required to create the textured surface
- Textured surfaces may trap dirt left behind by evaporation in the small grooves or low spots of the textured surface. That dirt can reduce the amount of transmitted energy and thus reduce the device's efficiency.

Figure 3 – Glint from Solar Farm

[1] Reflectance of the surface of a material is its effectiveness in reflecting radiant energy.

1.4 PANEL ORIENTATION, TILT AND TRACKING

Solar PV panels work best when their absorbing surface is perpendicular to the rays of the sun. As well as moving across the sky, the sun moves up and down the sky throughout a given year. Solar PV panels can be installed on two main types of systems – fixed and tracking. Tracking systems can either be single-axis trackers, where they pivot along the north-south axis and follow the sun east to west, or a dual-axis tracker, where they pivot along both the east-west and north-south axes to track the sun as it moves both across the sky.

A panel's orientation is its horizontal angle relative to North; a panel facing Southwards – for example – would have an orientation of 180 degrees from North.

The tilt of a PV panel is the angle between the panel surface and the earth's surface.

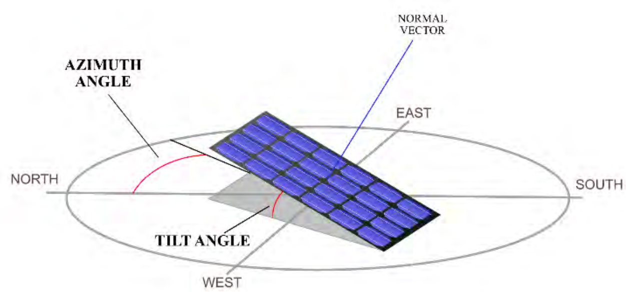


Figure 4 – Panel Orientation

1.5 GLINT AND GLARE

1.5.1 What is Glint and Glare?

Glare is generally described as direct sunlight or reflected sunlight from a surface for an extended duration. Glint is a momentary flash of light from a reflective surface, which can cause discomfort to those impacted.

Figure 5 – Glare from Panels

Reflections from a smooth surface are dependent on the angle of incidence of the light and surface conditions; as the angle of incidence increases, the amount of reflected light increases. Solar panels are designed to absorb as much light/solar energy as possible to attain maximum efficiency; they are designed to absorb light and not reflect it. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow and steel. Because of the solar panel's smooth surface, incident light is re-radiated in a specific direction, typically resulting in reflections that are considerably less than direct sunlight. It is reported that PV panels usually reflect 2% of incident sunlight[2].

The primary impact of glint and glare from solar panels is nuisance to the receptor.

[2] FAA, November 2010, Technical Guidance for Evaluating Selected Solar Technologies on Airports

1.5.2 Measures to mitigate impacts of Glint and Glare

Typical measures to mitigate glint and glare impacts from solar farms include:

- Choosing a panel with a rougher surface
- Reorienting the panels
- Shielding offending panels so they cannot be seen – via the use of screened fences or tree screens
- Changing the panel layout to reduce visibility
- Removing offending panels

2.0 GLINT AND GLARE MODELLING

2.1 GENERAL

The general objective of the modelling operation is to identify the time and day within a year when glare and glint from a solar PV farm may impact identified receptors (at select observation points).

2.2 GLARE MODELLING TOOL

A web based Solar Glare Hazard Analysis Tool (SGHAT) – developed by Sandia National Laboratories and currently licensed to ForgeSolar – was used to conduct solar glare analyses for this assignment. Most importantly, the tool provides a quantitative assessment of:

- When and where glare will occur throughout the year due to a proposed PV array
- Potential effects on the human eye at locations where glare occurs

A Google Map interface is used to position and size the PV array; information on the orientation and tilt of panels, reflectance, environment, and ocular factors – for example – can be entered by the user.

Once glare is found, SGHAT calculates the retinal irradiance and size/distance of the source of glare; the software also predicts ocular hazards ranging from temporary after-image to retinal burn.

2.3 MODEL INPUTS

Several model runs were done with different panel textures and finishes. Key data inputted into the model for the Harrow Solar farm were as follows:

- Time Zone: UTC -4
- Peak Direct Normal Irradiance[3] (DNI) – 1000 W/m^2
- PV Panel tilt – 13 degrees (fixed – no tracking)
- PV Panel orientation – 180 degrees South
- PV panel height above ground level – 600mm
- Panel material – various options (smooth glass with/without ARC; lightly textured glass with/without ARC, deeply textured glass)

2.4 OBSERVATION POINT LOCATIONS

Eleven (11) observation/receptor points and four (4) route receptors were determined based on locations where glint and glare could impact sensitive receptors. Satellite photography from Google Earth® was examined to determine the appropriate location and number of Observation Points that could possibly be affected by glint or glare emanating from the array. A field visit was then conducted to determine whether observation points could be clearly seen from the PV sites (see Photographs in Appendix 1). The Observation Points included nine residential communities in all directions around the array, a veterinary clinic located West of the array, and the spectator stands at Bushy Park Raceway to the Northeast of the array. Six of the nine residential properties are located on the project boundary. The four receptor routes are public roads traversing close to the site. The eleven (11) observation points (OPs 1 to 11) and four (4) route receptors (Routes 1 & 2) are detailed in the table below. Note that the ground elevation of the array ranges from 37m to 41m AMSL.

Table 1 – Observation Locations

Number	Latitude (deg)	Longitude (deg)	Elevation (m)	Remarks
OP1	13.130926	-59.473258	63.97	Harrow Plantation – a second-storey residence to the North of the Array
OP2	13.135241	-59.470198	66.08	Single-story residence to the Northeast of the Array
OP3	13.139399	-59.467971	69.40	Bushy Park Raceway – a spectator stands to the Northeast of the Array
OP4	13.130744	-59.456905	44.41	Second-storey residence to the East of the Array

[3] Radiant flux (power) received by a surface per unit area

Number	Latitude (deg)	Longitude (deg)	Elevation (m)	Remarks
OP5	13.125491	-59.463659	45.65	Congo Road Plantation – a single-storey residence to the Southeast of the Array
OP6	13.125210	-59.469831	49.99	Second-storey residence to the South of the Array
OP7	13.124343	-59.472310	47.58	Single-storey residence to the South of the Array
OP8	13.123371	-59.474799	46.52	Single-storey residence to the South of the Array
OP9	13.124311	-59.478747	49.32	Second-storey residence to the Southwest of the Array
OP10	13.125011	-59.481912	49.62	Eastern Veterinary Clinic – a second-storey building to the West of the Array
OP11	13.132421	-59.477747	70.34	Single-storey residence to the North of the Array
R1	Start: 13.135648 End: 13.127441	Start: -59.469339 End: -59.461789	Start: 66.95 End: 45.22	Bushy Park Road as it runs from Harrow Road in the North to Congo Road in the South
R2	Start: 13.120339 End: 13.127319	Start: -59.478393 End: -59.482565	Start: 43.36 End: 58.76	Sunbury Road as it runs from Harrow Road in the North to Marchfield Village in the South
R3	Start: 13.127435 End: 13.135568	Start: -59.482463 End: -59.469431	Start: 58.53 End: 66.79	Harrow Road as it runs from Sunbury Road in the West to Bushy Park Road in the East
R4	Start: 13.123002 End: 13.127401	Start: -59.470070 End: -59.461855	Start: 43.40 End: 45.16	Congo Road as it runs from Marchfield Village in the West to Bushy Park Road in the East

It was assumed that the height of a human receptor from ground level was 1.8m; the height from ground level to a human receptor in a second-storey building was set as 4.8m. For route receptors, it was assumed that the height of a receptor from ground level was 1.2m, and the view angle of passengers was 50 degrees.

Figure 6 – Harrow PV Point Receptors

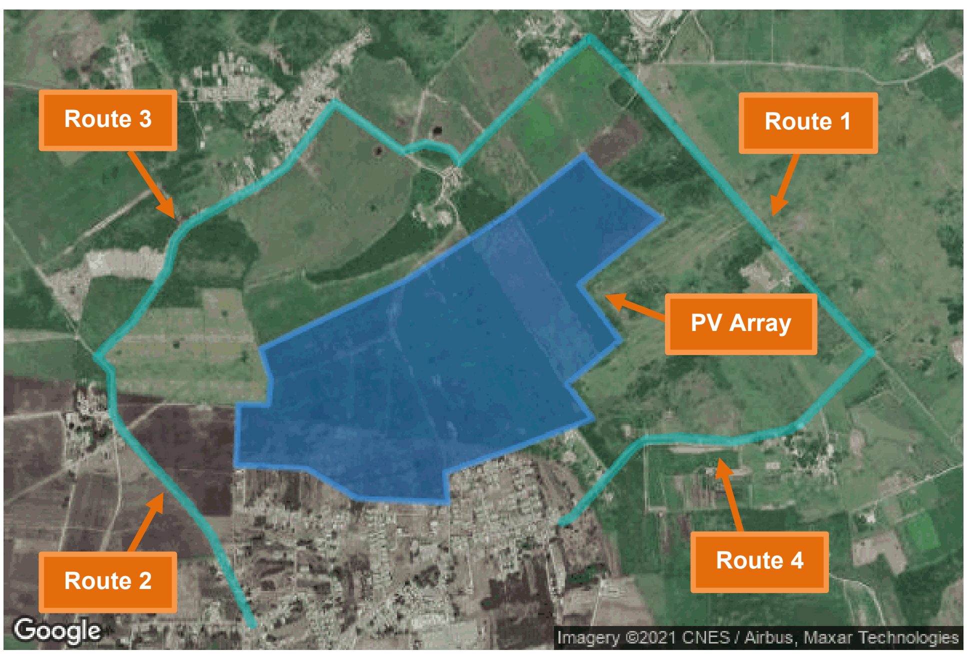


Figure 7 – Harrow PV Route Receptors

2.5 ASSUMPTIONS AND LIMITATIONS OF SGHAT

The following standard assumptions have been made through the course of the analysis; these are sourced from the SGHAT user manual[4]:

Assumptions:

- Ocular transmission coefficient[5] - 0.5
- Pupil diameter[6] – 0.002m
- Eye focal length[7] - 0.017m
- Sun subtended angle[8] – 9.3 mrad

Limitations

- Software only applies to flat reflective surfaces.
- The detailed geometry of a solar array system is not represented, such as – gaps between modules, variable height of PV arrays and support structures that may impact glare results.
- **The software does not consider man-made or natural obstacles in the path between the solar installation and observation points.**

2.6 GLARE HAZARD DEFINITIONS IN SGHAT

Three levels of ocular (eye) hazard as a result of glare are defined in SGHAT. These are as follows:

Green	**Low Potential Hazard**: Glare present with a low potential for a temporary after-image (a lingering image of the glare in the field of view). This hazard is shown green on the glare potential plots.
Yellow	**Moderate Potential Hazard**: Glare present with the potential to leave a temporary after-image of the glare. This hazard is shown yellow on the glare potential plots.
Red	**High Potential Hazard**: Glare present with the potential for permanent eye damage if observed. This hazard is shown red on the glare potential plots.

[4] Solar Glare Hazard Analysis Tool (SGHAT) User's Manual Version 3
[5] Ocular Transmission Coefficient – radiation that is absorbed in the eye before reaching the retina; value of 0.5 is typical
[6] Pupil diameter – the larger the diameter, the greater the amount of light entering the eye and reaching the retina. Typical values 0.002m for daylight adjusted eyes
[7] Eye focal length – Distance between nodal point (where ray intersects the eye) and the retina. Typical value 0.017m.
[8] Subtended angle of the sun – average subtended angle of the sun as viewed from the earth

2.7 HARROW PV SOLAR FARM MODELLING RESULTS

The SGHAT model was run a total of four times under various configurations. These configurations were as follows:

- **Config. 1:** Smooth PV panel surface with no Anti-Reflective Coating (ARC)
- **Config. 2:** Smooth PV panel surface with Anti-Reflective Coating (ARC)
- **Config. 3**: Lightly textured PV panel surface with no Anti-Reflective Coating (ARC)
- **Config. 4**: Lightly textured PV panel surface with Anti-Reflective Coating (ARC)
- **Config. 5**: Deeply textured PV panel surface with no Anti-Reflective Coating (ARC)

Modelling results are shown on the following pages.

Table 2 – Key Results

Configuration	Smooth Without ARC	Smooth With ARC	Lightly Textured Without ARC	Lightly Textured With ARC	Deeply Textured Panels
Total Annual Glare	**43,973 minutes (732.88 hours)**	**50,656 minutes (844.27 hours)**	**55,260 minutes (921 hours)**	**53,276 minutes (887.93 hours)**	**402,538 minutes (6,708.97 hours)**
OP1	4,899 minutes from late January to late November between 5:45AM and 7:00AM	5,727 minutes from early January to early December between 5:45AM and 7:00AM	6,317 minutes year-round between 5:45AM and 7:00AM	6,054 minutes year-round between 5:45AM and 7:00AM	46,230 year-round between 5:45AM and 9:00AM and between 4:00PM and 6:00PM
OP2	No glare	No glare	No glare	No glare	241 minutes from early November to late January between 5:00PM and 6:00PM
OP3	No glare	No glare	No glare	No glare	No Glare
OP4	404 minutes from early March to late April and from late August to early October between 5:30PM and 6:30PM	506 minutes from early March to late April and from late August to early October between 5:30PM and 6:30PM	568 minutes from early March to late April and from late August to early October between 5:30PM and 6:30PM	549 minutes from early March to late April and from late August to early October between 5:30PM and 6:30PM	2,931 minutes year-round between 3:45PM and 6:15PM
OP5	2,561 minutes from early March to early October between 5:15PM and 6:15PM	3,158 minutes from early March to early October between 5:00PM and 6:15PM	3,565 minutes from early March to early October between 5:00PM and 6:15PM	3,394 minutes from early March to early October between 5:15PM and 6:15PM	21,466 minutes year-round between 3:00PM and 6:15PM
OP6	11,356 minutes from late February to late October between 4:15PM and 6:15PM	12,113 minutes from late February to late October between 4:15PM and 6:15PM	12,632 minutes from late February to late October between 4:15PM and 6:15PM	12,408 minutes from late February to late October between 4:15PM and 6:15PM	74,513 minutes year-round between 6:00AM and 9:30AM and between 2:00PM and 6:30PM
OP7	5,632 minutes from late February to early October between 6:00AM and 6:45AM and between 5:00PM and 6:15PM	6,518 minutes from late February to late October between 6:00AM and 7:00AM and between 5:00PM and 6:15PM	7,132 minutes from late February to late October between 6:00AM and 7:00AM and between 5:00PM and 6:15PM	6,861 minutes from late February to late October between 6:00AM and 7:00AM and between 5:00PM and 6:15PM	60,423 minutes year-round between 5:45AM and 9:00AM and between 2:45PM and 6:30PM

Configuration	Smooth Without ARC	Smooth With ARC	Lightly Textured Without ARC	Lightly Textured With ARC	Deeply Textured Panels
OP8	4,732 minutes from late March to early September between 5:45AM and 7:00AM and between 5:00PM and 6:00PM	5,623 minutes from late March to late September between 5:45AM and 7:00AM and between 5:00PM and 6:15PM	6,237 minutes from late March to late September between 5:45AM and 7:00AM and between 5:00PM and 6:15PM	5,972 minutes from late March to late September between 5:45AM and 7:00AM and between 5:00PM and 6:15PM	47,233 minutes from late February to late October between 5:45AM and 9:00AM and between 3:00PM and 6:15PM
OP9	5,085 minutes from early March to early October between 5:45AM and 7:00AM	5,744 minutes from late February to early October between 5:45AM and 7:15AM	6,213 minutes from late February to late October between 5:45AM and 7:15AM	6,012 minutes from late February to early October between 5:45AM and 7:15AM	42,119 minutes year-round between 5:45AM and 9:30AM
OP10	1781 minutes from early March to early October between 5:45AM and 7:00AM	2,046 minutes from early March to early October between 5:45AM and 7:00AM	2,224 minutes from late February to early October between 5:45AM and 7:00AM	2,152 minutes from late February to early October between 5:45AM and 7:00AM	3,785 minutes year-round between 5:45AM and 9:00AM
OP11	428 minutes in March and from early September to early October between 5:45AM and 6:30AM	601 minutes from late February to early April and from early September to early October between 5:45AM and 6:30AM	725 minutes from late February to early April and from early September to early October between 5:45AM and 6:45AM	672 minutes from late February to early April and from early September to early October between 5:45AM and 6:30AM	13,396 minutes year-round between 5:45AM and 8:30AM
Route 1	1,709 minutes from early March to early October between 5:15PM and 6:15PM	2,014 minutes from early March to early October between 5:15PM and 6:15PM	2,180 minutes from early March to early October between 5:00PM and 6:15PM	2,124 minutes from early March to early October between 5:15PM and 6:15PM	6,381 minutes year-round between 3:15PM and 6:15PM
Route 2	600 minutes from early March to early April and from late August to early October between 5:45AM and 6:30AM	766 minutes from late February to early April and from late August to early October between 5:45AM and 6:30AM	879 minutes from late February to early April and from late August to early October between 5:45AM and 6:30AM	830 minutes from late February to early April and from late August to early October between 5:45AM and 6:30AM	8,211 minutes year-round between 5:45AM and 8:45AM
Route 3	1,802 minutes from late February to early October between 5:45AM and 6:45AM	2,250 minutes from late February to late October between 5:45AM and 6:45AM	2,574 minutes from late February to late October between 5:45AM and 6:45AM	2,416 minutes from late February to late October between 5:45AM and 6:45AM	36,367 minutes year-round between 5:45AM and 8:45AM and between 4:45PM and 6:00PM
Route 4	2,984 minutes from early March to early October between 5:00PM and 6:15PM	3,590 minutes from early March to early October between 5:00PM and 6:15PM	4,014 minutes from late February to early October between 5:00PM and 6:15PM	3,832 minutes from late February to early October between 5:00PM and 6:15PM	39,242 minutes year-round between 3:00PM and 6:15PM

Note: Green highlight denotes 'green level' glare, yellow highlight denotes 'yellow level' glare, and red highlight denotes 'red level' glare.

Key Observations

- The configuration that predicted the least number of glare-minutes was smooth panels without anti-reflective coating. Deeply textured panels are predicted to produce the most glare-minutes, although at a lesser intensity than other configurations – due to the reflective properties of these panels.
- For smooth and lightly textured panels, glare was predicted at all receptors except for OP2 (private residence to the Northeast) and OP3 (Bushy Park Raceway). Only 'yellow level' glare was predicted for smooth and lightly textured panels.
- For deeply textured panels, glare was predicted at all receptors except for OP3 (Bushy Park Raceway). Only 'green level' glare was predicted for deeply textured panels.
- For smooth and lightly textured panels, glare at receptors is predicted to occur at various times of the year in the early morning hours (between 5:45AM and 7:00AM) and in the early evening hours (between 4:15PM and 6:30PM). Two receptor points – OP7 and OP8 – are predicted to experience glare both in the morning and evening hours.
- For deeply textured panels, glare at receptors is predicted to occur year-round at all receptors excluding OP2, OP8, and OP10. Glare is predicted in the morning between 5:45AM and 9:30AM, and in the evening between 2:30PM and 6:30PM. Four receptor points – OP1, OP6, OP7, and OP8 – and one receptor route – Route 3 – are predicted to experience glare both in the morning and evening hours.
- Generally, receptors located East of the array (OP4, OP5, OP6) are predicted to experience glare just before sunset, while receptors located West of the array (OP1, OP9, OP10, OP11) are expected to experience glare just after sunrise. Receptors centrally located (OP7 and OP8) with view of the array to the East and West are predicted to experience glare both just after sunrise and just before sunset. The sun at these hours is low in the sky, providing a shallow reflective angle and allowing sunlight to reflect off the panels towards receptors.
- Sections of the Receptor Routes that bring passengers generally due East or West of the array – aligned such that the passengers face the array – are predicted to experience glare. This results in glare being predicted at specific sections of all four receptor routes.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

Land use in the environs of the proposed Harrow solar farm is mainly a mixture of residential and agricultural. Potential receptors are located in all along the site boundary, with a number of residential communities positioned along the same boundaries. Access to the future PV farm shall be provided via Harrow Road – connected to Bushy Park Road in the East and Sunbury Road in the West.

SGHAT – a glare modelling software – was used to estimate the potential glare at eleven (11) observation/receptor points and four (4) route receptors within the environs of the solar farm. Five different panel configurations were modelled – smooth panels with/without anti-reflective coating, lightly textured panels with/without anti-reflective coating, and deeply textured panels without anti-reflective coating. For smooth panels and lightly textured panels, glare was predicted at ten of eleven observation points, and all four observations routes. Smooth panels were predicted to generate less glare than lightly textured panels; ARC had a detrimental effect when applied to smooth panels and a beneficial effect when applied to lightly textured panels.

Several trends were observed from the model results regarding smooth and lightly textured panels. Receptors to the West of the farm are predicted to experience glare during the morning hours – just after sunrise – while receptors to the East of the farm are predicted to experience glare during the evening hours – just before sunset. The low angle of the sun at these hours provides an opportunity for sunlight to reflect off panels at a shallow angle and possibly affect receptors.

Deeply textured panels are predicted to produce far more glare-minutes than any other configuration, although at a lesser intensity. For smooth and lightly textured panels, glare was entirely 'yellow level' glare – with the potential to leave an after-image, while deeply textured panels produced exclusively 'green level' glare – with low potential to leave an after-image. This low-intensity glare is due to how deeply textured panels work – the deep texturing of the panel results in higher scattering of reflected light within grooves forming the textured surface thereby reducing the amount of light escaping the panel's surface. Predicted glare was most significant for receptors nearest to the farm, which are predominantly West and East of the solar array.

Impacts to the receptors identified, where glare was predicted, may be less than predicted or in some cases completely eliminated due to existing partial to full obstructions within the vicinity of the receptors and site. Although a number of receptors have clear lines of sight to sections of the array, there are quite a few who do not due to existing vegetation; the removal of vegetation would however put several of those locations within clear line of sight of the farm.

3.2 RECOMMENDATIONS

The following measures are recommended to mitigate potential glare impacts where they may occur:

3.2.1 Pre-construction

- A tree screen of height not less than 3m (10 feet) should be constructed along the site boundaries. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors in all directions, and by extension mitigate – if not eliminate – the potential for glare impacts. The implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm.

3.2.2 Post construction

If there are reports of impacts from residents or other land users near the development, then consideration should be given to the following:

- Replacing offending panels with a deep textured panel – to reduce glare intensity.
- Removing the offending solar panels.

4.0 REFERENCES

Ho, Cliffford K; Sims, Cianan A.; Yellowhair, Julius E., (Sandia National Laboratories) 2016 – Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v. 3.0

National Renewable Energy Laboratory (NREL). 2016. Analysing Glare Potential of Solar Photovoltaic Arrays. NREL/FS-6A10-67250. https://www.osti.gov/servlets/purl/1336899

APPENDICES

Appendix A

PHOTOGRAPHS

Image 1 – OP1

Image 2 – View of the Site from OP1 (facing South)

Image 3 – OP2

Image 4 – View of the site from OP2 (looking Southwest)

Image 5 – OP3

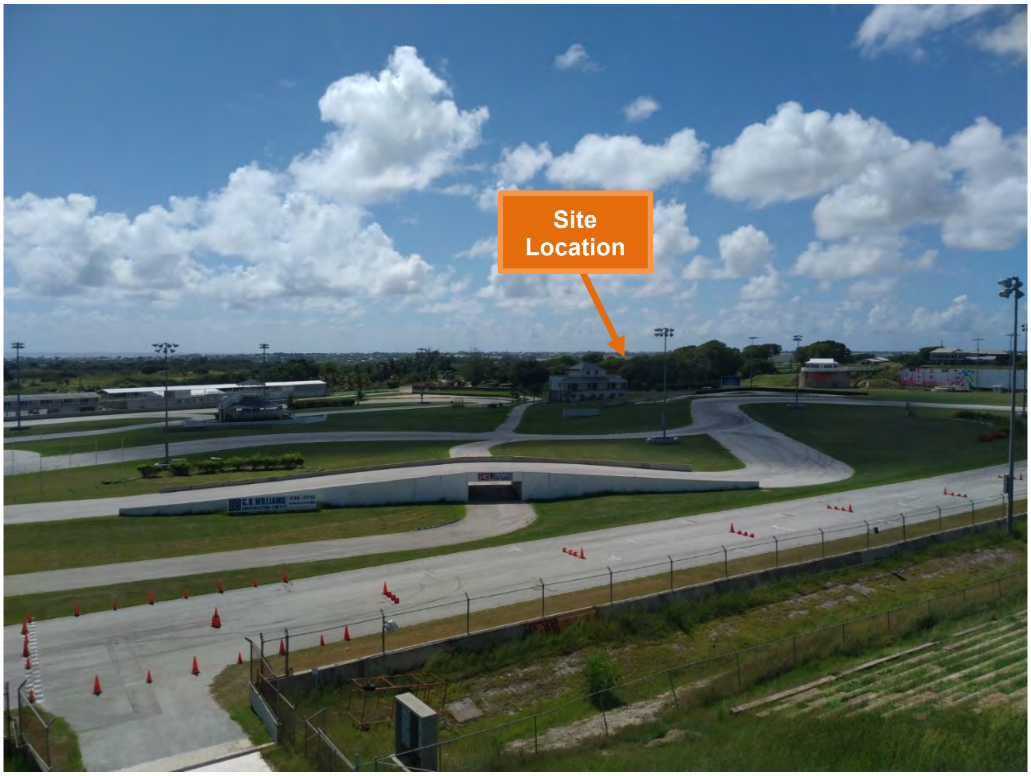


Image 6 – Obstructed view of the site from OP3 (looking Southwest)

Image 7 – OP4

Image 8 – Obstructed view of the site from OP4 (looking West)

Image 9 – OP5

Image 10 – Obstructed view of the site from OP5 (looking Northwest)

Image 11 – OP6

Image 12 – View of the site from OP6 (looking Northwest)

Image 13 – OP7

Image 14 – View of the site from OP7 (looking North)

Image 15 – OP8

Image 16 – Obstructed view of the site from OP8 (looking North)

Image 17 – OP9

Image 18 – View of the site from OP9 (looking Northeast)

Image 19 – OP10

Image 20 – Partially obstructed view of the site from OP10 (looking East)

Image 21 – OP11

Image 22 – Obstructed view of the site from OP11 (looking South)

Appendix B

SGHAT RESULTS

ForgeSolar

Harrow PV

Deeply Textured

Created Oct. 8, 2021
Updated Oct. 8, 2021
Time-step 1 minute
Timezone offset UTC-4
Site ID 59659.10542

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results Glare with low potential for temporary after-image predicted

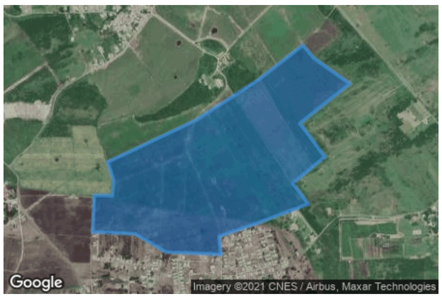
PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	13.0	180.0	402,538	0	-

Component Data

PV Array(s)

Total PV footprint area: 623,498 m^2

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 13.0 deg
Orientation: 180.0 deg
Footprint area: 623,498 m^2
Rated power: -
Panel material: Deeply textured glass
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 82.6 mrad



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.132593	-59.469503	57.47	0.60	58.07
2	13.132039	-59.469020	56.07	0.60	56.67
3	13.130921	-59.467411	54.10	0.60	54.70
4	13.129197	-59.469632	53.93	0.60	54.53
5	13.127755	-59.468516	50.68	0.60	51.28
6	13.126606	-59.469943	50.01	0.60	50.61
7	13.125697	-59.469256	50.07	0.60	50.67
8	13.124840	-59.471595	49.43	0.60	50.03
9	13.124297	-59.473215	48.75	0.60	49.35
10	13.123513	-59.473140	46.97	0.60	47.57
11	13.123618	-59.475586	48.26	0.60	48.86
12	13.124401	-59.476938	49.67	0.60	50.27
13	13.124485	-59.478837	49.82	0.60	50.42
14	13.126083	-59.478773	53.88	0.60	54.48
15	13.126073	-59.477968	54.00	0.60	54.60
16	13.126731	-59.477904	54.37	0.60	54.97
17	13.127525	-59.478172	55.99	0.60	56.59
18	13.129333	-59.474264	58.27	0.60	58.87
19	13.131115	-59.471450	59.91	0.60	60.51

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.135648	-59.469339	66.95	1.20	68.15
2	13.134467	-59.468116	58.68	1.20	59.88
3	13.129081	-59.463345	48.37	1.20	49.57
4	13.127441	-59.461789	45.22	1.20	46.42

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.120339	-59.478393	43.36	1.20	44.56
2	13.122659	-59.479487	47.07	1.20	48.27
3	13.123397	-59.480059	48.41	1.20	49.61
4	13.125341	-59.481840	50.49	1.20	51.69
5	13.125853	-59.482129	52.73	1.20	53.93
6	13.126971	-59.482194	57.75	1.20	58.95
7	13.127319	-59.482565	58.76	1.20	59.96

Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.127435	-59.482463	58.53	1.20	59.73
2	13.128250	-59.481594	57.66	1.20	58.86
3	13.129608	-59.480661	64.75	1.20	65.95
4	13.130339	-59.480489	66.49	1.20	67.69
5	13.130757	-59.480124	67.34	1.20	68.54
6	13.131877	-59.478083	69.21	1.20	70.41
7	13.132253	-59.477503	69.75	1.20	70.95
8	13.133946	-59.476184	74.28	1.20	75.48
9	13.132682	-59.474371	66.83	1.20	68.03
10	13.132880	-59.473781	66.11	1.20	67.31
11	13.132723	-59.473083	64.95	1.20	66.15
12	13.132389	-59.472836	64.60	1.20	65.80
13	13.134857	-59.470321	64.04	1.20	65.24
14	13.135568	-59.469431	66.79	1.20	67.99

Name: Route 4
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.123002	-59.470070	43.40	1.20	44.60
2	13.123164	-59.469784	43.96	1.20	45.16
3	13.124952	-59.468174	47.47	1.20	48.67
4	13.125156	-59.467837	47.29	1.20	48.49
5	13.125219	-59.466914	46.99	1.20	48.19
6	13.125109	-59.465487	46.50	1.20	47.70
7	13.125417	-59.463990	46.55	1.20	47.75
8	13.125569	-59.463706	45.61	1.20	46.81
9	13.127401	-59.461855	45.16	1.20	46.36

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.130926	-59.473258	63.97	4.80	68.77
OP 2	13.135241	-59.470198	66.08	1.80	67.88
OP 3	13.139399	-59.467971	69.40	1.80	71.20
OP 4	13.130744	-59.456905	44.41	4.80	49.21
OP 5	13.125491	-59.463659	45.65	4.80	50.45
OP 6	13.125210	-59.469831	49.99	4.80	54.79
OP 7	13.124343	-59.472310	47.58	1.80	49.38
OP 8	13.123371	-59.474799	46.52	1.80	48.32
OP 9	13.124311	-59.478747	49.32	4.80	54.12
OP 10	13.125011	-59.481912	49.62	4.80	54.42
OP 11	13.132421	-59.477747	70.34	1.80	72.14

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	13.0	180.0	402,538	0	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	6276	6451	8484	9513	11343	11881	11813	10392	8683	7572	6261	6052
pv-array-1 (yellow)	0	0	0	0	0	0	0	0	0	0	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

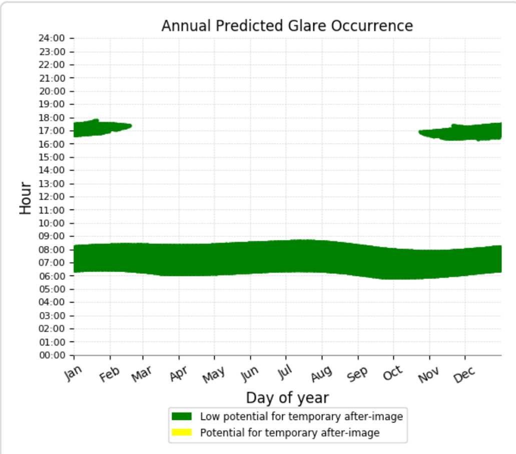
PV array 1 low potential for temporary after-image

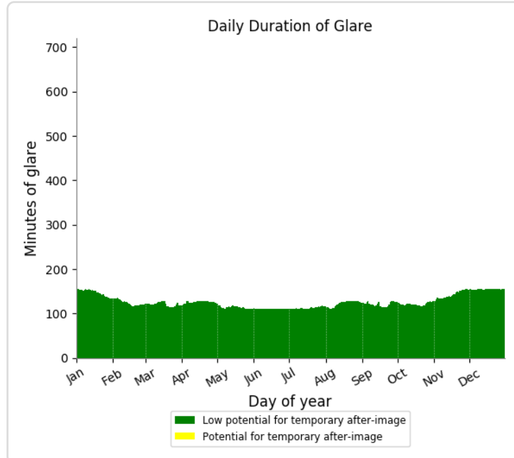
Component	Green glare (min)	Yellow glare (min)
OP: OP 1	46230	0
OP: OP 2	241	0
OP: OP 3	0	0
OP: OP 4	2931	0
OP: OP 5	21466	0
OP: OP 6	74513	0
OP: OP 7	60423	0
OP: OP 8	47233	0
OP: OP 9	42119	0
OP: OP 10	3785	0
OP: OP 11	13396	0
Route: Route 1	6381	0
Route: Route 2	8211	0
Route: Route 3	36367	0
Route: Route 4	39242	0

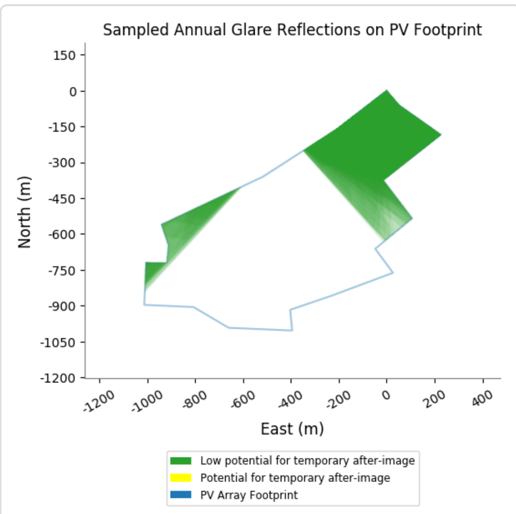
PV array 1 - OP Receptor (OP 1)

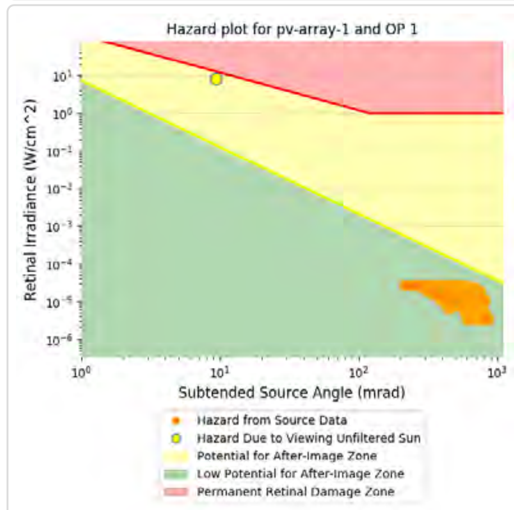
PV array is expected to produce the following glare for receptors at this location:

- 46,230 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





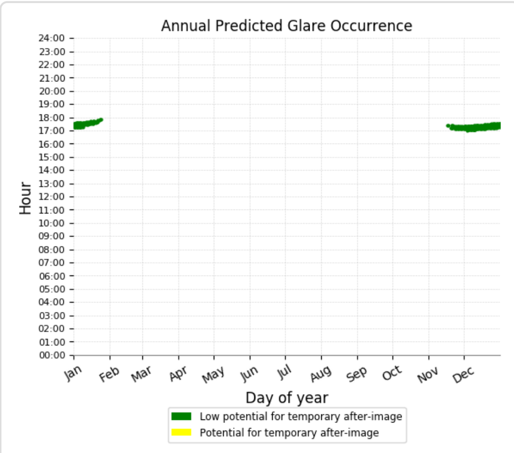


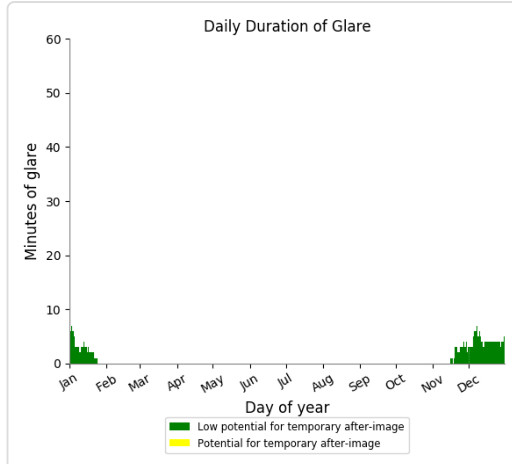


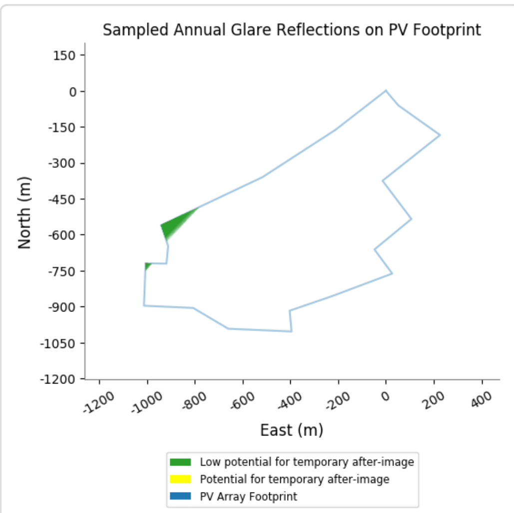
PV array 1 - OP Receptor (OP 2)

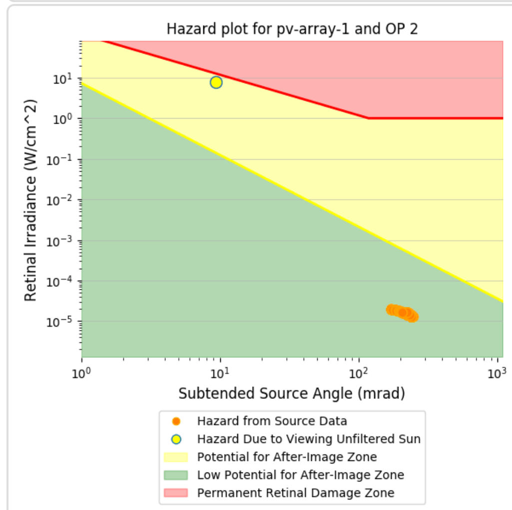
PV array is expected to produce the following glare for receptors at this location:

- 241 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









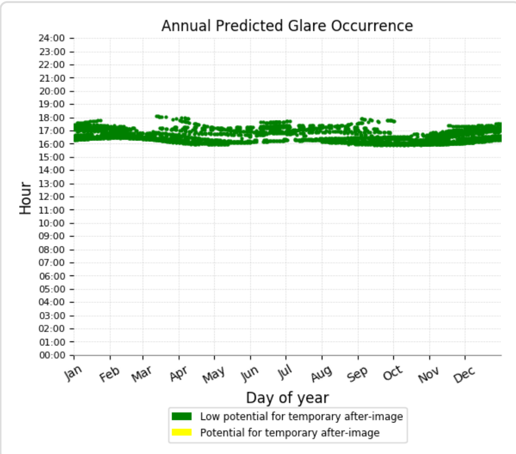
PV array 1 - OP Receptor (OP 3)

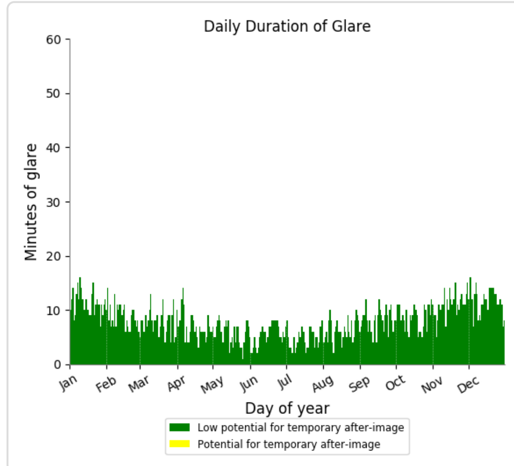
No glare found

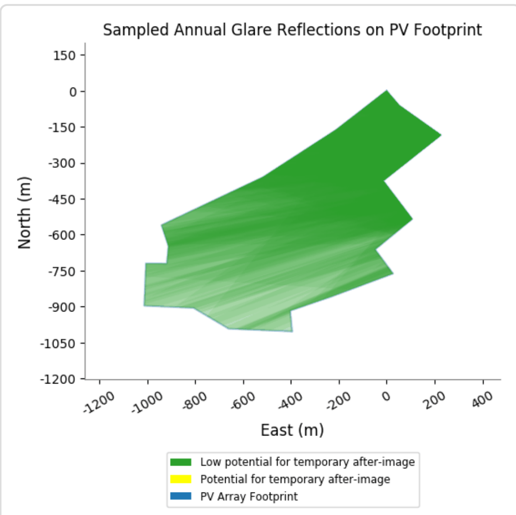
PV array 1 - OP Receptor (OP 4)

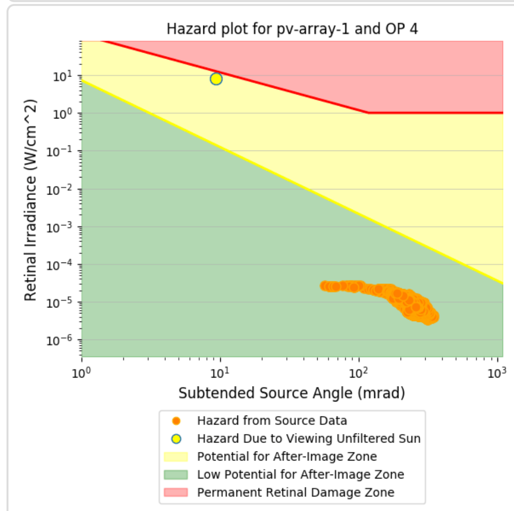
PV array is expected to produce the following glare for receptors at this location:

- 2,931 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





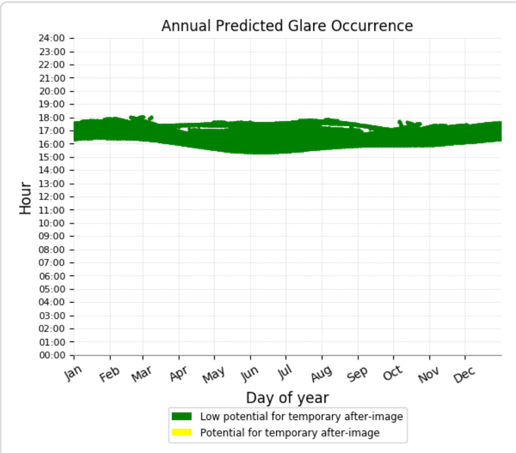


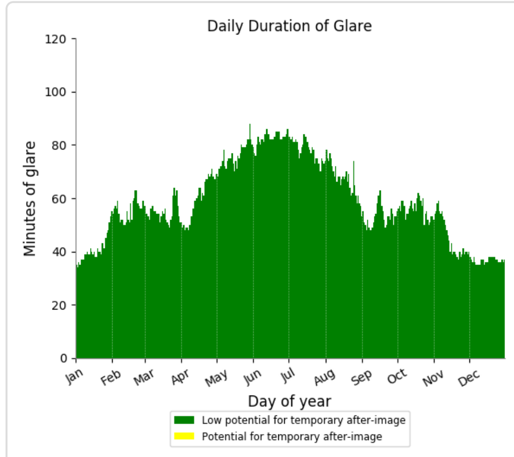


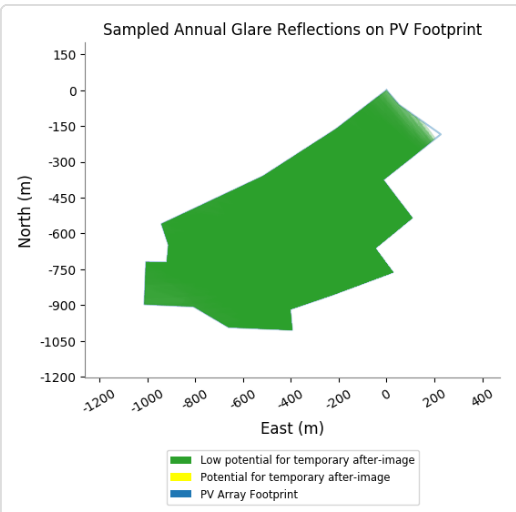
PV array 1 - OP Receptor (OP 5)

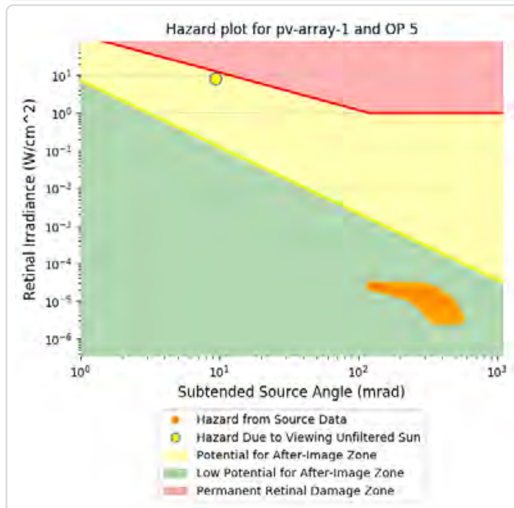
PV array is expected to produce the following glare for receptors at this location:

- 21,466 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





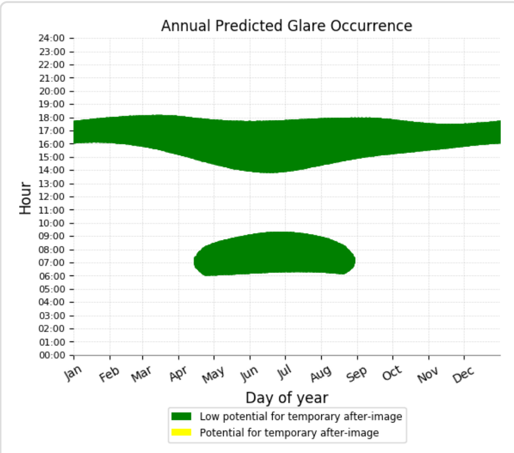


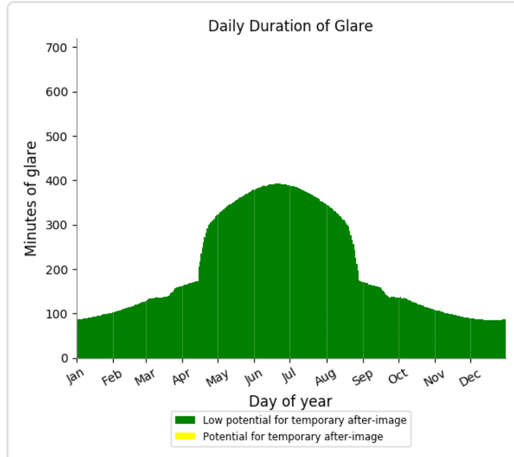


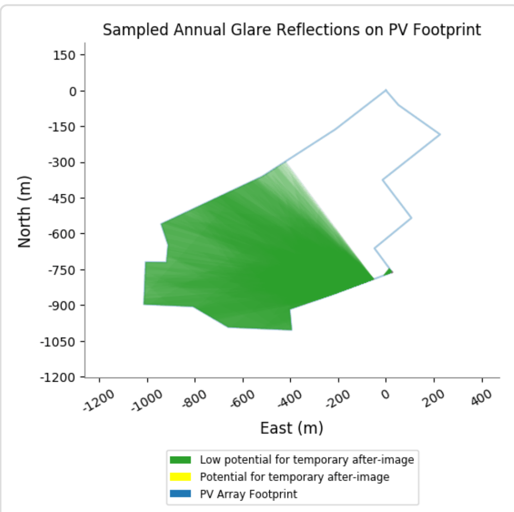
PV array 1 - OP Receptor (OP 6)

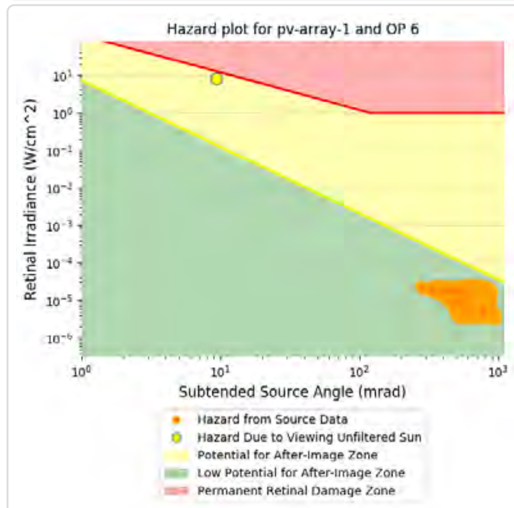
PV array is expected to produce the following glare for receptors at this location:

- 74,513 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





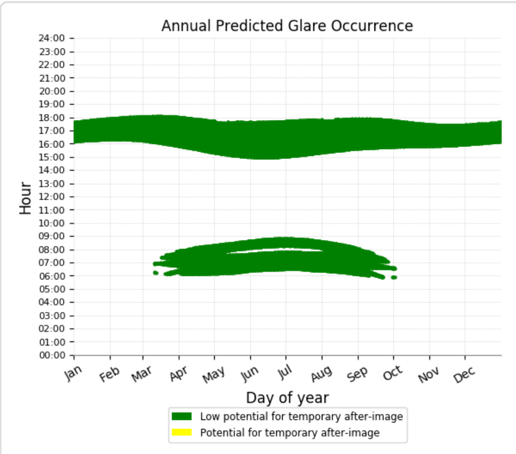


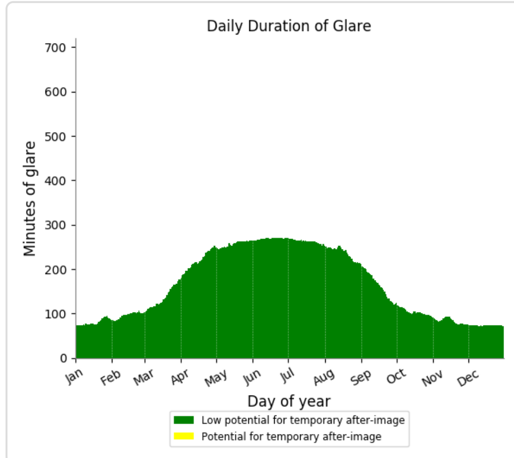


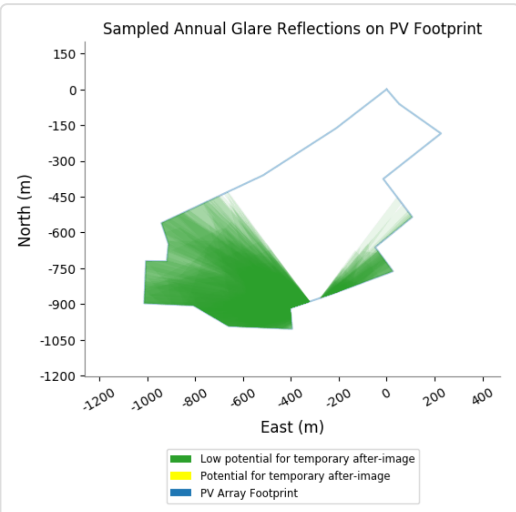
PV array 1 - OP Receptor (OP 7)

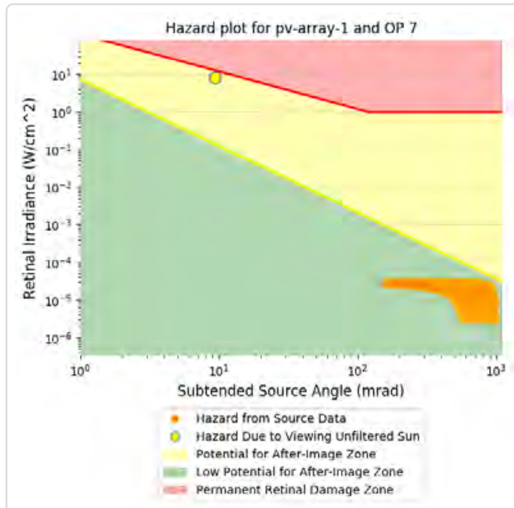
PV array is expected to produce the following glare for receptors at this location:

- 60,423 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





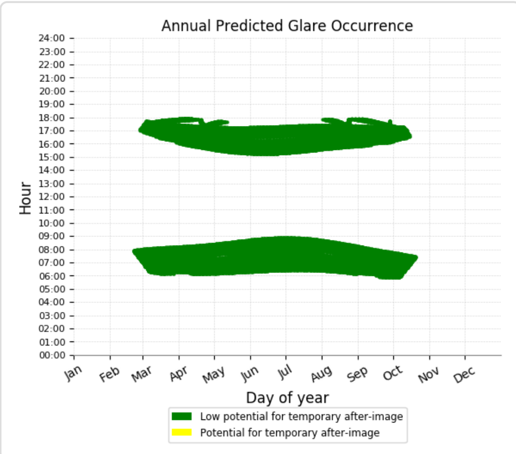


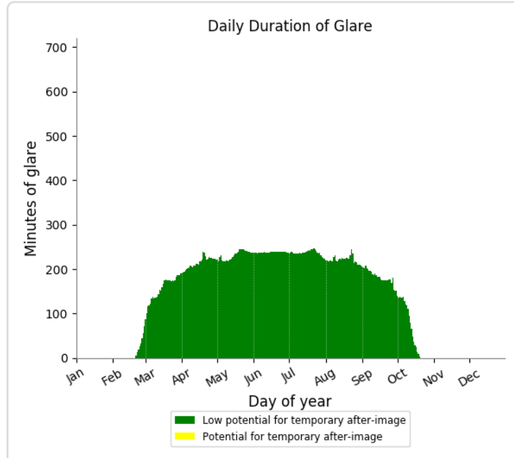


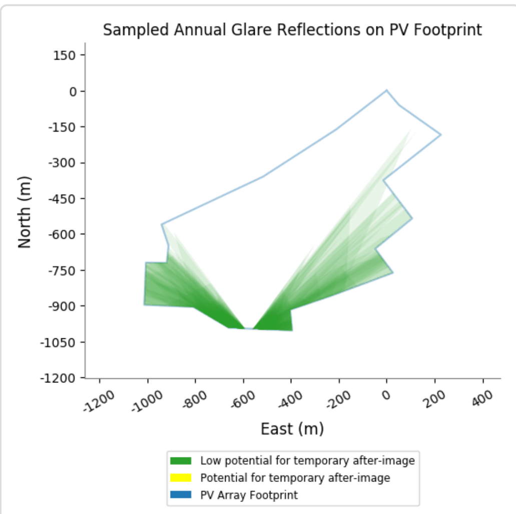
PV array 1 - OP Receptor (OP 8)

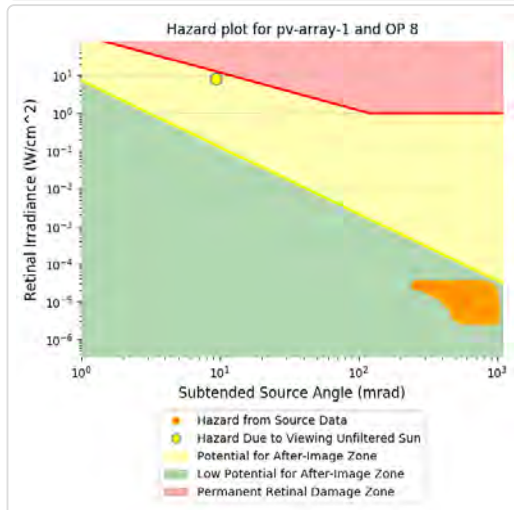
PV array is expected to produce the following glare for receptors at this location:

- 47,233 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





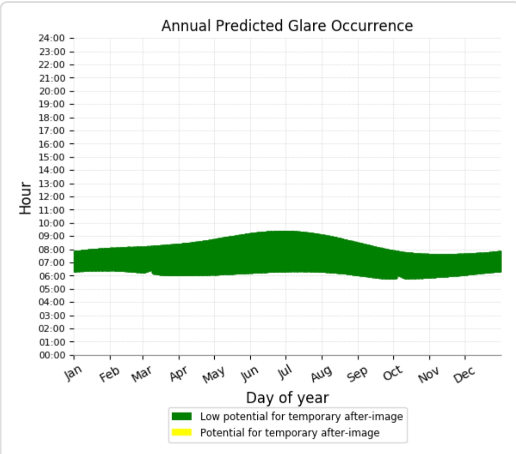


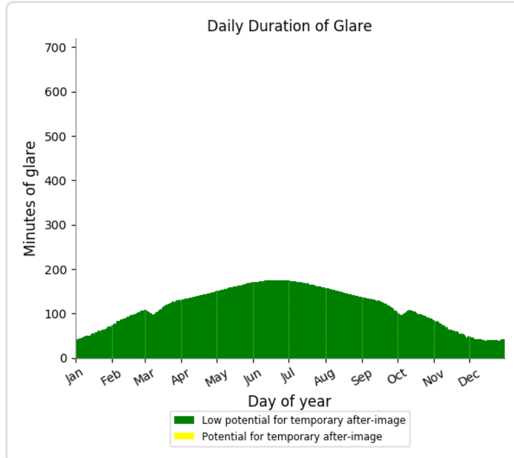


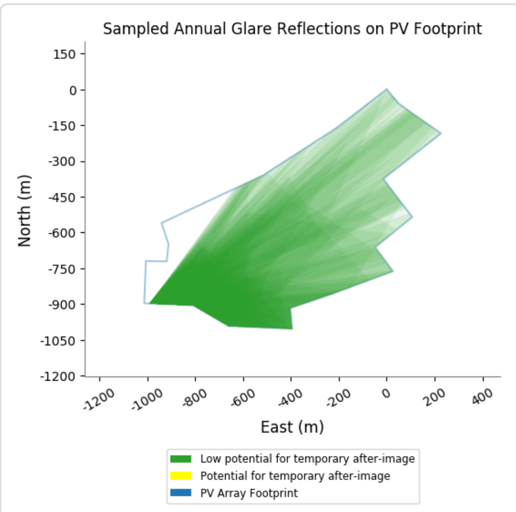
PV array 1 - OP Receptor (OP 9)

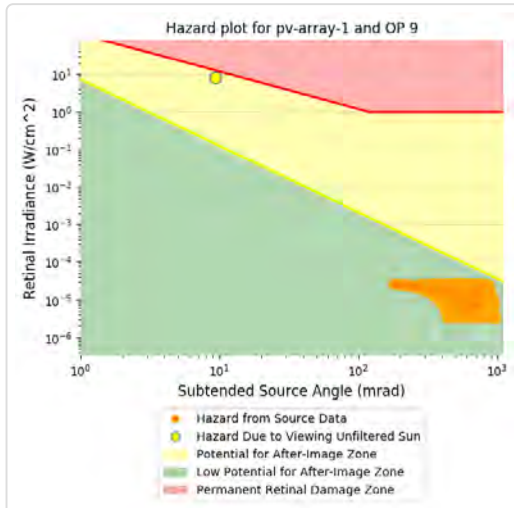
PV array is expected to produce the following glare for receptors at this location:

- 42,119 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





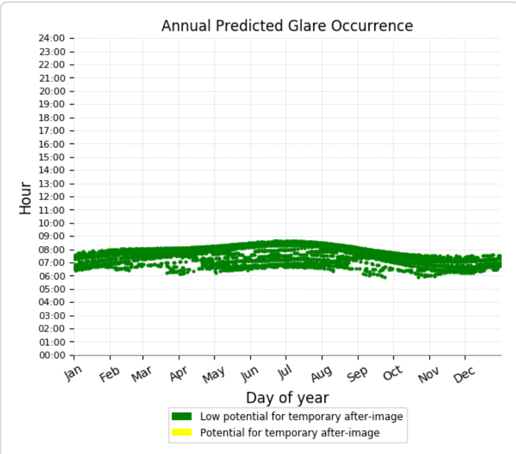


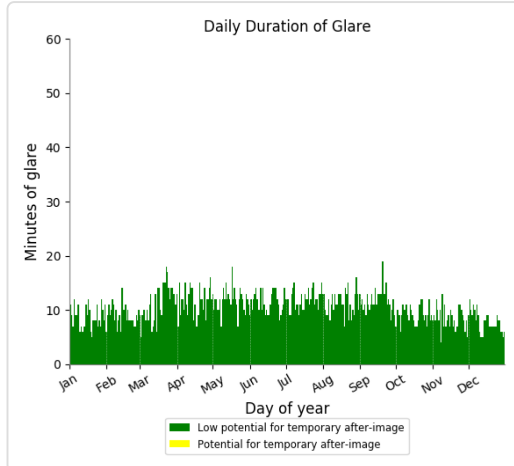


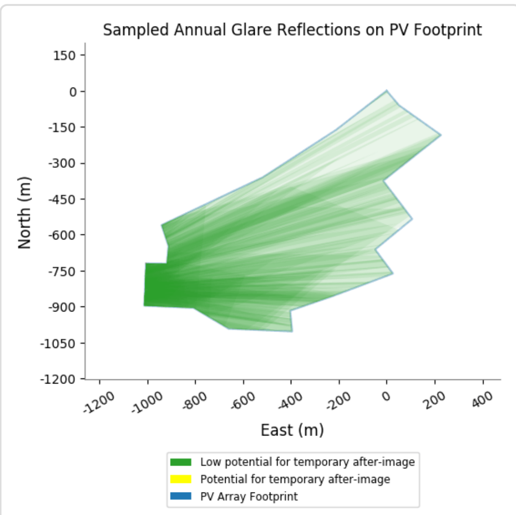
PV array 1 - OP Receptor (OP 10)

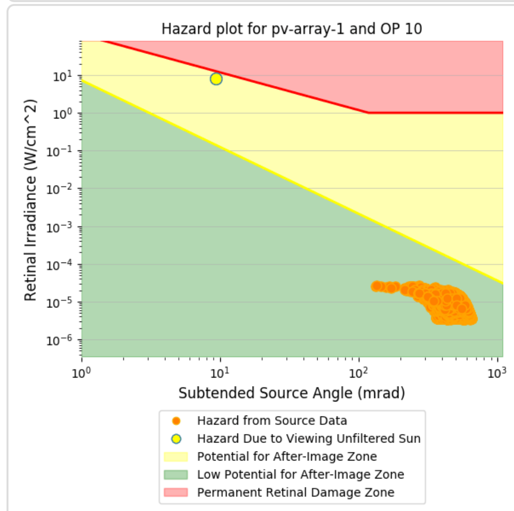
PV array is expected to produce the following glare for receptors at this location:

- 3,785 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





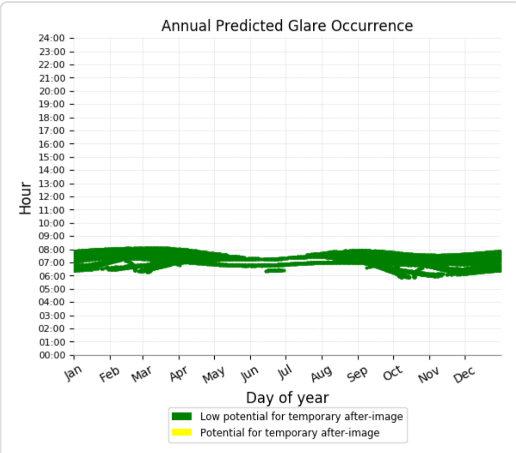


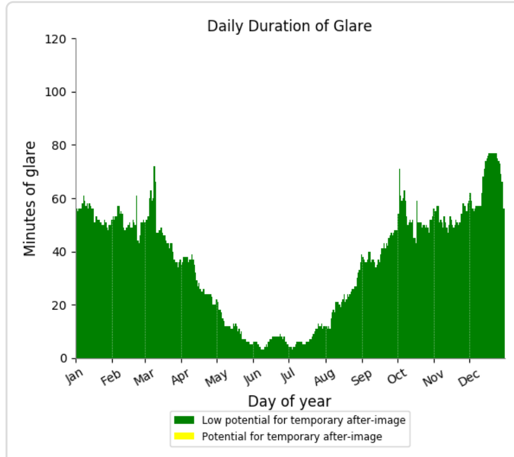


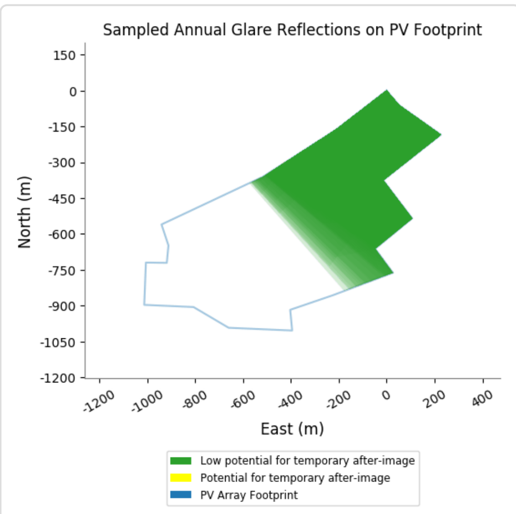
PV array 1 - OP Receptor (OP 11)

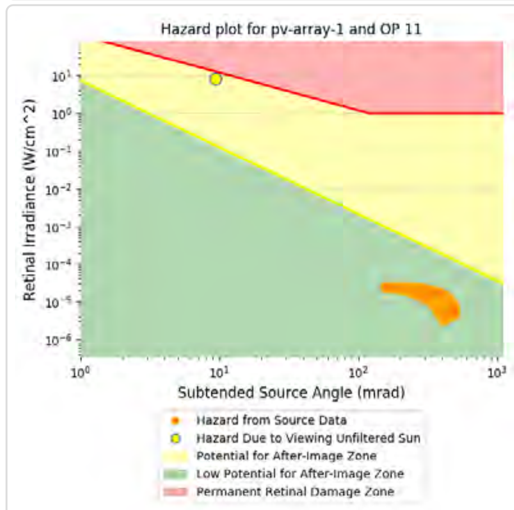
PV array is expected to produce the following glare for receptors at this location:

- 13,396 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





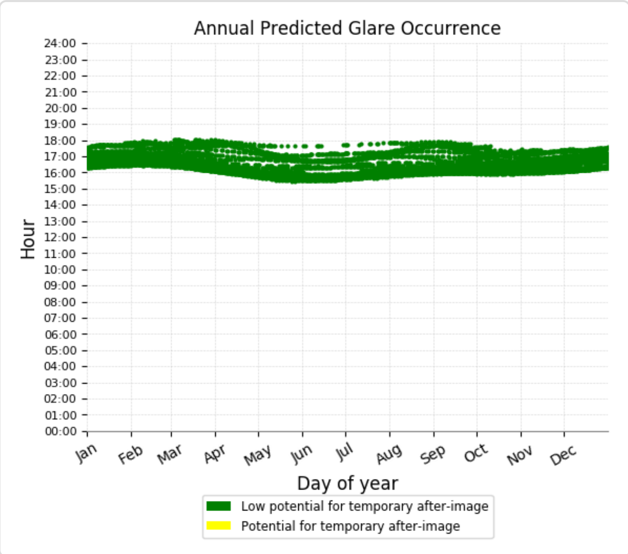


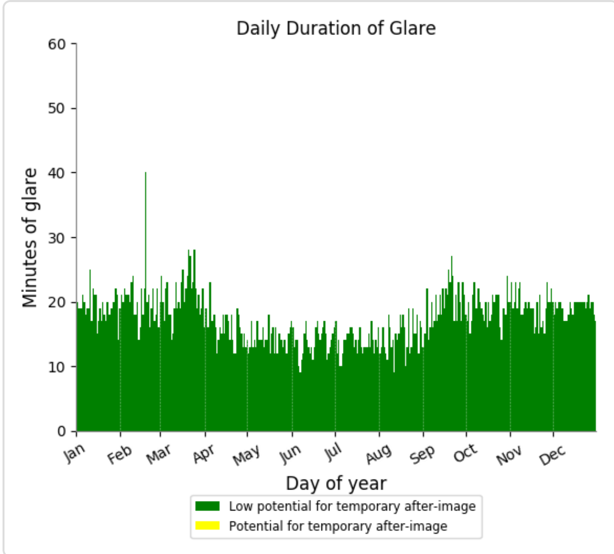


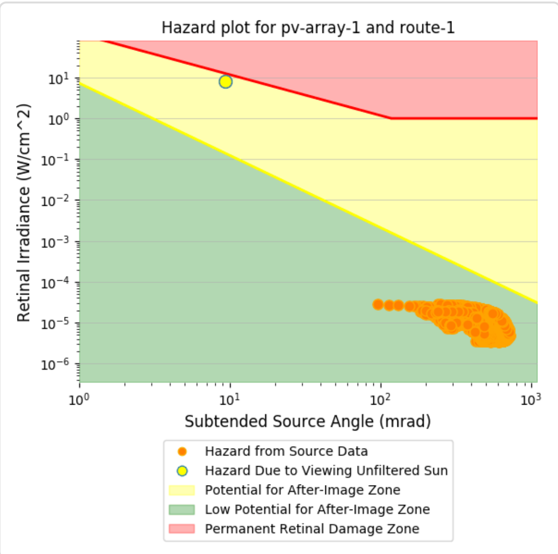
PV array 1 - Route Receptor (Route 1)

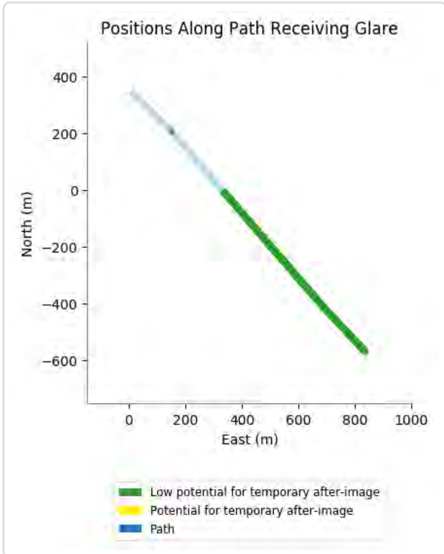
PV array is expected to produce the following glare for receptors at this location:

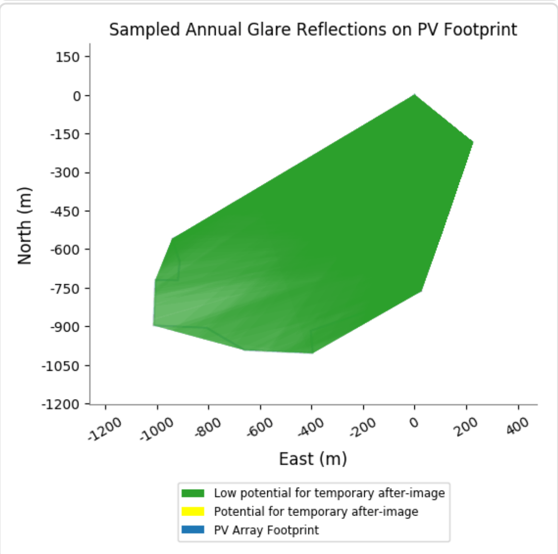
- 6,381 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







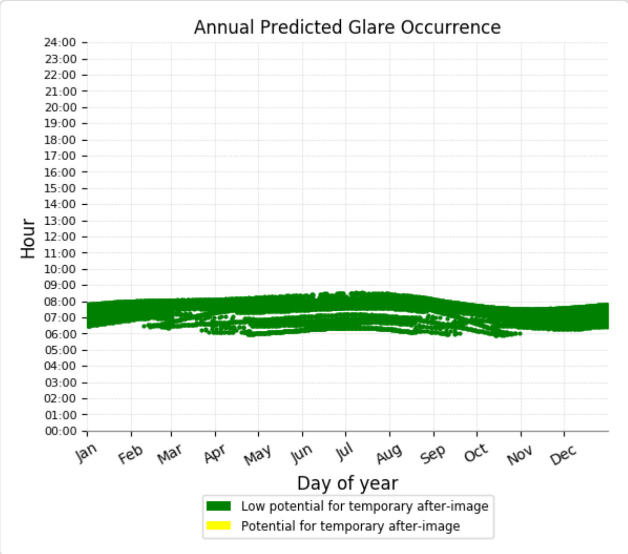


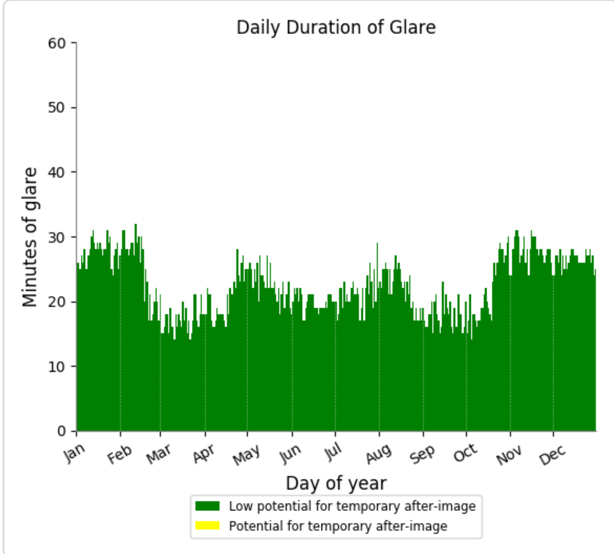


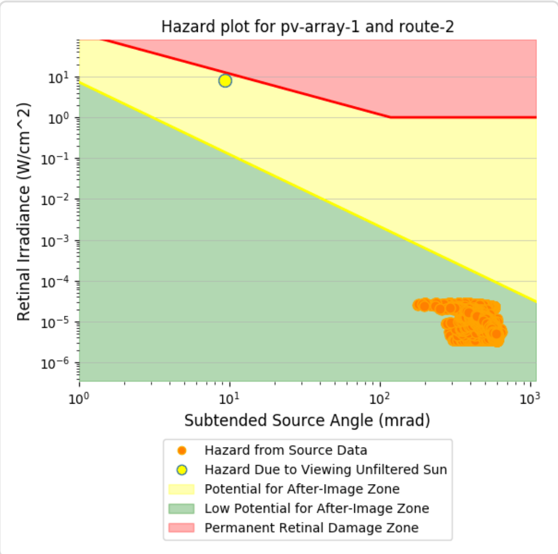
PV array 1 - Route Receptor (Route 2)

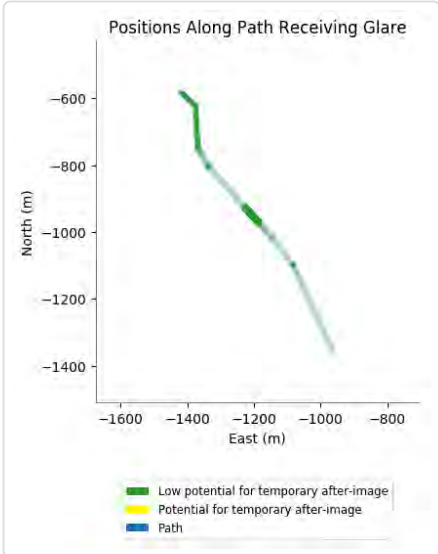
PV array is expected to produce the following glare for receptors at this location:

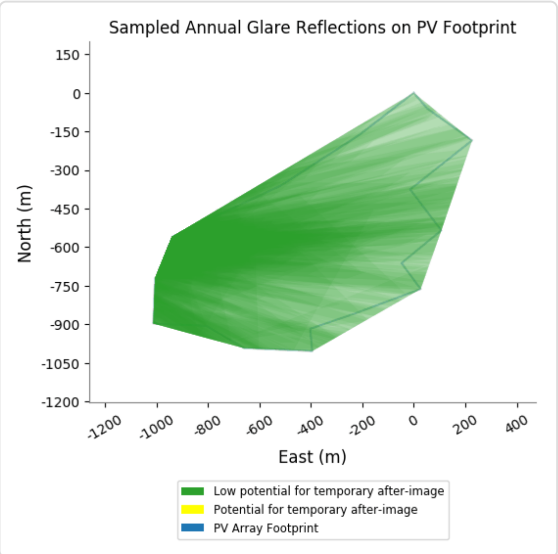
- 8,211 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







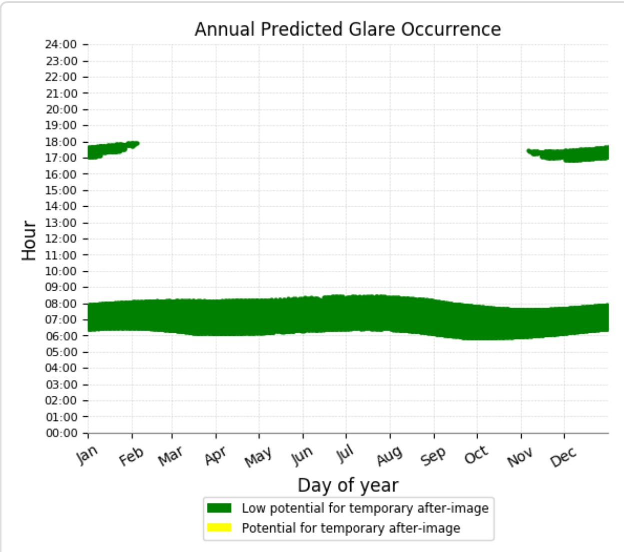


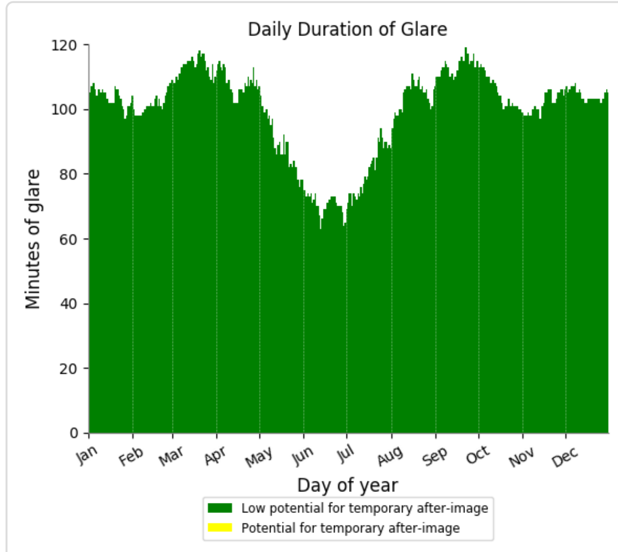


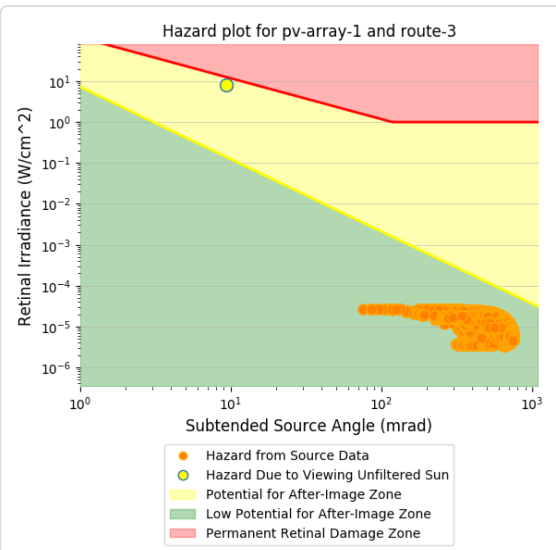
PV array 1 - Route Receptor (Route 3)

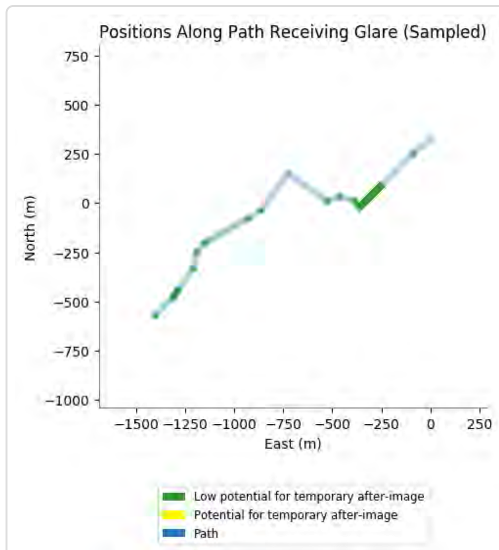
PV array is expected to produce the following glare for receptors at this location:

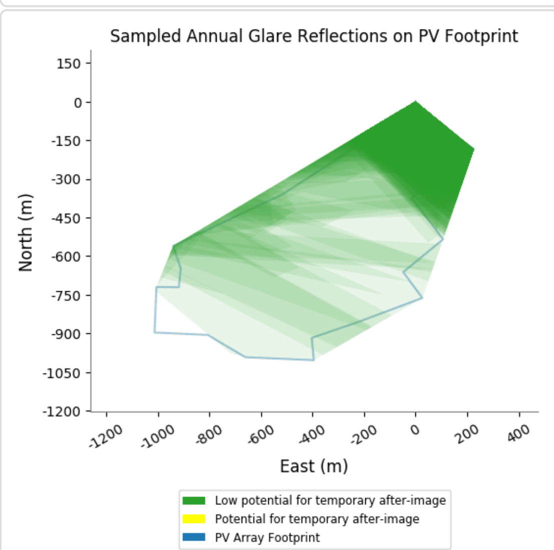
- 36,367 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







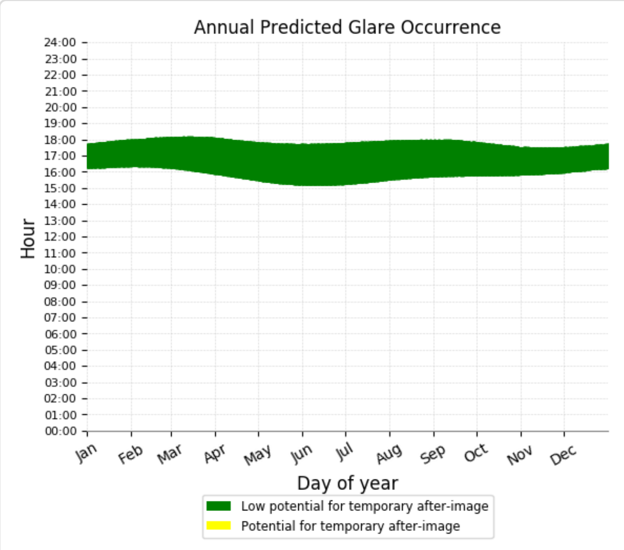


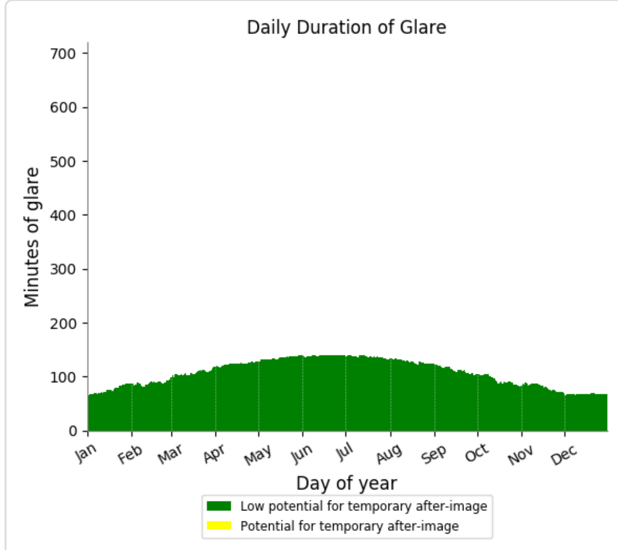


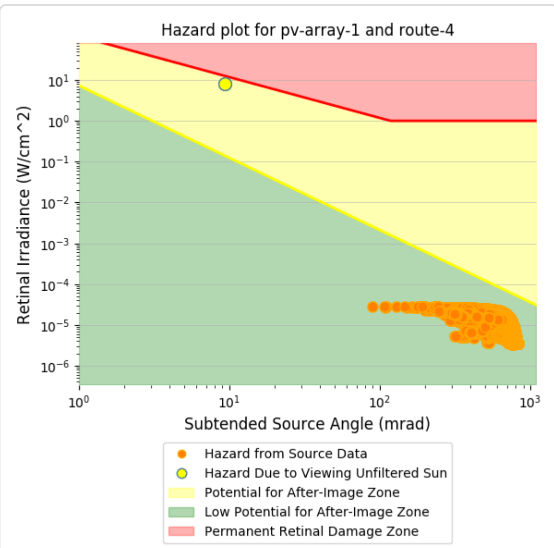
PV array 1 - Route Receptor (Route 4)

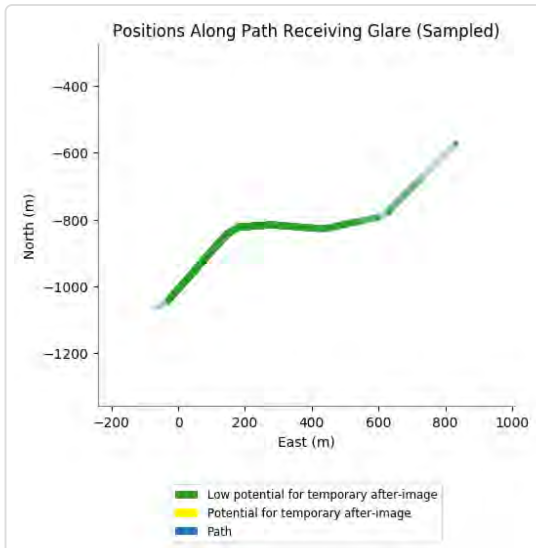
PV array is expected to produce the following glare for receptors at this location:

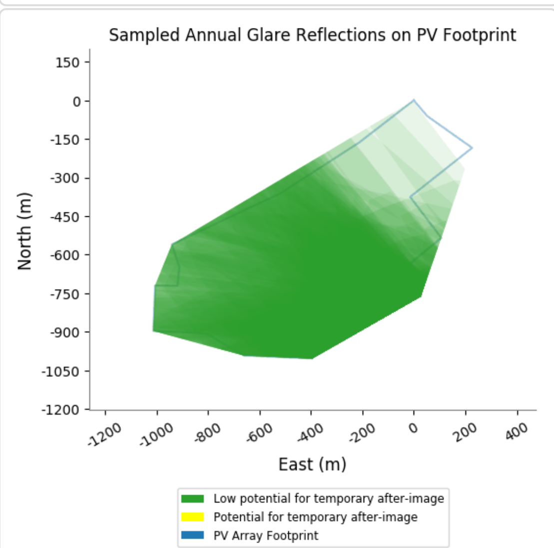
- 39,242 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Harrow PV

Smooth with ARC

Created Oct. 8, 2021
Updated Oct. 8, 2021
Time-step 1 minute
Timezone offset UTC-4
Site ID 59654.10542

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results Glare with potential for temporary after-image predicted

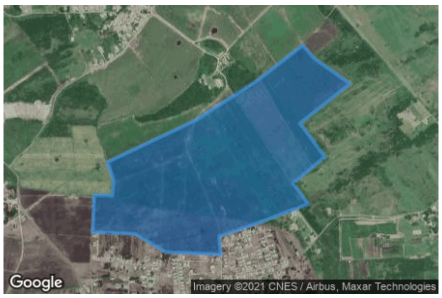
PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	13.0	180.0	0	50,656	-

Component Data

PV Array(s)

Total PV footprint area: 623,498 m^2

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 13.0 deg
Orientation: 180.0 deg
Footprint area: 623,498 m^2
Rated power: -
Panel material: Smooth glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 8.43 mrad



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.132593	-59.469503	57.47	0.60	58.07
2	13.132039	-59.469020	56.07	0.60	56.67
3	13.130921	-59.467411	54.10	0.60	54.70
4	13.129197	-59.469632	53.93	0.60	54.53
5	13.127755	-59.468516	50.68	0.60	51.28
6	13.126606	-59.469943	50.01	0.60	50.61
7	13.125697	-59.469256	50.07	0.60	50.67
8	13.124840	-59.471595	49.43	0.60	50.03
9	13.124297	-59.473215	48.75	0.60	49.35
10	13.123513	-59.473140	46.97	0.60	47.57
11	13.123618	-59.475586	48.26	0.60	48.86
12	13.124401	-59.476938	49.67	0.60	50.27
13	13.124485	-59.478837	49.82	0.60	50.42
14	13.126083	-59.478773	53.88	0.60	54.48
15	13.126073	-59.477968	54.00	0.60	54.60
16	13.126731	-59.477904	54.37	0.60	54.97
17	13.127525	-59.478172	55.99	0.60	56.59
18	13.129333	-59.474264	58.27	0.60	58.87
19	13.131115	-59.471450	59.91	0.60	60.51

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.135648	-59.469339	66.95	1.20	68.15
2	13.134467	-59.468116	58.68	1.20	59.88
3	13.129081	-59.463345	48.37	1.20	49.57
4	13.127441	-59.461789	45.22	1.20	46.42

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.120339	-59.478393	43.36	1.20	44.56
2	13.122659	-59.479487	47.07	1.20	48.27
3	13.123397	-59.480059	48.41	1.20	49.61
4	13.125341	-59.481840	50.49	1.20	51.69
5	13.125853	-59.482129	52.73	1.20	53.93
6	13.126971	-59.482194	57.75	1.20	58.95
7	13.127319	-59.482565	58.76	1.20	59.96

Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.127435	-59.482463	58.53	1.20	59.73
2	13.128250	-59.481594	57.66	1.20	58.86
3	13.129608	-59.480661	64.75	1.20	65.95
4	13.130339	-59.480489	66.49	1.20	67.69
5	13.130757	-59.480124	67.34	1.20	68.54
6	13.131877	-59.478083	69.21	1.20	70.41
7	13.132253	-59.477503	69.75	1.20	70.95
8	13.133946	-59.476184	74.28	1.20	75.48
9	13.132682	-59.474371	66.83	1.20	68.03
10	13.132880	-59.473781	66.11	1.20	67.31
11	13.132723	-59.473083	64.95	1.20	66.15
12	13.132389	-59.472836	64.60	1.20	65.80
13	13.134857	-59.470321	64.04	1.20	65.24
14	13.135568	-59.469431	66.79	1.20	67.99

Name: Route 4
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.123002	-59.470070	43.40	1.20	44.60
2	13.123164	-59.469784	43.96	1.20	45.16
3	13.124952	-59.468174	47.47	1.20	48.67
4	13.125156	-59.467837	47.29	1.20	48.49
5	13.125219	-59.466914	46.99	1.20	48.19
6	13.125109	-59.465487	46.50	1.20	47.70
7	13.125417	-59.463990	46.55	1.20	47.75
8	13.125569	-59.463706	45.61	1.20	46.81
9	13.127401	-59.461855	45.16	1.20	46.36

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	13.130926	-59.473258	63.97	4.80	68.77
OP 2	13.135241	-59.470198	66.08	1.80	67.88
OP 3	13.139399	-59.467971	69.40	1.80	71.20
OP 4	13.130744	-59.456905	44.41	4.80	49.21
OP 5	13.125491	-59.463659	45.65	4.80	50.45
OP 6	13.125210	-59.469831	49.99	4.80	54.79
OP 7	13.124343	-59.472310	47.58	1.80	49.38
OP 8	13.123371	-59.474799	46.52	1.80	48.32
OP 9	13.124311	-59.478747	49.32	4.80	54.12
OP 10	13.125011	-59.481912	49.62	4.80	54.42
OP 11	13.132421	-59.477747	70.34	1.80	72.14

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	13.0	180.0	0	50,656	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	39	394	1705	2351	3045	3272	3227	2634	2008	799	95	0

PV & Receptor Analysis Results

Results for each PV array and receptor

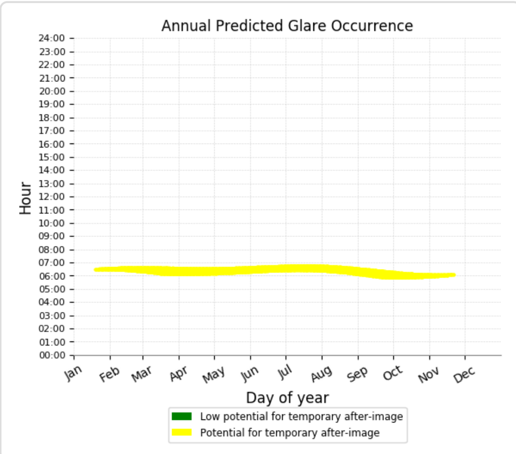
PV array 1 potential temporary after-image

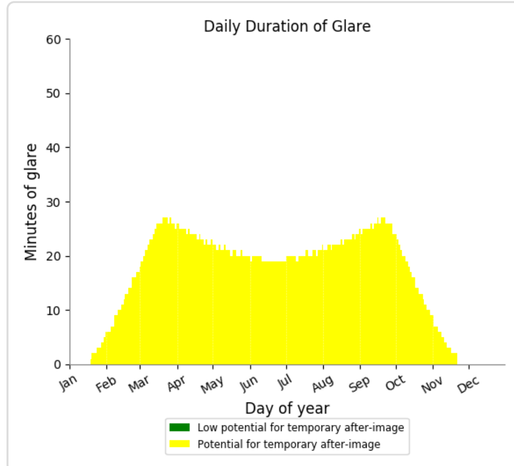
Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	5727
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	506
OP: OP 5	0	3158
OP: OP 6	0	12113
OP: OP 7	0	6518
OP: OP 8	0	5623
OP: OP 9	0	5744
OP: OP 10	0	2046
OP: OP 11	0	601
Route: Route 1	0	2014
Route: Route 2	0	766
Route: Route 3	0	2250
Route: Route 4	0	3590

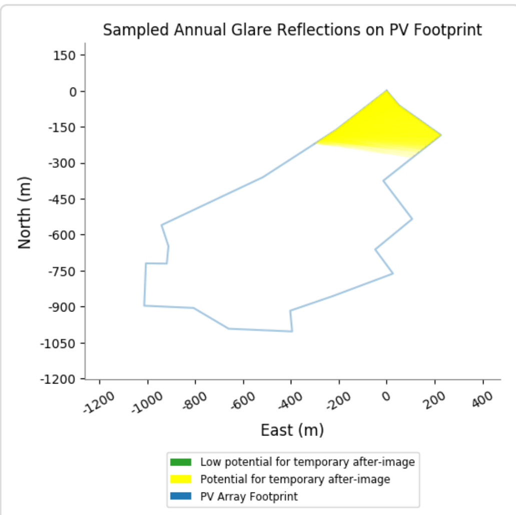
PV array 1 - OP Receptor (OP 1)

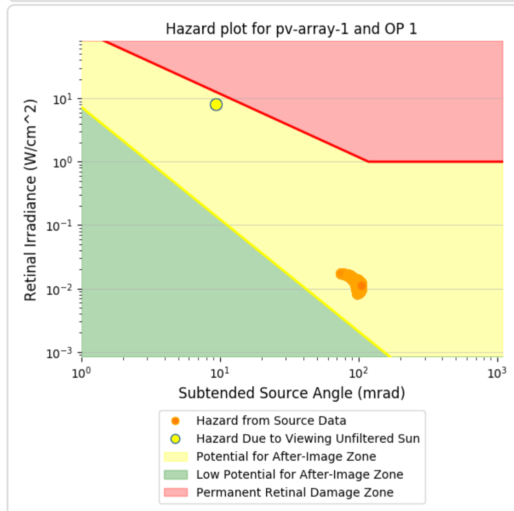
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,727 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - OP Receptor (OP 2)

No glare found

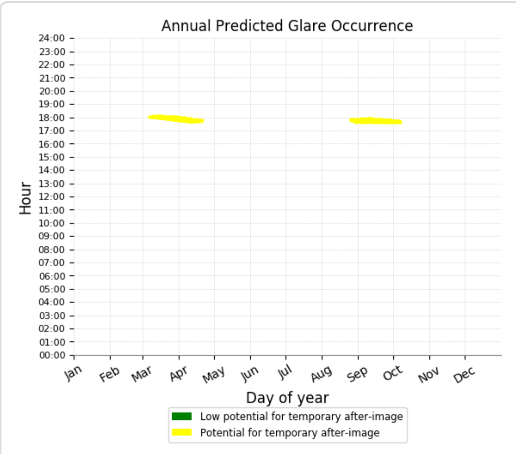
PV array 1 - OP Receptor (OP 3)

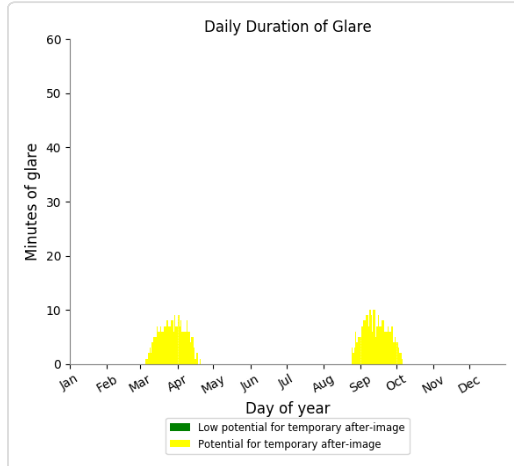
No glare found

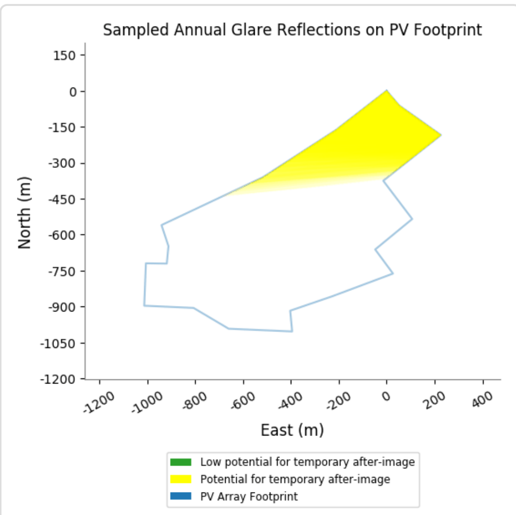
PV array 1 - OP Receptor (OP 4)

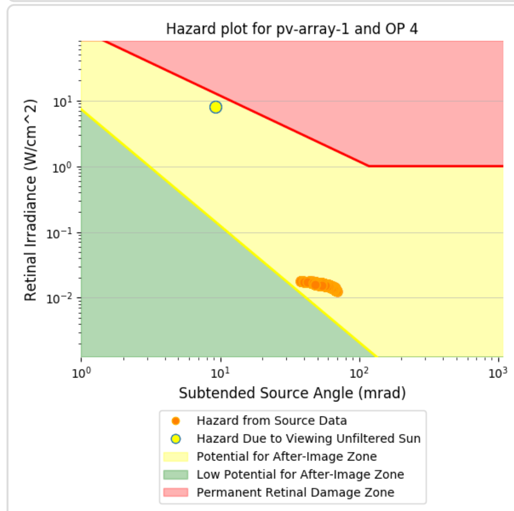
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 506 minutes of "yellow" glare with potential to cause temporary after-image.





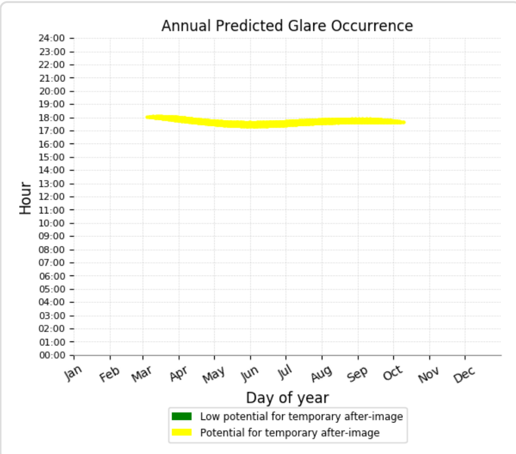


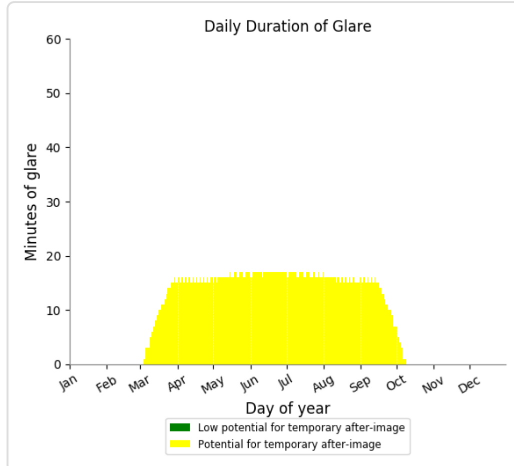


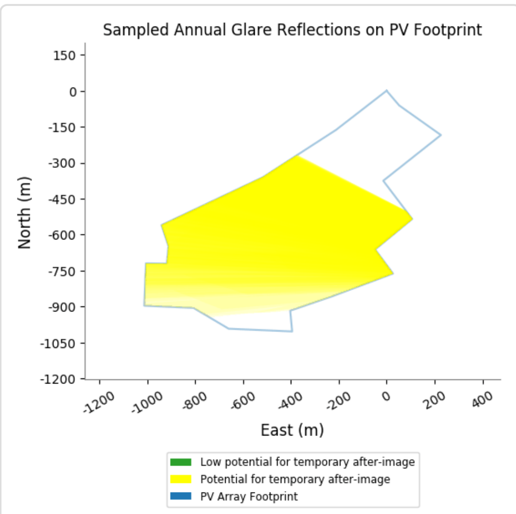
PV array 1 - OP Receptor (OP 5)

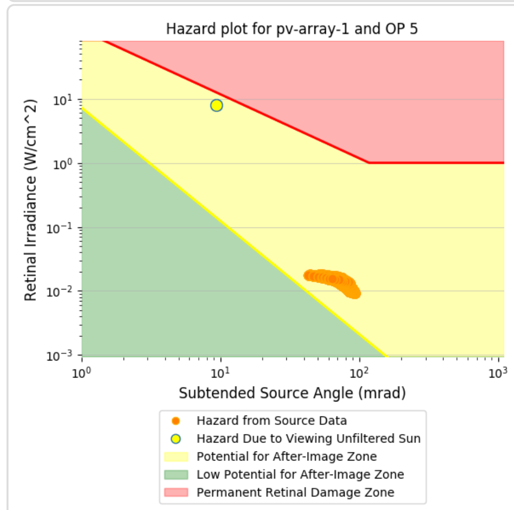
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,158 minutes of "yellow" glare with potential to cause temporary after-image.





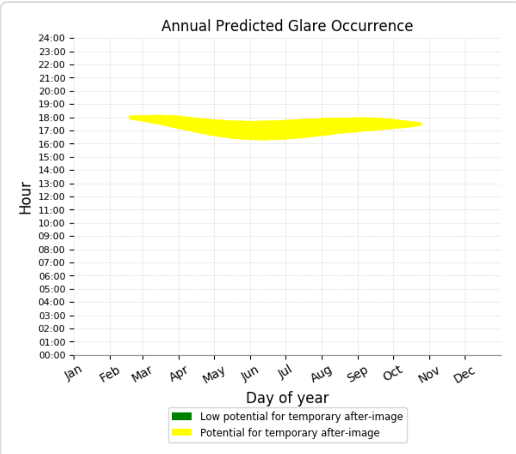


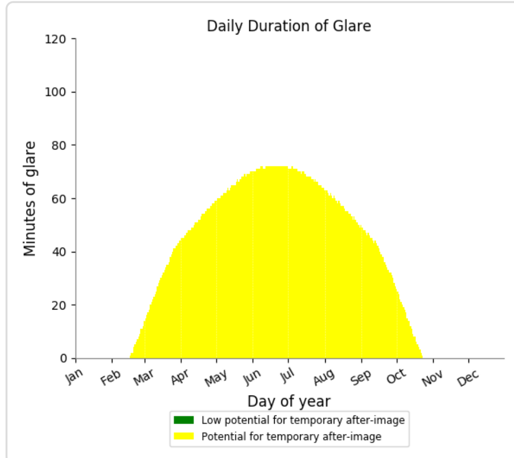


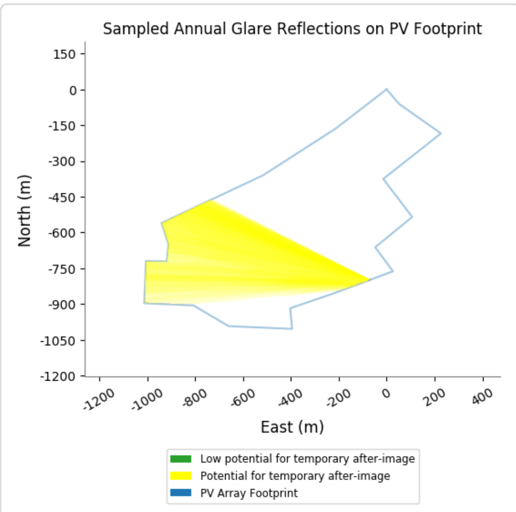
PV array 1 - OP Receptor (OP 6)

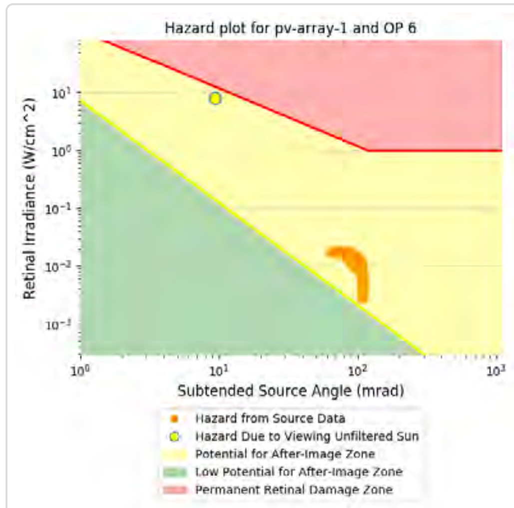
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 12,113 minutes of "yellow" glare with potential to cause temporary after-image.





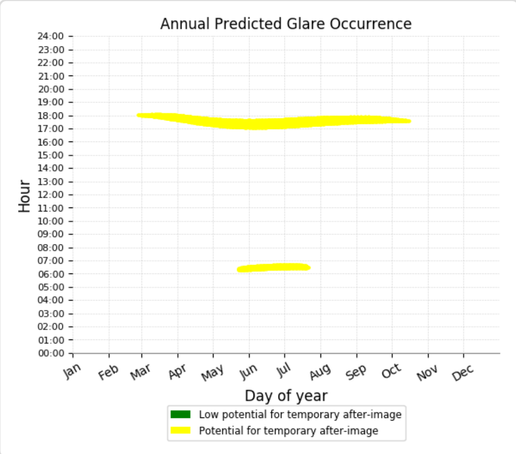


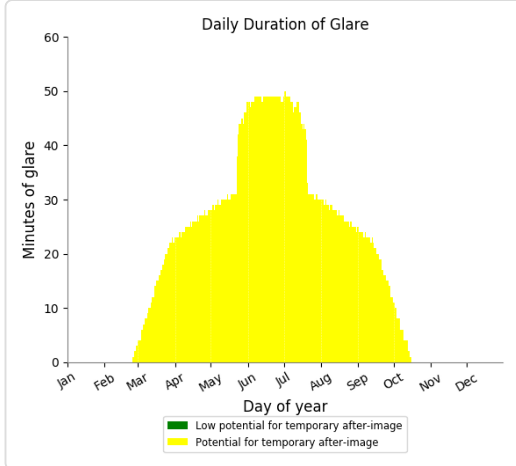


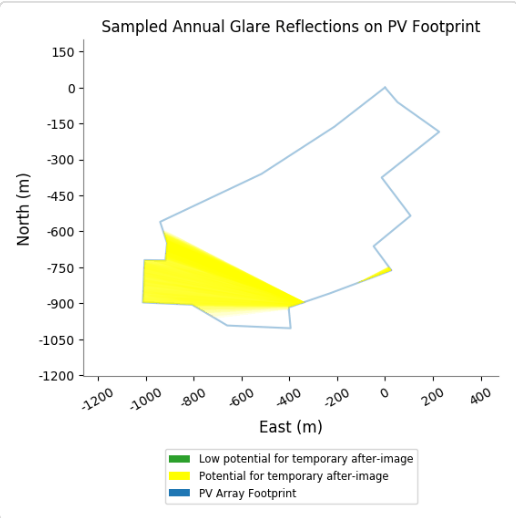
PV array 1 - OP Receptor (OP 7)

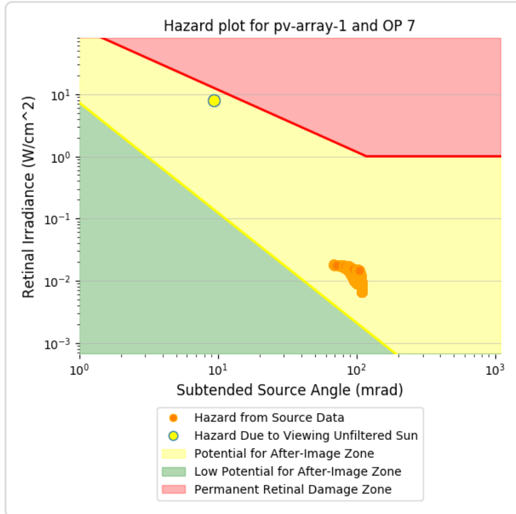
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,518 minutes of "yellow" glare with potential to cause temporary after-image.





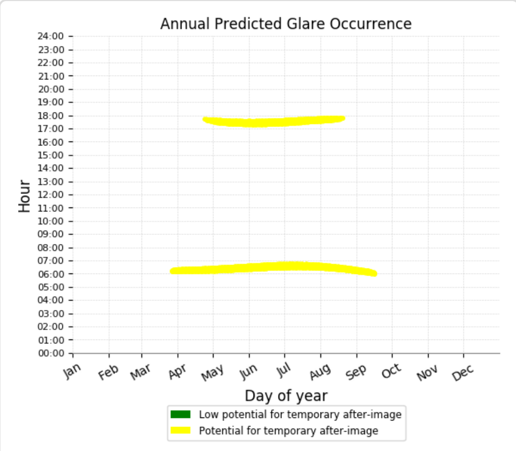


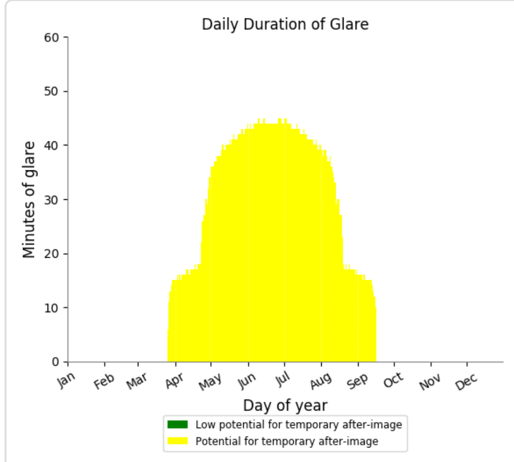


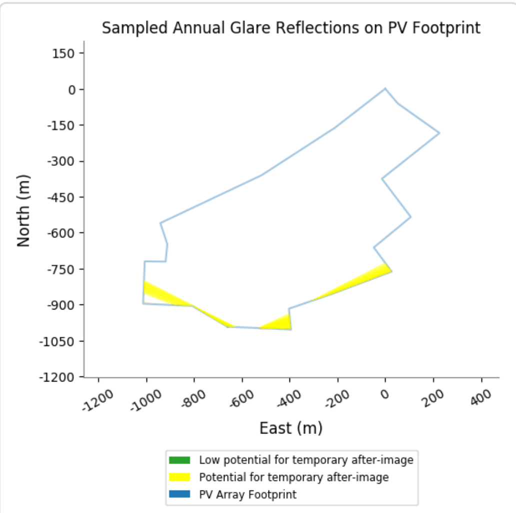
PV array 1 - OP Receptor (OP 8)

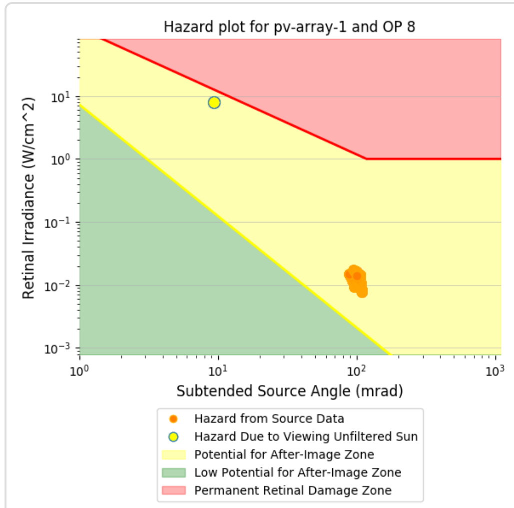
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,623 minutes of "yellow" glare with potential to cause temporary after-image.





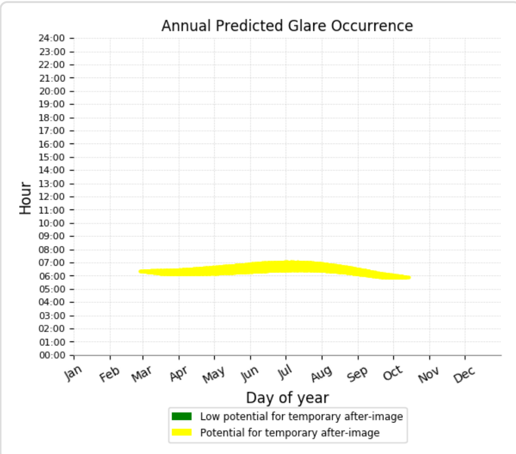


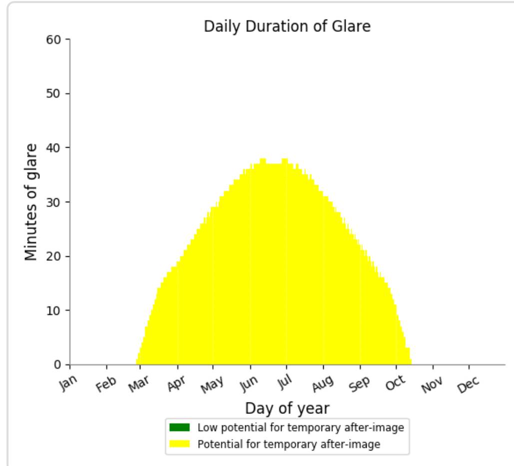


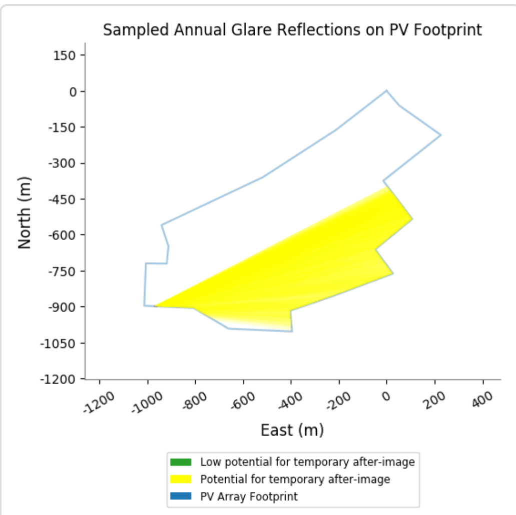
PV array 1 - OP Receptor (OP 9)

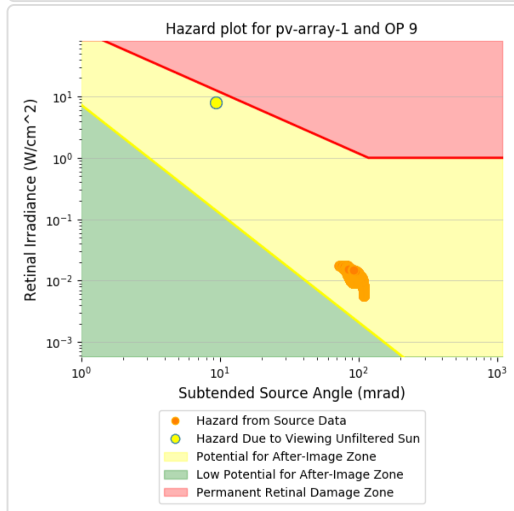
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,744 minutes of "yellow" glare with potential to cause temporary after-image.





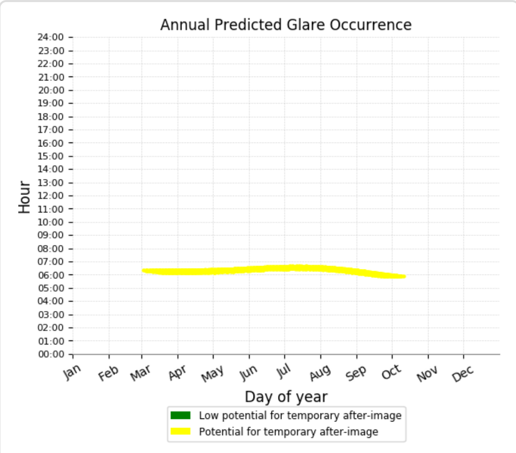


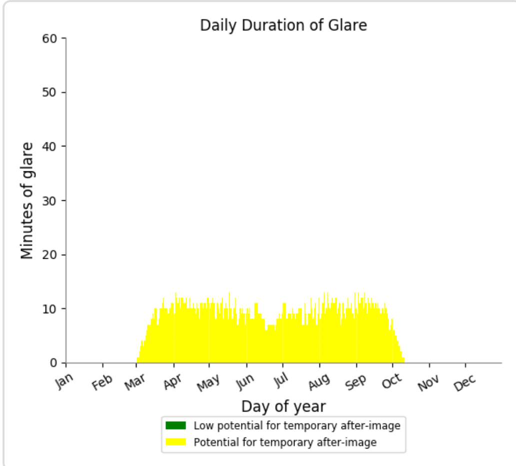


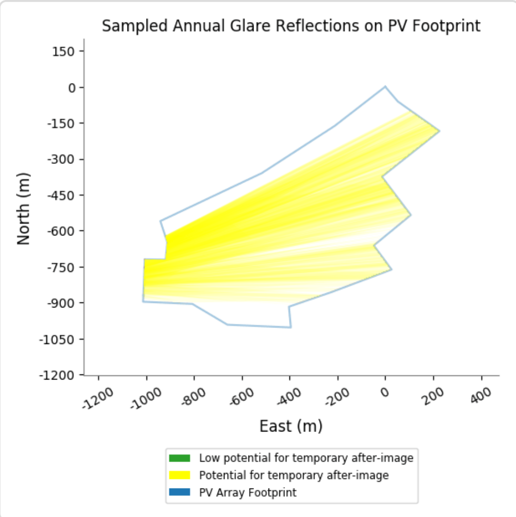
PV array 1 - OP Receptor (OP 10)

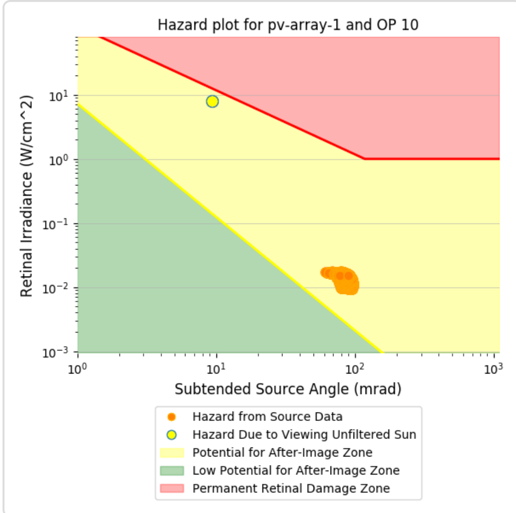
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,046 minutes of "yellow" glare with potential to cause temporary after-image.





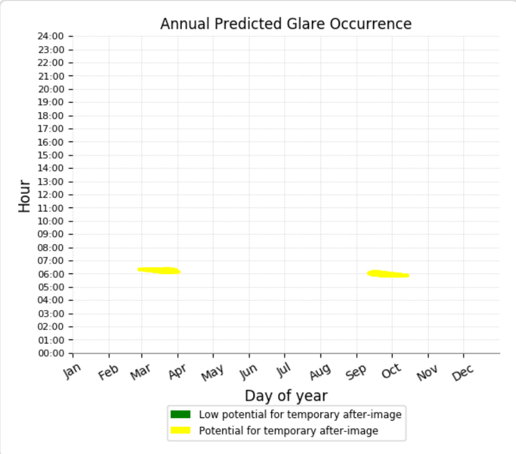


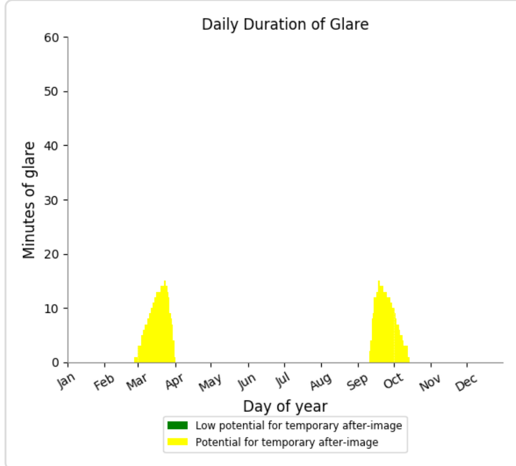


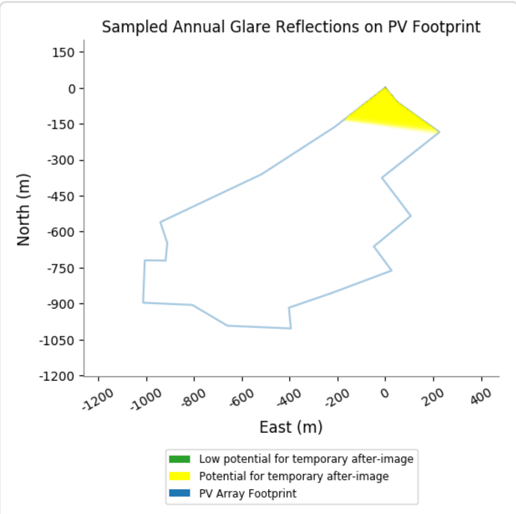
PV array 1 - OP Receptor (OP 11)

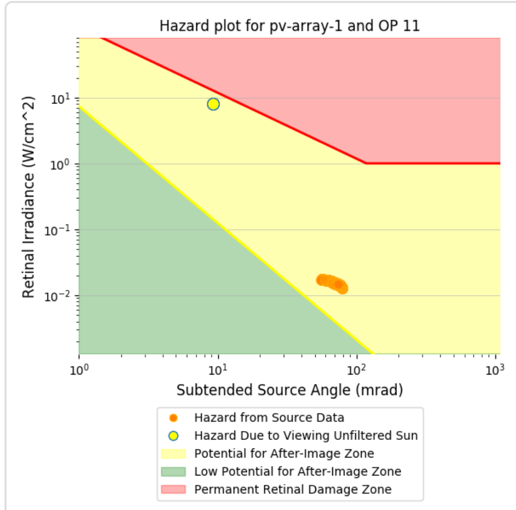
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 601 minutes of "yellow" glare with potential to cause temporary after-image.





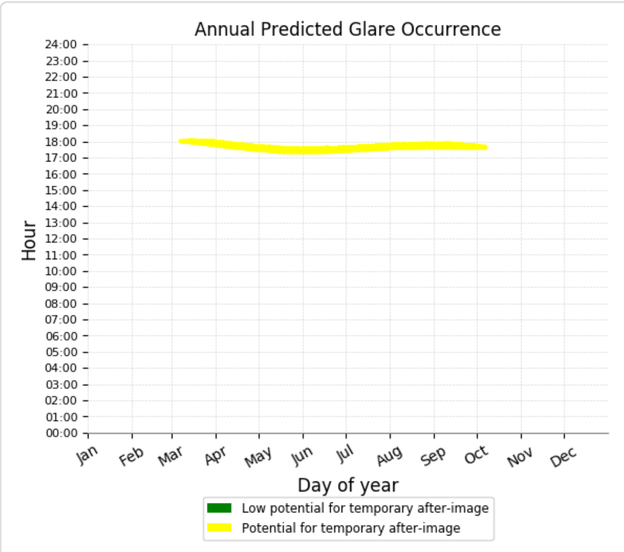


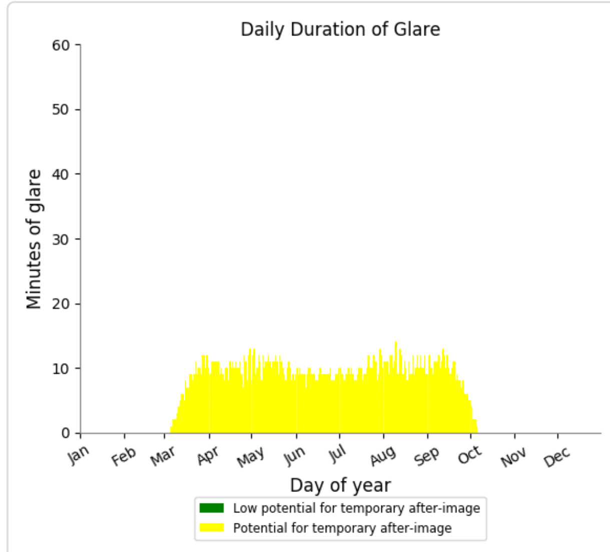


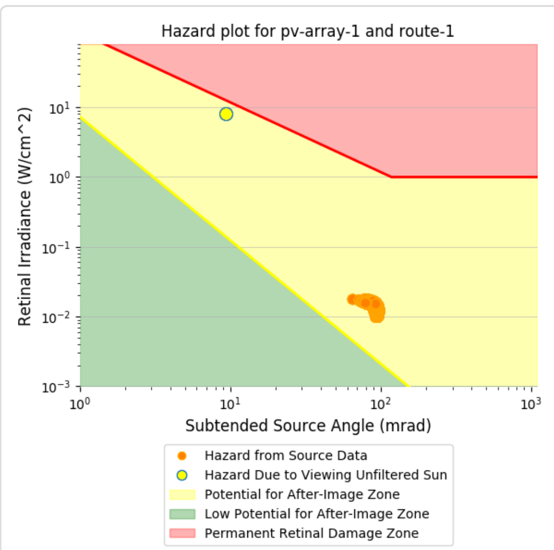
PV array 1 - Route Receptor (Route 1)

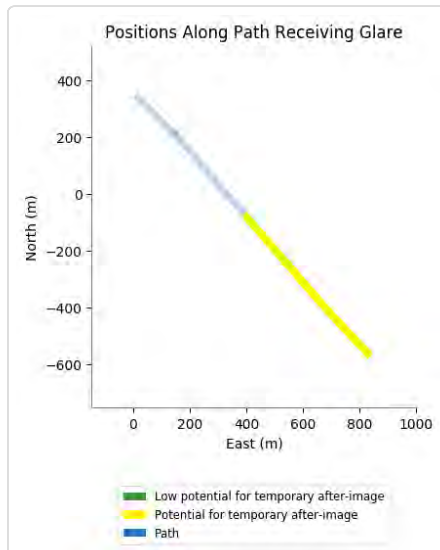
PV array is expected to produce the following glare for receptors at this location:

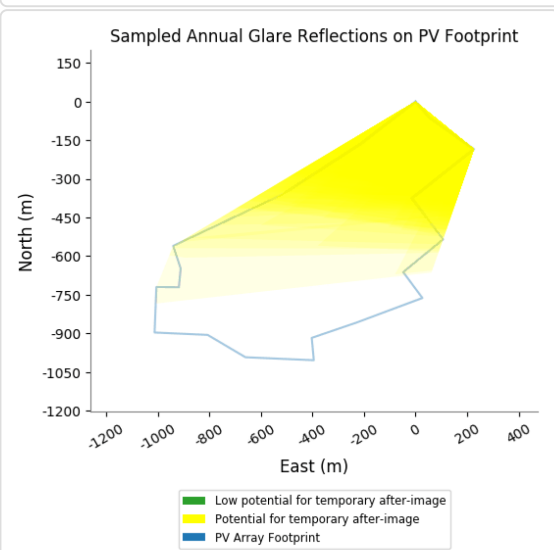
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,014 minutes of "yellow" glare with potential to cause temporary after-image.







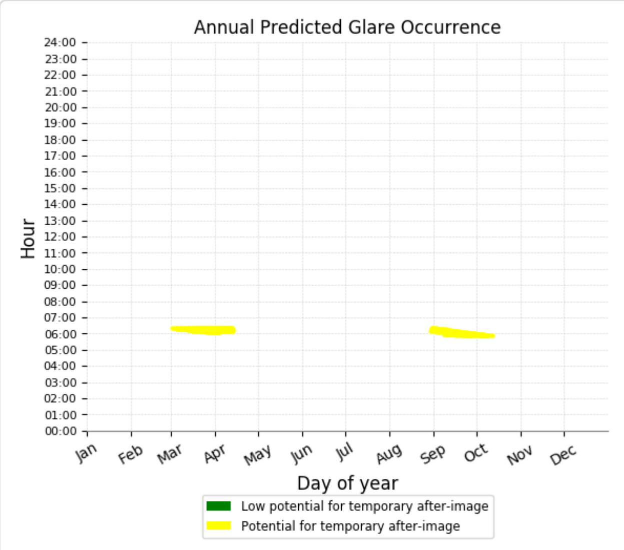


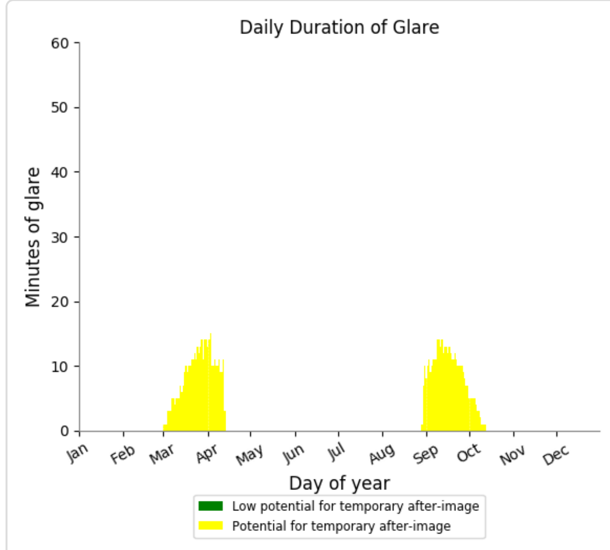


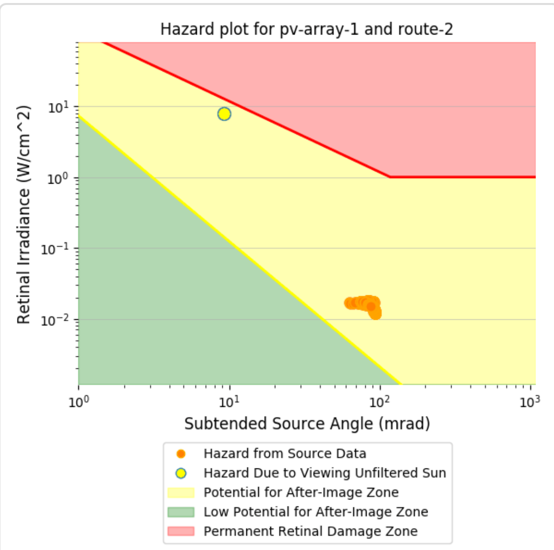
PV array 1 - Route Receptor (Route 2)

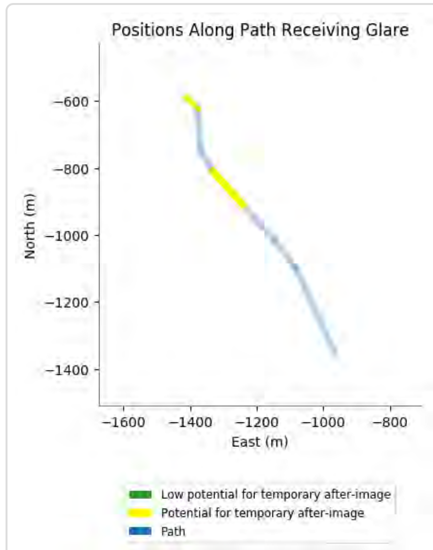
PV array is expected to produce the following glare for receptors at this location:

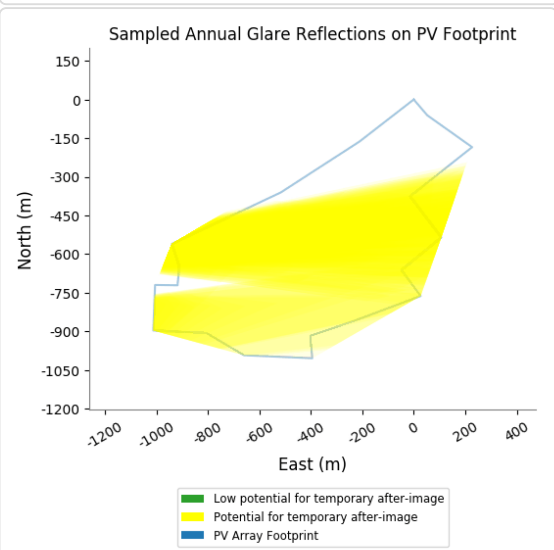
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 766 minutes of "yellow" glare with potential to cause temporary after-image.







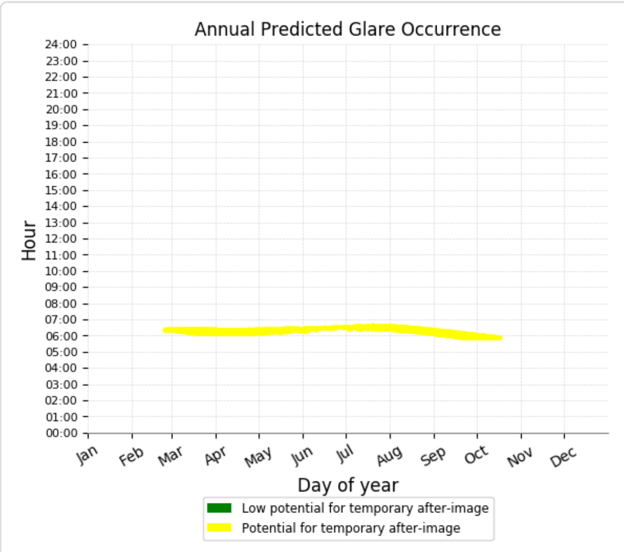


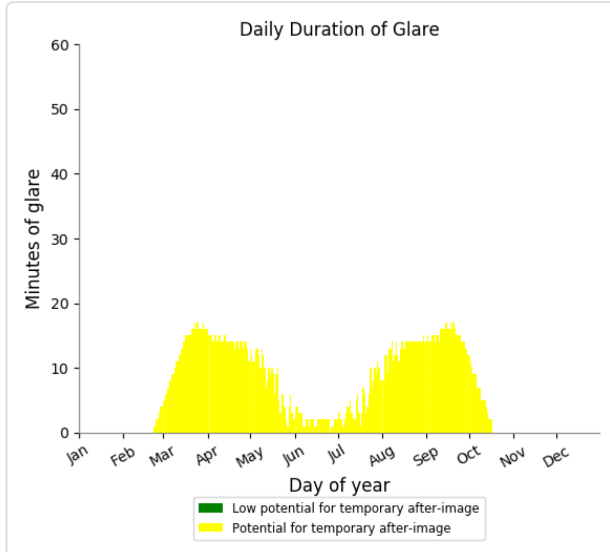


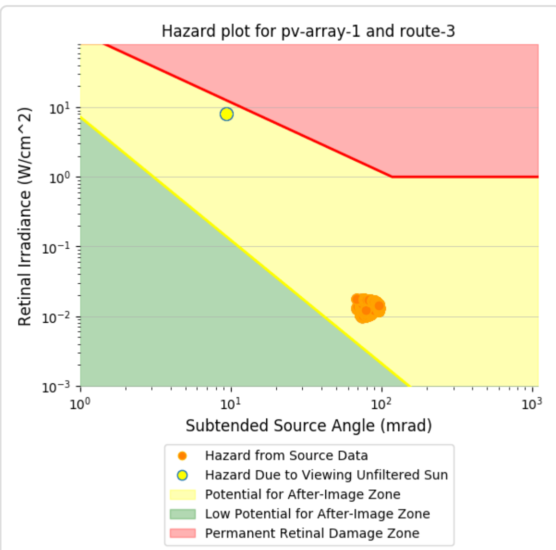
PV array 1 - Route Receptor (Route 3)

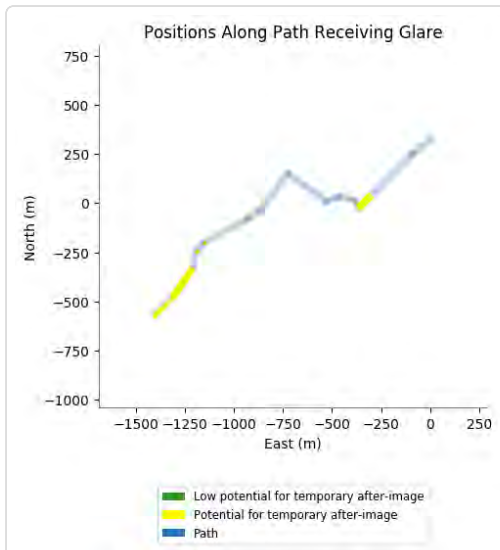
PV array is expected to produce the following glare for receptors at this location:

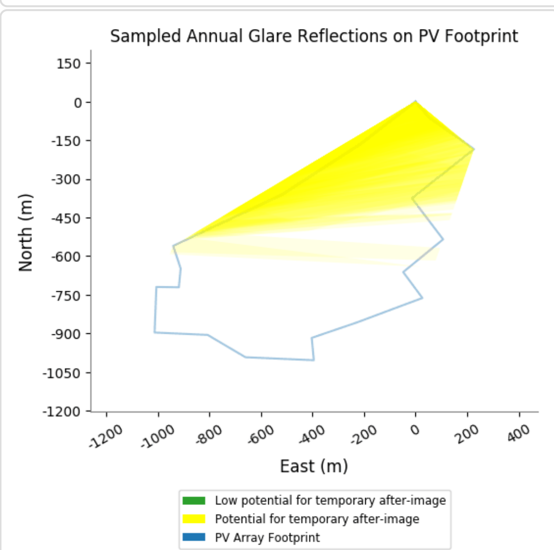
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,250 minutes of "yellow" glare with potential to cause temporary after-image.







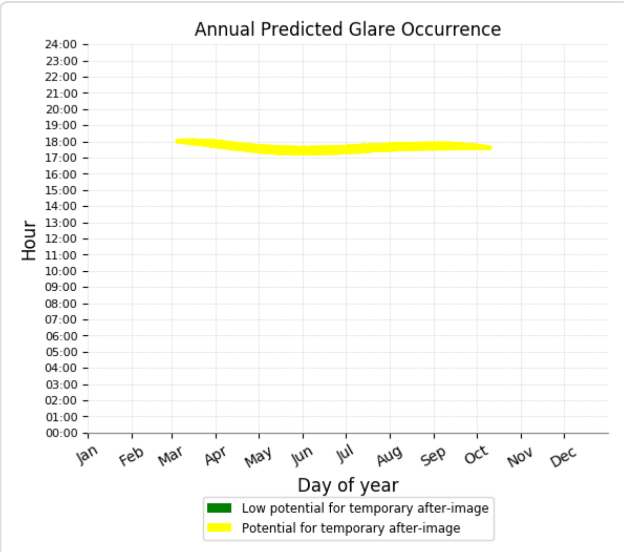


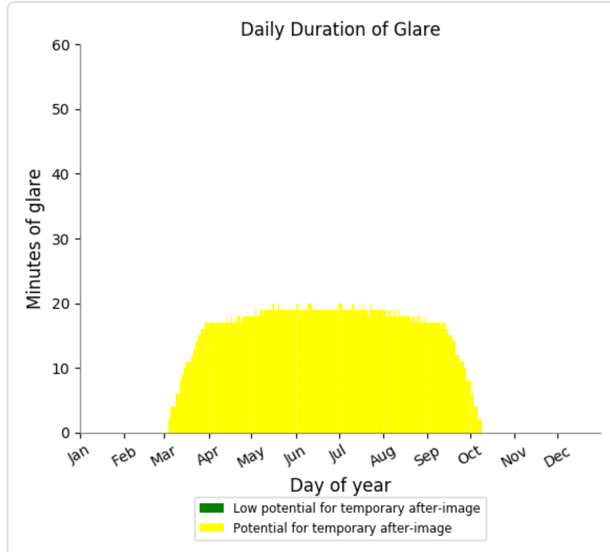


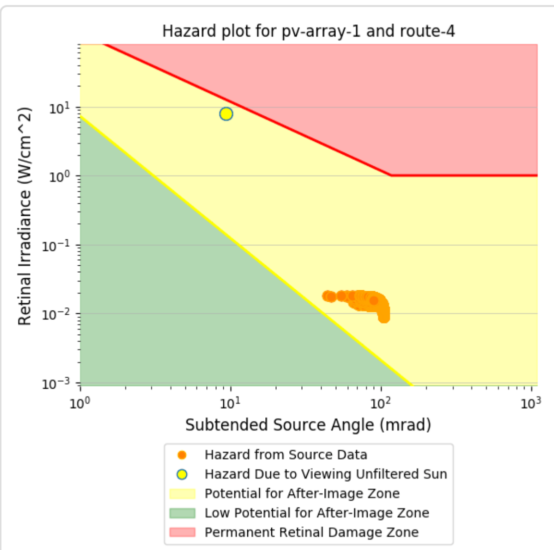
PV array 1 - Route Receptor (Route 4)

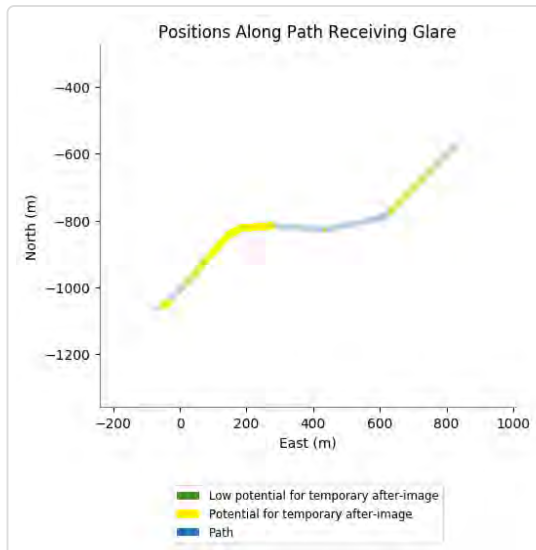
PV array is expected to produce the following glare for receptors at this location:

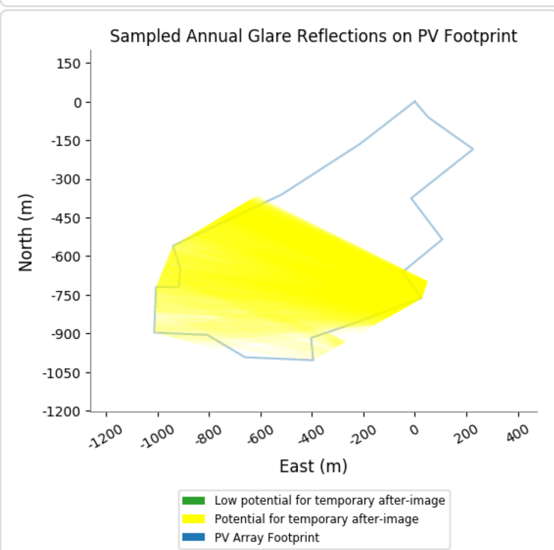
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,590 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Harrow PV

Smooth without ARC

Created Sept. 28, 2021
Updated Oct. 8, 2021
Time-step 1 minute
Timezone offset UTC-4
Site ID 59238.10542

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results Glare with potential for temporary after-image predicted

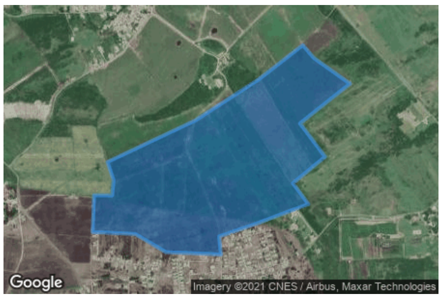
PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	13.0	180.0	0	43,973	-

Component Data

PV Array(s)

Total PV footprint area: 623,498 m^2

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 13.0 deg
Orientation: 180.0 deg
Footprint area: 623,498 m^2
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad



Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.132593	-59.469503	57.47	0.60	58.07
2	13.132039	-59.469020	56.07	0.60	56.67
3	13.130921	-59.467411	54.10	0.60	54.70
4	13.129197	-59.469632	53.93	0.60	54.53
5	13.127755	-59.468516	50.68	0.60	51.28
6	13.126606	-59.469943	50.01	0.60	50.61
7	13.125697	-59.469256	50.07	0.60	50.67
8	13.124840	-59.471595	49.43	0.60	50.03
9	13.124297	-59.473215	48.75	0.60	49.35
10	13.123513	-59.473140	46.97	0.60	47.57
11	13.123618	-59.475586	48.26	0.60	48.86
12	13.124401	-59.476938	49.67	0.60	50.27
13	13.124485	-59.478837	49.82	0.60	50.42
14	13.126083	-59.478773	53.88	0.60	54.48
15	13.126073	-59.477968	54.00	0.60	54.60
16	13.126731	-59.477904	54.37	0.60	54.97
17	13.127525	-59.478172	55.99	0.60	56.59
18	13.129333	-59.474264	58.27	0.60	58.87
19	13.131115	-59.471450	59.91	0.60	60.51

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.135648	-59.469339	66.95	1.20	68.15
2	13.134467	-59.468116	58.68	1.20	59.88
3	13.129081	-59.463345	48.37	1.20	49.57
4	13.127441	-59.461789	45.22	1.20	46.42

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.120339	-59.478393	43.36	1.20	44.56
2	13.122659	-59.479487	47.07	1.20	48.27
3	13.123397	-59.480059	48.41	1.20	49.61
4	13.125341	-59.481840	50.49	1.20	51.69
5	13.125853	-59.482129	52.73	1.20	53.93
6	13.126971	-59.482194	57.75	1.20	58.95
7	13.127319	-59.482565	58.76	1.20	59.96

Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.127435	-59.482463	58.53	1.20	59.73
2	13.128250	-59.481594	57.66	1.20	58.86
3	13.129608	-59.480661	64.75	1.20	65.95
4	13.130339	-59.480489	66.49	1.20	67.69
5	13.130757	-59.480124	67.34	1.20	68.54
6	13.131877	-59.478083	69.21	1.20	70.41
7	13.132253	-59.477503	69.75	1.20	70.95
8	13.133946	-59.476184	74.28	1.20	75.48
9	13.132682	-59.474371	66.83	1.20	68.03
10	13.132880	-59.473781	66.11	1.20	67.31
11	13.132723	-59.473083	64.95	1.20	66.15
12	13.132389	-59.472836	64.60	1.20	65.80
13	13.134857	-59.470321	64.04	1.20	65.24
14	13.135568	-59.469431	66.79	1.20	67.99

Name: Route 4
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.123002	-59.470070	43.40	1.20	44.60
2	13.123164	-59.469784	43.96	1.20	45.16
3	13.124952	-59.468174	47.47	1.20	48.67
4	13.125156	-59.467837	47.29	1.20	48.49
5	13.125219	-59.466914	46.99	1.20	48.19
6	13.125109	-59.465487	46.50	1.20	47.70
7	13.125417	-59.463990	46.55	1.20	47.75
8	13.125569	-59.463706	45.61	1.20	46.81
9	13.127401	-59.461855	45.16	1.20	46.36

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.130926	-59.473258	63.97	4.80	68.77
OP 2	13.135241	-59.470198	66.08	1.80	67.88
OP 3	13.139399	-59.467971	69.40	1.80	71.20
OP 4	13.130744	-59.456905	44.41	4.80	49.21
OP 5	13.125491	-59.463659	45.65	4.80	50.45
OP 6	13.125210	-59.469831	49.99	4.80	54.79
OP 7	13.124343	-59.472310	47.58	1.80	49.38
OP 8	13.123371	-59.474799	46.52	1.80	48.32
OP 9	13.124311	-59.478747	49.32	4.80	54.12
OP 10	13.125011	-59.481912	49.62	4.80	54.42
OP 11	13.132421	-59.477747	70.34	1.80	72.14

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	13.0	180.0	0	43,973	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	8	285	1531	2172	2851	3084	3033	2452	1838	652	42	0

PV & Receptor Analysis Results

Results for each PV array and receptor

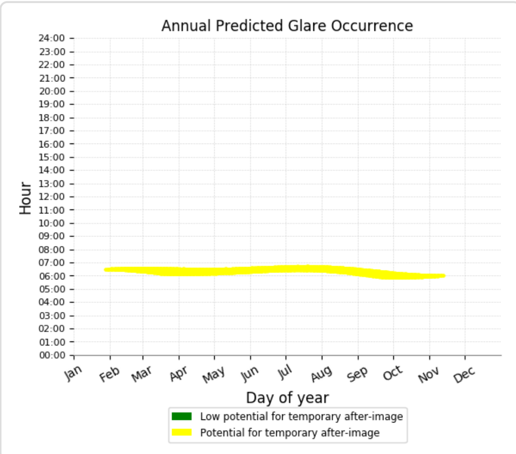
PV array 1 potential temporary after-image

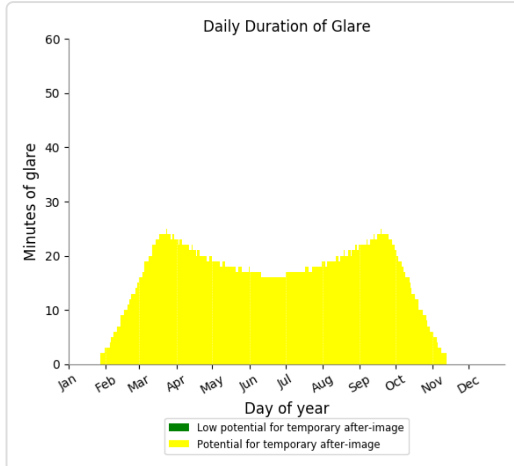
Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	4899
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	404
OP: OP 5	0	2561
OP: OP 6	0	11356
OP: OP 7	0	5632
OP: OP 8	0	4732
OP: OP 9	0	5085
OP: OP 10	0	1781
OP: OP 11	0	428
Route: Route 1	0	1709
Route: Route 2	0	600
Route: Route 3	0	1802
Route: Route 4	0	2984

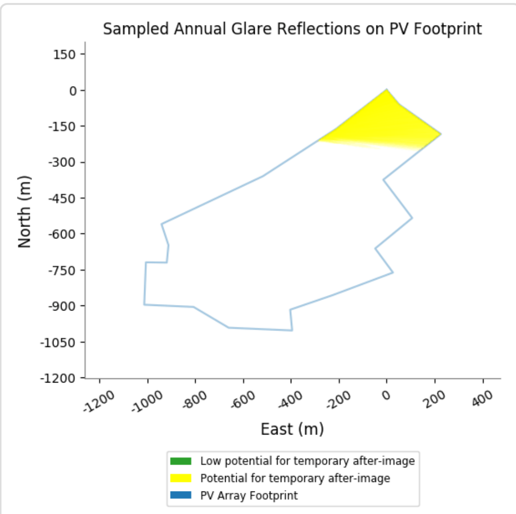
PV array 1 - OP Receptor (OP 1)

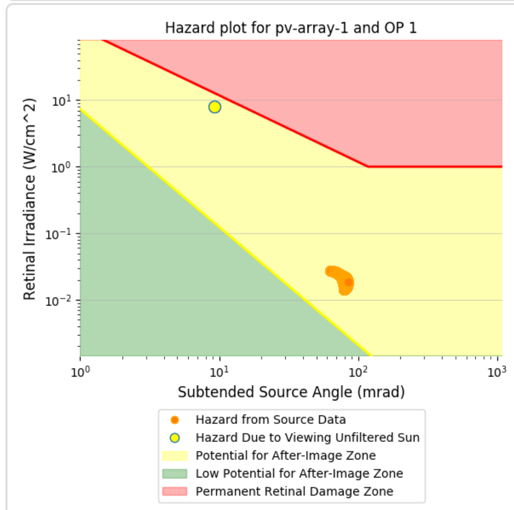
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,899 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - OP Receptor (OP 2)

No glare found

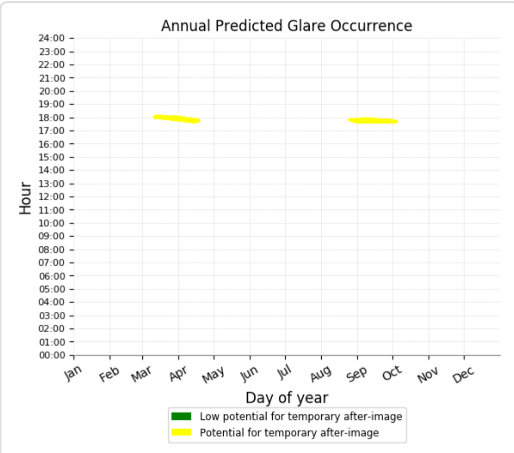
PV array 1 - OP Receptor (OP 3)

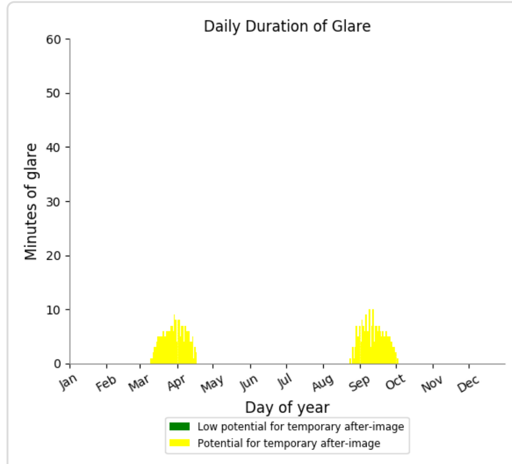
No glare found

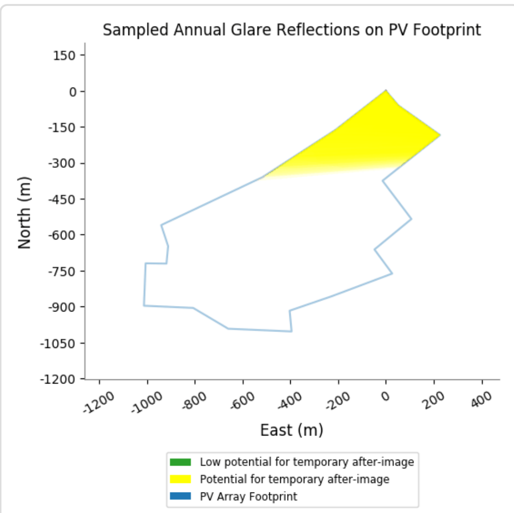
PV array 1 - OP Receptor (OP 4)

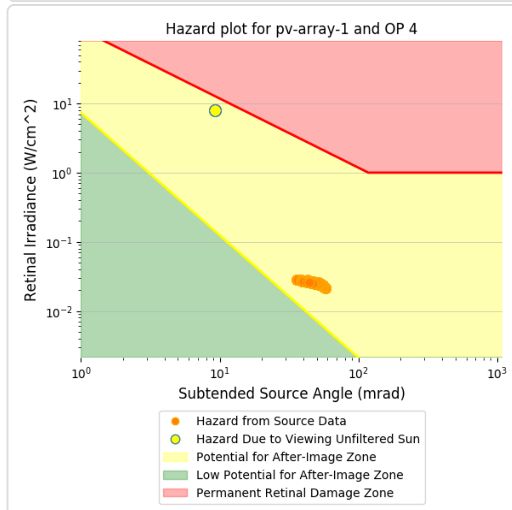
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 404 minutes of "yellow" glare with potential to cause temporary after-image.





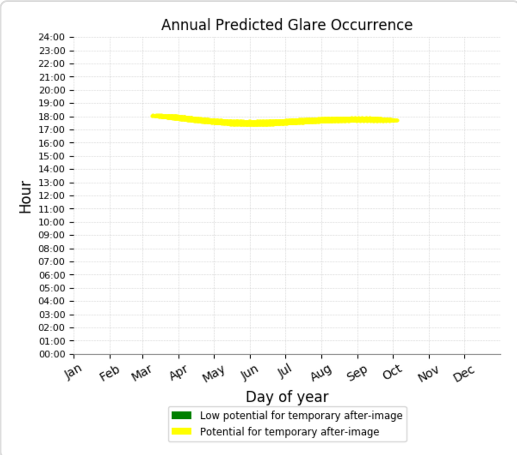


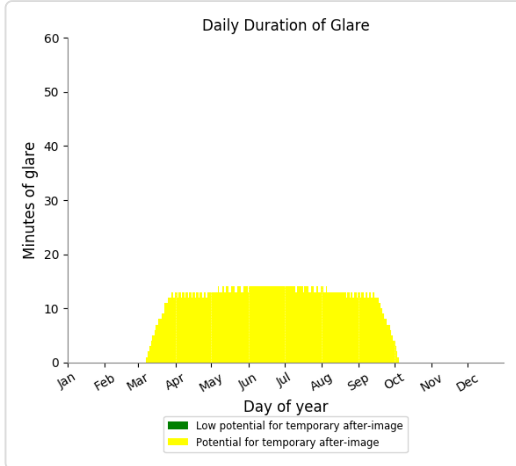


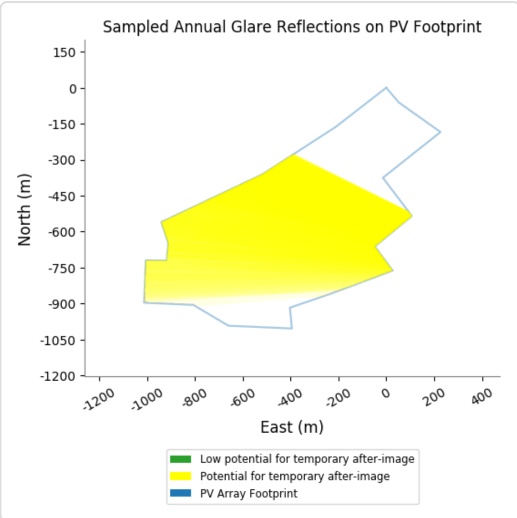
PV array 1 - OP Receptor (OP 5)

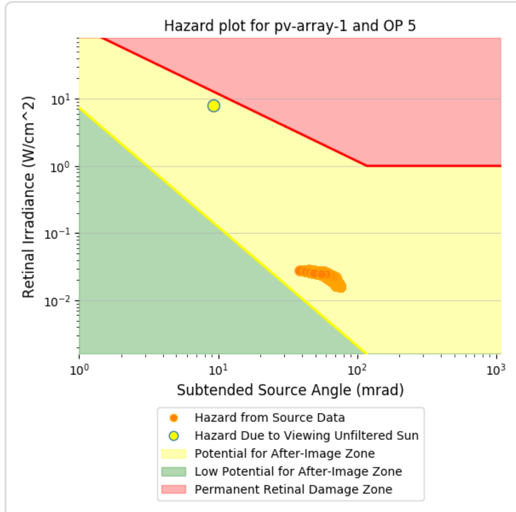
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,561 minutes of "yellow" glare with potential to cause temporary after-image.





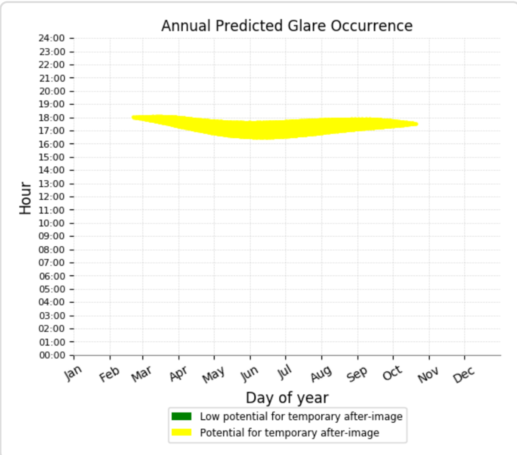


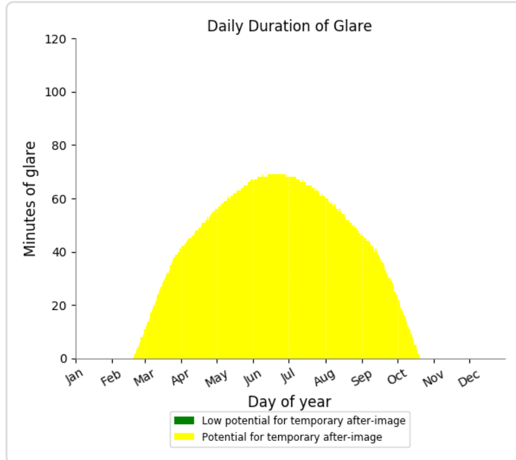


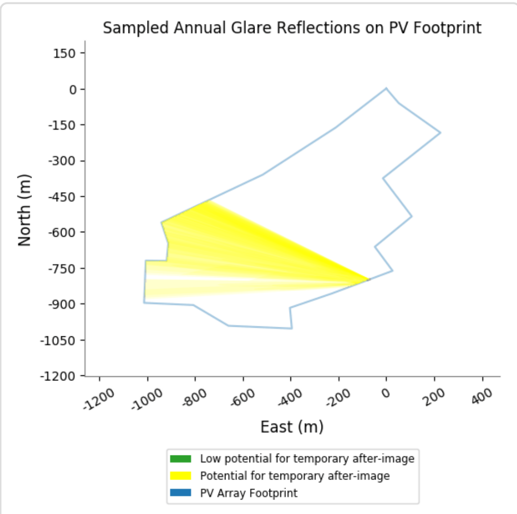
PV array 1 - OP Receptor (OP 6)

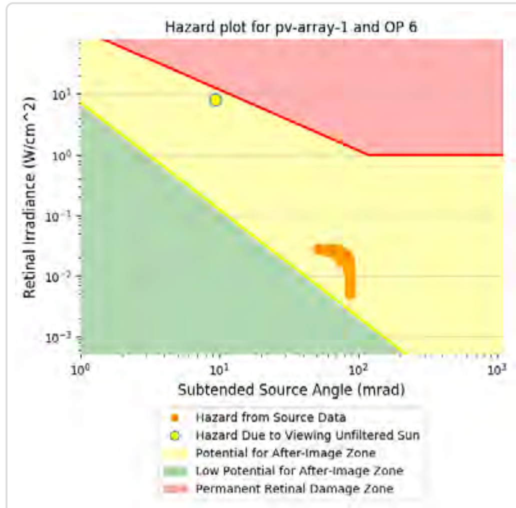
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 11,356 minutes of "yellow" glare with potential to cause temporary after-image.





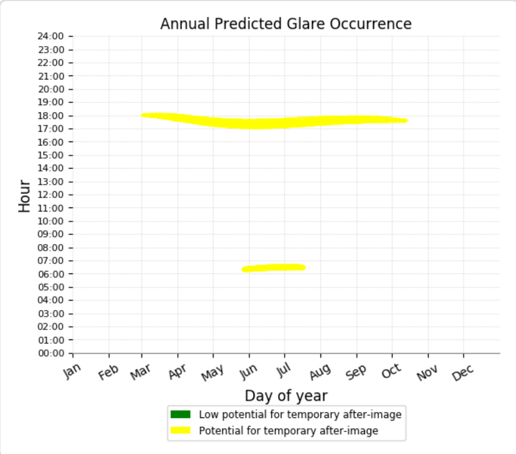


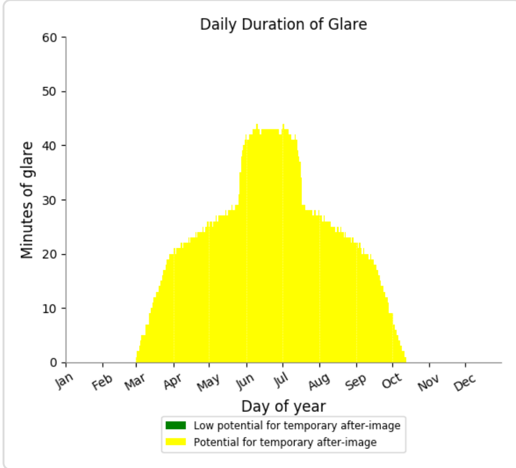


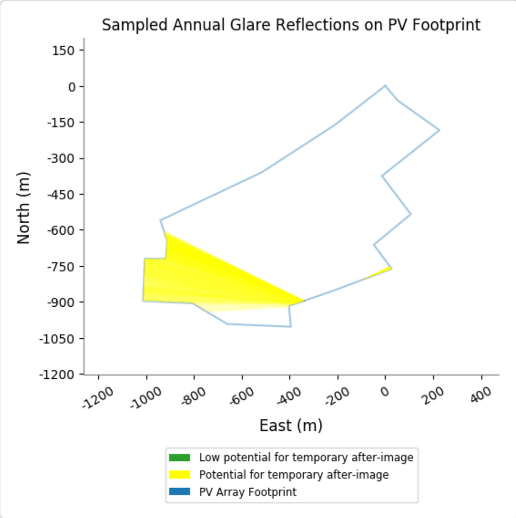
PV array 1 - OP Receptor (OP 7)

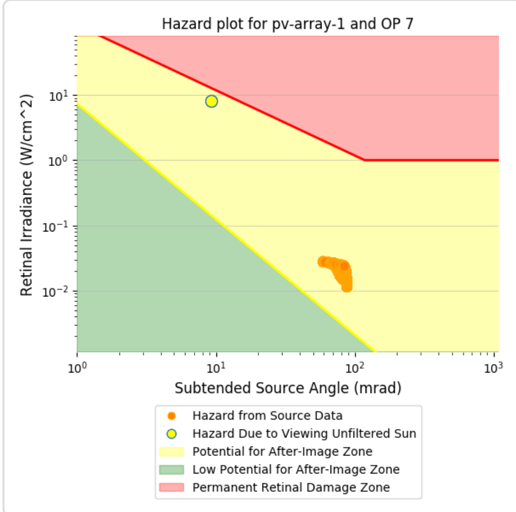
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,632 minutes of "yellow" glare with potential to cause temporary after-image.





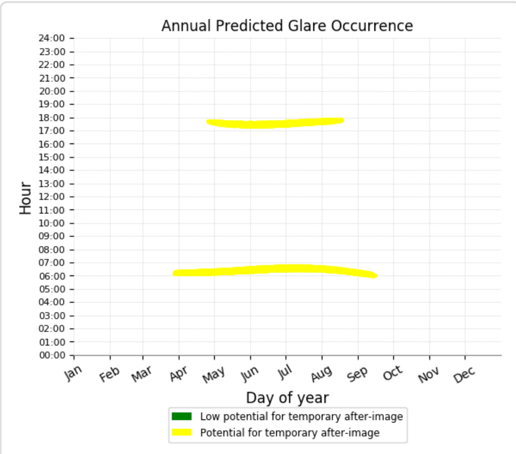


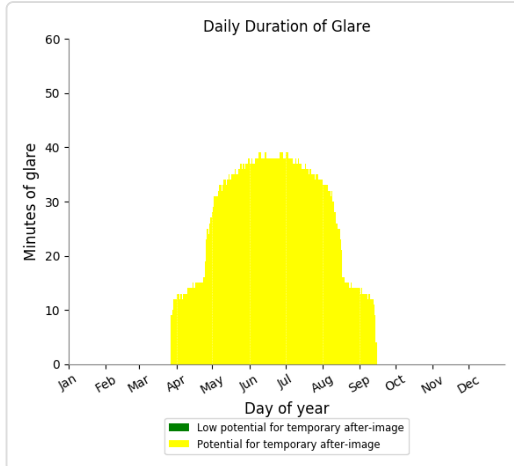


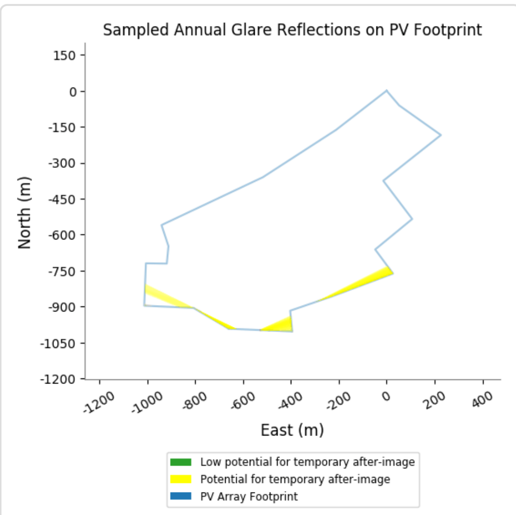
PV array 1 - OP Receptor (OP 8)

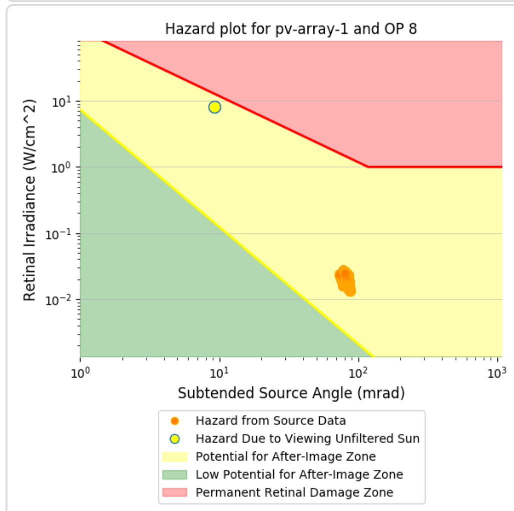
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,732 minutes of "yellow" glare with potential to cause temporary after-image.





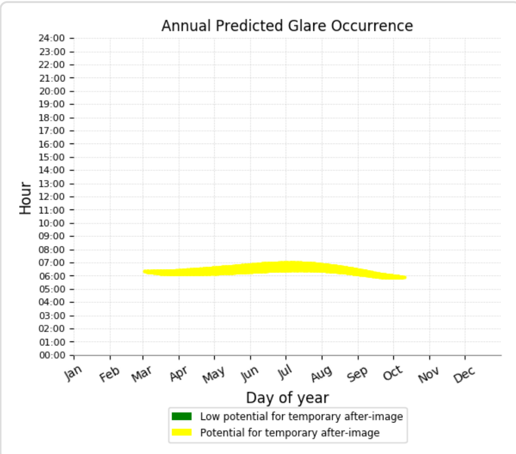


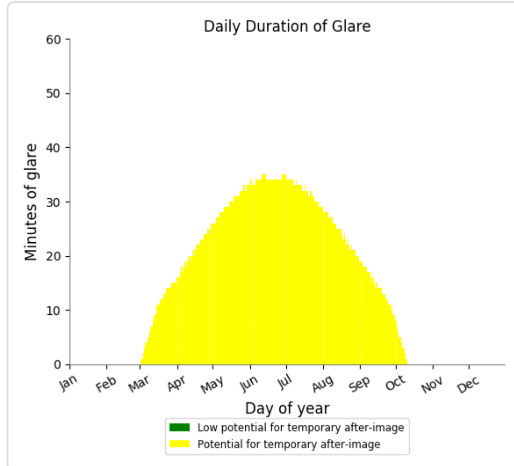


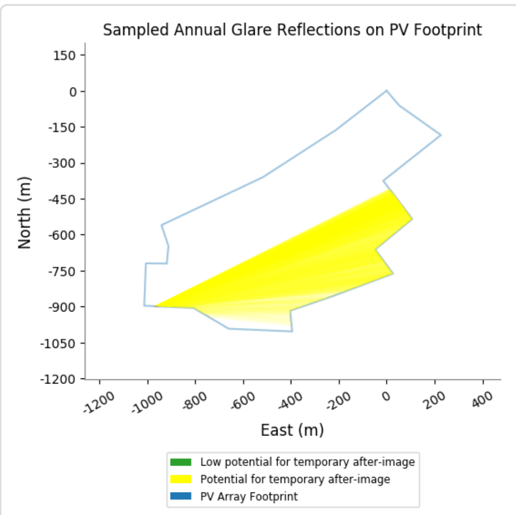
PV array 1 - OP Receptor (OP 9)

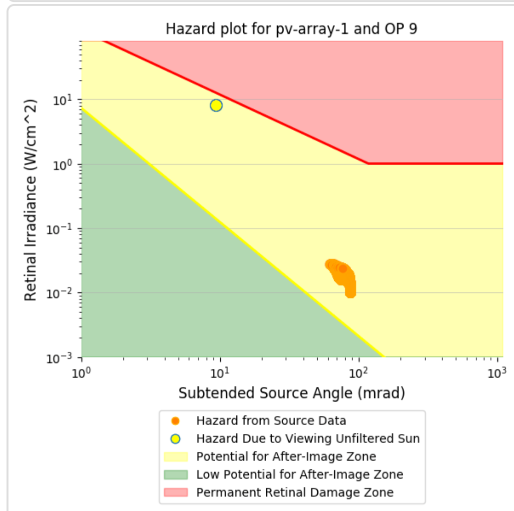
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,085 minutes of "yellow" glare with potential to cause temporary after-image.





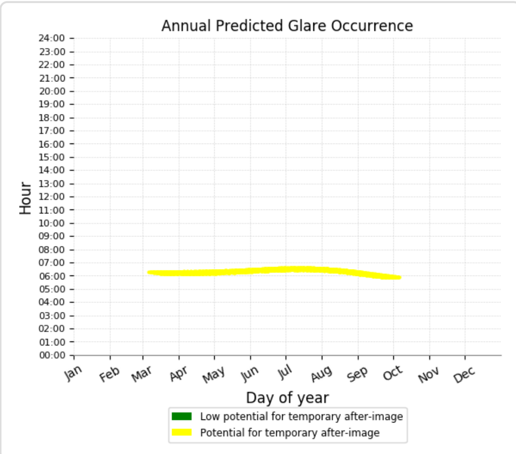


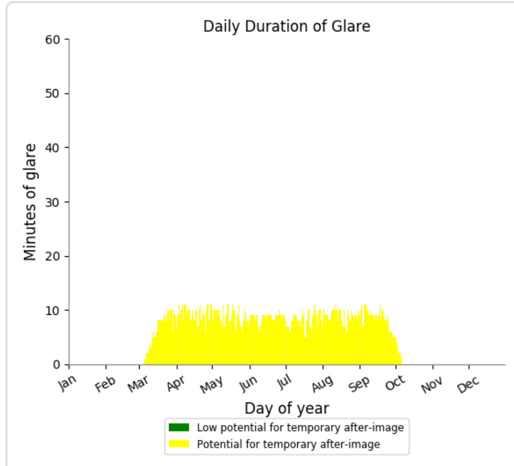


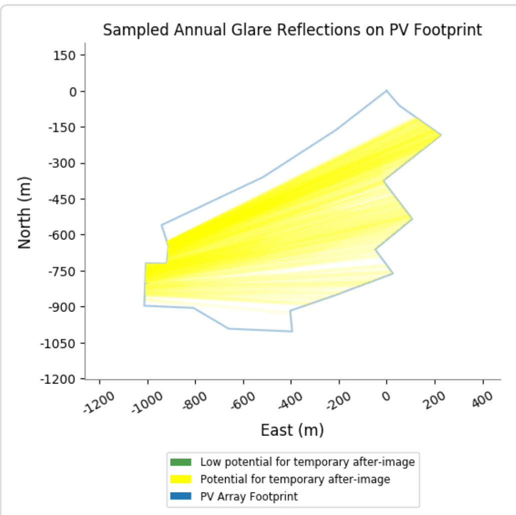
PV array 1 - OP Receptor (OP 10)

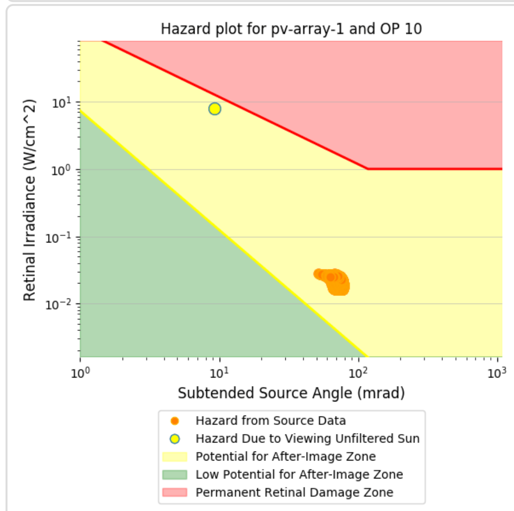
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,781 minutes of "yellow" glare with potential to cause temporary after-image.





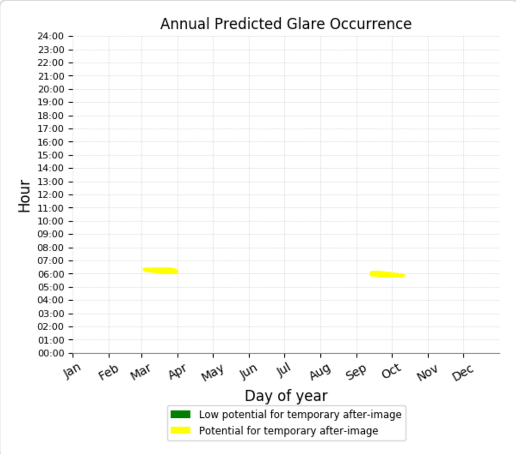


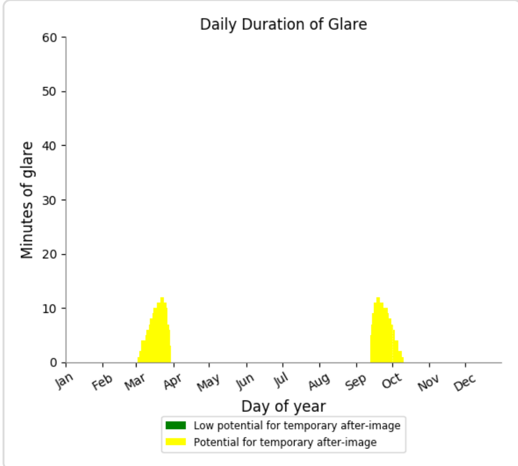


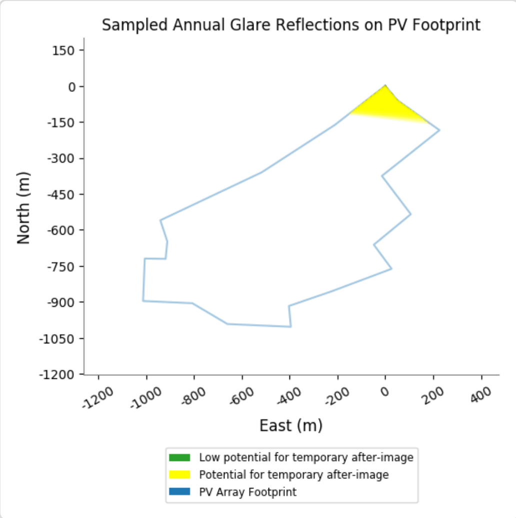
PV array 1 - OP Receptor (OP 11)

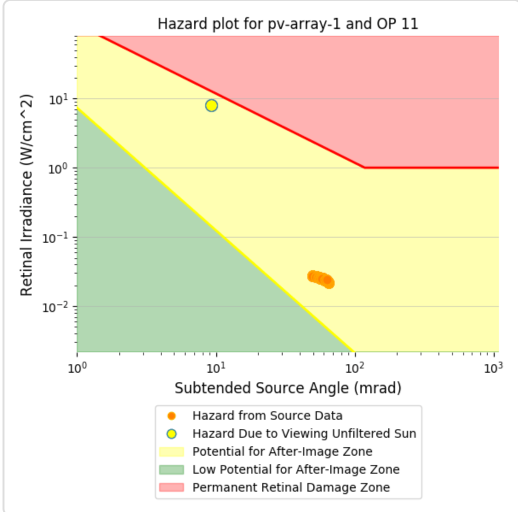
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 428 minutes of "yellow" glare with potential to cause temporary after-image.





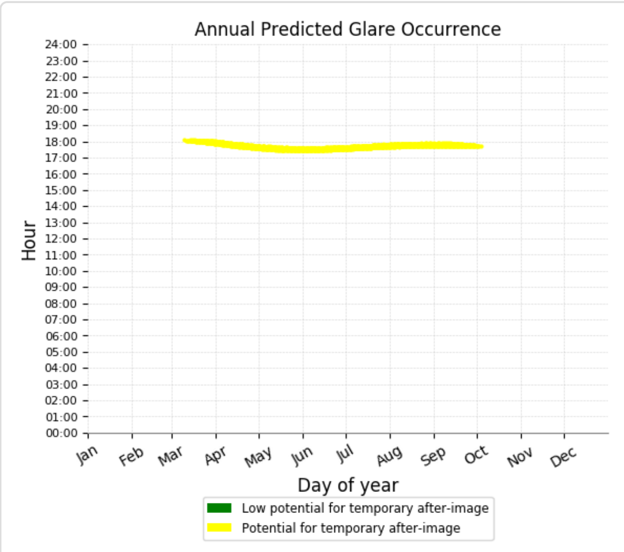


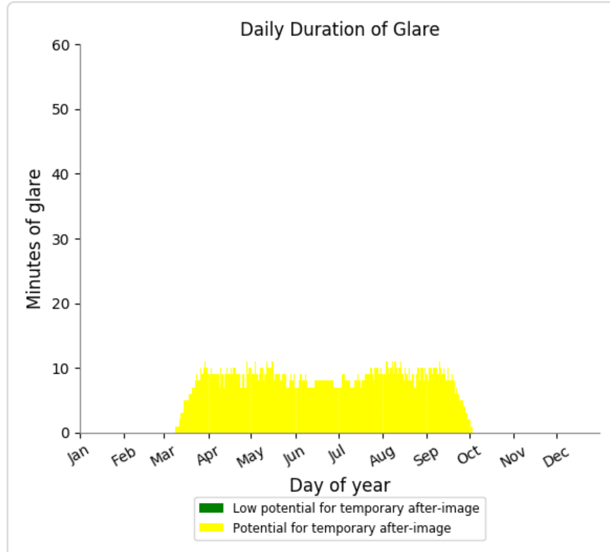


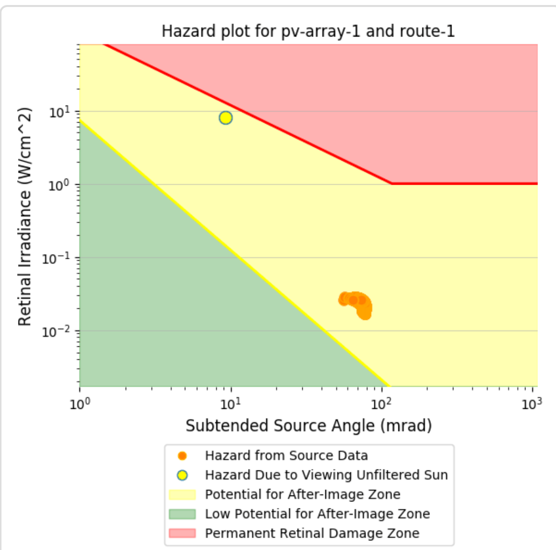
PV array 1 - Route Receptor (Route 1)

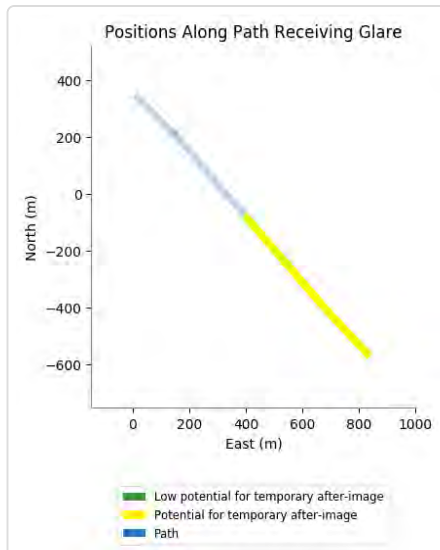
PV array is expected to produce the following glare for receptors at this location:

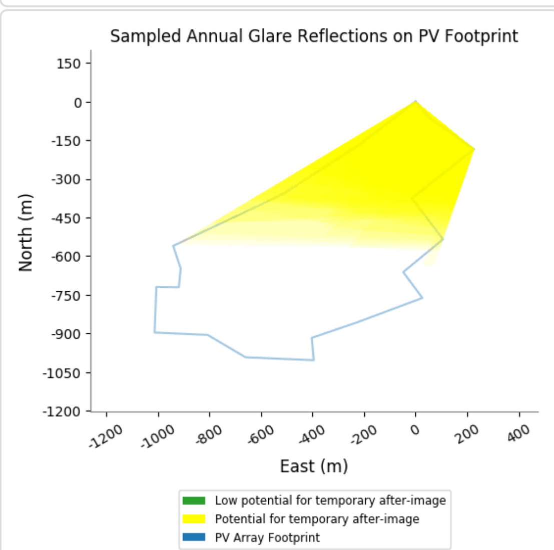
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,709 minutes of "yellow" glare with potential to cause temporary after-image.







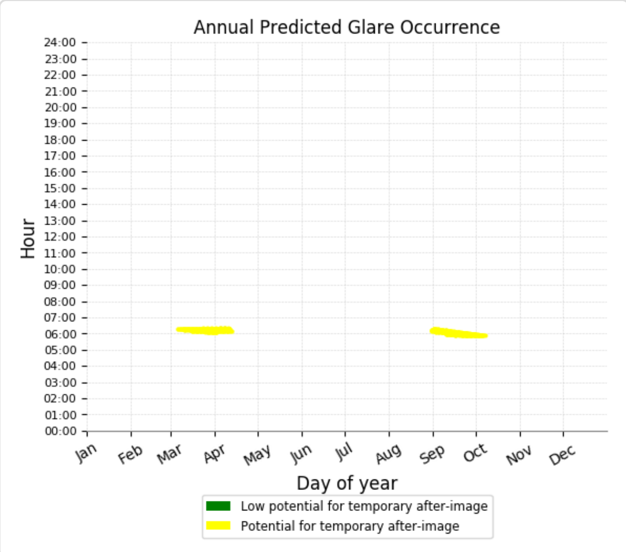


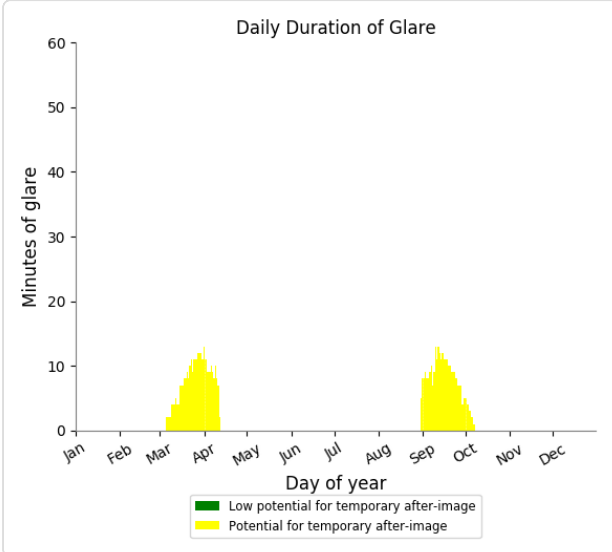


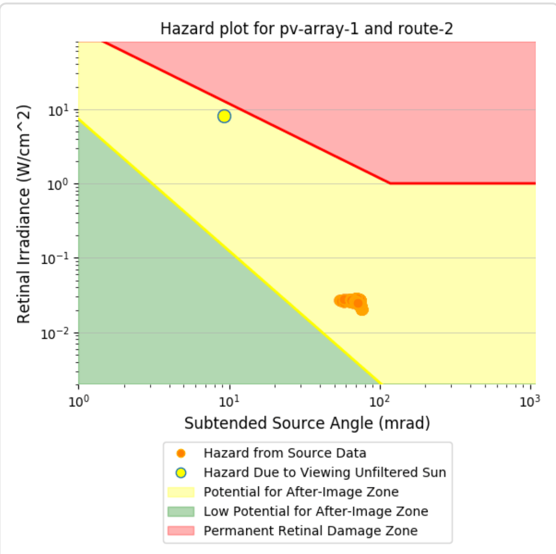
PV array 1 - Route Receptor (Route 2)

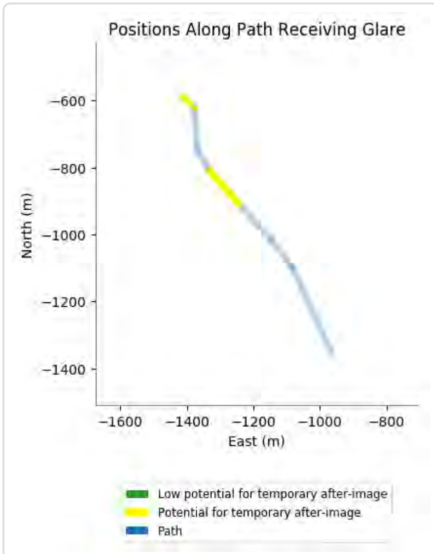
PV array is expected to produce the following glare for receptors at this location:

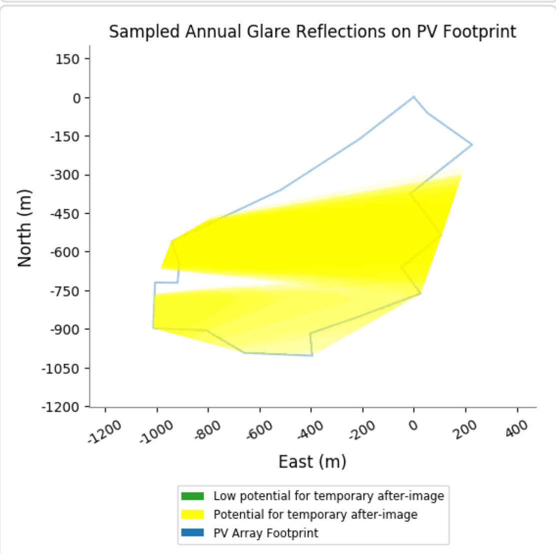
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 600 minutes of "yellow" glare with potential to cause temporary after-image.







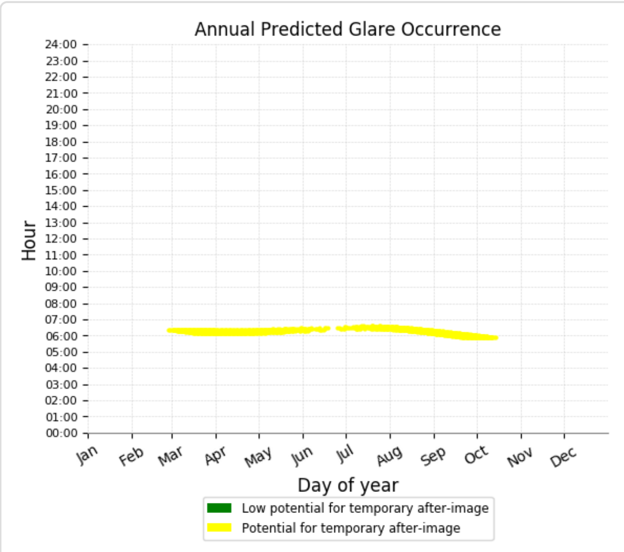


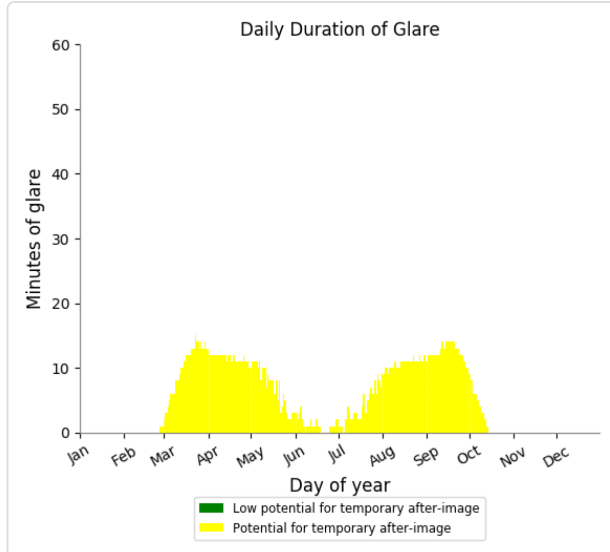


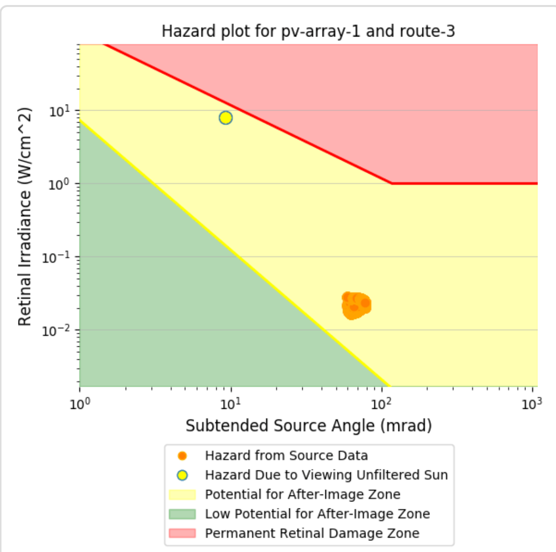
PV array 1 - Route Receptor (Route 3)

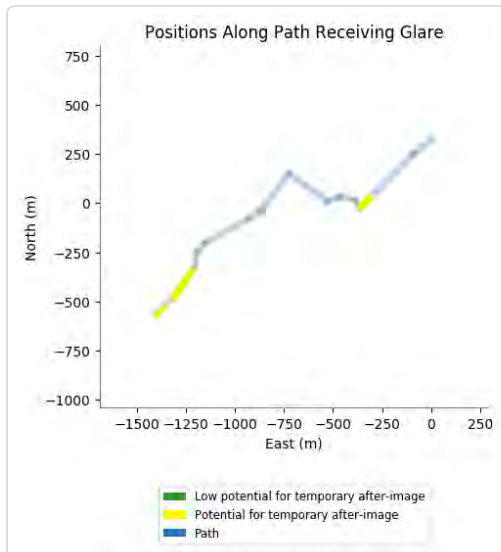
PV array is expected to produce the following glare for receptors at this location:

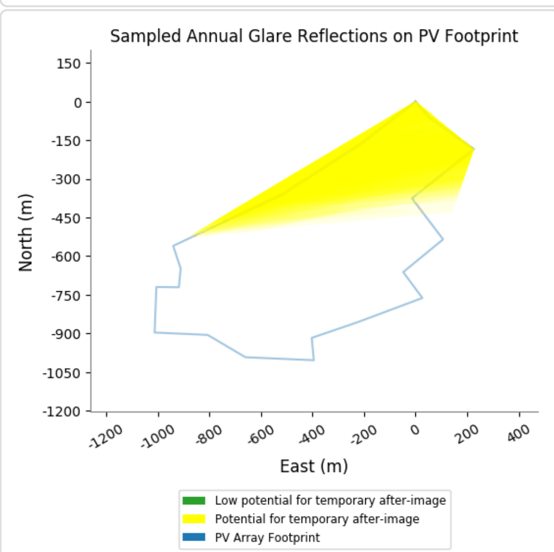
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,802 minutes of "yellow" glare with potential to cause temporary after-image.







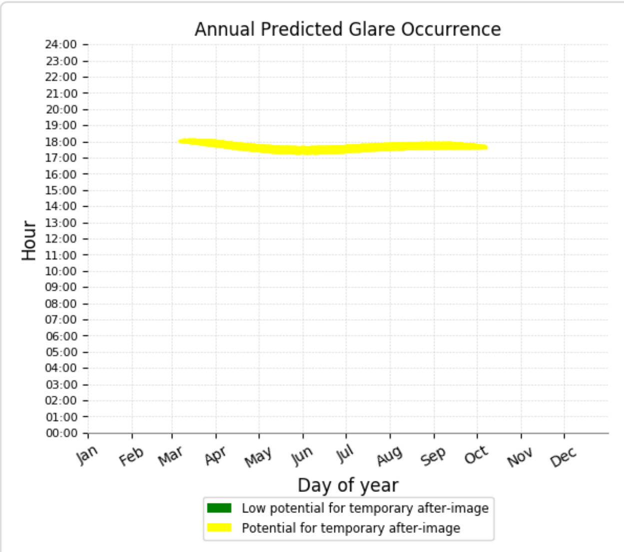


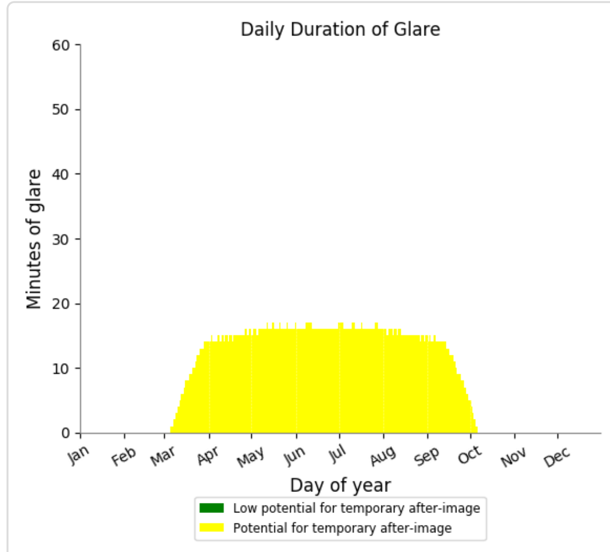


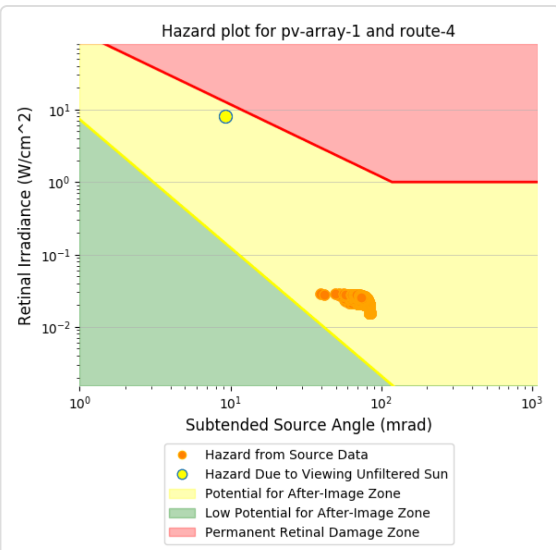
PV array 1 - Route Receptor (Route 4)

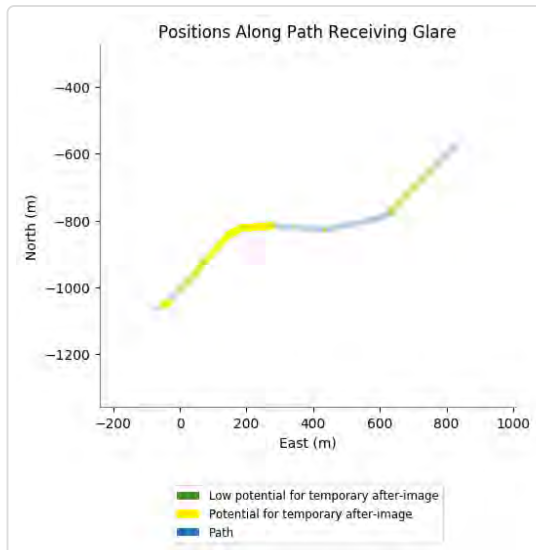
PV array is expected to produce the following glare for receptors at this location:

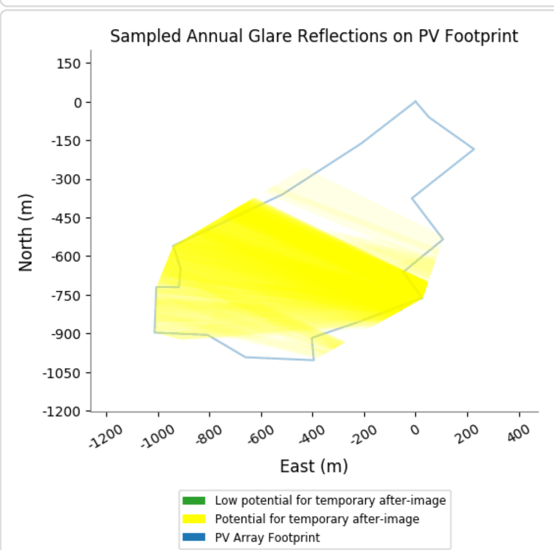
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,984 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Harrow PV

Textured with ARC

Created Oct. 8, 2021
Updated Oct. 8, 2021
Time-step 1 minute
Timezone offset UTC-4
Site ID 59658.10542

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results Glare with potential for temporary after-image predicted

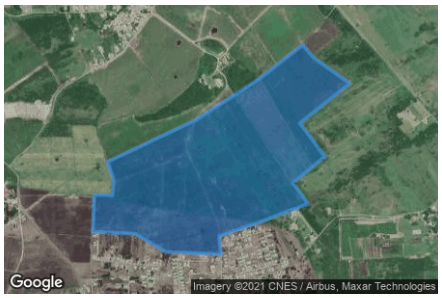
PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	13.0	180.0	0	53,276	-

Component Data

PV Array(s)

Total PV footprint area: 623,498 m^2

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 13.0 deg
Orientation: 180.0 deg
Footprint area: 623,498 m^2
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.132593	-59.469503	57.47	0.60	58.07
2	13.132039	-59.469020	56.07	0.60	56.67
3	13.130921	-59.467411	54.10	0.60	54.70
4	13.129197	-59.469632	53.93	0.60	54.53
5	13.127755	-59.468516	50.68	0.60	51.28
6	13.126606	-59.469943	50.01	0.60	50.61
7	13.125697	-59.469256	50.07	0.60	50.67
8	13.124840	-59.471595	49.43	0.60	50.03
9	13.124297	-59.473215	48.75	0.60	49.35
10	13.123513	-59.473140	46.97	0.60	47.57
11	13.123618	-59.475586	48.26	0.60	48.86
12	13.124401	-59.476938	49.67	0.60	50.27
13	13.124485	-59.478837	49.82	0.60	50.42
14	13.126083	-59.478773	53.88	0.60	54.48
15	13.126073	-59.477968	54.00	0.60	54.60
16	13.126731	-59.477904	54.37	0.60	54.97
17	13.127525	-59.478172	55.99	0.60	56.59
18	13.129333	-59.474264	58.27	0.60	58.87
19	13.131115	-59.471450	59.91	0.60	60.51

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.135648	-59.469339	66.95	1.20	68.15
2	13.134467	-59.468116	58.68	1.20	59.88
3	13.129081	-59.463345	48.37	1.20	49.57
4	13.127441	-59.461789	45.22	1.20	46.42

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.120339	-59.478393	43.36	1.20	44.56
2	13.122659	-59.479487	47.07	1.20	48.27
3	13.123397	-59.480059	48.41	1.20	49.61
4	13.125341	-59.481840	50.49	1.20	51.69
5	13.125853	-59.482129	52.73	1.20	53.93
6	13.126971	-59.482194	57.75	1.20	58.95
7	13.127319	-59.482565	58.76	1.20	59.96

Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.127435	-59.482463	58.53	1.20	59.73
2	13.128250	-59.481594	57.66	1.20	58.86
3	13.129608	-59.480661	64.75	1.20	65.95
4	13.130339	-59.480489	66.49	1.20	67.69
5	13.130757	-59.480124	67.34	1.20	68.54
6	13.131877	-59.478083	69.21	1.20	70.41
7	13.132253	-59.477503	69.75	1.20	70.95
8	13.133946	-59.476184	74.28	1.20	75.48
9	13.132682	-59.474371	66.83	1.20	68.03
10	13.132880	-59.473781	66.11	1.20	67.31
11	13.132723	-59.473083	64.95	1.20	66.15
12	13.132389	-59.472836	64.60	1.20	65.80
13	13.134857	-59.470321	64.04	1.20	65.24
14	13.135568	-59.469431	66.79	1.20	67.99

Name: Route 4
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.123002	-59.470070	43.40	1.20	44.60
2	13.123164	-59.469784	43.96	1.20	45.16
3	13.124952	-59.468174	47.47	1.20	48.67
4	13.125156	-59.467837	47.29	1.20	48.49
5	13.125219	-59.466914	46.99	1.20	48.19
6	13.125109	-59.465487	46.50	1.20	47.70
7	13.125417	-59.463990	46.55	1.20	47.75
8	13.125569	-59.463706	45.61	1.20	46.81
9	13.127401	-59.461855	45.16	1.20	46.36

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	13.130926	-59.473258	63.97	4.80	68.77
OP 2	13.135241	-59.470198	66.08	1.80	67.88
OP 3	13.139399	-59.467971	69.40	1.80	71.20
OP 4	13.130744	-59.456905	44.41	4.80	49.21
OP 5	13.125491	-59.463659	45.65	4.80	50.45
OP 6	13.125210	-59.469831	49.99	4.80	54.79
OP 7	13.124343	-59.472310	47.58	1.80	49.38
OP 8	13.123371	-59.474799	46.52	1.80	48.32
OP 9	13.124311	-59.478747	49.32	4.80	54.12
OP 10	13.125011	-59.481912	49.62	4.80	54.42
OP 11	13.132421	-59.477747	70.34	1.80	72.14

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array 1	13.0	180.0	0	53,276	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	57	435	1770	2418	3114	3351	3306	2707	2075	858	124	0

PV & Receptor Analysis Results

Results for each PV array and receptor

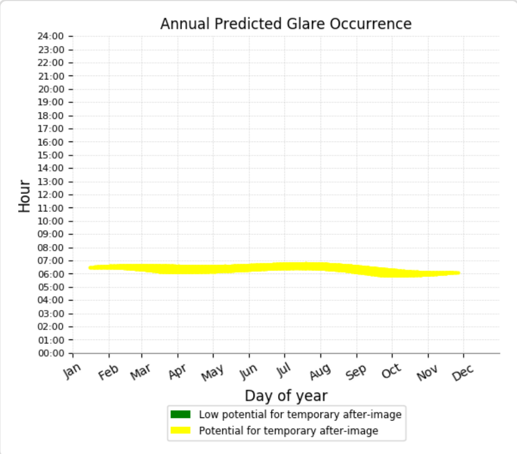
PV array 1 potential temporary after-image

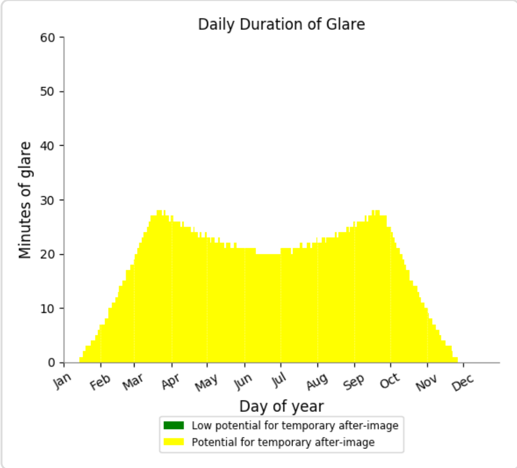
Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	6054
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	549
OP: OP 5	0	3394
OP: OP 6	0	12408
OP: OP 7	0	6861
OP: OP 8	0	5972
OP: OP 9	0	6012
OP: OP 10	0	2152
OP: OP 11	0	672
Route: Route 1	0	2124
Route: Route 2	0	830
Route: Route 3	0	2416
Route: Route 4	0	3832

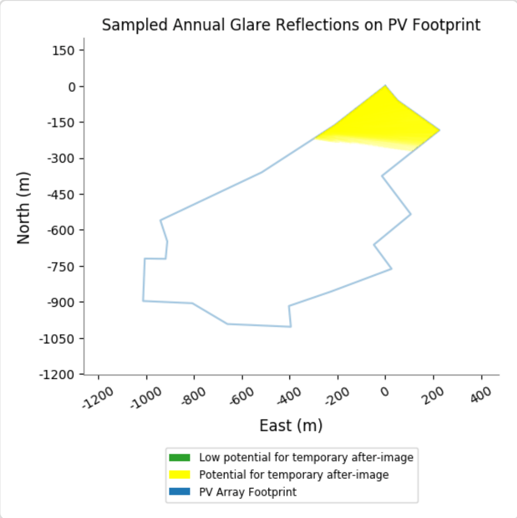
PV array 1 - OP Receptor (OP 1)

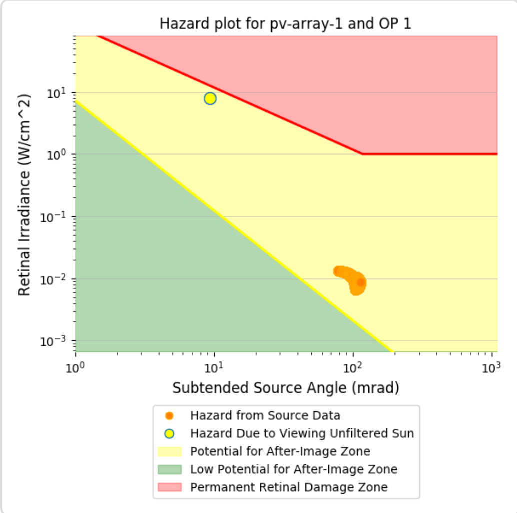
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,054 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - OP Receptor (OP 2)

No glare found

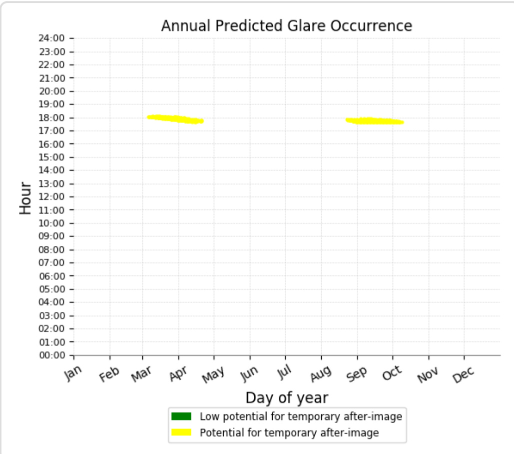
PV array 1 - OP Receptor (OP 3)

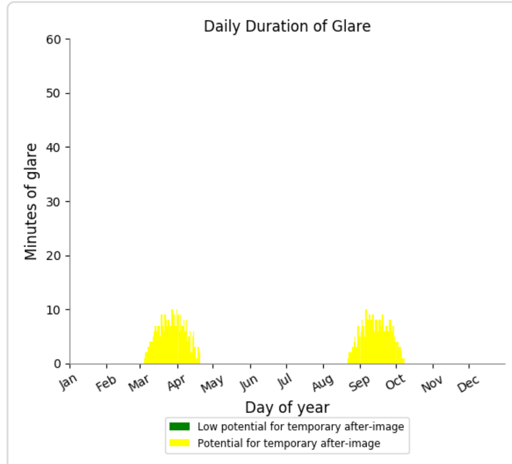
No glare found

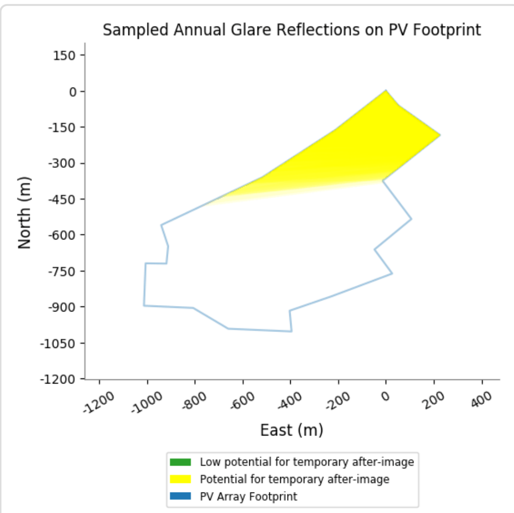
PV array 1 - OP Receptor (OP 4)

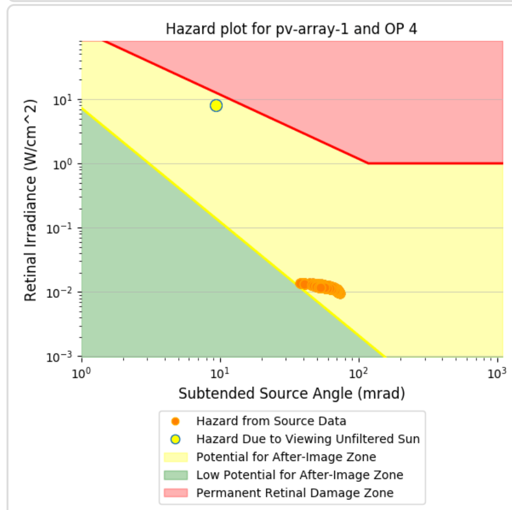
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 549 minutes of "yellow" glare with potential to cause temporary after-image.





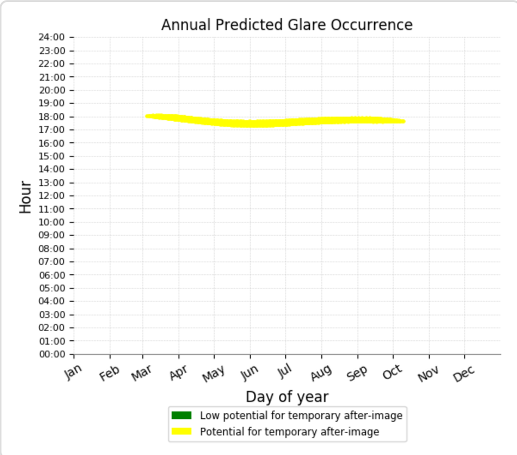


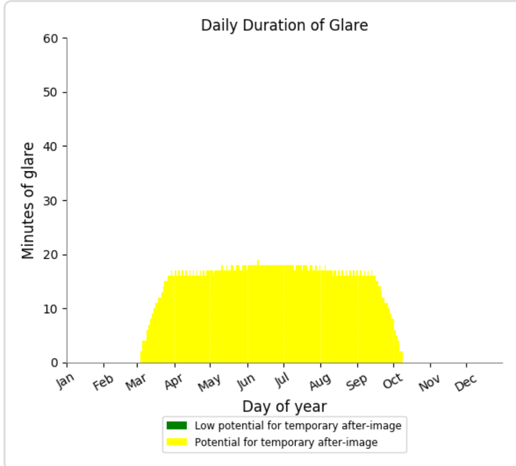


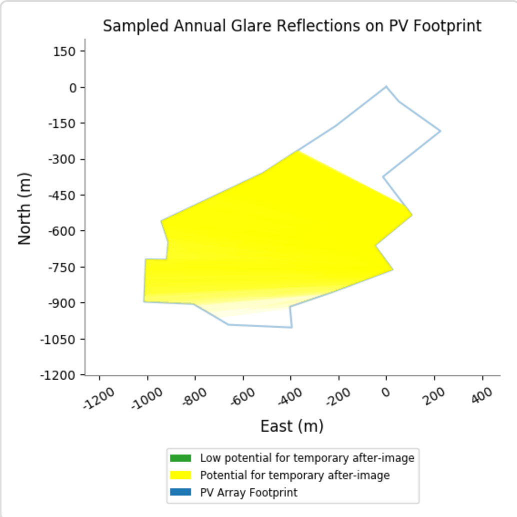
PV array 1 - OP Receptor (OP 5)

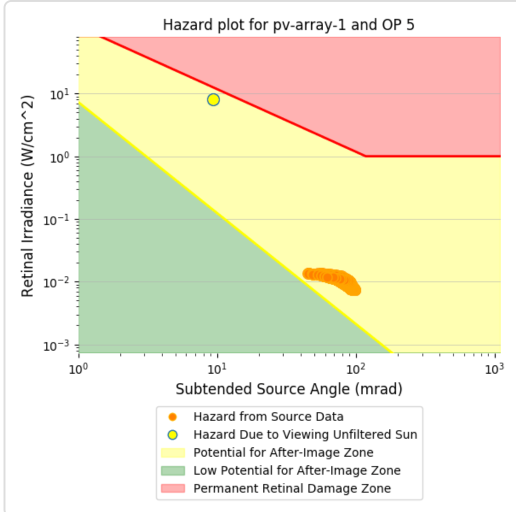
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,394 minutes of "yellow" glare with potential to cause temporary after-image.





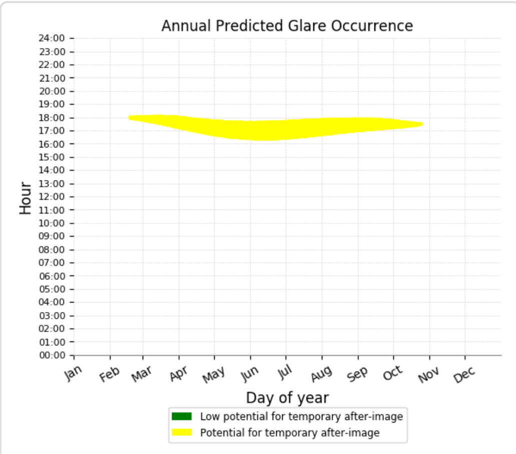


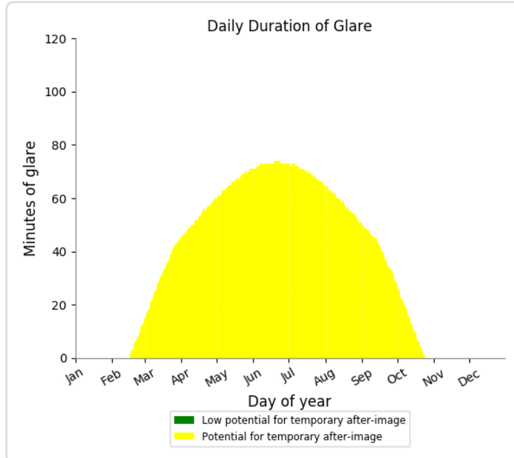


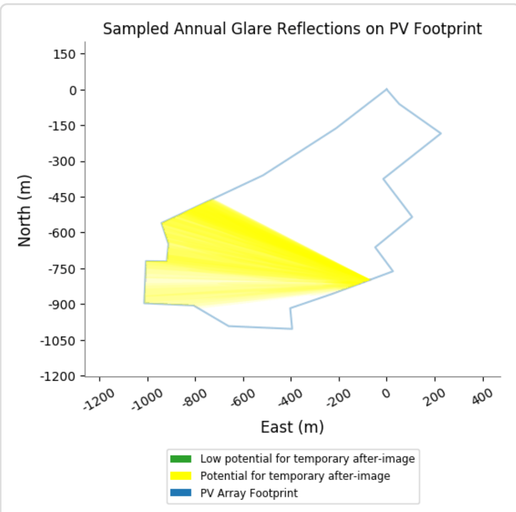
PV array 1 - OP Receptor (OP 6)

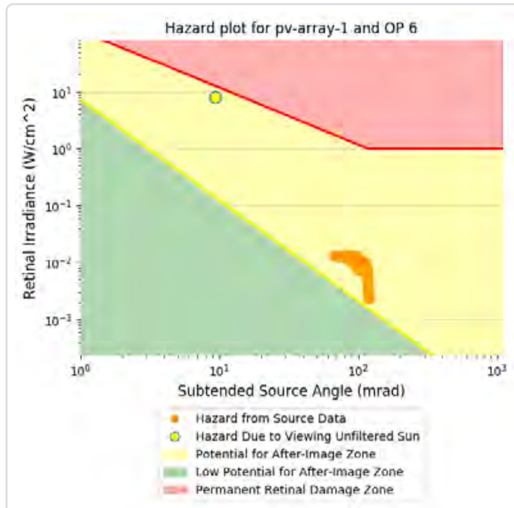
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 12,408 minutes of "yellow" glare with potential to cause temporary after-image.





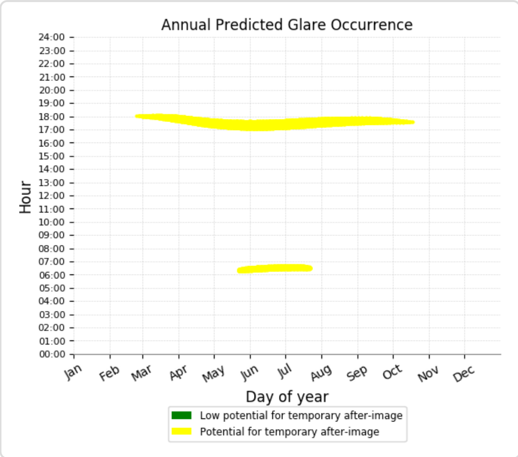


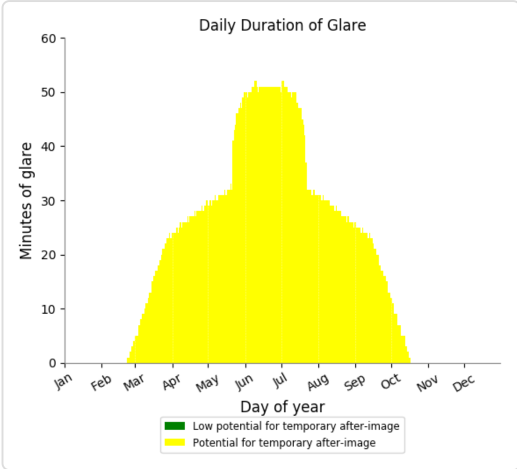


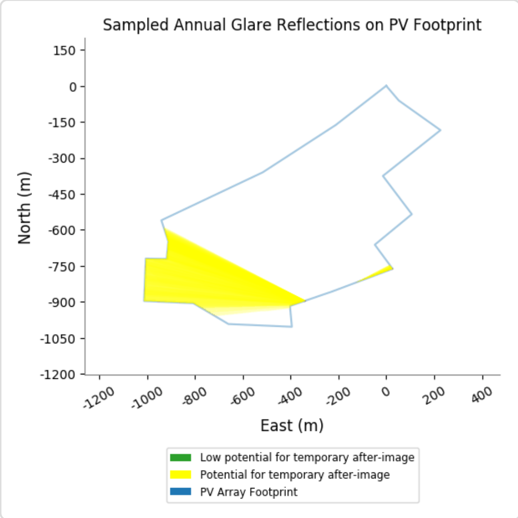
PV array 1 - OP Receptor (OP 7)

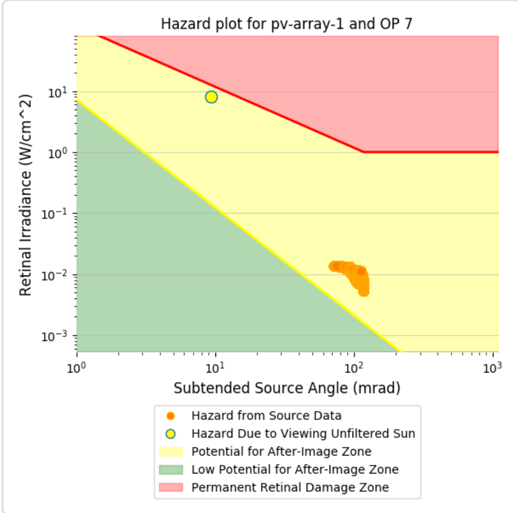
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,861 minutes of "yellow" glare with potential to cause temporary after-image.





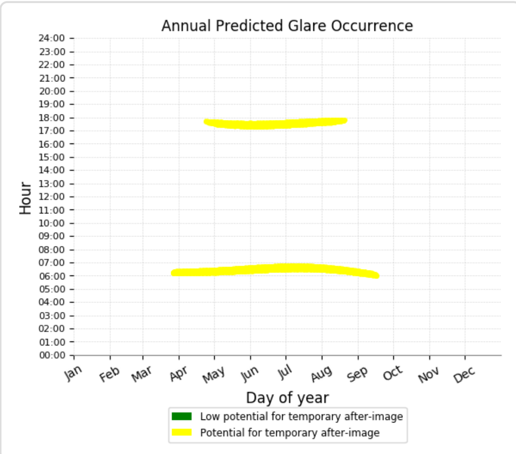


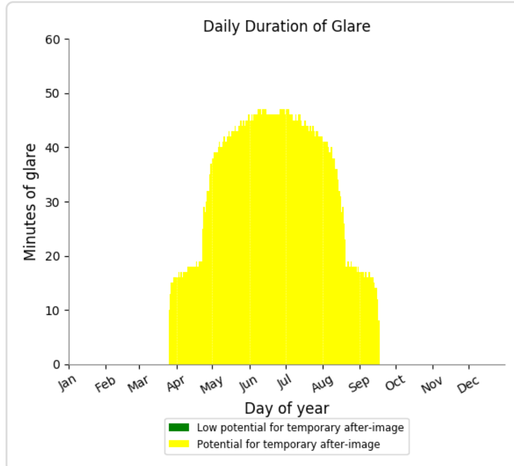


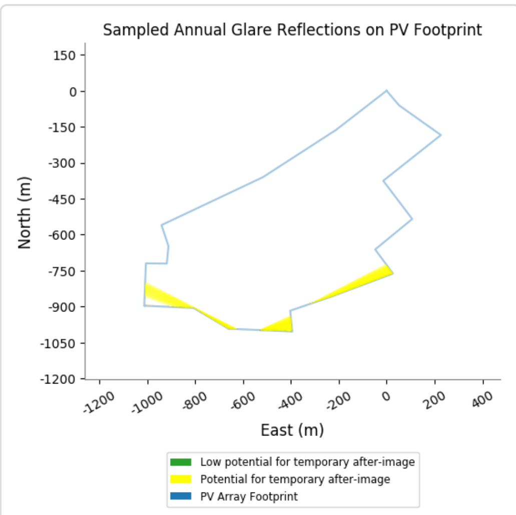
PV array 1 - OP Receptor (OP 8)

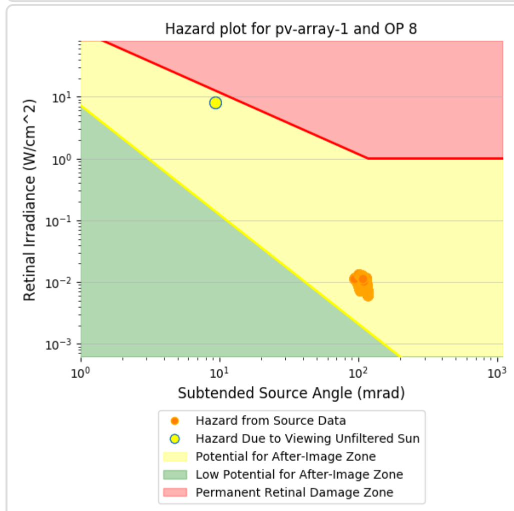
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 5,972 minutes of "yellow" glare with potential to cause temporary after-image.





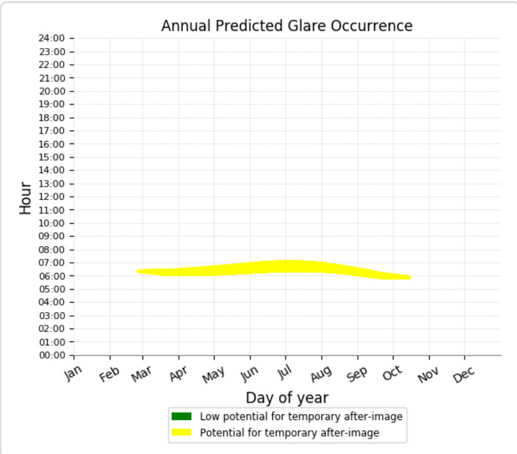


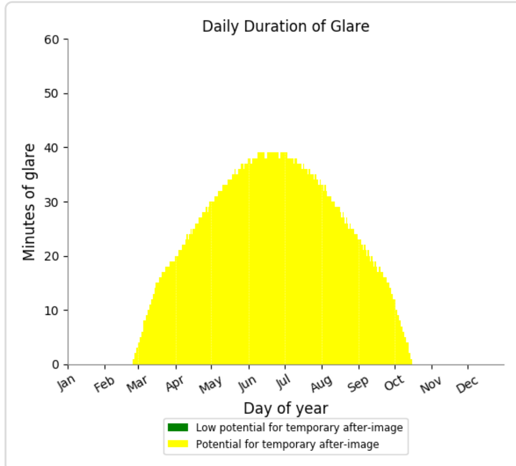


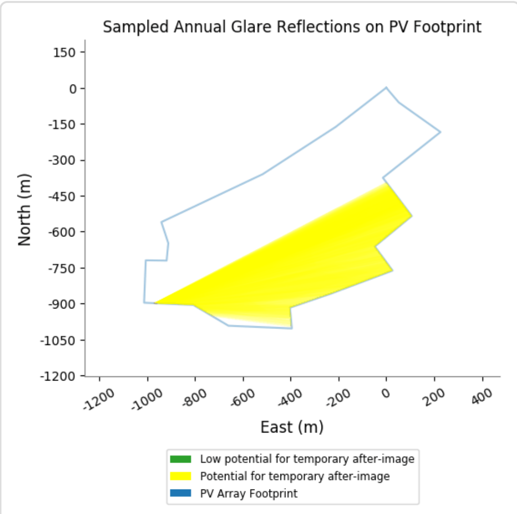
PV array 1 - OP Receptor (OP 9)

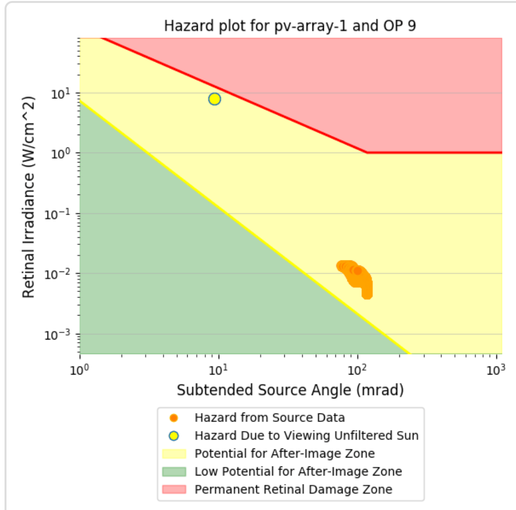
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,012 minutes of "yellow" glare with potential to cause temporary after-image.





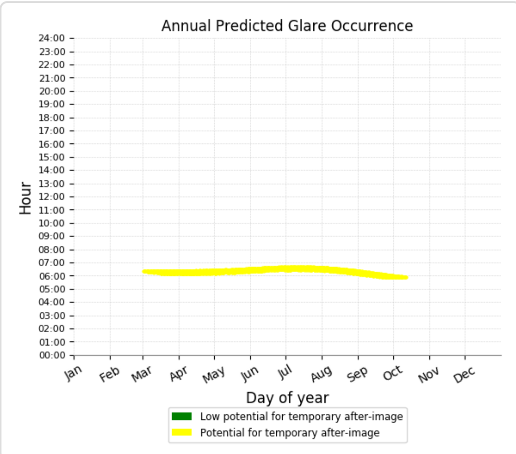


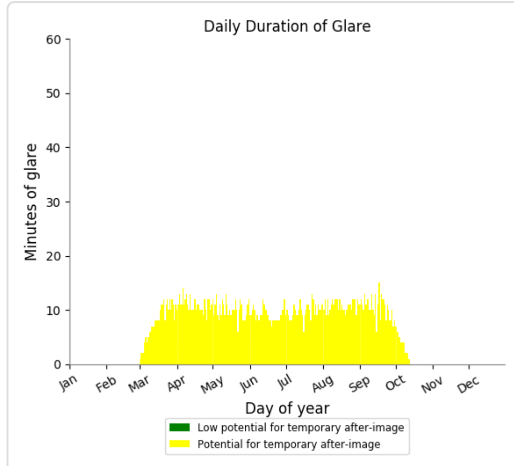


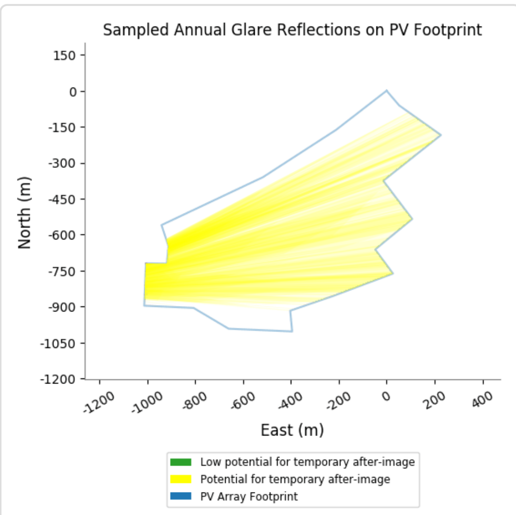
PV array 1 - OP Receptor (OP 10)

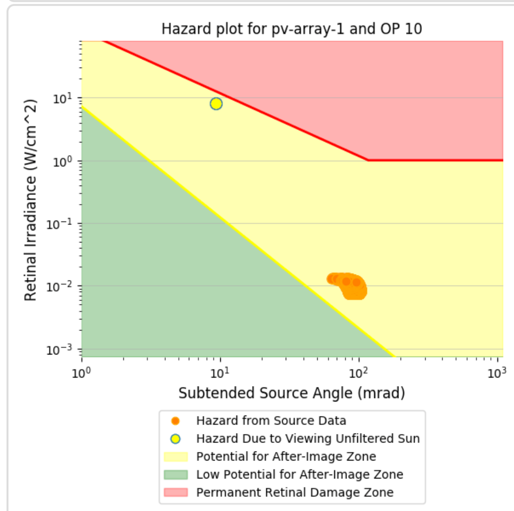
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,152 minutes of "yellow" glare with potential to cause temporary after-image.





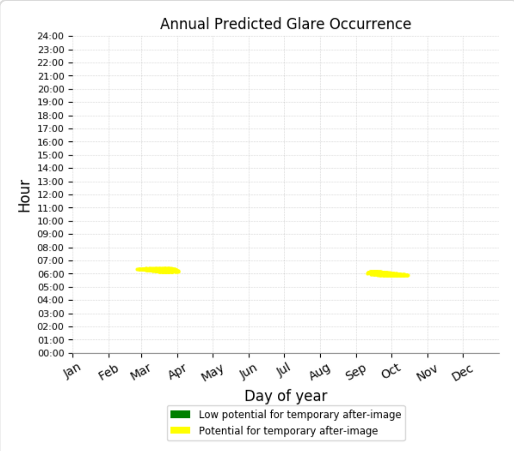


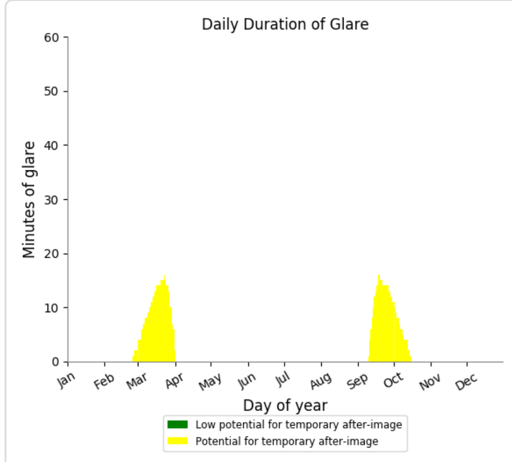


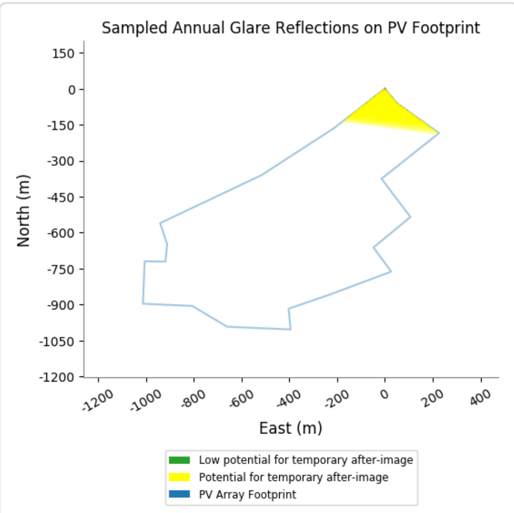
PV array 1 - OP Receptor (OP 11)

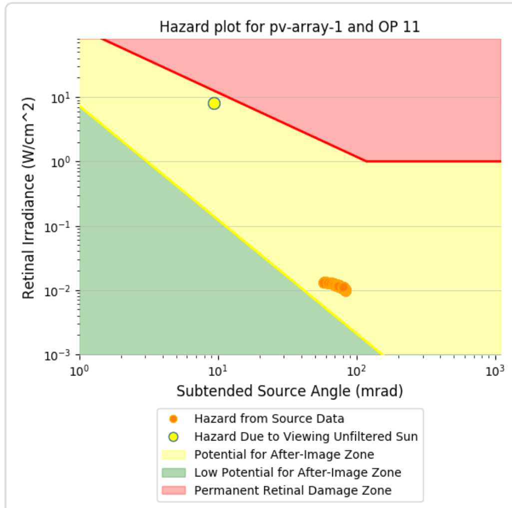
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 672 minutes of "yellow" glare with potential to cause temporary after-image.





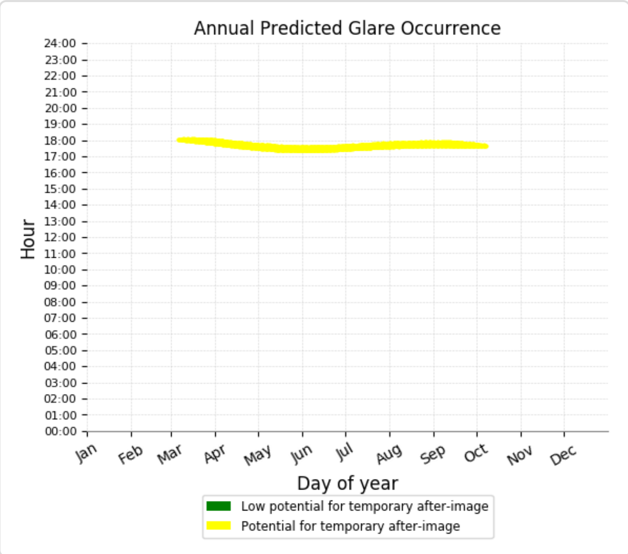


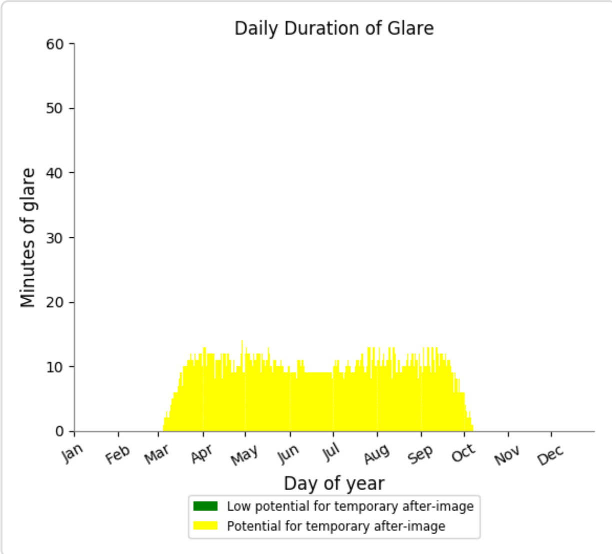


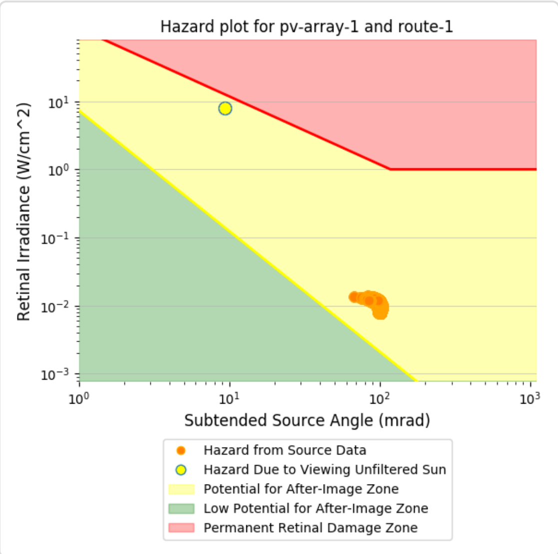
PV array 1 - Route Receptor (Route 1)

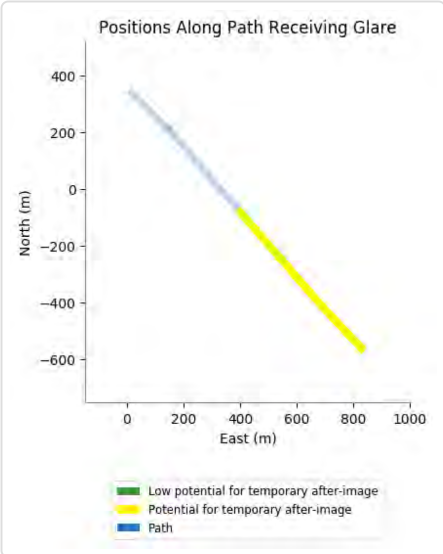
PV array is expected to produce the following glare for receptors at this location:

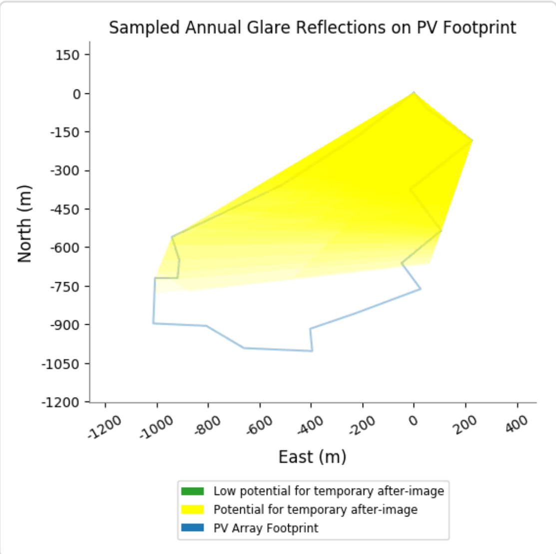
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,124 minutes of "yellow" glare with potential to cause temporary after-image.







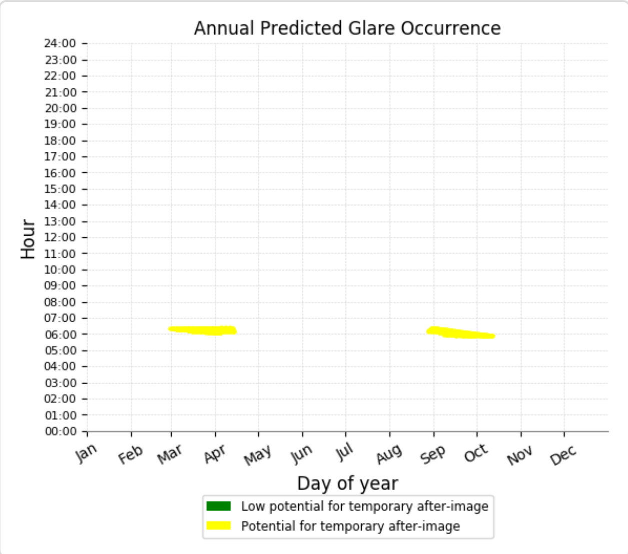


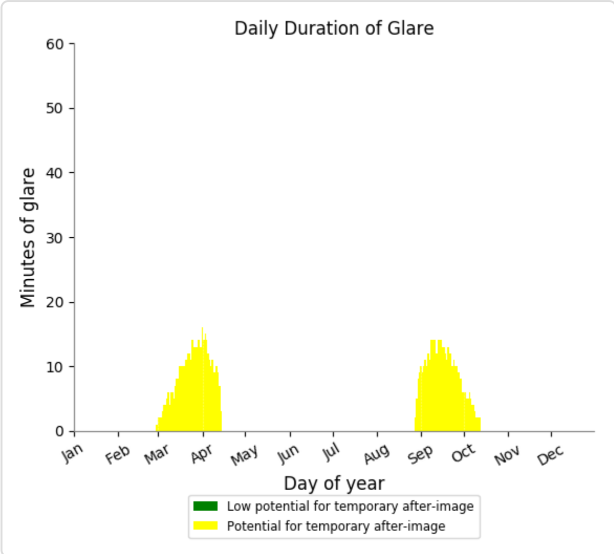


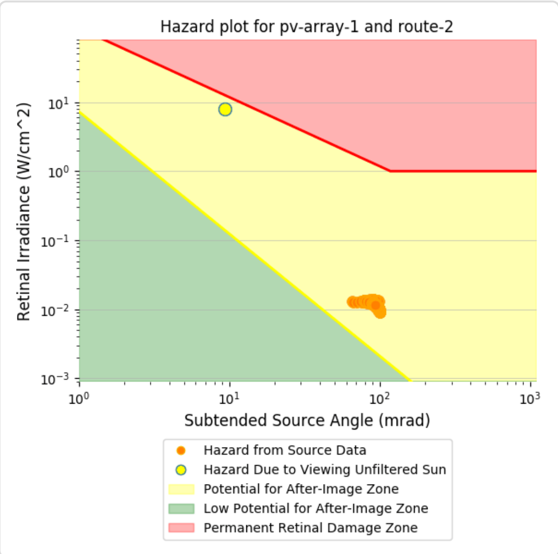
PV array 1 - Route Receptor (Route 2)

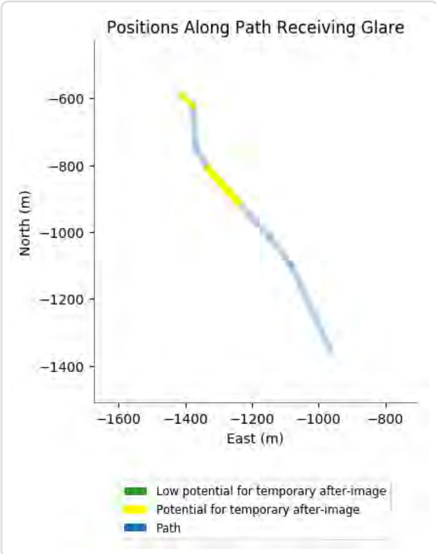
PV array is expected to produce the following glare for receptors at this location:

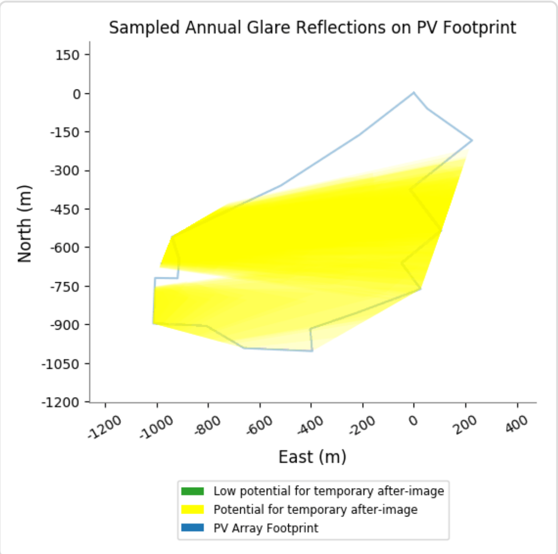
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 830 minutes of "yellow" glare with potential to cause temporary after-image.







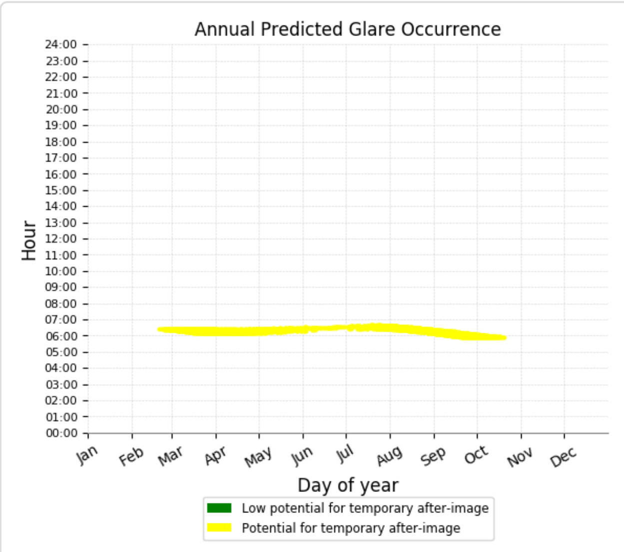


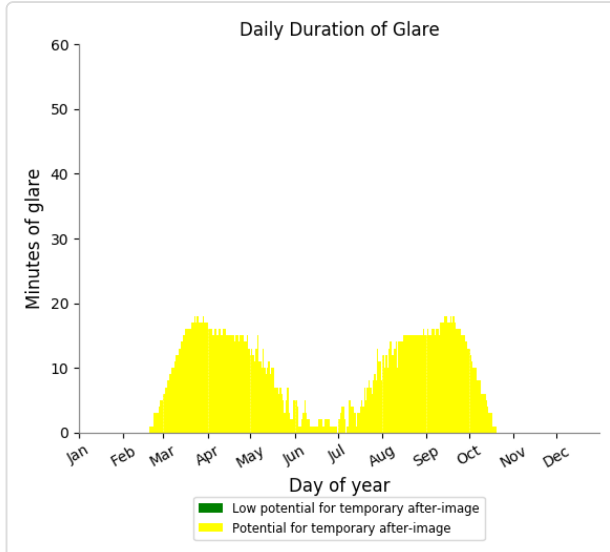


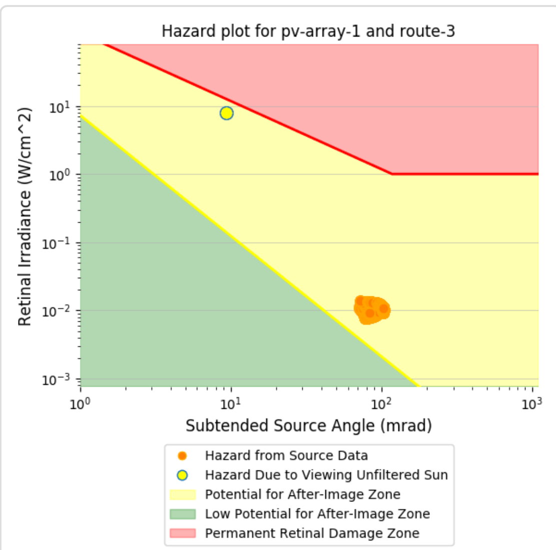
PV array 1 - Route Receptor (Route 3)

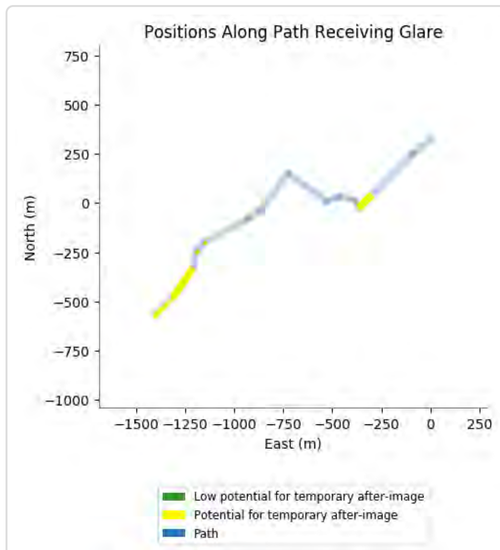
PV array is expected to produce the following glare for receptors at this location:

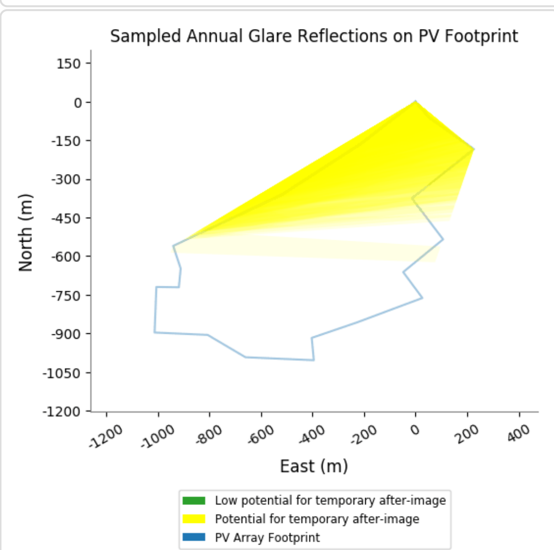
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,416 minutes of "yellow" glare with potential to cause temporary after-image.







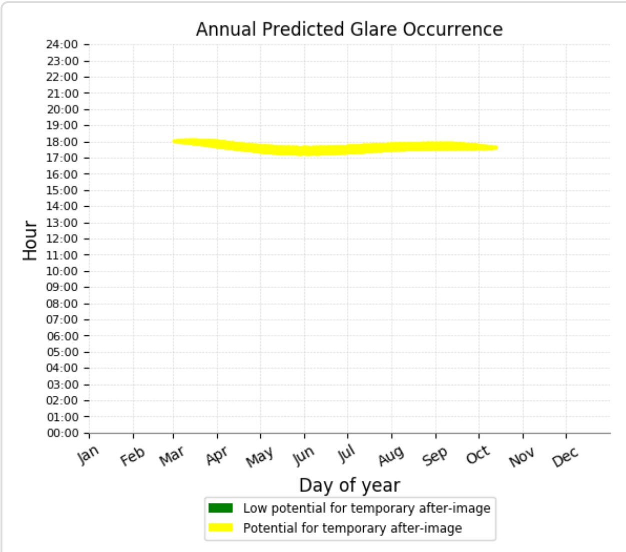


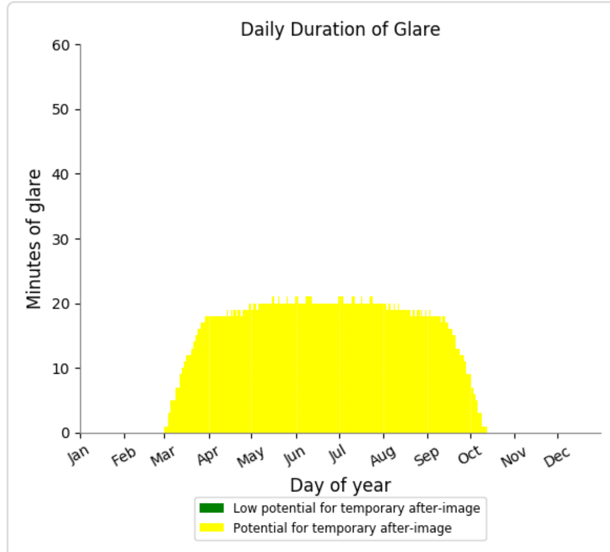


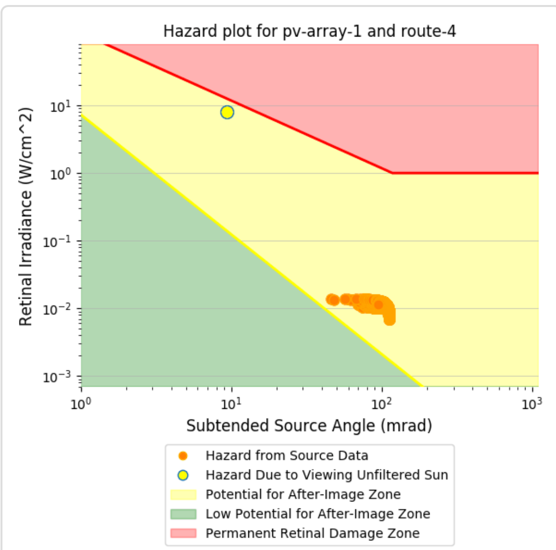
PV array 1 - Route Receptor (Route 4)

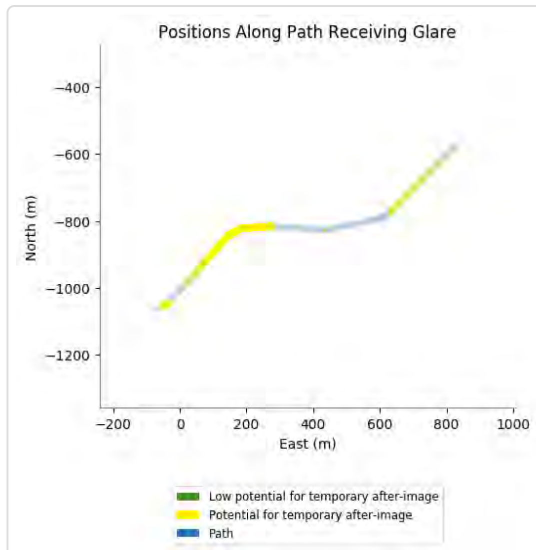
PV array is expected to produce the following glare for receptors at this location:

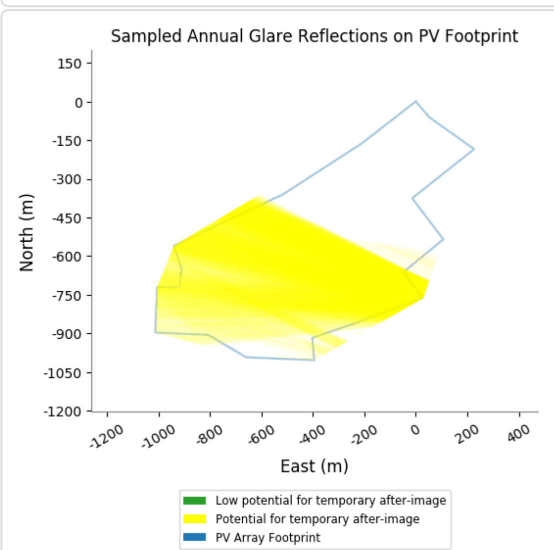
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,832 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Harrow PV

Textured without ARC

Created Oct. 8, 2021
Updated Oct. 8, 2021
Time-step 1 minute
Timezone offset UTC-4
Site ID 59656.10542

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results Glare with potential for temporary after-image predicted

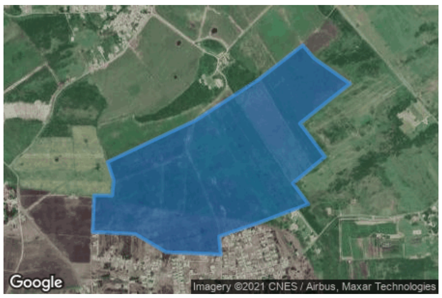
PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	13.0	180.0	0	55,260	-

Component Data

PV Array(s)

Total PV footprint area: 623,498 m^2

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 13.0 deg
Orientation: 180.0 deg
Footprint area: 623,498 m^2
Rated power: -
Panel material: Light textured glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.7 mrad



Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.132593	-59.469503	57.47	0.60	58.07
2	13.132039	-59.469020	56.07	0.60	56.67
3	13.130921	-59.467411	54.10	0.60	54.70
4	13.129197	-59.469632	53.93	0.60	54.53
5	13.127755	-59.468516	50.68	0.60	51.28
6	13.126606	-59.469943	50.01	0.60	50.61
7	13.125697	-59.469256	50.07	0.60	50.67
8	13.124840	-59.471595	49.43	0.60	50.03
9	13.124297	-59.473215	48.75	0.60	49.35
10	13.123513	-59.473140	46.97	0.60	47.57
11	13.123618	-59.475586	48.26	0.60	48.86
12	13.124401	-59.476938	49.67	0.60	50.27
13	13.124485	-59.478837	49.82	0.60	50.42
14	13.126083	-59.478773	53.88	0.60	54.48
15	13.126073	-59.477968	54.00	0.60	54.60
16	13.126731	-59.477904	54.37	0.60	54.97
17	13.127525	-59.478172	55.99	0.60	56.59
18	13.129333	-59.474264	58.27	0.60	58.87
19	13.131115	-59.471450	59.91	0.60	60.51

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.135648	-59.469339	66.95	1.20	68.15
2	13.134467	-59.468116	58.68	1.20	59.88
3	13.129081	-59.463345	48.37	1.20	49.57
4	13.127441	-59.461789	45.22	1.20	46.42

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.120339	-59.478393	43.36	1.20	44.56
2	13.122659	-59.479487	47.07	1.20	48.27
3	13.123397	-59.480059	48.41	1.20	49.61
4	13.125341	-59.481840	50.49	1.20	51.69
5	13.125853	-59.482129	52.73	1.20	53.93
6	13.126971	-59.482194	57.75	1.20	58.95
7	13.127319	-59.482565	58.76	1.20	59.96

Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.127435	-59.482463	58.53	1.20	59.73
2	13.128250	-59.481594	57.66	1.20	58.86
3	13.129608	-59.480661	64.75	1.20	65.95
4	13.130339	-59.480489	66.49	1.20	67.69
5	13.130757	-59.480124	67.34	1.20	68.54
6	13.131877	-59.478083	69.21	1.20	70.41
7	13.132253	-59.477503	69.75	1.20	70.95
8	13.133946	-59.476184	74.28	1.20	75.48
9	13.132682	-59.474371	66.83	1.20	68.03
10	13.132880	-59.473781	66.11	1.20	67.31
11	13.132723	-59.473083	64.95	1.20	66.15
12	13.132389	-59.472836	64.60	1.20	65.80
13	13.134857	-59.470321	64.04	1.20	65.24
14	13.135568	-59.469431	66.79	1.20	67.99

Name: Route 4
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.123002	-59.470070	43.40	1.20	44.60
2	13.123164	-59.469784	43.96	1.20	45.16
3	13.124952	-59.468174	47.47	1.20	48.67
4	13.125156	-59.467837	47.29	1.20	48.49
5	13.125219	-59.466914	46.99	1.20	48.19
6	13.125109	-59.465487	46.50	1.20	47.70
7	13.125417	-59.463990	46.55	1.20	47.75
8	13.125569	-59.463706	45.61	1.20	46.81
9	13.127401	-59.461855	45.16	1.20	46.36

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	13.130926	-59.473258	63.97	4.80	68.77
OP 2	13.135241	-59.470198	66.08	1.80	67.88
OP 3	13.139399	-59.467971	69.40	1.80	71.20
OP 4	13.130744	-59.456905	44.41	4.80	49.21
OP 5	13.125491	-59.463659	45.65	4.80	50.45
OP 6	13.125210	-59.469831	49.99	4.80	54.79
OP 7	13.124343	-59.472310	47.58	1.80	49.38
OP 8	13.123371	-59.474799	46.52	1.80	48.32
OP 9	13.124311	-59.478747	49.32	4.80	54.12
OP 10	13.125011	-59.481912	49.62	4.80	54.42
OP 11	13.132421	-59.477747	70.34	1.80	72.14

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	13.0	180.0	0	55,260	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	0	0	0	0	0	0	0
pv-array-1 (yellow)	76	469	1820	2470	3173	3405	3361	2760	2125	904	148	2

PV & Receptor Analysis Results

Results for each PV array and receptor

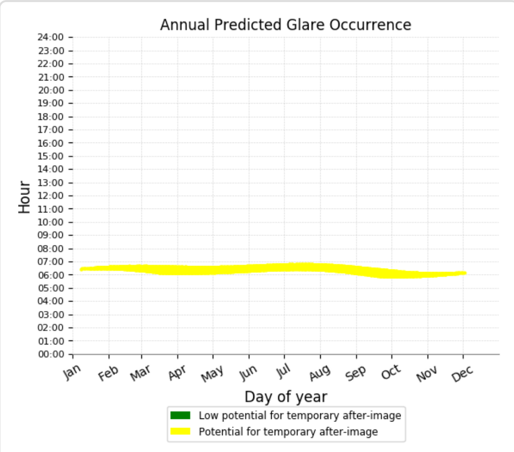
PV array 1 potential temporary after-image

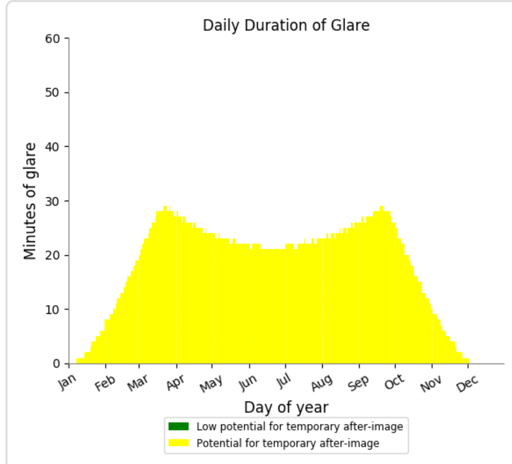
Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	6317
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	568
OP: OP 5	0	3565
OP: OP 6	0	12632
OP: OP 7	0	7132
OP: OP 8	0	6237
OP: OP 9	0	6213
OP: OP 10	0	2224
OP: OP 11	0	725
Route: Route 1	0	2180
Route: Route 2	0	879
Route: Route 3	0	2574
Route: Route 4	0	4014

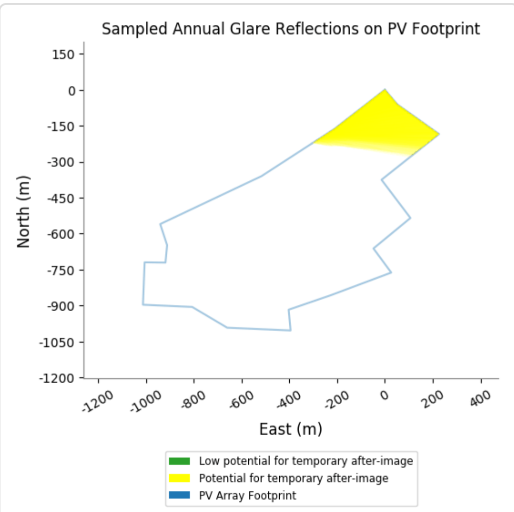
PV array 1 - OP Receptor (OP 1)

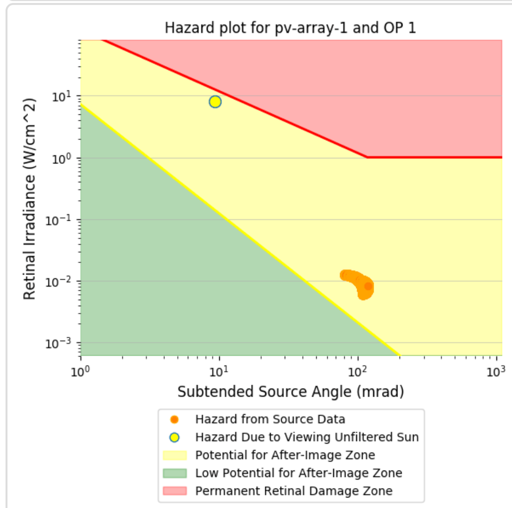
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,317 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - OP Receptor (OP 2)

No glare found

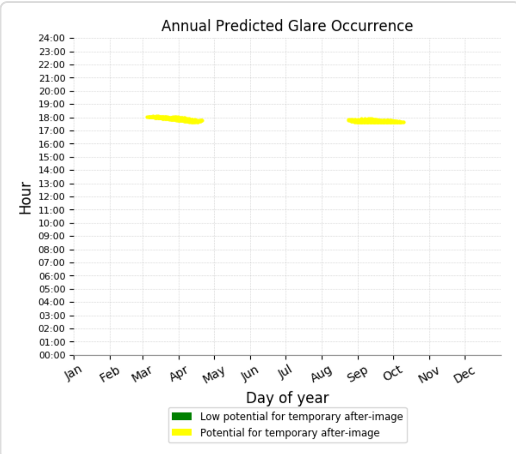
PV array 1 - OP Receptor (OP 3)

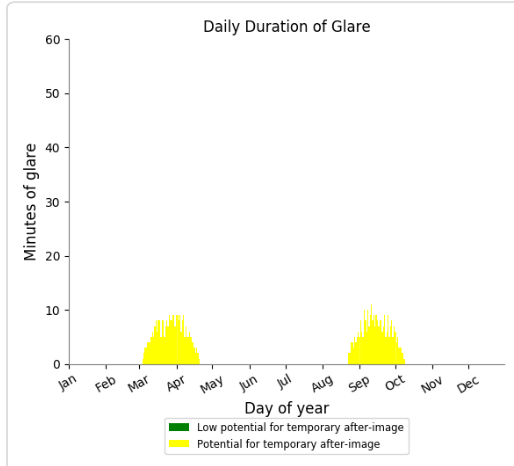
No glare found

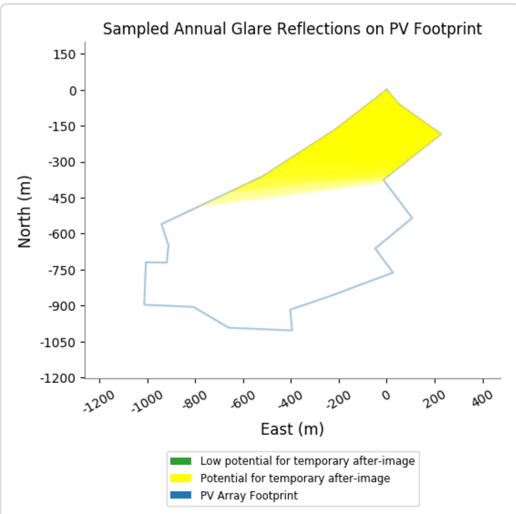
PV array 1 - OP Receptor (OP 4)

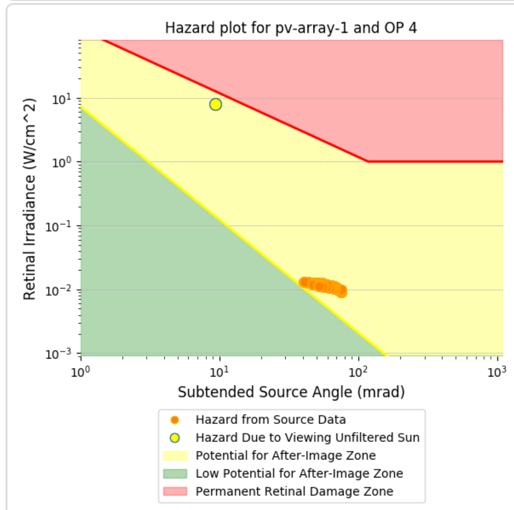
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 568 minutes of "yellow" glare with potential to cause temporary after-image.





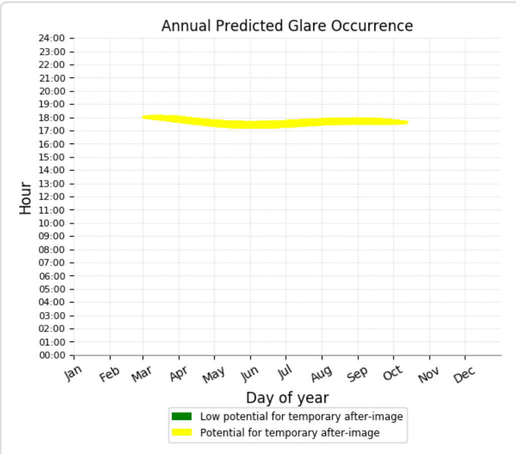


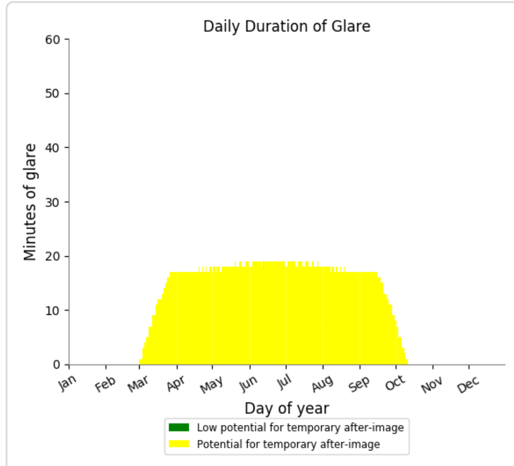


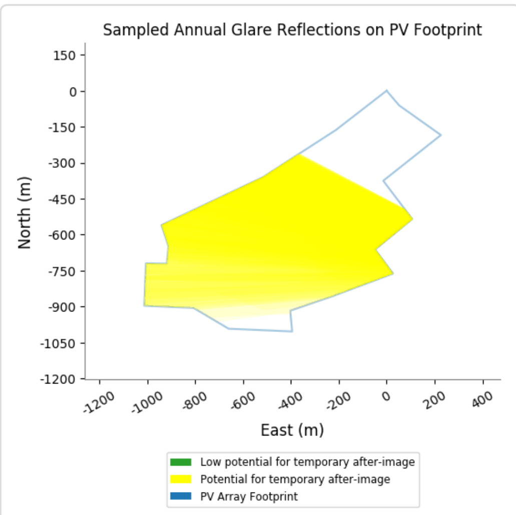
PV array 1 - OP Receptor (OP 5)

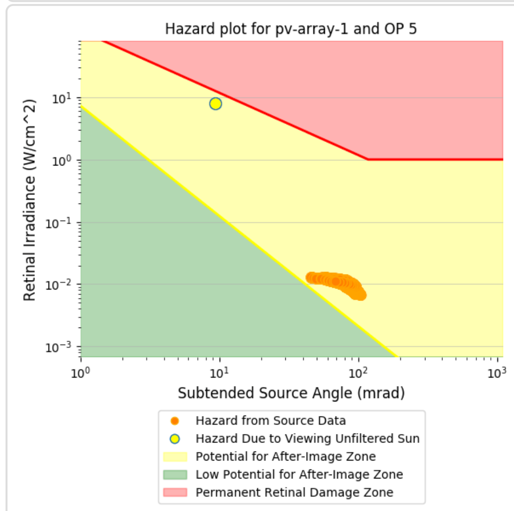
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,565 minutes of "yellow" glare with potential to cause temporary after-image.





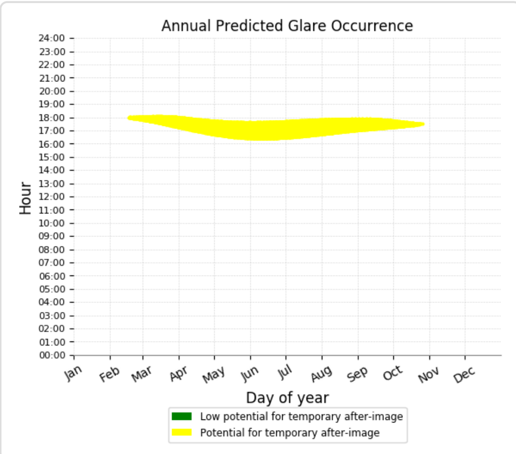


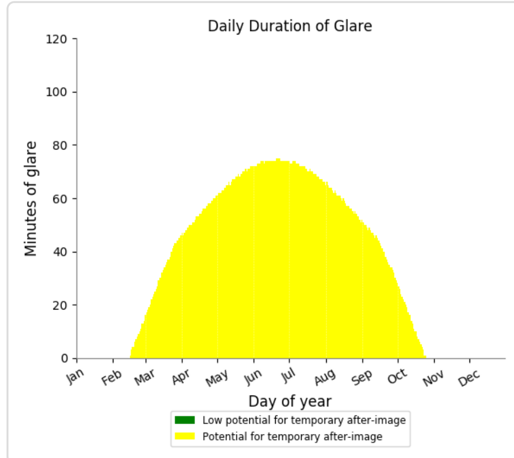


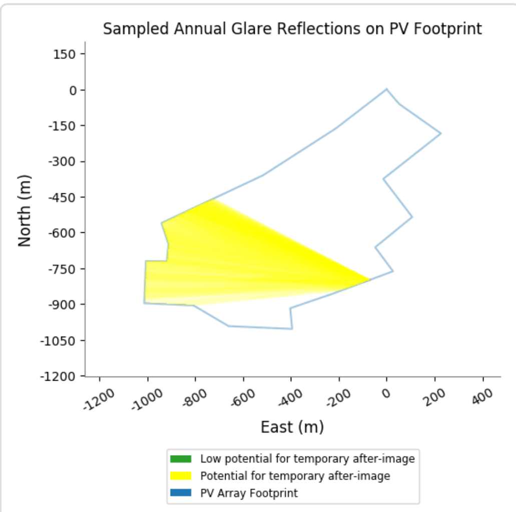
PV array 1 - OP Receptor (OP 6)

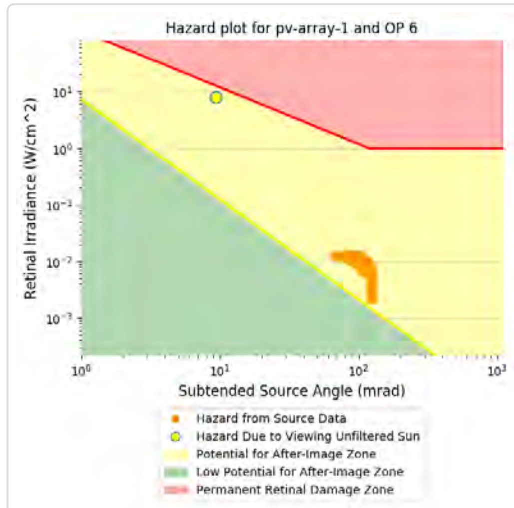
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 12,632 minutes of "yellow" glare with potential to cause temporary after-image.





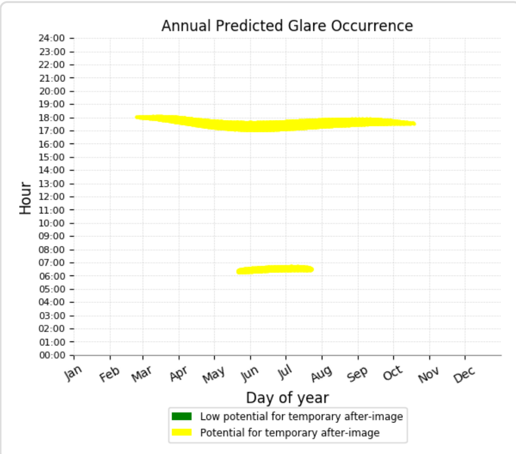


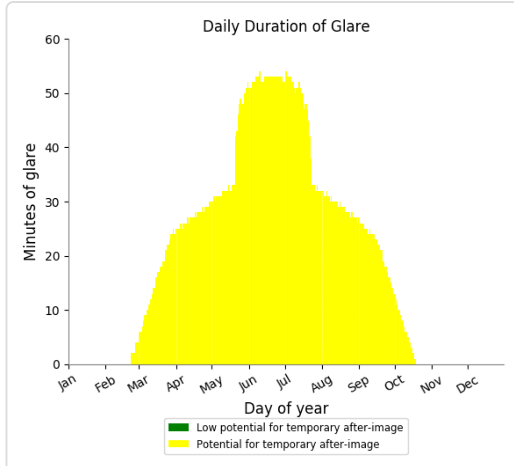


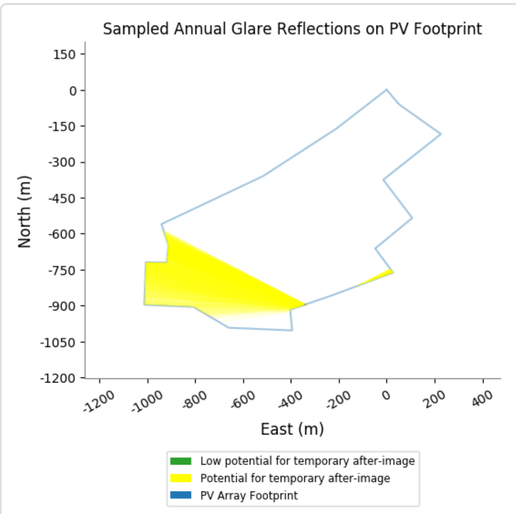
PV array 1 - OP Receptor (OP 7)

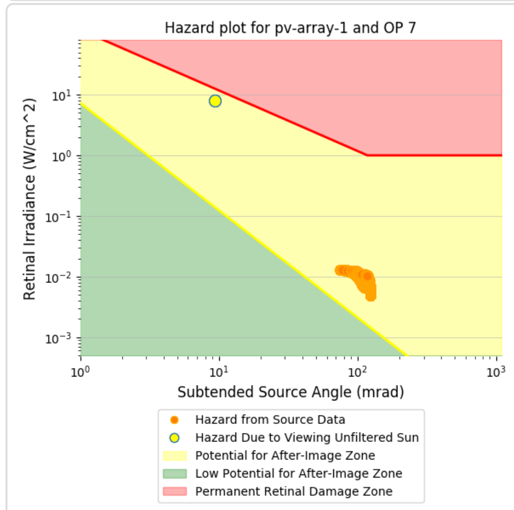
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 7,132 minutes of "yellow" glare with potential to cause temporary after-image.





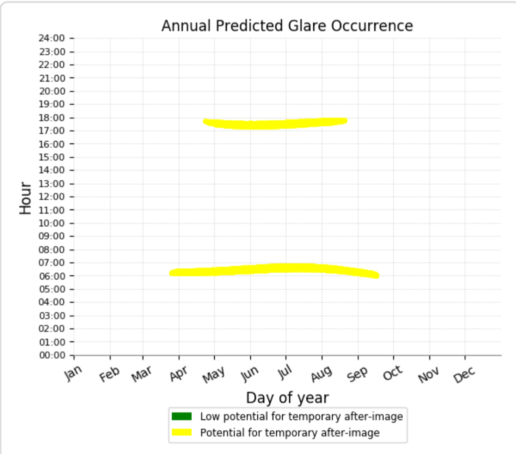


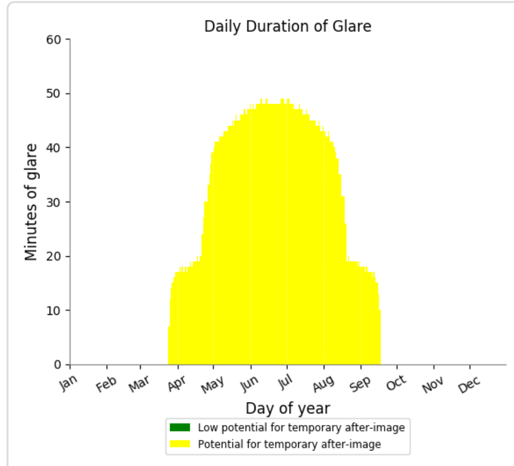


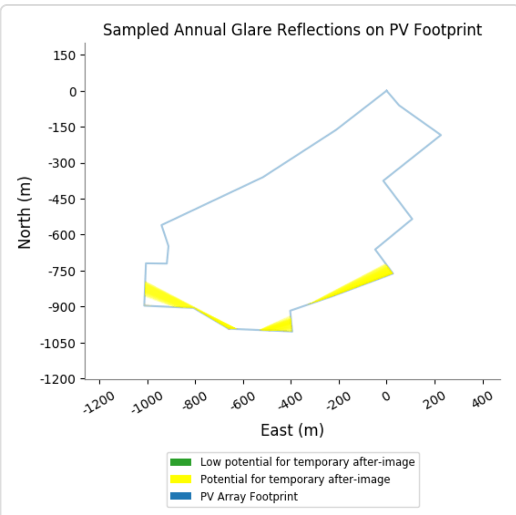
PV array 1 - OP Receptor (OP 8)

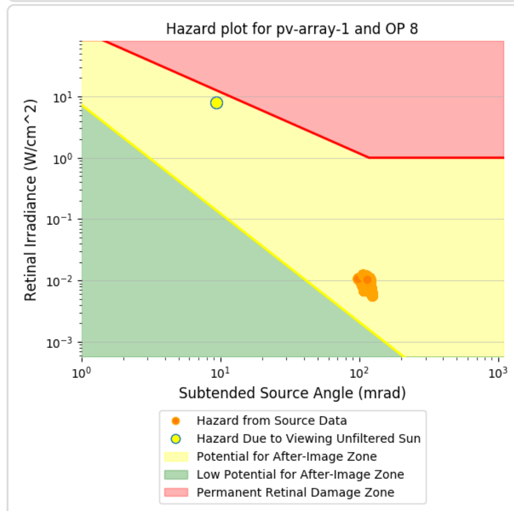
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,237 minutes of "yellow" glare with potential to cause temporary after-image.





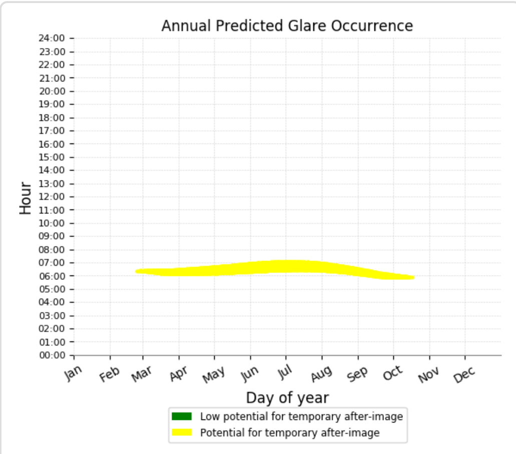


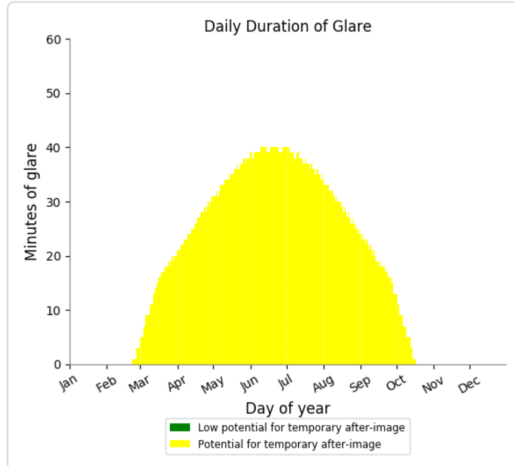


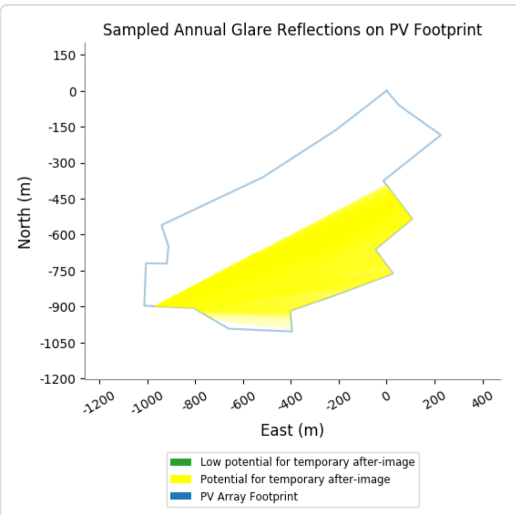
PV array 1 - OP Receptor (OP 9)

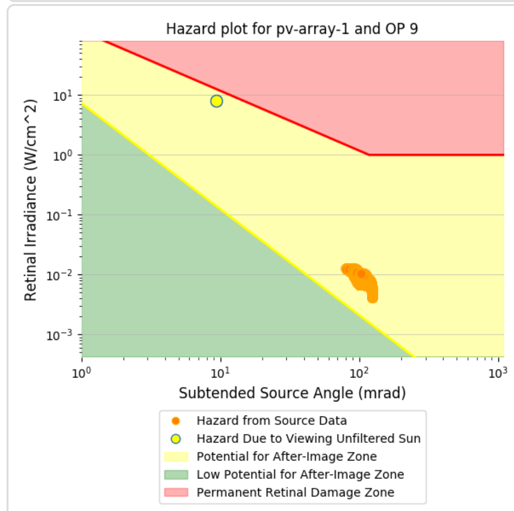
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 6,213 minutes of "yellow" glare with potential to cause temporary after-image.





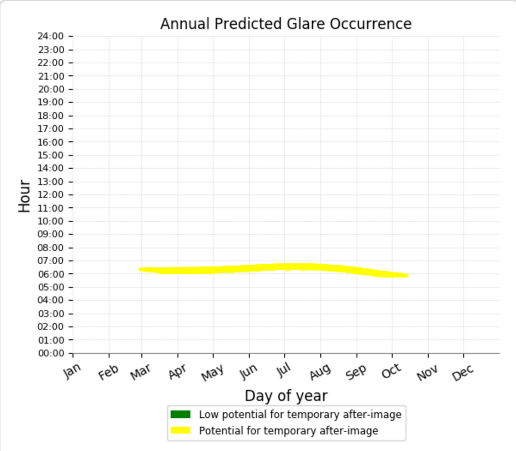


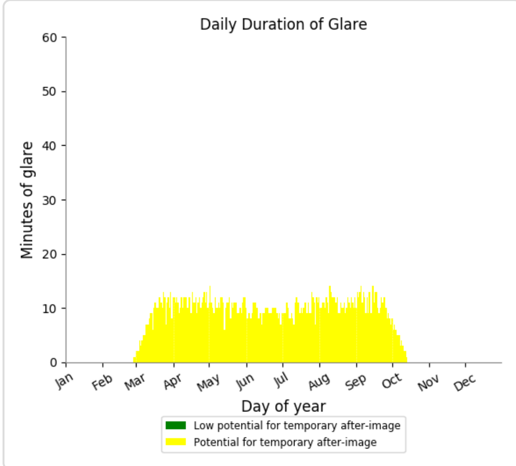


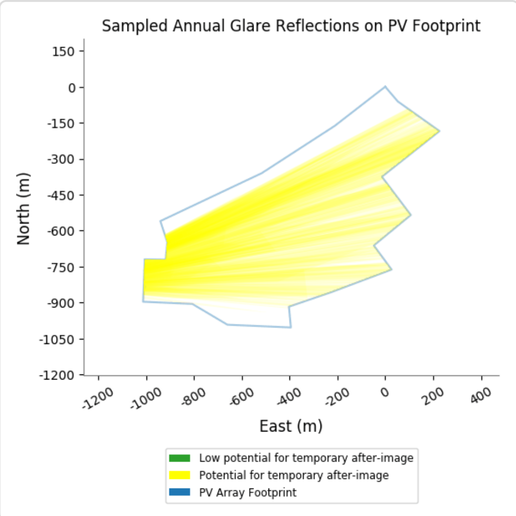
PV array 1 - OP Receptor (OP 10)

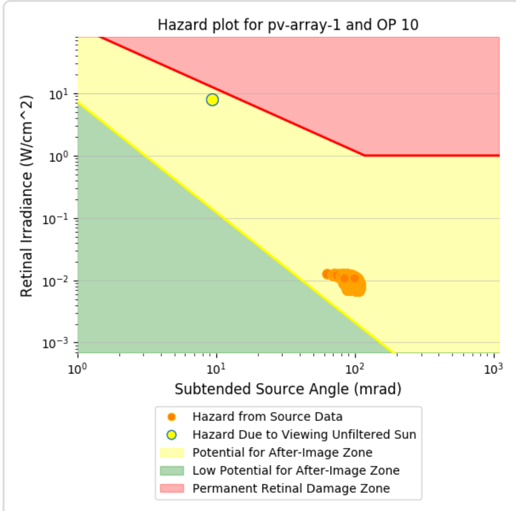
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,224 minutes of "yellow" glare with potential to cause temporary after-image.





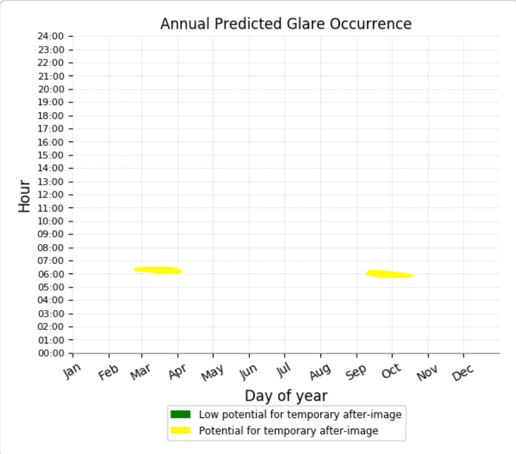


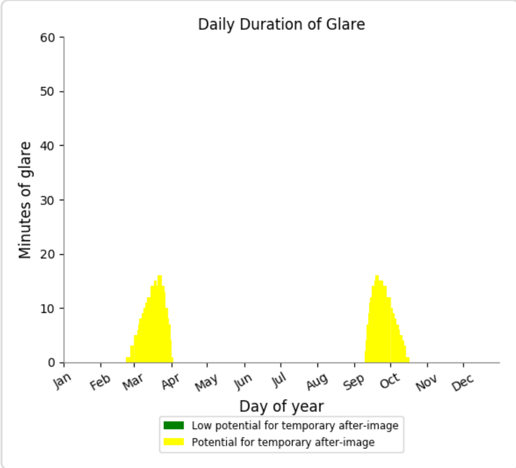


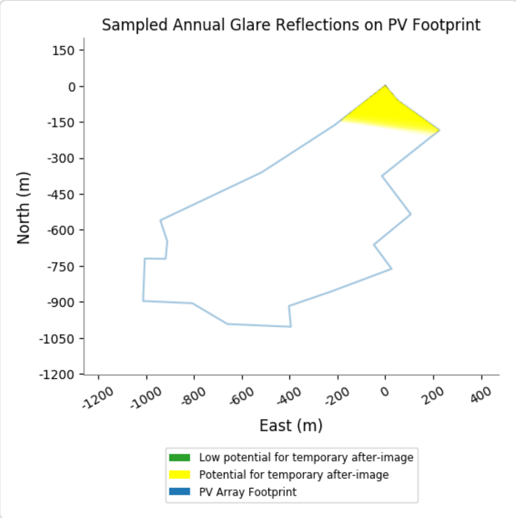
PV array 1 - OP Receptor (OP 11)

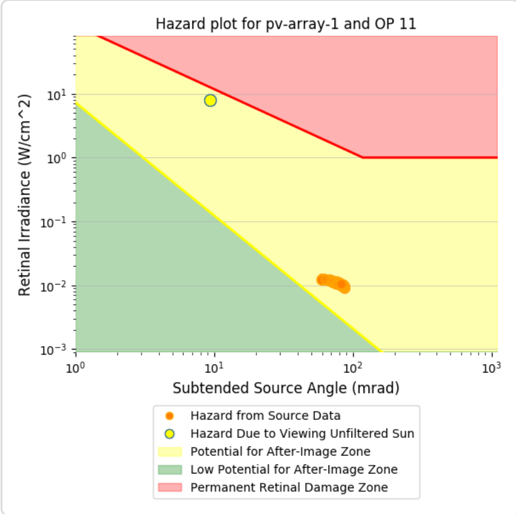
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 725 minutes of "yellow" glare with potential to cause temporary after-image.





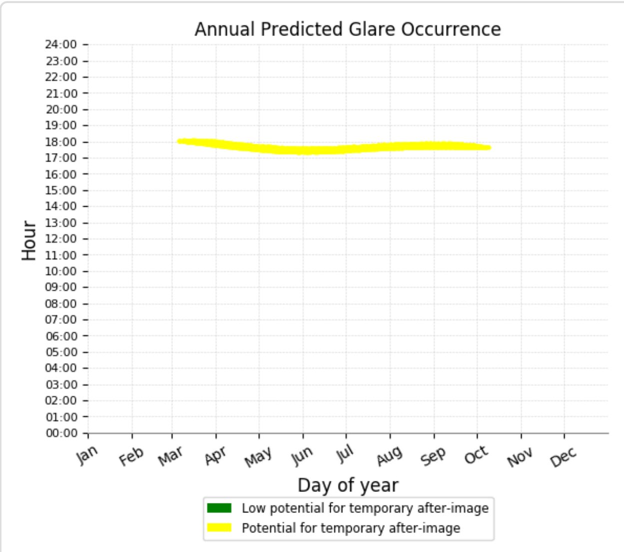


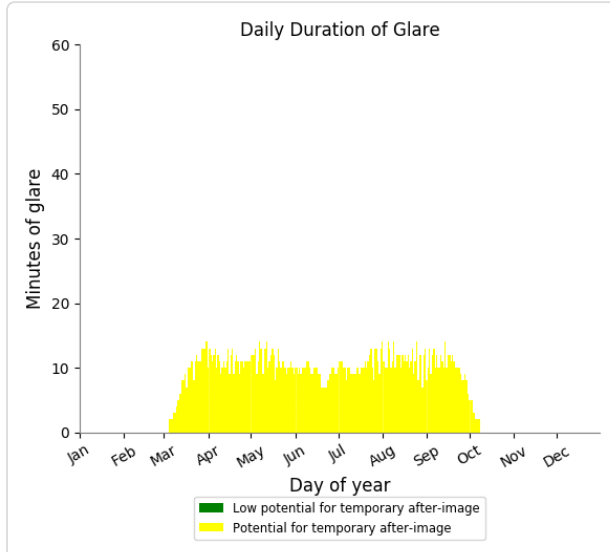


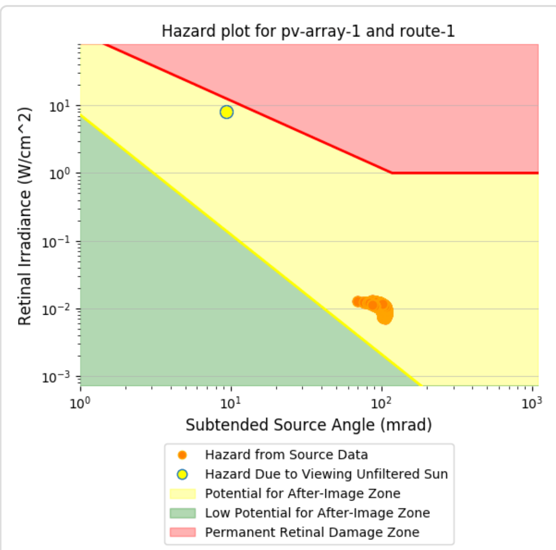
PV array 1 - Route Receptor (Route 1)

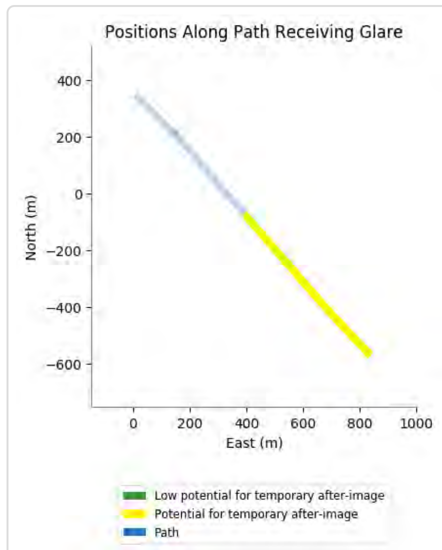
PV array is expected to produce the following glare for receptors at this location:

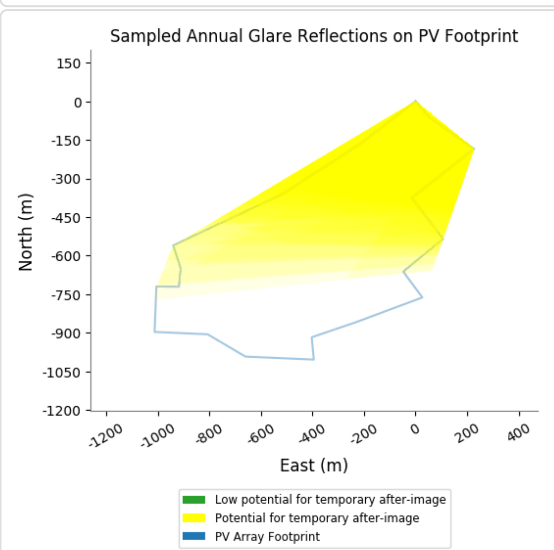
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,180 minutes of "yellow" glare with potential to cause temporary after-image.







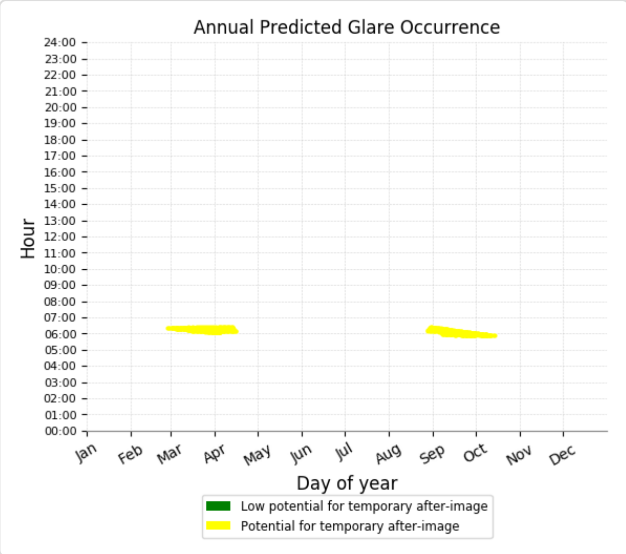


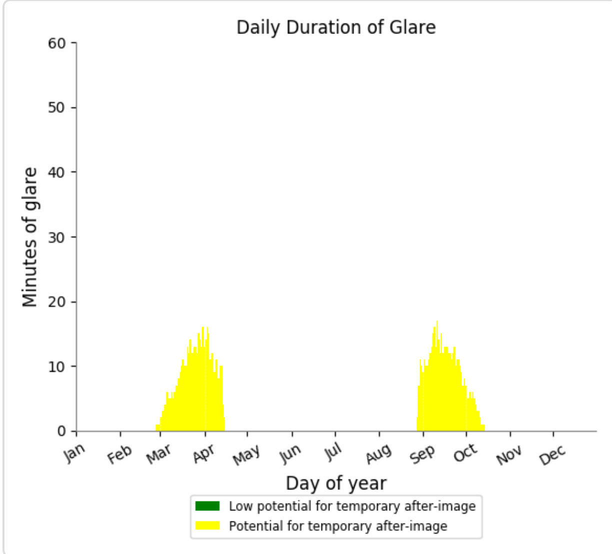


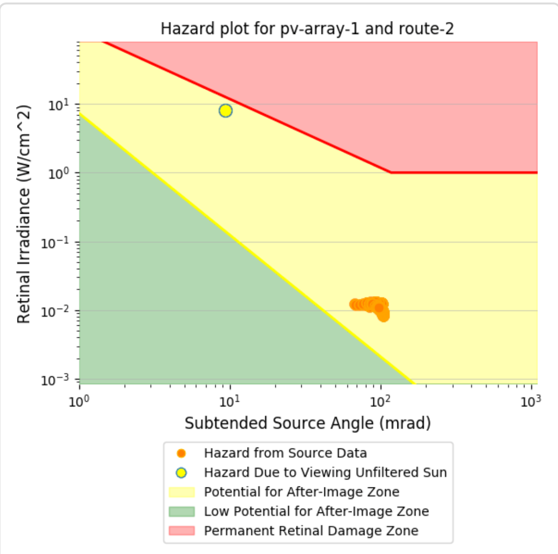
PV array 1 - Route Receptor (Route 2)

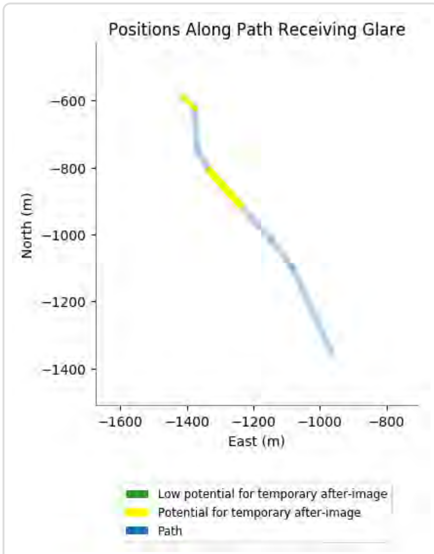
PV array is expected to produce the following glare for receptors at this location:

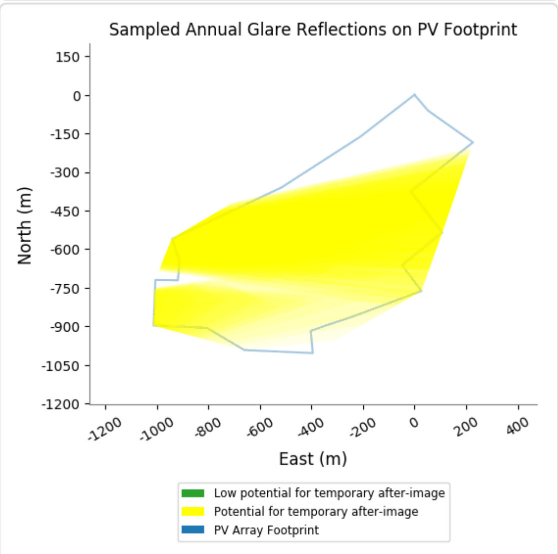
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 879 minutes of "yellow" glare with potential to cause temporary after-image.







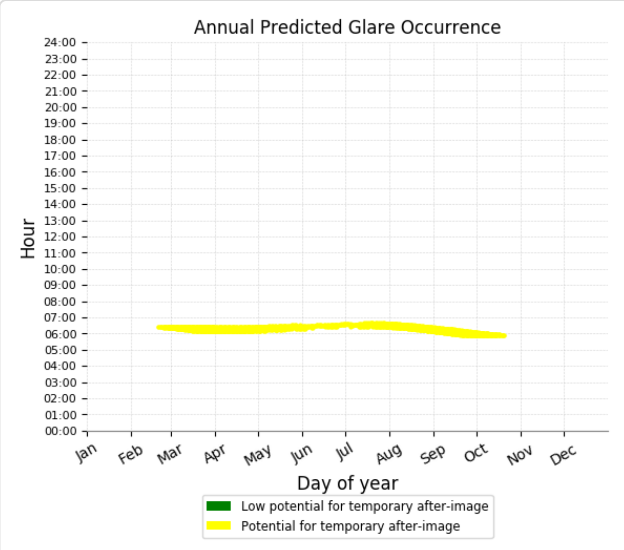


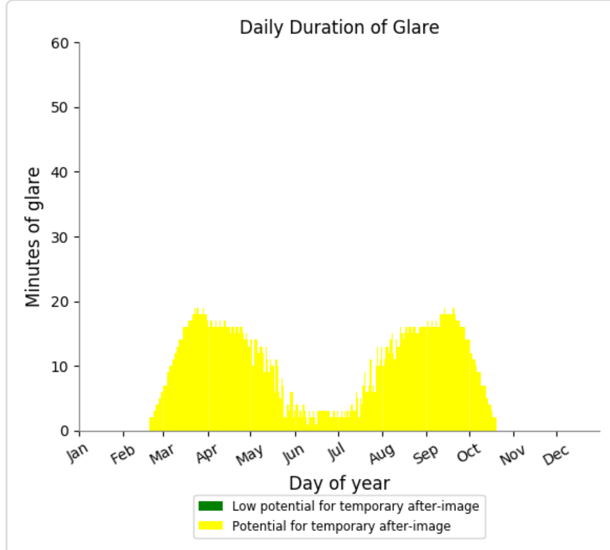


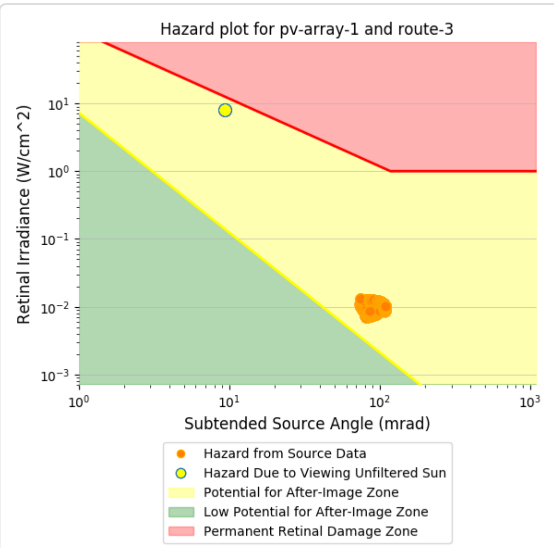
PV array 1 - Route Receptor (Route 3)

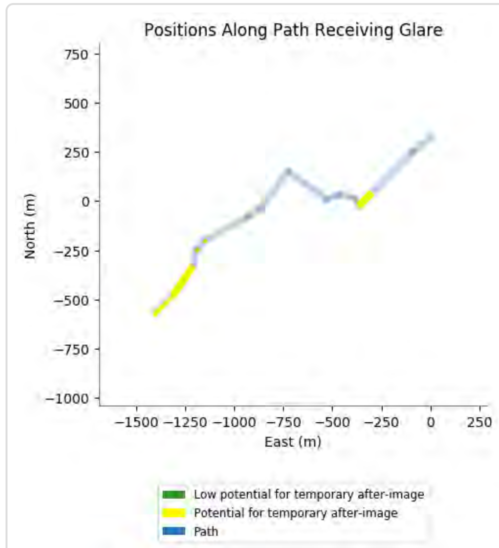
PV array is expected to produce the following glare for receptors at this location:

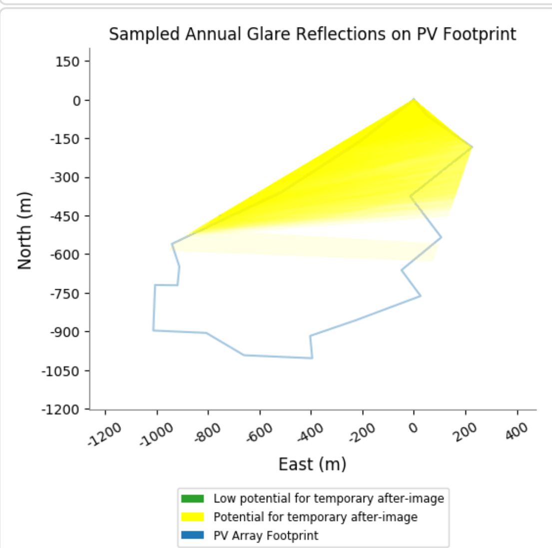
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,574 minutes of "yellow" glare with potential to cause temporary after-image.







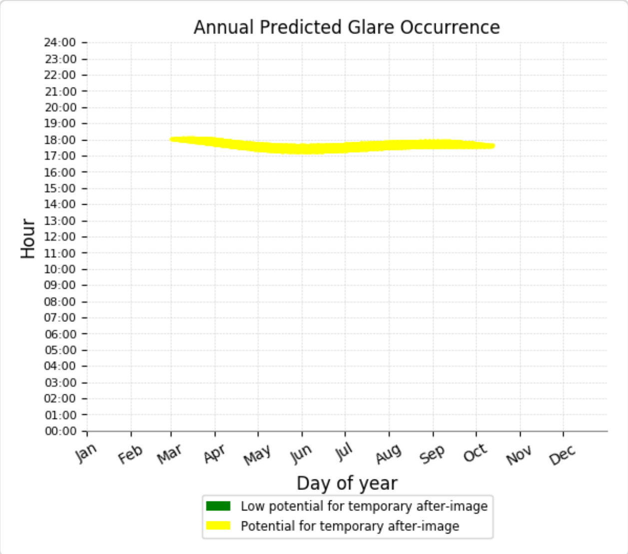


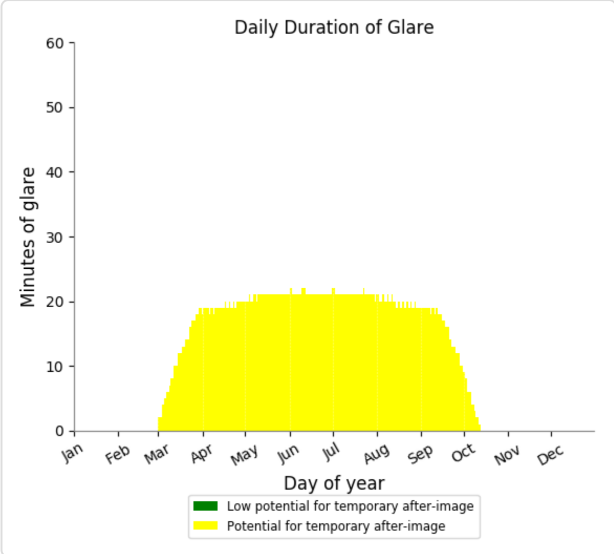


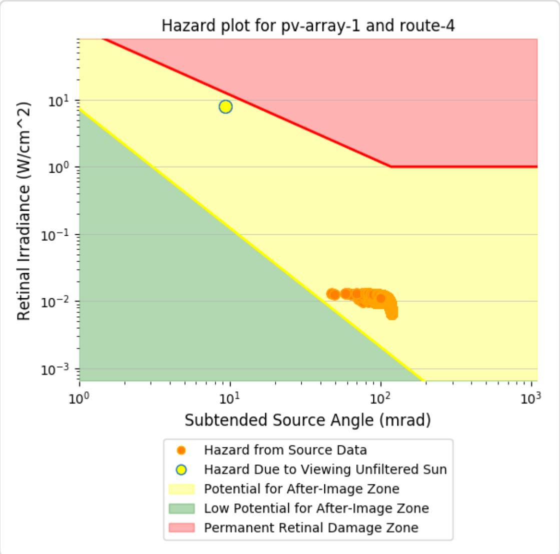
PV array 1 - Route Receptor (Route 4)

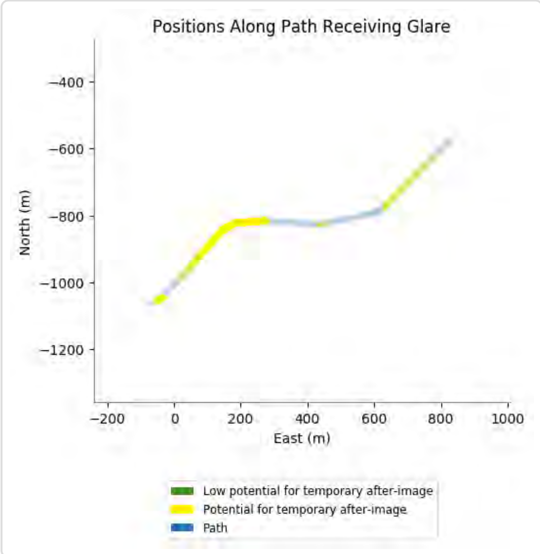
PV array is expected to produce the following glare for receptors at this location:

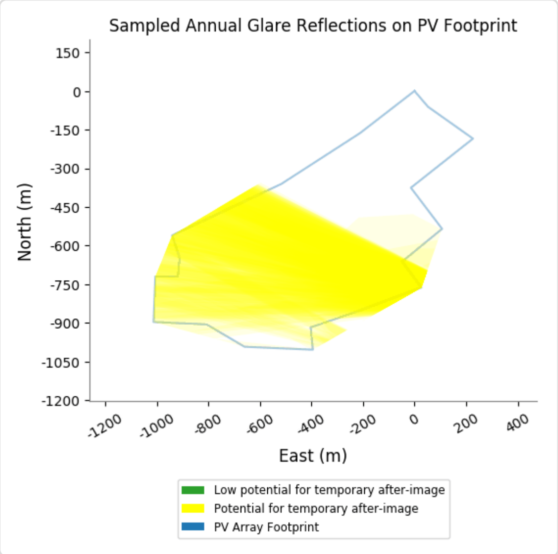
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,014 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

APPENDIX I

Environmental and Social Management Plan

Renewstable® Barbados Hybrid Solar Power Plant with Hydrogen Storage Environmental and Social Management Plan

May 24, 2022

Prepared for:

Renewstable (Barbados) Inc.

Prepared by:

Stantec Consulting Caribbean Ltd.
Winslow House, Black Rock, St. Michael
Barbados BB12056

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Abbreviations

AP	Affected Person(s)
BESS	battery energy storage system
BLPC	Barbados Light & Power Company
BNEP	Barbados National Energy Policy 2019–2030 (Government of Barbados 2019)
BWA	Barbados Water Authority
CCTV	Closed-Circuit Television
CR	Complaints Register
EIA	Environmental Impact Assessment
EMS	Energy Management System
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FTC	Fair Trade Commission
GRF	Grievance Record Form
GRM	Grievance Redress Mechanism
ha	hectare
HESS	hydrogen energy storage system
HSE	Health, Safety and Environment
HyPCe	Hydrogen Power Centre
KOH	potassium hydroxide
LOC	loss of containment
m	metre
MW	megawatt(s)
MWh	megawatt-hour(s)
NGO	non-governmental organization
PDP	Physical Development Plan (Government of Barbados 2003)
PGC	Project Grievance Committee
PL	Project liaison
Project, the	Renewstable® Barbados Project
PSA	Public Service Announcement
PSC	Project Steering Committee
PV	photovoltaic
QRA	Quantitative Risk Assessment
RER	Renewable Energy Rider
RSB	Renewstable (Barbados) Inc.
SEP	Stakeholder Engagement Plan
SMP	Social Management Plan
VC	Valued Component

1.0 INTRODUCTION

1.1 BACKGROUND

With the release of the Barbados National Energy Policy 2019–2030 (Government of Barbados 2019a), the Government of Barbados officially announced its intention for the island to achieve 100% renewable energy and carbon neutral transformational goals by 2030. Renewstable® (Barbados) Inc. (RSB, a Special Purpose Vehicle company fully owned by HDF Energy) is proposing to construct and operate a baseload hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados (the Project). The Project will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas. The Project will generate approximately 56,000 megawatt-hours (MWh) per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually (based on an average electricity consumption of 3,480 kilowatt-hour per inhabitant per year).

An Environmental and Social Impact Assessment (ESIA) has been prepared to support the Proponent's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project (Stantec 2022). This Environmental and Social Management Plan (ESMP) is a standalone document (presented to regulators as an Appendix to the ESIA) that is comprised of two plans: the Environmental Management Plan (EMP – Section 6 to 8) and the Social Management Plan (SMP – Section 9). The ESMP also contains the components of a Construction Management Plan (Section 6) and an Emergency and Disaster Management Plan (Section 10). This document is intended to be a field-usable, living plan that will outline the environmental protection procedures to be incorporated into the various Project phases.

1.2 OBJECTIVES AND SCOPE

The objective of this ESMP is to provide a comprehensive plan highlighting RSB's and the contractor's requirements for environmental and social management during the Project. The ESMP defines the potential impacts and risks of the Project activities and details mitigation measures to be followed by the RSB and the contractor during Project construction, operation and maintenance, and decommissioning. It also addresses the response procedures to be followed in the event of an environmental emergency and/or disaster, including a fire, vehicle accident, spill, erosion and sediment control failure, explosion or hurricane. A summary description of the Project is provided in Section 2, with a full description included in Chapter 3 of the ESIA.

1.3 REGULATIONS

Table 1.1 provides an overview of key Barbadian legislation and policies that are potentially relevant to the Project.

Table 1.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Legislation Associated with Renewable Energy in Barbados	
Electric Light and Power Act, 2013 and associated amendments and *Fees Regulations*	"An Act to revise the law relating to the supply and use of electricity, to promote the generation of electricity from sources of renewable energy, to enhance the security and reliability of the supply of electricity and to provide for related matters." • Allows for the generation and supply of electricity by independent power producers. • Establishes the requirement for licences to supply, distribute, store, transmit, and dispatch electricity. • Sets out licence application fees. • Allows for the public utility to make interconnections for electricity supply. • Allows for the Minister to set targets for the supply of electricity from sources of renewable energy. • Sets out licencees' powers, obligation, and restrictions in respect of electricity supply (e.g., in relation to the carrying out of works, the placement of electrical lines, etc.).
Fair Trading Commission Act, Cap. 326B	"An Act to provide for the establishment of a Fair Trading Commission to safeguard the interests of consumers, to regulate utility services supplied by service providers, to monitor and investigate the conduct of service providers and business enterprises, to promote and maintain effective competition in the economy, and for related matters." • Establishes a Fair Trading Commission to enforce the *Utilities Regulation Act.* • Allows for the Commission to set maximum rates and determine standards of service for providers of utility services, including the supply and distribution of electricity. • Empowers the Commission to investigate suspected breaches of the *Utilities Regulation Act* and take appropriate enforcement action.
Utilities Regulation Act, Cap. 282	"An Act to provide for the regulation of utility services." • Sets out requirements and principles for setting utility rates. • Establishes a duty to provide adequate utility service. • Allows for joint use of equipment by more than one service provider.
Electricity Act, Cap. 277	"An Act to provide for the inspection and control of electrical works and for other purposes in connection therewith." • Establishes requirements for inspection of electrical installations prior to the supply of electricity, and for inspection of alterations and extensions to installations. • Establishes requirements for reporting of accidents involving electrical works and circuits.

Table 1.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Legislation Governing Physical Development in Barbados	
Town and Country Planning Act, Cap. 240	"An Act to make provision for (a) the orderly and progressive development of land; (b) the grant of permission to develop land; (c) powers to regulate land use and development; and (d) related matters" • Regulates physical development, defined as "the carrying out of building, engineering, mining or other operations in, on, over or under any land, the making of any material change in use of any buildings or other land or the subdivision of land". • Establishes requirements for environmental impact assessments. • Superseded by the *Planning and Development Act, 2019*.
Planning and Development Act, 2019 and associated amendments and regulations	"An Act to make provision for (a) the orderly and progressive development of land; (b) the grant of permission to develop land; (c) powers to regulate land use and development; and (d) related matters" • Regulates physical development, defined as "the carrying out of building, engineering, mining or other operations in, on, over or under any land; the making of any material change in use of any building or land; or the subdivision of land". • Establishes requirements for environmental impact assessments. • Establishes a new Planning and Development Board and a new Planning and Development Department.
Safety and Health and Work Act, *2005* Cap. 356	"An Act to make provision (a) for securing the health, safety and welfare of persons at work; (b) for protecting other persons against risks to health and safety in connection with the activities of persons at work; (c) for controlling certain emissions into the environment; (d) to consolidate the law relating to health, safety and (e) for related matters." • Sets out general duties of occupiers and employers as well as duties and requirements in relation to safety, health, employee welfare, medical examinations. • Includes specific provisions for building operations and works of engineering construction; storage, handling and use of hazardous substances and articles in the workplace; processes involving special risks to safety and health of employees; use and management of pressure vessels.

Table 1.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Health Services Act, *1969*, Cap. 44 and associated amendments and regulations	"An Act relating to the promotion and preservation of the health of the inhabitants of Barbados." • Includes provisions for the abatement of nuisances and the removal or correction of conditions injurious to public health. • Authorises the Minister to compel works in the interest of public health. • The associated *Health Services (Nuisance) Regulations* allow for the control of nuisance, including any "matter, thing, deposit, or accumulation of liquid or solid matter" deemed unsanitary, injurious, or dangerous to health, or likely to become so; unpermitted discharge of industrial waste or other noxious matter; conditions that promote the proliferation of public health disease vectors. • The associated *Health Services (Building) Regulations* regulate the construction, extension, or alteration of buildings, with specific reference to drainage, sanitation, and ventilation.
Emergency Management Act, 2006	"An Act to provide for the effective organization and management of disasters and other emergencies in Barbados." • Authorises disaster hazard inspections in the event that the "condition of any premises is reasonably suspected of posing a danger of serious injury to persons outside of the premises in the event of an emergency or an impact of a hazard."
Trees (Preservation) Act, *1981*, Cap. 397	"An Act to provide for the preservation of trees." • Restricts the removal of trees over a certain size. • Authorises the Chief Town Planner to require planting, re-planting, maintenance, and protection of trees to preserve and enhance the amenity of "any land abutting upon, adjoining or near a public road".
Marine Pollution Control Act, 1998, Cap. 392A	"An Act to prevent, reduce and control pollution of the marine environment of Barbados from whatever source. " • Prohibits release of any pollutant into the environment if such releases violate standards, conditions or requirements specified under the Act or associated regulations. • Scope includes land-based sources of marine pollution.
Policies Associated with Renewable Energy in Barbados[1]	
National Strategic Plan of Barbados 2006–2025	The *National Strategic Plan of Barbados 2006–2025* was developed to enhance Barbadian society to become prosperous and globally competitive by 2025. One objective within the Plan was to ensure an efficient and reliable energy sector. The objective included programs to expand the supply of renewable energy. Specific targets included meeting 30% of energy requirements from renewable energy by 2025 and substantially increasing the number of renewable energy businesses by 2025 (Government of Barbados 2007).
National Sustainable Development Policy	The *National Sustainable Development Policy* attempted to encourage an integrated and holistic approach to sustainable development. In addition, the Policy emphasized that measures to support and promote the adoption of renewable energy, energy efficiency, and energy conservation would help Barbados to meet its obligations as a party to the *United Nations Framework Convention on Climate Change* (Government of Barbados 2004).

Table 1.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Sustainable Energy Framework for Barbados	The Sustainable Energy Framework is an ongoing technical assistance program with the Inter-American Development Bank, the objective of which is to promote renewable energy and energy efficiency to reduce fossil fuel dependency while enhancing energy security and environmental sustainability. The most recent instalment of the program includes a focus on further development and modernization of the electricity framework in Barbados to support adoption of renewable energy technologies (Government of Barbados 2019b).
Draft *National Sustainable Energy Policy*	Developed as a complementary policy to the Sustainable Energy Framework, the Draft *National Sustainable Energy Policy* addressed the high importation of fossil fuels. It sought to increase efficiency and sustainability in the energy supply and demand. In addition, the Policy aimed to encourage economically viable utility-scale renewable energy, promote energy cost reduction technologies, reduce fossil fuel dependency, and decrease the impacts of global warming (Government of Barbados 2019c).
Barbados National Energy Policy 2017–2037	The *Barbados National Energy Policy 2017–2037* aimed to provide a direction for Barbados to transition from a fossil fuel-based economy to mainly renewable energy. The Policy sought to ensure affordable energy security, a sustainable energy sector, and increased renewable energy and energy efficiency (Government of Barbados 2019d).
Barbados National Energy Policy 2019–2030 (BNEP)	The BNEP outlines the transition to a 100% renewable energy and carbon-neutral island by 2030. The policy attempts to ensure the provision of reliable, sustainable climate-friendly energy with zero domestic fossil fuel consumption and expansion of research and development in renewable energy (Government of Barbados 2019a).
Renewable Energy Rider (RER) Program	The former RER Program allowed domestic customers to sell energy back to the electrical grid at 1.6 times the level of the Fuel Clause Adjustment. In 2016, the RER credit rate began to be calculated using a resource cost approach, rather than being tied to the Fuel Clause Adjustment (Howard 2019). In 2019, the RER was replaced by a feed-in tariff, and RER agreements were grandfathered for a period of 20 years (FTC 2019).
Policies Associated with Physical Development in Barbados	
National Groundwater Protection Zoning Policy, 1963 (revised in 1973 and 2010) and Green Paper on the 2020 Water Protection and Land Use Zoning Policy	The *National Groundwater Protection Zoning Policy* delineates the island into five zones. Public water supply wells are located in the most restricted Zone 1 areas (Stantec 2022). The Green Paper (i.e., a tentative government consultation document of policy proposals for debate and discussion, which was produced by the Ministry of Energy and Water Resources, the Government of Barbados, and the Barbados Water Authority [BWA]) proposes that the groundwater protection zones introduced in the *National Groundwater Protection Zoning Policy* be re-configured for the following purposes (Stantec 2022): • To boost groundwater water quality protection due to the presence of more recalcitrant persistent pollutants. • To release more lands in the current Zone 1 protection areas for development. More specifically, the Green Paper states the following (Stantec 2022): • The existing *National Groundwater Protection Zoning Policy* is over 50 years old and does not protect against persistent chemical pollutants. • The existing Zones 1 to 5 are proposed to be replaced with Zones A to E, with Zone A termed a strict exclusion zone smaller than the existing Zone 1.

Table 1.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
	• Only agriculture Class Two will be permitted within Zone A; this type of agriculture includes "horticulture, fruit growing, seed growing, use of lands for farmers markets, bursary grounds, woodland or forestry". • Solar PV farms and wind farms – deemed to have low environmental impact – may also be allowed in Zone A areas under specific permitting conditions. • As described in Appendix B, the Project is currently located within a Zone 3 groundwater protection zone as per the existing Policy. If the Policy is revised as proposed in the Green Paper, the Project will be located within a Zone D groundwater protection zone.
Physical Development Plan (PDP) and associated 2003 amendment and draft 2017 amendment	The purpose of the PDP is to promote sustainable growth and development within Barbados by setting out policies and regulations to guide proponents of proposed developments, including requirements related to the conduct of an Environmental Impact Assessment (EIA) or Environmental and Social Impact Assessment (ESIA).

Note:
[1] The information regarding policies associated with renewable energy in Barbados was adapted from Evelyn (2020). Other sources are cited throughout the table where applicable.

2.0 DESCRIPTION OF THE PROJECT

The Project will be located at Harrow Plantation, in the Parish of Saint Philip, Barbados, which is situated on the southeastern end of the island (Figure 2.1). Harrow Plantation consists of approximately 123.0 hectares (ha) of privately-owned land, of which approximately 73.2 ha will be leased by RSB for the purpose of carrying out the Project.

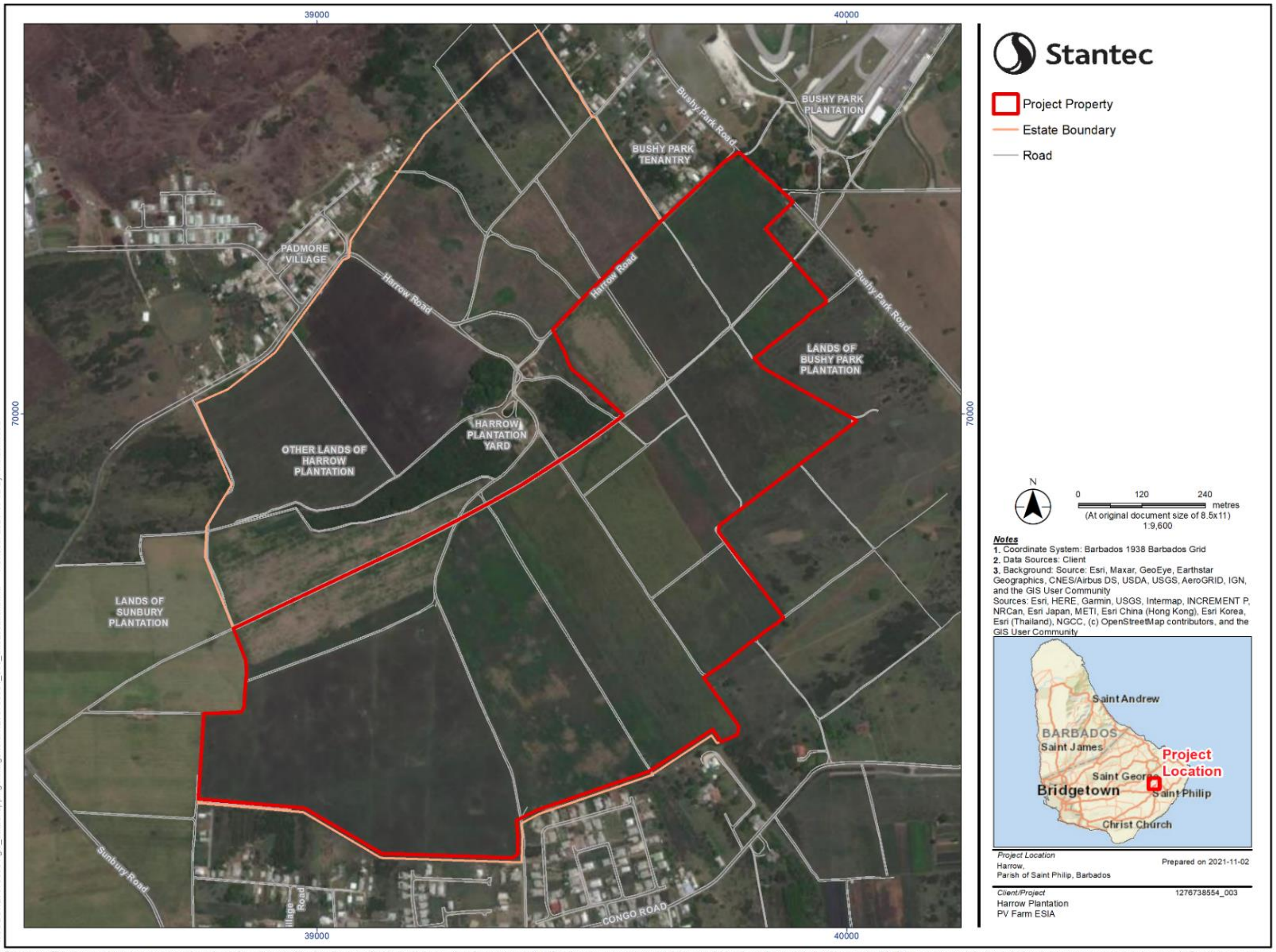

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Figure 2.1 Project Location

Project components include the following:

- Energy facilities, consisting of a:
- solar PV power plant, which will occupy approximately 59.1 ha and will consist of an array of 96,154 solar panels equipped with PV cells
- associated short-term battery energy storage system (BESS), consisting of eight 16.2 m x 2.9 m x 2.6 m cabinets, each with a maximum capacity of 2 megawatts (MW) / 6 MWh. Each cabinet will enclose Li-ion battery cells, as well as associated management systems, auxiliaries, cooling, fire safety, security systems, and comprehensive fault detection in charge/discharge cycles
- associated long-term hydrogen energy storage system (HESS), which include electrolysers (with a total capacity equivalent to 16 MW), compressors and 26 pressurized containers each with a storage capacity of 115 m^3 (enabling the long-term storage of approximately 7,300 kg of hydrogen), and hydrogen fuel cells with a total capacity equivalent to 3 MW
- Agricultural facilities used to raise sheep livestock (approximately 1,830 Blackbelly sheep, raised for the purpose of producing lamb/mutton meat, sheepskin, and manure for domestic and export markets; butchering will not take place on-site). Facilities will include, at a minimum, sheep pens, a barn for hay storage, a feed silo, water storage tanks, a designated waste skip area on a concrete pad, and a farm building/staff facility, all of which will occupy a total of approximately 2.3 ha
- Supporting infrastructure, facilities, and utilities
- Buildings, which include a guard building/security booth, farm building/staff facility, hay storage barn, feed silo, and office/equipment storage building
- Approximately 1.6-ha Hydrogen Power Centre (HyPCe) facilities yard (including an electrical building, power stations and various utilities on skids, a pump house, and a package water treatment plant)
- Laydown areas (for both outdoor storage and platforms for equipment assembly/installation)
- Access roads within the Project Property, ranging between 3 m and 5 m wide
- Site lighting, incorporating detection sensors or manual switches where possible
- A new 3.5 km transmission line connecting the proposed power plant to Barbados Light & Power Company’s (BLPC’s) existing Hampton substation
- Water supply, treatment, and storage
- Drainage reserve areas for the management of surface run-off, graded and contoured to direct runoff towards suckwells (i.e., artificial shafts excavated in soft carbonates to relieve surface flooding)

The Project activities associated with construction are described in Section 6.1, operation and maintenance in Section 7.1, and decommissioning in Section 8.1.

3.0 POTENTIAL ENVIRONMENTAL IMPACTS OF PROJECT ACTIVITIES

Potential adverse environmental impacts associated with routine Project-related activities are predicted to be not significant. Potential adverse environmental impacts associated with Project-related accidents, malfunctions, and disasters are predicted to be not significant for valued components (VCs) other than surface water and groundwater resources, agriculture and other land uses, and health and safety; the effects are predicted to be significant for these VCs. Table 3.1 summarizes the results of the impact assessment for each VC, in consideration of the design mitigation and environmental protection procedures incorporated into this Project.

Table 3.1 Summary of Valued Component Impact Assessment in Consideration of Identified Mitigation

Valued Component	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters
Atmospheric and Acoustic Environment	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or loss of containment (LOC) is predicted to be **not significant**.
Surface Water and Groundwater Resources	Residual adverse impacts are predicted to be low in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of a worst-case accidental spill, leak or LOC could be **significant**.
Flora and Fauna	Residual adverse impacts are predicted to be neutral to low in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.
Visual Environment	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.
Agriculture and Other Land Uses	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of a worst-case accidental spill, leak or LOC could be **significant**.
Health and Safety	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impact of a worst-case accidental spill, leak or LOC could be **significant**.
Human Capital	Positive impacts are predicted.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.
Economy	Positive impacts are predicted.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.
Cultural Values	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.

Table 3.1 Summary of Valued Component Impact Assessment in Consideration of Identified Mitigation

Valued Component	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters
Infrastructure and Services	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.
Social Dynamics	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.

4.0 MANAGEMENT OF THE ESMP

4.1 ROLES AND RESPONSIBILITIES

Key personnel involved with implementation of the ESMP are described in the following sections. The Contractor will be responsible for providing the necessary training for personnel during construction. RSB will be responsible for Project Management and arranging for key personnel to receive environmental and social training during operation to facilitate proper implementation of the ESMP. Responsibilities during both phases include measures that raise the environmental and social/gender awareness of personnel working on the Project to properly implement the environmental and social mitigation and safeguards detailed in this ESMP.

4.1.1 Construction Phase

During the Construction phase:

- The General Contractor for the construction of this Project is responsible for the implementation of the measures outlined in the ESMP, making it available on site and familiarizing the site Foreman or Supervisor with the ESMP
- The site Foreman or Supervisor is responsible for the coordination and implementation of the measures outlined in the ESMP. Workers will be made aware of the existence of the ESMP and designate to bring environmental issues of concern forward will be identified.
- The Site Engineer will be a representative designated by the Contractor
- The HSE Coordinator will have responsibility for implementing the programs for the environmental management of the operations, including coordinating HSE management functions, reporting HSE matters to Project management, monitoring compliance with relevant HSE standards, and acting as a spokesperson on HSE issues
- The Project Director acts as the RSB representative for the Project during this phase and is responsible for validation of the ESMP and alignment with RSB's company guidelines.

4.1.2 Operation and Maintenance Phase

During the Operation and Maintenance phase:

- The Plant Manager has overall accountability for implementing the ESMP, including providing adequate resources. During Project operations, the Plant Manager will also have the following responsibilities:
- executing and maintaining the programs for the environmental management of the operations, including coordinating HSE management functions, reporting HSE matters to management, monitoring compliance with relevant HSE standards, and acting as a spokesperson on HSE issues; and
- raising the social/gender awareness of personnel working on the Project.
- Staff are responsible for awareness of and compliance with the corporate HSE management procedures.

4.2 DOCUMENTATION

Implementation of the environmental and social management practices during Project construction and operation and maintenance requires the relevant and pertinent documents to be available to staff as well as regulatory agencies. Documentation associated with the ESMP (including, specifications, construction drawings, Construction Management Plan, EMP, SMP, Emergency and Disaster Management Plan, and all permits and approvals) will be present on site at all times. The practices and procedures outlined in these documents will be implemented and adhered to. Reporting required by regulations or this ESMP will be conducted in a timely manner.

4.3 AUDITS/REVIEW/CONTINUAL IMPROVEMENT OF THE ESMP

Periodic environmental audits during construction and operation and maintenance should be conducted to ascertain compliance with existing regulatory and ESMP requirements and to identify improvements that could be feasibly incorporated/implemented, contributing to an ongoing goal of a sustainably managed Project. In order to determine whether implementation of the ESMP has been successful (and whether the impact mitigation, management, and monitoring measures outlined in ESIA are effective, it is recommended that a third-party Environmental and Social Professional conduct audits every six months during the construction phase and every year during the first two years (and every 2 years thereafter) of the operation and maintenance phase.

4.4 TRAINING PERSONNEL

Personnel hired for the Project will receive training/orientation appropriate to their position in regard to the purpose and contents of the ESMP, in addition to appropriate guidance in respect of human health and safety.

RSB will require its contractors to have competency, training, and awareness programs in place which are consistent with RSB's programs and commitments in this ESMP. ESMP related training will allow personnel with ESMP roles and responsibilities to understand expectations related to commitments and obligations, mitigation measures, non-compliance and corrective actions, environmental contingency measures, incident reporting requirements, work subject to regulatory permit requirements, and construction site rules and regulations.

A conceptual overview of roles and responsibilities for RSB's competency, training, and awareness program is provided in Table 4.1.

Table 4.1 EMSP Roles and Responsibilities – Training

Role	• Responsibilities
Management	• Generate and endorse overall training processes and procedures • Source competent and trained personnel to support Project activities and verify competency
Site Supervision	• Ensure personnel have the required knowledge and skills to perform job tasks • Review and approve training plans for their personnel • Provide time/resources required for their personnel to complete/maintain training • Review training progress for their personnel on an annual basis • Consult with management on actions to take when a person does not meet the requisite knowledge/skills after training has occurred
Personnel	• Complete training requirements • Provide feedback on training received
Training Resources	• Provide HSE training programs with support from RSB personnel • Assist with delivery of training (where appropriate) and evaluate training results

RSB will employ competency, training, and awareness programs appropriate to the Project's needs. Training may be provided through a variety of means, including but not limited to, briefings, toolbox talks, coaching/mentoring, on-the-job training in specific elements or tasks, self-study, instructor-led training, seminars, workshops, computer-based training, or the provision of specific skills, as necessary. These and other means (such as posters, signs, site newsletters) may be used to promote environmental, socioeconomic, and regulatory compliance awareness. Training programs may be delivered by RSB, contractor, and/or third-party training resources. RSB's training will also cover emergency response, including conduct of drills, exercises and training intended to determine the readiness of emergency responders and assess and determine the adequacy of emergency plans and procedures. Contractors will also be required to show that their employees are trained on aspects of emergency response relevant to the roles and responsibilities of such individual employees.

4.5 CORPORATE SOCIAL RESPONSIBILITY

This ESMP has been developed for the Project such that goals and outcomes contribute to the goal of the Project as a sustainable facility.

4.6 QUALIFIED ENVIRONMENTAL MANAGEMENT PERSONNEL

The Project will hire qualified personnel to administer the ESMP during all phases of the Project. Personnel will be provided appropriate HSE training.

5.0 MITIGATION MANAGEMENT PLAN

Mitigation measures incorporated into the design of the Project are provided in Section 5.1. Mitigation measures associated with social impacts are described in Section 5.2. Phase-specific mitigation measures are detailed in Section 6.1 (Construction), Section 7.1 (Operation and Maintenance), and 8.1 (Decommissioning).

5.1 DESIGN MITIGATION

Key design mitigation features that will be incorporated into the Project include the following:

- The design of the Project as a dual land use project with integrated energy and agricultural facilities, which will enable baseload renewable energy production while preserving local agricultural activities and saving foreign exchange (refer to Section 4.2 of the ESIA).
- The design of the BESS and HESS as consisting mainly of cabinets and containerized enclosures equipped with internal systems to maintain safe operating conditions (refer to Section 3.2.1.2 of the ESIA) and mitigate the potential impacts of an accident, malfunction, emergency, or disaster (refer to Section 8.7 of the ESIA).
- The design of Project energy facilities to employ clean technologies that produce baseload renewable energy without any harmful operational emissions or process outputs (refer to Section 3.6.2 of the ESIA).
- The possible sale of animal by-products from the agricultural facilities (i.e., sheepskin and manure), in addition to the production of lamb/mutton meat (refer to Section 3.2.2 of the ESIA).
- The planned re-use of the mineralized water by-product of reverse osmosis for irrigation and washdown, which will reduce Project-related consumption of potable water (refer to Section 3.2.3.5 of the ESIA).
- The planned recycling of process water from the hydrogen fuel cells in the HESS, which will reduce Project-related consumption of potable water (refer to Section 3.2.3.5 of the ESIA).
- Evaluation of the viability of rainwater harvesting via water tanks located beneath Project buildings/ infrastructure and the planned establishment of drainage reserves for runoff management, which reduce Project-related consumption of potable water as well as mitigate potential erosion and sedimentation impacts (refer to Sections 3.2.3.5 and 3.2.3.6 of the ESIA).

5.2 MITIGATION MEASURES FOR SOCIAL IMPACTS

The Project will be compliant with the legal and statutory labour requirements, to safeguard community and worker safety and health. Potentially adverse impacts from the construction will be reduced and mitigated to the extent feasible to reduce impacts on the residents, and users of social amenities and commercial enterprises. There are a number of mitigation measures proposed to reduce the impacts of the Project on the social environment, including:

- Jobs for approximately 150 persons during Project construction and up to 20 full-time-equivalents during Project operation and maintenance, with approximately 10 persons employed at the sheep facility
- A carefully planned and implemented public awareness campaign to address the typical concerns raised about the construction of solar facilities on the scale of the Project, designed to clearly explain the design of the facility and the potential benefits that could accrue to Barbados
- Construction will include standard environmental protection procedures and mitigation measures that will be implemented for the management of noise, dust, vibration, wastes, and traffic, as are measures to mitigate potential impacts on the use of public roadways
- OHS plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans
- Provisions that will be made to enforce safety in and around construction areas include 24-hour security (through CCTV or equivalent monitoring systems), the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meet the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways
- Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorised personnel. The emergency and disaster management plan will include regular emergency drills
- Public service announcements will be provided so that commercial operators, residents, and the public are updated on and given appropriate advance notice of the construction activities, especially those, such as construction activities planned outside of typical work hours, such as late evening or night, that could be disruptive
- Contractors will be required to provide gender sensitization training to address critical on-the-job issues and facilitate positive interactions between workers and the surrounding residents
- Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the Project Development Area and a plan to protect the artefacts developed and implemented in conjunction with the Museum
- When operational, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities
- The Social Management Plan (Section 7) includes both a stakeholder engagement plan (SEP) and a grievance redress mechanism, which are designed to allow the best interests of relevant stakeholders to be considered during the Project

5.3 IMPLEMENTATION COSTS

The potential costs for implementation of the ESMP are unknown at this current stage in Project planning and design, as they will depend on the design-build contractor that is selected; the detailed methods for Project construction; and the construction schedule. Cost estimates cannot be provided until advances are made in the detailed planning for Project construction and operation.

6.0 ENVIRONMENTAL PROCEDURES FOR CONSTRUCTION

6.1 DESCRIPTION OF EXPECTED ACTIVITIES

The main activities associated with the construction phase of the Project will consist of site preparation, physical construction and equipment installation, and commissioning. The Project is expected to employ up to 150 people during peak construction activities, such as installation of the PV modules. Given the proximity and availability of potential accommodations in the local communities surrounding the Project Property, no workforce accommodation camps are currently proposed in support of the Project. However, the contractor may consider the use of construction camps to accommodate their workers as a means of limiting competition for housing on the island between workers and local community members.

Figure 6.1 depicts the proposed site layout for the main components of the Project, including the solar PV power plant, the HyPCe area containing the energy storage and management systems for the power plant, and the agricultural facilities associated with the Blackbelly sheep farm. Layouts of the HyPCe area and the agricultural facilities are shown in Figures 6.2 and 6.3, respectively.

6.1.1 Site Preparation

Project construction will begin with the clearing of vegetation and the levelling of soils where necessary throughout the Project Property. Limited vegetation removal will be required since the Project Property is currently mostly used for farming sugarcane and rotational crops and is therefore not forested or heavily vegetated other than with agricultural crops. Temporary laydown areas will be established for the outdoor storage of vehicles, heavy equipment, machinery, prefabricated Project components, construction materials, and other supplies. Site preparation activities will also include access road construction, internal road construction, platform levelling for the HyPCe area and other buildings, and the digging of trenches and construction of the drainage system for surface runoff management.

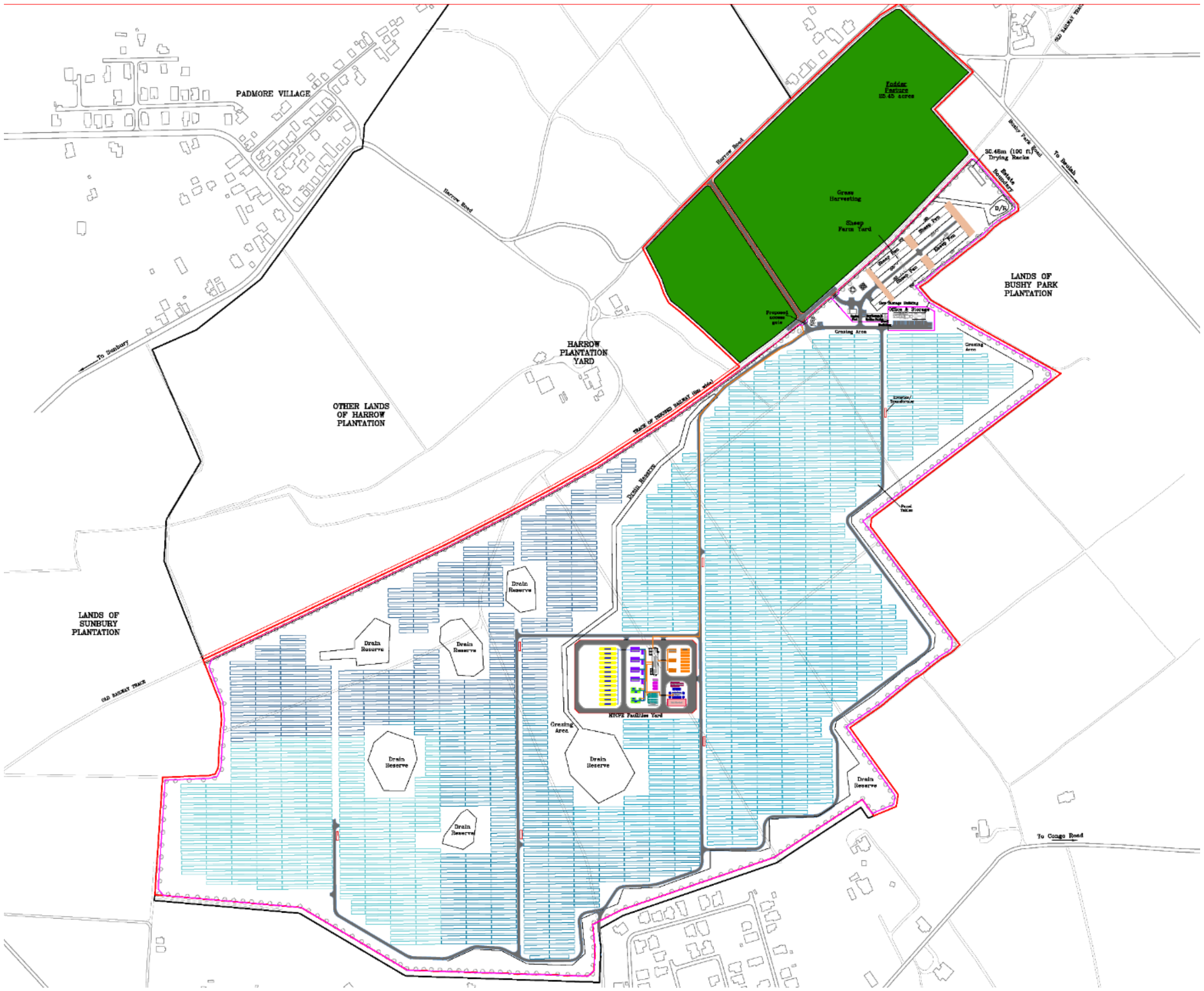


Figure 6.1 Overall Site Plan

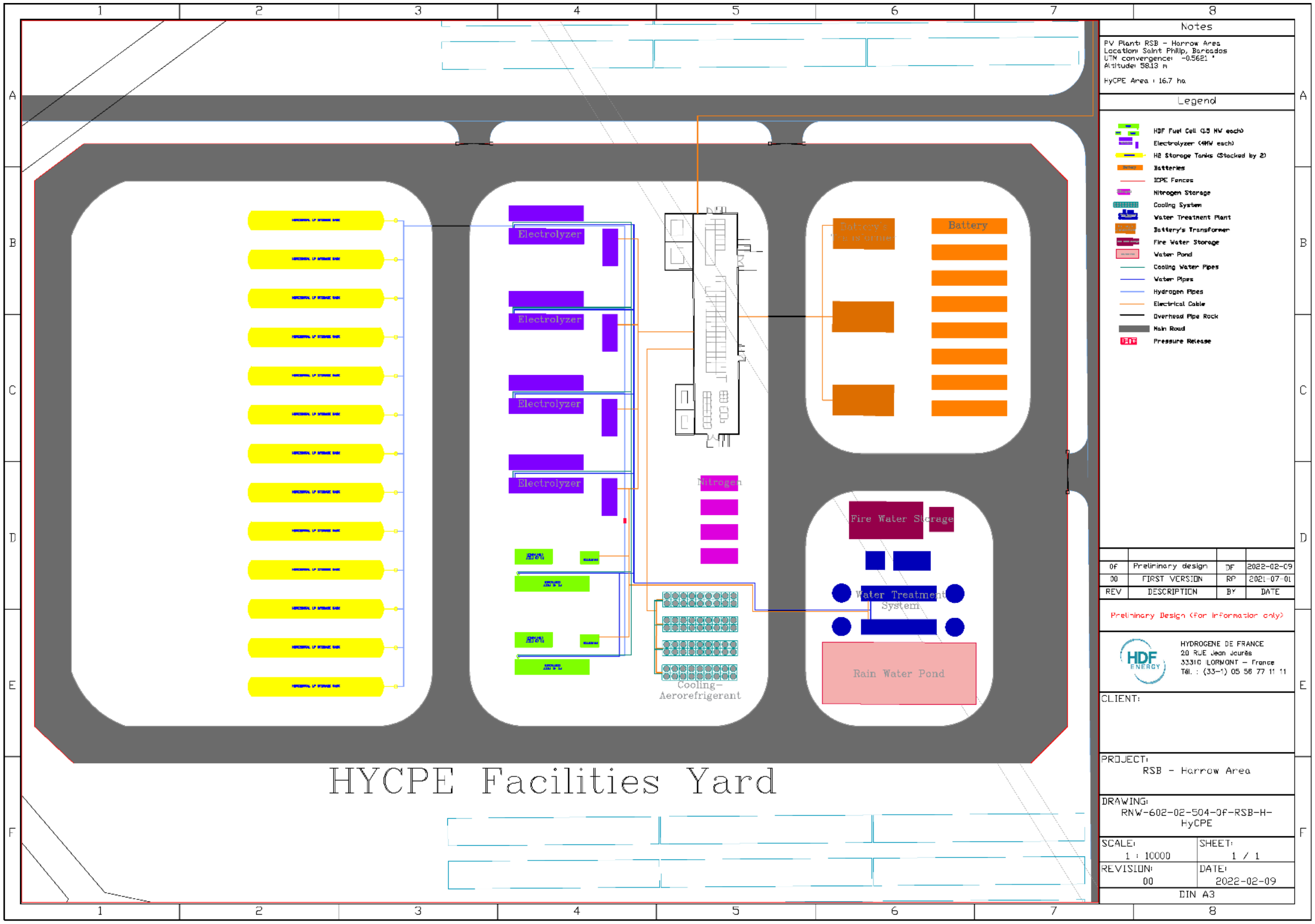


Figure 6.2 Layout of the HyPCe Area

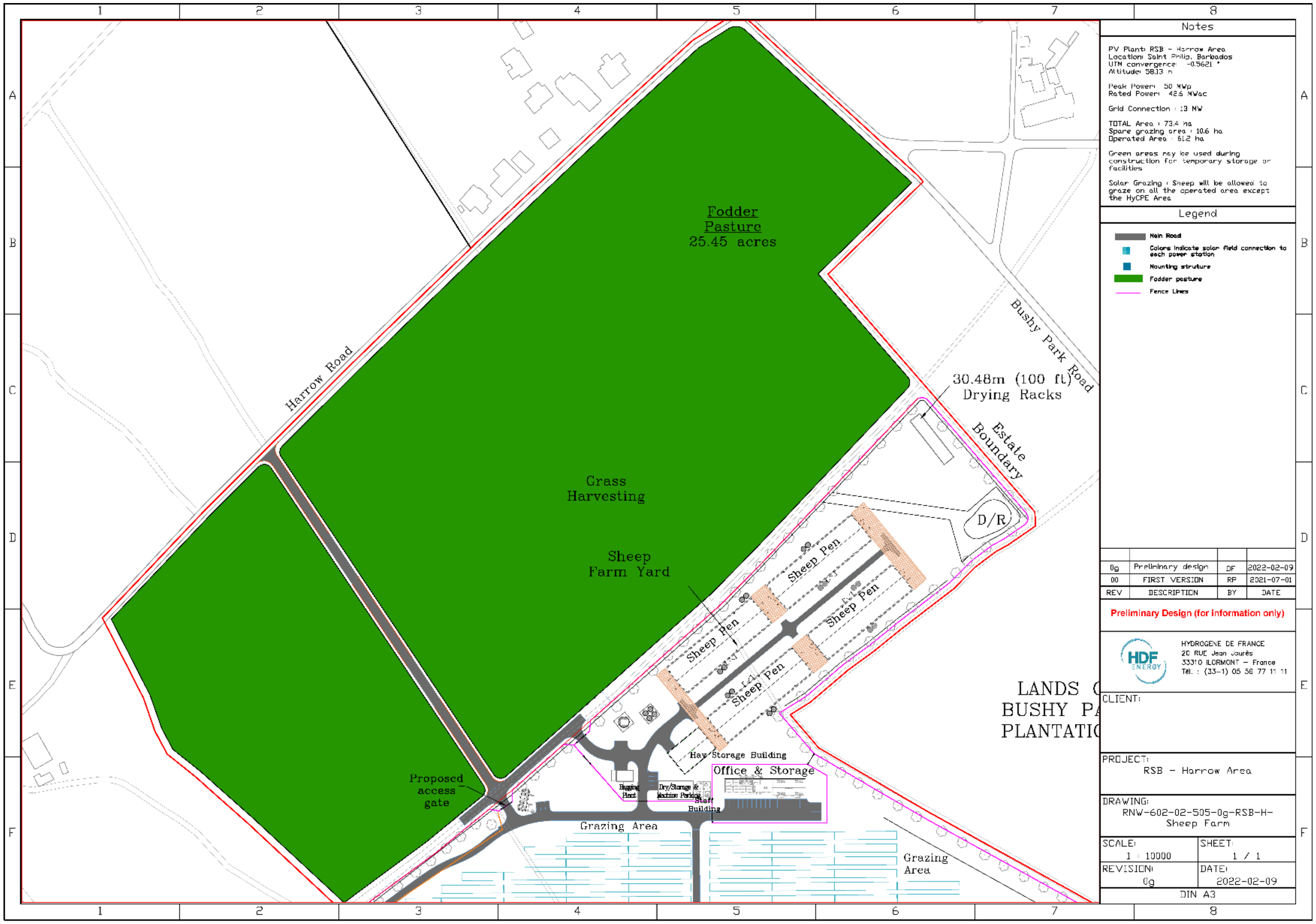


Figure 6.3 Layout of the Agricultural Facilities

6.1.2 Physical Construction and Equipment Installation

Once site preparation is complete, physical construction and equipment installation of the main Project components will commence and will involve the following:

- Construction of solar PV power plant, including:
- PV structure foundation construction
- PV structure assembly
- PV modules installation, which may require pile driving to secure panel support racking into the earth below
- Power station installation
- Installation of cabling, boxes, and auxiliaries connecting the PV modules to the power station and connecting the individual components of the HyPCe area to their respective power supplies
- Construction of HyPCe area facilities (i.e., BESS, HESS, and EMS), including:
- Foundation construction
- Electrical building construction
- Installation of integrated systems, containers, and associated power stations for the batteries, electrolysers, and fuel cells
- Erection of electrical and mechanical balance of plant components (e.g., cabling, piping, and auxiliaries)
- Construction of buildings associated with the agricultural facilities
- Construction/installation of remaining supporting infrastructure, facilities, and utilities, including other Project buildings (e.g., guard building/security booth and office/equipment storage building), fencing, lighting, package water treatment plant, water storage tanks, mechanical farm equipment, and drainage works.

The Project components required for physical construction and equipment installation will be transported to the Project Property by truck, primarily in 12-m shipping containers, although some raw materials may be transported in bulk and the hydrogen tanks will be transported as out-of-gauge cargo. It is estimated that approximately 450 trucks will be required to transport key Project components to the Project Property, including 350 trucks for the PV modules and structures, six trucks for the power stations, 50 trucks for containerized and skid systems associated with the HyPCe area, 10 trucks for bulk spare parts (e.g., cabling), and 26 trucks for the hydrogen tanks.

6.1.3 Finalization and Commissioning

Finalization of Project construction will include pre-commissioning of sub-systems (e.g., solar panels and PV cells, batteries, fuel cells), connection of the power plant, and connection to the grid. The electrical and mechanical systems associated with the Project will be commissioned as construction/finalization is completed, including full commissioning of the entire power plant and associated energy storage and management systems.

6.2 MITIGATION MEASURES

Table 6.1 provides a list of the general standard environmental protection procedures and VC-specific mitigation measures to be implemented during the construction phase of the Project. The general standard environmental protection procedures are broadly applicable to multiple VCs, while the VC-specific mitigation measures have been compiled from the impact assessments conducted for the various VCs in the ESIA. The list of general standard environmental protection procedures and VC-specific mitigation measures may be modified as the design of the Project progresses and becomes finalized.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

General Standard Environmental Protection Procedures
Waste Management
• During construction, the contractor will deal with surplus waste materials responsibly. Relevant waste and resource management procedures will be communicated to employees during the initial site induction. This will include procedures on segregation, handling, recycling, re-use, and return methods to be used. A specific area will be set out to facilitate separation of the various types of waste. • Appropriately licensed third-party service providers/waste contractors will be engaged to remove non-hazardous and hazardous wastes for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. • Proof of appropriate waste disposal, recycling, and/or treatment at approved waste management facilities must be provided by the contractor. • Separate secure containers will be provided for the collection of food wastes and other solid wastes, and the contents of these will be regularly disposed of at an approved landfill. • Materials defined as hazardous or toxic waste will be placed in appropriate designated containers. • Metals, wood, and other recyclable waste materials will be diverted to appropriate recycling facilities. • Waste will be reused / recycled as much as practical to reduce the total volume going to the landfill. • Paper, plastic, polystyrene, corrugated cardboard, and packaging material will be collected and separated for disposal in appropriate on-site bins for recycling. • Metal banding will be folded, flattened, and placed in designated areas for recycling. • Packaging materials will be removed from site and disposed of at appropriate recycling facilities. • General debris will be removed from the Project Property and disposed of at an approved site. • Dirt, dust, and debris will be collected from the roadway drainage gutters and properly disposed of on a regular basis. • Waste materials and debris will be collected in acceptable containers on-site and disposed of off-site in an environmentally acceptable and approved site. • Volatile wastes and materials, such as fuel, mineral spirits, oil, or paint thinner will be stored appropriately and will not be permitted to enter into waterways, storm drains, or sanitary sewers. • Project-related wastes will not be deposited in a location or manner that obstructs the flows of surface drainage or natural watercourses. • Vegetation removed from the site will be chipped and used as mulch on-site and/or disposed of at an appropriate off-site waste disposal facility. • To help prevent silt runoff and dust creation, waste soils that have been excavated from the site will be reused as backfill materials or re-distributed around the site and used for remediation and biodiversity enhancement features. • Portable toilet waste will be removed from the site by the supplier in a timely manner. • Fires and the burning of rubbish and waste materials on-site will not be permitted. • Rubbish and waste materials will not be buried on-site.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

Spill Prevention, Control, and Response

- Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer.
- Spill response kits will be available on-site.
- Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorized personnel.
- Fueling and servicing will be conducted at designated sites furnished with spill containment equipment.
- Fueling and servicing areas will be sited away from watercourses and drainage works where possible.
- The potential for spills will be reduced through the use of standard good practices, such as the use of appropriate containers, and avoiding overfilling.
- In the event of a spill, dry clean up and mopping techniques will be used as appropriate. The area will not be "washed down" as this could cause the spills to spread to the surrounding environment and potentially enter drainage works or environmentally sensitive areas.
- Spilled material and spent lubricants will be collected and removed from site for disposal at an approved location.
- Vehicles, heavy equipment, and machinery will be properly maintained to reduce the risk of leakage. Routine preventative maintenance and inspection of hydraulic equipment and machinery will be undertaken to avoid a hazardous material release.
- Soil which may have become contaminated during the course of construction will be remediated. This may be done on-site or removed from site for disposal at an approved location.
- Project vehicles will be equipped with appropriately sized spill kits containing the necessary supplies to handle the quantity and type(s) of hazardous materials that are on-site.
- Communication systems will be in place and functioning.
- Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor.

VC-Specific Mitigation Measures

Measures to Mitigate Impacts on the Atmospheric and Acoustic Environment (including Vibration)

- Only areas required for construction will be cleared.
- Where practical, Project vehicles, heavy equipment, and machinery will be sized to the smallest needed to perform the work.
- Air and acoustic emissions from Project vehicles, heavy equipment, and machinery will be managed by conducting regular inspection, repair, and maintenance activities as required for operation in accordance with manufacturer's recommendations and to reduce instances of visible sooty emissions or abnormally high sound levels. Defective vehicles or equipment will be taken out of service and not permitted to resume operations until they are repaired.
- Project vehicles, heavy equipment, and machinery will be outfitted with mufflers (and/or other appropriate sound attenuation devices) that meet international design standards.
- Project vehicles, heavy equipment, machinery, and associated exhaust systems and mufflers (and/or other appropriate sound attenuation devices) will be regularly inspected and maintained so that they remain operating in accordance with manufacturer's recommendations.
- Project vehicles, heavy equipment, and machinery will be shut down when stationary for long periods of time. The idling of vehicles and equipment will be avoided whenever practical.
- Dust from Project activities will be controlled where required by using applications of water. Waste oil will not be used for dust control, but other agents, such as wood chips, calcium chloride, matting, and revegetation may be considered on a site-specific or as needed basis.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

- Project-related fugitive road dust will be controlled through measures such as:
  - Establishing speed limits of less than 20 km/hour on Project-controlled gravel roads
  - Conducting road watering on an as-needed basis
  - Washing truck tires before leaving the construction area onto existing paved roads
  - Requiring trucks hauling material to have tarps to cover the load
- Dust emissions during Project activities will be further reduced by covers, screens, enclosures, or other similar methods, where necessary.
- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors, which will help to prevent the movement of dust onto surrounding areas.
- Cleared areas will be paved or revegetated, where possible.
- A cover of native grass will be planted and maintained under and between rows of solar PV panels and routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could produce dust emissions during dry conditions.
- Stockpiles of topsoil, overburden, and other potentially dust-generating materials will be kept covered and used as soon as practical.
- Waste materials will not be burned on-site.
- Haul distances to disposal sites will be reduced as much as possible.
- A construction fence will be retained along the perimeter of the site where feasible; this will act as a barrier to prevent the movement of dust onto surrounding areas.
- Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).
- Blasting will be avoided where possible during construction.
- If required and if feasible, augering will be conducted rather than pile driving. If pile driving cannot be avoided, it will be scheduled during daytime hours only and a vibratory hammer will be used since it is quieter and generates less vibration than an impact hammer.
- Nearby residents will be notified prior to potential pile driving (if required).
- With respect to potential vibration impacts, the contractor will have the required insurance policies in place to cover legitimate claims that may result from damage due to vibration during the construction phase.
- Project vehicles will drive within the speed limit to reduce engine noises as vehicles travel on roadways within adjacent communities and horns will be used only as necessary for safety purposes.
- Acoustical barriers (e.g., engineered materials or stockpiled overburden) will be used near loud sources during construction, if feasible.
- Walled enclosures may be constructed around especially noisy activities, or clusters of noisy equipment or machinery. In cases where it is technically and economically feasible to do so, physical noise controls (e.g., an enclosure for the BESS and physical barriers for transformers and inverters) will be established and Project components with noise reduction capabilities will be preferentially selected.
- Project-specific sediment, dust control, and noise management measures are included in this ESMP to reduce potential impacts to various receptors, including flora and fauna, surface water resources, and surrounding agricultural and other land users, residents, and businesses.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

Measures to Mitigate Impacts on Surface Water and Groundwater Resources
• Existing drainage systems within the Project Property – including land slopes, watercourses, depressions, suckwells, and dry ponds – will be retained and maintained where possible. • A cover of native grass will be planted and maintained under and between rows of solar PV panels to help slow the rate of runoff, control erosion, and reduce the transport of sediment/topsoil off-site. • Paved roadways within the Project Property will consist of kerb and slipper drains, with sets of catchbasins including gully grates to drain captured runoff to culverts leading to suckwells. • A 9-m wide drainage reserve has been proposed along the entire southern boundary of the Project Property. This would involve construction of a runoff interceptor drainage system within the aforementioned drainage reserve. This system may consist of an earthen swale with sloped embankments or an infiltration trench with vertical side faces. Suckwells/infiltration wells may be added to the interceptor drain to assist with the sub-surface drainage of captured rainwater. A hydrological study will be performed during detailed design which will seek to finalise drainage mitigation measures, including final selection of any interceptor drainage system(s) that would be required. • A vegetated buffer strip will be established at the downstream site boundary to control excess runoff. • Silt screens and/or bales of hay will be installed where necessary to contain and prevent the erosion and loss of topsoil from localized areas. • Temporary boulder barriers will be installed at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands. • Temporary stockpiles of topsoil that are not required for re-instatement will be removed from site as soon as possible to avoid migration of topsoil into the natural drainage system. • Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor. • The drainage system for the site will be designed to limit stormflows from the site. • The drainage system design for areas on-site where impermeable areas are to be added will focus on draining runoff to suckwells, and ultimately to groundwater, to reduce the amount of surface water runoff that could potentially impact communities downstream. • During detailed design, the implementation of a dry pond will be studied. If needed, the dry pond will be constructed on land to the west of the area proposed for sheep grazing, north of the Old Train Line Road, to capture a portion of runoff from the North Watershed, promote the infiltration and percolation of runoff to groundwater zones, and reduce to some extent the quantity of runoff that crosses the Old Train Line Road and enters the Project Property. The dry pond shall have shallow slopes, be grassed to facilitate grazing by sheep, and include suckwells with top and side entry inlets along its perimeter.
Measures to Mitigate Impacts on Flora and Fauna
• The mitigation measures identified above with respect to the Atmospheric and Acoustic Environment VC will also serve to mitigate the potential impacts of air, noise, vibration, and dust emissions on flora and fauna. • Only areas required for construction will be cleared, and construction equipment and vehicles will only operate in previously disturbed areas, where possible. Sensitive areas and habitats (if identified) will be fenced off to prevent damage by Project vehicles, heavy equipment, and machinery. • Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce the attraction of birds. • Native plants will be used for landscaping. • Cleared areas will be revegetated, where possible. • To avoid attracting wildlife, wastes will be securely stored, frequently removed from site, and properly disposed of in an environmentally acceptable manner at an approved site. • Erosion and sediment control measures will be established to reduce the potential for silty water runoff from construction areas to migrate off-site and/or into environmentally sensitive areas as described above for Surface Water and Groundwater Resources. These measures will also reduce potential impacts to flora and fauna.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

Measures to Mitigate Impacts on the Visual Environment

- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted in areas where potential off-site visual impacts are of such a nature and magnitude that warrants the introduction of vegetation/tree screens. During the growing-in period of the vegetation/tree screens, the perimeter fencing around the Project Property will be fitted with an opaque privacy screen.
- Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce visual impacts.

Measures to Mitigate Impacts on Agriculture and Other Land Uses

- Project-specific sediment, dust control, and noise management measures described for the Atmospheric and Acoustic Environment and the Surface Water and Groundwater Resources VCs will serve to reduce potential sensory/nuisance impacts to nearby land users (e.g., agricultural workers on the site or on adjacent lands), residents, businesses, and other off-site receptors. This ESMP (Section 9.1) also includes details of how RSB will liaise with the local community before each phase of development.
- Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).
- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors and will act as a buffer to adjoining lands.

Measures to Mitigate Impacts on the Social Environment

Health and Safety

- Measures to mitigate potential impacts on the health and safety of Project personnel (including contractors and employees) and site visitors include:
  - Project personnel will conduct weekly occupational health and safety (OHS) meetings.
  - OHS plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans.
  - The Project will be compliant with the legal and statutory labour requirements, to safeguard community and worker safety and health.
  - Personnel will be required to use protective gear to guard against on-the-job injuries.
  - Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers.
  - Only trained and/or certified persons will use specialized equipment and handle dangerous chemicals.
  - There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site.
  - Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorized personnel.
  - The emergency and disaster management plan (Section 10.0) will be implemented as part of this ESMP, with emergency drills regularly conducted so that Project personnel are able to respond swiftly and appropriately in the event of an incident.
  - Traffic management measures will be put in place and consistently implemented to control on-site traffic, as well as the practices of construction drivers to and from the construction site.
  - There will be adequate 24-hour security to prevent unauthorized entry into restricted Project areas, through CCTV or equivalent monitoring systems. Additional provisions that will be made to enforce safety in and around construction areas include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meet the universal design environmental access requirements/ standards for persons with disabilities, and the installation of open and unobstructed passageways.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

- Measures to mitigate potential impacts to public health and safety include the following:
  - Adequate signage, fencing, guardrails, and/or warning tape will be installed so that members of the public, particularly children, cannot wander into restricted Project areas, and sufficient security will be in place to monitor and enforce these restrictions.
  - Safety warning signs will be strategically placed near construction works to inform the public of prohibited activities. These signs will include both printed words and international symbols and will meet the universal design environmental access requirements/standards for persons with disabilities.
  - Notices will be published in the media to alert the public of the proposed construction works at least two weeks prior to the start of activities.
  - 24-hour security measures, through CCTV or equivalent monitoring systems, will be used to prevent unauthorized entry of persons after working hours.
  - Potentially hazardous areas within and adjacent to the site will be left in a safe condition (e.g., securing materials and equipment, fencing off or preventing entry into excavations or trenches).
  - If detours are planned, relevant local authorities will be notified of the alternative routes in advance.
  - Project drivers will be cautioned to obey the speed limit and other traffic laws, and should ideally be trained in defensive driving.
  - Unauthorized persons who enter the site will be escorted off the site as soon as they are discovered.
  - The area will be well-lit and the public advised on site restrictions.

Human Capital and Social Dynamics

- In addition to regular OHS training and the proposed capacity-building and skills development, contractors will be required to provide gender sensitization training to address critical on-the-job issues and facilitate positive interactions between workers and the surrounding residents. Topics to be included in the training include gender-responsive behaviour and interactions, avoiding sexual harassment, and conflict resolution skills. In addition, there will be transparent disclosure of the requirements for adequate work facilities and decent work, to allow employees to be apprised of their worker rights and benefits.

Economy

- To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being made available to unemployed residents of specifically neighbouring communities.

Cultural Values

- Concerns about the potential change to the aesthetics of the area will be addressed through a carefully planned and implemented public awareness campaign to address the typical concerns raised about the construction of solar facilities on the scale of the Project. An important component of this campaign will be to clearly explain the design of the facility and the potential benefits that could accrue to Barbados.
- Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the Project Property. In this event, the contractor will work with the Museum to develop and implement a plan to protect the artefacts.
- Public service announcements will be provided so that commercial operators, residents, and the public are updated on and given appropriate advance notice of the construction activities, especially those, such as construction activities planned outside of typical work hours, such as late evening or night, that could be disruptive.
- Construction will be based on approved construction management measures in this ESMP to reduce the impacts of noise, dust, vibration, wastes, and traffic.

Infrastructure and Services

- As indicated above, traffic management measures will be put in place and consistently implemented to control on-site traffic, as well as the practices of construction drivers to and from the construction site.
- Measures to mitigate potential impacts on the use of public roadways include:
  - Transport of material and equipment will be scheduled for off-peak hours, to the extent practical.
  - The use of long convoys or trucks during construction and operation will be avoided.

Table 6.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Construction

– Transport of over-sized loads (such as hydrogen tanks) will be coordinated with local traffic management authorities and / or the police. Arrangements will be made for police outriders to accompany long or wide loads during construction. – Flag-persons will be used at intersections with existing roads, or where single lane traffic is created during construction. – Signs will be used to indicate construction zone and movement of trucks and equipment. – High occupancy vehicles like buses will be used to transport workers to and from the site to the extent practical. – Roads, culverts, and bridges which are located along the access routes to the construction site will be inspected prior to the start of construction to check the stated load capacity. This should determine whether they can withstand the expected traffic loads and necessary mitigation should be carried out such as strengthening works, signing, diversions of routes. – Roads, culverts, or bridges which may be damaged as a direct result of construction traffic will be repaired. The nature of repairs will be determined in consultation with the Ministry of Transport, Works, and Water Resources, with repairs done as soon as practical. – Utilities will be properly mapped and considered during construction, and especially prior to ground disturbance activities. – Appropriate consultation will be carried out with utility providers and operators and arrangements will be made for addressing conflicts. – Prior to work, the contractor will consult with the local police service, the local fire service, and the local health authority to discuss proposed activities and possible implications for community services.

7.0 ENVIRONMENTAL PROCEDURES FOR OPERATION AND MAINTENANCE

7.1 DESCRIPTION OF EXPECTED ACTIVITIES

The Project will generate approximately 56,000 MWh per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 Barbadians annually[1]. The electricity generated by the Project will be purchased by the privately-owned utility BLPC, which is currently the sole electricity utility provider in Barbados, at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. During the term of this agreement, the Project will deliver the following power supplies to Barbados' national grid daily:

- 13 MW between the hours of 8:00 and 17:00;
- a two-hour dispatchable block of 13 MW firm to meet the end-of-day peak, when the marginal cost of generation in Barbados is the highest (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid); and
- 3 MW firm the rest of the time.

[1] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

The Project will achieve this by converting sunlight into electricity via the solar PV power plant, converting the electricity from the power plant into hydrogen using an electrolyser system, storing the hydrogen as compressed gas, and then using fuel cells to produce electricity whenever needed from the stored hydrogen gas; the resultant electricity will be delivered to the national grid. These processes will occur during the operational phase of the Project.

A dedicated team of Project personnel will be responsible for carrying out Project operation and maintenance activities, with support from subcontractors as needed. The EMS will enable aspects of the power plant and energy storage systems (i.e., the BESS and HESS) to be controlled remotely during Project operations. Since Project components in the HyPCe area will be mainly automated, the primary job of the operator will be to monitor the infrastructure (including associated cooling, fire safety, security, and fault detection systems) to support their safe, secure, and efficient operation.

Operation and maintenance of the power plant and associated energy storage and management systems in the HyPCe area will entail: regular visual inspections of the PV modules, cables, power stations, and other equipment; thermal control of electrical equipment (e.g., boxes and inverters); cleaning of the PV modules; grass cutting within the grounds of the power plant if solar grazing is insufficient to manage the vegetation in certain areas; transformer oil sampling and testing, and potential transformer retreatment (if necessary) at a specialized third party facility off-site; control of water quality (electrolysis input and output) through filtration, treatment, and product changing when necessary; and waste management.

Maintenance activities will also include corrective or preventative replacement of components such as electrolyte solution, PV modules, inverters, battery cells, and fuel cell stacks. It is expected that the potassium hydroxide (KOH) solution to be used as an alkaline electrolyte in the electrolysers will need to be replaced at least once during the operational lifetime of the Project (i.e., approximately every 10 years during Project operations), and that the batteries, fuel cell, and electrolyser stacks will require replacement once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations).

Agricultural activities during the operational phase of the Project will include sheep husbandry (i.e., the raising and breeding of approximately 1,830 domestic Blackbelly sheep) and the provision of associated feeding, watering, and veterinary care; the solar grazing of sheep between the solar panels of the power plant; irrigation of the fodder pasture as needed; the harvesting, bailing, and storage of grass from the fodder pasture; and washdown, sanitation, and waste management activities. The sheep will be raised for the purpose of producing lamb/mutton meat, sheepskin, and manure for domestic and export markets. No butchering will take place on-site.

7.2 MITIGATION MEASURES

Table 7.1 provides a list of the general standard environmental protection procedures and VC-specific mitigation measures that are proposed to be implemented during the operation and maintenance phase of the Project. The general standard environmental protection procedures are broadly applicable to multiple VCs, while the VC-specific mitigation measures have been compiled from the impact assessments conducted for the various VCs in the ESIA. The list of general standard environmental protection procedures and VC-specific mitigation measures may be modified as the design of the Project progresses and becomes finalized.

Table 7.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Operation and Maintenance

General Standard Environmental Protection Procedures
Waste Management
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • Solid waste generated on-site will be removed on a regular basis throughout the operational phase. • Sheep manure will be removed from the sheep pens daily to prevent the infestation of flies and other insects. • A waste inventory will be developed to support the management of general and hazardous operational waste streams.
Spill Prevention, Control, and Response
• Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer. • Spill response kits will be available on-site. • Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorized personnel. • Fueling and servicing will be conducted at designated sites furnished with spill containment equipment. • Fueling and servicing areas will be sited away from watercourses and drainage works where possible. • The potential for spills will be reduced through the use of standard good practices, such as the use of appropriate containers, and avoiding overfilling. • In the event of a spill, dry clean up and mopping techniques will be used as appropriate. The area will not be “washed down” as this could cause the spills to spread to the surrounding environment and potentially enter drainage works or environmentally sensitive areas. • Spilled material and spent lubricants will be collected and removed from site for disposal at an approved location. • Vehicles, heavy equipment, and machinery will be properly maintained to reduce the risk of leakage. Routine preventative maintenance and inspection of hydraulic equipment and machinery will be undertaken to avoid a hazardous material release. • Soil which may have become contaminated during the course of construction will be remediated. This may be done on-site or removed from site for disposal at an approved location. • Project vehicles will be equipped with appropriately sized spill kits containing the necessary supplies to handle the quantity and type(s) of hazardous materials that are on-site. • Communication systems will be in place and functioning. • Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor’s environmental management plan and implemented by the contractor.

Table 7.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Operation and Maintenance

VC-Specific Mitigation Measures
Measures to Mitigate Impacts on the Atmospheric and Acoustic Environment (including Vibration)
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project maintenance and decommissioning activities.
Measures to Mitigate Impacts on Surface Water and Groundwater Resources
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • Routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could result in a change of the runoff characteristics in those areas. • Paved areas within the HyPCe area and administration areas will be drained by a system of catchment basins, drainpipes, and suckwells. The use of suckwells is intended to promote on-site drainage of runoff to groundwater, rather than to natural drainage courses that convey runoff south and off-site. • The cleaning of PV panels will only be done with clean water. No detergents or cleaning chemicals will be used so that the water that runs off onto the ground does not have chemicals entrained. • Septic tanks and soakaways will be routinely inspected at least once every six months and cleaned as necessary.
Measures to Mitigate Impacts on Flora and Fauna
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating or adequate alternate technology, will be used to reduce the light reflecting from the panels. • Regular monitoring for evidence of avian mortalities / collisions with Project infrastructure will be conducted. Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations. • The vegetation/tree screens, which are proposed for reducing visual impacts, will also reduce sensory disturbance to fauna off-site.
Measures to Mitigate Impacts on the Visual Environment
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels. • An adaptive management approach will be employed if complaints regarding glint and glare are received from local residents or other surrounding land users, potentially including implementation of some or all of the following mitigation measures: – the establishment of additional and/or taller vegetation/tree screens and/or additional opaque privacy screens to further shield or obscure offending panels so that they cannot be seen – replacement of the offending solar panels with those that have a deeply textured surface, to reduce glare intensity – removal or reorientation of the offending solar panels • More generally, if complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in this ESMP and the potential implementation of additional mitigation measures as needed.

Table 7.1 Environmental Protection Procedures and Mitigation Measures to be Implemented during Operation and Maintenance

Measures to Mitigate Impacts on Agriculture and Other Land Uses
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • RSB will consult with neighboring landowners and request that the spraying of herbicides on adjoining fields be limited to days that are not windy in order to reduce dispersion onto the operational renewable energy facility and the sheep farm. • If complaints are received from agricultural or other land users regarding perceived Project-related impacts, RSB will work with the affected land users to address their concerns through the grievance redress mechanism outlined in this ESMP and the potential implementation of additional mitigation measures as needed.
Measures to Mitigate Impacts on the Social Environment
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. When operational, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. In addition to addressing the impacts of noise, air quality, vibrations, worker health and safety, and public health and safety, this ESMP includes a Social Management Plan (Section 9.0) that comprises both a stakeholder engagement plan and a grievance redress mechanism, which are designed to allow the best interests of relevant stakeholders to be considered during the Project.

8.0 ENVIRONMENTAL PROCEDURES FOR DECOMMISSIONING

8.1 DESCRIPTION OF EXPECTED ACTIVITIES

The Project will be designed, built, and maintained to be in operation for at least 25 years. While decommissioning or abandonment of the new facility is not currently envisioned, the Project will at some point be decommissioned or rebuilt at the end of its useful service life, in accordance with the applicable standards and regulations that are in effect at that time. Potential future decommissioning activities will likely involve dismantling and removal of the power plant and other on-site buildings, equipment, and facilities, including possible excavation and removal of concrete pads; transferring of waste materials to disposal, recycling, and/or treatment facilities, as applicable (where re-use is not possible); backfilling of ponds and ditches and re-establishment of natural drainage patterns; and recontouring and revegetation (via natural regrowth and/or seeding with non-invasive plant species) of disturbed areas of the site as necessary to facilitate the desired end land use of the Project Property by the landowner.

8.2 MITIGATION MEASURES

Table 8.1 provides a preliminary list of the general standard environmental protection procedures and VC-specific mitigation measures that are proposed to be implemented during the decommissioning phase of the Project. The general standard environmental protection procedures are broadly applicable to multiple VCs, while the VC-specific mitigation measures have been compiled from the impact assessments conducted for the various VCs in the ESIA. The list of general standard environmental protection procedures and VC-specific mitigation measures may be modified as the design of the Project progresses and becomes finalized.

Table 8.1 Environmental Protection Procedures and Mitigation Measures to be Implemented During Decommissioning

General Standard Environmental Protection Procedures
Waste Management
Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Spill Prevention, Control, and Response
• Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer. • Spill response kits will be available on-site. • Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorized personnel. • Fueling and servicing will be conducted at designated sites furnished with spill containment equipment. • Fueling and servicing areas will be sited away from watercourses and drainage works where possible. • The potential for spills will be reduced through the use of standard good practices, such as the use of appropriate containers, and avoiding overfilling. • In the event of a spill, dry clean up and mopping techniques will be used as appropriate. The area will not be "washed down" as this could cause the spills to spread to the surrounding environment and potentially enter drainage works or environmentally sensitive areas. • Spilled material and spent lubricants will be collected and removed from site for disposal at an approved location. • Vehicles, heavy equipment, and machinery will be properly maintained to reduce the risk of leakage. Routine preventative maintenance and inspection of hydraulic equipment and machinery will be undertaken to avoid a hazardous material release. • Soil which may have become contaminated during the course of construction will be remediated. This may be done on-site or removed from site for disposal at an approved location. • Project vehicles will be equipped with appropriately sized spill kits containing the necessary supplies to handle the quantity and type(s) of hazardous materials that are on-site. • Communication systems will be in place and functioning. • Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor.
VC-Specific Mitigation Measures
Measures to Mitigate Impacts on the Atmospheric and Acoustic Environment (including Vibration)
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project maintenance and decommissioning activities.
Measures to Mitigate Impacts on Surface Water and Groundwater Resources
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on Flora and Fauna
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.

Table 8.1 Environmental Protection Procedures and Mitigation Measures to be Implemented During Decommissioning

Measures to Mitigate Impacts on the Visual Environment
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on Agriculture and Other Land Uses
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on the Social Environment
• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.

9.0 SOCIAL MANAGEMENT PLAN

The SMP comprises both a stakeholder engagement plan (SEP) and a grievance redress mechanism, which are designed to allow the best interests of the relevant stakeholders to be considered during the Project. In addition, it also includes a Social Monitoring Plan.

The potential social impacts likely to arise from the Project largely result from the effects of the noise, dust and vibrations associated with the construction vehicles and equipment. There are also potential impacts related to occupational health and safety and public health and safety. The Environmental Management Plan contains measures required to avoid or reduce these effects. Therefore, this social management plan focuses primarily on engaging stakeholders and the mechanisms that will be put in place to provide information on the Project to the public and encourage participation of affected groups in a consultation process. As indicated above, the SMP comprises two components: 1) the SEP, which is intended to facilitate open and continuous communication and consultation between various groups including construction contractors, stakeholders, and the public; and 2) the grievance redress process to allow RSB to record, investigate, and address legitimate concerns of the Project stakeholders. The SEP will be initiated once the Project receives planning permission to commence activities.

9.1 STAKEHOLDER ENGAGEMENT PLAN

A SEP or process consists of four critical steps. These are:

1. Identification of required resources
2. Identification and analysis of the stakeholders
3. Developing key messages and selecting appropriate engagement channels
4. Implementing, reviewing and revising the engagement plan

9.1.1 Identification of Required Resources

RSB will develop a stakeholder engagement policy and have suitable trained staff to design and undertake the tasks as outlined below. The stakeholder engagement process will be led by a clearly designated Project Liaison (PL) who will communicate with internal and external stakeholders. The roles and responsibilities of the PL include*:*

- Implementation, review, and revision of the SEP
- Stakeholder mapping
- Preparation of communications with stakeholders
- Regular field visits to meet with stakeholders
- Responding to stakeholder enquiries
- Working collaboratively with members of the Project team
- Providing briefings to the Project team
- Arranging and attending stakeholder meetings with the Project team and providing feedback to stakeholder responses and requests within agreed timescales
- Providing monthly reports to the Project Manager

The PL will be experienced in managing engagement with stakeholder groups and in implementing SEPs. The PL will be supported by the Project team, who will provide the relevant information and resources so that the process is efficiently implemented. Critical resources needed to support the implementation of the SEP include, but are not limited to, the provision of a dedicated telephone line or cell phone to receive calls from the public, and a website where information can be made available.

9.1.2 Stakeholder Identification

Stakeholders are the persons, groups, or institutions with an *interest* in the Project or the ability to *influence* the Project outcomes, either positively or negatively. Stakeholders are diverse and may be affected by the Project either directly or indirectly. They can include target beneficiary groups, locally affected communities or individuals, government agencies, non-governmental organizations (NGOs), the private sector, unions, media, and other special interest groups.

Table 9.1 provides the initial list of stakeholders in this Project, their relationship to the Project, and indicates the extent to which gender is a concern with respect to accessing project benefits or vulnerability to adverse project impacts. This list will be maintained by the PL and expanded as needed.

Table 9.1 Preliminary Stakeholder Identification

Stakeholders	Relationship to the Project	Gender Analysis
RSB	Overall Project management	Both males and females in this group benefit from this Project. The current information does not suggest a gender bias.
Engineering Consultants	Quality control for the construction	Both males and females in this group benefit from this Project. The current information does not suggest a gender bias.

Table 9.1 Preliminary Stakeholder Identification

Stakeholders	Relationship to the Project	Gender Analysis
Contractors and construction companies	Responsible for the Project's construction	The preponderance of male workers in the construction industry means that more males than females are likely to benefit from employment opportunities in this Project.
Residents in nearby communities	Could potentially be adversely impacted by the noise, dust, and vibrations from the construction	Both males and females will be affected by the construction. Of specific concern are the retired residents who may be at home during the construction activities.
Town and Country Development Planning Office and Prime Minister's Office Planning Unit	Regulatory agencies responsible for ensuring the development is consistent with the Physical Development Plan and other national Plans and laws	Not applicable
Division of Energy	Regulatory agency responsible for monitoring and regulating the energy sector, renewable energy and energy conservation	Not applicable
Environmental Protection Department	Regulatory agency responsible for ensuring compliance with national or international standards for air quality, noise etc.	Not applicable
Labour Department	Regulatory agency responsible for ensuring decent work standards in the island	Not applicable
Unions	Responsible for protecting workers rights on the island	Not applicable
Media	A likely option for residents who are affected to share their complaints Will publicly report the residents' complaints Can provide a channel for sharing information about the Project with the public	Not applicable

9.1.3 The Communication Strategy

Depending on the objectives, audience and the available resources, various means may be used to communicate with stakeholders. As regulatory agencies are already aware of the Project, the main targets of consultation activities will be the residents in the immediate vicinity of the Harrow site and the wider public. The PL is responsible for implementation of the Communication Strategy.

In general, three levels of communication will be employed:

Step 1: Notifications / Introductions

- The PL will make introductory visits to the surrounding residents and businesses to share his/her contact details (telephone/email address/postal address) and to explain his/her role as liaison.
- Publication of articles and/or notices in the local newspapers and online media and television engagements describing the Project, its goals and objectives and the duration of the construction.
- Initiated in October 2021
  - 04 October 2021 – Article in the *Daily Nation*
  - 13 March 2022 – Television interview on CBC TV8's "The People's Business"
  - 29 March 2022 – Technical presentation for the Barbados Association of Professional Engineers

Step 2: Public Meetings

- Community/town-hall meeting designed to:
  (i) provide information about the Project
  (ii) respond to arising or ongoing concerns
  (iii) inform of the future process of engaging them and dealing with their Project related challenges.
- Invitations: Deliver individual invitations to residents in the immediate vicinity of the Project. These residents have already been identified during the survey, and approximately a quarter of those surveyed have provided email addresses and/or telephone numbers and have indicated an interest in participating in follow-up stakeholder engagement.
- Advertise: place an advertisement in local newspapers and on radio / TV two weeks and one week before the Public Meeting. Advertisement must include the purpose of the meeting, location, and date / time.
- In the current context of the COVID-19 pandemic and to facilitate stakeholders who have mobility challenges or health concerns, a remote option to attend this meeting will be provided; therefore a link to an online meeting platform (e.g., Zoom, Google Meet or Teams) will be included in the notice and invitations.

Step 3: On-going Communication

- On-going communication with government authorities and stakeholders frequency and topics, are described in Table 9.2 and will be implemented on an as-needed basis as the Project proceeds. On-going communication with stakeholders will be conducted by the PL. Communications with government authorities will be handled by RSB.
- In addition to the items identified in Table 9.2, Project social media and websites will be maintained on a regular basis, and a dedicated telephone line (land or mobile) will be available to stakeholders in order to ask questions or file complaints.
- After the preliminary Project community meeting the PL will make regular trips to the community to update residents and stakeholders on the progress of the Project. Concerns voiced by residents during these outreach visits will be reported by the PL to RSB and the Contractors.

- The PL will regularly prepare public service announcements that, following approval of RSB, will be submitted to print and electronic media to update the public on the Project, inform them of Project activities, such as late-night construction, that could cause adverse impacts, and invite participation in subsequent public meetings.
- The PL will maintain a record of visits to and meetings with the community and will submit monthly reports on activities to RSB.

Table 9.2 Communication Options

Stakeholder Groups	Recommended Engagement Technique	Topics	Engagement Frequency
Government Authorities	Formal meetings Site visits Progress reports Project website and social media	Update on project progress and activities Plans for next period Issues and changes	Quarterly/When changes occur
Local Residential	Informal/Formal face-to-face meetings A residential WhatsApp group (these already exist in some of the neighbourhoods) Print media, text/instant messaging, and radio announcements Project website and social media Grievance mechanism	Update on Project progress and activities Plans for next period Issues and changes Job opportunities Invitations to participate in meetings	Monthly/When changes occur
Suppliers of goods and services	Media advertisements Project website and social media	Local procurement	When the need arises
Project Employees	Formal meetings Phone/email/text messaging Workshops Corporate/Project website and social media	Update on project progress and activities Plans for next period Issues and changes	Quarterly/When changes occur
Local Media	Emails to points of contact Press releases Project website and social media	Update on project progress and activities Local procurement and employment data Invitations to attend meetings	When changes occur/ as the need arises

9.1.4 Engagement Tracking and Revision of the Stakeholder Engagement Plan

It is important to periodically review the plan to determine the effectiveness of stakeholder engagement and to modify the plan as necessary. To this end, sound record-keeping and reporting are key sources of information for the evaluation of the engagement process.

Meetings and consultations will be documented, including:

- Meeting date
- Time of start and closure of the meeting
- Persons present
- Agenda
- Main items discussed, and decisions made
- Actions to be taken and persons responsible

In addition to keeping meeting records, a stakeholder register will be maintained, building on the list provided in Section 9.1.2. The register will be disaggregated by gender, age groups, disability, and other criteria necessary to verify that vulnerable groups are being represented at the meetings and in other aspects of the engagement process. Contact details, dates of engagement with comments, and follow up requirements will be clearly and consistently recorded.

To evaluate implementation of the SEP, objectives and targets will be defined for each stakeholder engagement action or initiative. In this regard, critical evaluations questions include:

- What contribution did the specific activity make to the engagement process?
- Was the technique used appropriate for the group that was targeted?
- Were the objectives of the meeting/session achieved?
- Did women, children, the elderly, the disabled or their representatives attend the session?
- Were the issues of vulnerable groups represented in the session?

Concise questionnaires will be used at the end of sessions to obtain stakeholders' feedback on the content and process, and verbal feedback from participants will be noted. Feedback from the stakeholder groups, grievances recorded during the engagement process are also forms of evidence that can be used in assessing the effectiveness of the SEP.

9.1.5 Tracking and Reporting

The PL will maintain a log of engagement activities and interactions with stakeholders, and a record of materials developed and used for engagement purposes.

The PL will submit monthly reports to the Project Manager which include a record of engagement activities, as described above, along with an assessment of the effectiveness of the activities, and recommendations for improving effectiveness of the SEP.

The Project Manager will provide updates on the SEP at the Project Steering Committee (PSC), to report on the progress of the stakeholder engagement and highlight challenges experienced or benefits derived from its implementation.

9.2 THE GRIEVANCE REDRESS MECHANISM

People adversely affected by a project will complain about actual or perceived impacts and will seek to find satisfactory solutions to their concerns or problems. Affected persons (APs) must be able to raise their grievances and must have the assurance that those grievances will receive an adequate hearing. Satisfactory solutions should be generated that mutually benefit both the APs and the Project. It is therefore very important for APs to have access to transparent, fair, equitable, and effective mechanisms that are responsive to their complaints and concerns (Kvam 2019).

Grievance Redress Mechanisms (GRMs) can benefit the Project and APs in several ways. GRMs provide APs with accessible cost-effective ways to report complaints and grievances. They establish a forum whereby APs can report their concerns with dignity and with assurance of access to a fair hearing and suitable remedy. They facilitate APs' access to information and provide APs with opportunities to negotiate and influence decisions of the projects that could adversely affect them. Through GRMs, APs and the Project team are both provided with a structured and systematic way of resolving grievances and disputes relatively early and before they escalate to levels that are difficult to manage. By facilitating effective communication between the Project and APs, GRMs can help to win the trust and confidence of community members thereby creating productive relationships between the parties. GRMs aid in the equitable and fair distribution of benefits, costs, and risks, especially amongst vulnerable groups such as women, children, the disabled and the elderly. These mechanisms can mitigate or prevent adverse impacts of the Project on communities and produce appropriate corrective or preventive action. GRMs can ultimately help to avoid project delays and cost escalation and improve the quality of work (Asia Development Bank 2010).

Based on the social assessment, complaints about the dust and noise from the Project, especially from the residents in closest proximity to, and downwind of the construction zone, may occur. Odours from the sheep farm will also result in complaints during the operation phase. This GRM provides a process for addressing concerns that might arise during the Project, and a procedure that will be followed for the management of associated complaints and grievances. It describes the scope and procedural steps and specific roles and responsibilities of the parties involved. This GRM will be periodically revised and updated based on experience with its implementation and feedback received from stakeholders.

NOTE: This GRM is designed to deal with matters that can be addressed at the Project level. Matters that escalate to the level of lawsuits are not addressed by this mechanism.

9.2.1 GRM Definitions

These definitions were taken from the Grievance Redress Mechanism for the Vanuatu Infrastructure Reconstruction and Improvement Project (Ministry of Infrastructure and Public Utilities of Vanuatu 2018).

An **AP** is a person that is adversely affected temporarily or permanently as a result of the Project works.

A **complaint** is a statement (verbal or written) or expression of displeasure indicating that an impact or effect arising from a Project-related activity is unsatisfactory or unacceptable to the complainant. A complaint is a concern about a minor impact or effect that is typically temporary, short-term, low-risk, and that generally does not require an investigation but **does** require a specific response to remove or remediate the unsatisfactory or unacceptable impact or effect. Complaints that can be dealt with or resolved immediately can be referred to as minor complaints. If not dealt with appropriately and within a short timeframe (typically 2 days but a maximum of 14 days), unresolved complaints can become grievances.

A **grievance** is a statement (verbal or written) about an action, impact or effect arising from a Project-related activity that adversely affects the rights, health and/or well-being of an affected person or people to the extent that it forms legitimate grounds for grievance and if upheld, may result in compensation, legal action or a significant change to the Project in order to resolve the grievance. A grievance will require a specific response and potentially formal intervention by the Project team for resolution and such resolution must be formally agreed and recorded. Grievances may be raised verbally or in writing but must be reported using a designated Grievance Report Form, which must be completed in every instance.

9.2.2 GRM Principles

Grievance mechanisms have been structured and established with the following principles in mind:

1. Accessible – stakeholders should know that the mechanism exists and how they can access and utilize it. To achieve this, the GRM will be publicized.
2. Legitimate – stakeholders should know that they can express grievances without fear of reprisal, victimization, or other negative consequences.
3. Transparent – the process, including outcomes, should be reported on so that stakeholders know that the mechanism is working.
4. Culturally appropriate – the process should be designed to consider specific cultural attributes as well as traditional mechanisms for raising and resolving issues.
5. Confidentiality – whilst general information should be shared to comply with the principle of transparency, personal information and other important or identifying details must be kept confidential.

9.2.3 GRM Resources

The grievance mechanism will be adequately resourced with:

1. People – trained staff or external resources experienced in dealing with community concerns and complaints
2. Systems – systems to receive complaints and grievances and to record and track the response and redress process
3. Processes – written standard procedures for handling grievances, and responsibilities assigned for each step in the process as well as for management oversight.
4. Budget – arrangements to estimate, allocate, track, and report costs associated with grievance handing.

9.2.4 GRM Institutional Arrangements

A Project Grievance Committee (PGC) will be established comprising at minimum the Project Manager, the Project Director, and the PL. The PGC's responsibilities in relation to managing the GRM will include:

- Receiving grievances
- Investigating the grievances and liaising with the stakeholders
- Developing appropriate resolutions and actions to rectify any issues
- Tracking progress of individual grievances
- Documenting any interactions with external stakeholders
- Ensuring that the grievance mechanism procedure is being adhered to and followed correctly
- Ensuring that resolution actions are completed
- Maintaining a grievance register and monitoring any correspondence
- Monitoring grievances/trends over time and reporting findings to the PSC
- Raising awareness of the grievance mechanism among Project personnel and stakeholders.

The PGC will also update the grievance register/database to track the progress of formal grievances for the duration of the Project.

Contractors will be thoroughly apprised of the purpose, structure, and operation of the GRM and are expected to follow its requirements as part of the oversight of their work. Contractors are responsible for logging complaints, minor and otherwise, in the site daybook (or equivalent) for inspection by the Project Engineer or RSB. In addition to documenting complaints, contractors are also responsible for addressing and resolving minor complaints without undue delays.

The PL or a designated RSB team member will have lead responsibility for implementing the complaints and grievance procedures.

9.2.5 GRM Process

Source: UNDP 2017

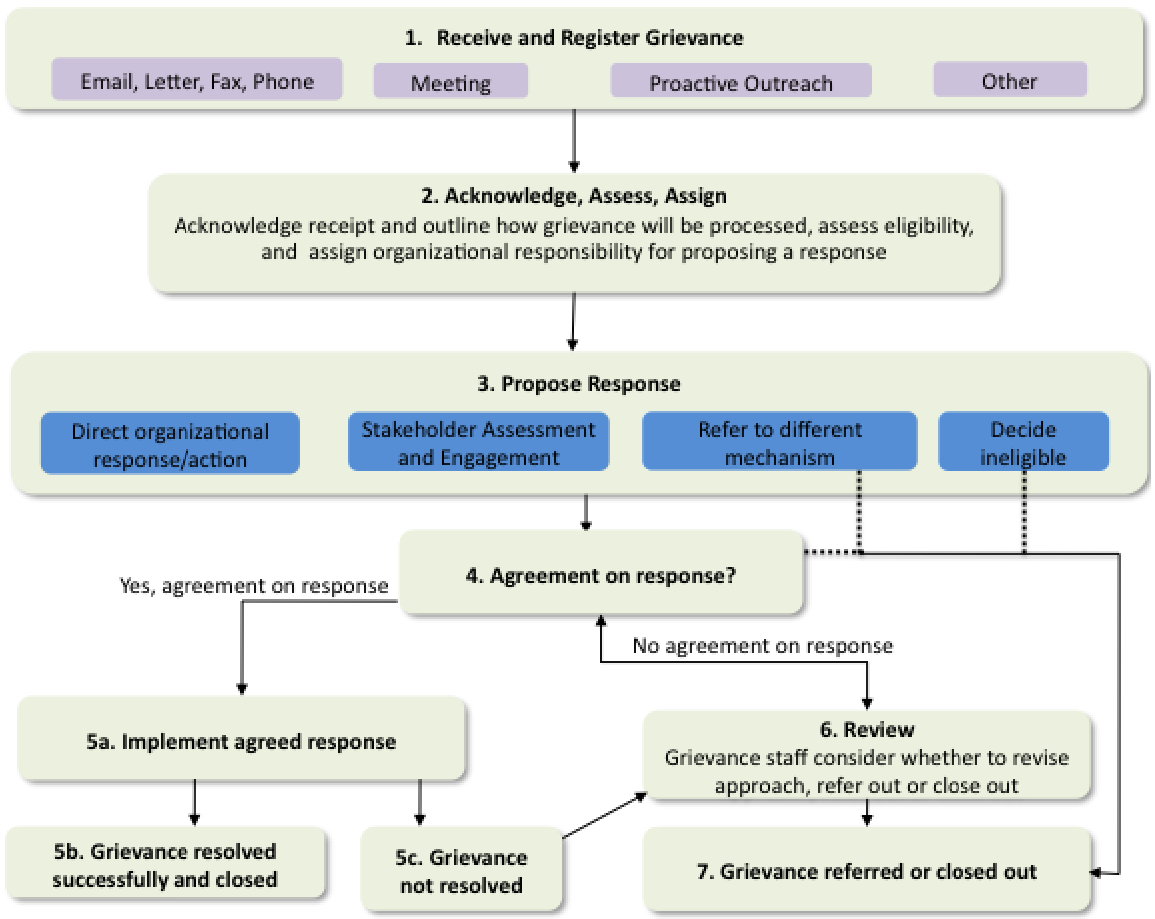
Figure 9.1 shows a typical grievance resolution procedure. Once a grievance is received, it will first be recorded in a standard form, then screened to determine the level of severity and action required, then acknowledged, and investigated in a timely manner. Appropriate response action will be taken and there will be follow-up with the complainants to verify that the actions taken had the desired effect in terms of resolving the issue. Complaints, which are more minor, should be more easily and swiftly addressed than grievances, which will likely require more time for investigation.

Project personnel, contractors, and stakeholders will be made aware of the grievance mechanism. The information disseminated about the grievance mechanism will include:

- Summary of the mechanism and how it should be used
- Clear explanation of who can raise complaints
- Details of the process, such as who is responsible for receiving and responding to grievances
- An outline of the sort of response that can be expected

- Details of the safeguards in place to ensure confidentiality
- Contact details for lodging a complaint or grievance

Communication about the grievance mechanism will be done via the channels identified in the SEP for ongoing communication about the Project's activities. These include the Project website, social media, conventional media, public meetings, and face-to-face meetings with stakeholders. Feedback on the GRM procedure received from stakeholders will be considered and implemented as appropriate to improve the process and tailor it for the Project.



Source: UNDP 2017

Figure 9.1 Grievance Resolution Procedure

Ongoing communication with stakeholders will be used as an opportunity to gain early insights into potential problems that can be averted through prompt action. Ongoing meetings, as part of the routine stakeholder engagement process, will also serve to assure the stakeholders that their concerns are being addressed.

Specific attention will be paid to situations that adversely affect or create disadvantages for women, children, the elderly, disabled persons, or other vulnerable groups. Such situations will be prioritized for resolution.

9.2.5.1 Dealing with Complaints

Any individual associated with the Project, who is the recipient of a complaint, will be required to refer the complaint to a member of the PGC, who will note it in the Complaints Register (CR), even if the matter has already been resolved (as may be the case with, for example, minor complaints that can be easily dealt with through the provision of information). Even for apparently minor complaints, a reliable record will be maintained, in case the matter becomes more serious over time and subsequent action becomes necessary. Complaints communicated via print, social or electronic media will also be followed up by a member of the PGC and recorded in the CR.

The CR will contain a comprehensive record of all complaints, even those that are minor and resolved immediately. Table 9.3 provides a complaint record template.

Table 9.3 Complaint Record Template

Complaint Record	
Date:	
Complainant:	Name: Address: Telephone: Email:
Received by:	Name: Designation: Telephone Email:
Action Taken:	
Further action recommended:	

Most complaints are anticipated to be of low-level severity and should be resolved within a week of receiving the report. The PGC will follow up receipt of the complaint via a written, e-mailed, or telephone acknowledgement of the complaint. If the matter was dealt with immediately by the person receiving the complaint, the purpose of the follow-up letter, e-mail, or call will be to confirm that the action taken was satisfactory and that the matter may be considered closed. If the matter remains to be addressed, the PGC follow-up will confirm the nature of the complaint and indicate the action that will be taken as well, as when it is expected that the matter to be resolved. Once the action is taken, the PGC will communicate this to the complainant and confirm that the matter is resolved. If the matter escalates to a more serious level, the grievance procedures (Section 9.2.5.2) will be utilized.

9.2.5.3 Grievance Procedures

Grievances will be reported to the PGC and recorded on a Grievance Record Form (GRF) for inclusion in the grievance register. Table 9.4 provides a template for a GRF.

Table 9.4 Grievance Records Form Template

Grievance Record
Date of complaint
Time of complaint
Name of person taking the complaint
Job title of person taking the complaint
Name of supervising officer
Complainant information:
Name of complainant
Telephone number of complainant
Address of complainant
Email address of complainant
Details of the complaint:
Nature of complaint: (*In recording the complaint please prompt for the following information where available – dates and times the incident(s) occurred; who was involved in the incident(s); gender and age of people impacted; cost of problem if possible (e.g., cost of doctor's visit and medication; cost of repair to vehicle, cost of repair of third party property, impact of utility outage, etc.)*)
Signature of person making the complaint: *(Complaints can be made by email or in person and ideally should be endorsed by the complainant to ensure accuracy. This can be done electronically without any need for hardware / software over and above a mobile phone or computer / laptop with internet access, via return email or e-signature. If internet access is not available or the complaint is made by phone the complainant should be encouraged to come in and sign off on the complaint. If mobility is an issue the PL should make an appointment with the complainant to obtain the endorsement. In the event that complainants wish to remain anonymous, the issue should still be investigated and a report compiled.)*
Details of the investigation:
Investigation recommended: Information to be gathered Persons/agencies to be contacted Assessment of resolution mechanisms to be utilized (e.g., mediation, compensation, etc.)
Reporting:
Record of the results of the investigation and actions recommended Cost of recommended solutions
Report of action(s) taken including the name of the person investigating the complaint
Date complainant contacted with the results of the investigation and action(s) taken

Relative to complaints, grievances are more serious; they are of mid- to high- level severity, compared to the low severity of complaints. Grievances tend to be repeated, extensive, and may attain a high profile. Prompt and transparent handling of grievances will be important for de-escalating the situation and preventing adverse impacts on the Project and/or stakeholders.

The PGC will formally acknowledge any grievance within five working days of receipt; this communication will be made in written form and ideally communicated by an acceptable electronic means. The acknowledgement will include a summary of the grievance, the method that will be taken to resolve the matter, an estimated timeframe for resolution or the matter, and a request for further information if required.

An investigation of the grievance will be initiated and may require collecting relevant documents, making site visits, consulting appropriate Project personnel, contacting stakeholders, and other activities. Thorough records will be kept of associated meetings, discussions, and activities. Information gathered during the investigation will be analyzed to inform how the grievance will be resolved.

Where necessary, outside parties such as lawyers or insurance companies will be engaged, particularly in cases where claims of loss or damage are involved. There may be a need for subsequent meetings with the complainant(s), to collect more evidence, conduct further investigation, and launch a dialogue towards resolution.

9.2.5.4 Action to Resolve the Grievance

After the investigation, the PGC will use the findings to formulate an action plan, outlining steps to be taken for resolution of the grievance. The PGC's responsibilities in respect of resolution include assigning actions, monitoring actions undertaken, and adherence to timelines and deadlines. The resolution action should be commensurate with the nature of the grievance.

As a part of good practice, proof of corrective actions will be collected, which may include photos, videos or other documentary evidence that demonstrate how the grievance was resolved.

Regardless of the outcome of the investigation, the PGC will communicate a response to the complainant in writing. The response will clearly state the results of the investigation and the status of the complaint. It will present details of the actions that will be taken, by whom and when, and the outcome expected. Even in cases where it is decided that no further action will be taken, this decision will be communicated, with a detailed and respectful explanation, as well as any compelling evidence of why such a decision has been made.

9.2.5.5 Follow Up and Close-Out

The PGC or its designate will contact the complainant within a month after the planned action to resolve the grievance has been completed. This contact will verify that the outcome was satisfactory to the complainant and is an opportunity to gather feedback from the complainant about the grievance handling process. Minutes of the meeting with the complainant will be recorded. Further repeated follow-up by the PGC or its designate may be required to confirm parties are satisfied, and to obtain a collective agreement to close out the claim.

Cases will only be closed out when agreement to do so is reached with the complainant(s).

The GRF and the grievance register will be updated with the necessary details. This includes confirmation from the complainants that the matter has been satisfactorily resolved.

9.2.5.6 Appeal

If the complainant is unhappy with the resolution and/or does not agree with the proposed actions, then the PGC will need to escalate the matter to the PSC. The committee will review the grievance and documentation gathered throughout the investigation and determine whether further actions are required to resolve it. If necessary, the PSC may seek advice from other independent parties, e.g., lawyers etc.

9.2.5.7 Reporting

The PSC will receive quarterly updates on stakeholder grievances from the PGC. Information outlining the number of grievances, time to resolution, and outcomes of grievances will be communicated utilizing a grievance register similar to the one shown in Table 9.5.

Table 9.5 Grievance Register Template

Stakeholder	Date Received	Officer Who Received the Grievance	Grievance Level*	Grievance Description	Cause of Grievance	Outcome	Grievance Status**	Additional Comments
* Low / Medium / High / Critical ** Resolved / Unresolved / Abandoned								

9.2.5.8 Review, Evaluate, and Revise the GRM

Review and assessment of the GRM's effectiveness will be informed by feedback obtained from stakeholders including, but not limited to the PL, Project staff, and complainants. Critical questions to focus the review include:

- Are stakeholders using the GRM?
- Are the frequencies of complaints and grievances increasing, decreasing, or remaining the same?

he PL and Project staff will be encouraged to provide feedback and offer suggestions for improving the GRM. Complainants will be invited to provide feedback on the GRM as part of the close-out process. Below is an example of a brief questionnaire that can be used to solicit this feedback; the questionnaire should ideally be communicated electronically.

1. How did you learn about the GRM?

Project Website	
Project Liaison	
By calling RSB	
Word of mouth	
Other (please specify)	

2. Please rate the following indicators based on your experience with using the GRM.

Indicator	Poor	Average	Good	Excellent
The time it took for your complaint to be acknowledged				
The quality of the Project officers communication with you during the process				
The length of time it took for your complaint to be resolved				
The resolution of your complaint				

3. Would you recommend the GRM to others?

Yes (why)	
No (why not)	

4. What would you recommend to improve the GRM?

9.3 SOCIAL MONITORING PLAN

The following tasks are to be undertaken by the Contractors to mitigate and reduce the negative social and gender impacts associated with the Project, while enhancing the positive impacts. Reports will be submitted monthly to facilitate the monitoring process.

9.3.1 Public Communication

Contractors will liaise with the Project Manager and PL to coordinate communication with the public about the Project.

9.3.1.1 Public Service Announcements

Contractors are required to inform the public of the works programme in instances where disruptions or nuisances are likely to be experienced. This information will be provided by means of Public Service Announcements (PSAs), which will be delivered via multiple media. Channels for distribution of PSAs will include announcements on local radio and television, information posted on social media, information on the Contractor's website, and/or information on the RSB and/or Project website. In the unlikely event of road closures or diversions, the PSA will be made no less than 48 hours and preferably up to seven days in advance of the closure or diversion.

9.3.1.2 Precautionary Signage

Contractors will erect and maintain clearly visible precautionary signs throughout the Project site. These signs will indicate safety procedures for users, including Project staff and visitors to the site. Use of barricades to restrict site access by non-construction personnel will be employed. Examples of signage are provided in Figure 9.2.

Figure 9.2 Examples of precautionary signage

9.3.1.3 Mitigation of Noise Dust and Vibration Impacts

Contractors will adhere to the plan for mitigation of noise, dust and vibration impacts as provided in Section 6.2. Contractors will be provided with a Register of Sensitive Receptors including their locations, with special attention paid to education facilities, health care facilities, facilities for the elderly, facilities for vulnerable persons, etc. During Project works, contractors will avoid or reduce impacts on these sensitive receptors. A sample template for the Register of Sensitive Receptors is provided in Table 9.6.

Table 9.6 Location of Receptors Sensitive to Dust, Noise or Vibrations

Site Ref #	Site/sensitive receptor	Distance from construction	Potential dust impact (*Check if applicable*)	Potential noise impact (*Check if applicable*)	Potential vibration impact (*Check if applicable*)	Comments

9.3.2 Complaints and Grievances

The Contractor will be required to comply with the GRM as outlined in Section 9.2.

9.3.3 Site Safety

Contractors will be required to operate within the requirements of the Barbados *Safety and Health at Work Act, 2005* and subsequent additional regulations associated with the Act. The Project team will include designated and qualified on-site Health and Safety Officers, responsible for verifying that the requirements of the Act and of RSB's own Health and Safety Policies are implemented at the Project site. All health and safety incidents on site, whether they involved Project personnel, will be recorded on an incident report form. An example of an incident report form is provided in Table 9.7.

Table 9.7 Example of a Health and Safety Incident Report Form

Health and Safety Incident Report	
Reported by:	
Contact details: Company: Email: Phone:	
Date of occurrence:	
Time of occurrence:	
Type of incident:	Accident Incident Near miss Violence Ill health Safety Other (Please specify)
Description of incident:	(*Include details that may have contributed to the incident (e.g., poor lighting, absence of signage*)
Description of the outcome:	(*Harm/health effects/damage*)
Description of the corrective measures taken to address immediate hazards related to the incident:	
The affected person:	
Description:	Male Female Worker Visitor Contractor Other (please specify)
Name:	
Address:	
Date of birth:	
Telephone:	
Email:	

Table 9.7 Example of a Health and Safety Incident Report Form

Health and Safety Incident Report	
Witness details	
Name:	
Address:	
Telephone:	
Email:	
First aid	
First aid provided:	Yes No Not applicable
Time of attendance:	
By whom:	Name: Address: Telephone: Email:
Details of provision:	
Post incident:	
Where did the person involved in the incident go next:	Hospital Clinic Private doctor Home Returned to work Other (please specify)
Was the health and safety officer notified of the incident	Yes No
Additional information:	

9.3.4 Monthly Reporting Requirement

The Project Engineer will be required to complete a Project Monitoring Checklist on a monthly basis (Table 9.8).

Table 9.8 Project Monitoring: Social and Gender Checklist

Public Consultation Monthly Reporting Requirement			
The Contractor is required to submit copies of the PSA text as well as copies of the receipts from the placements of the PSA in the local media as proof that these PSAs were transmitted.	Public Service Announcements transmitted (Yes or No)	Copies of PSA and/or received available (Yes or No)	Additional Comments
The Contractor is required to use precautionary signage on site.	Precautionary signage is in place and clearly visible (Yes or No)	Action recommended if signage is not in place and visible	Additional Comments
Air Quality (dust, noise and vibrations) Monthly Reporting Requirement			
The Contractor is required to comply with the specifications of the Environmental Management Plan	Evidence that the Contractor is operating in compliance with the Environmental Management Plan (Yes or No)	Action Recommended if there is evidence of non-compliance or if the measure is not effective	Additional comments
The Contractor has completed a Register of Sensitive Receptors	Register has been completed (Yes or No)	List the specific locations that have been affected in the past month	Additional comments (*should indicate any actions taken to address problems*)
Complaints The Contractor is required to submit copies of all the completed complaints forms to the Project Grievance Committee.	Complaints made and copies of forms were completed and delivered to the Project Grievance Committee. (Yes or No)	If complaints were made, review the complaints form and summarise the status of the situation	Additional comments
Site Safety Monthly Reporting Requirement			
Contractors are required to operate within the requirements of the local Safety and Health at Work Act	Yes	No	Comments
Health and Safety Officer is on site:			
Staff on site are using PPE correctly:			

Table 9.8 Project Monitoring: Social and Gender Checklist

On site safety signage is in place:			
Sanitary facilities are suitable and convenient:			
Facilities for staff to access and or consume meals are available:			
Incident log is in use:			
Incidents which occurred within the month have been/are being appropriately addressed:			
Emergency Plan is in place:			
Emergency numbers are visibly located on site:			
Evidence of Employment of Locals			
The Contractor is required to provide a list of locals who are employed during construction, as well as the nature and duration of the employment.	The list of employees is available (Yes or No)	Copy of employee list obtained (Yes or No)	Additional comments

10.0 EMERGENCY AND DISASTER MANAGEMENT PLAN

There is the potential for unplanned and/or accidental events to occur during the construction and operations and maintenance phases of the Project that could result in adverse environmental and social impacts. Table 10.1 identifies potential accidents, malfunctions, and emergencies that could occur during the construction, operation and maintenance, and decommissioning phases of the Project.

Table 10.1 Potential Project-Related Accidents, Malfunctions, Emergencies, and Disasters

Potential Accidents, Malfunctions, Emergencies, and Disasters	Potential Causes of Incident
Spills or leaks of petroleum products, hydraulic fluids, lubricants, or coolants during Project construction, operation and maintenance, or decommissioning	• Improper transportation, storage, handling, or use of petroleum products, hydraulic fluids, or lubricants • A malfunction or mechanical failure due to improper operation or maintenance of Project vehicles, heavy equipment, or machinery resulting • A collision, roll-over, other accidental event, or natural disaster resulting in physical damage to Project vehicles, heavy equipment, or machinery

Table 10.1 Potential Project-Related Accidents, Malfunctions, Emergencies, and Disasters

Potential Accidents, Malfunctions, Emergencies, and Disasters	Potential Causes of Incident
Spills or leaks of the KOH solution used as an electrolyte in the process of alkaline electrolysis during Project operation and maintenance	• Improper transportation, storage, handling, or use of KOH solution • A malfunction due to improper operation or maintenance of electrolyser equipment • A vehicle collision, other accidental event, or natural disaster resulting in physical damage to electrolyser equipment • Improper removal, handling or transportation of used KOH solution at the end of its useful life
Spills or leaks of oil from electrical transformers during Project operation and maintenance	• Improper transportation, storage, handling, or use of transformer oil • A malfunction due to improper operation or maintenance of electrical transformer equipment • A vehicle collision, other accidental event, or natural disaster resulting in physical damage to electrical transformer equipment • Improper handling of transformer oil during operational sampling and testing activities • Improper removal, handling or transportation of used transformer oil at the end of its useful life
LOC of flammable vapours from battery modules within the BESS during Project operation and maintenance	• Ruptures or leaks from battery modules within the BESS, which could occur as a result of the following: – A malfunction due to improper operation or maintenance of battery modules – A vehicle collision, other accidental event, or natural disaster causing physical damage to battery modules • Upset conditions such as fires within the BESS, runaway chemical reactions, or other accidents or malfunctions
LOC of hydrogen gas from the HESS during Project operation and maintenance	• Ruptures or leaks from H_2 storage tanks, process piping, electrolysers, or fuel cells, which could occur as a result of: – A malfunction due to improper operation or maintenance of these components – A vehicle collision, other accidental event, or natural disaster causing physical damage to these components • Upset conditions such as fires within the HESS, runaway chemical reactions, or other accidents or malfunctions

10.1 ENVIRONMENTAL EMERGENCY MANAGEMENT

The potential accidents/unplanned events or disasters that may occur during the project include

- Fire
- Vehicle Accidents
- Spills of Petroleum, Oils, Lubricants or other Hazardous Materials
- Erosion and Sediment Control Failure
- Explosions
- Hurricanes

Prevention is the first line of defense for an accident/unplanned event; preparation the second. Provided it is safe to do so, the Contractor is expected to respond to any accidental event that arises during the course of their work that may adversely impact the environment. To be able to respond, it is expected that the Contractor will maintain the materials necessary to respond to and address the accidental events listed above, including but not be limited to, spill kits, erosion and sediment control materials fire extinguishers, and shovel. Other materials may be stored in secure and convenient locations that are easily and quickly accessible. The Contractor should also have a recovery plan in the case of a natural disaster (i.e., hurricane).

As indicated in Section 4.4, training will also cover emergency response, including conduct of drills, exercises and training intended to determine the readiness of emergency responders and assess and determine the adequacy of emergency plans and procedures. Contractors will also be required to show that their employees are trained on aspects of emergency response relevant to the roles and responsibilities of such individual employees. First aid kits will be maintained on site at all times and designated personnel will be trained in first aid.

The emergency response procedures identified in Section 10.2.3 for accidental spills are consistent with the Barbados National Oil Spill Response Contingency Plan. Note that due to the nature and volume of oil and petroleum products to be used in association with the Project, a spill resulting from the Project would be considered a Tier 1 spill (i.e., a discharge of less than 1,000 gallons of oil). The Barbados National Oil Spill Response Contingency Plan considers these spills to be minor incidents that occur at or near a specific site of facility as a result of routine activities and that can be successfully responded to using the resources of the responsible party involved, without assistance from others.

10.2 INCIDENT AND SPILL REPORTING

Prior to the start of Project construction, a contact sheet will be developed and readily accessible on site at all times (and appended to these ESMP), with the name, numbers and roles of all RSB personnel and other resources with a role in emergency and disaster response. This contact sheet will include the following numbers:

- Police, Tel: 2-1-1
- Firefighters, Tel: 3-1-1
- Ambulance, Tel: 5-1-1

In the event of a Tier 1 spill, the spill must be reported to the Chair of the National Oil Spill Response Committee at the earliest possible opportunity, but no later than five days after occurrence.

In the event of an environmental incident, including a spill, an investigation will be conducted by a RSB-designated supervisor, with corrective actions identified through root cause analysis. Each corrective action identified will be assigned to a person who will be responsible to ensure that the action is carried out within the prescribed timeframe. The investigation process is summarized below.

1. Initial Verbal and Written Reporting: When an environmental incident occurs, immediate steps will be taken to respond to the scene, in accordance with RSB's emergency response procedures below.

The immediate supervisor and other trained authorized personnel will secure the scene, verbally report the incident to the RSB designate and take action to avoid/reduce further impact to the environment and ensure the area is made safe. The supervisor will then be responsible for completing an Incident and/or Spill Report Form and submit these to the RSB designate.

2. Identification of Direct Cause(s) and Corrective Actions: Corrective actions will be identified and implemented in response to direct cause(s) that are known or suspected as contributing to the incident (e.g., hydraulic hose break leading to a spill). The direct cause(s) and corrective actions will be identified on the Incident and/or Spill Report Form.
3. Investigation Team: A trained and/or qualified supervisor or management representative will perform an investigation of the incident, which may include others as appropriate to the severity or potential severity and type of incident.
4. Investigation Process: The incident site will be visited and photographs, witness statements and other evidence will to be collected. The investigation team will determine a sequence of events to identify relevant actions and decisions that occurred leading up to, during and immediately following the incident. When all pertinent information has been gathered, a root cause analysis will be conducted to determine the root cause(s) of the incident (for example, did the hose that malfunctioned have the appropriate pressure rating, was there a lack of scheduled inspection / maintenance that led to the eventual malfunction through wear and tear, etc.).
5. Recommended Corrective Actions: Recommendations will be made for corrective actions in response to the direct and root cause(s) that were identified during the investigation.
6. Investigation Report: The findings of the investigation as well as recommendations for corrective actions will be recorded on the Incident and/or Spill Report Form. A copy of the Report Form will be provided to RSB management for review and approval of corrective actions. If required, a copy of the investigation will be provided to government regulators.
7. Corrective Action Implementation and Tracking: Responsibility for the corrective actions will be delegated to the corresponding supervisors, who will be responsible for implementing the actions in the specified timeframe and documenting completion. The information on this and the investigation will be recorded in an Environmental Incident Tracker.
8. Follow-up and Lessons Learned: The Environmental Incident Tracker will be used to confirm that corrective actions were implemented and that the report was closed. The tracker will also be used to determine if the actions were effective in prevention of recurrence, to help identify trends, and determine areas for improvement.
9. Communication with Regulator(s): The RSB-designated supervisor will be responsible for following up with the applicable regulator(s) on progress of the investigation, corrective actions, and following these through to closure.

10.3 ENVIRONMENTAL EMERGENCIES AND PLANNING MEASURES

10.3.1 Fire

Fire prevention includes the following policies to help reduce the potential for a fire:

- Smoking by RSB and Contractor staff will be limited to designated smoking areas only
- The Contractor and all on-site personnel will take all necessary precautions to eliminate fire hazards and will keep the area free of flammable materials
- Safe handling and storage of fuels and other flammable hazardous materials training will be provided to Contractor crews
- Removal of flammable waste on a regular basis
- Fire-fighting equipment will be available and crews will be trained in their use
- A fire will be immediately reported using established Emergency communication provided to Contractor crews
- The permitting process for hot work will be followed at all times during construction and operation and maintenance work

Fire response (and reporting) will be conducted as per the RSB and Contractor Project-specific Emergency Response Plans (ERPs). In most cases, the appropriate local emergency response officials will be contacted in the event of a fire in order to support, coordinate, and direct fire-fighting activities.

- RSB and/or the Contractor will make available sufficient firefighting equipment in proper operating condition to suit its labour force and fire hazards. Such equipment will comply with, and be maintained to the manufacturer's standards, and will be inspected on a regular basis and personnel will be trained in the use of such equipment.
- In the event of a fire on site, RSB or the Contractor will take immediate steps to contain or extinguish the fire if safe to do so.
- The first person to observe a fire is to report the following information immediately to the site Supervisor and RSB's HSE Coordinator
  - name of the reporter and phone number
  - time of detection of the fire
  - size of the fire
  - location of the fire
  - number of staff at scene
  - equipment present
- The fire will be reported to firefighters by dialing 3-1-1.
- In the event of an uncontrolled fire, there is a risk of explosion (see Section 10.3.5). Personnel and members of the public will be directed to maintain a safe distance, and personnel will follow the directions of fire fighters when they arrive on scene.

10.3.2 Vehicle Accidents

Movement of construction materials and operation and maintenance personnel will result in an increase in vehicle traffic. As a consequence, there will be a potential for an increased risk of vehicular accidents that could cause property damage and/or injury to Project personnel or third parties (including pedestrians and non-Project vehicles).

Police and emergency response agencies will be contacted immediately in the event of a vehicular accident that results in injuries to Project personnel or the public. Project HSE personnel will also be promptly notified of an accident, regardless of the amount of damage to personnel, equipment, or the public.

Reducing risks to Project personnel and public health and safety will include:

- Identification of primary travel routes
- Providing driver training, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as required
- Designating and enforcing speed limits and obeying traffic laws
- Project trucks will use designated truck routes and observe speed limits and weight restrictions
- Restricting deliveries to avoid typical peak traffic hours, to the extent reasonably practicable
- Monitoring and managing driver fatigue
- Defining protocols for vehicle inspection and maintenance (including applicable safety equipment)
- Preparing a Traffic Management Plan if Project traffic has the potential to close or cause delays on public roadways, with the aim to identify alternative arrangements / routes / accesses and if none are available, to fix the closure or delay to non-peak traffic hours. The public will be notified of road closures prior to a closure

10.3.3 Spills

The heavy equipment used for the Project will require fuel, oils and/or lubricants, and this material has the potential to spill. Spills can happen during refueling and during the normal operation of equipment. The response to a spill will depend on the amount and type of material spilled and the location of the spill, Fuel can be damaging to vegetation, soil, surface water, ground water, wildlife, aquatic organisms, and human health and safety.

Consistent with the Barbados National Oil Spill Response Contingency Plan, the priority objectives for spill response are to:

- Where possible, prevent pollution and other damage from occurring by preventing, controlling or stopping the discharge
- Reduce the extent of pollution or damage that occurs by monitoring the fate of the spilled material, containing and recovering spilled oil, and protecting environmentally and economically sensitive areas
- Mitigate the effects of pollution or other damage that occurs by formulating and executing appropriate clean-up measures.

In keeping with these priorities, the following response procedures will be undertaken in the event of a hazardous material discharge:

- Fuels will only be handled by persons who are trained and qualified in handling these materials in accordance with the manufacturer's instructions and government laws and regulations
- The Contractor and RSB will have spill response equipment on site (e.g., absorbent material, shovels, mini boom)
- The individual who discovers the leak or spill will make all attempts to immediately stop the leakage and contain the flow
- Spill location, type of fuel, volume and terrain condition at the spill site will be determined and reported immediately to the Supervisor and the HSE Coordinator, who will then immediately report it to the appropriate authorities. For oil spills, the following information must be reported at a minimum as per the requirements of the Barbados National Oil Spill Response Contingency Plan:
  - The nature of the incident and the source/cause of the discharge or potential discharge
  - The identity and contact information of the reporting party
  - The identity and contact information of the responsible party
  - The type, size, location and name of vessel or facility involved
  - The type and estimated amount of fuel discharged
  - Current state of the incident
  - Measures undertaken to control the discharge
- Specific details to be taken note of for reporting purposes include:
  - time of spill or leak
  - time of detection of spill or leak
  - type of product spilled or leak
  - amount of product spilled or leak
  - location of spill or leak
  - source of spill or leak
  - type of accident - collision, rupture, overflow, other
  - if the spill or leaked product is contained, and if not, where it is flowing
  - wind velocity and direction
  - temperature
  - proximity to water bodies, water intakes, and facilities
  - terrain, and soil conditions
- The Supervisor and HSE Coordinator will be instructed to act as the "On-Scene-Commander" for the purposes of cleaning up a fuel spill. The person will be trained in spill clean-up procedures and how to mobilize the clean-up equipment (a boom should be available). The “On-Scene Commander” will assume the overall responsibility of coordinating a clean-up and maintaining this contingency plan current and up-to-date. They will have full authority to take necessary and appropriate action without unnecessary delay
- The On-Scene-Commander will act in consultation with the regulating authorities to:
  - assess site conditions and environmental implications of various cleanup procedures
  - recover spilled fuel
  - deploy on-site staff to mobilize pumps and deploy available drums or other appropriate storage containers to the spill site

  - deploy on-site staff to build containment dykes and commence pumping contaminant into drums
  - apply on-site absorbent as necessary
  - store, transport and dispose of contaminated debris, cleaning materials and absorbent material in compliance with local regulations (i.e., in an approved land-fill site for hazardous materials)
  - take necessary precautions to ensure that the incident does not recur
- In the event of a Tier 1 spill, the spill will be reported to the Chair of the National Oil Spill Response Committee at the earliest possible opportunity, but no later than five days after occurrence. Refer to Section 10.2 for incident reporting requirements.

10.3.4 Erosion and Sediment Control Failures

Erosion and sediment control mitigation measures include:

- A 9-m wide drainage reserve is proposed along the entire southern boundary of the PDA. A runoff interceptor drainage system will be constructed within the aforementioned drainage reserve. This system may consist of an earthen swale with sloped embankments or an infiltration trench with vertical side faces. Suckwells/infiltration wells may be added to the interceptor drain to assist with the sub-surface drainage of captured rainwater. The final selection of type of drainage interceptor system will be determined during detailed design
- A vegetated buffer strip will be established at the downstream site boundary to control excess runoff
- Silt screens and/or bales of hay will be installed where necessary to contain and prevent the erosion and loss of topsoil from localized areas
- Temporary boulder barriers will be installed at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands
- Temporary stockpiles of topsoil that are not required for re-instatement will be removed from site as soon as possible to avoid migration of topsoil into the natural drainage system

Project activities and unplanned events have the potential to result in erosion and sediment control failures, leading to unplanned erosion and sedimentation to watercourses on the Project Property:

- Erosion and sediment control measures will be inspected on a regular basis, including before and promptly after rain events to make sure they are secured, and to determine if maintenance or repairs are required
- Erosion and sediment control structures will be inspected during prolonged (> 8 hours) or particularly heavy rain events to confirm they are performing as intended. If they are found to be damaged, they will be repaired, replaced promptly (including during the rainfall event) and/or improved as required to avoid re-occurrence
- Affected waterbodies will be monitored, and remedial actions and reporting, if required, will take place in consultation with regulators

10.3.5 Explosions

Gaseous hydrogen will be produced and stored on site in pressurized storage cylinders at 30 barg. The primary hazards associated with an accidental release from the hydrogen system will result from the flammability of hydrogen gas along with the potential for a subsequent explosion. Leaks or ruptures could occur for the hydrogen gas storage cylinders, associated piping, or from the fuel cells or electrolysers.

Lithium-ion batteries will also be used to store electricity on site. The intrinsic hazard associated with the battery modules is the flammability of the vapours associated with the electrolyte solvent used. Uncontrolled releases of these vapours may result in fires or explosions.

The fire/explosion hazards associated with the Project include:

- Fireball/jet fire caused by the immediate ignition of the hydrogen gas
- Flash fire caused by the delayed ignition of the dispersing vapor cloud
- Vapor cloud explosion caused by significant structural congestion in the flammable region of the hydrogen gas vapour cloud, which causes flame speeds high enough to result in the formation of a pressure wave as the flame propagates through the region
- Vessel explosion caused by jet fire impinging on second storage cylinder, causing the liquid inside to boil and the pressure to increase beyond the maximum allowable for the cylinder
- Process enclosure explosion caused when sufficient vapours released from the battery storage system, hydrolyser, or fuel cells into their enclosures can lead to an explosion

The HyPCe area will be specifically designed to mitigate the risks associated with the energy storage equipment (e.g., fire or explosion due to a battery malfunction or hydrogen gas leak), for the protection of Project personnel and the surrounding community.

- A large setback, with a radius of more than 200 m between the HyPCe area fenceline and the Project Property boundary, is proposed as a safety zone
- The lithium-ion batteries are integrated in pre-assembled enclosures, and include cooling, fire detection, automatic fire extinguisher, and comprehensive fault detection in charge/discharge cycles

In the event of an explosion, the following response measures will be taken:

- Immediate priority will be on the health and safety of employees and members of the public and relocating those in continued risk to a safe distance.
- Police (Tel 2-1-1) and firefighters (Tel 3-1-1) will be notified, and personnel will follow their directions once they arrive on site.
- If an explosion results in injury, the ambulance will be called (Tel 5-1-1), and trained personnel will respond with first aid treatment, where safe to do so.
- If the explosion results in a fire, the measures outlined in Section 10.3.1 will be followed.

10.3.6 Hurricanes

Solar PV farms are generally vulnerable during a hurricane. Hurricanes (and other natural hazards) also have potential to cause damage to various other Project components, including equipment in the HyPCe area, Project agricultural facilities, and various supporting infrastructure, facilities, and utilities.

- The solar panel structures for the Project will be designed in accordance with local and international standards, and in particular to withstand a Category 4 hurricane
- When advanced warning is issued for a storm system:
  - Additional staff and shifts should be arranged for preparation and recovery support
  - An inventory of emergency repair equipment and supplies (emergency generators, sand, sandbags, shovels, first aid supplies, etc.) will be taken and restocked as necessary
  - Potential flood hazard areas should be vacated of vehicles and heavy equipment and staged in safer locations to allow for rapid deployment after the storm event
  - Personnel will only remain on site if adequate and appropriate shelter can be provided and where it does not contravene guidance from local authorities
- Once the storm system has dissipated:
  - Emergency operations and cleanup crews will be activated.
  - The inventory of emergency repair equipment and supplies will be monitored and restocked as necessary.
  - Vehicles will be kept on high ground while parked.
  - Debris removal will be coordinate and undertaken when safe to do so.
  - PV panels and electrical systems will be inspected for silt damage, mud and dirt and clean-up and repairs undertaken as needed.

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