EXPANSION OF THE PEDRO PLAINS IRRIGATION SYSTEM USING SURFACE FLOWS FROM THE BLACK RIVER

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

JUNE 2023

Contract N°			
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LIST OF ACRONYMS AND UNITS USED

AIC	AgroInvestment Corporation
EIA	Environmental Impact Assessment
SEIA	Social and Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FASEP	Fond d'Aide au Secteur Privé
GOJ	Government of Jamaica
GOV	Governmental institutions
IDF	Intensity-Duration-Frequency
MDAs	Ministries, Departments and Agencies
MEGJC	Ministry of Economic Growth and Job Creation
MICAF	Ministry of Industry, Commerce Agriculture and Fisheries
MWP	Maximum Water Pressure
NEPA	National Environment & Planning Agency
NIC	National Irrigation Commission Limited
NIDP	National Irrigation Development Plan
NWC	National Water Commission
ND	Nominal Diameter (of pipe in mm)
O&M	Operation and Maintenance
OUR	Office of Utilities Regulation
RSWL	Rural Water Supplies Limited
SCP	Société du Canal de Provence et d'Aménagement de la région provençale
ToR	Terms of References
WHO	World Health Organisation
WRA	Water Resources Authority
RADA	Rural Agricultural Development Authority
CVA	Climate Change vulnerability

Cum	Cubic meter
m^3	Cubic meter (IS)
m^3 / h	Cubic meter per hour (IS)
l/s	Liter per second (IS)
ha	hectare

Wh	Watt-hour
mWC	meter of Water column (unit of pressure) – 10 m WC ≈ 1 bar
m asl	elevation in meter above sea level (in fact above 0 of Geoïd)

1 EXECUTIVE SUMMARY

The Government of Jamaica is currently implementing aspects of the Vision 2030 Jamaica National Development Plan, and has made food security a priority.

The Pedro Plains Irrigation Development Project by water abstraction from the Black River in St. Elizabeth is therefore being proposed as a vital strategic solution towards continued rural development in the area; the project is truly a sustainable development project, since its objectives touch at the same time:

- The environment: the project aims to reduce uptake in the groundwater resource, to avoid saline intrusion and overexploitation of this precious resource.
- The social aspects: the project aims to increase agricultural productivity, reduce poverty levels and satisfy the area's general water supply needs.
- Economy: local area will benefit of increased income and wellness thanks to the securisation of farmer's production; and since Pedro Plains is the bread basked of Jamaica, the entire nation will benefit of the project, which will secure food supply and autonomy from imported products.

Feasibility study and preliminary design were funded by a Grant from the Government of the French Republic and implemented by the Société du Canal de Provence (SCP) Company on behalf the National Irrigation Commission Limited (NIC).

The project consists in a surface water abstraction from the Black River, in order to irrigate the Pedro Plains, and extend irrigation to additional districts; the following infrastructures are projected:

- Abstraction channel from the Black River at a site located at Lacovia (max uptake flow: 2.2 m3/s)
- A main pipeline of 1400 to 500 mm diameter, approx. 35 km long
- A finer distribution network is made with pipe diameter between 50/75 mm and 300 mm
- 4 pumping stations and 4 reservoirs
- Two photovoltaic power plants of 6 and 3,7 MWp, located respectively at Lacovia and Newell, and allowing to generate electricity to meet part of the pumping stations power demand.

The accompanying measures of the project include two components: assistance for operation and maintenance of the infrastructure, and rural development support.

The ecological baseline assessment of the project area was conducted during field campaigns carried between October 2019 and May 2023 by the ESL. Surveys were conducted at several points along the proposed pipeline network and in sites identified for the construction of pumping stations and reservoirs. This included the proposed site for the intake located in the northern section of the Black River Lower Morass in Lacovia, St. Elizabeth.

Flora

The vegetation observed within the project area can be classified into two categories**:** **riparian/wetlands** and **mixed woodland and cropland**. A total of 100 plant species from 65 families were observed and recorded, predominantly herbs, shrubs and fast-growing trees typically associated with the early stages of ecological succession. The vegetation structure (species composition, vegetation density) is an indication that the area has been significantly disturbed by anthropogenic factors, which is expected given that much of the project area has been previously cleared for or significantly influenced by agriculture and rural settlements.

Avifauna

The assessment identified a total of 51 species of birds, 42 of which are typically found in inland forests and 9 are commonly associated with wetland habitats. Of the total number of inland forest species identified, 5 were endemics, 31 are residents and 6 were identified as migrant birds. Most of the birds were observed in areas covered by secondary woodland. All of the wetland species observed were resident species.

A resident in the Black River Lower Morass, the West Indian Whistling Duck (Dendrocygna arborea) a rare, wetland bird considered by the IUCN to be vulnerable, was not detected during these surveys.

Herpetofauna

The most common reptiles were Anolis lizards, which were observed throughout the woodlands, residential and cultivated zones. Common reptiles included anoles such as *Anolis lineatopus* and *A. grahami*. Additionally, *Aristelliger praesignis* (geckos/croaking lizards) were common and were detected from their calls.

The alien invasive cane toads (*Bufo marinus*) were observed throughout the project area, particularly in moist areas. Other frogs were heard during evening visits to the site, the most common was the introduced, invasive *Eleutherodactylus johnstoni* (Johnsons Robber Frog), which was abundant in the more vegetated, woody areas. The *Osteopilus brunneus* (Laughing Frog) and the *Osteopilus crucialis* (Jamaican Snoring Frog) were also detected.

The American Crocodile, while not observed during the surveys for this assignment, is listed by IUCN as vulnerable and is protected. The current status and population is unknown especially within the Black River Morass due to migration and nesting variation and patterns.

The **Black River Lower Morass** forms part of the proposed Black River Protected Landscape (BRPL) and is a community of conservation concern because of declining abundance, sensitivity to disturbance and/or reliance of listed or sensitive species on the habitats that they create.

The sections of the Black River Lower Morass that fall within the project footprint can be characterised as follows[1]:

- Sedge Marsh dominated by Cladium jamaicensis (sawgrass);
- Riparian swale dominated by Typha domingensis (cat tail or bulrush);
- Swamp Forest dominated by Roystonea princeps (Endemic Swamp Cabbage or Royal Palm);
- Woodlands on limestone islands dominated by Sabal jamaicensis (Bull Thatch)

These communities provide foraging, breeding and refuge habitats for many wildlife species, particularly birds. Many of these communities have been lost or degraded due to land conversion to agricultural uses and urban development.

The area of interest for the proposed pipeline network can be classified as disturbed to highly disturbed. The portion that falls within the northern sections of the Black River Lower Morass (BRLM) show signs of significant anthropogenic influence, particularly the site identified for the intake and pumping station #1 as it is located on a vast animal farm where natural vegetation has been cleared. Similarly, the pipeline route and sites for the remaining pumping stations and reservoirs cross lands that have been historically cleared for conversion for use in agriculture, residential settlements and supporting infrastructure.

Main impacts of the project concern both preparation - contruction phase and operation phase.

Impacts on physical parameters related to <u>preparation and construction</u> of the pipeline network, intake, reservoirs, pumping stations and photovoltaic plants can be summarized as follows:

- Site cleaning, trench excavation, storage of soil aside during pipe laying or during construction of reservoirs or pumping station can create increased air pollution because of dust. Noise and vibrations can also occur but will be limited in time.
- Gas emissions will increase due to traffic of heavy duty vehicles.
- Generally, fuel recharge of vehicles or any other machine can imply surface water pollution. Sewage system can also have a negative impact on water quality.

Buildings (pumping station) or reservoirs can imply a modification of drainage patterns, but this will occur very locally and will not increase flooding risk. Surface water quality can be also

[1] As described in the Ramsar Information Sheet (NRCA, 1997)

affected by contruction works, because of increased erosion or drainage of water with a high rate of suspended solids.

During operation phase, main identified impacts can be of 3 types:

- impacts due to water uptake: these impacts are both physical (impact on water discharge and level) and environmental, on water related species habitat for example;
- impacts due to operation of the infrastructure itself (mainly environmental, such as periodic pipeline flushing)
- impacts due to the fact of using water for irrigation : these impacts are generally indirect, and are linked to the consequences of providing water for agriculture. They imply positive consequences (benefits for social and production aspects) but also possibly negative impacts due to increased use of pesticides, overproduction etc. All these aspects are discussed in paragraph 7.2.3.

Appropriate mitigation measures for the identified impacts of the development have been considered.

During construction phase:

- General principle will be adopted to avoid dust generation (e.g. prinkling during the fase of trench preparation), or any seepage into the soil or groundwater (ex. fuel recharge on impermeable surfaces).
- Only vehicles respecting gas emission standards will be allowed to operate, and their speed will be limited to avoid dust dispersion.
- Temporary chemical toilets will be located through the work sites.
- Solid waste generated during the project construction phases will end into approved disposal centres.
- The JNHT will be immediately alerted in case of discovery of any ancient monuments or sites.
- Works will avoid cyclonic season, especially in places where flooding can occur.

Concerning habitats, flora and fauna preservation, the following measures are proposed:

- Soils will be sorted in order to separate the surface layer, in order to favorize land cicatrisation.
- All works having possible impact on the river's water quality (creation of the intake channel) will benefit of an intermediate filtration system (ex. sheet pile wall and/or straw bale filtration) to avoid direct sediment weathering to the river.
- Wherever possible, preserve the trees along the pipeline route, paying special attention to trees that are used for bird nesting.

Specific additional measures concerning the protected area of the Morass are:

- Manual clearing of the area: in order to better identify eventual nests of birds, crocodiles or any other specific fauna.
- Presence of an ecologist during sensitive phases of the project: the ecologist will ensure awareness of the workers to environmental issues, will check that the environmental mitigation measures are applied and respected, will provide advice when specific situations occur.
- Disposal of invasive species encountered during the work, to avoid spreading them in other sites.

<u>During operation phase</u>:

Concerning environmental issues, two potential impacts have been identified during operation phase:

- Possible impact of water abstraction (especially during dry seasons). For that issue, a water flow monitoring programme will be engaged and coupled with remote control of the uptaken water, in order to guarantee environmental flow to the river section downstream from the intake point: riverine discharge will be measured at Lacovia bridge upstream from the uptake channel.

  The following rule will be applied: the uptake of water will be stopped if

  "upstream flow at Lacovia"- "uptaken flow" value < ecological flow

  This measure will allow to adapt (reduce) water abstraction during exceptionally dry seasons, ensuring the ecological flow.

- Suspended solid flows during pipe maintainance operations: specific rejection points should be identified during final design phase. The main rejection point will be the Black River. The mitigation measures associated to this kind of maintainance (that will occur every few years) are:
  - to reject water into a drying bed that will allow sedimentation of suspended matter.
  - To do the maintainance during wet season, when the river has naturally a high content of suspended solids.

If all the mitigation measures will be taken into account, the residual negative impacts of the project are evaluated to be minor or neglectable. And of course the project will bring also positive impacts in the area of Pedro Plains, and indirectly for the whole country.

The positive social impact of the project is an **increase** (from 900 to 4000) **of farms connected** to at least one private hydrant for agricultural use, and the **multiplication by 4 of water delivery volumes** for domestic and touristic use by NWC (from groundwater resource).

At the same time, thanks to resource substitution of ground water by surface water for irrigation purpose, the project **is expected to divide by 2 the overall volume of water abstraction from the aquifer,** with a positive effect on the latter.

Finally, positive impacts are also expected for agriculture: an **increase by at least 20% the added value of marketable production** of the area, thanks to the increases of the yields, of the number of crop cycles per year, and of the irrigation rate.

2 INTRODUCTION

The Government of Jamaica (GOJ) is currently focused on increasing economic activity and real gross domestic product (GDP) growth through the expansion of the agricultural sector. This is in keeping with the thrust to implement aspects of the Vision 2030 Jamaica National Development Plan to make food security a priority.

The Pedro Plains Irrigation Development Project by water abstraction from the Black River in St. Elizabeth is therefore being proposed as a vital strategic solution towards continued rural development in the area; the project is truly a sustainable development project, since its objectives touch at the same time:

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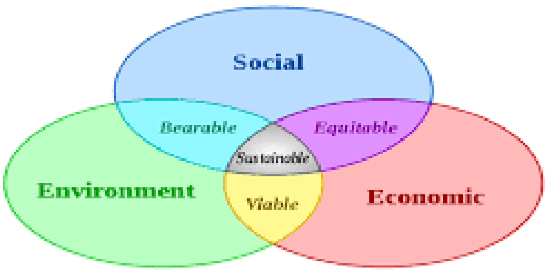


Figure 1 – The sustainability diagram according to Brundtland

Feasibility study and preliminary design were funded by a Grant from the Government of the French Republic and implemented by the Société du Canal de Provence (SCP) Company on behalf the National Irrigation Commission Limited (NIC).

The project described in the following chapters was submitted for a screening to NEPA, and needs an environmental and social impact assessment (present document).

3 POLICY, LEGISLATION AND REGULATORY CONSIDERATION

The following regulations apply to the project:

The Irrigation Act (1949) which sets out the roles of the Irrigation Authority (currently the NIC) in relation to irrigation schemes, its powers to abstract, divert, impound and distribute water, and outlines specific drainage responsibilities in the Black River area;

The Public Health Act (1985);

The NRCA Act (1991) which includes provisions for the discharge of effluents and general pollution of water resources;

Jamaica Water Sector Policy (1999) which deals with water resource management, urban water, drainage and sewerage, rural water and sanitation, irrigation water;

Water Sector Strategy and Action Plan (2004) which includes targets on service provisions in all major towns by 2020 and the rehabilitation of existing non-compliant facilities;

Water Resources Authority Act.

The Town and Country Planning Act.

Moreover part of the project is in the Black River Lower Morass, an area protected by the Ramsar Convention. The site covers an area of 85,664 ha.

The permits identified at that stage for the project are:

- Environmental permit,
- Planning permission,
- Building permission,
- Permit for installation of a pipeline, construction of dykes, aqueducts etc.,
- Water abstraction permit
- Solar farm permit.

4 PROJECT DESCRIPTION

4.1 GENERAL CONTEXT

The Pedro Plains area is located in the parish of St. Elizabeth. It lies between the coast in the South, the Black River Morass in the North, and the western slopes of the Santa Cruz Mountains. The topography is irregular, varying in height between several meters and 700 meters above mean sea level (amsl.).

The National Irrigation Commission is in charge of the water infrastructure for irrigation.

Although the new infrastructure will transport raw water for only irrigation purposes, the technical studies have calculated water requirements taking into account all water supply needs. This is because thanks to the Pedro Plains Irrigation Project, which uses water from the Black River, much less water will be needed for irrigation from existing wells. This groundwater volume will be thus partly available to satisfy non-irrigational needs. These total requirements are described below.

4.1.1 PEDRO PLAINS AREA AND EXISTING WATER INFRASTRUCTURE

The equipement of the area in water infrastructure started in the 1960s: approximately 1165 ha, serving Hounslow and Beacon Little Park areas, were equipped with a pressurized irrigation system, pumping from deep wells. The Hounslow irrigation scheme was constructed in the 1960s and rehabilitated in 2007. The Beacon Little Park irrigation scheme was constructed in 2007, and the abstracted water is used for both municipal and irrigation uses. Currently the licensed abstraction allocation cannot adequately satisfy both the existing irrigation and municipal demand.

☞ ***See map 001 – Existing irrigation infrastructures***

Table 1 - Existing irrigated areas

Scheme	Gross area (ha)	Water source	Licensed abstraction (m3/day)	Demand
Hounslow (D)	759	Groundwater	50,492	Irrigation
Beacon Little Park (J)	406	Groundwater	15,812	Irrigation, Municipal (NWC)
Total	1,165		66,304	

4.1.2 WATER DEMAND FOR IRRIGATION

Water demand for the project is calculated on the basis of the future needs. Continuous flows (Qc) are calculated with the specific flow determined during the 2019 study performed by SCP.

Table 2 - Specific continuous flows by sector

Sector	Specific flow L/s/ha
Hydraulic levels 1 & 2	0.65 L/s/ha
Pedro cross	0.75 L/s/ha
Hydraulic level 3	1.00 L/s/ha
Hydraulic level 4	1.23 L/s/ha

The specific flow is multiplied by the irrigated area taken as a percentage of the irrigable area. Irrigated area considered is taken as 65 % of the equipped area[2] (determined in the 2019-study).

For a given irrigation season, this rate takes into account:

- The non-irrigated fields by nature, such as non-irrigated meadows, guinea grass fields;
- The non-irrigated fields by human causes: change of farmers, land conflict, fallows;
- All part of the fields non-irrigated by technical reasons: borders, access lane, trees etc.

This rate generally varies between 30% and 70% for any pressurized irrigation network on-demand.

Peak flow (Qp) is determined by the Clement Formula as recommended by the Food and Agriculture Organization (FAO) for the design of on-demand pressure irrigation network.

4.1.3 DOMESTIC, INDUSTRIAL AND TOURISTIC WATER REQUIREMENT ASSESSMENT

The population for the 16 communities of the study area is 43,105 in 2010 (RSDC[3]). They are supplied with water from 4 working wells of NWC. With knowledge of the population growth

[2] The area equipped is almost the arable area. Housings area is not taken into account in the rate of irrigated area because it isn't usually included in the arable land. It is therefore difficult to estimate a difference in the rate of irrigated area by sector.
[3] Research Department Social Development Commission

rate and projection until 2050[4], population is calculated in 2019 and 2050. Different models of population for Jamaica show that population should decrease after 2030. In our local case, due to the potential attractiveness of area, it is chosen to maintain the population over the years 2030-2050 without decrease.

Consumption hypothesis comes from NWC and is equal to **50 imperial gallons per day and about 227.5 l/person/day**. For comparison, average consumption in France is 165 l/person/day).

For touristic needs, calculation is based on current estimated offer of rooms and future estimation. According to M. Henzell, Chairman and member of the "Breds- Treasure Beach" Foundation, there are currently about "750 rooms in Treasure Beach among hotels, cottages, guest houses and villas". Projections of the foundation are that this amount of rooms will "double to 1,500 over the next 10 - 15 years". Based on this estimation for Treasure Beach (where almost all touristic rooms in the study area are currently located), it is considered an optimistic linear progression up to 2,250 rooms for 2050 in the study area, and a water need of 50 imperial gallons/room/day.

For industrial needs, such as Grace food processing unit, gravel pits, carwashes etc., estimation is based on consideration of a 10 cubic meter use per unit and per day and an amount of 10 units that will be double until 2050.

Needs for public supply offices, schools, supermarkets, little business etc., are considered to be within the population need calculation.

Even though the projected infrastructure will transport raw water for irrigation purposes, the calculations of water needs during feasibility studies were done taking into account all water supply needs. This is because thanks to the Pedro Plains irrigation project with uptake from the Black River it will be possible to use much less water for irrigation coming from the existing wells. This groundwater volume will thus be partly available to satisfy non-irrigational needs.

[4] https://www.populationpyramid.net/jamaica/ and http://perspective.usherbrooke.ca/

4.1.4 FUTURE IRRIGABLE AREAS

The area served by the future project to satisfy the water demand is around 4,000 ha. The updated total areas are summarized in the table below according to the suggested resource.

The map below shows the distribution of the areas in the study area, divided into 4 hydraulic irrigation levels.

☞ ***See map 002 – Future equipped areas***

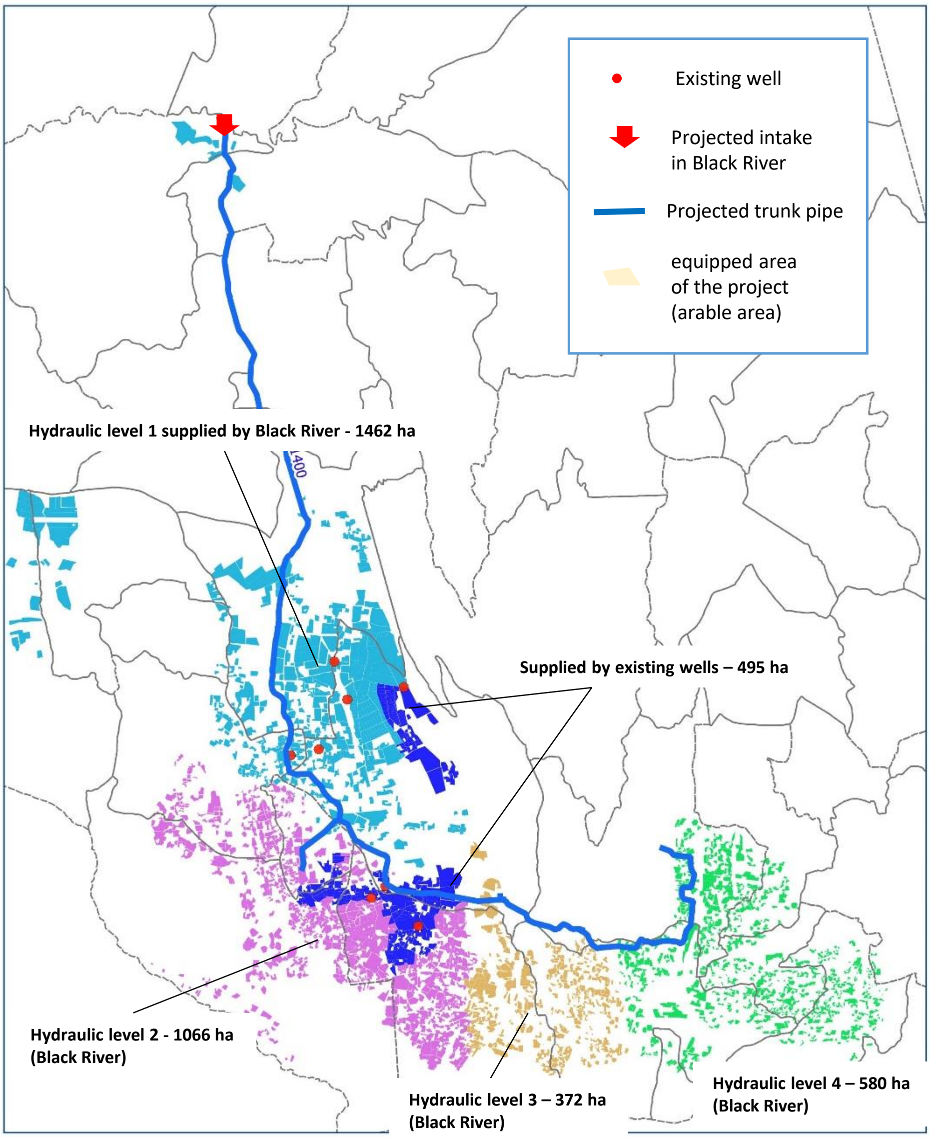


Figure 2 - Overview of projected irrigable areas by water resource

The blue areas will still be supplied by wells. Each color represents a hydraulic level supplied by the Black River.

Table 3 - 2022 irrigable area estimation of the project by water resource

Resource	Current equipped area (hectares)	Projected irrigable areas (hectares)
BR (level 1)	0	1461.95
BR (level 2)	0	1065.46
BR (level 3)	0	372.91
BR (level 4)	0	580.49
Wells	1381.5	495.31
Total		**3976.12**

BR = Black River. The water supplied by Black River is distributed in four hydraulic levels, based on altitude.

Wells = Areas supplied by existing NIC wells.

The irrigable area is equal to the future equipped area. The irrigable area includes arable land, i.e. crops, guinea grass and arable pasture.

The next figure shows the same areas distinguished by hydraulic antenna (a colored area is supplied by an antenna and a distribution network connected to the trunk pipe).

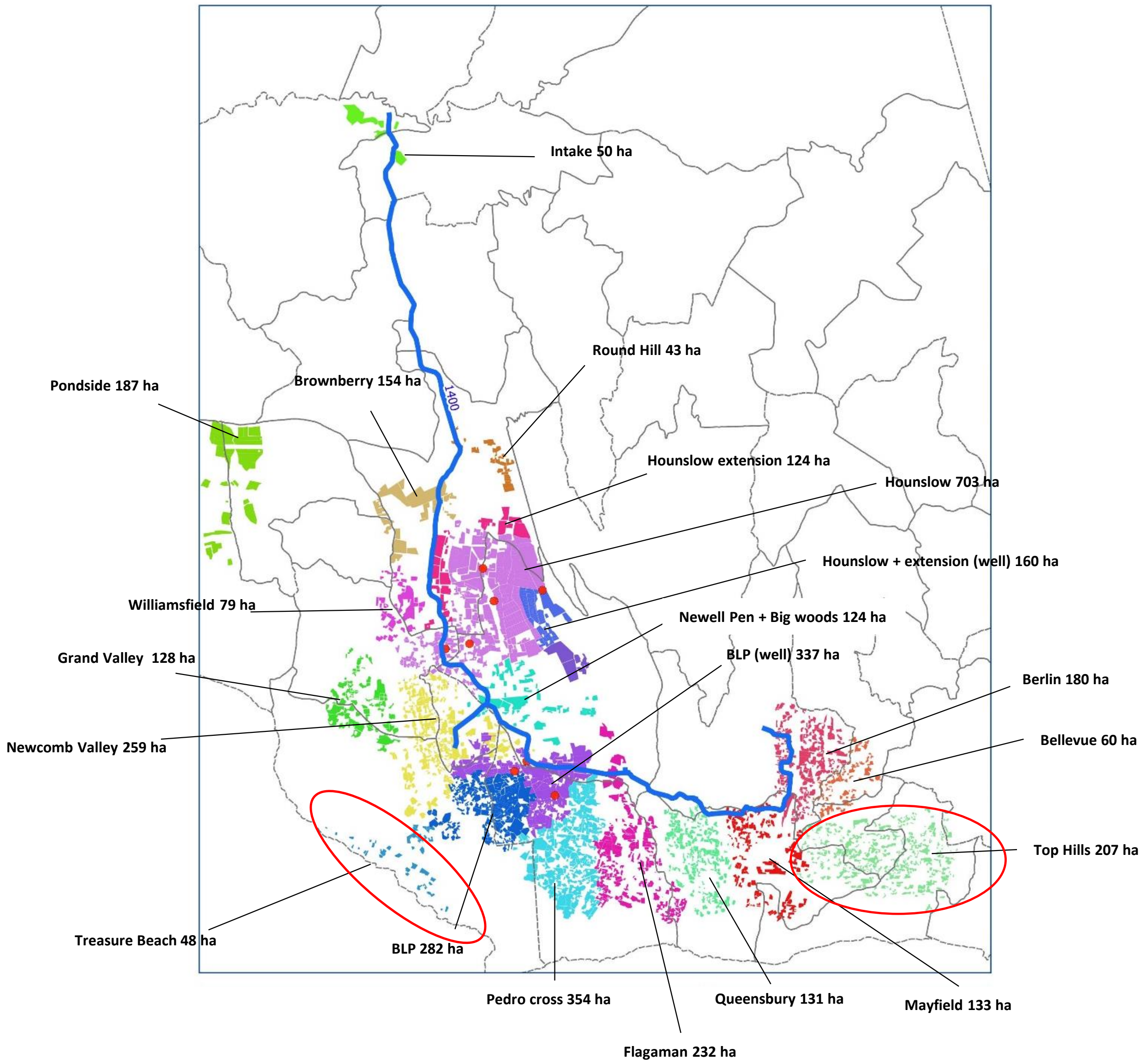


Figure 3 - Overview of projected irrigable areas by antenna

Table 4 - 2022 irrigable area estimation of the project by hydraulic antenna

Name of distribution area	Water ressource (BR = Black River)	Irrigable area (hectares)
Beacon Litlle Park - Wells	Wells	336.71
Beacon Little Park - Black River	BR (Level 2)	282.17
Bellevue	BR (Level 4)	60.07
Berlin	BR (Level 4)	179.73
Brownberry	BR (Level 1)	154.04
Flagaman	BR (Level 3)	242
Grand Valley	BR (Level 1)	127.8
Hounslow	BR (Level 1)	702.75
Hounslow - Wells	Wells	98.98
Hounslow extension	Level 1	124.31
Hounslow extension Wells	Wells	59.62
Intake	BR (Level 1)	50.04
Mayfield	BR (Level 4)	133.3
Newcomb Valley	BR (Level 2)	259.32
Newell Pen	BR (Level 1)	123.51
Pedro Cross	BR (Level 2)	353.93
Pondside	BR (Level 1)	184.82
Queensbury	BR (Level 3)	130.82
Round Hill	BR (Level 1)	43.15
Top Hill	BR (Level 4)	207.39
Treasure Beach	BR (Level 2)	42.24
Williamsfield	BR (Level 1)	79.33
Total (hectares)		**3976.12**

☞ ***See map 003 – Projected distribution sectors***

4.2 PROJECTED INFRASTRUCTURES ABSTRACTING WATER FROM THE BLACK RIVER

The project involves drawing surface water from the Black River to irrigate the Pedro plains and extend irrigation to other districts (see map 2); the following infrastructure is planned:

- Abstraction channel from the Black River at a site located at Lacovia
- A main pipeline of 1400 to 500 mm maximum diameter, 35 km long
- A finer distribution network is made with pipe diameter between 50/75 mm and 300 mm
- Four pumping stations and four reservoirs
- Two photovoltaic power plants, one located close to Lacovia, and another in Newell, and allowing to generate electricity to meet part of the pumping stations power demand.

☞ ***See maps 004, 005 and 006 - projected hydraulic sectors, general, zoom North and South***

As stated before, the design flow is chosen to supply irrigation demand of approx. 4000 ha during peak month (June/July) of a dry year (1 year/5), and taking into account Global Climate Change until the 2050s.

The amount of abstracted water was calculated in order to **respect the ecological flow** of the Black River. This value was calculated using the rule defined by WRA as:

Ecological flow = 60% of the stream flow on 7 days minimum – period of ten-year return

The value of 60% is a conservative value, because usually a 70% value could be used.

Detailed calculations of that value are presented in the impact section (chapter 7).

Table 5 - Hypotheses of design studies: projections of demand and abstraction flows (peak month, dry year1/5) in 2050

	Demand (l/s)	**Abstraction/supply (l/s)**		
Resource		*Black River*	*Ground water*	***Total***
Irrigation	1,852	1,800	52	**1,852**
Domestic, industrial & touristic	114		114	**114**
Total	**1,966**	**1,800**	**166**	**1,966**

Design peak flow for hydraulic development is about 2.2 m^3/s for an uptake during 20h. This corresponds to an average daily uptake of 1.8 m^3/s during the peak of irrigation season. Compared to existing districts and current maximum pumped flow, supplied peak flow for irrigation would be multiplied by 5, and supplied peak flow for domestic, industrial and touristic use, by 4.6. At the same time **pumped peak flow from ground water would drop by 55%**.

This design flow is significantly lower than the maximum sustainable abstraction flow from the Black River, which has been assessed by WRA at the value of 5.34 m^3/s at Lacovia.

During the year, the volume consumption would vary as follows:

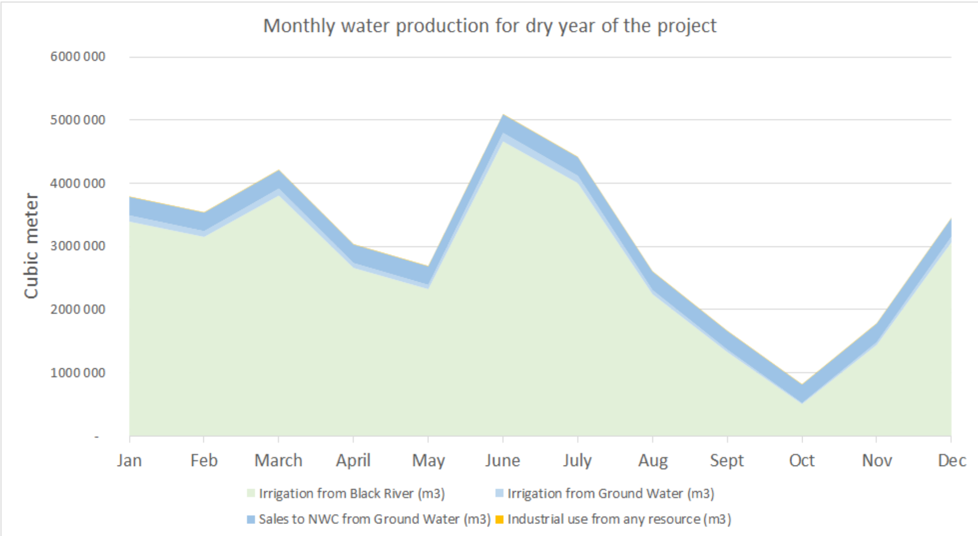


Figure 4 - Monthly volume consumption per use and per resource for dry year

Hydraulic development is based on on-demand distribution criteria, which offer better quality of service to customers (flow and pressure available 24/24) compared to a distribution with water turns.

In relation with these on-demand criteria and to ensure robustness of the system, pumping stations would be connected to reservoirs located in elevated sites. To limit design pressure (maximum working pressure) and according to the area topography, the development is based on 4 hydraulic levels, each of which fitted with a pumping station and a reservoir.

4.2.1 ABSTRACTION POINT INFRASTRUCTURE

As already mentioned, water is taken at Lacovia. A 3 m channel will allow to inptake water from the Black river, and convey it to the pumping station PS1. The inlet of the channel is equipped with an automatic trash rake. Another finest filtration is made upstream of the pumping inside the pump house, by a travelling bandscreen, having a cut off point of 2 mm.

Picture 1 – Example of trash rake

The PS1 pumps water under pressure through a filtration plant (cutoff point of 80 microns) located near the intake, up to the reservoir 1. The filtered sediments from the filtration plant are automatically thrown in a drying bed, and at a given frequency, they are transported to a final storage area (e.g. for use in agriculture, or landfill).

Picture 2 – Example of pressurised filtration system in Southern France

Buildings and areas required for operation are:

- A life base for the operating team, or the pump house chief.
- A meeting room
- A workshop room
- A hangar for vehicles (bobcat for channel and infiltration bed cleaning, dump truck for sediment evacuation)
- A parking space
- A turning area for vehicules

The intake is completed with a possibility of doing bleeding for the 1,400 mm trunk pipe. This bleeding structure is composed of:

- A bleed pipe
- A energy dissipation hole
- An open channel for water outlet to the river

The total required space for intake and related facilities is about 2.3 hectares.

4.2.2 SOLAR FARMS

Two solar farms are projected, with the aim of providing energy to the pumping stations (PS1 and PS2). The best size for solar farms has to be calculated with these two criterias:

• the solar energy has to be maximized (and so the farm size) in order to provide the best percentage of renewable energy to minimize the water cost for the farmers;

• the excess solar energy produced has to be minimized.

A 6 MWp photovoltaic farm (PV1) will be located in Lacovia, west from the pumping station 1.

A second photovoltaic farm (PV2) will be located in Newell, on the site of the pumping station 2.

The photovoltaic design has been done on the following hypothesis:

- 500 Wp panel sizes are 1300mm per 2mm
- Each block of panels is composed of 60 panels : 3 lines of 15 panels in a portrait mode:

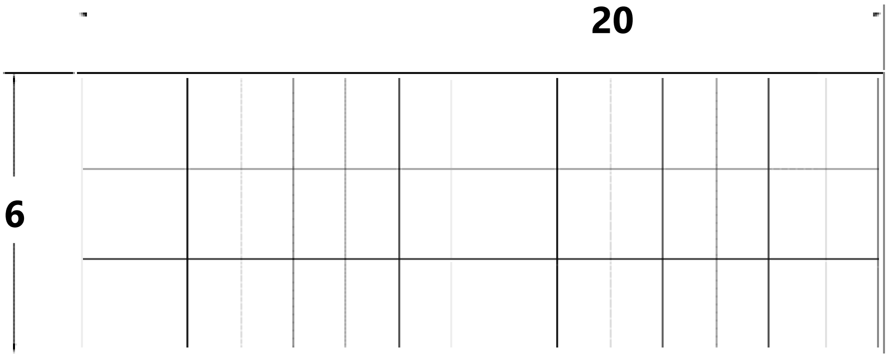


Figure 5 - One photovoltaic block (3 lines of 15 panels = 45 panels)

- Each block is inclined, with a 20° tilt

Each block is far from the other (3.5m distance between each block) to avoid shading:

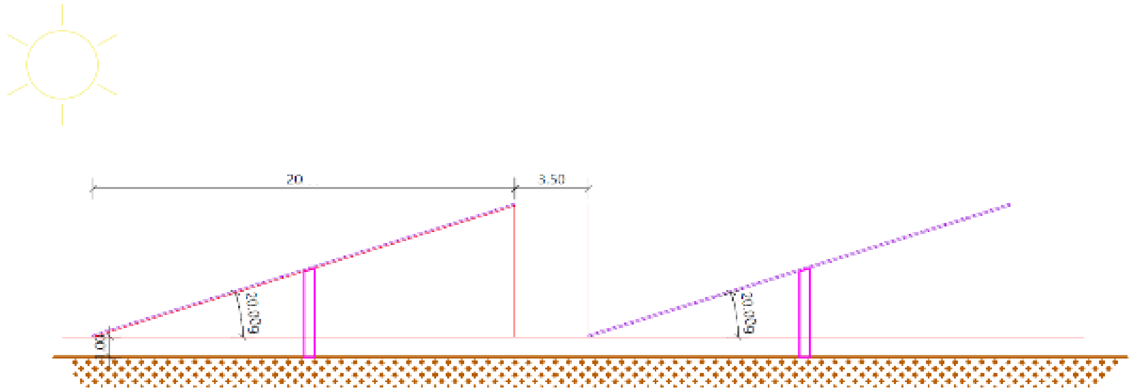


Figure 6 - Distance between each block (in meters)

Picture 3 – Example of PV plant (Paradise Park, Jamaica)

Under these hypotheses, the figure summarizes the characteristics of PV plant designs.

Table 6 - PV plant features

	PV plant Power (MW)	PV plant area (ha)	Panel numbers	Block numbers
Pumping station 1	6,00	9,35	12 000	260
Pumping station 2	3,70	5,76	7 400	160

The panels orientation is south for the best production.

The projected PV plant sizing leads to the following renewable energy ratios for the consumption of the pumping stations PS1 and PS2.

Table 7 – Rate of PS energy requirements provided by PV plants

	PV plant area (ha)	Energy provided by the PV plant (kWh/year)	Energy required to buy from JPS (kWh/year)	% renewable energy used	Potential resale
Pumping station 1	9,35	9 486 000	11 098 806	40%	22%
Pumping station 2	5,76	5 849 700	7 720 072	39%	15%

See maps 007 and 008 - projected photovoltaic farms PV1 and PV2

Figure 7 - Lacovia solar farm (PV1) location

Figure 8 - Newell solar farm (PV2) location

4.2.3 RESERVOIR 1 – SITE AT NEWCOMBE VALLEY

The site identified for reservoir 1 is located at Newcombe Valley area. The elevation of the site is between 108 and 114 m. The capacity of this embankment reservoir will be of 28 000 m^3.

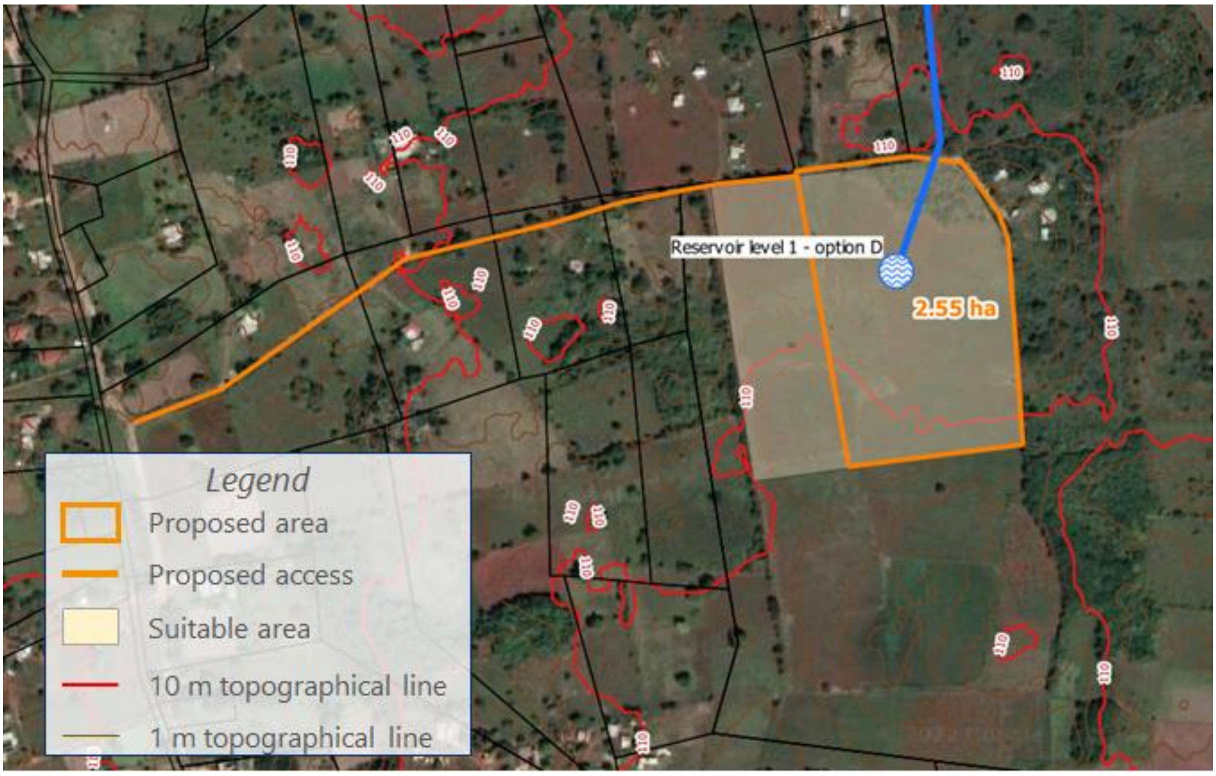


Figure 9 - Projected area for reservoir R1

Picture 4 – Example of water reservoir (Southern France)

The site is shown on picture below.

Picture 5 - Site view for the reservoir R1

The site is quite flat. Around 3.5 ha could be suitable. So this surface is big enough to install the reservoir.

4.2.4 PUMPING STATION 2 – NEWELL

The pumping station 2 is a booster station from PS 1 to reservoir 2. The area around the site should be also suitable for a 5 ha solar farm. The site proposed is in Newell Pen and shows two large meadow parcels measuring together about 10 ha. Elevation of the site is between 20 and 24 meters.

The following map shows the suitable area and the parcel of 7 hectares proposed for acquisition.

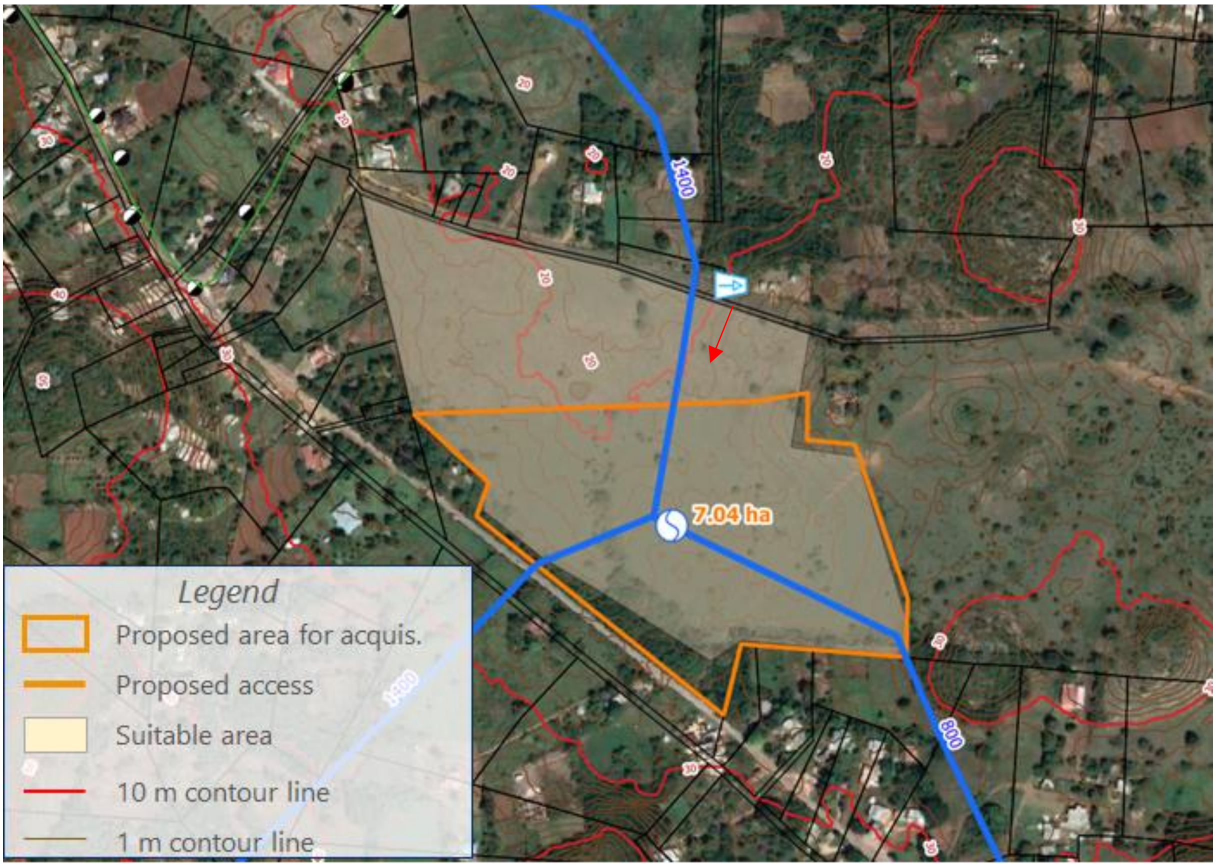


Figure 10 - Available area and proposed area

The site is shown in the following picture:

Picture 6 - Site view for pumping station PS2

The area presents different slight slopes, that don't seem problematic for the location of the pumping station neither the solar farm.

4.2.5 RESERVOIR 2 AND PUMPING STATION 3 – ROUND HILL

Reservoir 2 and Pumping Station 3 are located in Round Hill area. For these infrastructures, a single site was also selected, because gross area suitable is approximately 4.5 ha (more than twice the area required):

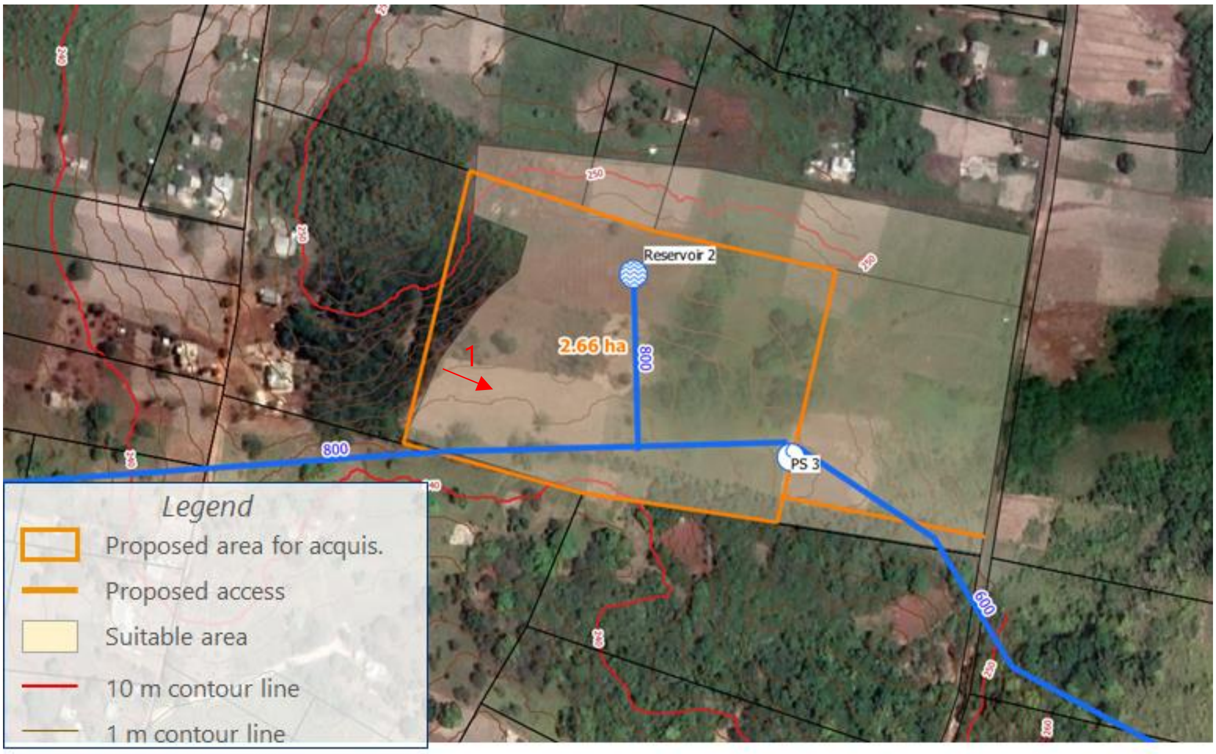


Figure 11 - Available and projected area

The elevation of the site is between 241 and 250 m. The site is shown below, facing East. The capacity of this embankment reservoir will be of 17 000 m^3.

Picture 7 - Site view of reservoir R2 and pumping station PS3

The slope is steeper in the eastern part of the area, so the proposed parcel for acquisition concerns the Western part.

4.2.6 RESERVOIR 3 AND PUMPING STATION 4 – QUEENSBURY

The reservoir 3 next to the pumping Station 4 will be located in Queensbury area.

The site was identified thanks to a NIC operating officer working in Hounslow. The elevation of the site is between 548 and 558 m, so it's a bit lower than the site #1.

The map below show the suitable area and the proposed parcel for acquisition. The capacity of this reservoir will be of 8 000 m^3.

Figure 12 - Suitable area and proposed parcel

The site is shown on pictures below.

Picture 8 - Site#2 view for reservoir R3 and pumping station PS4

The area is slightly sloping in an east- west direction, implying terrain cutting in the slope (picture 2). The flat area (picture 1), lower, is suitable for the pumping station.

The parcel proposed for acquisition measures about 1 hectare.

4.2.7 RESERVOIR 4 – UPPER BERLIN

The reservoir 4 is located upper Berlin area. The elevation of the site is between 750 and 752 m.

The fallowing map shows the suitable area (2 ha) and the proposed parcel (0.63 ha)

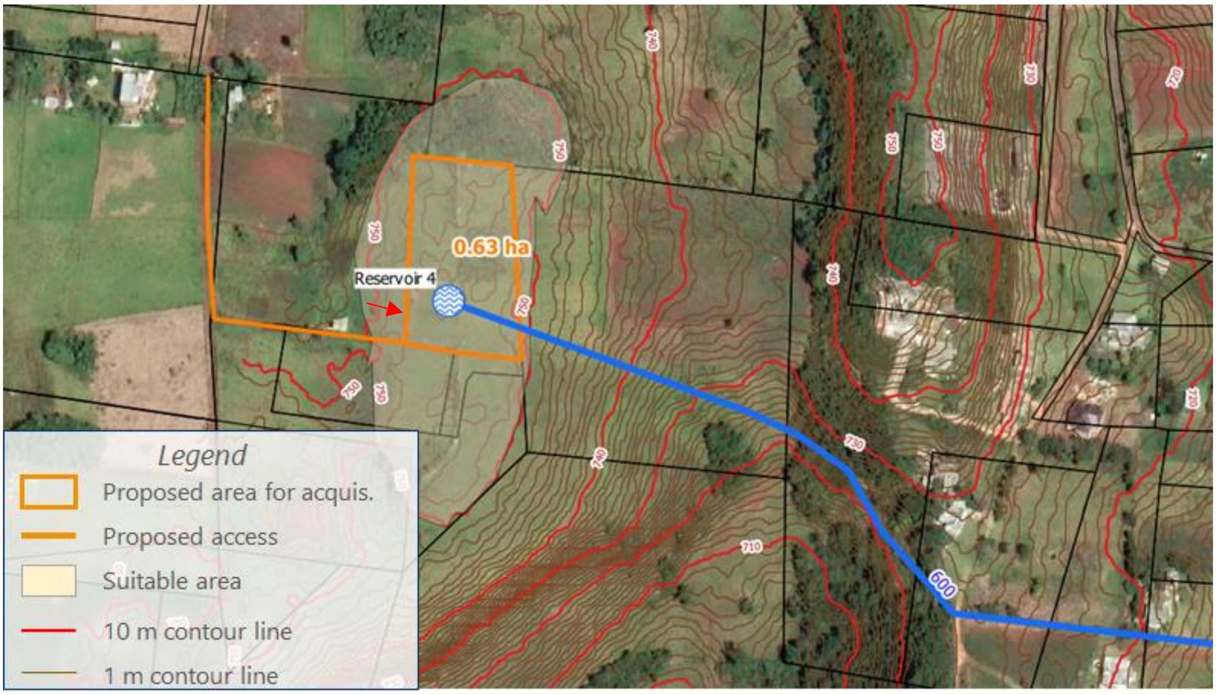


Figure 13 - Available area and proposed area

The picture below shows the site.

Picture 9- Site view for reservoir 4

The site is on the top of a hill. The area is flat and free of housings for the installation of the reservoir. The suitable area measures approximately 2 ha. The capacity of this embankment reservoir will be of 15 000 m^3.

4.2.8 GENERAL TRENCH AND PIPELINE SPECIFICATION

The space needed for to settle the pipeline depend on the diameter of the pipe. The general scheme of the work space is indicated below.

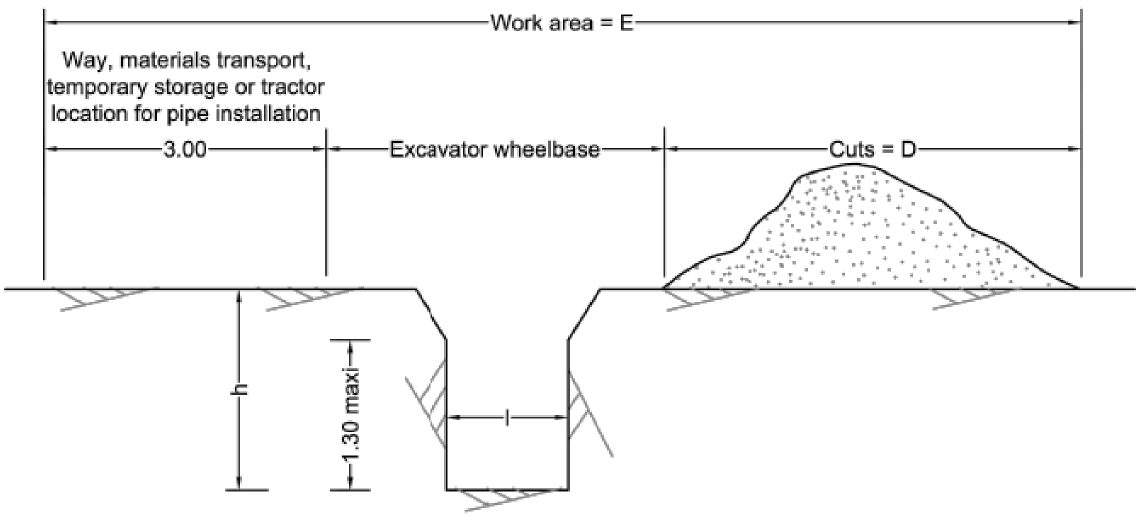


Figure 14 – Work area for pipes laying

Spaces to take into account are:

- Space taken by the cuttings of soil, given the ground loose (about 25-30%)
- Space taken by vehicles for the excavation,
- Space taken by trucks for pipes transport on site,
- Space taken by pipes if they are temporary stored next to the pit.

General work area requirement (E) for trunk pipes are:

- DN 700 : 12 meters
- DN 800 :-14 meters
- DN 1000: 16 meters
- DN1400: 20 meters

First step before dig is a general cleaning of top soils in the work area on a depth of about 30 cm (the depth can be variable). Top soil are stored separately from other cuttings, and reused after pipe laying and pit filling up for work area reinstatement.

Material used for filling up are detailed in the figure below. Material for primary coat, base layer and pipe protection (beddings) have to be imported if site materials are suitable.

Table 8 – Beddings materials composition for trunk pipe laying

Pipes materials	External surfacing and protection	Particle size grading od beddings material (mm)
DUCTILE IRON	--	40
STEEL	Polyethylene ou polypropylene	10 / 40[5]
	Polyethylene + cement	100
	Polypropylene ≥ 5 mm	100

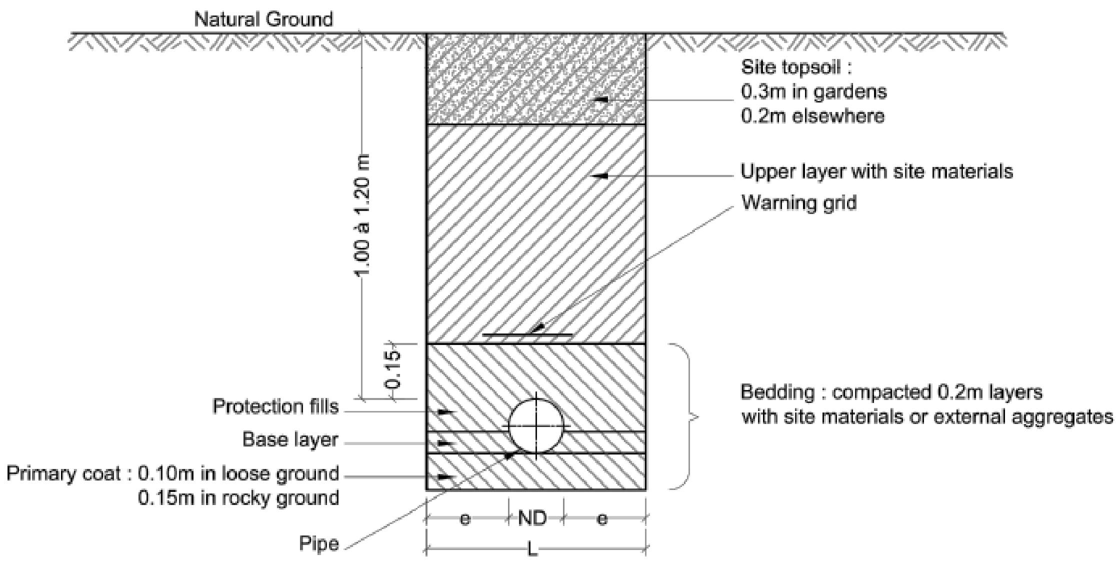
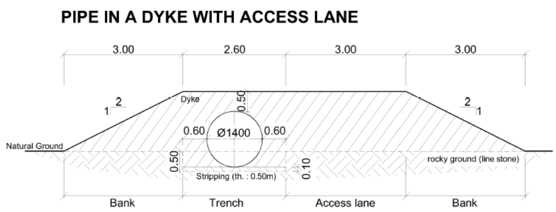
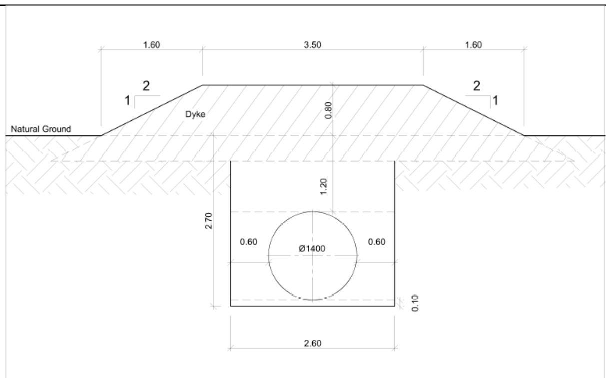


Figure 15 – Fills material for standard trench

Four specific types of trunk pipe laying are recommended below.

[5] 10 mm for primary coat

Table 9 - Recommended laying according to soil typology

<table>
<tr><th>Laying typology</th><th>Estimated length (km)</th><th>Recommended laying</th></tr>
<tr><td>Laying in dyke (rocky soil)</td><td>9.55 km</td><td>
</td></tr>
<tr><td>Morass crossing (buoyancy)</td><td>0.60 km</td><td>

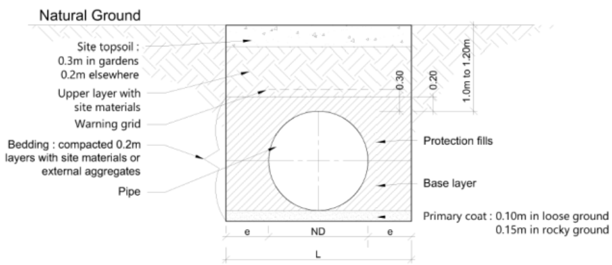
Dyke section is 15 meters long and spacing between section is 3 meters to allow cross flow of water</td></tr>
<tr><td>Standard trench in deep soil</td><td>17.42 km</td><td rowspan="2">
</td></tr>
<tr><td>Standard trench in rocky soil</td><td>7.23 km</td></tr>
<tr><td>Total</td><td>34.80 km</td><td></td></tr>
</table>

Table 10 - Dimensions of the trench for standard laying, according to the DN/ND

ND/ED (mm)	L mini (m)	e mini (m)	Maxi depth (m)		Maxi volume of materials bedding (m^3/m)	
			Loose Ground	Rocky Ground (LG+0.05)	Loose Ground	Rocky Ground
500	1.10	0.30	1.80	1.85	0.70	0.75
600	1.20	0.30	1.90	1.92	0.80	0.90
800	2.00	0.60	2.10	2.15	1.75	1.85
1200	2.40	0.60	2.50	2.55	2.50	2.60
1400	2.60	0.60	2.70	2.75	2.90	3.05

The sections concerned per type of laying are identified in the following map.

Regarding the sections laid in a dike, provisions are made to allow the crossing of water.

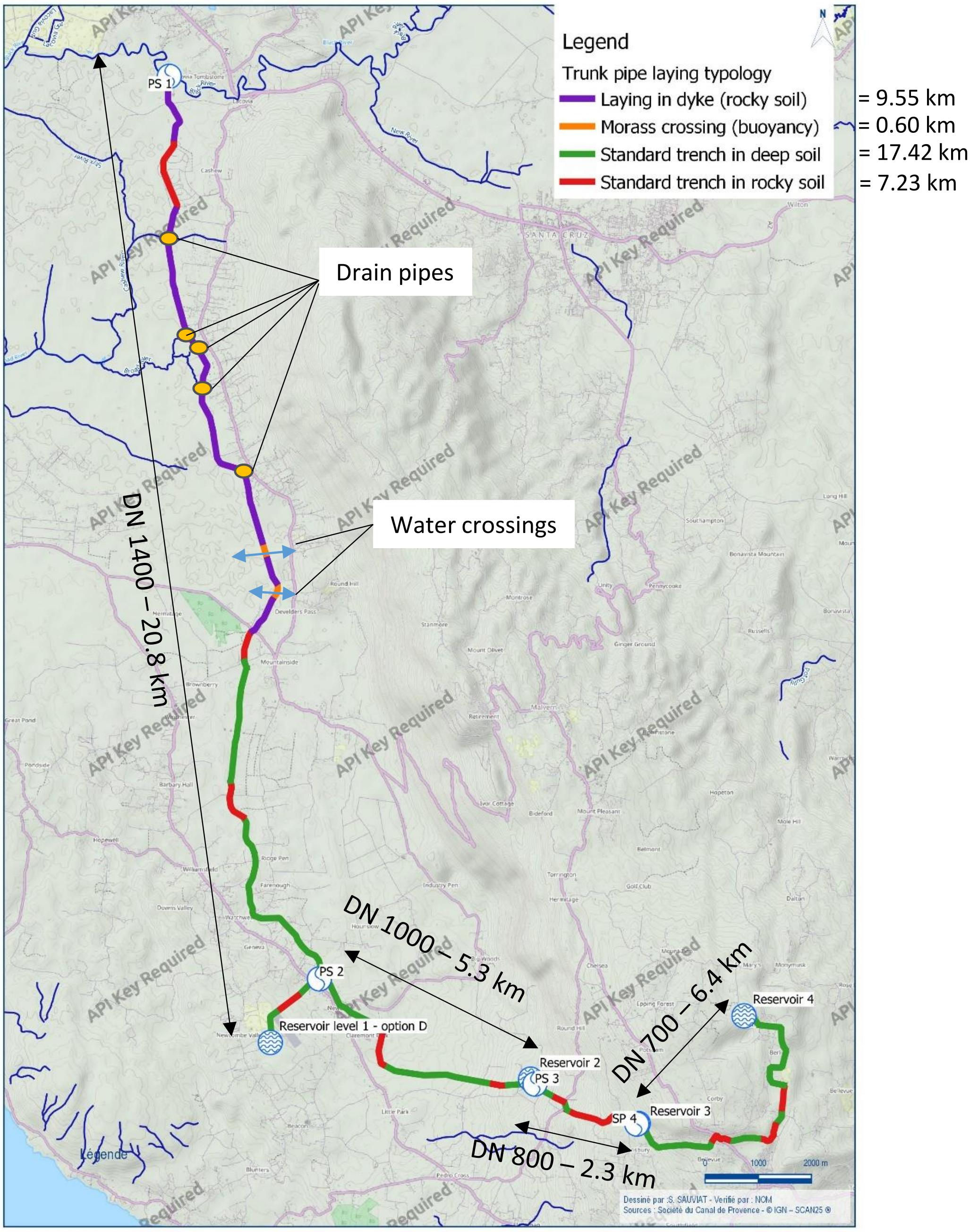


Figure 16 - Map of trunk pipe laying typology (estimation)

Table 11 - Trunk pipe length estimation by laying typology and diameter

DN	Laying in dyke (rocky soil)	Morass crossing (buoyancy)	Standard trench in deep soil	Standard trench in rocky soil	Total
DN 1400	9.55 km	0.60 km	7.7 km	2.95 km	**20.8 km**
DN 1000			4.26 km	1.05 km	**5.31 km**
DN 800			0.66 km	1.63 km	**2.30 km**
DN 700			4.83 km	1.59 km	**6.42 km**

A safety coefficient of 2% on the length should be taken for the costs estimate.

An easement width for construction and operation is recommended following the specifications below, as well as an access lane that will be created along the main pipe.

Table 12 - Trunk pipe suggested easement width by diameter

Pipe diameter (mm)	**Laying**	**Easement width for operation**	**Standard laying width for construction***
DN 1400	with dyke and access lane	12 meters	20 meters
DN 1400	buried with access lane	6 meters	20 meters
DN 1000	buried with access lane	5 meters	16 meters
DN 800	buried with access lane	5 meters	14 meters
DN 700	buried with access lane	5 meters	12 meters
400 ≤ DN ≤ 500	buried	4 meters	10 meters
100 ≤ DN ≤ 350	buried	3 meters	8 meters
DN < 100 mm	buried	3 meters	4 meters

* recommended width for the laying of the pipe (construction phase)

4.2.8.1 SPECIFICATIONS FOR MORASS CROSSING

It is inevitable that the DN 1400 trunk pipe has to cross some arms of the morass at the edge, on about 600 linear meters. On these sections the ground water level is often above the natural ground. To avoid the buoyancy up of the pipe according Archimedes' principle, it necessary to weigh down the pipe with one of the two possibilities or a combine of both:

- Replaced the bedding of the pipe with aggregates materials by concrete bedding.
- Create artificial dike above the natural ground to prevent buoyancy.

For the project we recommend to use non reused materials from excavation to create the dike.

Minimum height of the dike will be 0.8 m above natural ground, top will be 3.5 m wide, with 2/1 slopes.

Because the morass receives natural run-off from Santa Cruz Mountains, the dike won't be continuous. Dike bund will be 15 meters length with bund spacings of 3 meters length.

4.2.8.2 FINE DISTRIBUTION PIPELINES

The fine distribution network is represented as areas that will benefit of the water delivered by the project. At that stage of the development the precise location of the trenches can change, and for that reason the areas that will host them are represented as surfaces and not lines.

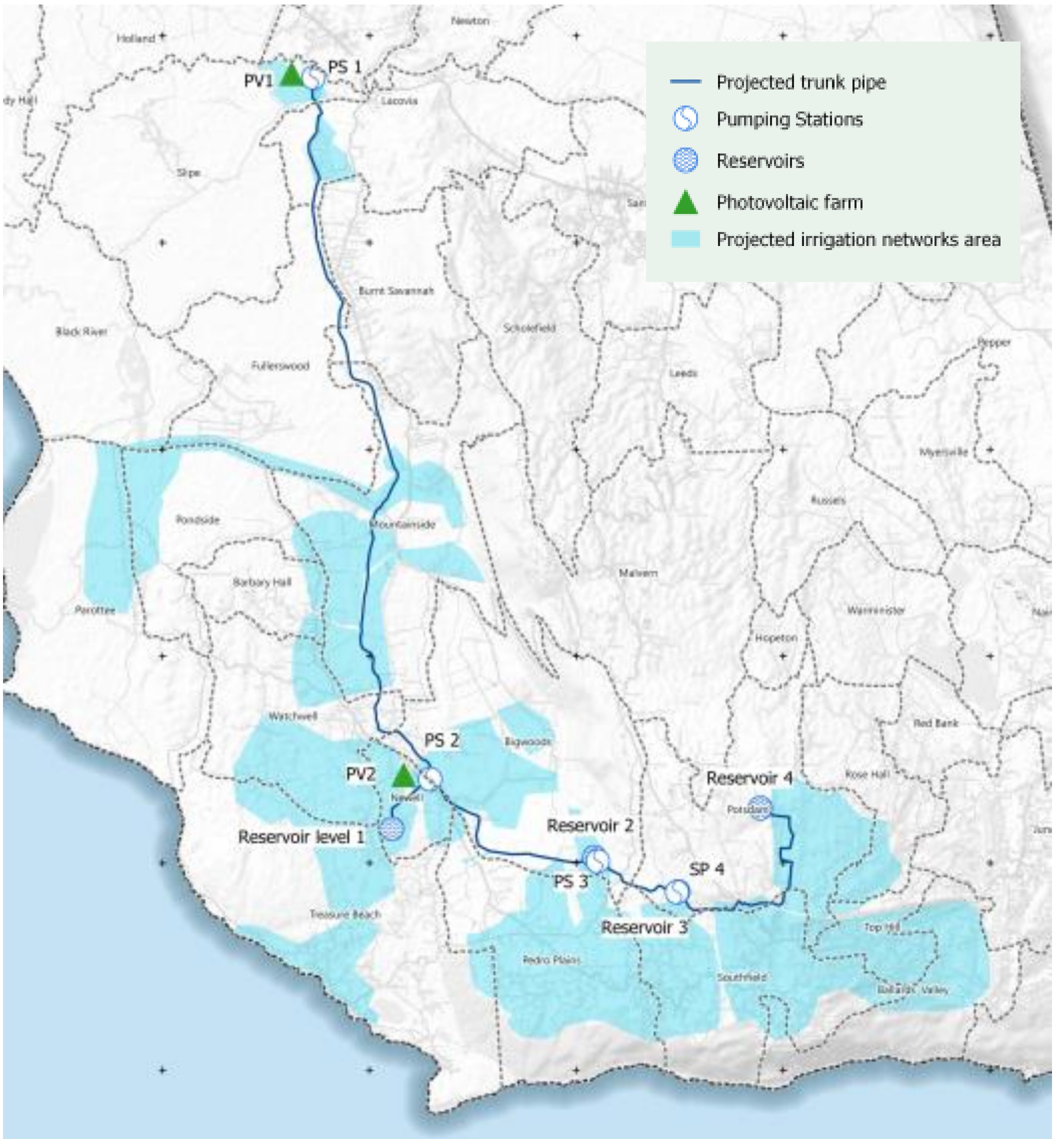


Figure 17 – Map of the projected infrastructure including distribution areas

4.2.9 SYNTHESIS AND PROJECTED INFRASTRUCTURE

The locations of the recommended sites are indicated on the schematic map below.

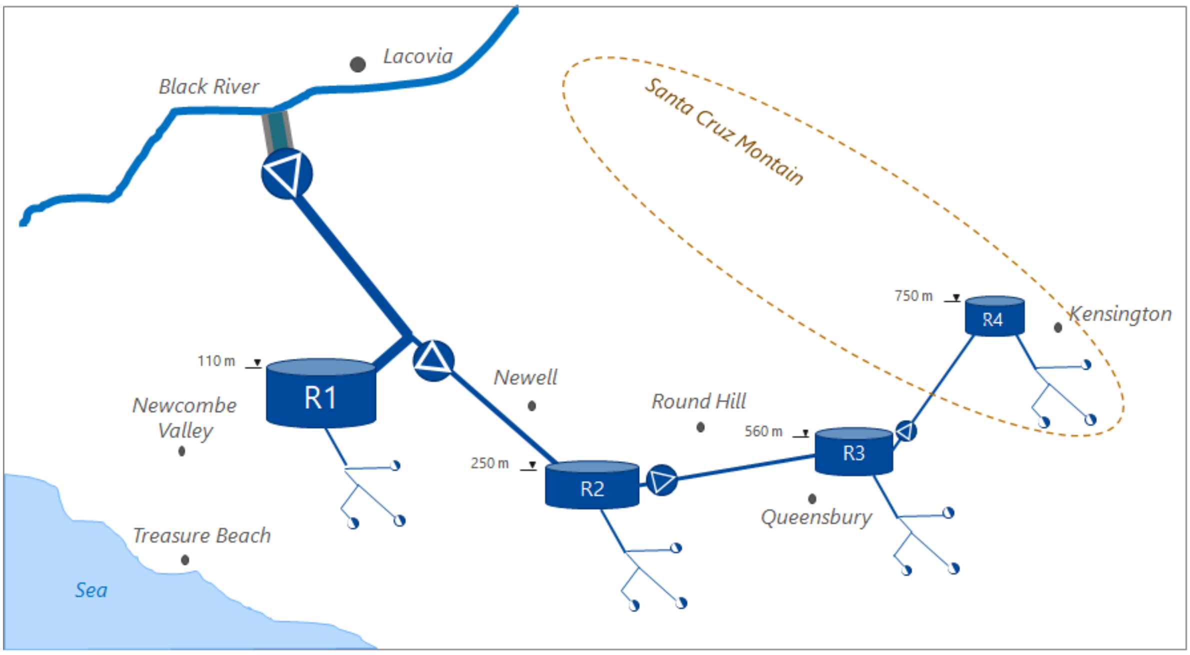


Figure 18 - Schematic map of the projected infrastructure

Flow and pipe features are estimated in the table below.

Table 13 - Hydraulic flow and pipe features

	Flow (m^3/s)	Pipe diameter (mm)	Pipe length (km) + 2 %
Black River>R1	2.2	1400	21.20
R1>R2	1.3	800	5.33
R2>R3	0.7	600	2.70
R3>R4	0.37	500	6.12

Regarding the water volumes to be supplied (hypothesis of 20 hours per day during the peak month), pumping station characteristics are reported here.

Table 14 - Pumping stations features

	Design flow (maximum flow)		Head	Gal Power
	l/s	Cum/hour	m WC	kW
Pumping station 1	2 206	7 941	152	4199
Pumping station 2	1 416	4 654	157	2784
Pumping station 3	848	2 420	318	3377
Pumping station 4	557	1 365	216	1507

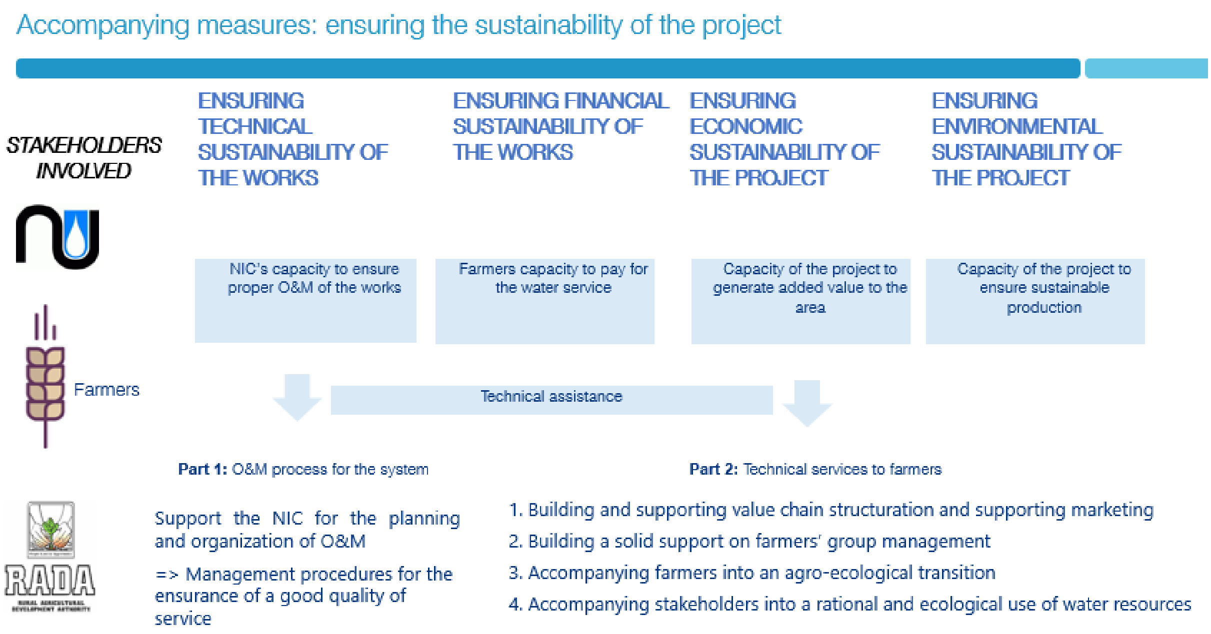
Concerning the reservoirs, their features are described in the table below.

Table 15 - Volumes of reservoirs

Resevoir	Net volume (m3)
R1	28 000
R2	17 000
R3	8 000
R4	15 000

4.3 ACCOMPANYING MEASURES

The accompanying measures include two components: assistance for operation and maintenance of the infrastructure, and rural development support.



4.3.1 OPERATION AND MAINTAINANCE OF THE INFRASTRUCTURES

The project includes support the NIC for the planning and organization of O&M. Sharing management procedures will ensure a good quality of service, and optimal use of the infrastructure.

4.3.2 RURAL DEVELOPMENT

As already mentioned, the Pedro Plains irrigation project is not only a technical project to transfer water through an hydraulic infrastructure, but also a rural development project, aiming to provide benefits to agricultural productivity, farmers, community in general, and improve the rational use of the water resource.

The feasibility studies have identified the main stakes agriculture has to face and a few levers to tackle them:

- Building and supporting value chain structuration and supporting marketing
- Building a solid support on farmers' group management
- Accompanying farmers into an agro-ecological transition aiming both targets: decreasing environmental impacts and decreasing production costs
- Accompanying all stakeholders into a rational and ecological use of water resources in a context of climate change.

For those reasons the following chapters take into account the impacts of the project on the development of the area.

The action plan presented at the end of this chapter was built thanks to:

- The discussions with farmers in the framework of the agricultural assessment conducted in January-February 2019
- A workshop organized with RADA and NIC in April 2019
- The experience of SCP in accompanying agricultural evolutions from dry production systems to irrigated systems

This action plan provides ideas and proposals but these have not been evaluated and their feasibility is not necessarily guaranteed.

The survey conducted provided precious data on the global needs of farmers in the area and of people who are not farmers already but who are interested in farming. Out of the 167 people who declared not to be farmers, 108 declared to be interested in farming 64 %, 28 said they were not interested (17 %) and the rest did not know. To the question "what would you need to start a farm", people answered[6]:

More land	45
Ensured market	29
Training	20
Higher prices	13
Credit	18
Water	12

Water comes at 5th position and the other constraints are economic issues (ensured market, higher prices and credit), the difficulty to access to land and the need for training. This confirms

[6] Interviewees had the possibility to choose many answers.

the assessment made in the agricultural assessment phase that identified four major topics to work on:

- Marketing;
- The use of inputs to improve economic results and limit environmental consequences;
- Farmers' structuration in order to improve economic results (by improving marketing and decreasing costs of production) and facilitate access to credit;
- Irrigation technics.

4.3.2.1 BUILDING AND SUPPORTING VALUE CHAIN STRUCTURATION AND SUPPORTING MARKETING

Building and supporting value chain structuration and supporting marketing is a major topic. Marketing was identified as the main issue farmers have to deal with and, if this issue is not tackled properly, farmers are concerned that marketing issues could worsen in case of the development of irrigation.

Marketing officers play a major role on capacity building of farmers concerning the stakes of marketing. The support provided by the Government through their action is overriding. However, it is not enough to improve the sharing of the added value between the value chain and the risks.

Most farmers are the primary stakeholders in enduring the risk of minor and major damages to crops as higglers refuse to buy them. Higglers are essential to marketing as farmers do not have the time nor the transportation means to market themselves. However, the relationship between farmers and higglers is not always trustful and farmers suspect them to cheat on the prices to maximize their profits. The losses are also taken upon the farmer as the higgler takes the crops in credit, and gives back to the farmer the products he was unable to sell.

Middlemen intervene differently in the value chain as they intervene on national whole sale markets. They are able to influence the supply and demand in order to create the demand and maintain the prices high. On the other hand, middlemen are taking high risks: they transport significant amounts of goods and if there is a rotting problem, or prices are too low, the losses are proportional. Just as they can suffer from severe drawbacks, they also benefit from great profits when they manage to keep the prices high.

Grace agro-processing would have the capacity of processing more goods but to do so the demand of processed products has to be looked at carefully: currently, the Jamaican demand is not mostly turned towards processed goods. Grace would also have more success with farmers if they proposed a processing solution for downgraded products. In addition, the trust relationship between Grace and farmers would have to be reinforced, as it is of the interest of both, farmers and Grace, in order to upscale processing in the factory.

An existing agro-processing facility already developed by RADA is certainly a first step to help farmers improving their marketing issues.

However, farmers will still have to sort out the issues of:

- Transportation and
- Even more complex, the marketing of the processed goods

Some farmers have ideas on the outlets of processed goods like supplying schools now that sodas have been forbidden. But local stakeholders do not have a global vision of the marketing opportunities they can grasp. This small-scale initiative is not dimensioned to process and sort out the issues of marketing of the tons of crops produced annually in the study area which represent the supply of 80 % of the consumption demand of Jamaica. This facility can rather be used as a test to help the structuration of farmers' groups and see if they seize the opportunity of processing small amounts of products for local consumption, before thinking of enlarging the scale.

Working on the marketing and value chain pursues a double target for the project:

- Increase farmers income
- Strengthen the value chain in order to improve the supply of agricultural goods and thus improve self-sufficiency at Jamaican level

4.3.2.2 THE ACTION PLAN (SEE ACTION PLAN FOR RURAL DEVELOPMENT

Table 17 – Action Plan : recommended actions to maximize benefits for sustainable agriculture) aims at reaching both by developing the actions that will be described below.

4.3.2.3 INCREASING THE ADDED VALUE PRODUCED BY FARMERS AND OPTMIZING PRODUCTION COSTS TO IMPROVE FARMERS' INCOME

Farmers are not especially in the best position to negotiate with higglers and middlemen as they do not always have a clear vision on the markets, market prices and the added value that they can create. Therefore, we propose to optimize the existing databases JAMIS and COP and combine the calculations in order to calculate the margins thanks to the prices of products contained in JAMIS and the costs of production which already have a marketable yield estimation. This way, it can be easier for farmers and marketing officers to have a better vision of the economic market. This could be a concrete implementation of the Farming as a Business training provided by RADA.

To add value to the production, an implementation of the product's grading and packaging can be implemented. This would enable farmers to value all of the production and limit the losses at the hedge of the plot as illustrate by this picture. Grading could also allow farmers to obtain a higher value of the best quality products.

Picture 10 - Good shaped tomatoes refused by a higgler, rotting at the edge of a plot in Beacon. Source: SCP

Developing agro-processing by farmers' groups can bring a solution to limit the loss in the value chain. Poor quality products or abundant products could be valued instead of flowing the market.

Moreover, in order to increase the income of farmers selling products directly to end users or supermarkets and hotels, to maintain a good selling price could also be developed.

Optimizing the added value could also be achieved by reducing costs of production. Purchasing farm inputs in groups could decrease production costs as farmers would buy in bulk and would be able to negotiate better prices with sellers.

In order to develop a sustainable production to farmers, the access to credit is fundamental. Currently, access to credit is insufficient in the study area as most of the farmers interviewed do not benefit from it. Reintroducing an effective access to credit can be a lever to develop farmers income and has thus to be included in the accompanying measures program.

4.3.2.4 STRENGHTEN THE VALUE CHAIN IN ORDER TO IMPROVE FOOD SELF SUFFICIENCY

The Pedro Plains is the main agricultural area of Jamaica and supplies the local market in fresh products for the whole country. Strengthening the value chain aims certainly in one hand to increase farmers' income but also in the other hand to improve the supply of the markets and in the end improving the self-sufficiency of the island.

To achieve this, we propose first of all, that a specific marketing analysis that would identify the consumers (like hotels) and the volumes needed. This study has to lead to the building of a database in order to improve the vision of the market needs. In order to do so, a mechanism allowing to final consumers or middlemen to declare their needs in terms of volumes and types of crops could be implemented to facilitate the update of the market data. This would allow all stakeholders to better assess the needs and in the end, to adapt the production.

On the other hand, to facilitate the global vision of the markets, supply and demand, we propose to develop a similar database for farmers so they could declare the production surfaces and volumes.

Both information could be centralized thanks to the development of an application named "Good Products in Jamaica" that could be inspired by apps already existing like the following examples of apps where consumers and farmers communicate what they would like to buy and sell.

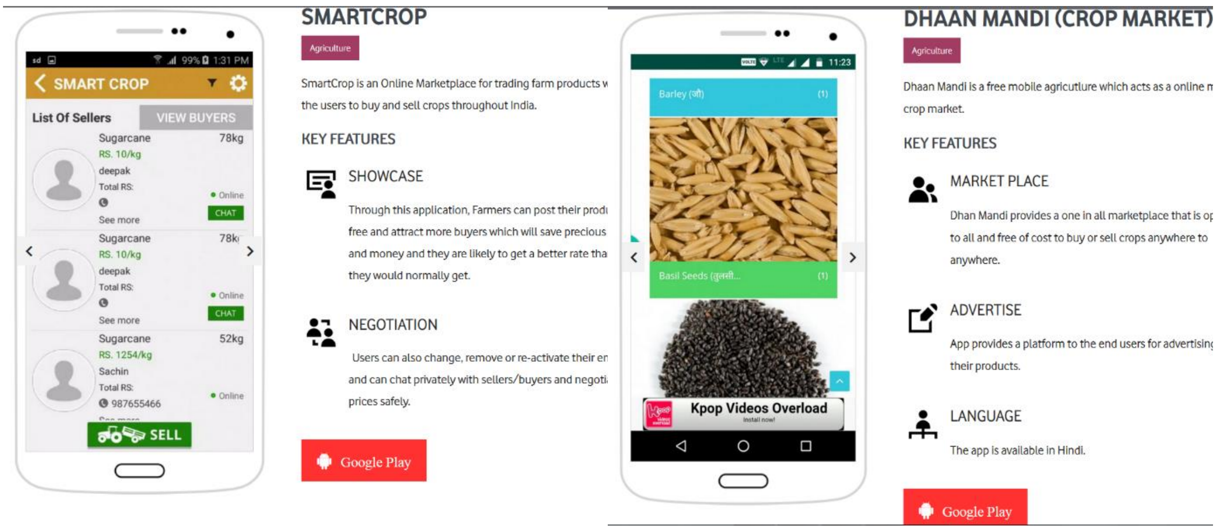


Figure 19 - Examples of app developed in India for the marketing of products. Source: medium.com

All of the stakeholders during the workshops suggested storage as a solution to regulate the excess of production and the supply to markets. First of all, if the project wants this solution to be profitable to farmers, farmers themselves have to manage the storages. Otherwise, the added value generated would not profit to them. Nevertheless, farmers are not easy to organize which could be a threat for the success of the management of storages. Secondly, it has not been proved that storage, in the Jamaican and Pedro Plains context, would be economically profitable as O&M costs are very high mainly due to energy costs. An assessment has therefore to be conducted to measure the profits of the investment for new storages or the rehabilitation of old ones.

Developing networks of refrigerated transportation in order to conserve the fresh products quality could also be considered. If farmers' groups become strong enough, they could even operate the refrigerated trucks themselves.

As mentioned before, the supply of local agricultural markets has to be improved. In order to do so, investing in the development of transportation infrastructures could be considered to facilitate the transportation of goods.

During the workshops was also mentioned the possibility of supplying to public institutions and schools with local and fresh products. Farmers could take advantage of the public Health program to prevent obesity that forbids the distribution of cokes in schools and propose to replace them by fruit juices.

4.3.2.5 ACCOMPANYING FARMERS INTO AN AGRO-ECOLOGICAL TRANSITION

At the centre of farmers production technics is the grass mulching practice developed in the area for many purposes. This practice has to be supported and developed by any means as it is a major step into an agro-ecological transition. Therefore, it is urgent that the demonstration site reintroduces the grass mulching technic even if it increases the production cost on the short term. On the long term, grass mulching represents a valuable investment.

Based on practices that farmers have developed themselves, the reflection on reducing pesticides and fertilizers can be **both environmentally and economically** oriented.

Redesigning with farmers the whole technical operations from seeds to plant, to the harvest can be a good opportunity to monitor and develop a low-input agriculture. Producing local and high quality seeds, adapted to the different "terroirs"[7], has to be at the centre of this strategy in order to considerably limit pest attacks and pesticides.

Irrigation can be a good opportunity to act as a lever for agro-ecological transition if farmers are convinced and supported to go into this direction by encouraging the production of guinea grass for mulching and improving the integration of cattle and crop farming, which would have a positive consequence in the decrease of the use of fertilizers and the increase of organic matter in the soil.

Accompanying an agro-ecological transition has to be done through many levers, and the first of all is training. Training has to be designed especially for farmers, using their words and their own plots as a support. Recognizing and formalizing the good practices of farmers through the signature of a charter of "good agro-ecological practices" has also to be implemented. Within all of the agro-ecological practices, a special focus has to be conducted with the use of fertilizers that can be a great source of water pollution. Many different actions can be proposed within the action plan. The development of local seeds adapted to the specific weather and soil conditions, able to resist to pest attacks would be developed on the long-term.

4.3.2.6 IMPLEMENTING THE CONDITIONS OF ON-FARM TRAININGS AND AGRO-ECOLOGICAL GOOD PRACTICES

4.3.2.6.1 Ensuring a dialogue between RADA and NIC

In order to implement the accompanying measures program, all of the stakeholders intervening with farmers must have in mind the same goals and present the official line of the project. To do so, it is necessary that RADA and NIC, which are the most important agencies implementing the accompanying measures, create a coordination committee in charge of setting the goals and the official line of the accompanying measures program.

It is important that the demonstration site currently managed by NIC fully understands and illustrates the changes within the agricultural approach that would lead to agro-ecological good practices. For instance, promoting mulching through the project will imply that the demonstration site also practices mulching in order to "practice what we preach".

[7] Terroir is the set of special characteristics that the geography, geology and climate of a certain place, interacting with plant genetics, express in agricultural products such as wine, coffee, chocolate, hops, tomatoes, heritage wheat, and tea. Source: http://en.wikipedia.org/wiki/Terroir

4.3.2.6.2 Ensuring a high quality training to farmers

In order to ensure the follow up of plots and farming technics and high quality trainings to farmers, **training to trainers** has to be delivered to RADA and NIC officers to facilitate the coordination between both institutions in terms of messages and general content to deliver to farmers.

Picture 11 - Training session of Haitian Ministry of Agriculture staff

Picture 12 - Training session to Haitian Ministry of Agriculture staff

Building the conditions for training on the plot is a priority of the accompanying measures program. To do so, we propose the establishment of a farmers and plots network that would be used as a basis to discuss of production technics and their results.

For this network of plots and farmers each one of the production technic will be assessed in order to measure production results, costs and benefits in order to provide farmers with a global vision of the results for all of the agro-ecological technics promoted.

This network of plots and farmers will be used as a support for training in order to propose only practices that present real global advantages for farmers and the environment. In terms of trainings, many different topics can be mobilized like:

- The use of forbidden chemicals and the risks related to their use
- The promotion of agro-ecological practices like mulching
- The diversification of production and the benefits of this technic, etc.

The complete program has to be designed in collaboration with RADA and NIC, these are a few leads based on the discussions that we could have with farmers in one hand and NIC and RADA in the other hand.

The tools to implement training have to be developed according to pedagogical aims and each training will have to have a summary of the content, length, aims, public targeted, number of days, etc. like in the example below.

Parcours de l'exploitant(e)

Bases hydrauliques des postes, réseaux et ouvrages

Principes fondamentaux et application au métier de l'exploitant(e)

NIVEAU 1 NIVEAU 2 2 jours

DOMAINE DE FORMATION

METIER

CONTEXTE de la FORMATION

Cette formation s'attache à présenter les informations théoriques fondamentales de l'hydrostatique et de l'hydrodynamique. Des parallèles sont établis avec les situations courantes d'exploitation qui peuvent être rencontrées au niveau réseaux de distribution.

PARTICIPANTS

Public : Agents d'exploitation
Effectif : 5 à 6 stagiaires
Prérequis : Notions mathématiques

FORMATEURS

Guillaume JEAN : Responsable d'Opérations – *Service Maitrise d'Ouvrage*
Jean-François PUIGT : Chef de Groupe Analyses et Méthodes – Service Méthodes et procédés
Michel ROUX : Technicien expert d'études et travaux – *Service Maintenance BGC*
Richard SPEDO : Technicien Coordinateur – *CE Saint Cannat – Service Exploitation*

INFORMATIONS PRATIQUES

Durée : 2 jours
Lieux : Le Tholonet et Pôle Laboratoires des Milles

MODALITES PEDAGOGIQUES

Formation en salle et sur le terrain

COMPETENCES A DEVELOPPER

M1A2 - Contrôler les caractéristiques de fonctionnement d'un poste de livraison d'eau individuel
M1A4 - Réaliser des manœuvre d'isolement, de vidange et de remise en eau de réseau pour des Opérations d'urgence et programmées
M3A1 - Faire les relevés systématiques sur les ouvrages
M3A3 - Remplir et transmettre les formulaires métier (constat de sinistre, attachement, constat de terrain, fiche de rejet, déchets, ...)

OBJECTIFS PEDAGOGIQUES

A la fin de la formation, les participants seront capables de :

- Appréhender les phénomènes hydrauliques
- Utiliser le langage hydraulique adapté
- Mesurer les risques liés à la manipulation des systèmes sous pression
- Identifier une panne liée à un manque débit/pression
- Apporter une solution technique aux problèmes de manque débit/pression

PROGRAMME

Les principes fondamentaux de l'hydraulique des réseaux sous pression
- La SCP : réseaux sous pression/canaux surface libre
- Notion d'hydrostatique et d'hydrodynamique

Application au métier de l'exploitant :
- Fonctionnement d'un réseau de distribution
- Traitement des situations de maintenance corrective sur les réseaux

Visite de la zone d'essai du LMH
- Observation sur modèle réduit des phénomènes physiques

6

Figure 20 - Example of the design of the contents trainings within SCP. Source: SCP

The recognition of the good practices developed by farmers can be ensured through the establishment of a "Charter for good practices". The precise content of this charter has to be discussed with farmers, RADA, NIC and environmental stakeholders like NEPA or NGOs. This Charter should be conceived in two parts, the engagements from farmers and the engagements from Jamaican authorities. For instance, the engagements from farmers could be continuing crop rotations, enhancing crop diversification, carrying on mulching etc. Whereas the engagements from Jamaican authorities could be to guarantee the access to trainings, the access to water for irrigation, the subsidies of good practices like mulching or the reduction of pesticides. An audit dispositive will have to be established to control engagements from both parts.

4.3.2.6.3 Implementing a controled fertilizer management

Amongst all inputs used in irrigated systems, fertilizers are the ones that farmers develop the most as their consumption is directly related to the yields obtained and irrigation increases the potential yield farmers can expect. If not conducted properly, fertilizers can severely pollute aquifers and water resources (included the Caribbean Sea) in general.

To prevent this, different tools to enhance fertilization management can be proposed. First of all, soil analysis for fertilization decision making could be implemented within the plots network developed by the project. According to the types of soils, their biodiversity characteristics, the crops grown and the agricultural technics (tilling or no tilling, heavy mulching or not), an adapted advice on fertilization has to be developed by RADA officers. The integration of biodiversity data on the soils in France has completely modified our approach on the use of fertilizers and has allowed improve soil structures but also economic results at farm level.

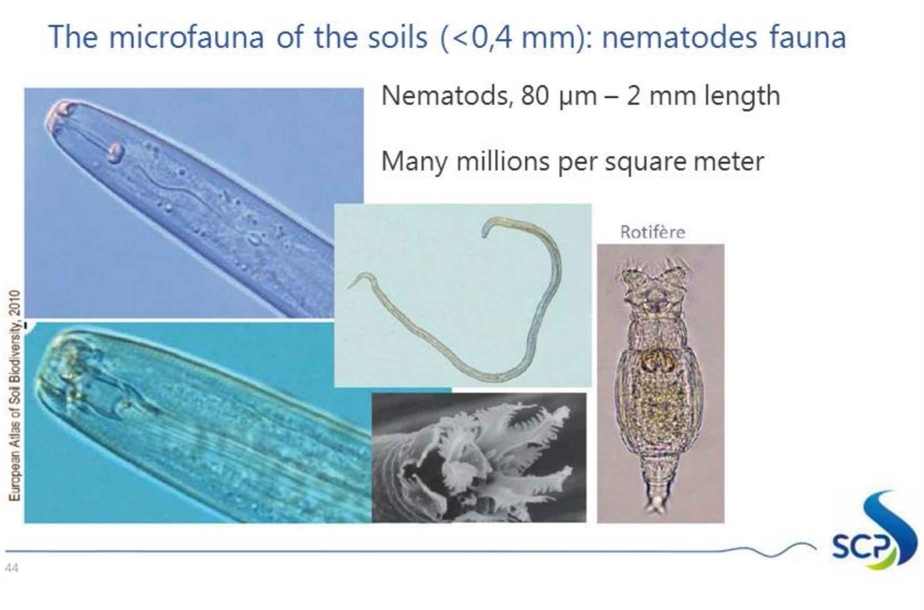


Figure 21 - Nematodes of the soil currently used to develop an integrated fertilization approach based on the soil needs in France. Source: Regain project – Ellisol partner.

To support farmers, other aid decision tools could be promoted for the adjustment of the fertilization management like nitrogen balances but within the plot. Most of these approaches have been traditionally developed to implement a homogeneous fertilization at plot level, but new tools promote the adaptation of the doses of fertilizers within the plot. We can cite SCP's solutions based on the analysis of satellite imagery analysis, NDVI (Normalized Difference Vegetation Index) that provide information on geographic deficit areas for water and fertilizers as we can see in the example below.

These solutions have been developed for specific geographic contexts and have to be adapted to the Jamaican stakes and specifically to the Pedro Plains context.

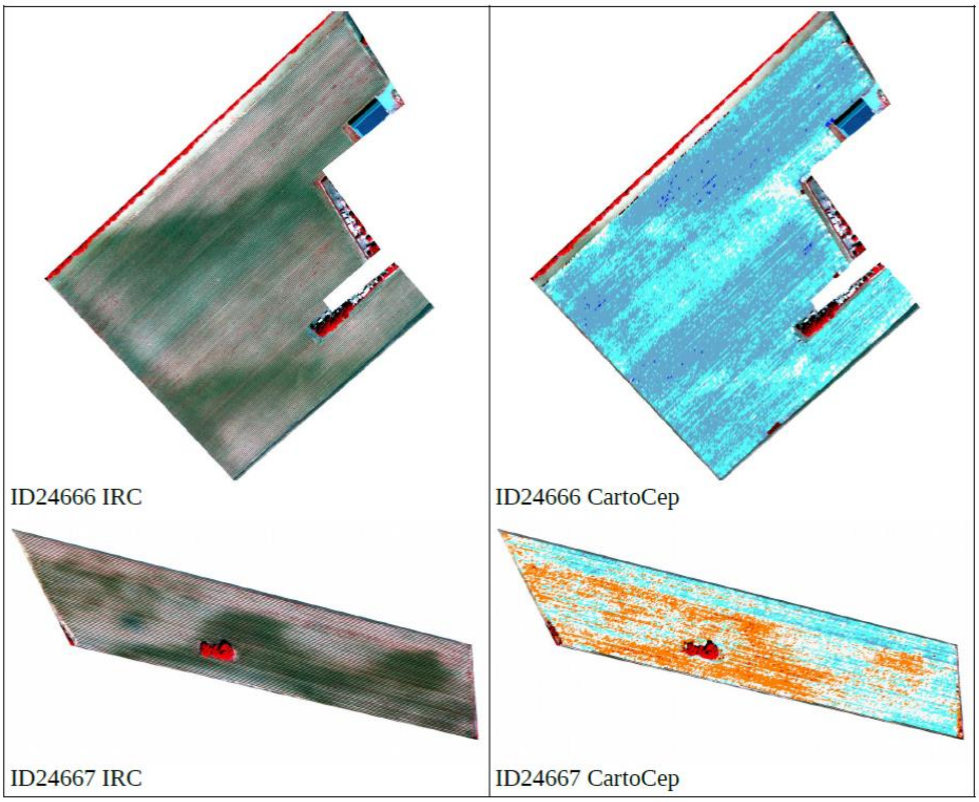


Figure 22 - NDVI maps for vineyards developed in France for the implementation of decision tools for fertilization and irrigation. Source: SCP.

4.3.2.7 IMPROVING GENETICS TO A BETTER ADAPTATION TO LOCAL CONDITIONS

All of the seeds farmers buy in the study area are imported except for sweet potatoes. The imports come from a wide range of countries as we can see on the following pictures.

Picture 13 - Imported seeds from Thailand, the USA and Taiwan. Source: SCP

The main brands are Bonanza seeds, Ansa, Seminis, Tropical Pride Seed, Known you. The seeds are expensive, they cost around 14 000 JM $/ acre (34 600 JM $/ha) for crops that are not too expensive but the cost reaches 40 000 to 50 000 JM $/ha when it comes to carrots which is one of the most expensive crop to grow in the area. Buying seeds at that price is very risky. Seeds are developed abroad, in different weather and soil conditions and distributed by farm stores locally. Seeds do not seem to be adapted to Southfield climate, which affects the germination rates. Sometimes seeds do not even germinate at all and farmers lose their initial investment, which already represent significant amounts of money. Rodents can also cause damages to farmers as they eat the seeds on the fields.

Imported seeds cannot be replanted because they are hybrids. In addition, the seeds are sensitive to diseases and not always adapted to the local climatic conditions.

The quality of imported seeds is not guaranteed: commercial seeds are certified for a certain percentage of germination. In Jamaica, farmers cannot find quality A seeds that guarantee higher germination rate.

Seeds quality is an issue especially for the onion production. Farmers are encouraged by RADA to have a record keeping in order to identify batch numbers that have bad germination rates. Specifically for onions, RADA conducts germination tests.

Organic farmers import their own seeds from abroad first because there is a shortage of organic seeds in Jamaica and second to make sure they are really organic and non-hybrid.

Axing research on the development of seeds especially adapted to the Pedro Plains terroir (ecosystem, soils and meteorological conditions) is the most powerful lever to lead to agro-ecology. Plants themselves could be selected to resist to fungi extreme climatic conditions, etc. Mobilizing the Jamaican research to develop seeds directly in the area should also thought of as a mean to reduce production costs for farmers.

4.3.2.8 ACCOMPANYING ALL STAKEHOLDERS INTO A RATIONAL AND ECOLOGICAL USE OF WATER RESOURCES

The study of irrigation in the plains has shown that:

- Most of the land is already irrigated, even outside of the irrigation schemes (even if the consumptions are not high due to the water price)
- Different irrigation strategies are developed according to the source of water and mostly, to its cost
- Farmers within schemes tend to over irrigate

The irrigation project is expected to decrease significantly the production costs due to the decrease of the water cost. Nevertheless, other costs are going to rise like the leasing of land. Farmers are expecting to access to an irrigation network also to reduce the drudgery of the manual watering and to reduce the risks of bad germination or, insufficient filling of the fruits (melons and water melons too small in case of insufficient water).

If production costs are mechanically going to rise due to the increase of other costs like the costs to access to land, farmers will have a greater pressure to ensure the success of their crops. Ensuring a reliable access to water becomes therefore a prerequisite for the success of the project.

Farmers are expecting the irrigation network to switch from a deficit irrigation to a “securing irrigation”. The accompanying measures will have to focus on this topic in order to prevent “securing irrigation” to become “over irrigation” and to tend as much as possible to the water requirement of the crop.

4.3.2.9 ENSURING A RELIABLE WATER SERVICE

4.3.2.9.1 Ensuring the « water right » on the long term

Currently, the access to the water allocation is guaranteed on a yearly basis by the WRA. Investments realized for the project are consequent and fall within at least a 50 years perspective. At first sight, this situation does not guarantee to farmers nor to the Jamaican authorities themselves sufficient guarantees that it will be possible to take water from the Black River on that 50 year investment perspective. Thus, we recommend that a legal study would be conducted to guarantee the continuity of the water allocation to irrigation for the future years.

4.3.2.9.2 Ensuring a reliable water service

Within the Charter of good practices mentioned above, but also in the contracts between farmers and NIC, the conditions to the access of a reliable water service have to be defined.

The accompanying measures will also focus on the implementation by NIC of good procedures for operation and maintenance that would guarantee to farmers the continuity in the water service.

4.3.2.10 ENSURING A RATIONAL WATER USE IN FARMING

Farmers, on their side, will also have to engage in not consuming more water than needed by the crop. To do so, a few levers can be mentioned and presented below.

4.3.2.10.1 Ensuring a low dependance of crops to water needs

As mentioned above, the main lever for the reduction of water consumption is the genetic lever. The identification and promotion of drought resistant crop varieties could be a lever to limit irrigation needs.

4.3.2.10.2 Creating references on good irrigation practices

Water consumption analysis can be conducted thanks to the watermeters and surfaces declared followed up by NIC. The data followed up could enable NIC to compare the water consumption for different farms according to their crops and surfaces and encourage farmers to the reduction of water consumption by, for instance, establishing a bonus for those whose consumption is lower than expected or by comparing farmers to the average consumption and giving bonuses to those who have a significantly lower water consumption.

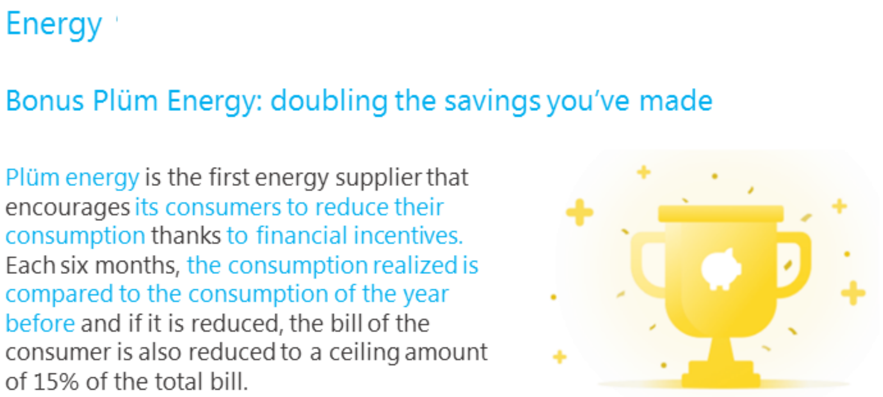


Figure 23 - Example of incentives implemented in France for the reduction of energy consumption. Source: Plüm energy website.

In the Pedro Plain area, lots of information on meteorological data is created but not transmitted to farmers. We would suggest the establishment of a newsletter providing information on irrigation needs thanks to the analysis of weather conditions and the follow-up of tensiometers on the field.

NIC and RADA could follow-up costs of production related to irrigation and in particular to irrigation material in order to analyze the investments and return of investments and the water costs compared to the yields and marketable production increase.

All of the irrigation references developed thanks to the project could be mobilized to feed the contents of trainings to farmers, on irrigation, demonstration of irrigation material, costs of production due to irrigation.

4.3.2.10.3 Encouraging low water consumption

A final lever to limit the water consumption for irrigation could be mobilized through the water tariff. Farmers could be encouraged to limit or reduce their consumption by the implementation of a water tariff that would be staged according to levels previously defined. The tariff grid could be organized as follows (please do not consider the figures, they are just put as an illustration of the principle, the figures have, of course, to be negotiated and justified before the implementation of such a grid):

Water consumption levels => to be defined by NIC and RADA for 1 ha	Water tariff by cubic meter in Jamaican dollars
0 to 100 m^3	0.7
100 to 1000 m^3	1
1000 m3 to 5000 m^3	2
More than a 5000 m^3	3

Table 16 - Example of the principles of an incremental water grip tariff according to the consumption for 1 ha.

4.3.2.11 BUILDING A SOLID SUPPORT ON FARMERS' GROUP MANAGEMENT

All stakeholders agree that farmers gathering in groups would be of great benefits for farmers themselves. Farmers groups intervene in different levels:

- Constitute in selling groups to move up in the value chain and make farmers benefit from more added value
- Constitute in buying groups to decrease the inputs costs
- Constitute in saving groups to tackle the issue of accessing to credit
- Defend farmers' interests within irrigation schemes

Gathering farmers together and improving their collective capacities would have a positive impact on many aspects. This is why the Jamaican Government is propelling farmers to organize in farmers' groups.

Organization of farmers in the area is in process. Farmers' groups have just started and have a lot to do to enhance their functioning to accomplish their functions of defending farmers' interests and improving farmers' incomes.

Different types of support has to be provided in order to help farmers' groups in accomplishing their mission. SDC and RADA are the two main stakeholders involved in providing support to them.

4.3.2.12 CONSTITUTE FARMERS IN SELLING, BUYING AND SAVING GROUPS IN ORDER TO DECREASE COSTS OF PRODUCTION

4.3.2.12.1 Building a solid support on farmers' group management

A solid support has to be implemented to ensure the good functioning and cohesion of the group.

From previous missions in Senegal, SCP has noted that the accompanying program to farmers associations in the Senegal River Valley has been a great success. This program has built from scratches an institution financed by both farmers groups and the Senegalese government to provide technical assistance on a wide range of services like:

- Providing training to elected farmers on the ruling and management of an association
- Providing daily support on the democracy of associations: organizing fair elections, implementing transparency in the accounts, establishing rules and procedures for the buying of products, etc.
- Providing accountability services like the registration of invoices, the follow up of the bank accounts, cash flow, etc.

RADA officers could be mandated by the project to ensure these missions but it could also be considered to establish a public-private institution specifically in charge of accompanying farmers groups. In any case, it is important that farmer groups participate in the funding of this operation to involve them in the process.

Building the capacities of stakeholders in this topic is absolutely crucial and at the same time very challenging as collective action is not necessarily part of the socio-economic reality of the Pedro Plains. Yet, all stakeholders agree that this has to be the way.

It would be interesting to identify partners like CERFRANCE or like ATAG (Association for the Accompanying of Group Agriculture) that could provide the training required to build this know-how in Jamaica.

Figure 24 - Website of the association that accompanies Farmers Groups in the Tarn department in France. Source: ATAG Website

4.3.2.12.2 Building capacity to farmers' groups

Once the structures in charge of the support to farmers' groups operational, trainings and follow up to farmers' groups can be organized. Many different topics can be part of the training like building trust within the farmers' group, accountability, management of groups, participative decision-marketing, or on leadership for instance.

4.3.2.13 SHARE OF GOOD PRACTICES, INNOVATIONS, AND KNOWLEDGE

Farmers groups can also play a significant role in the exchange of good practices between farmers themselves. Farmers groups can thus be a lever to the dissemination of good agricultural practices.

4.3.2.14 ACTION PLAN FOR RURAL DEVELOPMENT

Table 17 – Action Plan : recommended actions to maximize benefits for sustainable agriculture

Topic	Target	Secondary target	Action	N°	Operational action	Intermediate result indicators	Research or study	Organization	Training	Monitoring	Investment	Beneficiary	Leading institution	Others stakeholders involved	Implementing institution	Duration	Costs
Marketing	Build and support value chain structuration and support marketing	Increase farmers' income	Increase the added value produced by farmers and optimize production costs		Complete the COP database with prices from JAMIS in order to ensure a follow up of the margins to farmers	Data base completed and updated	X			X		Farmers	RADA	Farmer groups	RADA	5 years	20k$/year
					Implement grading and packaging of products	Proportion of agricultural goods graded and processed	X	X				Farmers	RADA	Farmer groups	RADA+consultant	3 years	20 k$
					Organize agro-processing of excess of produce/poor qualities by farmers' groups	Proportion of agricultural goods graded and processed		X				Farmers	RADA	Farmer groups		3 years	25 k$
					Organize the selling of produces directly to end users or supermarkets	Proportion of products sold directly to end-users		X				Farmers	RADA	Farmer groups		3 years	25 k$
					Purchase farm inputs in groups to reduce production cost	Proportion of inputs purchased in groups		X	X			Farmers	RADA	Farmer groups		3 years	50 k$
					Improve the access to credit for farmers through, for instance, farmer groups	Access to credit improved	X	X				Farmers	RADA	Farmer groups		6 months (feasibility)	20 k$
		Strengthen the value chain in order to improve food self sufficiency	Improve the supply of agricultural products		Conduct of a specific marketing analysis and organize stakeholders to keep it up to date ex. encouraging hotels to declare their needs for fruits and vegetables all through the year	Marketing analysis completed and updated	X					Value chain	RADA	Farmer groups, hotels, wholesalers, Parish	RADA	one shot then 4 years	30k$ then 5k$ per year
					Enhance the current databases of production volumes and organize stakeholders to keep it up to date through an app that could be developed ex. encouraging farmers to declare through the app the surfaces and crops produced	Database and app operational	X					Value chain	RADA	Farmer groups	Consultant	one shot then 4 years	30k$ then 5k$ per year
					Evaluate the profitability of investing for new storage or rehabilitate old storages and ensure their O&M	Studied completed	X				X	Value chain	RADA	Farmer groups	Consultant	6 months	15k$
					Work with farmers groups in order to study and develop collective storages and the possibility of organizing collective refrigerated trucks to improve marketing of products	Collective storage studied and operational	X	X			X	Value chain	RADA	Farmer groups	RADA	3 months	15 k$
					Develop the transportation infrastructures						X	Value chain	Ministery of Transport and Mining	Farmer groups, Parish			
					Develop the supply of schools and public institutions with local products like fruit juices in replacement of cokes for instance	number of public institutions supplied		X				Value chain	RADA/ Parish	Farmer groups, Ministery of Health and Education, Parish	RADA/consultant	1 year (feasibility)	15 k$
Agricultural practices	Accompany farmers into an agro-ecological transition	Optimize the development of agricultural products through the promotion of agro-ecological practices already existing and to be developed	Train farmers and develop agro-ecological good practices		Ensure the dialogue and the coordination between RADA and NIC	A coordination comitee on the topic of agricultural practices is set and functional		X				RADA and NIC	MICAF	NIC and RADA	MICAF		
					Use the demonstration site managed by NIC as a support to good agricultural practices starting with the reintroduction of grass mulching technic	Demonstration site operational and applying agro-ecological technics		X			X	Farmers and environment	NIC	RADA, farmers groups	NIC	5 years	100k$
					Organize training to trainers to RADA and NIC Officers in terms of agro-ecological stakes and methods	30 people trained			X			RADA and NIC	RADA	NIC, Farmer groups	Consultant	2 years	50 k$
					Set up and monitor a network of different types of farms in terms of production technics, production results, production costs and benefits, environmental impacts (fertilization, weeding, etc.)	Network set and monitored	X			X		Farmers and environment	RADA	Farmer groups	RADA	5 years	100k$
					Use this network of farms to support trainings, try new agricultural techniques allowing to decrease pollution	25% farmers trained (around 1000 farmers)			X			Farmers and environment	RADA	Farmer groups	RADA	5 years	100k$
					Sensitize to the use of chemicals, forbidden chemicals, risks related to their use, etc.	25% farmers trained (1000)			X			Farmers and environment	Pesticides Control Authority	RADA, Farmer groups	RADA/consultant	2 years	50 k$
					Promote mulching technics, drip irrigation and rational water use in order to limit weeding and fungi attacks	25% farmers trained (around 1000 farmers)			X			Farmers and environment	NIC	RADA, farmers groups	NIC	5 years	100k$
					Implement a Charter for good practices: farmers engage in continuing crop rotations; enhance crop diversification; carry on mulching; etc. The precise content has to be discussed with farmers	25% farmers trained (around 1000 farmers)		X	X			Farmers and environment	RADA	Farmer groups	RADA	5 years	100k$
			Implement a controled fertilizer management		Set up and implement soil analysis - tests labs in RADA and within the farms' network in order to adapt fertilization techniques to the soil composition	10% farmers trained (around 400 farmers)			X		X	Farmers and environment	RADA	Farmer groups	RADA	5 years	100k$
					Promote aid decision tools for prediction of fertilization management and for the daily operation of inputs like nitrogen balances, BeApi solutions (multidimensional analysis including maps, satellite imagery analysis, NDVI etc.)	Online tool operational			X		X	Farmers and environment	RADA	Farmer groups	NIC	5 years	100k$
			Improve genetics to a better adaptation to local conditions		Develop resistant crops to fungus, extreme climatic conditions (droughts, etc.) and adapted to the local production conditions of St Elizabeth and the Pedro Plains	1 research program developped	X					Farmers and environment	MICAF ?	MICAF, Farmer groups	Mona University, IRD, CIRAD, INRA Antilles (French Research agencies)	5-10 years	

Topic	Target	Secondary target	Action	N°	Operational action	Intermediate result indicators	Research or study	Organization	Training	Monitoring	Investment	Beneficiary	Leading institution	Others stakeholders involved	Implementing institution	Duration	Costs
Irrigation	Accompany all stakeholders into a rational and ecological use of water resources	Ensure a reliable water service	Secure the water right at the Black river on the long term		Conduct a legal study to guarantee the continuity of the water right at the intake on the Black river	Water right secured	X	X				Farmers and environment	WRA	RADA, NIC, WRA, farmers' groups	Consultant + NIC	1 year	15 k$
			Ensure a reliable water service		Help NIC in establishing a reliable water service.	Satisfaction of users - Update customer contracts with new clauses - O&M procedures manual implemented		X	X			Farmers and environment	NIC		Technical assistance	3 years	500 k$
		Ensure a rational water use in farming	Ensure a low dependance to water needs		Identification and promotion of drought resistant crop varieties	1 research program developped	X					Farmers and environment	Mona University ?	MICAF, farmer groups	Mona University, IRD, CIRAD, INRA Antilles (French Research Agencies)	5-10 years	
			Create references on good irrigation practices		Monitor water consumptions thanks to watermeters and surfaces declared => comparison of water consumption at a secondary network level and according to the crops and surfaces declared => encourage water consumption reductions => develop incentives for best practices among consumers	water consumptions monitored	X			X		Farmers and environment	NIC	Farmer groups	NIC + technical assistance	3 years	300 k$
					Analyse weather conditions and monitor tensiometers in order to develop newsletters indicating information on irrigation needs	newsletters operational	X			X		Farmers and environment	NIC	MetService, WRA, RADA, Farmer groups	NIC +technical assistance	3 years	150 k$
					Follow up costs of production related to irrigation and in particular to irrigation material => investment and return of investment + water costs compared to yield and production increase	Production and irrigation costs monitored	X			X		Farmers and environment	NIC	RADA, Farmer groups	Consultant	Year 1, year 3, year 5	25 k$
					Training on irrigation, demonstration of irrigation material, costs of production due to irrigation	10% farmers trained (400)			X			Farmers and environment	NIC	RADA, Farmer groups	NIC + consultant	Year 1, year 3, year 5	25 k$
			Encourage low water consumption		Implementation of an increasing water tariff grid related to the water consumption	Water tariff operational	X	X				Farmers and environment	NIC	RADA, Farmer groups	NIC + consultant		
Farmers group	Empower farmers' groups	Constitute farmers in selling, buying and saving groups in order to decrease costs of production	Build a solid support to farmers' group management		Organize training to trainers to RADA Officers in terms of collective management of farmers' groups and constitution of farmers' groups	10 officers trained		X	X			RADA	RADA	Farmer groups	Consultant	2 years	50 k$
					Organize the follow-up of farmers' groups by RADA officers: assign officers to this mission and provide them with means to ensure their mission of support	10 officers ready for action		X				Farmers	RADA	Farmer groups	RADA	5 years	120 k$
			Build capacity of farmers'groups		Organize trainings to farmers' groups on accountability, management of groups, participative decision-making, leadership, etc.	50 % of farmers groups boards trained			X			Farmers	RADA	Farmer groups	RADA		included above
		Share of good practices, innovations, and knowledge	Build capacity of farmers'groups		Strengthen the capacity of farmers groups to ensure sharing of good technical practices	50 % of farmers groups boards trained			X			Farmers and environment	RADA+NIC	Farmer groups	RADA		included above

4.4 TIMEFRAME AND INVESTMENT COSTS

The project corresponds a construction phase of approx. 3,5 years, after 15 months of final design.

The provisional budget is of 167 M USD, 6 M USD being for accompanying measures.

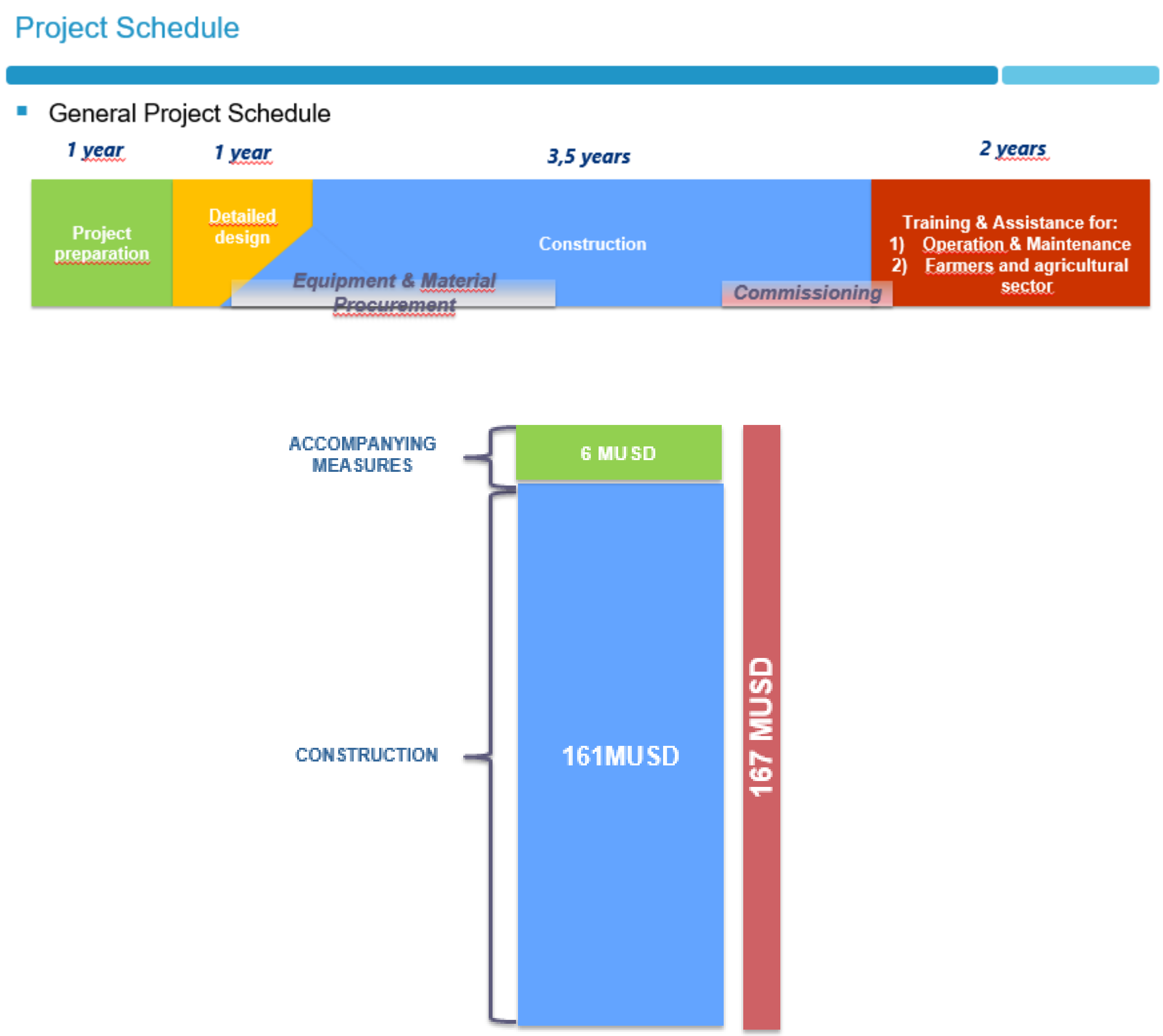


Figure 25 – Project schedule and investment cost

5 DESCRIPTION OF THE ENVIRONMENT

5.1 PHYSICAL ENVIRONMENT

5.1.1 CLIMATE

Jamaica has a bimodal rainfall pattern which consists of two peaks periods with higher values of rainfall and corresponding periods of lower rainfall. The primary peak occurs in October and the secondary in May. The lowest amounts are at a minimum during the period February to March and the month of July. This is based on long-term reports but deviations from this pattern do occur year to year.

Among the most important climatic influences in Jamaica are the Northeast Trade Winds, the range of mountains which runs east-southeast to west-southwest along the center of the island, the warm waters of the Caribbean Sea, and weather systems such as upper- and low-level low-pressure centres, troughs and cold fronts.[8]

In the area, winds are significant and dry. Farmers have developed a know-how to protect the crops from erosion and dryness.

The cold fronts, usually weak after migrating from the North American continent, are evident from mid-October to mid-April; whilst the Tropical Weather Systems, namely Tropical Waves, Tropical Depressions, Tropical Storms and Hurricanes occur from April to December. The official hurricane season is from June to November.[9]

[8] http://metservice.gov.jm/our-climate/
[9] http://metservice.gov.jm/our-climate/

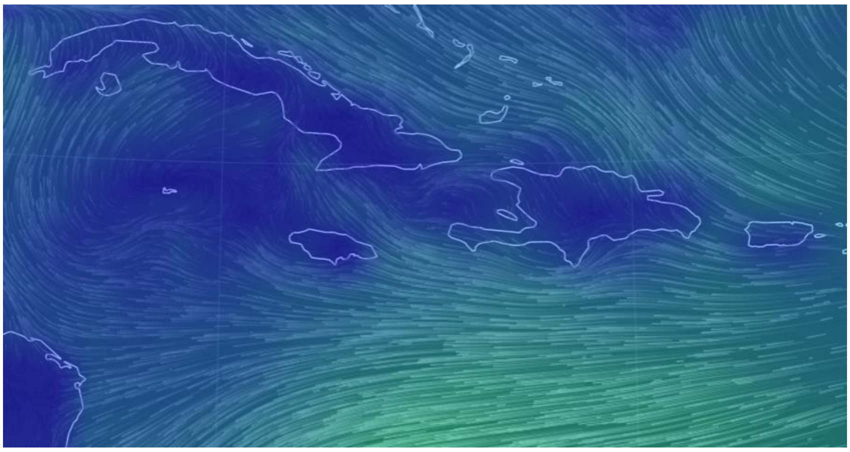


Figure 26 - Winds affecting the Caribbean - Source: http://metservice.gov.jm/our-climate/

The following map shows the average rainfalls according to the parishes of Jamaica. Within St Elizabeth, most of the study area receives between 1500 and 1750 mm per year. It is not the driest part in Jamaica but it is still not very rainy compared to the ET_0 demand.

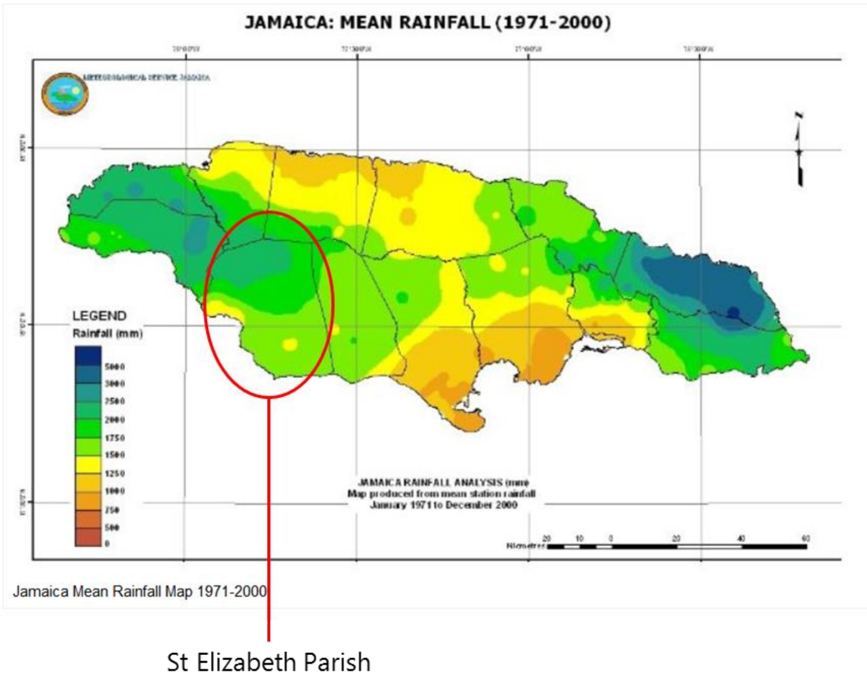


Figure 27 – Map of mean annual rainfall for Jamaica (mm) - Averaging period is 1971-2000

Source: http://metservice.gov.jm/our-climate/ [10]

The climatic demand calculated according the Penman-Monteith formula shows that the project area is on a high climatic demanding zone (in red in the following map).

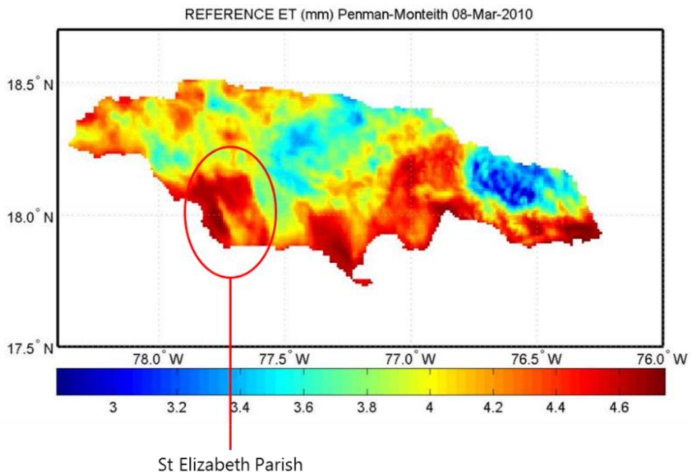


Figure 28 - ET0 in mm calculated according to Penman-Monteith formula for March 8th 2010

Source: http://metservice.gov.jm/our-climate/ [11]

The climate projections for **mean temperature** and **precipitation precipitation** in this document are those of the latest available SSP scenarios at high spatial resolution via the WorldClim2.1 dataset.

Moreover, additional sources of information were consulted regarding **sea level rise** as well as **hurricanes** (cf. paragraph 5.3 about natural hazards). In particular, the results of the latest baseline report for Jamaica "The State of Jamaican Climate 2019", as well as data from the latest Intergovernmental Panel on Climate Change (IPCC AR6) were used.

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IPCC6 climate scenarios

The latest climate scenarios represented here are the following:

- SSP2-4.5: Scenario of moderate greenhouse gas emissions, with a stabilization of the greenhouse effect from 2100.
- SSP5-8.5: Scenario of very high greenhouse gas emissions, assuming no public policies to limit global warming.

Note: Scenario 2.6 corresponding to the 2015 Paris Agreement target is not represented here. Indeed, this objective will not be reached if the efforts do not go beyond the commitments that the states have already officially formalized through the national NDC plans (**N**ationally **D**etermined **C**ontributions). As a reminder, the 2.6 scenario corresponds to low greenhouse gas emissions, which would limit the global temperature rise in 2100 to between 1.5 and 2°C compared to the pre-industrial era.

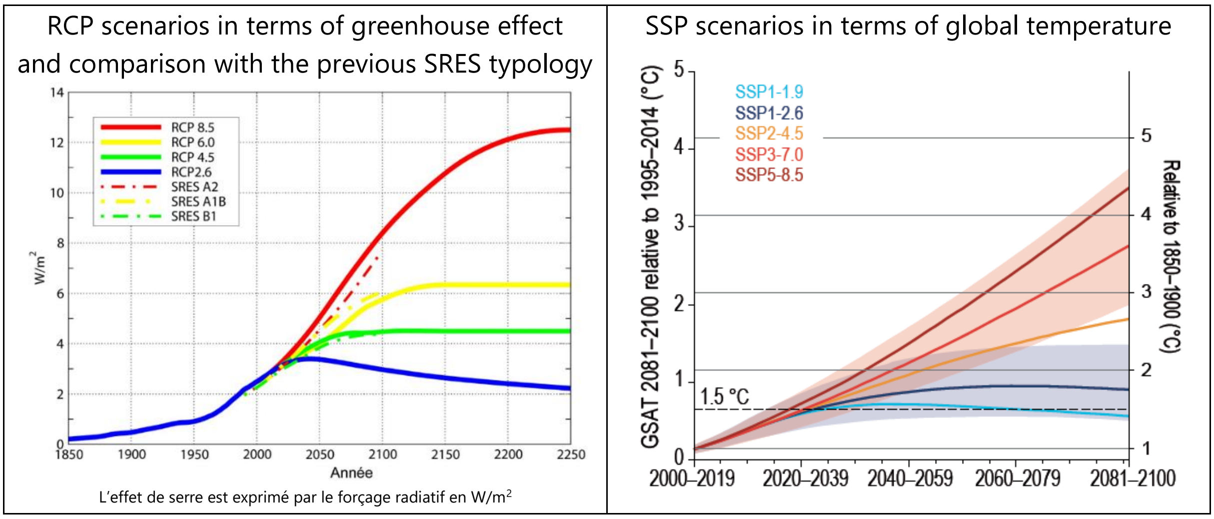


Figure 29 – RCP & SSP Climatic Scenarios of Intergovernmental Panel for Climate Change (IPCC)

Temperature and Precipitation Projections (WorldClim2.1 dataset)

The average temperatures and precipitation presented here are representative of the entire area of St. Elizabeth Parish. For this purpose, the WorldClim2.1 data available on a high spatial resolution grid (10 km), were averaged for all the grid cells of the territory.

- The median values shown correspond to the central values of 25 models among the 50 or so provided by research groups from all over the world.
- The minimum and maximum values describe the variability of the results of the 25 models, i.e. the uncertainty of the temperature and precipitation projections.

The projections are translated into deviations from the 1970-2000 reference period. The deviation is expressed in °C for temperature and in % for precipitations. The deviations provided can be applied to the entire territory of St. Elizabeth Parish, regardless of the reference value for temperature (22.5 to 27°C annually) and precipitations (1400 to 2500 mm/year). Thus, the projections shown can be applied, as needed, to both the future Pedro Plains irrigated area and the Black River watershed on which the water resource depends.

5.1.1.1 TEMPERATURE

The map below represents the average annual temperatures of the reference period 1970-2000. Over the territory of St. Elizabeth Parish (in red on the map), annual temperatures prior to the year 2000 averaged between 22.5°C (on the tops of the reliefs) and 28.5°C (on the coast). The future projections presented in the graphs and table below can be summarized as follows.

On an annual scale, the average temperature increases are differentiated according to the projection horizon:

- Horizon 2050: relatively close increases for the 2 scenarios +1.7 or +2.0°C
- Horizon 2090: Very different increases for the 2 scenarios +2.5 or +3.9°C

On a sub-annual scale, the greatest increase will be observed during the hottest months, i.e. up to +2.6°C or 4.2°C on average depending on the scenario for the 2090 horizon (July to September).

The uncertainty of these projections is very significant, since it is of the order of +/-1°C on an annual scale by 2090.

Finally, it should be noted that these increases are expressed in relation to the 1970-2000 reference period, which is already about 20 years old. Therefore, it should be considered that **an increase of 0.5°C has already occurred, and that it is deducted from the indicated increases if we want to apply them to recent average precipitation**.

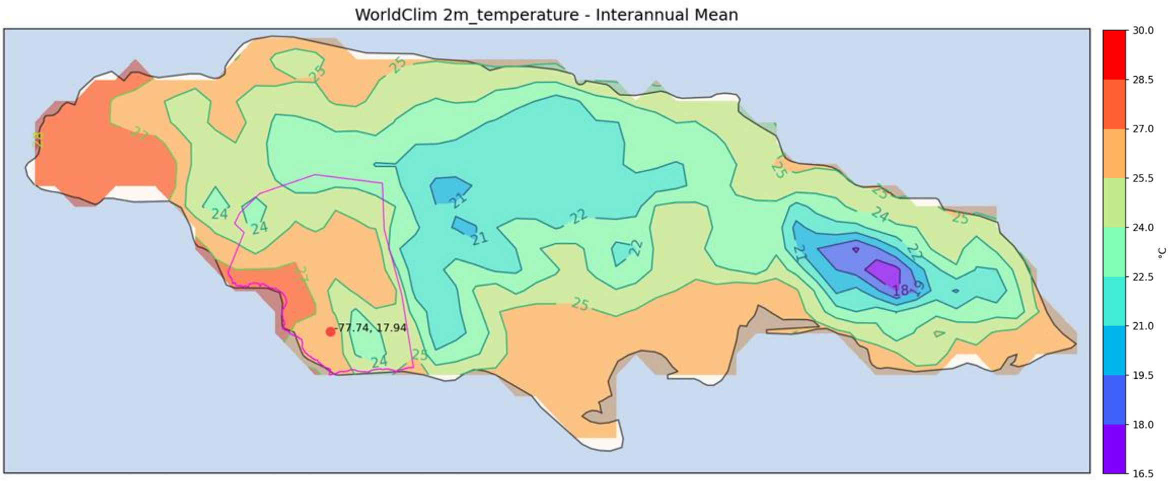


Figure 30 – Annual Mean Temperature of the reference period 1970-2000 (WorldClim2.1) °C

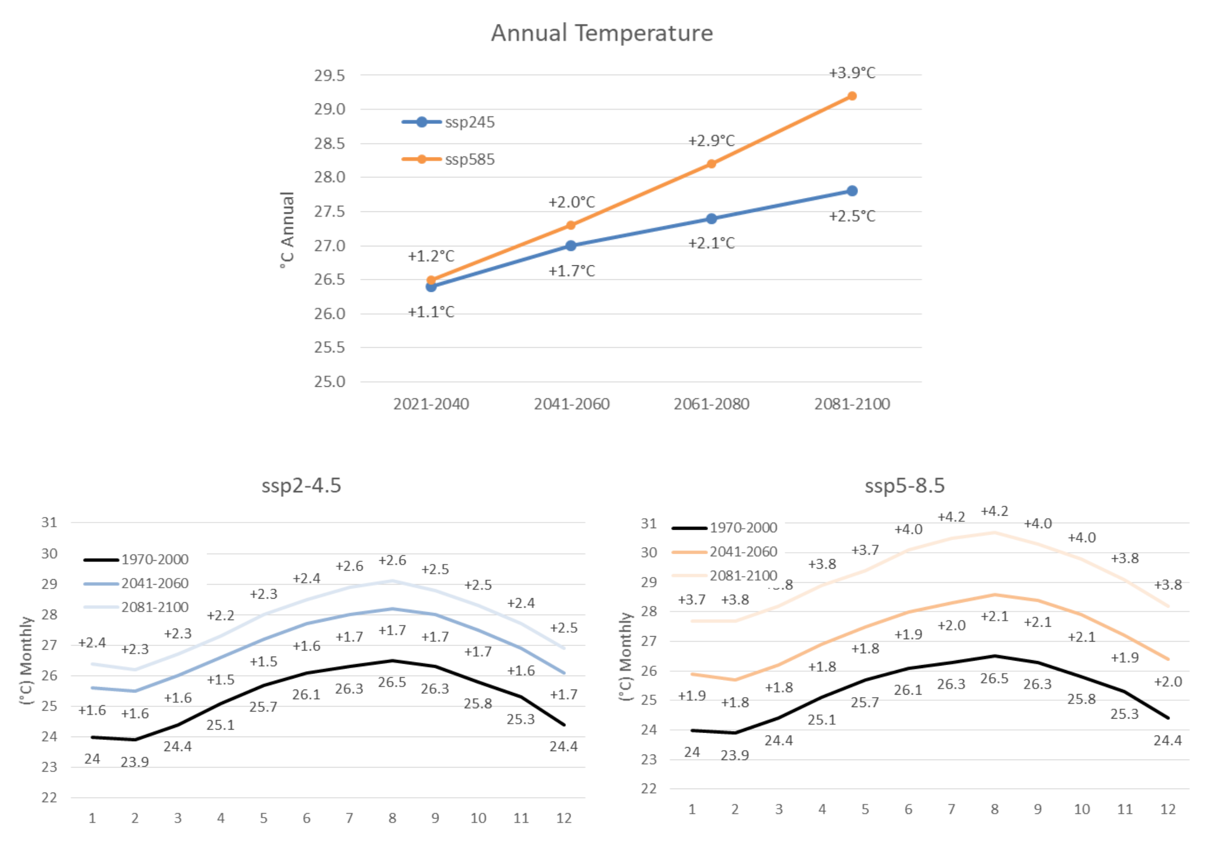


Figure 31 – Annual and monthly Mean Temperature Changes relative to 1970-2000 for St Elisabeth parish (WorldClim2.1 CMIP6)

Table 18 - Annual and seasonal Mean Temperature Changes relative to 1970-2000 for St Elisabeth parish (WorldClim2.1 CMIP6)

SSP2-4.5

2041-2060 °C	DJF	MAM	JJA	SON	ANN
Min	+1.1	+1.1	+1.1	+1.1	+1.1
Median	+1.6	+1.5	+1.7	+1.7	+1.7
Max	+2.3	+2.2	+2.2	+2.3	+2.3

2081-2100 °C	DJF	MAM	JJA	SON	ANN
Min	+1.5	+1.4	+1.5	+1.5	+1.5
Median	+2.4	+2.3	+2.5	+2.5	+2.5
Max	+3.3	+3.0	+3.1	+3.3	+3.2

SSP5-8.5

2041-2060 °C	DJF	MAM	JJA	SON	ANN
Min	+1.4	+1.4	+1.4	+1.4	+1.4
Median	+1.9	+1.8	+2.0	+2.0	+2.0
Max	+2.8	+2.6	+2.8	+2.8	+2.7

2081-2100 °C	DJF	MAM	JJA	SON	ANN
Min	+2.5	+2.5	+2.5	+2.6	+2.6
Median	+3.8	+3.8	+4.1	+3.9	+3.9
Max	+5.1	+4.9	+5.3	+5.3	+5.1

5.1.1.2 AVAILABLE INPUT DATA FOR LOCAL AREA

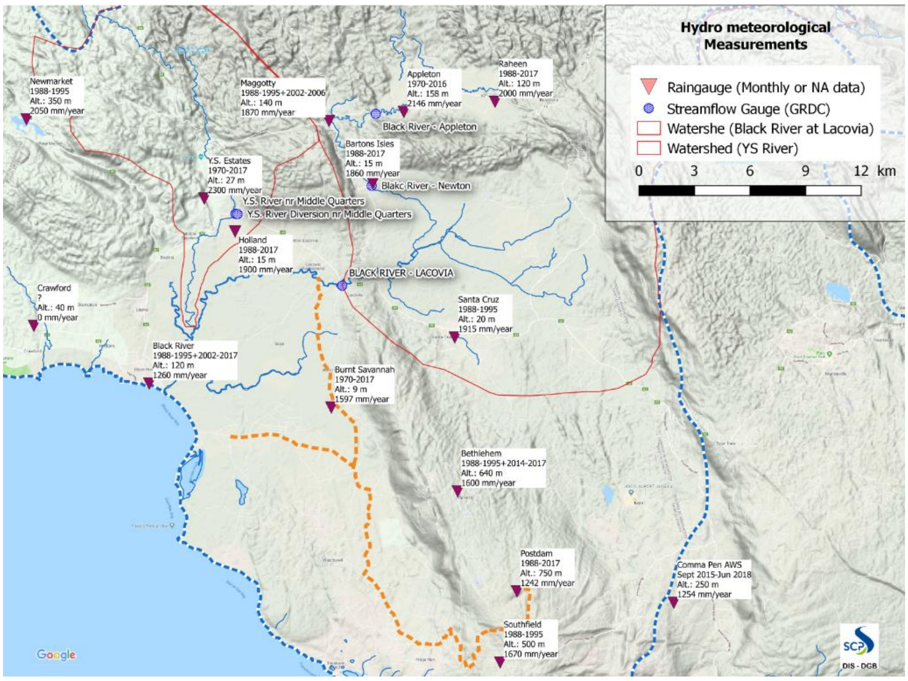


Figure 32 – Location of raingauges and streamflow gauges in the study

Rainfall:

- Monthly Rainfall: Burnt Savannah, Y.S. Estates, Appleton (Milton Henry, August 2018)
- Daily Rainfall: Burnt Savannah, Comma Pen (Meteorological Service, September 2018)

Table 19 - Available data on rainfall

Rain gauge	Annual Rainfall	Period	Note
Appleton	2,146 mm	1970-2016	Watershed Intake
Bartons Isles	1,891 mm	1988-2017	Watershed Intake
Bethlehem	1,954 mm	1988-1995+2014-2017	
Black River	1,257 mm	1988-1995+2002-2017	
Burnt Savannah	1,597 mm	1970-2017	

Comma Pen	1,254 mm	Sept2015-June2018	Very short history
Crawford	-	No available data	
Holland	1,886 mm	1988-2017	Watershed Intake
Maggotty	1,742 mm	1988-1995+2002-2006	Watershed Intake
Newmarket	2,022 mm	1988-1995	
Postdam	1,242 mm	1988-2017	Irrigation perimeter
Raheen	1,983 mm	1988-2017	Watershed Intake
Santa Cruz	2,116 mm	1988-1995	
Southfield	1,890 mm	1988-1995	Irrigation perimeter
Y.S. Estates	2,302 mm	1970-2016	Watershed Intake

ET_0[12]:

Daily ET_0 : Comma Pen, Potsdam (Meteorological Service, November 2018)

Table 20 - Available data on monthly evapotranspiration

ET0 measurement	Annual ET0	Historic	Note
Comma Pen	1 300 mm	Oct2015-Jan2018	Very short history

5.1.1.3 RAINFALL

5.1.1.3.1 Annual rainfall

Table 21 - Annual rainfall – Average & 10-year return period

Average	**1,600 mm** **1,200 to 1,900 mm** **1,900 to 2,300 mm**	West of the perimeter in the plain (Burnt Savannah - 54 years) East of the perimeter from 20 to 750m in height (3 rain gauges) In the Black River watershed (average from 7 to 54 years)

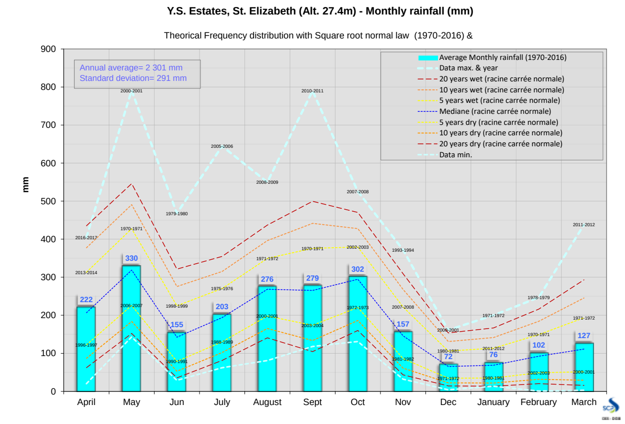
12 ET_0 = Reference Evapotranspiration. The FAO recommends this terminology instead of ETP (evapotranspiration potential)

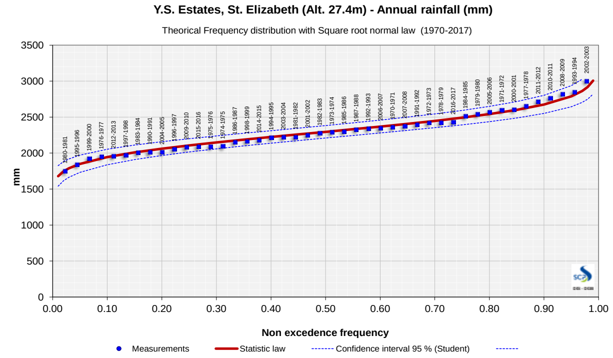
Decennial wet-year recurrence	**1,140 mm**	West of the perimeter in the Burnt Savannah plain, the only station with a long-term historical database (see figures below)

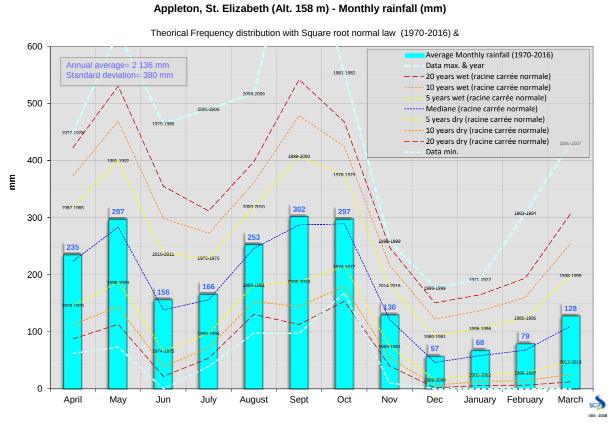
Despite the short distances considered, the geographical variability of rainfall is therefore quite large, mainly because of the terrain. This is also the case at the perimeter's narrowest point (from west to east), due to the presence of a north-south mountain chain.

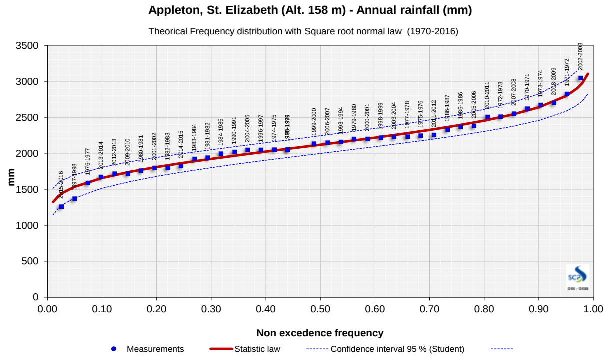
5.1.1.3.2 Monthly and annual rainfall

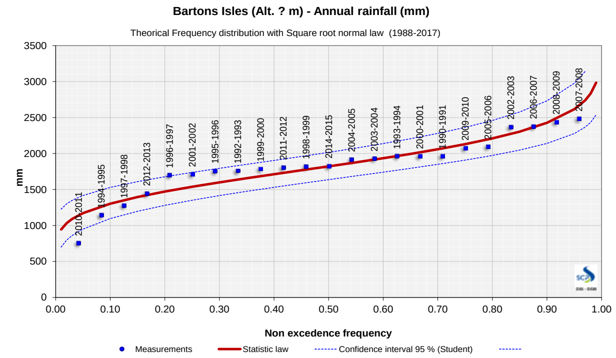
In terms of rainfall data available in early 2019, monthly data are available for the following positions (see tables and figures below).

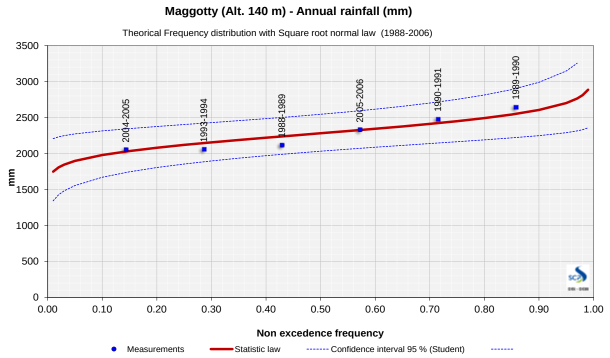


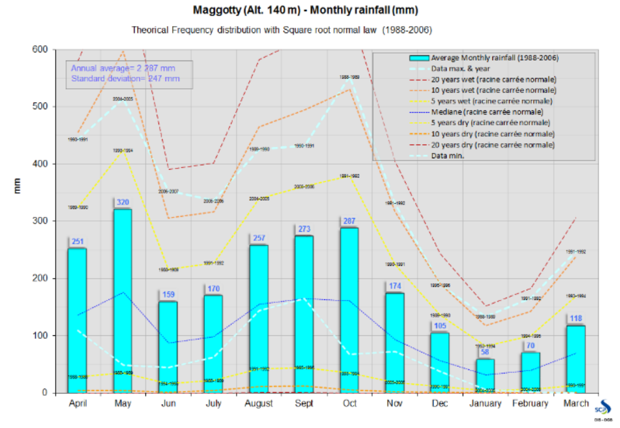


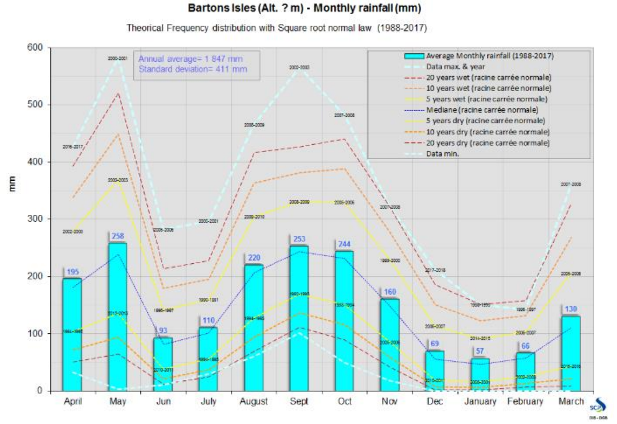

Appleton, St. Elizabeth (Alt. 158 m) - Monthly rainfall (mm)
Theorical Frequency distribution with Square root normal law (1970-2016) &
Annual average= 2 136 mm
Standard deviation= 380 mm
Average Monthly rainfall (1970-2016)
Data max. & year
20 years wet (racine carrée normale)
10 years wet (racine carrée normale)
5 years wet (racine carrée normale)
Mediane (racine carrée normale)
5 years dry (racine carrée normale)
10 years dry (racine carrée normale)
20 years dry (racine carrée normale)
Data min.
mm
April
May
Jun
July
August
Sept
Oct
Nov
Dec
January
February
March
235
297
156
166
253
302
297
130
57
68
79
128

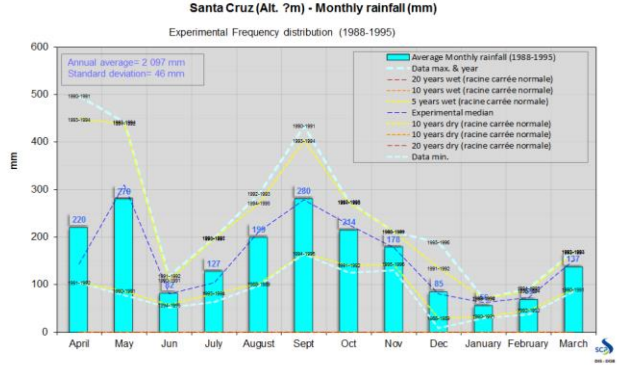

Appleton, St. Elizabeth (Alt. 158 m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1970-2016)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)


Bartons Isles (Alt. ? m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1988-2017)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)


Maggotty (Alt. 140 m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1988-2006)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)


Maggotty (Alt. 140 m) - Monthly rainfall (mm)
Theorical Frequency distribution with Square root normal law (1988-2006)
mm
April
May
Jun
July
August
Sept
Oct
Nov
Dec
January
February
March





Many gaps (only 2 full years)

Annual statistic not possible

Figure 35

- Five rain gauges covering the southern half of the area (lowest area in the Black River watershed)
- Five rain gauges located in very different areas of the project perimeter, both in terms of terrain and potentially of climatology, particularly due to the presence of the north-south mountain chain:
  - Western part: Burnt Savannah at 9 m of height in the north (**1,600 mm/year**),
  - Eastern part: Santa-Cruz 20 m (**1,900 mm/year**), Bethlehem 60 m (**1,600 mm/year**),Potsdam 750 m (**1,200 mm/year**) and Southfield 500 m (**1,700 mm/year**).

    The Comma Pen rain gauge was not consulted, since its historical data is insufficient.

5.1.1.4 RAINFALL IN THE PERIMETER OF THE PROJECT

The statistics are as follows on the three positions located on the study area (Comma Pen has only two full year data).

Comma Pen (Alt. 250m) - Monthly rainfall (mm)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	170.5	168.8	74.1	84.6	98.0	106.7	195.4	126.9	39.9	36.9	53.5	75.5	**1407.8**
Standard deviation	121.8	97.4	97.2	110.0	48.9	126.5	33.0	61.9	26.4	51.2	36.7	37.6	**407.6**
Experimental median	213.6	166.0	22.4	84.6	98.0	70.2	203.8	100.4	32.0	7.6	32.8	88.4	**1407.8**
Data max.	264.9	267.6	186.2	162.4	132.6	247.4	223.4	197.6	69.4	96.0	95.8	105.0	**1696.1**
Data min.	33.0	72.8	13.6	6.8	63.4	2.4	159.0	82.6	18.4	7.0	31.8	33.2	**1119.6**

Table 22 - Monthly rainfall at Comma Pen (Oct.2015-Juin2018)

Burnt Savannah, St. Elizabeth (Alt. 9 m) - Monthly rainfall (mm)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	nual rainfa
Average	157.1	210.5	87.1	104.6	186.8	202.7	236.0	147.7	62.4	49.0	63.6	95.1	**1591.1**
Standard deviation	95.3	120.7	73.1	62.6	82.5	99.8	113.3	88.7	60.3	37.3	43.6	74.8	**331.5**
Experimental median	137.0	218.4	70.0	95.0	184.1	166.5	203.0	146.7	45.7	50.0	54.5	78.0	**1612.5**
Data max.	375.0	483.0	388.0	281.9	413.0	489.0	577.0	351.0	233.0	116.0	190.0	350.0	**2079.0**

Table 23 - Monthly rainfall at Burnt Savannah, basic statistics (1970-2017)

Postdam, St. Elizabeth (Alt. 750 m) - Monthly rainfall 1988-2017 (mm)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	113.4	167.5	62.2	70.3	122.2	152.7	221.0	123.1	61.5	53.0	49.6	82.3	1234.9
Standard deviation	63.1	129.9	68.6	44.6	98.0	157.0	148.8	70.2	51.2	37.4	24.8	61.7	409.4
Experimental median	89.0	120.3	35.1	56.0	89.0	110.1	169.7	116.0	55.0	37.9	52.0	66.7	1162.9
Data max.	216.0	600.9	244.4	187.0	391.0	807.3	671.6	302.1	199.1	139.7	88.0	225.0	2438.0
Data min.	20.0	14.0	0.0	12.2	19.7	20.8	68.2	27.6	0.0	3.3	7.8	11.7	702.2

Table 24 - onthly rainfalls at Postdam, basic statistics (1988-1977°

For positions of Burnt Savannah and Postdam (only long-term historical data), charts 3 et 4 below show complete statistics with monthly values in table above, and rainfall of different periods (2, 5, 10 and 20 years - dry and wet).

Annual rainfall are presented in charts 2 and 3 (Burnt Savannah) and 5 and 6 (Postdam)

The recent decrease in annual rainfall (is rather doubtful, as it was not recorded at the other rainfall stations which have been analyzed (Moreover, the R^2=19% trend coefficient is not significant).

***Comma Pen** – Very short historic (Only 2 full years)*
No Statistic
Burnt Savannah

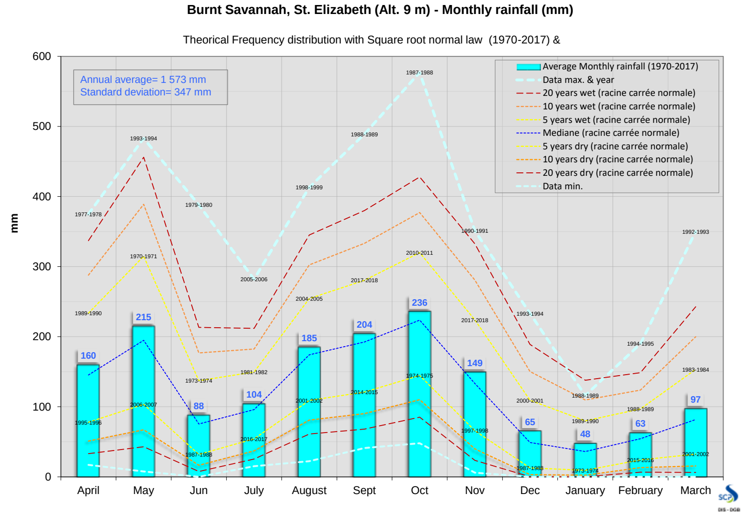


Chart 1-Burnt Savannah monthly rainfall statistics

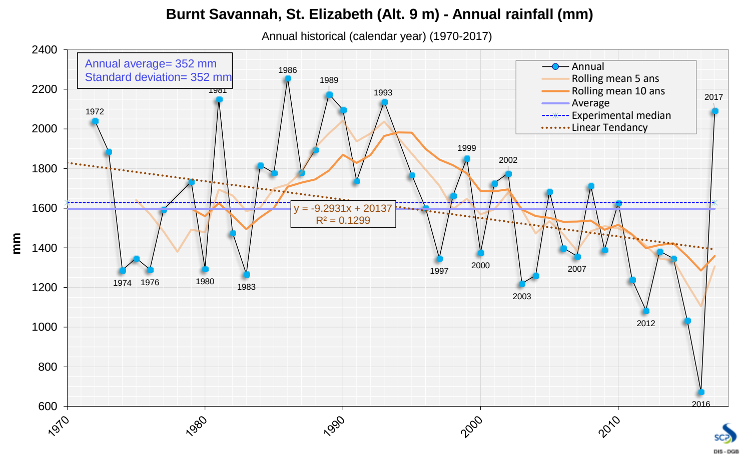


Chart 2-Burnt Savannah annual rainfall historic

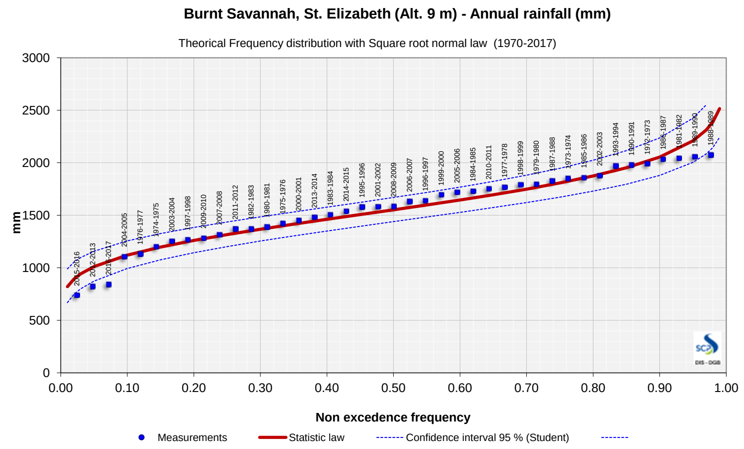


Chart 3-Burnt Savannah Annual rainfall statistics

Figure 33 - Statistical rainfall data for Burnt Savannah

Postdam

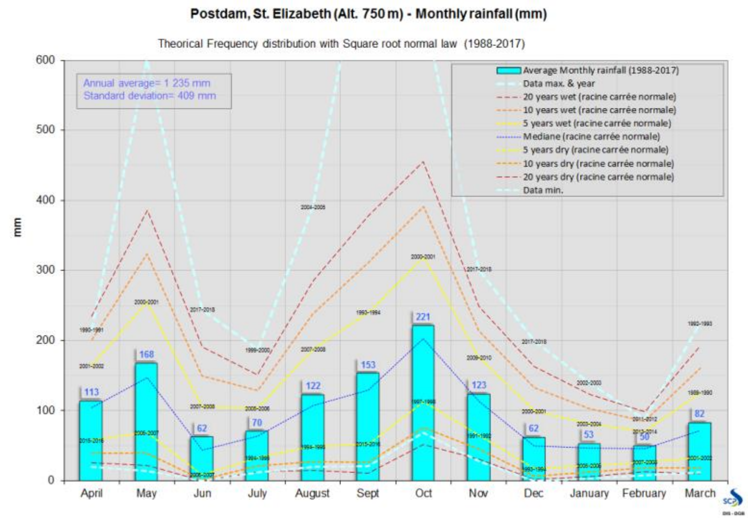


Chart 4-Postdam monthly rainfall statistics

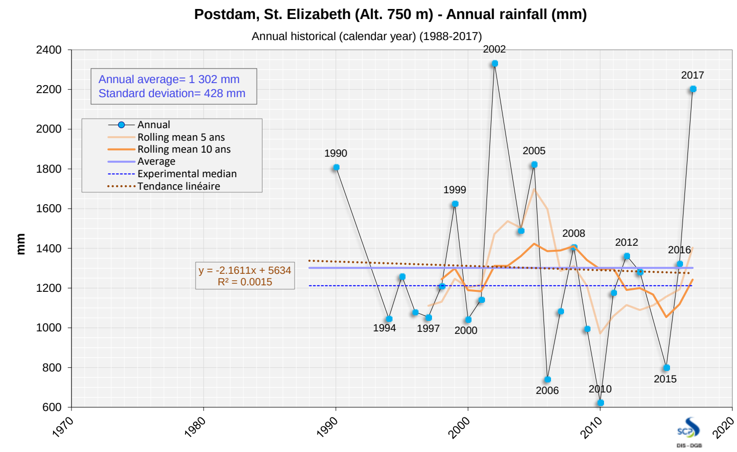


Chart 5- Postdam annual rainfall historic

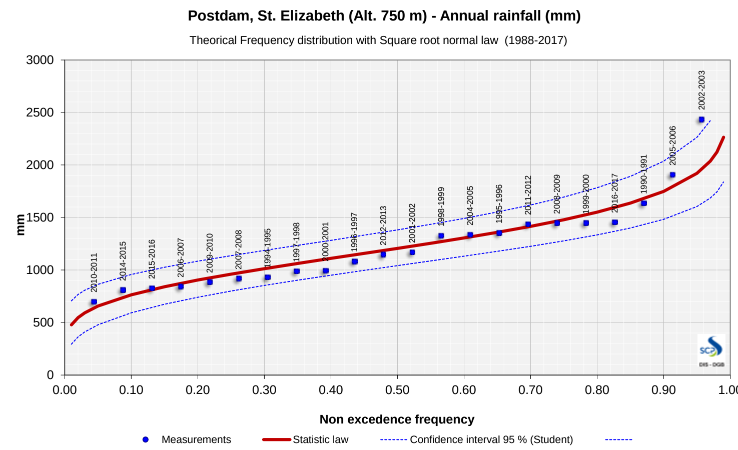


Chart 6 --Postdam Annual rainfall statistics

Figure 34 - Statistical rainfall data for Postdam

5.1.1.5 RAINFALL ON THE BLACK RIVER WATERSHED

Statistics on the six rain gauges available in the Black River watershed are given below.

Table 25 - Monthly rainfall on the watershed, basic statistics

Y.S. Estates, St. Elizabeth (Alt. 27.4m) - Monthly rainfall 1970-2017 (mm)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	221.5	331.9	155.8	204.1	275.3	275.8	300.8	157.4	73.4	76.7	101.9	129.3	2303.6
Standard deviation	105.0	129.1	92.7	94.3	89.6	137.7	94.8	81.6	41.8	48.6	58.7	86.7	287.9
Experimental median	211.5	311.0	135.0	182.0	280.5	246.0	271.6	150.0	71.5	67.8	92.9	127.2	2290.5
Data max.	404.8	791.0	468.0	644.6	550.1	790.0	525.4	372.0	161.0	200.0	247.0	438.5	3005.2
Data min.	20.0	143.0	29.0	62.0	81.0	118.0	131.0	31.9	4.0	13.4	0.8	2.8	1752.0

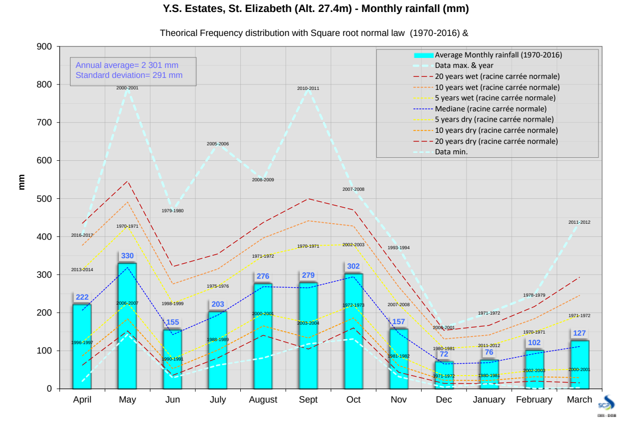
Appleton, St. Elizabeth (Alt. 158 m) - Monthly rainfall 1970-2016 (mm)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	235.0	297.1	156.3	165.7	252.6	301.6	296.9	129.8	57.1	67.9	79.3	127.8	2135.9
Standard deviation	99.6	128.6	105.3	84.2	84.7	147.2	101.3	59.9	44.6	44.6	61.3	99.5	380.3
Experimental median	223.0	284.0	123.0	149.0	237.2	286.0	276.0	133.0	49.5	68.8	74.5	104.0	2149.7
Data max.	449.0	625.0	465.0	490.2	517.4	837.0	554.0	259.0	177.0	192.0	308.0	430.7	3054.2
Data min.	62.0	73.0	0.0	39.0	97.7	97.0	168.0	10.0	0.0	0.0	0.0	0.0	1269.0

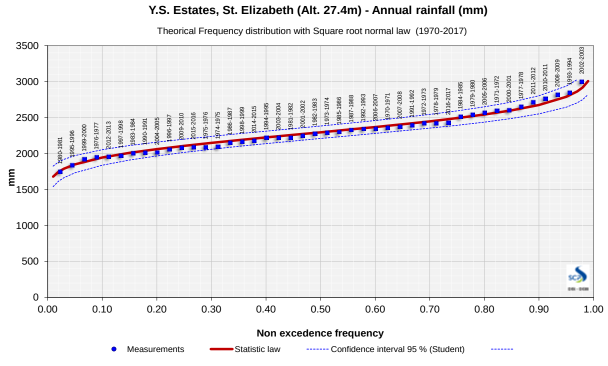
Maggotty (Alt. 140 m) - Monthly rainfall 1988-1996+2004-2006 (mm) (Only 6 full years)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	251.3	320.3	159.0	169.6	257.4	273.4	287.5	173.7	104.8	58.5	70.1	117.8	**2286.8**
Standard deviation	99.0	152.1	107.9	88.8	80.7	85.3	131.2	81.9	44.2	42.9	49.7	70.6	**246.9**
Experimental median	241.0	327.5	156.0	182.0	242.0	290.0	300.0	161.0	100.7	54.5	74.0	112.8	**2230.3**
Data max.	443.0	514.3	353.2	336.5	426.0	432.0	553.0	332.0	189.0	134.0	166.0	248.0	**2653.0**
Data min.	109.0	48.7	44.8	63.0	143.7	165.0	67.4	72.6	38.0	5.6	2.0	0.0	**2057.1**

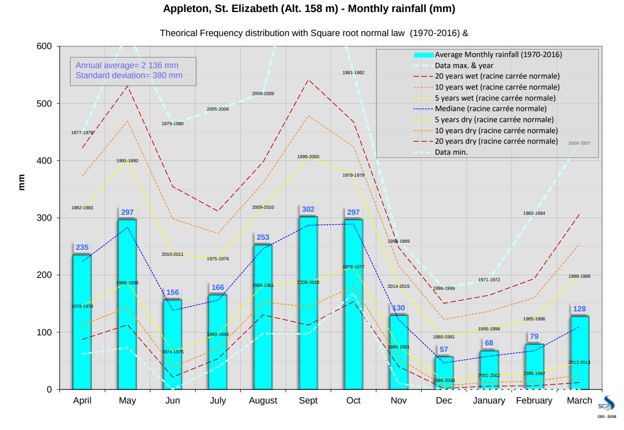
Bartons Isles (Alt. 15 m) - Monthly rainfall (mm)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	195.5	257.8	92.7	110.2	219.6	252.8	243.6	160.3	69.5	57.1	66.2	130.3	**1847.0**
Standard deviation	104.3	131.0	66.3	69.9	107.7	102.9	101.7	79.8	58.0	43.0	41.1	98.0	**410.7**
Experimental median	188.0	226.0	86.0	80.5	214.1	238.2	242.0	157.5	56.0	51.1	70.6	97.0	**1830.6**
Data max.	427.5	582.0	282.0	297.0	465.6	565.6	482.1	322.5	211.4	151.0	143.0	361.4	**2487.5**
Data min.	33.0	3.0	11.4	29.6	61.0	101.0	49.8	18.0	0.2	0.0	0.0	0.0	**759.6**

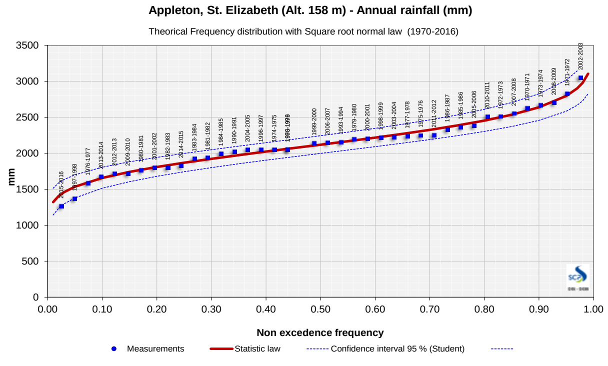
Santa Cruz (Alt. 20 m) - Monthly rainfall 1988-1995 (mm) (Only 2 full years because of gaps)													
	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Annual
Average	219.6	279.2	82.3	127.3	198.9	280.0	213.8	178.3	84.6	55.6	68.5	136.8	**2096.5**
Standard deviation	166.0	163.9	22.8	52.5	73.0	107.6	59.2	30.7	56.1	17.7	19.0	36.9	**46.0**
Experimental median	143.0	310.0	81.0	104.0	211.0	278.5	225.5	178.0	80.0	62.0	72.5	151.5	**2096.5**
Data max.	497.0	442.0	118.0	198.0	291.0	434.0	275.0	211.0	189.0	71.0	92.0	169.0	**2129.0**
Data min.	104.0	78.0	52.0	63.0	97.0	165.0	125.0	131.0	8.0	30.0	37.0	86.0	**2064.0**

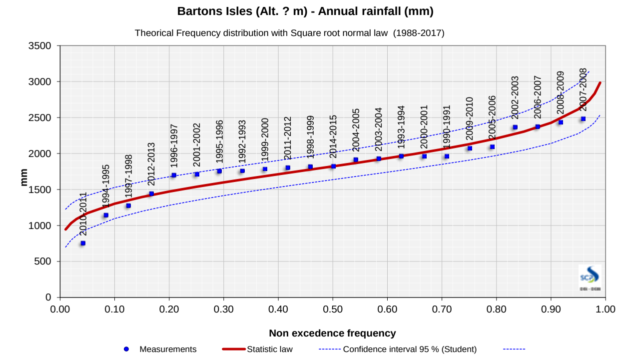
Raheen (Alt. 120m) - Monthly rainfall 1988-2017 (mm)													
	April	**May**	**Jun**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**January**	**February**	**March**	**Annual**
Average	225.8	296.2	111.3	123.3	222.7	305.4	275.6	129.3	63.3	48.6	65.1	134.5	1969.1
Standard deviation	110.5	126.1	67.5	82.3	96.8	172.5	88.6	59.7	61.0	42.4	52.1	100.6	415.3
Experimental median	216.4	292.5	89.0	96.2	215.3	256.0	286.5	118.8	56.5	33.3	56.9	119.6	1965.9
Data max.	501.0	576.0	277.5	355.9	468.0	801.0	514.7	283.0	318.0	170.0	188.1	426.2	2765.3
Data min.	32.0	66.0	25.0	5.0	42.0	57.0	118.0	12.0	0.0	0.0	0.0	7.0	1117.0

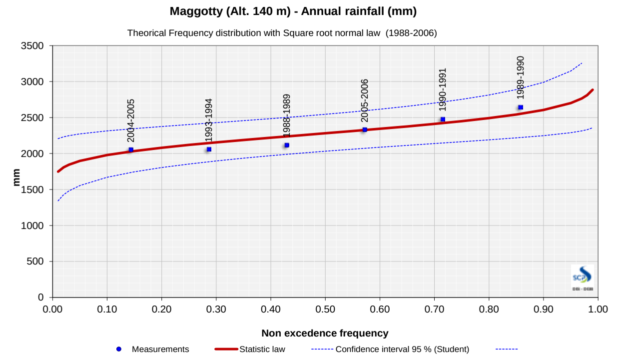

Y.S. Estates, St. Elizabeth (Alt. 27.4m) - Monthly rainfall (mm)
Theorical Frequency distribution with Square root normal law (1970-2016) &
Annual average= 2 301 mm
Standard deviation= 291 mm
Average Monthly rainfall (1970-2016)
Data max. & year
20 years wet (racine carrée normale)
10 years wet (racine carrée normale)
5 years wet (racine carrée normale)
Mediane (racine carrée normale)
5 years dry (racine carrée normale)
10 years dry (racine carrée normale)
20 years dry (racine carrée normale)
Data min.
mm
April
May
Jun
July
August
Sept
Oct
Nov
Dec
January
February
March

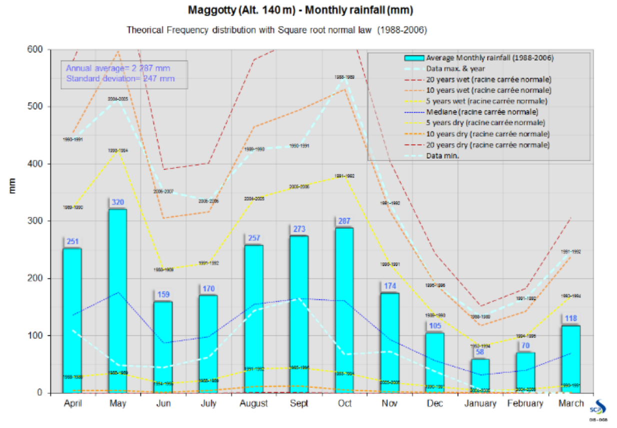

Y.S. Estates, St. Elizabeth (Alt. 27.4m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1970-2017)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)

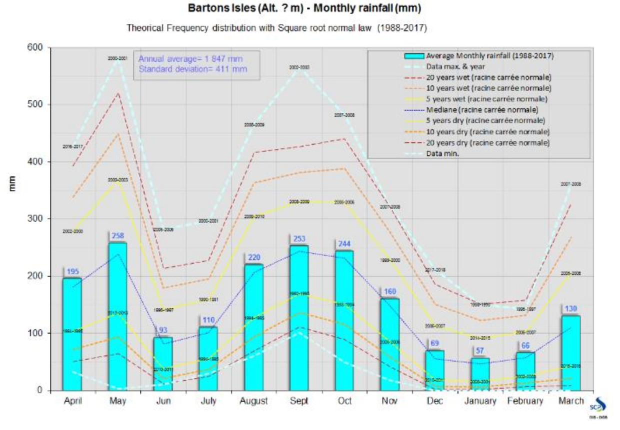

Appleton, St. Elizabeth (Alt. 158 m) - Monthly rainfall (mm)
Theorical Frequency distribution with Square root normal law (1970-2016) &
Annual average= 2 136 mm
Standard deviation= 380 mm
Average Monthly rainfall (1970-2016)
Data max. & year
20 years wet (racine carrée normale)
10 years wet (racine carrée normale)
5 years wet (racine carrée normale)
Mediane (racine carrée normale)
5 years dry (racine carrée normale)
10 years dry (racine carrée normale)
20 years dry (racine carrée normale)
Data min.
mm
April
May
Jun
July
August
Sept
Oct
Nov
Dec
January
February
March

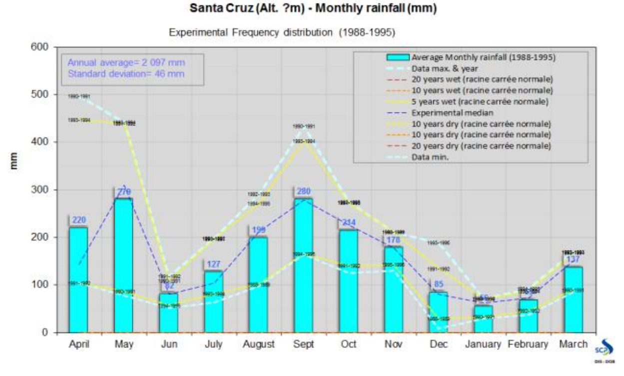

Appleton, St. Elizabeth (Alt. 158 m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1970-2016)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)


Bartons Isles (Alt. ? m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1988-2017)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)


Maggotty (Alt. 140 m) - Annual rainfall (mm)
Theorical Frequency distribution with Square root normal law (1988-2006)
mm
Non excedence frequency
Measurements
Statistic law
Confidence interval 95 % (Student)


Maggotty (Alt. 140 m) - Monthly rainfall (mm)
Theorical Frequency distribution with Square root normal law (1988-2006)
Annual average= 2 287 mm
Standard deviation= 247 mm
Average Monthly rainfall (1988-2006)
Data max. & year
20 years wet (racine carrée normale)
10 years wet (racine carrée normale)
5 years wet (racine carrée normale)
Median (racine carrée normale)
5 years dry (racine carrée normale)
10 years dry (racine carrée normale)
20 years dry (racine carrée normale)
Data min.
mm
April
May
Jun
July
August
Sept
Oct
Nov
Dec
January
February
March





Many gaps (only 2 full years)

Annual statistic not possible

Figure 35 - Watershed rainfall, Monthly & Annual statistics

5.1.1.6 RAINFALL PROJECTIONS

The map below represents the average annual precipitation for the reference period 1970-2000. Over the St. Elizabeth Parish area (in red on the map), precipitation prior to the year 2000 averaged between 1200 mm (on the coast) and 2500 mm (at the top of the Black River watershed). The future projections presented in the graphs and table below can be summarized as follows.

The average precipitation will show a decreasing trend in the future. However, the evolution is differentiated according to the scenario and the projection horizon:

- By 2050, the decrease is not very noticeable, regardless of the scenario.
  Indeed, a decrease in the central value less than or equal to -4.2% is not significant, especially since the uncertainty of the projections is such that some models predict, on the contrary, an increase of up to +20%.
- By 2090, the decrease in the central value is still not significant for the moderate scenario ssp2-4.5.
  The decrease is more significant (-16% for the central value) for the high emission scenario ssp5-8.5, but this projection is uncertain since some models predict, on the contrary, an increase of +14% for the same scenario.

On a sub-annual scale, the decrease is concentrated on the rainy months from May to September, but spares the month of October, which has nevertheless the highest average rainfall of the year.

Finally, it should be noted that these increases are expressed in relation to the reference period 1970-2000, which is already about 20 years old. However, it turns out that **the recent period 2001-2018 has a rainfall 10% higher than the period 1970-2000**. This finding, which is the opposite of the trend in future projections, illustrates both the great natural variability of precipitation and the high uncertainty of climate projections.

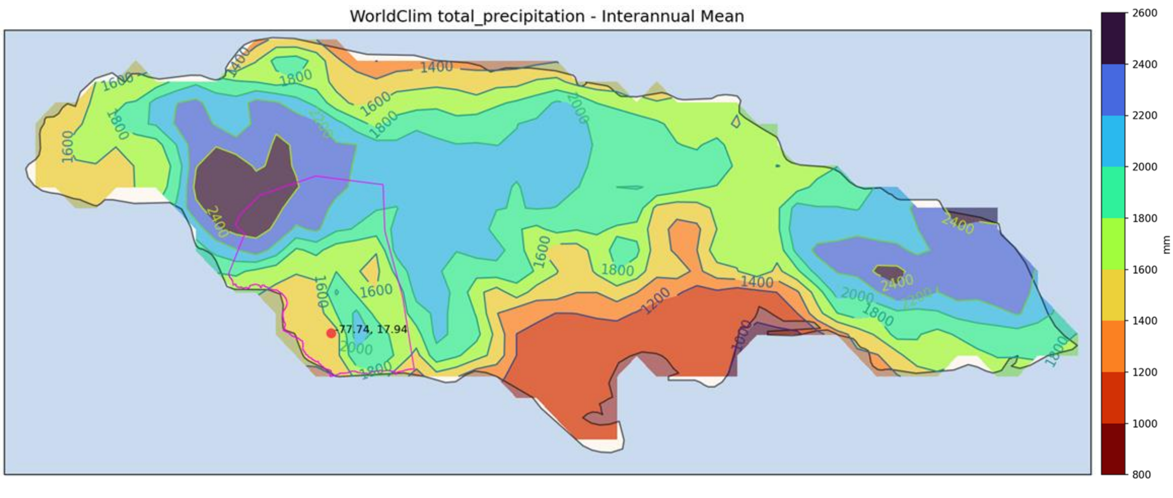


Figure 36 – Annual Precipitations of the reference period 1970-2000 (WorldClim2.1) mm / year

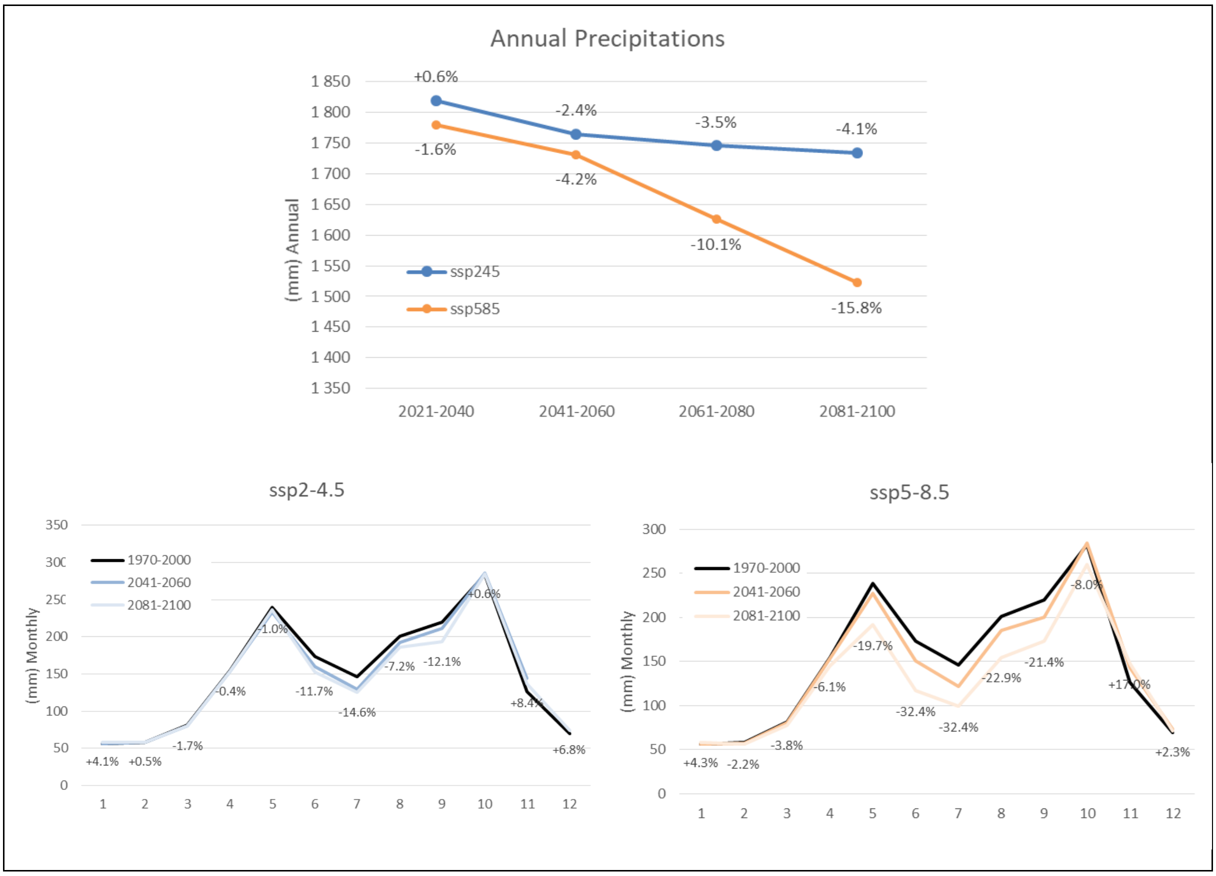


Figure 37 - Annual and monthly Precipitation Changes relative to 1970-2000 for St Elisabeth parish (WorldClim2.1 CMIP6)

Table 26 - Annual and seasonal Precipitations Changes relative to 1970-2000 for St Elisabeth parish (WorldClim2.1 CMIP6)

SSP2-4.5

2041-2060					
mm	DJF	MAM	JJA	SON	ANN
Min	-10.8%	-17.0%	-27.2%	-16.1%	-9.2%
Median	+2.1%	-1.6%	-7.3%	+1.9%	-2.4%
Max	+21.0%	+15.7%	+20.6%	+38.7%	+23.4%

2081-2100					
mm	DJF	MAM	JJA	SON	ANN
Min	-14.7%	-14.5%	-35.9%	-23.0%	-12.2%
Median	+4.0%	-0.9%	-10.8%	-2.3%	-4.1%
Max	+32.2%	+16.2%	+20.4%	+36.3%	+22.6%

SSP5-8.5

2041-2060						2081-2100					
mm	DJF	MAM	JJA	SON	ANN	mm	DJF	MAM	JJA	SON	ANN
Min	-14.7%	-14.5%	-35.9%	-23.0%	-12.2%	Min	-21.7%	-31.7%	-68.5%	-45.1%	-36.1%
Median	+1.7%	-2.9%	-11.8%	-0.2%	-4.2%	Median	+1.5%	-12.6%	-28.7%	-7.7%	-15.8%
Max	+38.2%	+18.6%	+15.9%	+30.0%	+22.1%	Max	+32.7%	+17.3%	+15.9%	+32.6%	+13.7%

Rainfall extremes

Information on the future evolution of maximum rainfall is taken from the latest baseline report "The State of Jamaican Climate 2019" (2021).

Indeed, statistical downscaling over the area of Norman Manley International Airport (Kingston) suggests **large increases in mean daily precipitation in all RCP scenarios** (old CMIP5 scenarios, which are however comparable to the new SSP scenarios in CMIP6).

For example, the increase by the 2050s could be as much as 48% for June and up to 68% for December.

In addition, the intensity of extreme rainfall associated with tropical cyclones is projected to increase by 5-25%, as explained below in the paragraph on this topic.

5.1.2 GEOLOGY

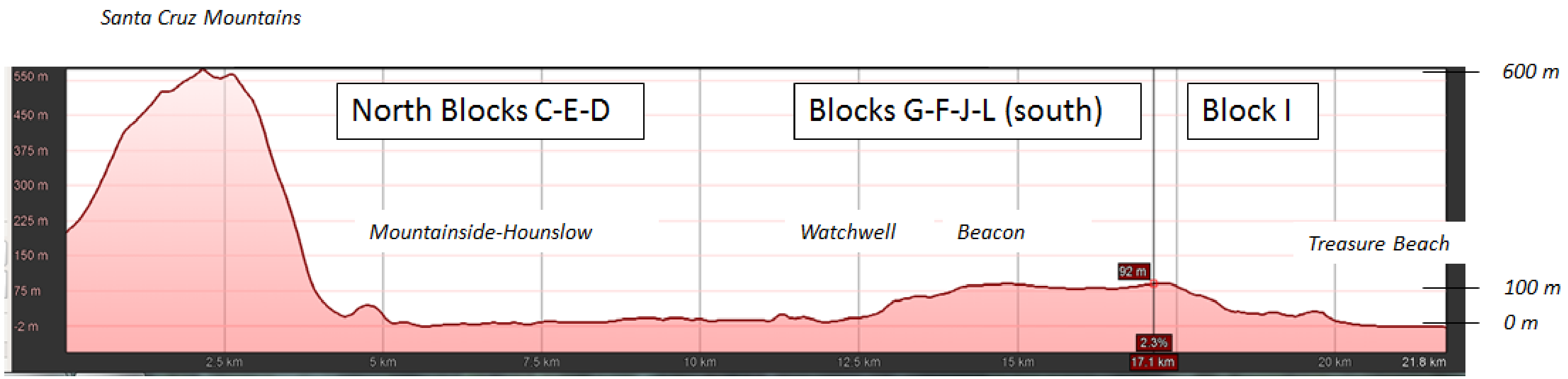
The study area is delineated by the lower Morass to the north, which is a wide wet area covered with reeds and bodies of water forming part of the Black River delta, by low limestone hills to the west, by steep, wooded hills to the east, and by the coast to the south. The area rises to an altitude of 700 meters in the South-East.

Grassland and brush, most often located on hillsides and limestone outcrops, often hide the cultivated fields, which are enclosed by barbed-wire fences or hedgerows. Urbanization consists of scattered housing extending along parish roads and paths. Behind the houses there are also cultivated gardens and, in particular, cash-crop fields.

☞ ***See map 009 - Geology***

The topography of Pedro Plains is shown on the following transects, divided into blocks corresponding partly to the future irrigable area.

North-South Transection



North-West to South-East Transection

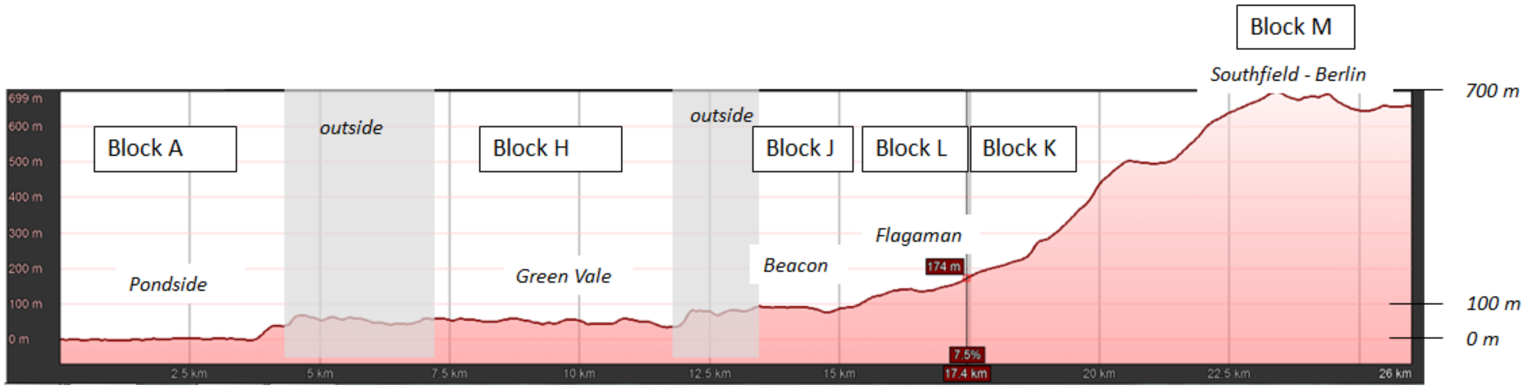


Figure 38 - Google transections of the study area

Picture 14 - General view of Pedro Plains

The topography is related to the dissolution and erosion of limestone from emerged reefs, which gave the land its present-day characteristics of small plains, plateaux and karstic residual hills during the Quaternary era. These karstic formations are due to the water which, has shaped them biochemically dissolving carbonates of calcium and magnesium. Water infiltrates rapidly and does not give rise to surface runoff except during periods of prolonged, heavy rainfall.

.

Picture 15 - View of the pedological cover: almost continuous on low hills with well-developed agriculture.

According to the geological map of Jamaica, the Study area of Pedro Plains is located on a tertiary-era white limestone formation referred to as Newport (noted fm). Only a small percentage of the area is in the alluvium and Morass of the Black river.

The digital pedological database provided by WRA is presented in thematic maps. It allows the potential and constraints of the soil cover to be characterized. Soil investigations and samplings, using manual augers, were conducted by SCP's soil expert. Drilling locations were chosen randomly to allow the survey of the whole study area within the given time between January 22 and January 31, 2019. Auger drilling makes it possible to collect soil samples between 0 and 25 cm deep for analysis in a laboratory in Kingston. The field reconnaissance associated with sampling allows an overview of the organization and characteristics of soils cover delineated on the map and in the landscape.

☞ ***See maps 009A, 009B, 009C, 009D, 009E, 009F***

A detailed description of geological, geomorphological and pedological characteristics was made by block or block group, as described below.

Block A extends near the coast and Morass of the left bank of the Blake River at a low altitude (0-10 meters). The lowest part near the coast is occupied by non-cultivable swamp formations and by alluvial deposits covered with meadows and usually grazed, though sometimes mown. Small cash-crop gardens exist around the houses and in the southern part, drip-fed from plastic drums and black tanks replenished by trucks. Small, scattered areas of limestone outcrops appear here and there. Generally, alluvial soils have a good water storage capacity.

Higher up, limestone appears either in the form of surface slabs (see Picture 16) or summit points made of heavily karstified boulders (Picture 17 below). The geological formation of white limestone is the surface formation that covers the whole of the Pedro Plains study area, and which forms small residual landforms which are usually forested and sometimes used for housing areas.

Picture 16 - In the background, landforms of karstified limestone outcrops.

The three main soil types are characterized by different pedo-agronomic potential.

1 / shallow soils on limestone outcrops (Picture 17)

Topographically, these are at a higher altitude than the two other types of soil. The soil cover is shallow, discontinuous, and fills pockets and dissolution cracks in the limestone. It is covered with brush (shrubs and short trees), and not used for crop-growing (very low agricultural aptitude), but rather for extensive grazing.

Picture 17 - Deteriored pasture on surface limestone slab

- discontinuous shallow soil in pockets or in limestone cracks
- main texture : stony loam
- low fertility
- very low water storage capacity
- hasty vertical drainage capacity
- homogenous surface runoff

Outside these reliefs, the soil cover is thicker, and degradation of limestone results in yellow clay formations:

2 / medium-thick soils derived from yellow clay with ferruginous and manganese concretions in areas above low wetlands

Auger drilling A1 reveals two horizons:

- Surface horizon with a dark brown color between 0 and 30 cm deep
- A thick horizon with a markedly yellow clay color with many ferruginous and manganese concretions

Picture 18 - Drilling A1

- variable soil thickness, medium thickness
- stony clay loam and clay texture, dark brown or dark gray clay on the surface turning to markedly yellow, malleable and sticky clay deeper down.
- Water storage capacity is high (because of the thickness of the yellow clay) but available water for vegetation is low (high permanent wilting point). The soil is quite sensitive to drought
- Low vertical drainage capacity despite karstic substrate, whose depth is unknown

3 / Deep-water saturated soils in marshes. Agricultural development is impossible without drastic drainage development.

Three drillings were conducted:

- A1 in soil developed on yellow clays
- A2 and A3 in soils present on hard limestone residual reliefs

Block B

Block B runs lengthwise along the eastern flank of the relief bordering the coast. The relief consists of moderately-wooded limestone hills that isolate block B from the coastline.

Grassland and brushland are dominant, with plentiful brushland in the north and many homes in the south with micro-plots for cultivation of cash-crops. These plots are watered by drip systems connected to drums.

The geology is made up of Newport limestone.

Two auger drillings were conducted.

The soil is generally shallow (0 to 50 cm deep, sometimes less) with a thin layer of yellow clay. The pH is moderately alkaline.

Agricultural development is limited by the following soil characteristics:

- shallow soils
- stony loam texture
- low water storage capacity, drought-sensitive soil
- slow internal drainage linked to the yellow clay layer, which has very low permeability
- limited rooting depth

Blocks C, D, E, F, G and J can be grouped together, since their geologic substratum is the same Newport limestone, and their geomorphology is quite uniform, with gently undulating relief and small dry plains. They make up the central part of the study area, sandwiched between the western slopes of the Santa Cruz range and the coastal hillside.

• Block C has not been fitted out by NIC. Three auger surveys were carried out. The agricultural land is made up of reasonably large parcels of pastureland for cattle grazing (this area has a tradition of extensive cow breeding). The center of this block is largely covered with fallow land.

• Block E, which has not been fitted out, consists of small and large plots surrounded with woodland. Some crops are irrigated in the vicinity of block D. Two auger surveys were conducted on this block.

• Block D is supplied with irrigation water from the NIC network. It is a hilly area characterized by a mix of meadows and various crops. Some pastureland is irrigated. This block seems less intensively cultivated than block J, especially in its northern part. Three auger drillings were conducted.

• Block G is not fitted out, and three auger surveys were carried out. It is characterized by a multitude of small wooded plots with houses, and some medium size plots for irrigated cash-crops or for grassland.

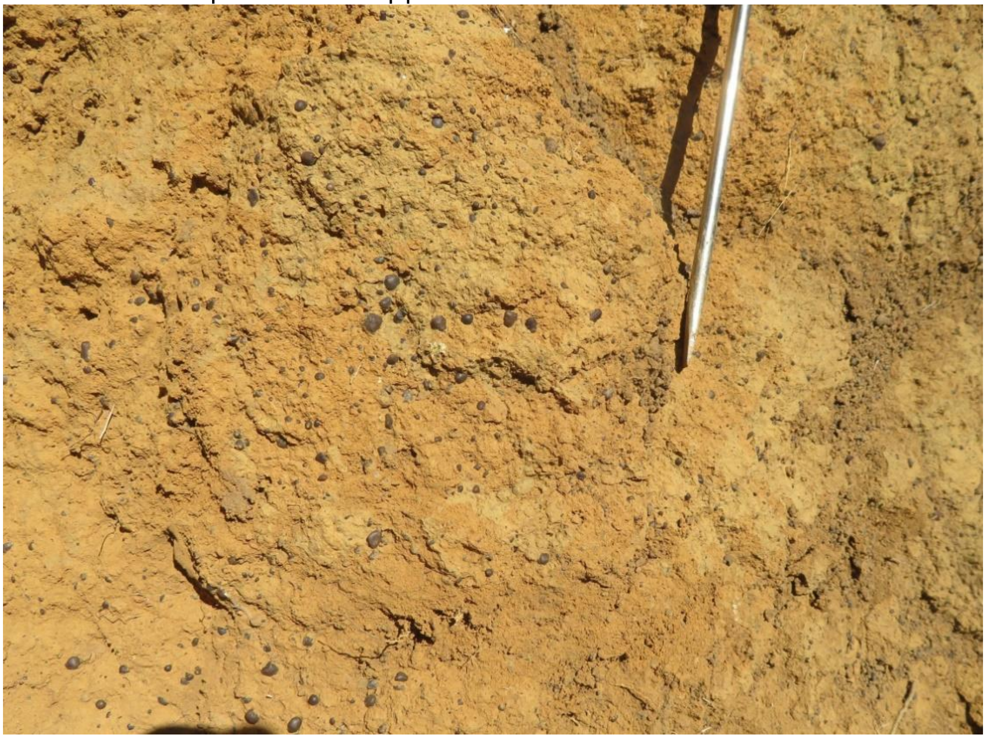
• Block F is not fitted out either, with very large grassy tracts to the west and north-east, and with dense fallow land to the south. Small parcels with houses and their gardens are scattered around the area. Three auger surveys were conducted.

• Block J is fitted out. There are many cultivated fields (for various irrigated cash crops). Four auger drilling were conducted to characterize soils.

Two main types of soil were observed in these 6 blocks thanks to 18 auger drillings:

1. shallow to medium-thick soils resulting from the alteration of a yellow clay with ferromanganese concretions characterized by the following 7 surveys:
   - D1: 0 to 20cm brown 20 to 50cm bright ocher ferromanganese concretions
   - F2: Brown to bright yellow ocher, clayey, thickness up to 100cm; dry pastureland with mono-specific grass
   - G1: 0 to 25 cm ocher brown, 25 to 70 cm ocher with ferromanganese concretions; fallow with mulch
   - C1: 0 to 25cm deep yellowish brown, 25 70 cm, powdery dry ocher, ferromanganese concretions
   - C2: 0 to 40 cm dark brown to dark blackish, clayey, many ferromanganese concretions, water at 30 cm; pastureland with cattle
   - C3 0 to 50 cm, yellowish brown becoming ocher with ferromanganese concretions; fallow
   - E1 0 to 40 cm brown , further drilling prevented by pebbles, peanut cultivation

The immobilization of iron can result in nodules or concretions measuring a few millimeters in redox conditions (temporary oxidation reduction). This phenomenon is related to the up-down movement of a shallow water table. Manganese (if present) is redistributed in the same way as iron by the formation of black ferromanganese concretions, which are more or less indurated by precipitation of iron and manganese. These millimeter-sized nodules persist in the soil even after the aquifer has disappeared.



Picture 19 - These numerous black nodules are ferro-manganese concretions.

2. Thick browny-red to bright red soil characterized by 11 surveys:

- D2: 0-40cm dark brown (mulch) 40-100cm bright red, papaya trees
- D3: 0-90cm clayey red on limestone, pebbly, fallow post-cassava
- E2: 0-20 cm dark red-brown 20 to 120 cm bright red-brown clay; watermelons harvested on plastic and natural mulch, drip system
- F1: 0-40cm: dark reddish-brown, stopped by structured fresh pebbles, cucumbers on mulch and drip system
- F3: 0-25 cm dark red-brown 25 -100 cm bright red-brown less than 5% limestone pebbles, irrigated peanuts
- J1 0-100 cm dark red soil, dark, thick, fresh to wet from 70cm, beetroots
- J2: 0-25 cm: dark red-brown 25 -100 cm: bright red-brown; thick fresh soil, guinea grass
- J3: 0-80 cm bright red-brown, 5% of limestone pebbles, stopped by rocky bed, irrigated watermelons on mulch
- J4 dark red-brown becoming bright red brown, clayey and fresh, stopped at 50cm deep, cucumber on mulch with drip system
- G2 Bright red-brown, clayey thickness 100 cm with some limestone pebbles, mulch
- G3 0-75 cm bright red-brown, stopped by pebbles, pumpkins with grass

Picture 20 - Survey J1 red soil, slightly acidic pH, thick soil without pebbles under mulch and cultivation of beetroot

Picture 21 - Survey J4: red soil with slightly acidic pH, thick with few pebbles, pumpkin cultivation

These soils are deep (0 to 100 cm, sometimes more) and homogeneous, with a fine granular structure.

Soil characteristics are very favorable to agricultural development, under the condition that the soil potential is protected:

- good thickness
- silty clay surface texture, sometimes stony loam
- clay texture deeper down, polyhedral structure
- moderate to low water storage capacity, drought-sensitive soil
- rapid internal drainage because of karst substrate
- deep rooting depth
- neutral or slightly acidic pH at the surface, more acidic at depth
- sensitive to rain erosion, guinea grass mulch is used everywhere, soil examined still fresh up to 1m deep.

Blocks L, K and M are described together, since the type of soil in the 9 holes drilled in these 3 non-equipped blocks is the same.

Block L has a rather flat, gently rising topography (glacis), medium-sized plots, and a large number of cultivated fields, some of which are irrigated from cisterns in the fields. The soil is homogeneous.

- L1: 0 to 30cm: dark red-brown 30 to 100cm bright red-brown; beets, eggplants and green onion on dry mulch.
- L2: 0 to 30cm: dark red-brown 30 to 100cm dry bright red-brown, some limestone pebbles around 50 cm.
- L3: 0 to 40cm: bright red-brown, stopped by pebbles, guinea grass.

The soil is deep (0 to 100 cm, sometimes more) and homogeneous, with a fine granular structure. The soil characteristics are very favorable to agricultural development, under the condition that the soil potential is protected:

- good soil thickness
- silty clay surface texture, sometimes stony loam
- deeper clay texture and polyhedral structure
- moderate to high water storage capacity, drought-sensitive soil
- rapid internal drainage because of karst base
- deep rooting depth
- neutral or slightly acidic pH at the surface, more acidic at depth
- sensitive to rain erosion, guinea grass mulch is used everywhere, soil examined still fresh up to 1m deep.

Block K extends to a higher altitude, between 100 and 400m above sea level, and has fairly steep slopes, especially in the central part of the block where the steeper slopes are covered with brush and patches of woodland. Cash-crops are grown next to or near many houses. 3 surveys describe the red soils, which result from the alteration of the hard limestone substrate.

- K1: 0 to 20cm: dark red-brown, 20cm to 70cm bright red-brown, argillaceous stop at 70cm per cx, guinea herbs.
- K2: 0 to 20cm: dark reddish-brown, turning to bright red-brown clay at 20 cm to 100cm, cultivation of guinea herbs.
- K3: 0 to 40cm: dark red-brown with a sudden stop due to pebbles and limestone blocks, watermelons on dry mulch.

These soils are deep (0 to 100 cm, sometimes more) and homogeneous, with a fine granular structure. On the slopes, rocks and loose boulders areas can be seen close to the surface, and these may hinder local agricultural development, since they reduce the workable surface area and available volume of soil.

Picture 22 - Red soil with hard, limestone stones and rocks

Nevertheless, the soil characteristics are favorable to agricultural development under the condition that the soil potential is protected:

- good soil thickness except where limestone blocks, pebbles and stones are present
- silty clay surface texture, sometimes stony loam
- more clayey texture deeper down
- moderate to high water storage capacity, drought-sensitive soil
- rapid internal drainage because of karst substrate
- deep rooting depth
- neutral or slightly acidic pH at the surface, more acidic at depth
- sensitive to rain erosion, guinea grass mulch is used everywhere, soil examined still fresh up to 1m deep.

Block M is located at a high altitude, between 300 and 700 m. The fields are generally very steep along the main road, which has heavy traffic. Cash-crops are everywhere, especially in the upper part of the block. Red soils are omnipresent, often with hard limestone outcrops that prevent crop farming.

- M1 0 to 100cm bright red, fresh clay, 10 to 15% of calcareous pebbles, watermelons
- M2 0 to 100cm bright red, clay, grazed brushland
- M3 0-25cm dark red brown, many pebbles, onions on dry mulch.

These soils are most often deep (0 to 100 cm, sometimes more) and homogeneous, with a fine granular structure. Rocky outcrops and dense areas of pebbles, stones and boulders hinder local agricultural development.

The soil characteristics are very favorable to agricultural development, under the condition that the potential of these soils is protected:

- good soil thickness
- silty clay surface texture, sometimes stony loam
- clayey texture deeper down
- moderate to high water storage capacity, drought-sensitive soil
- rapid internal drainage because of karst substrate.
- deep rooting depth
- neutral or slightly acidic pH at the surface, more acidic at depth
- sensitive to rain erosion, guinea grass mulch is used everywhere, soil examined still fresh up to 1m deep.

5.1.2.1 Pedological survey in the area of the proposed main pipeline for water transport from Black River to Moutainside.

A brief soil reconnaissance was also carried out along the area of the proposed 14 kilometer-long main pipeline, which will convey water from the Black River to the targeted blocks. This area is located on the edge of the morass. It is recommended to place the pipeline outside the marshes, which have hydromorphic soils, in order to avoid heavily-corrosive conditions. An old embankment and many outcrops of limestone should allow the buried pipe to be laid in areas with little agricultural value.

5.1.2.2 SYNTHESIS

From the pedological point of view, the soils in the study area are derived from the deterioration of two different substrates, namely:

• Recent alluvium

• Hard white limestone

The majority of soils in the survey area have developed on tertiary, sedimentary, hard white limestone

Data extraction from the 6 types of soils present in the mapped soil units in the study area has resulted in the following synthesis:

The following mapped soil-unit characteristics have been extracted from the database:

Table 27 - Extract from soil database (source: MICAF)

Soil No.	Soil Type	Description and Main Location	Important Characteristics
77	Bonnygate Stony Loam	**Topsoil** - brown or red-brown or clay loam, in crevices or as a thin mantle over hard white limestone. **Subsoil** - none; hard white limestone immediately below topsoil. (Throughout the Island).	An extremely shallow soil, neutral to slight amount of free lime, low fertility, very rapid internal drainage, surface runoff fair.
78	St. Ann Clay Loam	**Topsoil -** red-brown clay loam **Subsoil** - red or dusty red clay. (Throughout the Island).	May be very deep, acidic, low fertility, very rapid internal drainage, erodes readily.

According to the World Soils Map (scale 1: 5,000,000, source FAO - UNESCO Volume 4 1971), which only represents cartographic units which are associations of soils subdivided according to texture and slope. They are indicated on the map extract for the whole island of Jamaica by symbols. Dominant soils are represented by various colors, while phase differences are indicated by codes. In the study area, the map units show that most of the area consists of a soil association dominated by NITOSOLS (Nd36-3bc), according to the World Reference Base (WRB), and that a small part of the surface area in the lower Black River valley consists of young FLUVIOSOLS soils (Je44-2a).

In WRB classification, a NITISOL is a deep, red, well-drained soil with a 30 % clay content and a polyhedral structure.

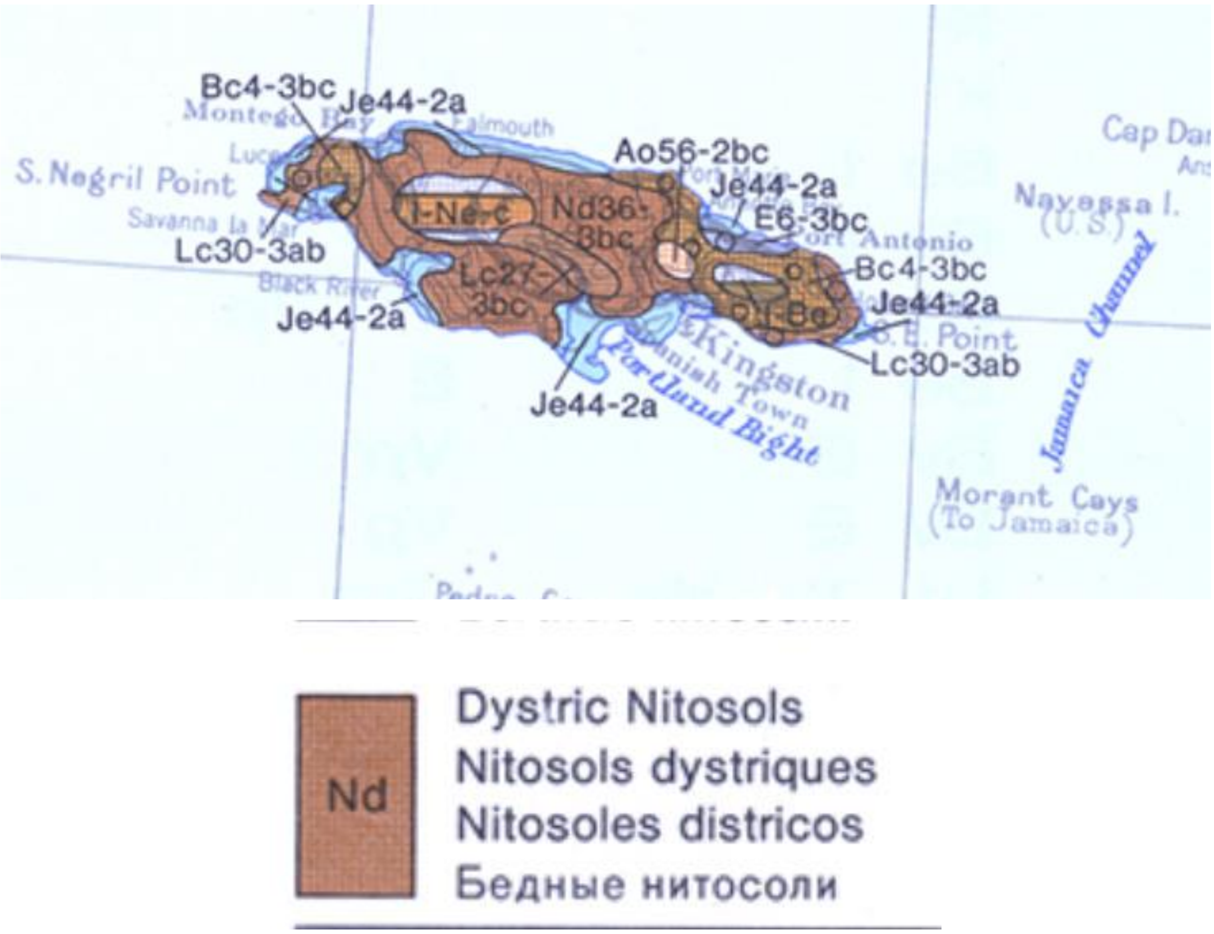


Figure 39 - Extract of the 1:5 000 000 World Soil Map

According to the 2008 soil reference system, NITOSOLS are generally observed in tropical or subtropical climates with a short dry season (mean annual rainfall of 1,500 to 3,500 mm). NITOSOLS are characterized by clay subsurface horizons (> 50% of the fraction <2 mm) whose fraction <2 µm consists mainly of halloysite, but also of goethite and hematite minerals.

The presence of halloysite with a medium to high Cationic Exchange Capacity, which allows good adsorption of exchangeable cations and moderate retention of phosphorus, makes these soils potentially very fertile. Nevertheless, the original stock of Ca, Mg and K should be maintained at a minimum rate to avoid acidification, and nitrogen and phosphorus stocks should also be maintained so as to be easily available. In addition, these soils have a large usable water storage capacity (moisture at field capacity minus moisture at the permanent wilting point), and good permeability with a cover of forest or grassland.

5.1.2.3 SOILS ANALYSIS RESULTS

During the field mission, 33 soil samples were taken at depths of between 0 and 25 cm, which is more than sufficient given the quasi-absence of mechanized farming equipment. The fertile organo-mineral has the same average thickness across the area studied. These soil samples were sent to a soil laboratory in Kingston (ESL).

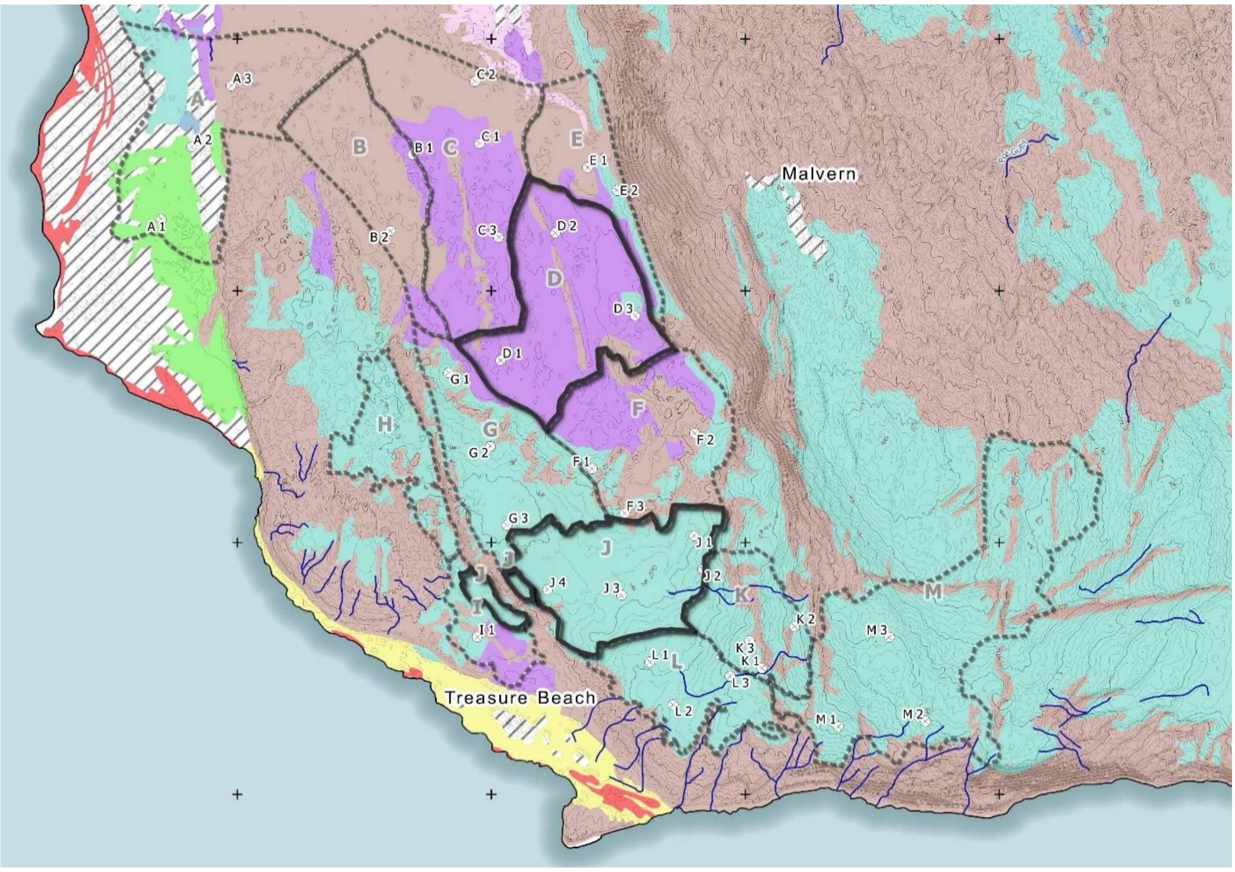


Figure 40 - Location of auger drillings and samplings

20 samples correspond to red soils under different crops and have the following physicochemical characteristics:

An attempt to classify general types of soil based on their color is proposed below.

Table 28 - Soil analysis results for 24 samples (source SCP)

Land Occupation	irrigation Modality	Sample identifiant	couleur du sol	Clay	Loam or Silt fraction	sand	Texture	water pH	total Calcareous	organic carbon	Organic matter tot	Nitrogen total	rapport C/N	CEC Cations exchange capacity	Electric Conductivity
pasture	no	**A 3**	**brun rouge**	29,85	55,33	14,82	Silty Loam	7,5	0,16	1,58	2,72	0,41	3,9	38,57	0,17
fallow land	no	**A2**	**brun rouge**	27,35	50,81	21,84	Silty Loam	8,2	1,53	1,17	2,02	0,3	3,9	21,48	0,3
garden	yes	**B1**	**brun rouge**	16,88	67,39	15,73	Silty Loam	7,3	0,22	1,53	2,63	0,31	4,9	23,49	0,19
pasture	no	**C1**	**brun rouge**	23,18	57,7	19,12	Silty Loam	7,3	0,11	1,78	3,06	0,33	5,4	15,61	0,09
pasture	no	**C2**	**brun rouge**	17,05	40,01	42,94	Loam	7	0,13	3,24	5,59	0,52	6,2	24,42	0,18
fallow	no	**C3**	**brun rouge**	31,09	55,67	13,24	Silty Clay Loa	7	0,04	1,98	3,42	0,33	6,0	19,18	0,1
Pumpkin	G à G	**D1**	**brun rouge**	51,26	44,76	3,99	Silty Clay	7,4	0,07	0,86	1,48	0,2	4,3	11,19	0,14
papaya tree	G à G	**D2**	**brun rouge**	23,12	59,61	17,27	Silty Loam	7,2	0,16	1,58	2,72	0,28	5,6	14,81	0,16
cassava	G à G	**D3**	**brun rouge**	25,34	59,97	14,69	Silty Loam	7,3	0,15	1,71	2,95	0,28	6,1	17,81	0,12
peanuts	no	**E1**	**brun rouge**	20,91	56,78	22,31	Silty Loam	7,2	0,08	1,69	2,91	0,25	6,8	11,84	0,15
water melon	GàG	**E2**	**brun rouge**	21,51	64,39	14,1	Silty Loam	6,8	0,2	1,37	2,35	0,3	4,6	14,71	0,15
Cucumber	G à G	**F1**	**brun rouge**	19,51	72,75	7,74	Silty Loam	7	0,27	1,91	3,29	0,43	4,4	32,09	0,2
pasture	no	**F2**	**brun rouge**	45,34	48,93	5,73	Silty Clay	6,6	0,1	1,74	3	0,36	4,8	13,05	0,18
Peanuts	G à G	**F3**	**brun rouge**	31,23	75,63	6,86	Silty Loam	7,1	0,12	1,46	2,51	0,29	5,0	13,12	0,14
fallow land	no	**G2**	**brun rouge**	23,21	76,58	0,21	Silty Loam	6,7	0,25	2,19	3,78	0,24	9,1	13,59	0,17
Pumpkin	G à G	**G3**	**brun rouge**	23,21	75,93	0,86	Silty Loam	7,2	0,23	2,13	3,67	0,23	9,3	13,21	0,14
beetroot	G à G	**J1**	**brun sombre**	30,33	65,48	4,2	Silty Loam	6,5	0,25	2,79	4,82	0,31	9,0	19,94	0,15
Guinéa gras	no	**J2**	**brun sombre**	36,43	61,32	2,25	Silty Clay Loa	6,2	0,28	1,77	3,06	0,24	7,4	8,28	0,09
Guinéa gras	no	**K2**	**brun sombre**	38,19	54,69	7,12	Silty Clay Loa	5,5	0,3	1,36	2,34	0,17	8,0	5,75	0,06
beetroots	no	**L1**	**brun rouge**	40,21	55,09	4,7	Silty Clay Loa	5,1	0,1	1,86	3,2	0,23	8,1	10,67	0,14
beetroots	no	**L2**	**brun rouge**	42,24	53,93	3,83	Silty Clay	4,5	0,1	1,67	2,87	0,23	7,3	8,2	0,13
water melon	no	**M1**	**brun rouge**	40,19	57,33	2,48	Silty Clay	4,5	0,31	1,31	2,27	0,15	8,7	9,02	0,28
fallow land	no	**M2**	**brun rouge**	64,76	33,58	1,66	Clay	5,6	0,1	2,14	3,68	0,22	9,7	9,43	0,08
onions	no	**M3**	**brun rouge**	30,52	65,13	4,35	Silty Clay Loa	5,8	0,14	2,36	4,06	0,24	9,8	10,03	0,14

24 soil samples come from clay soil, with colors ranging from browny-red to dark brown and bright red. They show the following physicochemical characteristics:

- The dominant texture is silty loam in 13 samples out of 24 and two samples have more loamy textures; sample M2 with almost 65% clay and sample C2 with 40% silt and 43% sand. More generally, the silty fraction is very dominant and present in high levels.

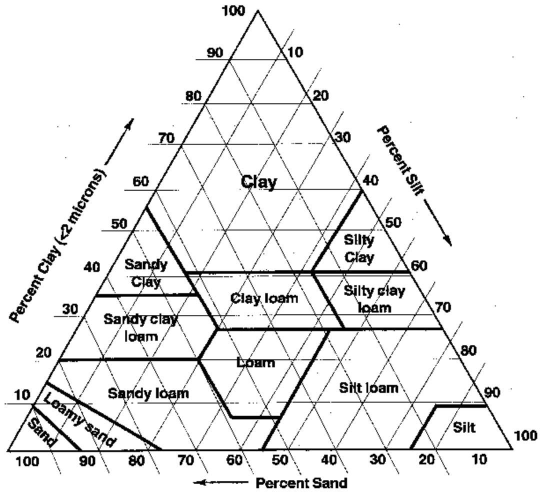


Figure 41 - Diagramm of soil textures

- The pH is variable with two clearly acidic samples (samples L2 and M1)
- limescale levels are low
- organic matter content varies between 1.4 (satisfactory level) and over 5% (high level)
- total nitrogen levels are low
- the C / N ratio is low. Values lower than 8 rates reflect a high mineralization of organic matter in the soil, while values between 8 and 10 reflect normal mineralization.
- The cations exchange capacities (CEC) vary between 5 and 20, which is low and shows that the fertilizing macro-mineral supply is probably insufficient because of an insufficient stock of Ca, Mg and K. The latter avoid soil acidification while maintaining a readily-available stock of nitrogen and phosphorus
- Electrical conductivity is low and there is no salinity risk

Table 29 - Soil analysis results for 9 samples (source: SCP)

Land Occupation	irrigation Modality	Sample identifiant	couleur du sol	Clay	Loam or Silt fraction	sand	Texture	water pH	total Calcareous	organic carbon	Organic matter tot	Nitrogen total	rapport C/N	CEC Cations exchange capacity	Electric Conductivity
pasture	no	**A 1**	**brun/ocre**	67,45	14,79	17,76	Clay	7,5	0,28	1,13	1,95	0,28	4,0	41,4	0,31
pasture	no	**B2**	**ocre vif**	33,46	61,92	4,62	Silty Clay Loam	7,2	0,05	1,71	2,97	0,37	4,6	17,61	0,18
fallow land	No	**G1**	**brun ocre/ocre vif**	51,48	40,55	7,97	Silty Clay	6,8	0,13	1,06	1,82	0,23	4,6	11,42	0,16
fallow land	no	**I1**	**brun ocre/ocre vif**	49,93	45,22	4,85	Silty Clay	5,5	0,03	1,4	2,42	0,15	9,3	8,93	0,88
water melon	G à G	**J3**	**brun/ocre**	36,75	61,1	2,15	Silty Clay Loam	5,9	0,34	1,51	2,6	0,2	7,6	8,59	0,18
cucumber	G à G	**J4**	**brun / ocre**	26,72	71,39	1,89	Silty Loam	7,2	0,39	2,1	3,63	0,29	7,2	13,2	0,23
Guinéa grass	no	**K1**	**brun ocre/ocre vif**	37,24	60,78	1,99	Silty Clay Loam	7,1	0,89	2,66	4,58	0,3	8,9	14,93	0,16
water melon	yes	**K3**	**brun ocre**	36,88	60,32	2,8	Silty Clay Loam	5,2	0,1	1,84	3,16	0,24	7,7	6,98	0,14
Guinéa grass	no	**L3**	**brun/ocre**	35,98	57,99	6,03	Silty Clay Loam	5,9	0,34	2,06	3,56	0,22	9,4	7,98	0,13

9 samples come from brown to ocher-brown clay soils that become ocher or yellow at deeper levels and have the following physicochemical characteristics:

- A texture dominated by the silty clay loam texture class for 6 samples. 3 textures are heavily clay, with a clay content of between 49% and 67%
- The granulometric sand fractions are very small, under 8% in 8 samples out of 9.
- pH ariation remains significant, between 5.2 and 7.5
- limescale levels are very low
- Organic matter content varies between 1 and 2.6% with a generally very low C / N ratio, barely sufficient for 3 samples around a value of 9
- CEC levels are low and insufficient except for sample A1, which has a high clay content and a sufficient organic matter content
- Electrical conductivity is low and there is no salinity risk

In conclusion, these analytical values show considerable variability, particularly on account of the different pH values according to the types of soils and their pedogenic evolution. This does not in any way prejudge their irrigability. At the same time, however, the soils require:

- a precise follow-up of the level of soil fertility during crop rotations, especially market gardening vegetables,
- a fertilization control adapted to the needs of each crop, to the restitution of organic matter from crop residue, and to the physicochemical characteristics of these soils.

5.1.2.4 SOIL MAPPING AND THEMATIC ANALYSIS

A soil survey was conducted over several years by the University of Trinidad and led to the publication of a Land Use report for thirteen of the fourteen parishes (CVD 1958-1970) of Jamaica. Soils have been classified into ten categories according to their geological origin. A total of two hundred and ninety-two soil types have been identified and named after the name of the districts in which they were first described.

To this end, a semi-detailed soil survey of the Pedro area was carried out in 1983 by the Soil Survey Departement of the Central Regional Planning Unit, and funded by a bi-lateral Soil Survey Project between the Governments of Jamaica and Netherlands.

To identify, describe, analyze, define, correlate, map and evaluate soils in a precise, significant and time-effective way, two approaches have to be combined:

- the pedological approach stricto sensu ensures that the different types of soils mapped are recognizable on the field;
- the pedo-agronomic approach ("edaphological approach") concerns the relevant evaluation of agronomic potential (aptitudes and constraints of soils for different kinds of crop) and in this case includes aptitude of soils for irrigation. Soil units distinguished on the map must be relevant for the user.

Thanks to the development of digital tools, a pedological database has been digitized by the Ministry of Agriculture. After analytical processing it allowed the establishment of thematic maps presenting soil characteristics and potential.

This wide-ranging database includes 12 metadata completing 292 soil mapping units and 10 soil parameters, and describes each map unit (with texture, water storage capacity, pH soil depth, internal drainage, erosion sensitivity, mean nitrogen content , Phosphorus and Potassium), as well as the topographic parameter, slope.

The following thematic maps were used in this study:

- texture
- depth of loose soil (Root limit)
- soil names
- acidity and alkalinity
- water storage capacity (soil moisture), internal drainage

- constraints
- sensitivity to erosion.

5.1.2.5 SOIL APTITUDE FOR IRRIGATION

The use of old soil maps can pose many challenges in terms of interpretation or updating, especially when building thematic maps applied to current concerns. In this case, there is an issue with the interpretation of the water storage capacity of soils, called moisture in the database. With the pedological database provided by the RADA and our own assessment, we have rebuilt a soil aptitude map for irrigation taking into account the parameters characterized in the table below.

	Parameters →	**Soil Texture**	**Water storage capacity (moisture)**	**Thickness (Root_Limit)**	**Slope_Range**
Soil aptitude for irrigation ↓	Class number ↓				
No data	**0**				
Very good aptitude	**1**	clay / Loam /Clay loam	high	High	If > 10% -> soils go to class 4
Good aptitude	**2**	sandy / sandy loam / clay/ loam	moderate/ moderate to low	High	If > 10% -> soils go to class 4
Low aptitude	**3**	stony loam/ peat / stony clay loam	low / low to moderate	moderate	If > 10% -> soils go to class 4
Not irrigable	**4**	Sand / peat	very low	bed rock / high water table/swamp	

Table 30 - Method for classification of soil aptitude for irrigation (source SCP)

Concerning slope, the following rules are advised:
- Sprinkler irrigation is only possible for slopes under 8% ;
- Between 8% and 10% of slopes, only drip irrigation is possible ;
- It is not recommended to water fields with slopes above 10%. In the method for classification of soil aptitude for irrigation, all soils with slopes above 10 % are downgraded to class 4.

The point which is subject to delicate interpretation is the initial assessment of red soils as having a low capacity for low to moderate water storage, which does not appear justified in view of field observations and the expertise of the soil scientist, who considers that these red soils have a moderate to high water storage capacity. A finer analysis should be conducted in order to settle this question.

Summary

Following the soil assessment, the distribution of acreages by aptitude class for irrigation and by block is shown in the following table:

		Distribution of acreage by aptitude class for irrigation and by block										
PRO_BLOCKS	Total block acreage (ha)	Class 0 (no data)		Class 1 (best aptitude)		Class 2		Class 3		Class 4 (not good for irrigation)		
		ha	%	ha	%	ha	%	ha	%	ha	%	
A	1166	242	**21**	494	**42**					430	*37*	
B	673					92	*14*			581	*86*	
C	1213					676	*56*			537	*44*	
D*	1050					950	*90*	16	*2*	83	*8*	
E	461					70	*15*	85	*18*	307	*67*	
F	900					325	*36*	184	*20*	391	*43*	
G	803					64	*8*	622	*77*	117	*15*	
H	408							343	*84*	65	*16*	
I	209					79	*38*	81	*39*	48	*23*	
J*	888							853	*96*	32	*4*	
K	461							369	*80*	92	*20*	
L	551							506	*92*	45	*8*	
M	1791							1497	*84*	294	16	Amount
Irrigable surfaces out of D and J blocks				**494**		**1306**		**3687**				**5 487**
Total irrigable surface				**494**		**2164**		**4556**				**7 214**
(*) equipped block												

Table 31 - Distribution of acreage by aptitude class for irrigation and by block

Not counting blocks D and J, which have already been fitted out, the irrigable surface area is 494 ha for class 1 soils (in Block A), 1,306 ha for class 2 soils (mainly in Block C and F, then I, E,G), and 3,887 ha for class 3 soils (mainly in Blocks M, G, L, K, H, F, then I and E).

5.1.3 HYDROLOGY

Black River stream flow date were analysed from the data available on:

http://webmapjam.dyndns.pro/webmap/app/db/index.php

Stream gauge	Watershed area	Annual streamflow	Historic	Note
Black River at Lacovia	640 km2	20.1 m3/s	1963-2017	
Y.S. River nr Middle Quarters	158 km2	4.9 m3/s	Sept 2013-2015	Very short historic (2.5 years)
Y.S. River Diversion nr Middle Quarters	-	0.41m3/s	1968-1987	
Styx River nr Lacovia	-	0.136 m3/s	1967-1969	Very short historic (3 years)

Table 32 - Available data for river streamflows

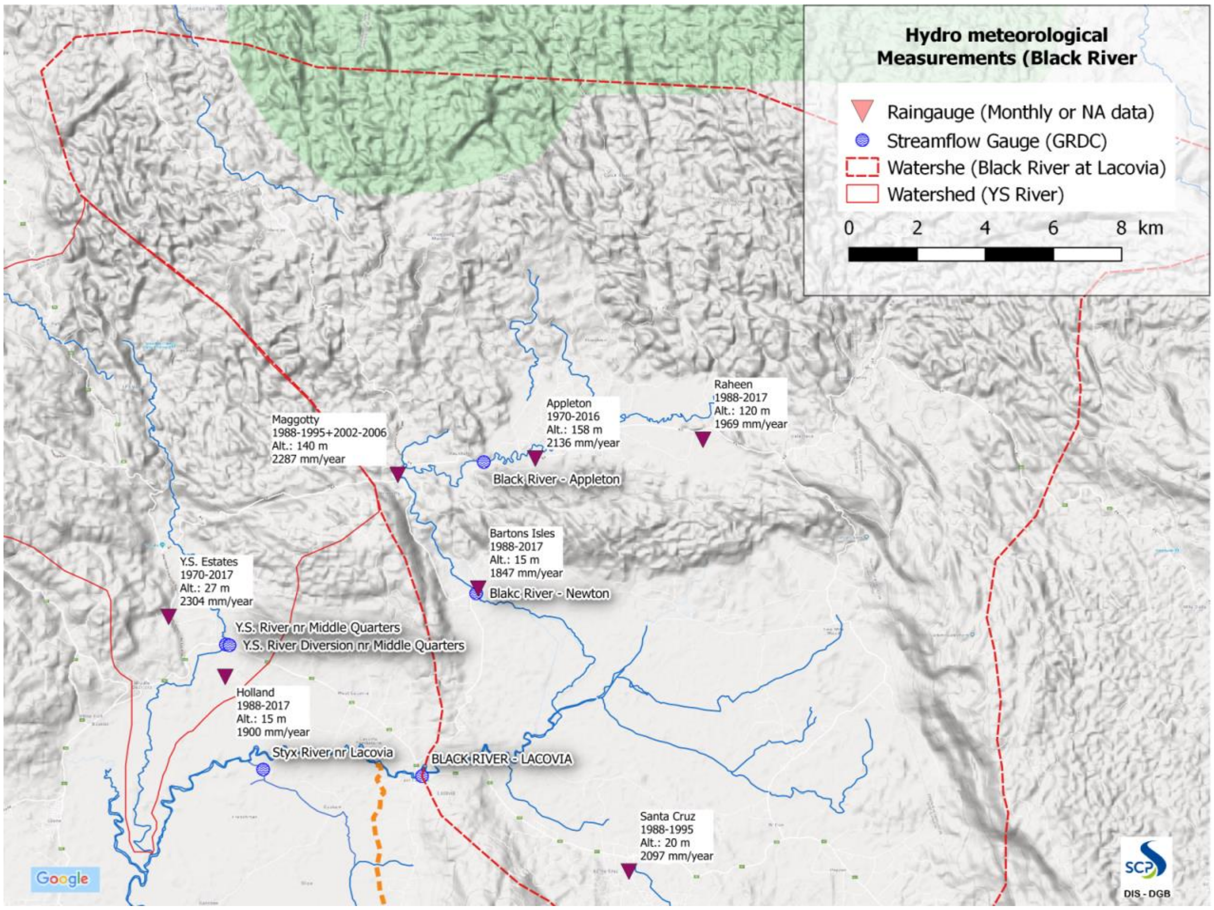


Figure 42 - Black River stream gauges situation map

5.1.3.1 MONTHLY & ANNUAL STREAM FLOW OF BLACK RIVER AT LACOVIA

	April	May	Jun	July	August	Sept	Oct	Nov	Dec	January	February	March	Mean
Annual mean	15.4	25.6	23.0	17.2	19.5	26.7	34.7	29.7	17.5	12.4	10.8	10.3	**20.1**
Q spécifique (l/s/km2)	24.0	39.9	35.9	26.9	30.4	41.7	54.3	46.4	27.4	19.4	16.8	16.1	31.4
Standart deviation	6.641	8.451	10.113	7.299	4.980	8.678	14.390	9.996	5.415	3.542	2.878	2.930	**4.462**
Exp. Median	13.1	25.5	21.0	15.7	19.3	27.1	30.9	27.9	16.0	11.4	10.2	9.8	**19.9**
Data min.	5.240	6.967	7.723	7.886	10.017	9.717	13.766	13.765	8.939	7.164	6.315	5.866	**12.107**
Data max.	29.796	45.429	53.757	50.967	39.685	60.500	100.512	57.379	34.331	20.692	16.549	19.374	**31.880**

Table 33 - Black River monthly stream flows (1963-2017) basic statistic

Frequency distribution of monthly flows (flows for return periods 2, 5, 10 and 20-year wet and dry):	See chart of *Figure 43*
Average annual flow:	**20.1 m³/s**
Dry ten-year annual flow:	**15 m³/s** environ (See Chart of *Figure 45*)
Annual minimum Monthly Flow of 5-year return periode (Low water indicator in monthly steps)	**7.46 m³/s** (See Charts of *Figure 43* and *Figure 46* below

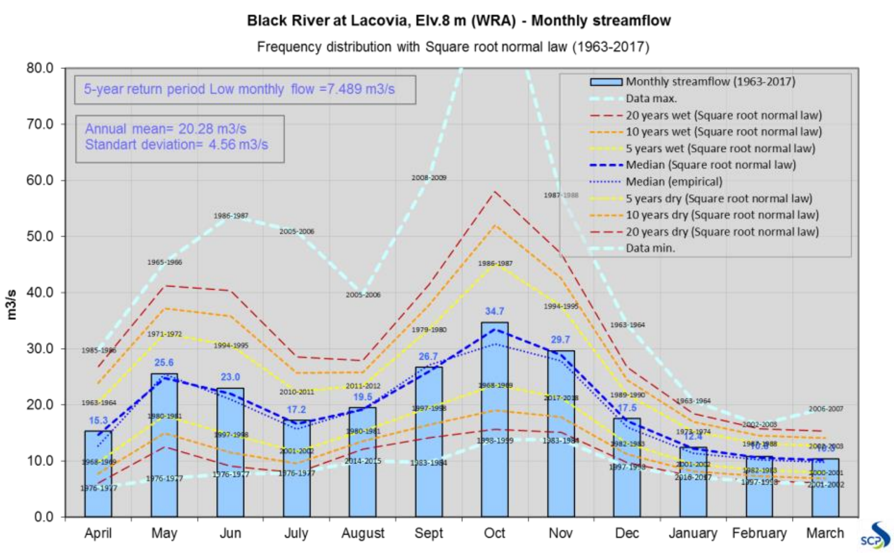


Figure 43 - Monthly Stream flow statistics

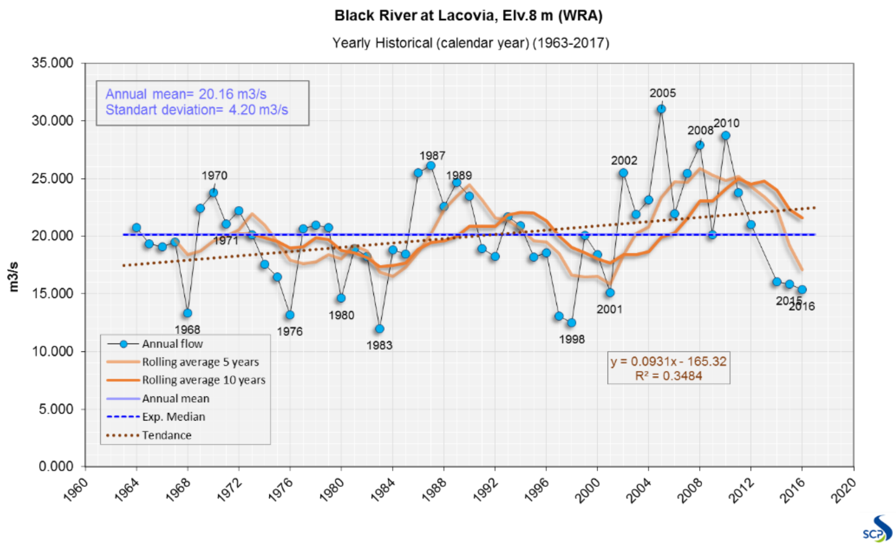


Figure 44 - Annual Stream flow historical

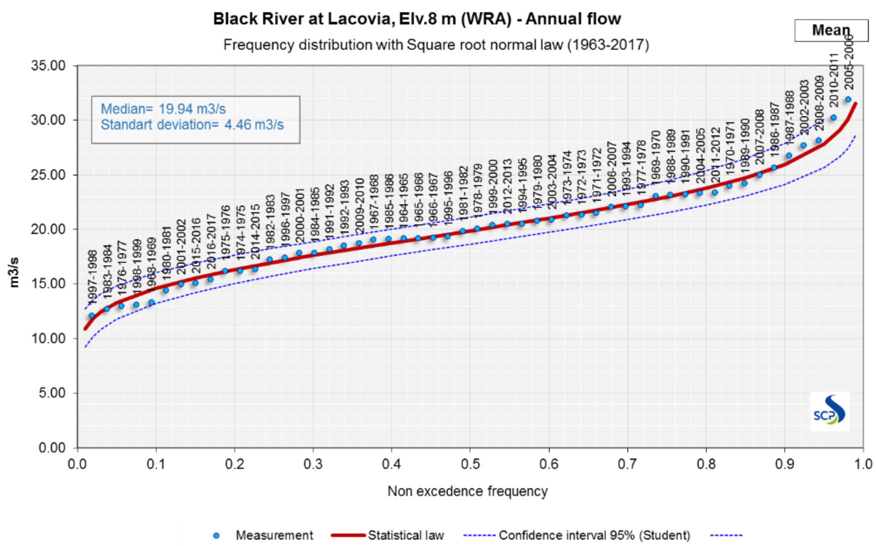


Figure 45 - Annual Stream flow statistics

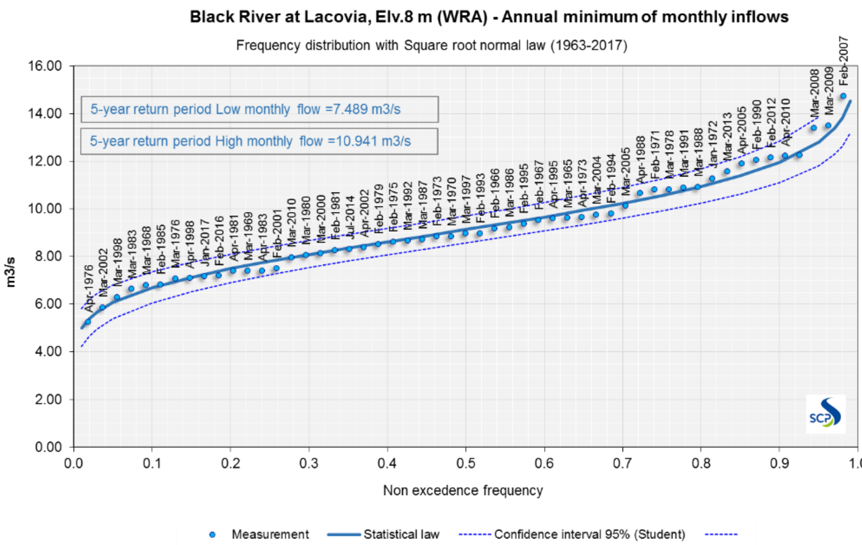


Figure 46-Minimum monthly stream flow statistics

5.1.3.2 MONTHLY & ANNUAL STREAM FLOW OF « STYX RIVER » AND « Y.S. RIVER »

The measurements available on "Y. S. River" (right bank tributary of "Black River") are of limited statistical representativeness due to a too short history (2.5 years). In addition, it is unknown whether the measurements were taken upstream or downstream of the river diversion, the measurements of which are also reproduced below (Y.S. River Diversion nr Middle Quarters).

The station "Styx River nr Lacovia" is located on what looks on the map as a human-made canal, which seems to be connected both to "Black River" and to "Broad River" further south. (land drainage between the two rivers?). The short history of 3 years shows relatively low inflows (0.136 m^3/s on average).

Year	January	February	March	April	May	Jun	July	August	Sept	Oct	Nov	Dec	Annual
2013									6.04	9.54	6.26	1.63	
2014	1.00	1.86	1.37	6.37	9.95	4.39	4.78	6.73	11.95	6.95	3.39	1.92	**4.93**
2015	1.09	0.95	0.71	1.29	2.12	3.06	1.14	12.95	7.74	9.51	4.49	2.04	
Average	1.04	1.40	1.04	3.83	6.03	3.73	2.96	9.84	8.58	8.67	4.71	1.86	**4.93**

Table 34 - Y.S. River Monthly stream flows (2013-2016)

Year	January	February	March	April	May	Jun	July	August	Sept	Oct	Nov	Dec	Annual
1968			0.342	0.790	0.925	0.667	0.516	0.424	0.364	0.364	0.343	0.280	
1969	0.324	0.227	0.247	0.357	0.395	0.391	0.343	0.273	0.232	0.221	0.268	0.281	0.297
1970	0.257	0.204	0.277	0.273	0.633	0.578	0.503	0.426	0.344	0.339	0.304	0.314	0.371
1971	0.243	0.446	0.409	0.270	0.795	0.676	0.516	0.405	0.383	0.281	0.243	0.234	0.408
1972	0.238	0.162	0.135	0.277	0.324	0.255	0.211	0.179	0.142	0.140	0.194	0.249	0.209
1973	0.182	0.320	0.513	0.461	0.642	0.583	0.493	0.435					
1974	0.577	0.376	0.615	0.995	0.592	0.570	0.502	0.384	0.344	0.396	0.267	0.408	**0.502**
1975	0.659	0.528	0.572	0.538	0.562	0.569	0.233	0.094	0.092	0.020	0.025	0.281	**0.348**
1976	0.627	0.550	0.661	0.397	0.545	0.626	0.550	0.476	0.542	0.522	0.442	0.589	**0.544**
1977	0.563	0.775	0.456	0.862	0.807	0.709	0.674	0.557	0.556	0.492	0.355	0.236	**0.587**
1978	0.480	0.572	0.565	0.717	0.620	0.493	0.417	0.330	0.359	0.286	0.233	0.177	**0.437**
1979	0.510	0.546	0.664	0.771	1.043	0.709	0.638	0.602	0.514	0.522	0.248	0.641	**0.617**
1980	0.772	0.650	0.566	0.620	0.707	0.675	0.197	0.058	0.053	0.043	0.018	0.080	**0.370**
1981	0.208	0.304	0.455	0.275	0.487	0.691	0.673	0.440	0.214	0.283	0.183	0.070	**0.357**
1982	0.198	0.264	0.364	0.595	0.540	0.393	0.343	0.334	0.253	0.102	0.076	0.041	**0.292**
1987			0.231			0.344	0.249	0.177	0.169		0.392	0.306	
Average	0.417	0.423	0.442	0.547	0.641	0.558	0.441	0.350	0.304	0.287	0.239	0.279	**0.411**

Table 35 - Y.S. River Diversion Monthly stream flows (1968-1987)

Year	January	February	March	April	May	Jun	July	August	Sept	Oct	Nov	Dec	Annual
1967	0.058	0.033	0.030	0.154	0.152	0.130	0.078	0.077	0.078	0.167	0.333	0.143	**0.119**
1968	0.079	0.052	0.032	0.046	0.026	0.025	0.035	0.105	0.123	0.243	0.248	0.129	**0.095**
1969	0.078	0.066	0.060	0.087	0.247	0.452	0.130	0.179	0.240	0.413	0.238	0.124	**0.193**
Average	0.072	0.050	0.041	0.096	0.142	0.203	0.081	0.121	0.147	0.275	0.273	0.132	**0.136**

Table 36 - Styx River Monthly stream flows (1967-1969)

5.1.3.3 ECOLOGICAL FLOW OF BLACK RIVER AT LACOVIA

Definition "Ecological Flow" according to WRA: 60% of the decennial value of the minimum annual flow of the flow over 7 dayss.

5.1.3.3.1 Statistical determination on the basis of daily flows

Decadal Minimum flow over 7 consecutive days: **5.77 m^3/s**

Ecological flow: **3.46 m^3/s**

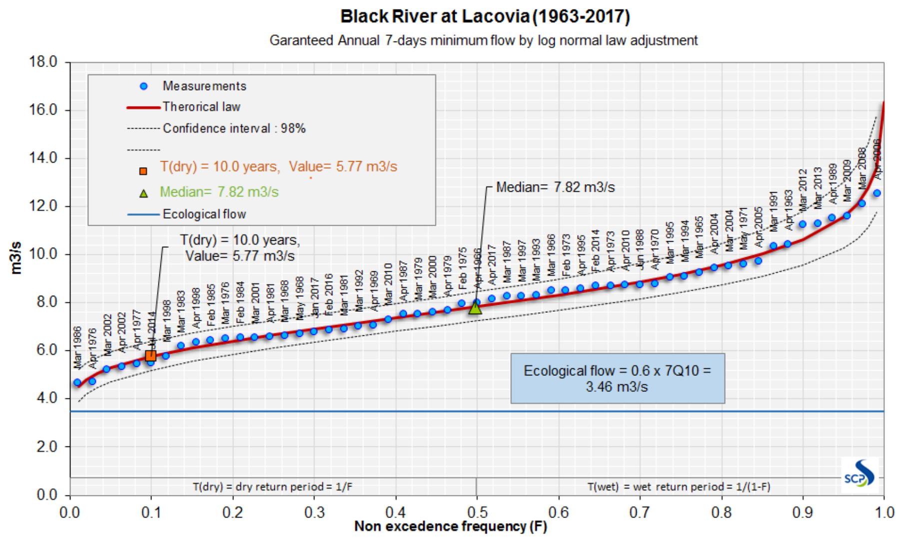


Figure 47 - Annual minimum 7 days Stream flow statistics

5.1.3.3.2 Historical evolution of the minimum flow over 7 days

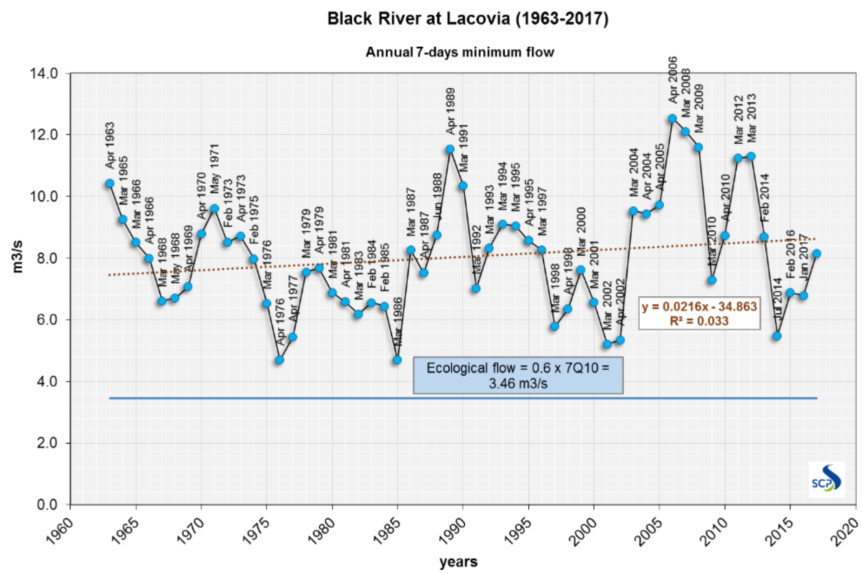


Figure 48 - Annual minimum 7 days Stream flow historical

5.1.4 SURFACE WATER QUALITY

This issue is tackled by analyzing results from years 2009 – 2010 (BRIM Programme), 2010 – 2011 (JPS hydroplant EIA), 2014-2018 (NEPA monitoring) as well as field observations and water analysis in 2019 (SCP) and a survey conducted in 2023 by ESL.

5.1.4.1 NATIONAL STANDARDS

Jamaica issued national ambient freshwater quality standards in 2009, proposing standard ranges that can lead to interpretation of analysis.

Yellow lines in the table below highlight the water quality parameters that were analyzed in the data we collected.

Parameter	Measured as	Standard Range	Unit
Calcium	(Ca^{+2})	40.00 – 101.0	mg/L
Chloride	(Cl^{-})	5.00 – 20.0	mg/L
Magnesium	(Mg^{+2})	3.60 – 27.0	mg/L
Nitrate	(NO^{-3})	0.10 – 7.5	mg/L
Phosphate	(PO_4^{-3})	0.01 – 0.8	mg/L
pH	(-)	7.00 – 8.4	-
Potassium	(K^{+})	0.74 – 5.0	mg/L
Silica	(SiO_4 or Si^{+2})	5.00 – 39.0	mg/L
Sodium	(Na^{+})	4.50 – 12.0	mg/L
Sulfate	(SO_4^{-2})	3.00 – 10.0	mg/L
Hardness	($CaCO_3$)	127.00 – 381.0	mg/L (as $CaCO_3$)
Biochemical Oxygen Demand		0.80 – 1.7	mg/L
Conductivity		150.00 – 600	ΦS/cm
Total Dissolved Solids		120.00 – 300	mg/L

Table 37 - Jamaican ambient freshwater quality standards (2009)

5.1.4.2 BLACK RIVER INTENSIVE MONITORING PROGRAMME (2009-2010)

Jamaica is divided into twenty six (26) Watershed Management Units (WMUs).

During the **period 2009-2011** the National Environment Planning Agency (NEPA) established **significant environmental monitoring initiatives in the Black River Watershed Management Unit (WMU)**. The catalyst for these activities was a 2009 fish kill in the Black River. The initiatives resulted in output of several successful activities executed through the collaborative effort of NEPA and other governmental agencies.

4 different activities were conducted.

① **Black River Intensive Monitoring (BRIM) Programme** was a measure introduced by the Agency to closely observe the Black River for the following reasons:

1. to preserve and maintain the Black River Lower Morass (BRLM) Ramsar Site
2. to regularly monitor facilities that discharge effluent along the river
3. to identify changes in water quality over the period of investigation
4. to conduct Bio-Monitoring exercises at strategic locations along the river
5. to substantiate events such as pollution incidents with scientific evidence and data

The technical aspect of the programme was based on the regular collection and subsequent analyses of water samples from points identified along the Black River. Water samples were collected from the monitoring stations and the analytical results were evaluated.

② **Water Quality Monitoring, Early Warning and Response Network** aimed at developing a positive change in attitudes towards the environment. This activity commenced with the training of watershed residents to collect water and biological samples during pollution events. These stakeholder sensitization sessions equipped users of the river to identify changes along the river as well as to collect and preserve water and biological samples in the event of a pollution incident. These River Guardians or First Responders would be operating within a network of twelve (12) communities.

This initiative was facilitated by the Social Development Commission (SDC); the SDC engaged the residents and selected the venues for training fora. A programme document which distilled the approaches of the Intensive Monitoring Programme and the Early Warning and Response System was prepared in February 2010[13].

③ **Pollution Flow Simulation Modelling in the Black River WMU** was supported by a network of agencies and institutions which previously embarked on hydrological basin modelling and comprised the Water Resources Authority (WRA) and the University of the West Indies (UWI).

It was envisioned that predicting the most probable destination and time of emergence of a pollutant plume would increase the effectiveness of the Agency's response to pollution incidents. Water quality, landuse, geological and hydrological data were consolidated to support the software to model pollution flows.

④ **Assessment of Potential Black River Polluter Facilities** was conducted in September 2011 by a multi-disciplinary team consisting of representatives from different branches of NEPA[14].

The activity focused on thirteen (13) facilities whose activities could represent significant environmental impacts. This survey is the focus of the initiative and it culminated in the evaluation of a total of fourteen (14) facilities since Appleton Estate Ltd. was surveyed in March 2011 after a pollution incident.

Among results regarding NIC Pedro Plains future irrigation project, the following can be noted:

- **BOD** exceeding national standards range at downstream Appleton and Lacovia
- Global **Faecal contamination** in the WMU
- No **nitrate** exceeding range, except close to the Sydney Pagan agricultural school (slurry landspreading)
- Same for **phosphorous**
- Global **TDS** and **potassium** exceeding range *(this cannot be considered as a pollution and has most probably a natural origin)*

5.1.4.3 JPS HYDROPLANT EIA (2010 – 2011)

JPS hydropowerplant Environmental impact assessment contains an analytical campaign of Black River at Maggotty and Casa Marantha, between 2010 and 2011, led by Appleton estate.

13 "Black river water quality monitoring early warning and response programme" (NEPA, February 2010)
14 "Assessment report of potential black river polluter facilities" (CEPA, February 2012)

The results are presented below:

	BOD mg/L	Nitrate mg/L	Phosphate mg/L	pH Units	Conductivity ΦS/cm	TDS mg/L	TSS mg/L
Ambient Freshwater Standard	0.8 – 1.7	0.0 – 7.5	0.01 – 0.8	7 – 8.4	150 - 600	120 - 300	-
14-Apr-10	<3	0.3	0.09	7.93	349	-	--
28-Apr-10	<6.00	0.5	0.19	7.86	386	-	-
31-May-10	1	0.5	0.09	7.95	323	-	-
10-Jun-10	<0.10	2.64	0.04	7.8	348	-	-
12-Aug-10	1	2.2	0.05	8.02	338	61 +/-4	36 +/- 2
26-Aug-10	-	<0.30	0.1	7.84	348	178.4	29.5
9-Sep-10	1.3	0.88	0.03	8.33	299	97 +/-5	52 +/- 3
23-Sep-10	4	6.2	0.07	8.16	340	163.3	25.2
12-Oct-10	0.1	<0.30	0.04	8.18	344	177.8	25.8
25-Oct-10	0.8	0.88	0.07	8.08	342	47 +/- 4	26 +/- 2
11-Nov-10	1	1.76	0.05	7.85	355	142 +/- 8	33 +/- 2
24-Nov-10	0.6	<0.30	0.12	8.07	356	177	21
Dec 2, 201	0.6	0.5	0.05	7.82	356	151 +/- 8	19 +/- 1
17-Dec-10	3	<0.30	<0.02	7.74	351	164.3	24
6-Jan-11	0.4	0.5	0.04	7.83	386	150 +/- 10	3.7 +/- .2
17-Jan-11	0.4	<3	0.09	7.41	377	152.4	16

Appleton Estates 2010 – 2011

Table 38 - Water analysis at Maggotty (source: NJS EIA report)

	BOD mg/L	Nitrate mg/L	Phosphate mg/L	pH Units	Conductivity ΦS/cm	TDS mg/L	TSS mg/L
Ambient Freshwater Standard	0.8 – 1.7	0.0 – 7.5	0.01 – 0.8	7 – 8.4	150 - 600	120 - 300	-
14-Apr-10	2.2	0.6	0.14	8.05	338	-	-
28-Apr-10	1.7	0.5	0.08	8.06	377	-	-
31-May-10	2	0.5	0.09	7.95	350	-	-
10-Jun-10	0.7	2.2	0.05	8.25	303	-	-
12-Aug-10	1.4	1.76	0.06	8.29	322	-	35 +/- 2
26-Aug-10	-	<0.30	0.06	8.28	337	172	21.5
9-Sep-10	2.2	<0.44	0.05	8.5	315	138 +/-7	106 +/- 7
23-Sep-10	0	0.9	0.03	8.21	339	167.8	33.6
12-Oct-10	0.3	<0.30	0.03	8.6	333	165.1	46.2
25-Oct-10	1.1	0.44	0.21	8.52	334	270 +/- 20	22 +/- 1
11-Nov-10	1.6	1.76	0.3	7.7	347	63 +/- 4	48 +/- 3
24-Nov-10	2.4	<0.30	0.17	8.13	354	171	22.4
Dec 2, 201	1.1	0.4	0.04	8	349	430 +/- 20	35 +/- 2
17-Dec-10	0.2	<0.30	0.02	8.09	348	162.6	15
6-Jan-11	1.2	0.6	0.02	7.85	350	250 +/- 20	26.4 +/- 2
17-Jan-11	2	<0.30	0.09	7.73	359	169.5	16.7

Appleton Estates 2010 – 2011

Table 39 - Water analysis at Casa Marantha (source: NJS EIA report)

Numbers in red color show parameters which exceed national standards range.

The results show punctually **little organic pollution** (BOD), but low concentrations of nutrients N and P, low salinity (Ec).

Turbidity is not measured but **Total suspended solids** (TSS) varies between 15 and 106, with an average value of 35 mg/L. TSS and turbidity are correlated.

Microbiological contamination is not measured.

23-Aug-10	Arsenic mg/L	Chromium mg/L	Copper mg/L	Lead mg/L	Potassium mg/L	Zinc mg/L	Sodium mg/L	Manganese mg/L	pH Unit	Cond ΦS/cm
Maggotty	<0.013	<0.001	<0.001	<0.001	0.469	0.001	2.35	<0.002	7.99	345
Casa	<0.013	<0.001	<0.001	<0.009	0.458	0.001	2.32	<0.002	8.23	339

Appleton Estates 2010

Table 40 - Others water analysis parameters for Maggotty and Casa Marantha (Source NJS EIA report)

Results show that trace metals concentration is negligible, thus no pollution is noted.

5.1.4.4 BLACK RIVER WMU WATER QUALITY DATA (2014-2018)

146 water analyses on 15 sampling points were conducted by NEPA between 2014 and 2018.

The following table shows that:

- **BOD** exceeds range for 1/3 of the samples of the WRU (this proportions rises to 2/3 of the samples at Lacovia); the peak of BOD reaches 100 mg/L and is located downstream Appleton in February 2014,
- **Faecal coliforms** exceed range for 21% of the samples (the proportion rises to 27% at Lacovia)
- **PO4 and NO3** exceed range for 3 to 4% of the samples (none of them at Lacovia)

	PO4 (mg/l)	**NO3 (mg/l)**	**BOD (mg/l)**	**Faecal Coliform (MPN/100ml)**	**TSS (mg/l)**	**TDS (mg/l)**	**pH**
Nb samples	*126*	*127*	*125*	*144*	*100*	*79*	*106*
Min	0,002	0,004	0,080	2	0	40	6,6
Max	11,6	32,9	100,5	1600,0	658,0	9396,0	8,5
Mean	0,4	2,0	4,6	453	36	904	7,8
Median	0,1	1,0	1,2	110	18	230	7,8
Standard Limit	0.8	7.5	1.7				8.4
Nb exceeding	*4*	*5*	***47***	***30***			*6*

Table 41 - Water quality analysis for Black River WRU (2014-2018 period)

- **pH is very variable**, and ranges from 6.6 to 8.5 on all sites, possibly according to seasonal fluctuations due to rainfall and dilution of the geological river basin water.

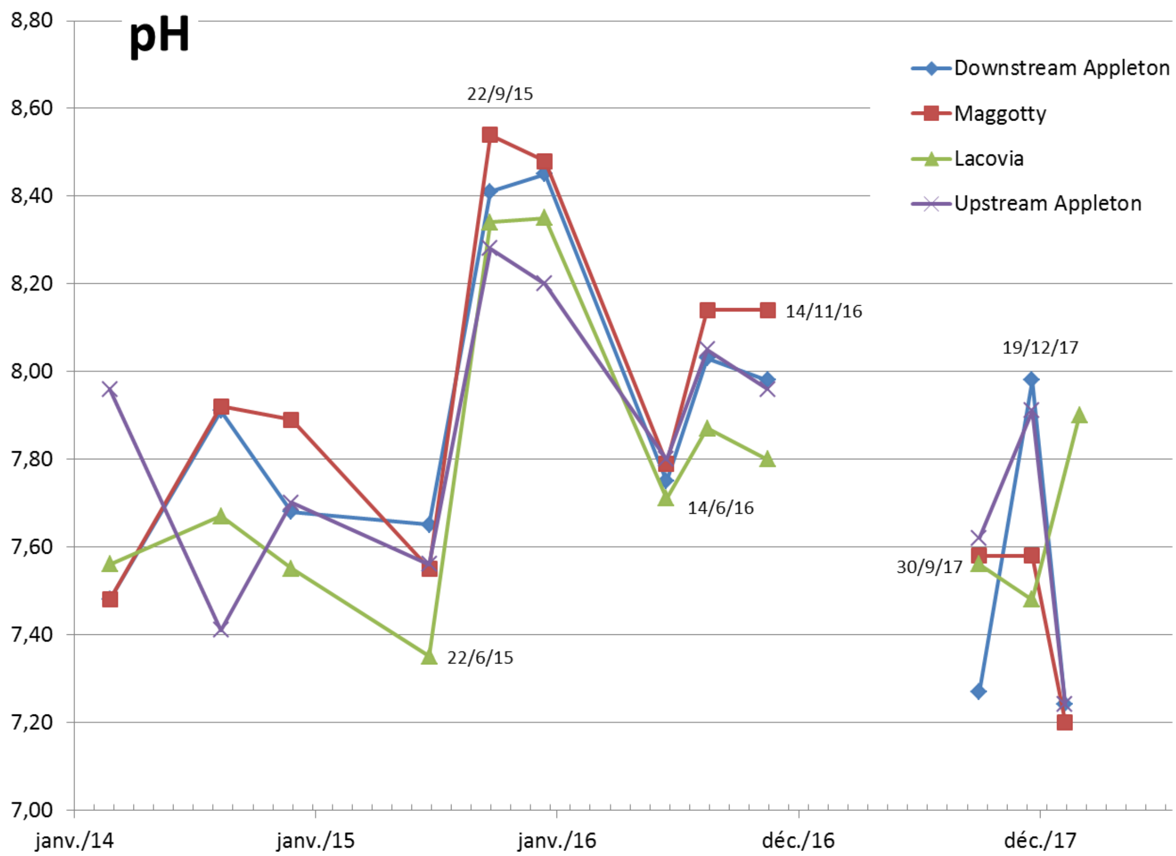


Figure 49 – pH variation at different locations (2014-2018 period)

5.1.4.5 WATER QUALITY SAMPLING (2019)

ESL undertook analyses of Black River waters at Lacovia in early March 2019, which main results are:

- **O_2** 9.59 mg/L: excellent quality
- Low **BOD** (<0.1)
  NB: this last result is questionable
- Presence of **microbiological** contamination (total coliforms 1 600 and E Coli 920 in 100 mL)
- No **conductivity** nor **salinity** issue (Ec 423 µS/cm)
- Little **nitrate** concentration (<0.3 mg NO3-, standard established at 7.5)
- Little **phosphate** concentration (0.06 mg PO4, standard established at 0.8)
- **No heavy metals** issue
- **No positive pesticide** screening

5.1.4.6 INVESTIGATION OF UPSTREAM ACTIVITIES (2019)

Visits of three important upstream activities were conducted in early March 2019.

5.1.4.6.1 Appleton Estate

Appleton estate belongs to J Wray & Nephew limited, which is a major sugarcane and distillery company in Jamaica, and hires some 300 workers.

The factory is located upstream Black River, and is sourrounded by sugarcane fields.

Abstractions rights in the Black River are 57 500 m^3/d.

Figure 50 – Appleton estate water infrastructures (source: Google Earth)

In February 2014, a pollution episode occurred in Appleton estate, due to accidental discharge of untreated wastewater. The pollution caused high losses in the fishfarm nurseries downstream, and a temporary closure of the sugarcane factory. Since then, no incident occurred.

The pollution risk is important considering toxicity of the effluent (BOD, COD, DO…), but it is managed so far.

No precise data could be collected from NEPA, despite our insistence.

Picture 23 - Appleton estate wastewater treatment component (source: SCP)

Appleton Estate Ltd. has to conduct monitoring of water quality daily and distillery waste application to the cane fields at various sites on and off the factory and measure dissolved oxygen, conductivity and pH. NEPA also monitors water quality and a comparison of the respective data was set between 2009 and 2010.

The data depict a **four-fold difference between NEPA and Appleton's results** when the samples are taken from Appleton's main drain.

Among other results:

1. The results for the **BOD** as reported by Appleton exceed the standard limit at two points

2. **Nitrate** results reported by NEPA and Appleton are lower than the standard value.

3. **Potassium** concentrations as reported by NEPA have exceeded the standard value, while those reported by Appleton are below the 5.0 mgL-1 standard value. The high potassium levels in the main drain are quite possibly due to the high ion concentration in the dunder leaving the factory via this route.

4. All **pH** results reported by both entities are just below the upper limit of 8.4.

5. Ortho **Phosphate** results are below the standard value of 0.26 mgL-1 at all sites except at Windsor Bridge where NEPA reported 0.543 mgL-1.

6. High **COD** and **BOD** results were also observed in the Appleton main drain in 2010 and it is quite possible that the reason posited for this phenomenon in 2009 is still relevant.

5.1.4.6.2 JPS hydropower plant

Jamaica public service (JPS) hydropower plant at Maggoty is situated on the Black River between Appleton Estate and Algix fishfarm.

Water is taken from the river in a pipe, according to 2 licences of 640 000 and 550 000 m^3/d, and discharged some 3 km below.

Considering the distance to Lacovia, the effect on NIC Pedro Plains irrigation project will be negligible.

5.1.4.6.3 Algix fishfarm

Algix fishfarm produces 70 tons /mo of Red tilapia and Pangasus fishes for Jamaican local market, diverting water from Black Rivers to more than 50 fishponds.

Volumes abstracted from the river are laid back 2 km downstream. Abstraction rights is 241 000 m^3/d but average value for 2017, 2018 and beginning of 2019 is close to 220 000.

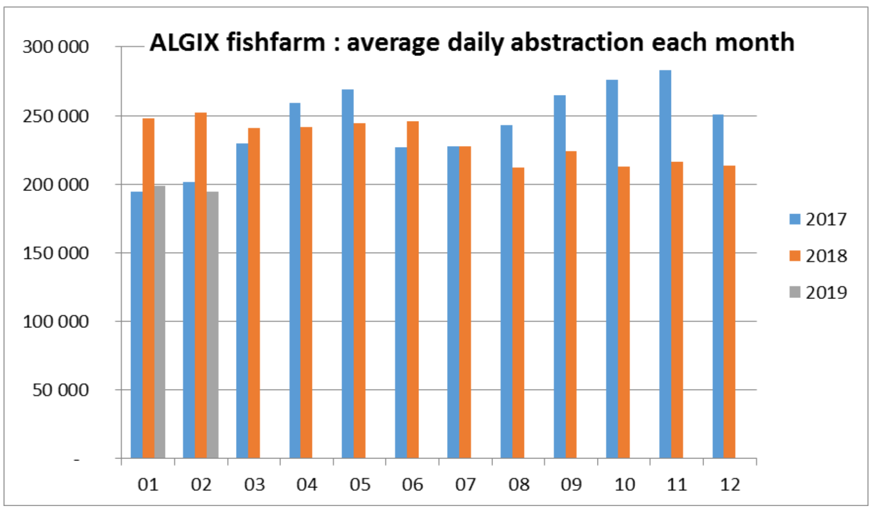


Figure 51 - Algix fishfarm daily abstraction each month (in m^3) source: WRA

Figure 52 - Algix fishfarm water operations (source: Google Earth)

Picture 24 - Algix fishfarm water canal and fishponds alimentation

Water quality is monitored on a regular basis, especially dissolved oxygen which is fundamental to hydrobiology, both within the fishpond and downstream.

2017 analyses show that:

- **Inlet DO** averages 7 mg/L
- **Outlet DO** averages 4 mg/L

According to European Water Framework Directive, the inlet would be categorized as 'good quality' water according to this parameter, whereas the outlet would be 'medium quality'.

There is a degradation of water quality regarding this parameter, but the question is: what is the incidence of water quality at Lacovia, and could this affect NIC Pedro Plains irrigation project?

⇨ Considering March 2019 SCP analyses, O_2 at Lacovia is 9.6 mg/L. Thus it seems that Algix fishfarm dissolved oxygen degradation upstream resorbs after some 12 km, and doesn't affect this O_2 parameter at the future uptake point of the Pedro Plains irrigation projet.

5.1.4.7 WATER QUALITY SAMPLING (2023)

Water quality samples were collected from the Black River, within approximately 1km, upstream and downstream of the proposed abstraction location to establish the existing conditions of this water body prior to the start of the proposed project (see **Figure 53**). Information from the sampling activities conducted for the water quality assessment was supplemented by existing data not exceeding 5 years. The results from this assessment and the comparison of data are presented at the end of this section. A third water quality sampling point (indicated as WQ3 in **Figure 54**) was proposed to have been collected, however, during both sampling activities this area did not contain any water (see pictures belowErreur ! Référence non valide pour un signet.).


Picture 25: Sampling Point WQ3 during the Wet (Right Picture) and Dry (Left Picture) Seasons

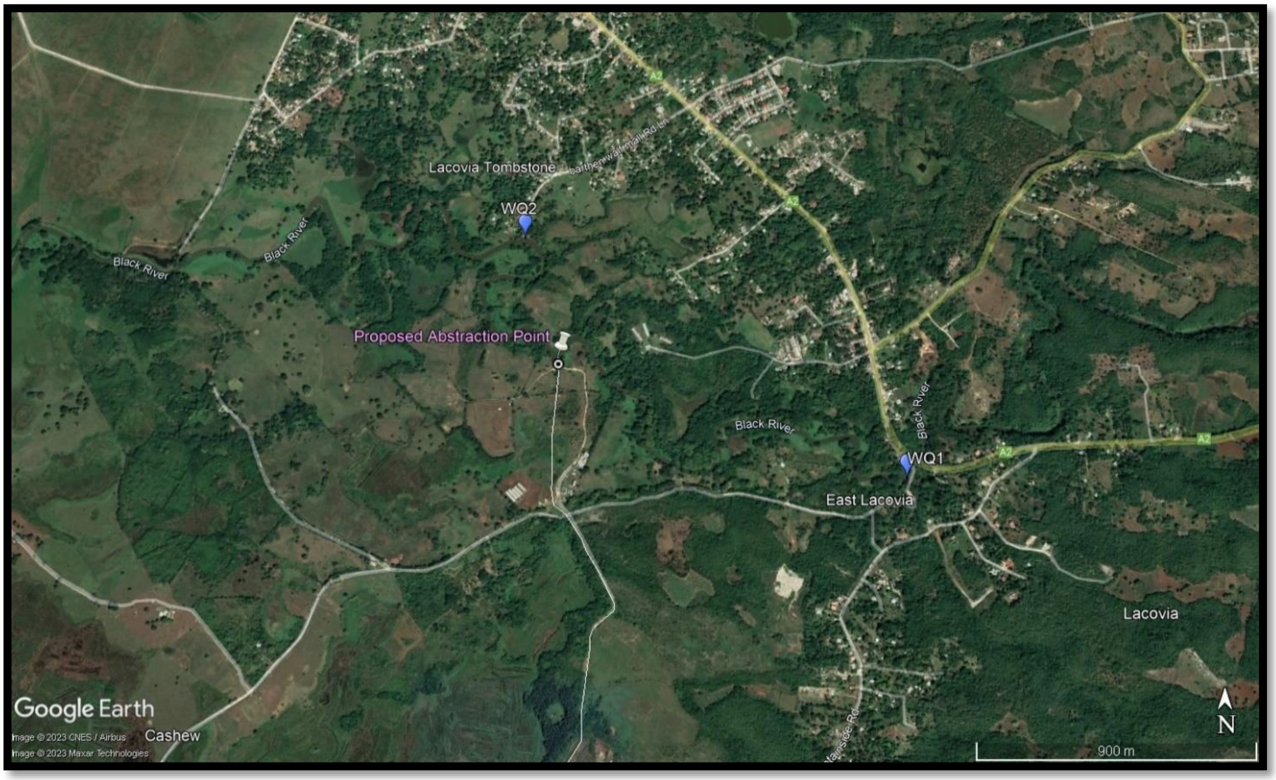


Figure 53: Water Quality Sampling Points

☞ ***See map 010- Water quality sampling points***

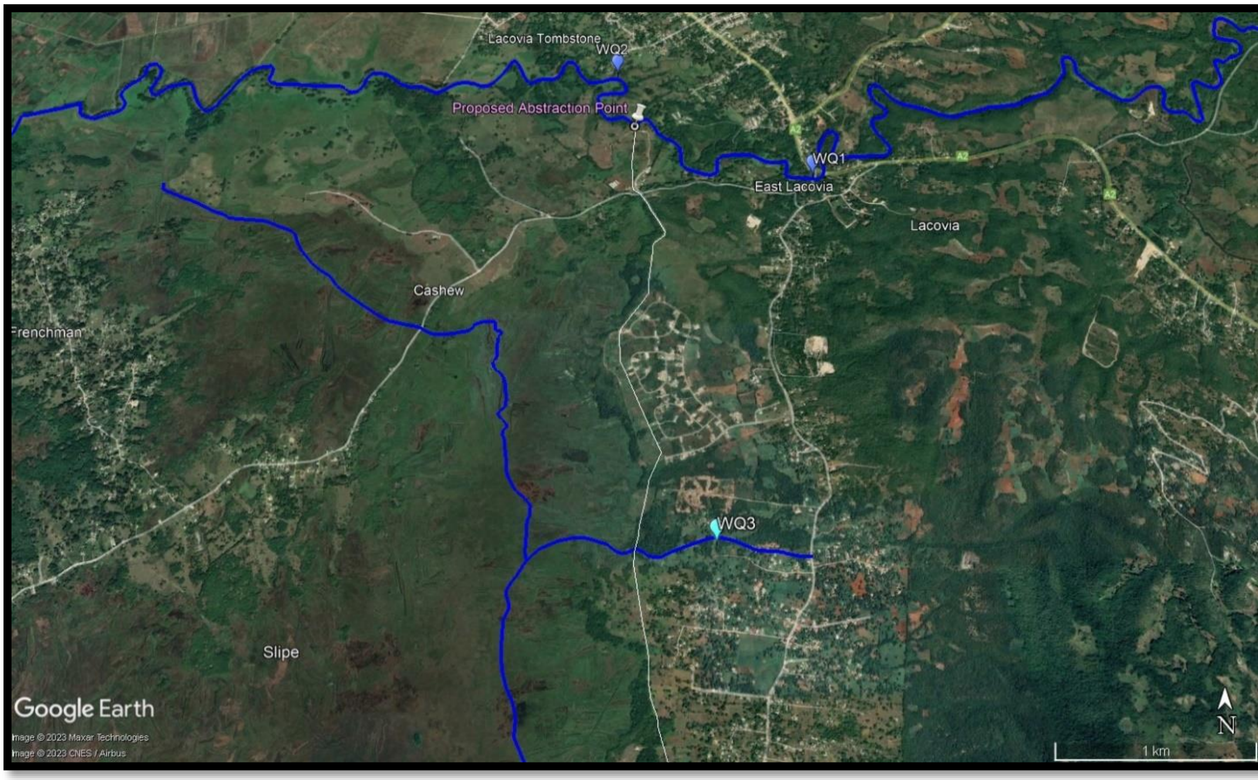


Figure 54: Proposed Water Quality Sampling Points

Parameters assessed include those presented in Table 42. Two (2) grab water samples were collected from freshwater sources for the full scope of parameters listed; parameters highlighted in blue indicate samples that were measured *in situ*.

Table 42: Parameters Analysed for the Water Quality Sampling Exercise

➢ **Freshwater Samples**	
➢ pH (pH units)	➢ Dissolved Oxygen (mg O_2/L)
➢ Conductivity (mS/cm)	➢ Salinity (ppt)
➢ Total Dissolved Solids (mg/L)	➢ Biochemical Oxygen Demand (mg O_2/L)
➢ Faecal Coliform (MPN/100mL)	➢ Chemical Oxygen Demand (mg O_2/L)
➢ Orthophosphates (mg PO_4^{3-})	➢ Turbidity (NTU)

➢ Nitrate (mg NO_3^-)	➢ Chloride (mgCl^-/L)
➢ Total Suspended Solids (mg/L)	➢ *E.coli* (MPN/100mL)
➢ Total Coliform (MPN/100mL)	➢ Faecal Enterococci (MPN/100ml)
➢ Potassium (µg K/L)	➢ Sodium (µg Na/L)
➢ Fats, Oil and Grease (mg/L)	➢ Pesticide Screen (µg/L)
➢	

Other field observations and *in situ* measurements (parameters highlighted in blue), were made with respect to smell, colour, and temperature at each site. Salinity, pH, temperature, conductivity, total dissolved solids, and dissolved oxygen were measured using a YSI ProPlus Model Multiparameter system (MPS).

The major objectives of the water quality assessment were to: -

1. (Re) establish the existing water quality conditions of the area.
2. Assess land use practices and their impacts on the existing environment prior to the construction and operation of the proposed project.
3. Make recommendations for the monitoring and management of water resources based on the proposed activities.

All samples collected were kept below 4°C and transported to the ISO/IEC 17025 accredited Quality and Environmental Health Laboratory at Environmental Solutions Limited for analysis bearing in mind the analysis hold time for each test parameter. Water quality results were compared Jamaica's National Resource and Conservation Authority's (NRCA) Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009.

As described above, two (2) water samples were collected approximately 1 km upstream (WQ1) and within 1 km downstream (WQ2) of the proposed abstraction area. The proposed project involves the abstraction of water from the Black River with the uptake point within the Lacovia area. The Black River is close to 40 miles long[15] and flows in a south-westerly direction. According to the Water Resources Authority (WRA), the proposed project area is located within the Black River Hydrologic Basin with the project primarily being located within the Lower Black River. However, some areas of the proposed pipeline route and reservoirs are located within the Upper Black River. This basin is primarily comprised of white limestone overlain by alluvial deposits and is primarily drained by the Black River. [16]

The proposed abstraction point and where the water samples were collected are located within an area of the Black River basin that is characterised as an alluvium aquiclude; however, some areas of the proposed pipeline will pass through a limestone aquifer as shown in **Figure 55** below. The yellow boundary indicates the Black River Hydrologic Basin while the purple boundary shows the area within this basin that is characterised as an alluvium aquiclude. Other areas of the basin are characterised as predominantly limestone aquifer.

[15] https://www.sam.usace.army.mil/Portals/46/docs/military/engineering/docs/WRA/Jamaica/Jamaica%20WRA%20-%20English.pdf
[16] https://www.wra.gov.jm/wp-content/uploads/2020/06/WRA-Water-Quality-Atlas-2019.pdf

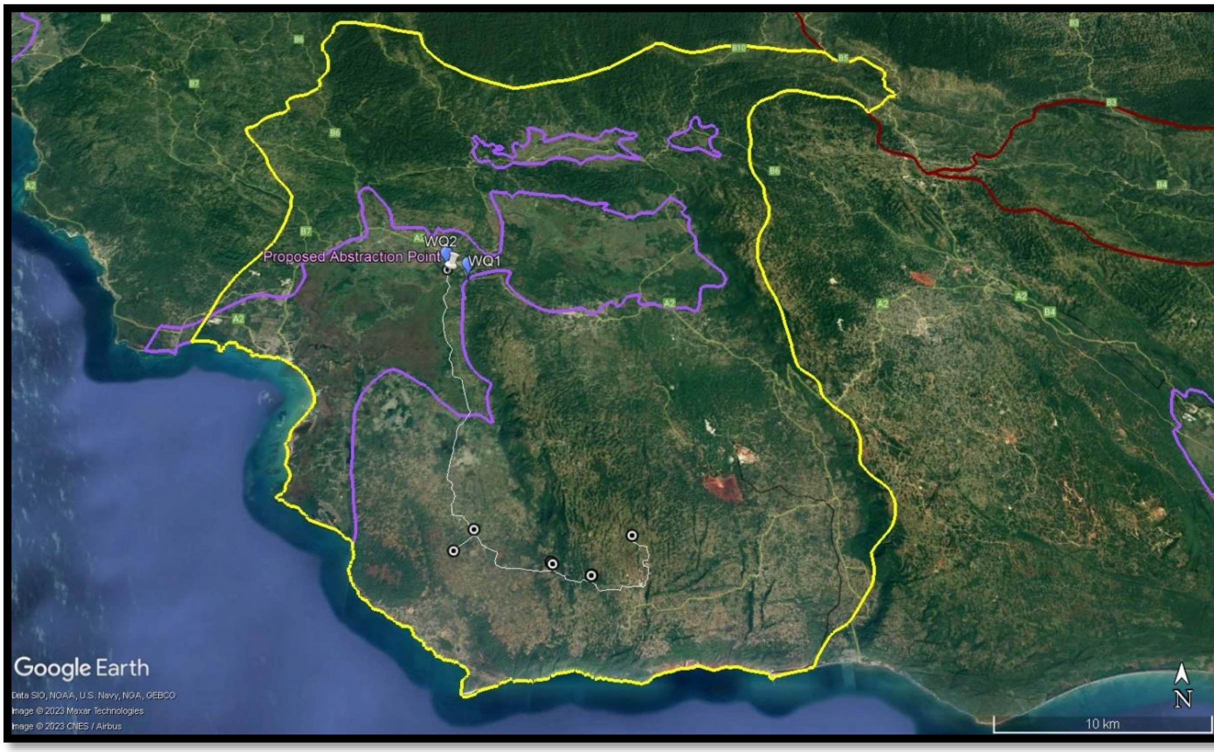


Figure 55: Black River Hydrologic Basin and Proposed Pipeline Route[17]

1. General Characteristics of Water Samples

Based on the results obtained, the Black River upstream and downstream of the proposed Lacovia abstraction point (see **Figure 56**) generally exhibited characteristics typical of a Jamaican freshwater sample. Parameters that did not fall within the range established in the Draft Jamaica NRCA Ambient Water Quality Standard – Freshwater, 2009 included chloride, BOD, potassium, and sodium for the dry season (February 2023) assessment while chloride and sodium were non-compliant with the cited standard during the wet season (May 2023) assessment.

From the dry season (February 2023) assessment, the Chloride and BOD for WQ1 were lower than the range specified by the Draft NRCA Ambient Water Quality Standard – Freshwater, 2009. Similarly, potassium was lower than said standard for both samples collected. However, the

[17] Pipeline indicated by the white line stemming from the Proposed Abstraction Point

sodium concentration obtained for both samples were slightly elevated as compared to this standard.

Based on data obtained for the wet season (May 2023) assessment, the chloride results attained for WQ1 and the sodium results attained for both sampling locations were slightly above the range specified by the Draft NRCA Ambient Water Quality Standard – Freshwater, 2009.

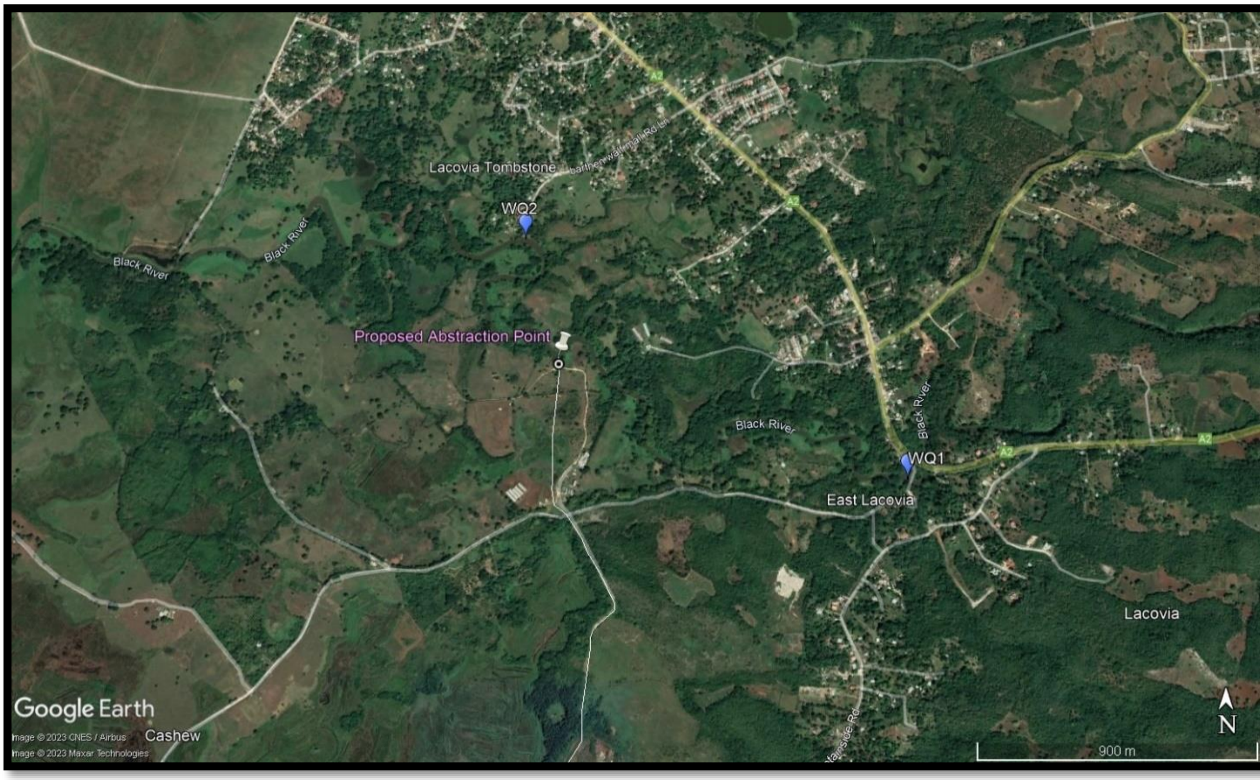


Figure 56: Water Quality Sampling Points

For the dry season (Feburary 2023) assessment, parameters tested that did not have a range specified by the Draft Jamaican NRCA Ambient Water Quality Standard – Freshwater, 2009 such as total suspended solids (TSS), chemical oxygen demand (COD), turbidity etc., were typical of what is expected for relatively unpolluted freshwater systems. For example, the water bodies had relatively low chemical oxygen demand (COD) and turbidity. The water body also had no levels of detected pesticides or fats, oil, and grease (FOG).

Although the pesticides and FOG concentrations obtained during the wet season (May 2023) assessment remained relatively low or not detected, there was a general increase seen in microbial, organic, and physical parameters such as TSS and turbidity as compared to the dry season (February 2023) assessment.

2. Oxygen Demand

The COD of a natural water system gives information on how much oxygen is required for the oxidation of waste to carbon dioxide and water, with all organic matter in the sample being converted to carbon dioxide. COD concentrations are generally ≤20 mgO_2/L in unpolluted surface water samples.[18] Both water samples collected in the dry season were below this value indicating that the water body was not being impacted by activities that may cause elevated levels of oxygen demand. Furthermore, FOG - substances that are generally immiscible in water and are commonly used in industrial or daily activities such as cooking or washing- which can also contribute to the oxygen demand of a water body was undetected in both water samples.

However, the COD concentration for both samples collected during the wet season exceeded 20 mgO_2/L and, although low, FOG was detected at WQ1. This suggests that the water body during the wet season is being impacted from activities that could result in an increase in its oxygen demand. Furthermore, the BOD obtained during the wet season assessment, although still within what is specified by the Draft NRCA Ambient Water Quality Standard – Freshwater, 2009, was slightly elevated as compared to the results attained during the dry season assessment.

3. Water Clarity

The clarity of a water body is important for the functioning of an aquatic system as reduced water clarity can decrease the amount of light that can penetrate a water column. This can affect other processes such as photosynthesis and have other indirect effects also. Turbidities in freshwater systems are largely dependent on the particular water body of concern, however, it is generally accepted that turbidity values of less than 10 NTU for rivers and other water systems is considered one of low turbidity.[19]

For the dry season assessment, both water samples exhibited turbidity values of less than 10 NTU indicating their relative clarity. Similarly, the parameter total suspended solids is also a measure of water clarity and it was seen that the sample with the highest turbidity also had the highest suspended solids value. The suspended solids value for both of these samples was relatively low as well correlating with the values obtained for turbidity.

[18] S.K. Jain, V.P. Singh, Water Resources Systems Planning and Management in Developments in Water Science, 2003
[19] https://datastream.org/en/guide/turbidity

However, for the wet season assessment, both samples were fairly turbid and had turbidity values which were between 10 NTU and 25 NTU.[20] It was also seen that the suspended solids in both of these water bodies were higher than that seen in the dry season assessment.

4. Change in Water Quality between Sampling Locations

Based on the information obtained from the sampling activities and the parameters tested, the quality of the water at WQ1 and WQ2 seem to be similar based on the organic, physical, microbiological, and dissolved solid constituents (e.g., nutrients and metals). This suggests that as the water flows from WQ1 to WQ2, there is no input to the water body that may result in a significant change in these parameters. However, it was observed that there was a pattern seen in the pH values for the samples collected at both locations where was a slight increase in pH as the water flowed from WQ1 to WQ2. This does suggest that there may be a source contributing to the elevated pH level as the water traverses from WQ1 to WQ2.

5. Possible Anthropogenic Impacts on Water Quality

Based on the results obtained from the assessment, there appears to be a source contributing to the pH of the water system as it travels from WQ1 to WQ2. Anthropogenic activities such as the production of runoff from agricultural events can influence the change in pH as well as run-off from other processes that contain detergents or soap-based products. As the surrounding area is largely agricultural, the possibility of agricultural related anthropogenic impacts is likely, however, other parameters that would suggest this impact such as the presence of pesticides or elevated parameters such as nitrates, phosphates, potassium etc., were not detected at WQ2. Additional investigations would have to be done to ascertain the cause of this trend seen.

Given the elevated concentration of sodium seen in the water body, it indicates that there may be a possible source of sodium into the water body upstream of WQ1. Elevated levels of sodium, especially when not coupled with chloride, point to an anthropogenic source such as water softeners or chemicals used for pH adjustment. Given the proposed use of the water to be abstracted and piped to areas for purposes such as agricultural activities, elevated sodium in the water body may be a cause for concern as continuous elevated levels can impact the yield of crops depending on their sodium sensitivity.

20 https://www.researchgate.net/publication/284559473_Water_Turbidity_Impact_on_Discharge_Decrease_of_Groundwater_Recharge_in_Recharge_Reservoir/download

Total coliform, faecal coliform, *E. coli* and faecal enterococci were present in all water samples. Faecal coliform, faecal enterococci, and *E. coli* in water samples, though typical of Jamaican surface waters, are linked to a recent source of faecal contamination. It is possible that untreated or improperly treated sewage or run-off from yards, farms and roads can contribute to the microbial levels seen in this water body. This water may need to be properly treated before distribution as these organisms can create health problems in humans, as well as animals, such as, but not limited to, diarrhea, urinary tract infections and respiratory illnesses, especially if proper sanitation practices while handling this water is not practiced.

6. Comparison of Dry Season and Wet Season Assessment

Based on the sampling activities conducted, there was a general increase seen in chloride and the physical, organic, and microbiological parameters when the data from the wet season assessment was compared to that of the dry season.

Surface waters can be impacted during the wet season as more consistent and heavier periods of rainfall can cause soil surfaces, especially those that may be exposed from agricultural activities, and run-off from residential and industrial activities to be washed into the water body. Sediments that have settled in the water body can also be resuspended. This can cause the elevation of several parameters inclusive of turbidity and suspended solids as soils and sediments can impact these.

Similarly, surface run-off can carry substances that can result in the elevation of organic, inorganic, and microbiological parameters directly into streams/ rivers. For example, some fertilizers and waste/wastewaters (sewage) produced from human activities can contain chloride which may explain the elevated levels seen during this sampling activity. Soils and other sediments, as well as improper wastewater disposal can also increase the organic and microbial load of a water body. However, it was seen where the conductivity (and related parameters e.g., TDS and Salinity) of the water body was lower in the wet season than the dry season. This could possibly be due to the volume of the water being greater in the wet season. If the sources of substances that affect the conductivity of the water body remain largely unchanged during both seasons, then this may explain the decrease seen in the conductivity of the water bodies.

The pH obtained for both sites during both seasons was comparable.

Table 43: Results of the Freshwater Assessment

Parameter (Units)	**February 2023**		**May 2023**		**NRCA Ambient Water Standard - Freshwater**
	WQ1	**WQ2**	**WQ1**	**WQ2**	
pH (pH units)	7.29 @ 23.8°C	7.45 @ 24.2°C	7.24 @ 26.5°C	7.48 @ 26.8°C	**7.00-8.40**
Dissolved Oxygen (mg O_2/L)	6.69 @ 23.8°C	6.21 @ 24.2°C	5.57 @ 26.5°C	7.17 @ 26.8°C	**-**
Conductivity (mS/cm)	423 @ 23.8°C	427 @ 24.2°C	392@ 26.5°C	389 @ 26.8°C	**150.0-600**

Parameter (Units)	**February 2023**		**May 2023**		**NRCA Ambient Water Standard - Freshwater**
	WQ1	**WQ2**	**WQ1**	**WQ2**	
Salinity (ppt)	0.21 @ 23.8ºC	0.21 @ 24.2ºC	0.18 @ 26.5ºC	0.18 @ 26.8ºC	-
Total Dissolved Solids (mg/L)	281.45 @ 23.8ºC	282.10 @ 24.2ºC	247.65 @ 26.5ºC	247.65@ 26.8ºC	**120.0-300**
In situ Temperature (°C)	23.8ºC	24.2 ºC	26.5 ºC	26.8ºC	-
Turbidity (NTU)	8.87	5.59	14.30	14.70	-
Nitrate (mg NO_3^-/L)	2.6	3.1	3.8	2.6	**0.1-7.5**
Nitrate as Nitrogen (mg NO_3^-N/L)	0.6	0.7	0.8	0.6	-
Orthophosphate (mg PO_4^{3-}/L)	0.03	0.03	0.02	0.03	**0.01 - 0.8**
Orthophosphate as Phosphorus (mg PO_4^{3-}-P /L)	0.01	0.01	0.01	0.01	-
Chloride (mg Cl^-/L)	<3.0	5.3	20.1	10.2	**5.0-20.0**
Faecal Coliform (MPN/100ml)	240	140	540	140	-
Total Coliform (MPN/100ml)	1600	>1600	>1600	>1600	-

Parameter (Units)	**February 2023**		**May 2023**		**NRCA Ambient Water Standard - Freshwater**
	WQ1	**WQ2**	**WQ1**	**WQ2**	
E.Coli (MPN/100ml)	240	140	540	140	**-**
Faecal Enterococci (MPN/100ml)	170	130	350	350	
Total Suspended Solids (mg/L)	11.2	8.2	20.2	17.8	**-**
Chemical Oxygen Demand (mg O_2/L)	<3	4	43	29	**-**
Biochemical Oxygen Demand (mg O_2/L)	0.6	0.8	1.2	1.5	**0.8-1.7**
Fats, Oil & Grease (mg/L)	<1	<1	2	<1	**-**
Potassium (mg K/L)	0.73	0.70	0.87	0.86	**0.74-5.0**
Sodium (mg Na/L)	15.62	15.11	12.26	12.15	**4.5-12.0**
Pesticide Screen (ppb)	Not Detected	Not Detected	Not Detected	Not Detected	**-**

Table 44: Description of Water Quality Assessment Areas

Sample Location	**GPS Coordinates**	**Description**	
		February 2023	**May 2023**
WQ1 (Sampling Location upstream of Abstraction Point)	18.0759830, -77. 568010	At the time of sample collection, the sample appeared clear and colorless with little suspended and settled solids and no odor. The sample was taken from under the Old Lacovia Bridge and the water in the river appeared cloudy and was flowing rapidly in a southern direction. The sample was collected approximately 4ft deep and the river was approximately 20ft wide. The river banking was heavily vegetated and small aquatic animals were seen in the river.  Environmental conditions: Clear skies with little to no wind	At the time of sample collection, the sample appeared pale yellow, translucent and had suspended particles with no odour. The sample was taken from the southern banking of the section of the Black River that passes under the Old Lacovia Bridge. The area was heavily vegetated, and the ground was damp. The flow of the river was moderate at this location. The water appeared very cloudy.  Environmental conditions: Overcast skies with no wind
WQ2 (Sampling Location downstream of	18.0839037, -77.7697629	At the time of sample collection, the sample appeared clear and colorless. The sample was taken approximately 5ft from the river banking at a depth of approximately 3-4 feet. The river at this sampling point was approximately 100 ft wide. The surface of the water was relatively clear; however, natural debris was seen on the surface of	At the time of sample collection, the sample appeared pale yellow, translucent and had suspended and settled particles. The sample was collected from the northern banking of the Black River. The area was vegetated, and the ground was damp. The river was approximately 100ft wide with natural debris seen on the surface. Sections of the river banking were exposed. The water at

Sample Location	**GPS Coordinates**	**Description**	
		February 2023	**May 2023**
Abstraction Point0		the water body. The river banking was vegetated with grass like plants, however, there were some exposed areas. Large trees and acacias were also seen growing along the river banking. Goats were seen grazing near to the sampling location and cow tracks were observed on the banking across from the sampling location. Man-made debris was seen near river banking. The bottom of the water was partially visible.  Environmental conditions: Scattered clouds, light winds	this sampling point had a moderate flow and travelled in a southern direction. The water appeared cloudy, and bubbles were seen emerging on the surface of the water periodically.  Environmental conditions: Overcast skies with no wind; very humid

7. Comparison of Data to Existing Information

Several assessments have been done in the general area of where the NIC plans to abstract their water from such as from the Water Resources Authority (WRA) and Environmental Solutions Limited.

Information from the Water Resources Authority can be found in their Water Quality Atlas published in 2019 where data from their sampling activities in 2016/2017 and from other historical water quality data was used to provide information on Jamaica's freshwater quality. [22] **Figure 57** shows the locations that the WRA would have sampled from and/or collated historical data for. Sampling point #5 in this image indicates the sampling location at 'Black River @ Lacovia' – the same sampling location as or close to sampling station WQ1.[21]

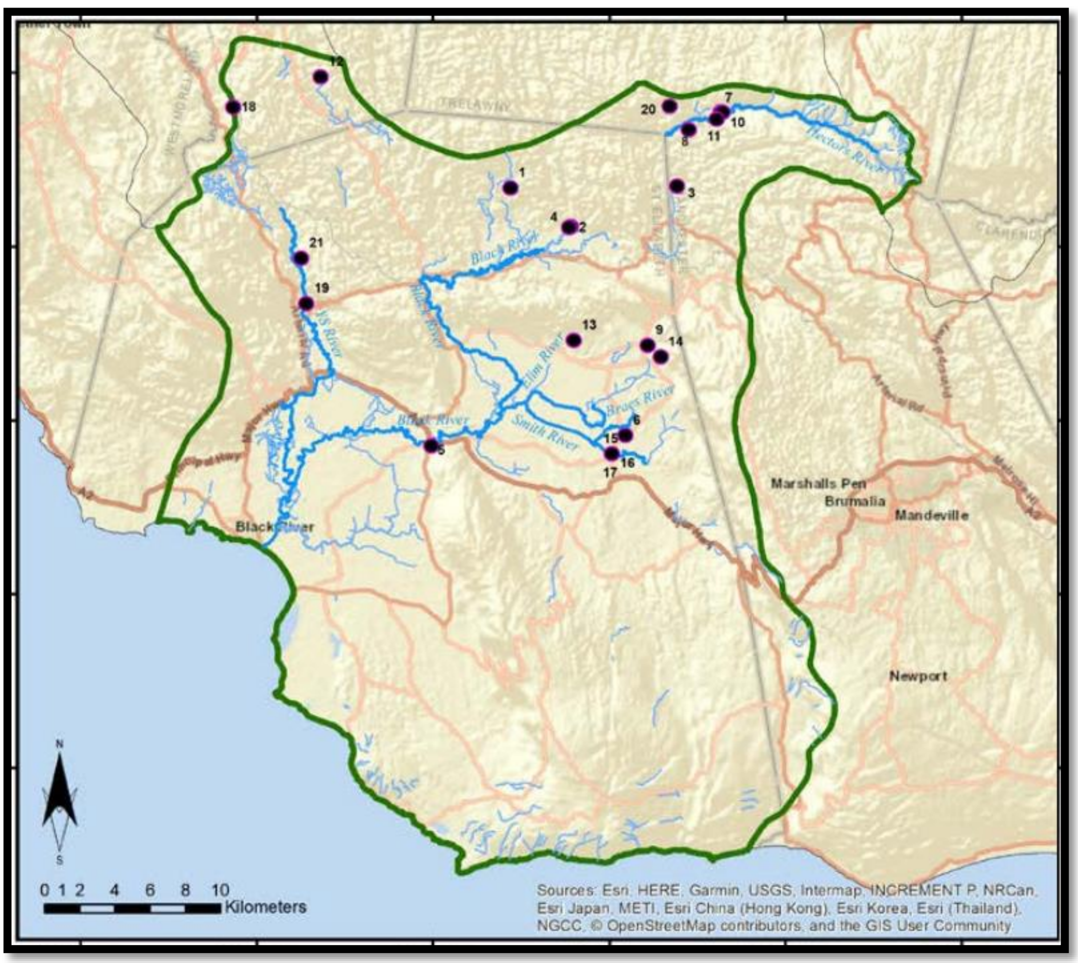


Figure 57: WRA Surface Water Sampling Points in the Black River Hydrologic Basin[21]

Based on the information obtained from the atlas with respect to the parameters: nitrates, sodium, chloride and TDS, the water quality at this location would have fallen within the same classification as excellent/high quality with the exception of sodium. [21] However, as shown in **Figure 58**, elevated levels of sodium were seen areas upstream of the sampling station which can have an impact on the downstream characteristics over a period of time.

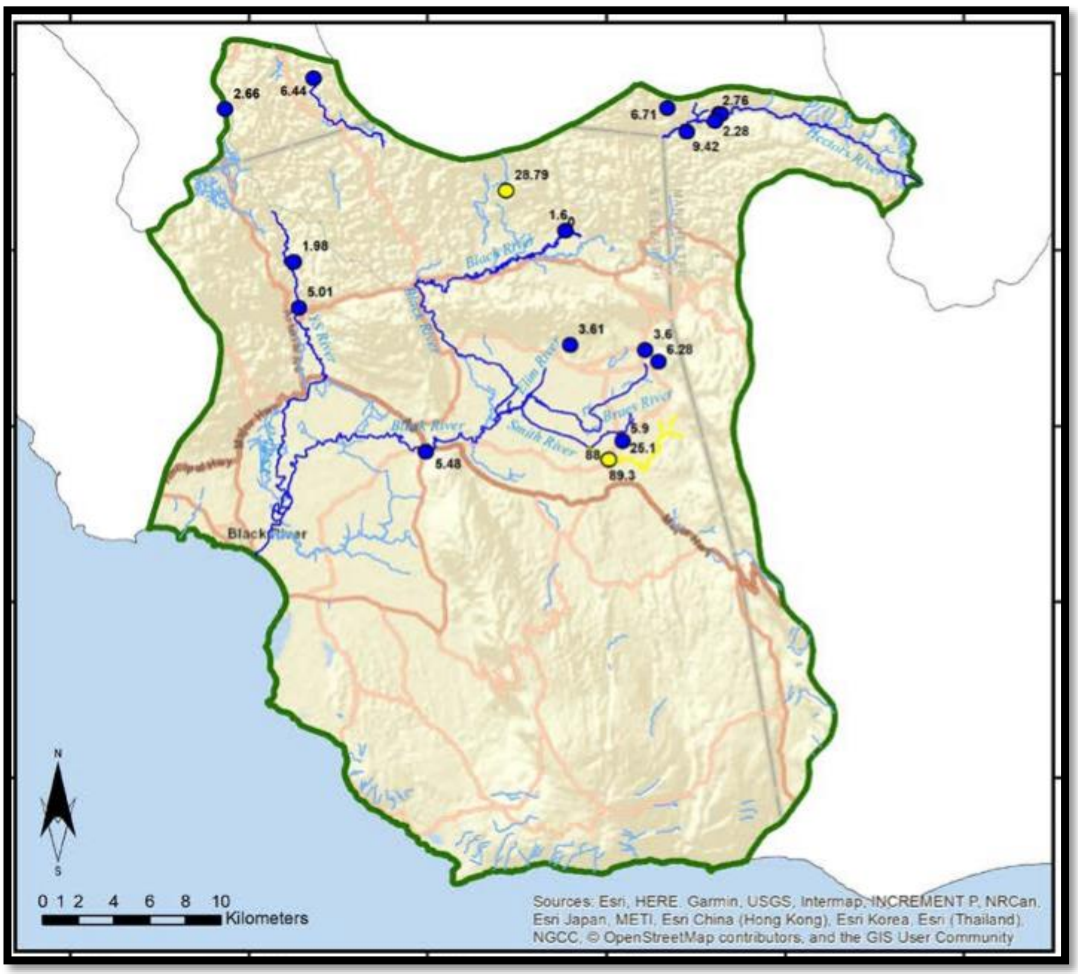


Figure 58: WRA Surface Water Sodium Levels in the Black River Hydrologic Basin[22]

[21] https://www.wra.gov.jm/wp-content/uploads/2020/06/WRA-Water-Quality-Atlas-2019.pdf
[22] https://www.wra.gov.jm/wp-content/uploads/2020/06/WRA-Water-Quality-Atlas-2019.pdf

Information from Environmental Solutions Limited includes that information published by the company and submitted to the NEPA in the Carrying Capacity Report for Black River and its Tributaries. Based on the information presented in this report, sample #7 would have been collected at the same position as WQ1.[23] Data was collected during the wet and dry seasons of November 2015 and June 2015 respectively. The data obtained from each season is presented in **Table 45** below and compared to the results obtained from this sampling exercise.

When the parameters analyzed across the current assessment period were compared to those from the Black River Carrying Capacity (2016) report, it was observed that there was a similar trend seen in the wet season and dry season with the *in-situ* readings. It was seen that there was a decrease in the dissolved solids concentrations when the dry season was compared to the wet season. This could be due to the precipitation: dilution effect where reduced rainfall and water flow, as well as high evaporation rates can cause an increase in the concentration of some parameters.

Similarly, it was seen that the individual seasons, the characteristic of the Black River remained largely unchanged. For example, during the dry season for the assessment done in the 2016 Carrying Capacity Report as well as the current assessment, the Black River was characterized by a low oxygen demand as evidenced by the low COD, BOD, FOG and relatively high dissolved oxygen levels obtained, low nutrient and mineral concentrations which fell within or below the Draft Jamaica NRCA Ambient Water Quality Standard – Freshwater, 2009, relatively good water clarity as evidenced by the TSS value obtained and contained the presence of faecal coliforms in the water body.

It was also seen where there was an increase seen in the parameters chloride, chemical oxygen demand and faecal coliform when the dry season was compared to the wet season.

[23] Environmental Solutions Limited, Carrying Capacity Report for Black River and its Tributaries Final Report, 2016

Table 45: Data Comparison for Current Water Quality Assessment and the Data Obtained from the Black River Carrying Capacity Report (2016)

Parameter (Units)	**Dry Season Assessment**		**Wet Season Assessment**		**NRCA Ambient Water Standard - Freshwater**
	February 2023	**June 2015 (BRCC)***	**May 2023**	**November 2015 (BRCC)***	
	WQ1	**Sample 7**	**WQ1**	**Sample 7**	
pH (pH units)	7.29 @ 23.8ºC	-	7.24 @ 26.5ºC	6.91 @ 25.3°C	**7.00-8.40**
Dissolved Oxygen ($mg\ O_2/L$)	6.69 @ 23.8ºC	5.83 @ 26.78°C	5.57 @ 26.5ºC	6.38 @ 25.3°C	**-**
Conductivity (mS/cm)	423 @ 23.8ºC	416 @ 26.78°C	392@ 26.5ºC	374 @ 25.3°C	**150.0-600**
Salinity (ppt)	0.21 @ 23.8ºC	0.19 @ 26.78°C	0.18 @ 26.5ºC	0.18 @ 25.3°C	**-**
Total Dissolved Solids (mg/L)	281.45 @ 23.8ºC	260 @ 26.78°C	247.65 @ 26.5ºC	242 @ 25.3°C	**120.0-300**

Parameter (Units)	**Dry Season Assessment**		**Wet Season Assessment**		**NRCA Ambient Water Standard - Freshwater**
	February 2023	**June 2015 (BRCC)***	**May 2023**	**November 2015 (BRCC)***	
	WQ1	**Sample 7**	**WQ1**	**Sample 7**	
In situ Temperature (°C)	23.8°C	26.78°C	26.5 °C	25.3°C	**-**
Turbidity (NTU)	8.87	-	14.30	-	**-**
Nitrate (mg NO_3^-/L)	2.6	<1.3	3.8	<1.3	**0.1-7.5**
Nitrate as Nitrogen (mg NO_3^-N/L)	0.6	<0.3	0.8	<0.3	**-**
Orthophosphate (mg PO_4^{3-}/L)	0.03	0.09	0.02	0.04	**0.01 - 0.8**

Parameter (Units)	**Dry Season Assessment**		**Wet Season Assessment**		**NRCA Ambient Water Standard - Freshwater**
	February 2023	**June 2015 (BRCC)***	**May 2023**	**November 2015 (BRCC)***	
	WQ1	**Sample 7**	**WQ1**	**Sample 7**	
Orthophosphate as Phosphorus (mg PO_4^{3-}-P /L)	0.01	0.03	0.01	0.01	**-**
Chloride (mg Cl^-/L)	<3.0	4.2	20.1	8.4	**5.0-20.0**
Faecal Coliform (MPN/100ml)	240	170	540	540	**-**
Total Coliform (MPN/100ml)	1600	>1600	>1600	>1600	**-**
E.Coli (MPN/100ml)	240	-	540	-	**-**
Faecal Enterococci (MPN/100ml)	170	-	350	-	

Parameter (Units)	**Dry Season Assessment**		**Wet Season Assessment**		**NRCA Ambient Water Standard - Freshwater**
	February 2023	**June 2015 (BRCC)***	**May 2023**	**November 2015 (BRCC)***	
	WQ1	**Sample 7**	**WQ1**	**Sample 7**	
Total Suspended Solids (mg/L)	11.2	16.8	20.2	8.5	**-**
Chemical Oxygen Demand (mg O_2/L)	<3	<3	43	7	**-**
Biochemical Oxygen Demand (mg O_2/L)	0.6	0.6	1.2	0.2	**0.8-1.7**
Fats, Oil & Grease (mg/L)	<1	1	2	<1	**-**

Parameter (Units)	Dry Season Assessment		Wet Season Assessment		NRCA Ambient Water Standard - Freshwater
	February 2023	June 2015 (BRCC)*	May 2023	November 2015 (BRCC)*	
	WQ1	Sample 7	WQ1	Sample 7	
Potassium (mg K/L)	0.73	-	0.87	-	**0.74-5.0**
Sodium (mg Na/L)	15.62	-	12.26	-	**4.5-12.0**
Pesticide Screen (ppb)	Not Detected	-	Not Detected	-	**-**

***BRCC – Black River Carrying Capacity Report, 2016**

5.1.4.8 TURBIDITY ISSUES

Turbidity and TSS parameters may lead to filtration unit requirement.

During the 2010 -2011 campaign mentioned in JPS EIA, TSS at Maggotty and Casa Marantha, that is upstream Lacovia, was comprised between 3.7 and 106 mg/L (24 samples, median at 25 mg/L)

During the 2014-2018 NEPA monitoring, TSS at Lacovia was comprised between 12 and 132 mg/L (12 samples, median at 21 mg/L).

Measurement early March 2019 show that turbidity is 4.11 NTU and total suspended solids is 6.5 mg/L.

- ⇨ TSS measurement is consistent, around 20 to 30 mg/L, and with rare peaks (5% of measurements) comprised between 100 and 150 mg/L.

Particle size should be measured in order to precise potential filtration equipment technical features.

5.1.4.9 SUMMARY OF MAJOR SURFACE WATER QUALITY ISSUES

Based on the data we could collect, the following points summarize the issue of Black River water quality regarding our project:

- **3 major industrial players** are located on the river, upstream from the possible NIC project pumping station at Lacovia :
    - **Sugar and rum factory Appleton Estate**. Appleton has abstractions rights from Black River (57 500 m^3/d), as well as from groundwater. Previous discharge in Black River proved to have serious impact on water quality and hydrobiology (see fish mortalities in 2009 and 2014). Current discharge remains unclear since we couldn't get specific data from NEPA nor Appleton; nevertheless no recent pollution episode is noticed.
    - **Maggotty hydro-powerplant from JSL**. The pipe by-passes the river on about 3 km, between Appleton and Algix fishfarm at Newton. Abstraction rights are 643 040 m^3/d. This unit will have no impact on NIC project.
    - **Algix fishfarm.** Water abstraction is considerable (220 000 m^3/d average, all year long), but water goes back downstream to Black River. Impact on the river dissolved oxygen is important (40% reduction between inlet and outlet), but as shown in our March 2019 analysis, O_2 is back to normal at Lacovia, and no BOD pollution seems to occur.
- **Analyses conducted at Lacovia or closely upstream in 2009-2011, 2014-2018 and 2019** are consistent and show:
    - large variation of **pH**, probably according to seasons and rainfall,
    - **punctual organic pollution (BOD)**, probably resulting from nearby sanitation or cattle breeding sources,
    - for the same reason **microbiological contamination**, since E Coli, for example, reaches 10^3 per 100 mL E Coli; according to French regulations on water REUSE, this water would reach B quality and should not be used for growing vegetable eaten raw
    - low level of nutrients such as NO_3 (< 2 mg/L) and phosphate (< 0.06 mg/L)
    - absence of either heavy metals nor pesticide pollution,

- **Turbidity and TSS** are quite low; TSS is comprised between 20 to 30 mg/L, with rare peaks slightly above 100 mg/L. Particle size has to be measured.

5.1.5 GROUNDWATER WATER QUALITY

This section of the report is based mainly on data collected through WRA website GIS database, completed with 4 samplings and analysis of Hounslow and Beacon Little Park.

5.1.5.1 GROUNDWATER ISSUE IN THE PEDRO PLAINS

Pedro Plains aquifer made is of **karstic calcareous limestone**. No surface water circulation can be observed: water is rapidly drained and infiltrates in the bedrock.

☞ ***See map 09 - Geology***

WRA identifies **salinization** as a major risk for the Pedro Plains aquifer. Thus water levels have to be thoroughly monitored, and abstractions controlled in case of watertable depletion to avoid seawater intrusion.

Both NIC and NWC have **abstractions rights** in the aquifer, the former for irrigation through Hounslow and Beacon Little Park irrigation blocks, the latter for drinking supply.

5.1.5.2 GROUNDWATER LEVELS

WRA website contains several long term monitoring data of groundwater levels at Hounslow and Beacon Little Park. The two following graphs were based on this data.

Following water levels give indication of the risks

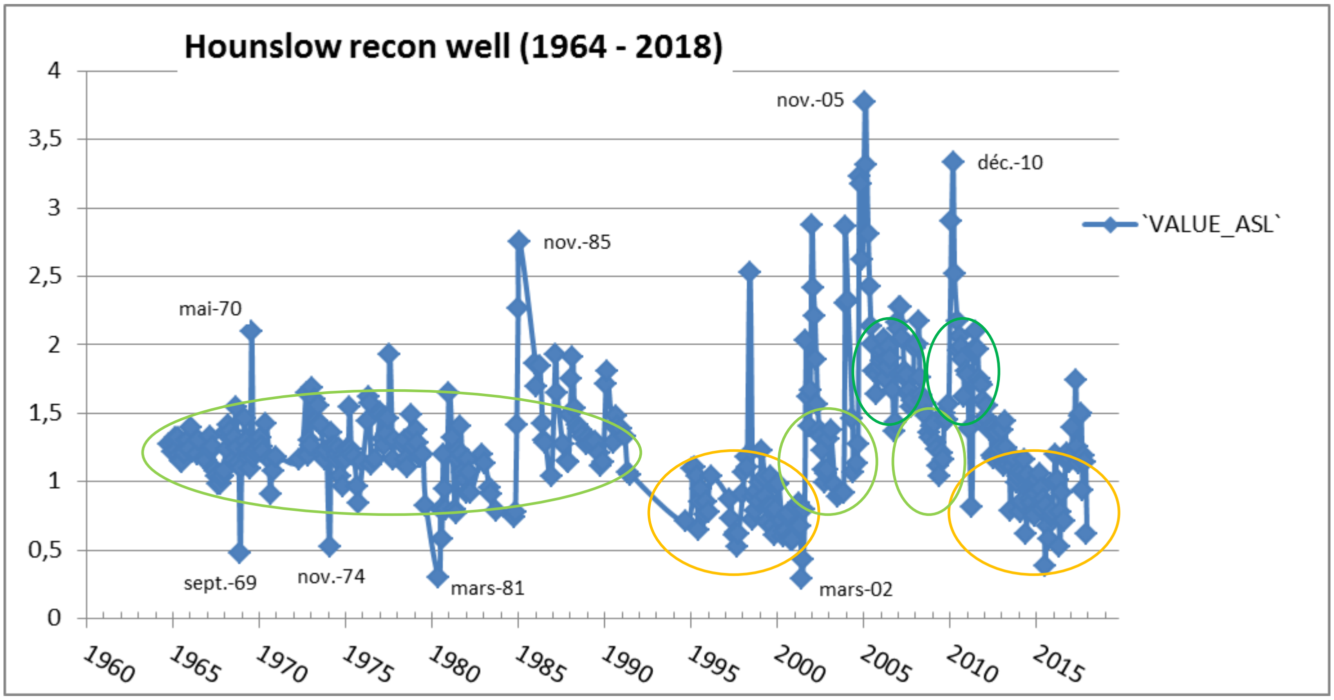


Figure 59 - Groundwater levels monitoring at Hounslow (source: WRA)

We notice for **Hounslow recon well** that the water level mainly ranges between 0.5 and 1.5 m above sea level, with high and low peaks.

- **Between 1964 and 1993**, levels are mainly comprised between 1 and 1.5 meters above sea level, which is sufficient to prevent from seawater intrusion; some rare points are below 0.5 m
- **Between 1994 and 2002**, levels are comprised between 0.5 and 1 meter above sea level, which is more risky but is probably enough to maintain freshwater dome against see intrusion; again specific points below 0.5 are noticed, and have to be avoided
- **Between 2003 and 2013**, again levels are globally comprised above 1m, even frequently rising over 2m
- **Since 2013**, levels are again comprised between 0.5 and 1 m; this security margin should be enough, but nonetheless groundwater quality has to be checked in order to identify eventual saline intrusion.

High and low peaks are probably due to specific climatic events.

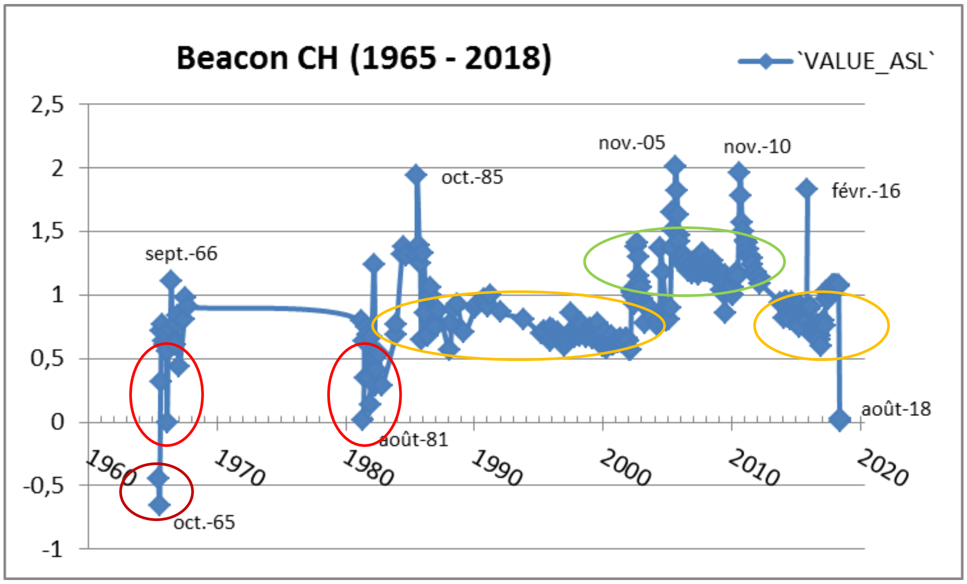


Figure 60 – Groundwater levels monitoring at Beacon (source : WRA)

We notice for **Beacon CH** that the water level mainly ranges between 0 to 1 m above sea level, with high and low peaks.

- **Between 1965 and 1968**, levels are comprised between 0.5 and 1 meter above sea level, which is risky, with even an extreme episode of watertable levels below sea level;
- **Between 1980 and 1982** a similar episode of hazardous low levels is noticed, between 0 to 0.5 m,
- **Since 1982,** level monitoring and control seems efficient, since all the points (except what seems to be an artefact in August 2018) are comprised between 0.5 and 1 m above sea levels,
- An episode of levels comprised above 1 m high is noticed **between 2003 and 2013**

Both for Hounslow and Beacon, ,**groundwater level management seems efficient since 80's**, with close monitoring and levels maintained between 0.5 to 1m above sea level. In the period ranging from 2003 to 2013, levels were maintained above 1.m.

High peaks (October 85, November 2005, November 2010) are globally similar to Hounslow recon well, which confirms impact of specific climatic events.

5.1.5.3 GROUNDWATER QUALITY

No recent data could be gathered on WRA website nor from any other source.

5.1.5.3.1 Hounslow (1966-1980)

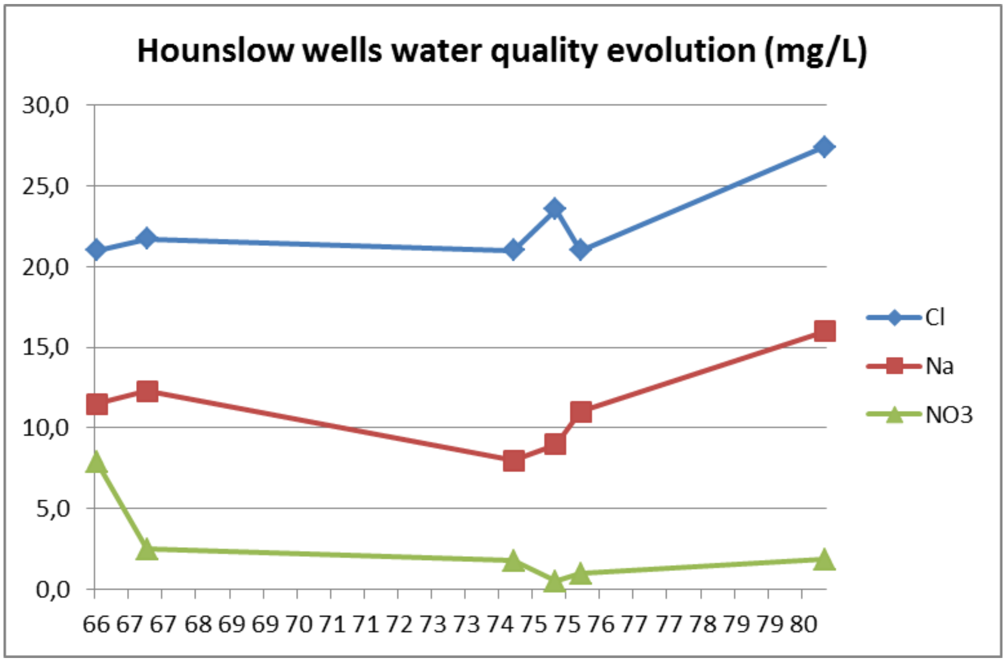


Figure 61 - Hounslow wells water quality evolution (source: WRA)

Measurements stop in the early 80's.

For Hounslow, **Cl and Na**, which may sign seawater contamination, remains quite low, close to the standard ranges for fresh surface water (which is 5-20 mg/L for Chloride, and 4.5 to 12 mg/L for Sodium). There is no evidence of seawater intrusion at this period.

No nitrate contamination is noticed since values are below standard range for freshwater (0.1 – 7.5 mg/L).

5.1.5.3.2 Beacon (1967-2004)

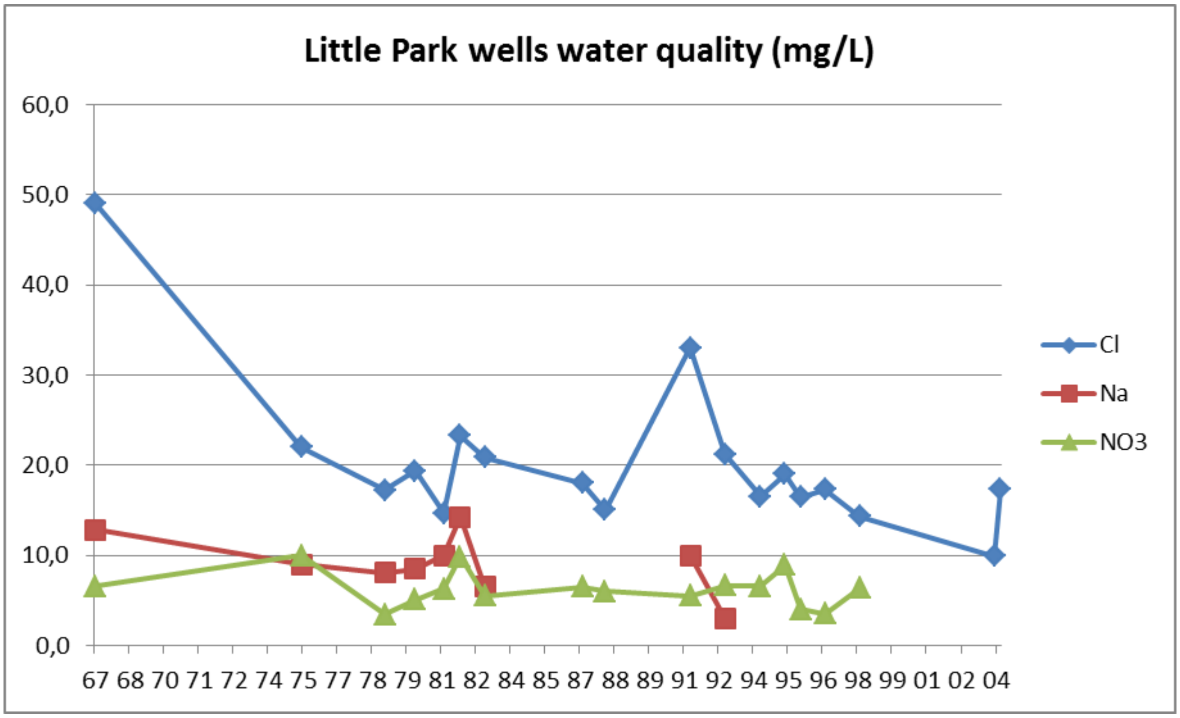


Figure 62 - Little Park wells water quality evolution (source WRA)

As for Hounslow, Cl or Na levels in Beacon do not indicate seawater contamination on the period. There had probably a **high level of Cl in the end of 60's**, correlated to low levels of watertable as seen above, which may sign overexploitation.

No nitrate contamination of groundwater is noticed, same as Hounslow.

5.1.5.3.3 Additional SCP data (2019)

SCP sampled 4 wells in March 2019 for the current study, focusing on 7 families of parameters.

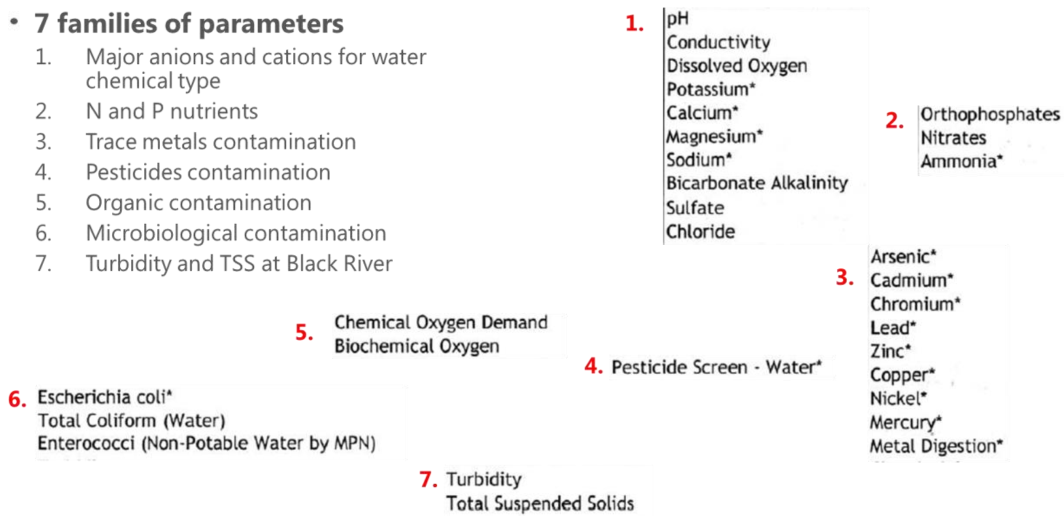


Figure 63 - Parameters analyzed for the SCP water sampling

Results show:

- **No evidence of seawater intrusion**, since values of Cl and N are very close to standard ranges for surface freshwater
- **No evidence of severe nitrate contamination**

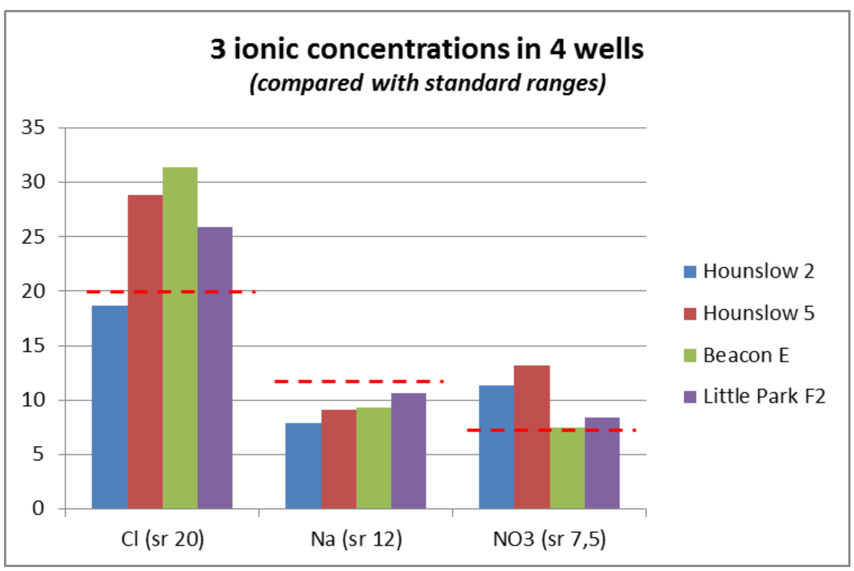


Figure 64 – Ionic concentrations in wells

Regarding other parameters:

- No trace metals nor organic pollutants contamination (below detection range)

- No bacteriological contamination (below detection range)
- No pesticide contamination (the chromatogram indicated the absence of pesticide residues)

5.1.5.4 SUMMARY OF MAJOR GROUDWATER QUALITY ISSUES

The following points summarize the situation of Pedro plains aquifer regarding our project:

- **Watertable levels are only 0.5 to 1.5 meters above sea level**, both for Hounslow wells (which in surface are about 25 to 30 meters high) and for Beacon Little Park (which in surface are 80 to 100 meters high). Thus, salinization risk from sea intrusion is important, as identified by WRA.
- However episodes of alarming decrease of watertable are now quite rare, and levels stay above 0.5 meters ASL, which means situation may well be under control considering current abstractions rights.
- As a result, **salinity of abstracted water remains low**, with Ec comprised in our March 2019 campaign between 423 and 616 µS/cm, and Cl- concentration between 18.7 and 31.4 mg/L.
- Despite intensive vegetable growing practices on the land, and despite karstic nature of the bedrock, it seems that groundwater quality is not affected by agricultural pollution (NO_3, PO_4 or pesticide)

Pedro Plains groundwater body seems currently properly managed, both in quantity and in quality. Neither irrigation or drinking water abstraction nor anthropic activity seem to threaten this resource, considering the data we have in our possession.

5.1.6 AIR QUALITY AND NOISE

5.1.6.1 SAMPLING METHODOLOGY

The objective of the air quality assessment and noise survey was to determine the existing conditions of the entire proposed project area inclusive of the area where the main pipeline is proposed to be placed, the proposed abstraction point and where reservoirs and smaller pipes are proposed to be placed (see Figure 4). The locations for the air quality and noise level sampling stations were selected based on the requirements of the terms of reference (TOR) received which indicated that the study area should include at least the area within a 1 km radius of the abstraction and storage points, as well as 250 m on either side of the route of the pipeline point of the proposed project area.

For the air quality assessment and noise survey, all equipment were calibrated prior to use and where applicable, field blanks were used for quality control purposes. Monitoring devices were placed away from any known sources to prevent bias in the data collected.

Detailed observations were made at all sampling stations which were georeferenced for traceability and for all monitoring requirements.

In addition to the requirements of the TOR, the locations of the sampling stations were chosen to represent the use of the land in the project sphere which is generally used for residential and farming activities with the remaining land being primarily open fields. Sites likely to be most affected by changes in air quality, for example, those areas with high human populations (e.g., schools, health centres, town squares) were considered for this exercise as these sites were determined to be some of the most sensitive receptors. A summary of the justification of the sites selected is presented in table below.

☞ ***See map 010- Air and noise level sampling points***

Table 46 - Summary of the Justification of Sites Selected

Site	Justification
AQ1	**High School** located in a **1km radius** of proposed abstraction point
AQ2	**Farm Area** located in a **1km radius** of proposed abstraction point and approx. **5m to the east** of the proposed pipeline trunk route.
AQ3	**Community Centre** located in a **1km radius** of proposed abstraction point
AQ4	**Residential home north of Open Lands** located in a 1km radius of proposed abstraction point
AQ5	**Church** situated off a main road in an area with residential houses and open lands approximately **230 m to the east** of the proposed pipeline trunk route.
AQ6	**Open Land** situated in between residential homes and more open fields approximately **255 m to the east** of the proposed pipeline trunk route.
AQ7	**Community centre** located in an area primarily surrounded by open lands approximately **165 m to the east** of the proposed pipeline trunk route.
AQ8	**High school** located approximately **300 m to the west** of the proposed pipeline trunk route.
AQ9	**Residential home in farming community** located approximately **150m southwest** of the proposed pipeline trunk route.
AQ10	**Residential home** in community that may be affected by impacts associated with **quarrying** located approximately **140 m to the southwest** of the proposed pipeline trunk route.
AQ11	**Residential home** mainly surrounded by **open lands** in an area where **minor pipelines and/or reservoirs** may be placed.

Site	Justification
AQ12	Residential home just north of the coast in general area where **minor pipelines and/or reservoirs** may be placed.
AQ13	Residential home surrounded by other homes, open lands, and farmlands where **minor pipelines and/or reservoirs** may be placed.
AQ14	Residential home surrounded by other homes, open lands, and farmlands where **minor pipelines and/or reservoirs** may be placed.
AQ15	Residential home surrounded by other homes, open lands, and farmlands where **minor pipelines and/or reservoirs** may be placed.

The concentration of respirable particulates (PM10) for air quality and the noise level in dBA was assessed.

Air quality and noise level sampling points are identified in figure below.

Particulate Matter

Particulate matter is the term given to small solid or liquid particles suspended in either a gas or liquid medium. The size of these suspended particles not only determines the lifespan of the particles within the atmosphere, but also its fate if breathed in by individuals. The size range of greatest concern to human health lies between 0.1-10µm; these are referred to as respirable particulates (PM10). Effects of the exposure of PM10 on human health include but are not limited to effects on the respiratory system, damage to lung tissue, cancer, and premature death. The extent of these effects will be influenced by the age and health of the affected individuals.

To minimize the potential impact of particulate matter on the health of people and the environment, the United States Environmental Protection Agency (USEPA) and the National Environment and Planning Agency (NEPA) have published national air quality standard which states that the maximum daily concentration should not exceed 150 µg/m3.

Particulate matter was measured using calibrated air pumps (with flow rates between 5-10L/min), attached to pre-weighed Polyvinyl Chloride (PVC) filters. The pumps were calibrated before use with a factory calibrated primary flow meter from Bios International Corporation. In the field, the pumps were placed at the approximate respiratory height of the individual/s for a 24 ± 4-hour period. After the 24-hour sampling period, the pumps were collected, and the filters returned to the laboratory where they were stabilised and weighed to determine a Time Weighted Average (TWA) value for the particulates.

The results at the end of the sampling period were compared to the National Environment and Planning Agency (NEPA) and the US EPA Ambient Standard.

Noise

The noise survey was completed at the same position where the air quality assessment was conducted (see Figure below).

Noise measurements were taken using a calibrated Quest SoundPro SE/DL series sound level meter, which conforms to the IEC 616721-1-2002 Class 2, Sound Level Meter Type 2, ANSI S1.4 – 1983 (R2001) Octave Band &1/3 Octave Band Filter Class 1, IEC 61260:2001 Octave Band & 1/3 Octave Band Filter Class 1, ANSI S1-11-2004 and ANSI S1.43 -1997 (R2002) Type 2 standards. The average high and low noise level readings taken over a 3-minute interval and recorded in decibels (dBA). Wind direction and any unusual local noise sources were documented at each sampling location. In addition, before and after the survey, the instrument was checked with a calibrator, which is pre-calibrated at the factory.

The results at the end of the sampling period were compared with NEPA Standard of 55dBA for Residential Areas.

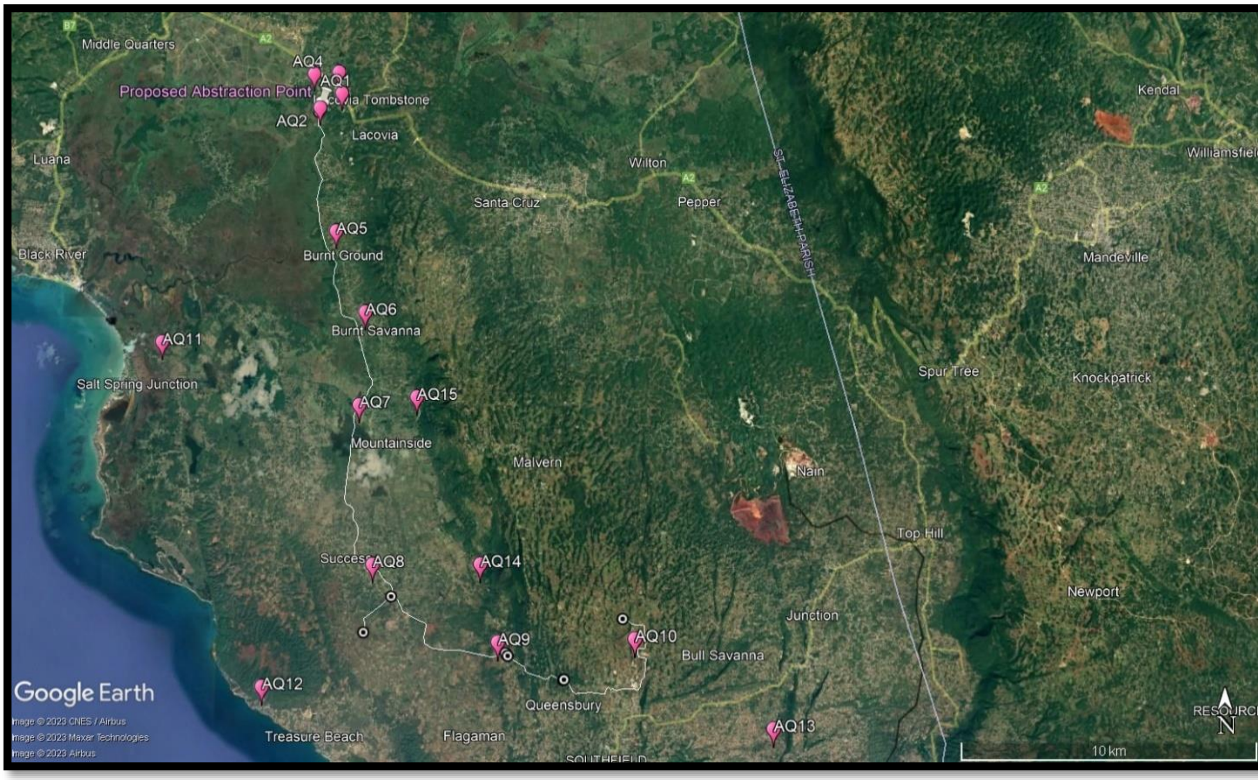


Figure 65 - Air quality and noise level sampling stations

5.1.6.2 AIR QUALITY SURVEY RESULTS

The description and location of each of the fifteen (15) air quality locations assessed in both February 2023 and May 2023 are presented in **Table 48**.The table below presents the results obtained from each site with respect to respirable (PM_{10}) particulates in the areas assessed. Given the observations made during the site assessments, sources of particulate matter generated from direct or indirect activities include, but are not limited to, those produced from vehicular emissions, the disturbance of unpaved or non-grassed areas from vehicles traversing or wind and the burning of garbage.

The hourly wind speed and wind direction for the period January 1, 2021 to May 1, 2023 was obtained from the Meteorological Service Climate Branch and was used to determine the prevalent wind speed (in knots) and direction of six sites (see **Figures 10 - 17**) which include:-

- Holland Bamboo – A community to the northwest of the proposed main pipeline route
- Flagaman – A community located south of the proposed main pipeline route
- Pondside – A community located to the west of the proposed main pipeline route
- Santa Cruz – A community located to the north of the proposed main pipeline route
- Mayfield – A community located to the southeast of the proposed main pipeline route

- Newcombe Valley – A community located to the west of the proposed main pipeline route

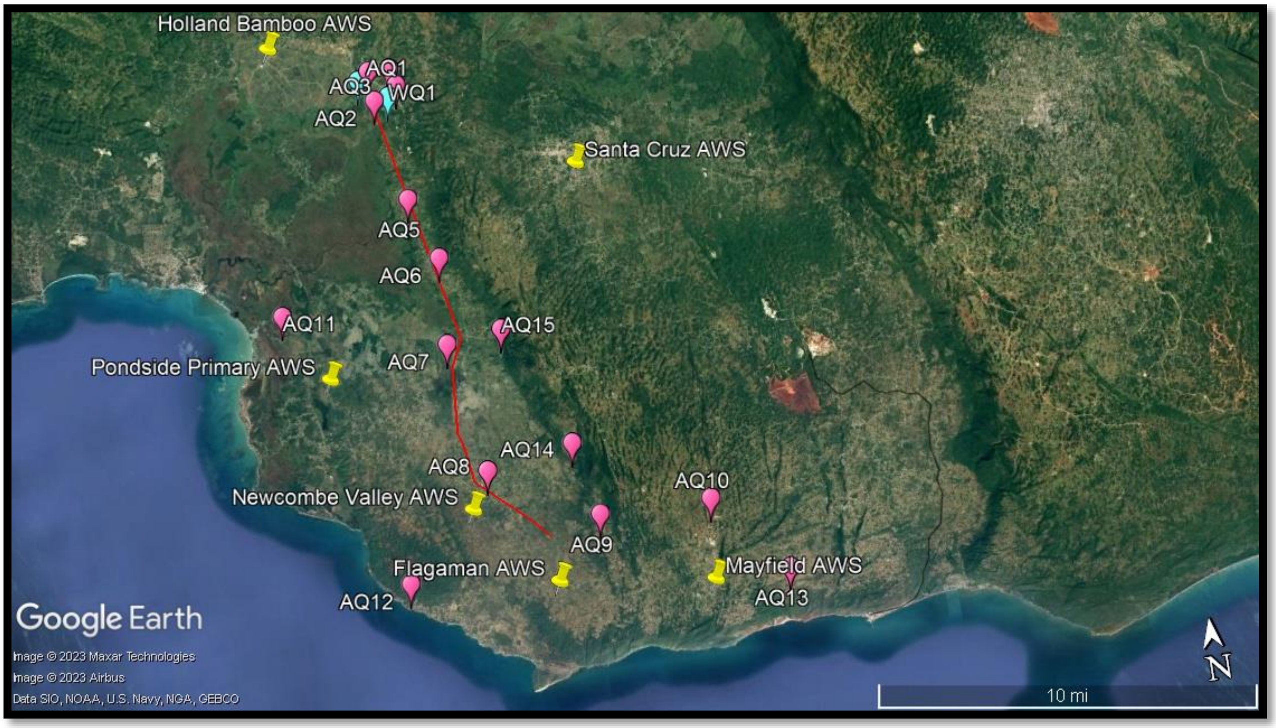


Figure 66: AWS Stations in Relation to the Proposed Pipeline

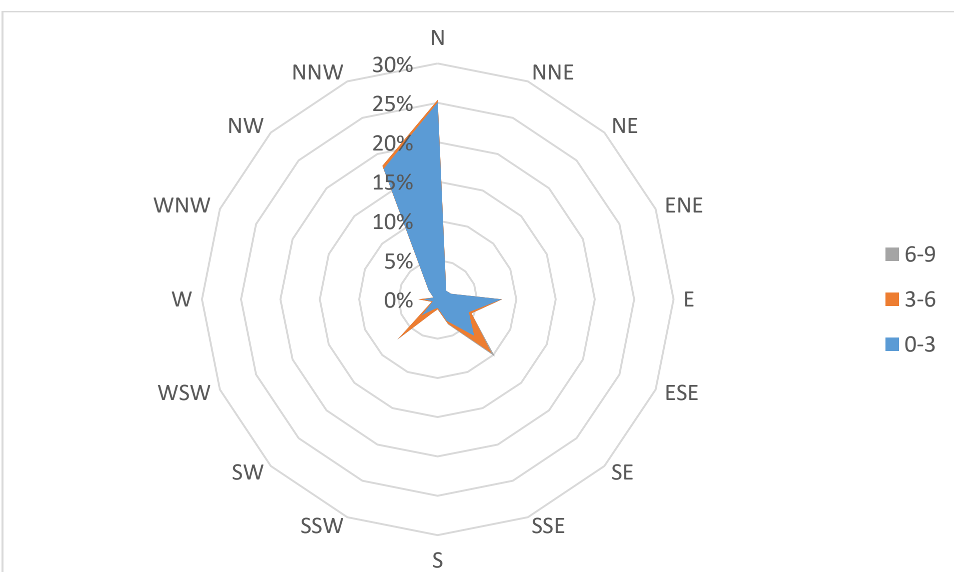


Figure 67: Windrose Showing Wind Speeds (in knots) and Direction in the Holland Bamboo Community

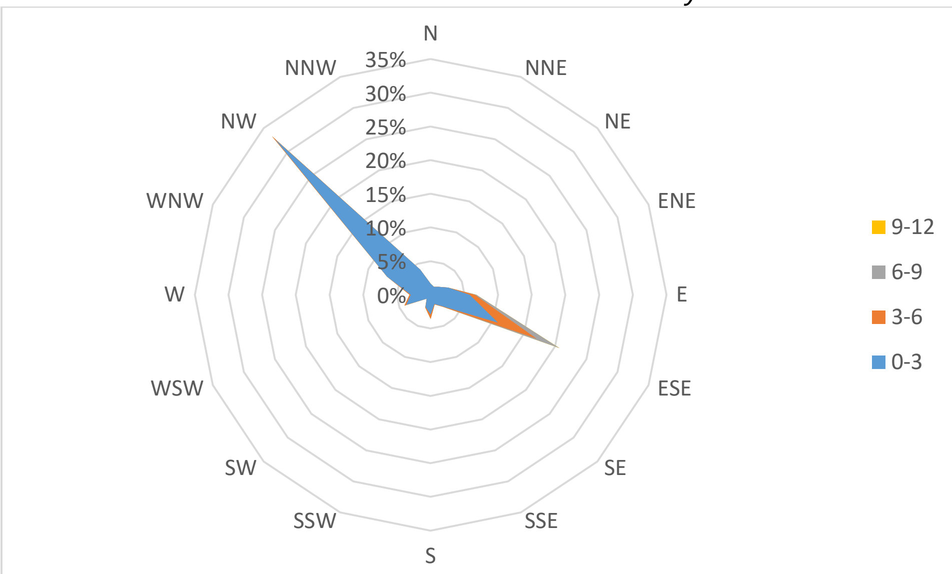


Figure 68: Windrose Showing Wind Speeds (in knots) and Direction in the Pondside Community

Figure 69: Windrose Showing Wind Speeds (in knots) and Direction in the Newcombe Community

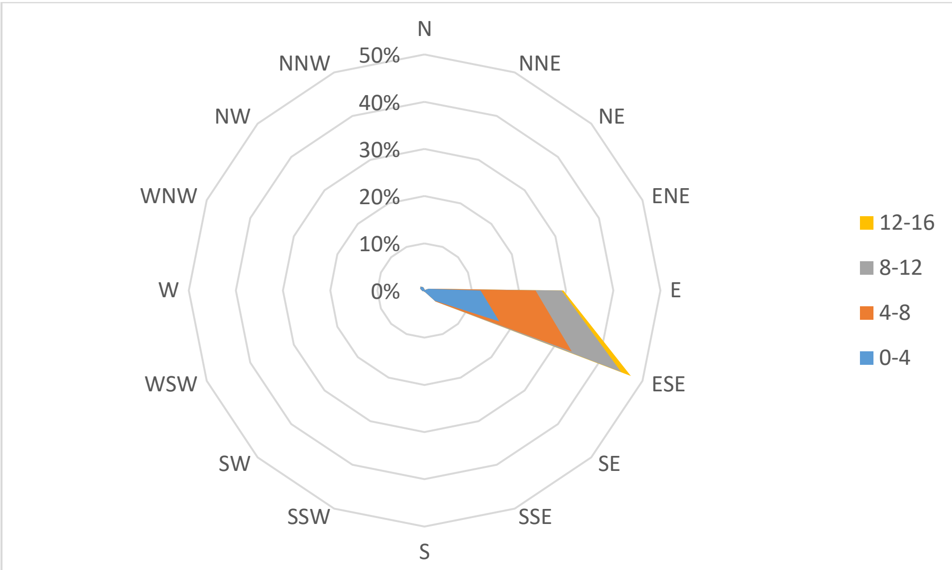


Figure 70: Windrose Showing Wind Speeds (in knots) and Direction in the Mayfield Community

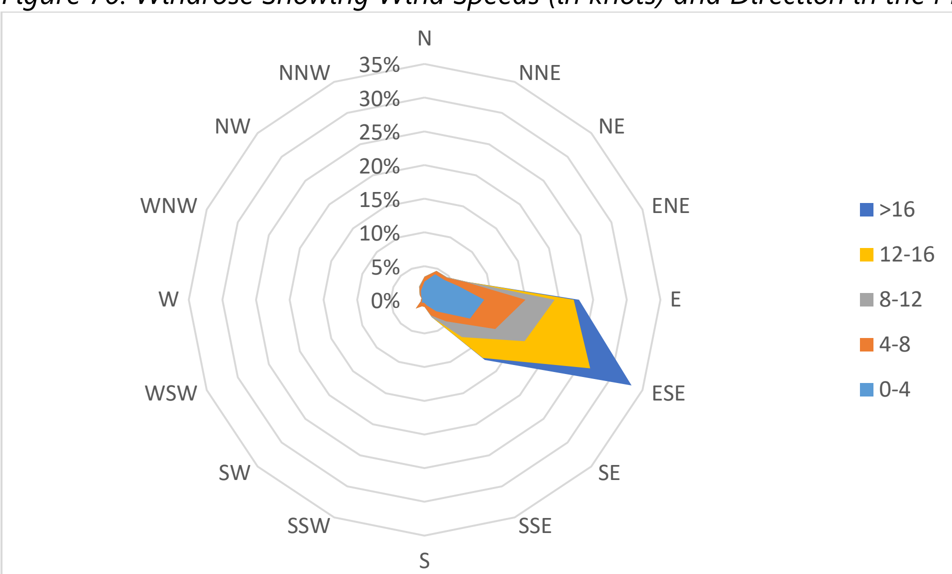


Figure 71: Windrose Showing Wind Speeds(in knots) and Direction in the Flagamans Community

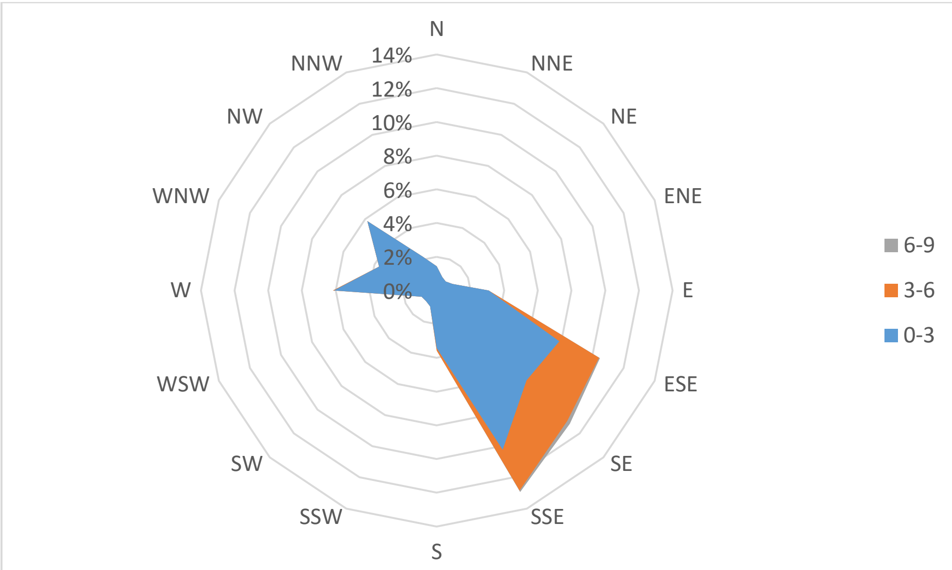


Figure 72: Windrose Showing Wind Speeds and Direction in the Santa Cruz Community

Based on the information obtained, the prevailing winds in the Flagaman, Mayfield and Newcombe communities originate primarily from the ESE and SE with winds up to greater than 16 knots and up to 16 knots for Mayfield and Newcombe. Similarly in the Santa Cruz community, the prevailing winds originated from the SE and SSE with winds up to 9 knots. However, the Pondside and Holland Bamboo communities have prevailing winds coming from the NW and N respectively with speeds up to 3 knots.

Based on the data obtained (with strong consideration given to the strength of winds in each community), sites possibly upwind or most likely to be impacted by activities of the pipeline, especially during the construction phase, include those in a western or northwestern direction from the southern half of the proposed main pipeline route.

Table 47 below indicates the results obtained for the air quality assessment conducted in February and May 2023. Based on the results obtained, it was seen that none of the sites with the exception of the particulate matter concentration obtained for AQ6 in the dry season, exceeded the standard value of 150 µgm^{-3} . In the dry season, the air quality data ranged from a minimum of 2.7 µgm^{-3} at location AQ8 to a high of 185.8 at location AQ6 while air quality data ranged from a minimum of <1.0 µgm^{-3} at locations AQ5 and AQ15 to a high of 72.1 at location AQ6. It must be noted however that heavy rainfall was experienced during the dry season assessment and as such the data obtained may not be an accurate representation of the PM_{10} concentrations in the dry season. The high particulate matter concentrations seen at AQ6 during both assessments seem to be atypical of the data set and observations made, however, there was an unpaved roadway close to the sampling location. Vehicles traversing this roadway could influence the amount of particulate matter in the air which could in turn affect the particulate matter concentration obtained. Similarly, AQ4 exhibited a high particulate matter concentration in the dry season as compared to the data

set, however, there was evidence of burning at this site as well as there was a partially exposed roadway in which vehicles use close to the pump set up location.
The data from both of these sites highlight the susceptibility of residents to increased particulate matter in areas where proper road infrastructure is not present, or debris burning is being done. The NIC will need to consider the conditions of the roads when determining the routes to be used during the transportation of equipment and materials to and from the areas where the pipelines will be built.

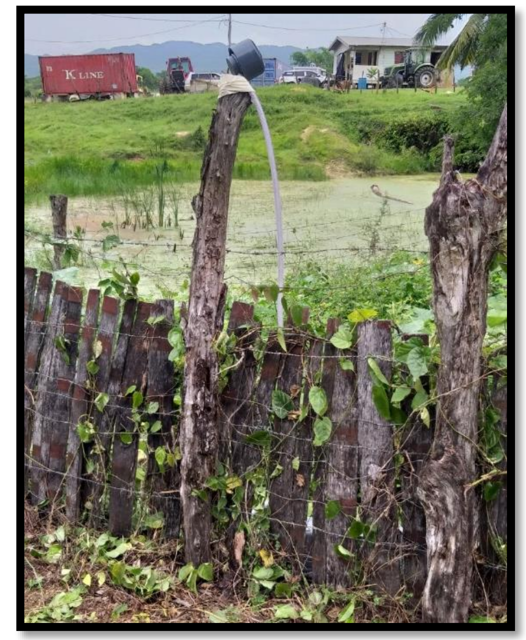
Table 47: PM10 Results for Samples Each Location during the Wet and Dry Season Assessments

Location	**PM_{10} Concentration (μgm^{-3})**	
	February 2023	**May 2023**
AQ1	11.1	59.2
AQ2	17.6	3.5
AQ3	21.2	66.0
AQ4	76.4	31.9
AQ5	2.8	<1.0
AQ6	185.8	72.1
AQ7	8.5	52.4
AQ8	2.7	1.4
AQ9	20.0	53.1
AQ10	20.7	68.3
AQ11	3.5	59.9
AQ12	13.9	18.8
AQ13	5.8	60.1
AQ14	19.4	57.6
AQ15	3.4	<1.0
Values in red indicate those points that would have exceeded the NRCA Particulate Matter Concentration (μgm^{-3}) for 24-hour Period Standard of 150.		

Table 48: Observations and Locations for Each Air Quality Assessment Point

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
AQ1	18.079973, -77. 760845	The pump was placed on the roof of the loft at the Lacovia High School. The pump area was free from the cover of trees or shelter. The surface of the roof has areas with chipped concrete, debris (both natural and man-made). A large ball field is located towards the northwest of the pump location and a series of classrooms is located towards the east of the pump location. There was evidence of burning to the south of pump set up location and a roadway was located about 75 ft to the south of the pump set up area.	Pump placed on roof of school in loft above ground level. Evidence of recent rainfall from the ponding water on the roof. The sixth form block located on the ground towards to the west of pump set up location while a block of classrooms located to the east. To the east of the pump, there was litter, exposed steel & PVC pipes. Gravel and large & medium rocks located on roof as well. An open field located towards the northwest of pump set up area and thick trees border school area to the west. Garbage seen on ground.

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		 **Environmental Conditions: Sunny with scattered clouds and light rainfall.**	 **Environmental Conditions: Sunny with broken clouds and very light winds**
AQ2	18.074951, -77.768266	The pump was placed on a light post approximately 50ft north of an asphalt road. Cars traversed this road sporadically. The roadway leading up to the area was grassed with piles of marl seen towards either side. There were containers, a water body and an open area surrounding the pump. Cows were located towards the south of the pump	The pump was placed on a fence post approximately 15 ft north of a road that's sporadically traversed. Leaf litter seen on the ground and pumpkin patch seen nearby to pump location. During the assessment, a truck passed on the road carrying marl. The main road towards the south of the pump set up location is paved while the

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		set up location in an enclosed farm area across the asphalted road. Chickens were observed on site.  **Environmental Conditions: Light rainfall, overcast and cool.**	roadway to the farm has exposed gravel & dirt. Few manmade debris seen on the ground. Area densely vegetated with trees seen to the south of the pump set up area. Farmland located towards the north of the pump set up location was not heavily vegetated, and areas of exposed dirt were seen.  **Environmental Conditions: Light winds, overcast, humid**
AQ3	18.086987, -77.762117	The pump was set up on an open lawn, approximately 50ft west of the Lacovia Community Center and 50ft east of a busy main road. Weeds were seen in otherwise	The pump was placed in an open field approximately 50 ft to the west of a community centre and 50 ft to the east of a busy main road. Grass in the area is tall and natural

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		relatively low grass. No debris was seen; however, cow dung was observed on the ground. There were residential homes, a carwash, and a church nearby to this community center.  **Environmental Conditions: Overcast skies (recent heavy rainfall)**	debris was seen on the ground. Community center appears to be well maintained. A few trees were observed at a fair distance from the pump set-up location. Cow manure was seen on the ground.  **Environmental Conditions: Light winds, broken clouds, sunny, humid**
AQ4	18.086177, -77.768497	The pump was placed on a light post approximately 20 feet south of two residential homes. A small, graveled road was directly in front (to the north) of the pump. A farm husbandry area (with pigs, goats, and chickens) was seen approximately 15ft south of the pump location. Goat dung and debris were seen adjacent to sample set up area. Chickens were seen on the lawn directly behind (to the north) the pump area. A marl heap was observed approximately 20 ft to the west of the pump location. There was charred ground near the pump location.	The pump was placed on a light post approximately 2 ft from a minor infrequently traversed road. A small tree was located approximately 4-6 feet from the pump site. Areas where garbage is burnt were seen approximately 15 ft from pump location, minor road has some exposed areas of gravel & dirt. Man-made and natural debris seen littering as ground. Informal farm seen in 50 ft from pump location (hogs, cows, goats & chicken). Grass seen on the other side of road. Houses seen to back of pump location. Marl heap and area to mix concrete also seen close to homes.

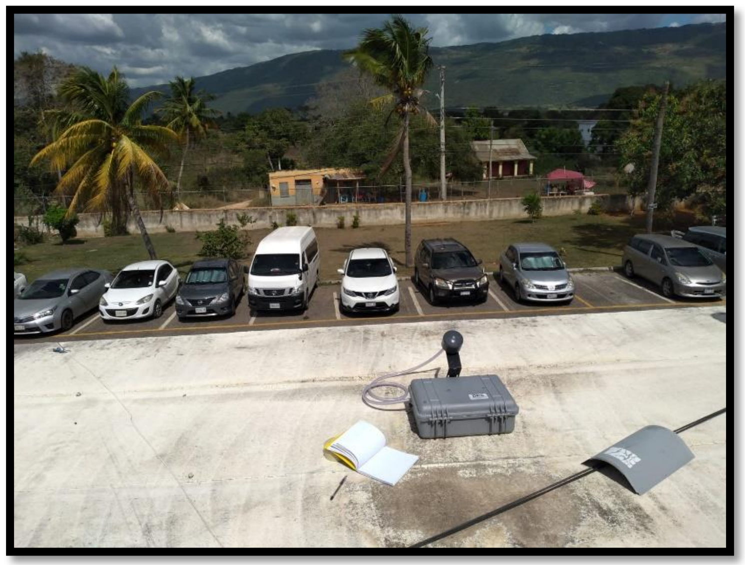
Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		 Environmental Conditions: Very light rainfall, overcast skies, cool	 Environmental Conditions: Light winds, broken clouds, humid

<table>
<tr><th rowspan="2">Sample Location</th><th rowspan="2">GPS Coordinates</th><th colspan="2">Description</th></tr>
<tr><th>February 2023</th><th>May 2023</th></tr>
<tr><td>AQ5</td><td>18.035261,
-77.761895</td><td>The pump was placed on a makeshift basketball hoop in an open area. The ground was a grassed area with partially exposed areas of dirt. Birds were seen near the sampling area. The area was approximately 150 ft from a relatively busy roadway. There was marl on the ground southwest of the set-up area. The sampling location was bordered with fruit trees and vegetables. There was evidence of burning west of the pump set up location.
</td><td>The pump was set up on a concrete column approximately 50 ft from the main road. Church unoccupied during pump set up. Driveway to the east of pump location unpaved. Goats were seen nearby pump location along with natural and man-made debris on the ground. Several large fruit trees were seen on the property and two heaps of marl were observed 30 ft & 50 ft to the east of the pump set-up locations. A ball field was observed further east of the pump set up area which was not well maintained. An open patio to the direct south of pump set up location seems to be a place for equipment and material storage.</td></tr>
</table>

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		Environmental Conditions: Damp, cool with light winds.	 **Environmental Conditions: Humid, warm, light winds, overcast.**
AQ6	18.009402, -77.751612	The pump was set up in an open field situated between two concrete houses. Blocks and other construction material were seen close by. Goats and pigs were observed close to the pump set up area. There was a marled road with exposed areas seen to the north of pump set up area. This road is traversed sporadically. A busy main road	Pump placed in open field situated in between two houses. Area pump placed on grassy. Mature trees seen close by pump location. A truck, car & concrete blocks were observed close to the pump area. There was a marled road with exposed areas seen approximately 50 ft north of pump location. Goats & pigs were seen near the pump

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		can be seen through the trees in the distance to the south-east of the pump set up location.  at the **Environmental Conditions: Damp and cool with light winds**	location. A busy main road can be seen through the trees in the distance to the south-east of the pump set up location.  **Environmental Conditions: Light rain drops, humid, warm, overcast.**
AQ7	17.980097, -77.753053	The pump was placed in an open field approximately 100ft north of the community center. The ground of the field was grassed, and the pump location was approximately 300ft south of a paved roadway. The ground was moist from recent rainfall.	The pump was placed in an open field. The ground of the field was grassed and had grazing animals (goats and sheep). The ground was moist from recent rainfall.

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		 Environmental Conditions: Cool, light winds	 Environmental Conditions: Overcast skies with little to no winds

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
AQ8	17.930653, -77.747633	The pump was placed on a relatively clean concrete roof away from any obstacles at Newell High School. The nearest building was approximately 100 feet away from the pump location. The roof was relatively clean.  **Environmental Conditions: Partly Cloudy, sunny skies with light to moderate winds blowing in an easterly direction**	The pump was placed on the roof of the Newell High School. A classroom to the west of the pump location was being drilled. The pump location had heavy northwesterly winds. A paved roadway was located on the ground approximately 80 feet from the pump location. Vehicles were in the parking lot while cars and bikes were passing on this road.  **Environmental Conditions: Very windy, sunny**

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
AQ9	17.907297, -77.706399	The pump was placed on a concrete pavement away from any obstacle. The area around this concrete pavement was grassed. **Environmental Conditions: Overcast skies with heavy winds blowing in a north-westerly direction.**	The pump was placed on top of a concrete base approximately 50ft southwest of a house. The place was damp from recent rainfall. Vegetation present in the yard.

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
			 **Environmental Condition: Overcast skies with moderate to strong winds blowing in a westerly direction.**
AQ10	17.908879, -77.662272	The pump was placed in front of a house ~20 ft on top of a hill which is located about 600ft northeast of an active quarry site. The front of the yard in which the pump was placed was heavily vegetated. A major thoroughfare was ~150 ft upwind of but below the sampling site.	The pump was placed approximately 20ft south of the house which is located on top of a hill. An active quarry is located approximately 600 ft in a northeast direction from the sampling site. A busy thoroughfare is also located approximately 150ft northeast but below the sampling site. The area was damp from recent rainfall.

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
		 **Environmental Conditions: Overcast with moderate to heavy winds blowing in a north-westerly direction.**	 **Environmental Conditions: Overcast with light winds blowing in a northwesterly direction.**

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
AQ11	17.999925, -77.818724	The pump was placed on a chain link fence approximately 60ft from a main road. A gazebo and a residential home were located approximately 20 and 35ft south of the pump set up area respectively. An open lot was located to the east of the pump set up location. There was a paved driveway located to the west of the pump set up location and tents with items for sale and trucks were seen in the yard. **Environmental conditions: Overcast with light winds**	The pump was placed in an open grassy section of a residential home. The pump's location was approximately 50 ft south of a busy main road. There were a few mature trees located in this residential home. The home was located approximately 35 ft south of the pump set up location. Another house was located approximately 25ft to the west of the pump set up location.et from pump set up to the left of pump set up location. Tents and other materials were located to the east of the pump location.

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
			 **Environmental Conditions: Light rainfall, broken clouds, sunny**
AQ12	17.893559, -77.782708		The pump was placed on a light post approximately 30ft from a paved roadway. Immediately to the west of the pump location was an unpaved roadway. Residential homes were located to the immediate east and approximately 15ft to the west of the

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
			pump set up location. Dogs were barking in an adjoining fence. Goats, pigs, and chickens were in the yard space. 

<table>
<tr><th rowspan="2">Sample Location</th><th rowspan="2">GPS Coordinates</th><th colspan="2">Description</th></tr>
<tr><th>February 2023</th><th>May 2023</th></tr>
<tr><td></td><td></td><td></td><td>Environmental Conditions: Windy, sunny, northeastern winds</td></tr>
<tr><td>AQ13</td><td>17.881465,
-77.618033</td><td>The pump was located ~ 25 ft east of the house. The front of the house was grassed with a dirt track to the immediate left of the premises. A paved road was located ~60 ft from the sampling site and west of the house.

Environmental Conditions: Scattered Clouds, Sunny with light winds coming from a south-westerly direction</td><td>The pump was placed 20ft east of a house in a well-grassed area. A busy throughfare is located 60 feet east of the sampling site. However, a paved roadway was located towards the east of the sampling location. The vehicular traffic at this location is moderate and includes bikes and motor trucks and cars.
</td></tr>
</table>

Sample Location	GPS Coordinates	Description	
		February 2023	May 2023
			Environmental Conditions: Sunny and partly cloudy skies with high to moderate winds blowing in a north-easterly direction. Relatively dry surroundings.
AQ14	17.930790, -77.712530	The pump was placed on the roof of the house. A large tree was located ~25ft away from the sampling location. A mountain was located a few meters in an eastern direction from the sampling site. A paved road was also located ~75 ft in an eastern direction from the house.  **Environmental Conditions: Overcast Skies with little winds**	The pump placed on a roof top approximately 20 feet from grassed yard. The ground was damp from recent rainfall. **Environmental Conditions: Overcast skies with light to moderate winds going in an easternly direction.**

<table>
<tr><th rowspan="2">Sample Location</th><th rowspan="2">GPS Coordinates</th><th colspan="2">Description</th></tr>
<tr><th>February 2023</th><th>May 2023</th></tr>
<tr><td>AQ15</td><td>17.982551,
-77.734000</td><td>The pump was placed on a set of blocks ~8 ft high away from trees and other objects. The yard was grassed with a dirt track leading to the house.

Environmental Conditions: Light winds and overcast skies with very light rainfall</td><td>The pump was placed in a pile of blocks, approximately 8 feet above the ground. The yard of the property is primarily grassed. A marled road is located approximately 50ft southwest of the property.

Environmental Condition: Overcast skies with light northwesterly winds</td></tr>
</table>

5.1.6.3 NOISE LEVELS

Noise measurements were taken at the same fifteen (15) sites as the air quality samples. The measurements were taken at these locations to determine the existing environmental conditions with respect to noise in the project area of influence. Noise readings were taken at areas within or approximately 250m from the proposed main pipeline route and in areas where smaller pipelines and reservoirs may be placed. The description of the noise survey sites, and the noise readings obtained at each location are presented in **Table 50**. The average noise levels and their relation to the NEPA Ambient Noise Standard for Residential Areas is presented in **Table 49** below.

The average noise levels ranged from a low of 52.5 dBA (site AQ4 and AQ6) to a high of 89.0 dBA (site AQ9) in the February 2023 assessment while it ranged from a low of 46.1 dBA (site AQ7) to a high of 85.9 (site AQ5) during the second assessment conducted in May 2023. Although a standard value of 55dBA is being used, it must be noted that there were schools located at sites AQ1 and AQ8 which would be classified as silent zones while in operation. In these cases, the noise level should not exceed 45 dBA. In both seasons, the noise level at these two locations (AQ1 – Lacovia High School & AQ8 – Newell High School) exceeded this range. However, important to note is that the noise levels at these locations could also be attributed to activities of the school (e.g., chatter from school children, school maintenance activities etc.) and not solely to external factors in the environment such as vehicular noise.

Table 49 - Average Noise Levels obtained for Each Site in both Seasons

Sample Location	**February 2023 Assessment**			**May 2023 Assessment**		
	Day 1	**Day 2**	**Avg**	**Day 1**	**Day 2**	**Avg**
	Noise Level (dBA)			**Noise Level (dBA)**		
AQ1	61.6	58.5	60.1	79.3	53.5	66.4
AQ2	61.9	57.2	59.6	101.3	48.7	75.0
AQ3	59.8	65.9	62.9	98.1	67.5	82.8
AQ4	56.6	48.4	52.5	101.5	66.6	84.1
AQ5	53.6	60.1	56.9	101.1	70.7	85.9
AQ6	49.1	55.8	52.5	104.0	62.5	83.3
AQ7	61.0	61.2	61.1	40.9	51.3	46.1
AQ8	75.7	62.7	69.2	77.7	108.7	93.2
AQ9	89.0	63.2	76.1	62.0	64.6	63.3
AQ10	75.3	74.3	74.8	66.5	65.8	66.2
AQ11	65.6	78.9	72.3	108.8	60.9	84.9
AQ12	79.0	61.5	70.3	78.8	102.3	90.6
AQ13	67.3	72.1	69.7	54.6	48.1	51.4
AQ14	52.7	78.9	65.8	51.2	63.0	57.1
AQ15	57.3	52.1	54.7	46.8	50.3	48.6
*Values in red indicate those average noise values that would have exceeded the NEPA Ambient Noise Standard of 55 dBA.						

The noise level for each of survey locations would have exceeded the NEPA Ambient Noise Standard of 55dBA (for residential areas) either in the first assessment or the second assessment for all the sites with the exception for site AQ15. This sampling site was located in a relatively quiet neighborhood. Common sources of sound at each sampling location, regardless of the assessment period, include those from vehicular traffic and animal sounds. This highlights the susceptibility of the communities where the pipeline may be placed to unwanted noise due to not only the construction of the pipeline but also to the passage of trucks and other heavy machinery especially during the construction phase. Based on this, it is imperative that a maintenance and transportation schedule be developed by the NIC to ensure that: -

- Trucks and other machinery being operated are maintained to reduce any additional noise impacts due to improperly maintained vehicles.
- Operations are done within a specified time frame to minimise the impact of unwanted noise in affected communities especially during the night-time.

Given that a noise survey was conducted (over separate 3-minute periods) rather than a noise assessment, the results obtained are not atypical of what may be seen during the regular day-to-day activities of a community. For example, conversational speech levels are often noted to have an unweighted sound level of about 60dB, typical street traffic is noted to have a sound level of about 70dB and car horns can have sound levels of up to 110dB.[24] As such, it is recommended that additional assessments be done to derive a baseline representative of the existing communities.

[24] https://www.noisequest.psu.edu/noisebasics-basics.html#:~:text=A%20sound%20level%20of%200,the%20human%20ear%20as%20discomfort.

Table 50 - Noise Survey Locations, Descriptions and Levels at Each Sampling Location

Sample Location	GPS Coordinates	February 2023				May 2023			
		Day 1		Day 2		Day 1		Day 2	
		Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)
AQ1	18.079973, -77. 760845	Rustling leaves, few cars traversing roadway in the distance and loud chatter from school children	61.6	Loud chatter from school children, rustling noises from light winds, rooster in background	58.5	Chatter and loud noises from school children, birds in near distance and water dropping on ground near survey point	79.3	Chatter and birds chirping in distance	53.5
AQ2	18.074951, -77.768266	Birds chirping, chatter, distant music, car motor running, thunder, and light rainfall	61.9	Car throttling, motorbike, birds chirping and rustling noises from wind	57.2	Cars throttling, truck passing with its horn blowing, chatter in distance and birds chirping	101.3	Birds chirping and noise from leaves rustling	48.7
AQ3	18.086987, -77.762117	Thunder and cars traversing busy roadway	59.8	Welding, trucks, and cars traversing on busy main road, music in distance	65.9	Cars and motorcycles passing on busy main road, rustling from trees and crickets in background	98.1	Frequent vehicular noise, trucks, and construction noises	67.5
AQ4	18.086177, -77.768497	Thunder, sporadic car movement, distant chatter, and chickens squawking	56.6	Music playing in distance, cow bellowing, vehicular noises in distance	48.4	Roosters crowing, birds chirping, hogs, TV in distance, crickets, goats bleating, light rustling of trees, cars in distance on main road	101.5	Music playing in the distance, grass cutting in the distance, metal clanking noise and noise from kids playing football in the distance	66.6

Sample Location	GPS Coordinates	February 2023				May 2023			
		Day 1		Day 2		Day 1		Day 2	
		Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)
AQ5	18.035261, -77.761895	Music in distance, birds chirping, construction noise, roosters and goats bleating	53.6	Construction noises, birds chirping and dogs barking	60.1	Lawn mower and weed wacker in distance, children playing, sporadic car movement on main road, roosters crowing	101.1	Chatter and construction noises	70.7
AQ6	18.009402, -77.751612	Goats bleating, birds chirping, chatter in distance and vehicular noise	49.1	Rustling leaves, construction in background, goats, vehicles in distance	55.8	Goats bleating, chatter, vehicles in distance, birds chirping, dogs barking in distance and car motor throttling	104.0	Chatter and rustling noise form light winds in distance	62.5
AQ7	17.980097, -77.753053	Goats bleating and chatter	61.0	Chatter, rustling leaves, and vehicles in distance	61.2	Birds chirping and sporadic vehicular passage	40.9	Birds chirping in distance, dogs, roosters and rustling from light winds	51.3
AQ8	17.930653, -77.747633	Loud chatter from school children and sporadic vehicular noises	75.7	Bikes and motorcars in distance, chatter and the movement of desks and chairs	62.7	Chatter from kids, drilling of wall, rustling from heavy winds,	77.7	Chatter from kids, birds chirping and cars and bikes sporadically passing area	108.7
AQ9	17.907297, -77.706399	Rustling leaves, chatter, and dogs barking	89.0	Rustling leaves, chatter, and sporadic passage of vehicles	63.2	Birds chirping, goats bleating, rustling of leaves and sporadic passage of bikes	62.0	Birds chirping, goats bleating, rustling of leaves and sporadic passage of vehicles	64.6

Sample Location	GPS Coordinates	February 2023				May 2023			
		Day 1		Day 2		Day 1		Day 2	
		Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)
AQ10	17.908879, -77.662272	Heavy machinery in distance and vehicular traffic	75.3	Few cars traversing roadway, lawn mower in distance and chatter	74.3	Vehicular noises, birds chirping, heavy equipping operating in distance	66.5	Vehicular noises, birds chirping, heavy equipping operating in distance	65.8
AQ11	17.999925, -77.818724	Sporadic passage of vehicles, birds and rustling from light winds	65.6	Cars traversing roadway, chatter, rustling from light breeze and birds chirping	78.9	Loud chatter, cars passing sporadically, birds and rustling from light winds	108.8	Cars traversing roadway, chatter, rustling from light breeze and birds chirping	60.9
AQ12	17.893559, -77.782708	Cars traversing roadway, dogs barking and chatter	79.0	Cars and trucks traversing roadway and rustling leaves	61.5	Dogs barking, pig and goats bleating and rustling from winds	78.8	Bikes and other vehicles sporadically passing location, music playing in the distance and rustling from winds	102.3
AQ13	17.881465, -77.618033	Sporadic passage of vehicles, rustling leaves and birds chirping	67.3	Music in distance, dogs barking, cars traversing on roadway and car throttling in distance	72.1	Vehicular noise in distance	54.6	Vehicular noise in distance	48.1
AQ14	17.930790, -77.712530	Roosters crowing, birds chirping, bike and cars sporadically passing and frequent thunderclaps	52.7	Sporadic car movement, light chatter in background and rustling noises from light winds	78.9	Birds chirping, rustling leaves and the sporadic passage of bikes	51.2	Vehicular noises and rustling leaves	63.0

Sample Location	GPS Coordinates	February 2023				May 2023			
		Day 1		Day 2		Day 1		Day 2	
		Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)	Sources	Noise Level (dBA)
AQ15	17.982551, -77.734000	Birds chirping, chatter and sporadic vehicular traffic	57.3	Birds chirping, chatter and sporadic vehicular traffic	52.1	Chatter, birds chirping, rooster crowing and the sporadic passing of bikes	46.8	Birds chirping, chatter and sporadic vehicular traffic	50.3

5.2 ECOLOGICAL BASELINE ASSESSMENT

An ecological baseline assessment was conducted by the specialised team Environmental Solutions to characterise the flora and fauna along the proposed pipeline route. In general, it is impractical for an ecological assessment to consider every individual species and habitat that may be potentially impacted by development. As such, the focus is given to rare, threatened, endangered, endemic, protected, invasive and economically important species. Additional species (flora and fauna) known either from previous surveys of the site or from areas nearby have been included in discussions since they are likely to occur. For example, the mention of neotropical migrant warblers is relevant and therefore included as migration peaks between September and May. All species identified during the field visits are presented in the species list appended to this report.

5.2.1 MAIN FEATURES

The area of interest for the proposed pipeline network can be classified as disturbed to highly disturbed. The portion that falls within the northern sections of the Black River Lower Morass (BRLM) show signs of significant anthropogenic influence, particularly the site identified for the intake and pumping station #1 as is located on a vast animal farm where natural vegetation has been cleared. Similarly, the pipeline route and sites for Pumping Stations #2 to #4 and Reservoirs #1 to #4 cross lands that have been historically cleared for conversion for use in agriculture, residential settlements and supporting infrastructure.

Appropriate mitigation measures for the identified impacts of the development will be considered in chapter 6. In particular, the pipeline route that runs from the intake to Burnt Savannah is characterised as morass/marshland, is a unique landscape of considerable conservation value.

5.2.2 EXISTING FLORA AND FAUNA

5.2.2.1 PLANTS

Plant communities were assessed using Google Earth images and the results used to stratify sampling. Comprehensive lists of plants in the main habitat types were developed based on field surveys on October 10 and 11, 2019. All plants were identified to the species level by examining morphological features such as leaf arrangement, leaf pattern, pattern of branching, and morphology of floral and fruiting structures in conjunction with the use of Adam's (1972) iii Flowering Plants of Jamaica and the Plant Net© application. Unknown plants were photographed or collected and identified at the University of the West Indies Herbarium. All plant species observed were recorded and each species was given a DAFOR[25] rating based on their abundance relative to the entire site and not on sectional abundance. A site visit on February 8, 2023 served to confirmed that the ecology of the project area remained in similar condition as it did during

[25] Dominant (D), Abundant (A), Frequent (F), Occasional (O), Rare (R)

the 2019 assessment. The flora and fauna identified are the same and no new species were identified.

5.2.2.2 BIRDS

Point Counts

The point count method was utilized to be able to identify differences in species composition between habitats and abundance of different species at a set location. The method is widely employed in the Caribbean (as per Wunderle et al. 1994 for sampling birds in the Caribbean), particularly in terrain characterised as rugged or dense, scrubby vegetation. Points were chosen that were as close to the alignment of the pipeline as possible in order to be representative of the habitat along the route. The point counts were conducted at six-minute intervals recording all birds detected (whether seen or heard) and used to calculate an abundance index for each species, where the total number of individuals was weighted by the number of points where they occur and the total number of points. In total, at least two point counts were conducted approximately 50-100m apart at each of the sites identified in

Table. The number of species and individuals of all species were recorded.

Table 51 - Coordinates for Point Counts along pipeline route

Site #	Site	Location	Date	Time	Longitude	Latitude	Elevation[26]
1	Pumping Station #4 + Reservoir #3	Queensbury	October 10, 2019	08.30	-77.682571	17.89967741	250m ASL
2	Reservoir #1 Option A	Pedro Plains Road	October 10, 2019	10.45	-77.726507	17.89361052	110-125m ASL
3	Reservoir #1 Option C	Beacon	October 10, 2019	12.00	-77.716055	17.90183804	110-125m ASL
4	Pumping Station #3 + Reservoir #2	Round Hill	October 10, 2019	13.30	-77.702938	17.90881174	250m ASL
5	Reservoir #4	Berlin	October 10, 2019	15.30	-77.663521	17.92120607	740m ASL
6	Intake and Pumping Station #1 (Lacovia, Black River)	Lacovia	October 11, 2019	06.45	-77.768535	18.07968439	7m ASL
7	Lacovia Bridge (1.8km upstream from Intake and Pumping Station)	Lacovia	October 11, 2019	07.15	-77.756707	18.075939	7m ASL

[26] ASL – Above Sea Level

Site #	Site	Location	Date	Time	Longitude	Latitude	Elevation[26]
8	Black River (1.2km downstream from Intake and Pumping Station)	Lacovia	October 11, 2019	07.30	-77.771726	18.08349776	7m ASL
9	Pipeline Route #1	PS1 to Burnt Savannah	October 11, 2019	08.00	-77.767331	18.071296	
10	Pipeline Route #2	PS1 to Burnt Savannah	October 11, 2019	8.30	-77.756707	18.075939	
11	Reservoir #1 Option B	Newcombe Valley	October 11, 2019	10.30	-77.757771	17.9161004	110m ASL
12	Pumping Station #2	Claremont Park	October 11, 2019	11.00	-77.730226	17.9117249	50m ASL

5.2.2.3 OTHER FAUNAL SURVEYS

Other faunal surveys were conducted through direct observation of species within a randomly selected area. Local persons encountered during the visits were interviewed to gather additional background information about the presence or absence of other fauna and flora including butterflies, amphibians and reptiles. The use of burrows, nests and tracks was also included to ensure a complete assessment of all the fauna.

5.2.3 EXISTING ECOLOGICAL ENVIRONMENT

5.2.3.1 HABITAT TYPES

The study area was strongly influenced by human activities and can be characterised as disturbed to highly disturbed. The habitats along the pipeline route have been divided into two zones based on the differences in the habitat structure and land use cover types, namely (i) Mixed woodland and cropland (ii) Riparian/Wetlands. Each is described in sub-sections below. A general habitat characterization is illustrated in the figure below.

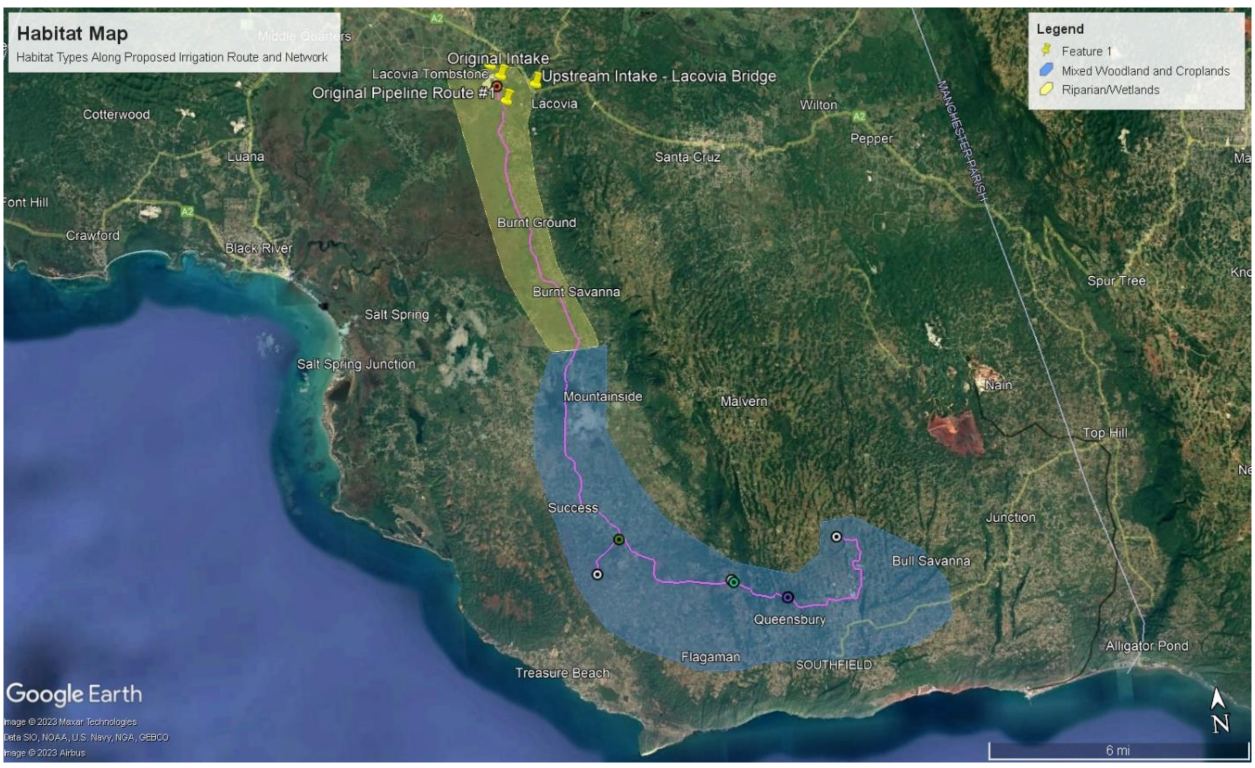


Figure 73 - Habitat types within the project footprint (Source: Google Earth, 2019)

As illustrated in the figure above, the following are some of the key areas that were examined during the ecological assessment: Lacovia, Burnt Ground, Burnt Savanna, Mountainside, Ridge Pen, Newell, Cashew, Queensbury, Beacon, Pedro Plains, Flagaman, Ballard's Valley, Newcombe Valley, Watchwell, Bigwoods, Berlin, Top Round Hill, Bethany District, Claremont Park, Southfield, Bull Savannah and Treasure Beach.

5.2.3.1.1 Mixed Woodland and Cropland

These sections of land (including locations for Pumping Stations 2 to 4 and Reservoirs 1 to 4, Table 76 –) have historically experienced significant anthropogenic influence. The existing vegetation is interrupted by major and minor road networks, buildings, farmlands and other infrastructure associated with residential developments, indicating that significant portions have been cleared in the past. The farmlands in question have been largely cleared of natural vegetation.

This section of the proposed pipeline crosses the following general land cover types (USGS 2011):

- Cultivated cropland: Areas used to produce annual crops (mainly vegetables, fruits and tubers);
- Pasture/hay: Areas of grasses, legumes or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops;
- Grassland herbaceous: Areas dominated by gramanoid or herbaceous vegetation such that these species generally represent more than 80% of total vegetation. These areas are not subject to intensive management;
- Mixed forest: areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover;
- Shrub/Scrub- areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions;
- Developed, Low Intensity- areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.

Figure 74 - Aerial images of proposed sites for pumping stations and reservoirs (source: Google Earth 2019)

Figure 75 - Images illustrating land cover types in Mixed Woodlands and Cropland Habitat along pipeline (October 2019 to February 2023)

5.2.3.1.2 Riparian/Wetland – The Black River Lower Morass (BRLM)

Wetlands are areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year. Water saturation largely determines how the soil develops and the types of plant and animal communities supported by the wetland. Wetlands provide food and habitat for a diverse array of plants and animals, act as buffers to flooding and erosion and serve as key links in the global water cycle

The proposed site for the intake (Pumping Station #1) is located within the northern sections of the Black River Lower Morass (BRLM). The BLRM is Jamaica's largest and most diverse wetland covering approximately, 6,075 hectares (61km^2) (Webber, 2010). It is characterised as a complex area of shallow brackish lagoons, limestone islands, tidal marshes, mudflats and mangroves near the coast, and extensive freshwater marshes with peat formations (ESL 2016).

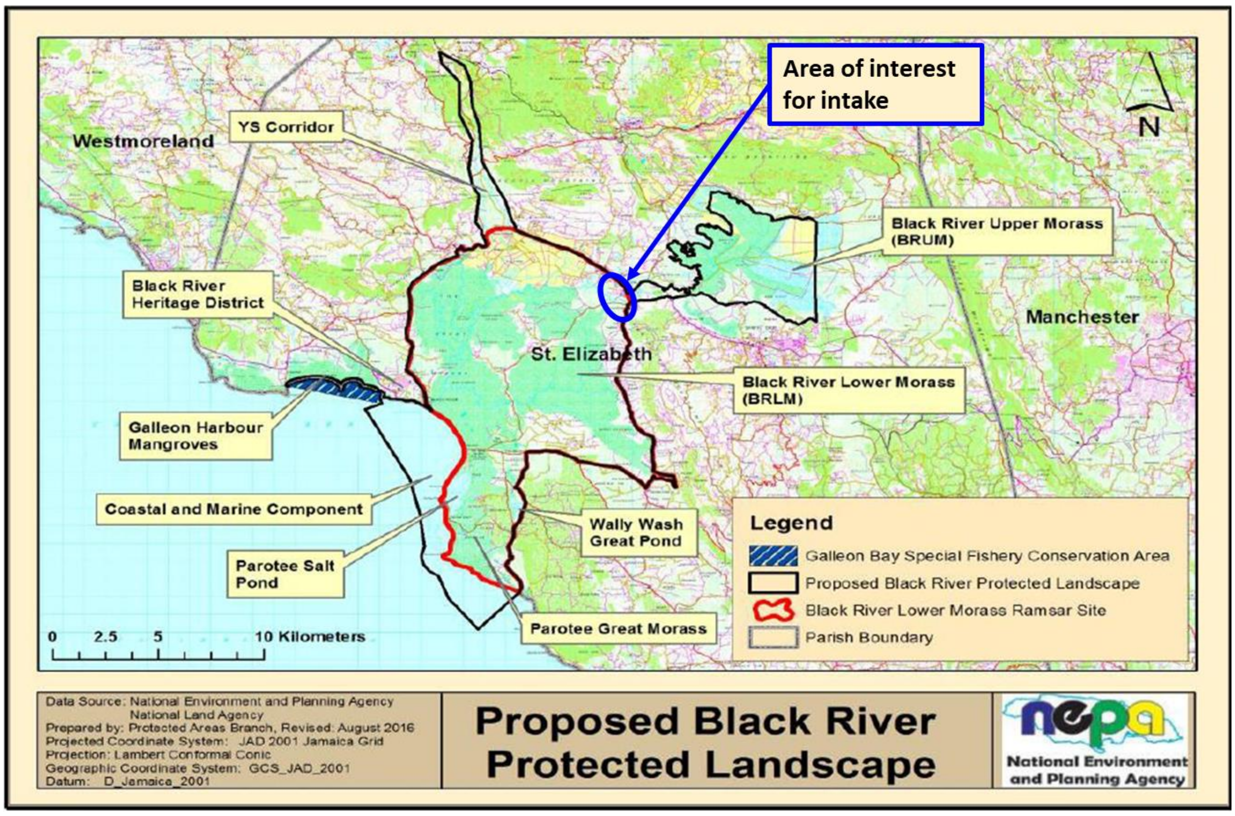


Figure 76 - Location and Boundary of the Proposed Black River Protected Landscape showing project area of interest (Source: Draft Black River Protected Landscape Management Plan 2017 – 2022, 2016)

Since the 1940s, the BLRM (and area of interest for the intake) has been historically used for cane farming, rice cultivation, vegetable crops, fisheries, as well as timber and charcoal derived from hardwood trees and for pasturelands during the dry season. Several local communities have been established in and around the Morass and the land use changes and heavy dependence of local users on BLRM resources (specifically in the northern sections) have resulted in significant changes to the vegetation and hydrology (BRPL 2016).

With regards to ecology, the BLRM comprises different types of vegetations and habitats influenced by water quality, hydrology and soil type. Wade (1985) reported that the BRLM is home to 92 species of flowering plants, 23 of which are considered rare, and eight of which are endemic to Jamaica. Studies also indicate that 10% of the plants found in the Morass are rare in Jamaica, and these include the Night-Blooming Water Lilies, the Royal Palm and the Alligator Pear plant (Massa and Hayes-Sutton, 1999 in *The Greater Treasure Beach Sustainable Development Plan*, 2013). However, the magnitude and intensity of land use changes have negatively influenced the ecology and vegetative cover in the area.

The Black River at this point is several metres wide and was noted to be silted or turbid during the assessment, which took place in the rainy season. The riparian vegetation along the banks of the river was significantly dominated by *Haematoxylum campechianum* (Logwood tree) and *Samanea saman* (Guango tree), many of which were laden with vines and those that had branches stretching far over the river were laden with lianas. Immediately along the banks were dominated with various types of reeds and grasses. Small clumps of water hyacinths were observed floating along the river.

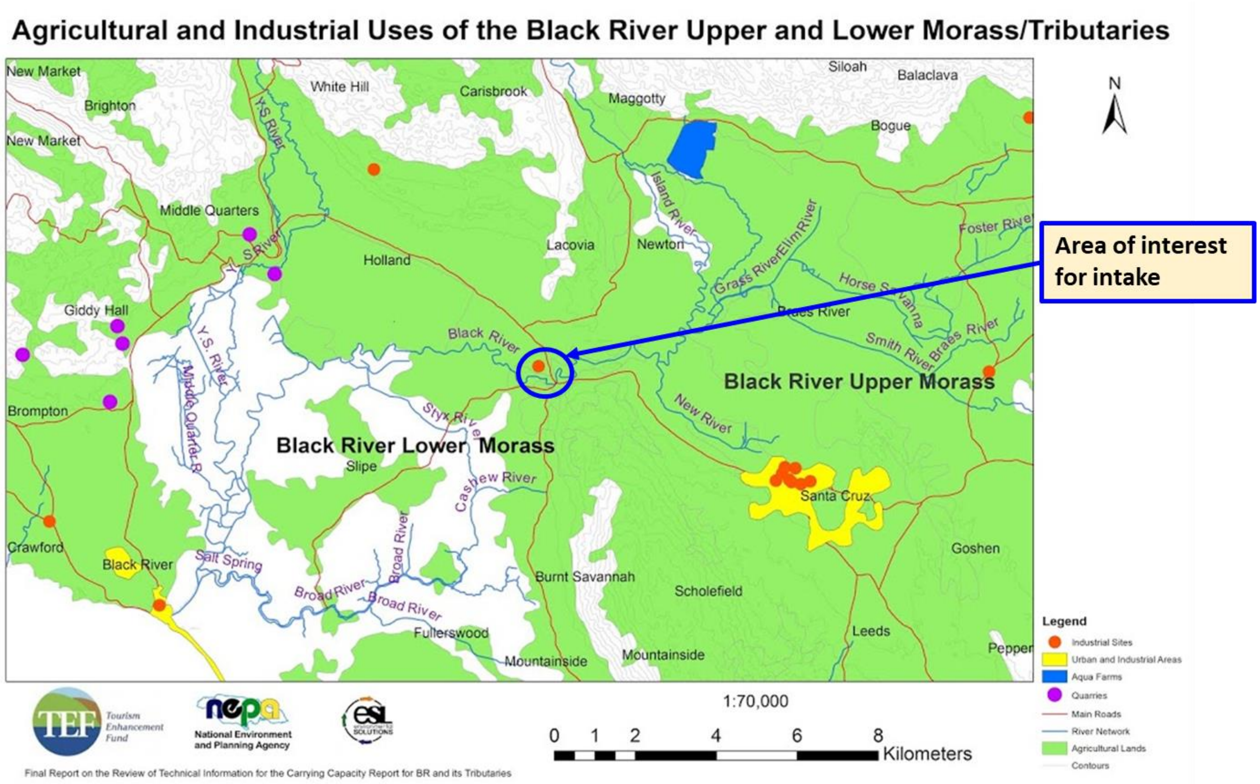


Figure 77 - Land Use (Agricultural and Industrial) in the Black River Upper and Lower Morass relative to proposed area of interest for the intake and pumping station #1 (Source: ESL, 2015)

Figure 78 - Aerial image showing proposed location for intake and pumping station #1 (Source: Google Earth, 2019)

5.2.3.2 FLORA/VEGETATION

Overall, species diversity was moderate with 100 plant species from 65 families observed and recorded, most of which were herbs, shrubs and fast-growing tree species typically associated with early stages of ecological succession. The majority of the trees encountered were seedlings or saplings, and only a small proportion of the trees were mature. Of the few mature trees observed during the assessment, species included *Samanea saman* (Guango tree), *Cecropia peltate* (Trumpet tree) and *Guaiacum officinale* (Lignum Vitae), Jamaica's national tree, currently listed as endangered on the IUCN Red List of Threatened Species[27]. Most of the plant species encountered were classified as being commonly found locally, especially in thickets and in secondary woodlands (mostly introduced with only 30 native species to the island/region). Only one endemic species was noted during the surveys, *Roystonea princeps* (Royal Palm), observed in the northern regions of the Lower Morass (location of intake and Pump Station #1, along the from Pump Station #1 to Bull Savannah). The invasive species *Panicum maximum* (Guinea Grass), *Haematoxylum campechianum* (Logwood) and *Bambusa vulgaris* (Bamboo) were also noted during surveys, however in most instances they were being intentionally cultivated. As expected, the more urbanized areas are characterized by non-native fruiting or ornamental trees mixed with various weeds and invasive trees. With the exception of Lignum Vitae, no rare or endangered plants were identified during the field surveys. A full species list can be found in the Appendix.

5.2.3.2.1 Biologically Unique Landscapes and Vegetation Communities of Conservation Concern - Black River Lower Morass

The Black River Lower Morass forms part of the proposed Black River Protected Landscape (BRPL) and is a community oy of concern because of declining abundance, sensitivity to disturbance and/or reliance of listed or sensitive species on the habitats that they create. The sections of the Black River Lower Morass (BLRM) that fall within the project footprint can be characterised as follows[28]:

- Sedge Marsh dominated by *Cladium jamaicensis* (sawgrass);
- Riparian swale dominated by *Typha domingensis* (cat tail or bulrush);
- Swamp Forest dominated by *Roystonea princeps* (Endemic Swamp Cabbage or Royal Palm);
- Woodlands on limestone islands dominated by *Sabal jamaicensis* (Bull Thatch)

[27] https://www.iucnredlist.org/species/33701/68085935

[28] As described in the Ramsar Information Sheet (NRCA, 1997)

Figure 79 - Examples of vegetation observed during surveys of the BLRM that fall within the project footprint (October 2019)

Figure 80 - Examples of vegetation observed during field visit of the BLRM that fall within the project footprint (February 2023)

These communities provide foraging, breeding and refuge habitats for many wildlife species, particularly birds. Many of these communities have been lost or degraded due to land conversion to agricultural uses and urban development.

5.2.3.3 FAUNA

5.2.3.3.1 Avifauna

51 species of birds were observed in the study area during field visits (includes additional species of migrant warblers). Fifteen (15) of Jamaica's twenty-nine (29) extant endemic species were observed in the field in the vicinity of the project footprint comprising wetland and terrestrial species. These are the more common and widespread species that typically occur in disturbed or mixed forests. None of the rare endemics (that are dependent on natural forests) were observed in the area. A full species list can be found in the Appendix.

Endemic bird species - In general all the species encountered are common and widespread residents in Jamaica. Most of them are also very tolerant of human disturbances and are more likely to be encountered in suburban areas as well as micro habitats within urban areas (e.g. gardens, parks, farmlans) but are also in native forest habitats. No species of birds considered to be "Endangered" under the IUCN Red List programme were observed on the site. Only four of Jamaica's twenty-nine extant endemic species were detected namely the Jamaican woodpecker

(*Melanerpes radiolatus*), the Jamaican (*Vireo modestus*), the Jamaican Parakeet (*Eupsittula nana*) and the Jamaican Mango hummingbird (*Anthracothorax mango*).

- Jamaican woodpeckers are often associated with large trees with wide trunks and were commonly detected in the very large Guango trees growing around Big Pond.
- Jamaican vireos are common in secondary and natural forested habitats in dry or wet areas throughout the island. This species is often very vocal and has an unusually loud voice for its diminutive size and it is also known to make a wide range of other sounds including mimicking the calls of other bird species and even non-natural sounds from its environment.
- The Jamaican Parakeet (*Eupsittula nana*) (formerly known as the Olive–throated Parakeet, *Aratinga nana*) has recently been reclassified as a distinct species from what is now called the Aztec Parakeet (*Eupsittula astec*) which is the new name given to the population in Meso and Central America.

5.2.3.3.2 Herpetofauna

The most common reptiles were Anolis lizards, which were observed throughout the woodlands, residential and cultivated zones. Common reptiles included anoles such as *Anolis lineatopus* and *A. grahami*. Additionally, *Aristelliger praesignis* (geckos/croaking lizards) were common and were detected from their calls.

The alien invasive cane toad, (*Bufo marinus*) were observed throughout the project area, particularly in moist areas. Other frogs were heard during evening visits to the site, the most common was the introduced, invasive *Eleutherodactylus johnstoni* (Johnsons Robber Frog), which was abundant in the more vegetated, woody areas. The *Osteopilus brunneus* (Laughing Frog) and the *Osteopilus crucialis* (Jamaican Snoring Frog) were also detected.

5.2.3.3.3 Mammals

Given that the pipeline route crosses several farmlands and the site identified for the intake and pumping station #1 rests on an animal farm, several mammals were noted, specifically pigs, cattle and goats.

By virtue of the habitat type, *Herpestes javanicus* (Small Indian Mongoose) and *Rattus norvegicus* (brown rats) are likely to be found within the project area, though none were detected during surveys.

5.2.3.3.4 Rare and Endangered Species

As mentioned above, the only endangered species noted during the survey is the Lignum Vitae tree (*Guaiacum officinale*), which is listed on the IUCN Red List. However, there are other rare and endangered species commonly known to the Black River Lower Morass (BRLM), including the location of the intake and Pumping Station #1. These include:

- The American Crocodile, while not observed during the surveys for this assignment, is listed by IUCN as vulnerable and is protected. The current status and population is unknown especially within the Black River Morass due to migration and nesting variation and patterns. Of note is that: (i) crocodiles are often poached for meat and the eggs., and (ii) the availability of undisturbed nesting habitats is the most important limiting factor;
- The West Indian Whistling Duck (Dendrocygna arborea) a rare, wetland bird is considered by the IUCN to be vulnerable and is resident in the BRLM.

5.2.3.3.5 Invasive/Alien Species

According to the Strengthening the operational and financial sustainability of the National Protected Area System (NPAS) Project - Draft Black River Protected Landscape Management Plan 2017 – 2022 (NEPA 2016):

"The Mitigating the Threat of Invasive Alien Species in the Insular Caribbean (MTIASIC) Project was recently completed and the Black River Lower Morass was one of its targeted sites. This project and the studies conducted to guide McLaren, 2016 note the following invasive alien species of particular concern: -

- *Water Hyacinth (Eichornia crassipes) – floats on the water and has been present for many years;*
- *Wild Ginger (Alpinia allughas) – spreading along riverbanks and appears to be a recent invader;*
- *Paperbark Tree (Melaleuca quinquenervia) – spreading throughout the Morass and is a recent invader;*
- *Australian Red-claw Crayfish (Cherax quadricorinatus) – in the lower Morass and considered a threat to the pepper shrimp industry;*
- *Suckermouth Catfish or Pond Cleaner (Pterygoplichthys pardalis) – in the lower Morass and is a threat because it is generally not considered edible;*
- *Armour-plated Catfish (Hoplosternum littorale) – in the lower Morass and is a threat because it is generally not considered edible;*
- *Perch (Oreochromis mossambicus) – has been in the Morass since at least the 1980s;*
- *Carp (Cyprinus carpio) – appears to be a newly introduced species."*

Observations and anecdotal information collected during surveys suggest that all the above species are common to the area of interest for the intake, pumping station #1 and some portions of the northern section of the pipeline route (to Burnt Savannah).

5.2.3.4 SPECIES LIST

Table 52 - Plant list for proposed pipeline route

Family Name	Species Name	Common Name	Growth habit	Provenance	Mixed Woodland and Cropland							Riparian/Wetland		
					PS3+R2	PS4+R3	R2	R1A	R1B	R1C	R4	Pipe1	Pipe2	PS1
Adoxaceae	*Viburnum tinus*		Shrub	I	f									
Agavaceae	*Agave americana L.*		Tree-like	I							r			
Alismataceae	*Sagittaria lancifolia*		Herb	U									a	
Amaranthaceae	*Beta vulgaris*	Beet root	Herb	I	a					f				
Amaryllidaceae	*Allium cepa L.*	Onion	Herb	I		r								r
	Allium fistulosum	Escallion	Herb	I	a	a								a
	Hymenocallis littoralis	Beach Spider Lily	Herb	I		o								o
Amaryllidaceae	*Allium fistulosum*	Escallion	Herb	I	a	a								a
Anacardiaceae	*Anacardium occidentale*	Cashew	Tree	N										
	Mangifera sp.	Mango	Large tree	I	o	r		a		f	o			r
	Spondias mombin	Hog plum	Herb	N										
Annonaceae	*Annona squamosa*	Sweet sop	Small tree	N	o	r			o		o			r
Apiacae	*Foeniculum vulgare Mill.*	Fennel	Herb	I				r						
Apocynaceae	*Calotropis gigantea*	Giant Milkweed	Herb	I						f				
	Cleome viscosa		Herb	I	f		f	a	f	a		f		
	Mandevilla laxa	Chilean jasmine	Vine	I							r			

Family Name	Species Name	Common Name	Growth habit	Provenance	Mixed Woodland and Cropland							Riparian/Wetland		
					PS3+R 2	PS4+R 3	R2	R1A	R1B	R1C	R4	Pipe1	Pipe2	PS1
	Samanea saman	Guango	Large tree	N			a					a		
	Urechites lutea	Nightshade	Vine	N	o	o	r	r	r			r		o
Araceae	*Alocasia macrorrhizos*	Upright Elephant Ears	Herb	I									a	
	Epipremnum aureum	Devil's Ivy	Vine	I										
Arecaceae	*Cocos nucifera*	Coconut	Tree	I				f					f	
	Roystonea princeps	Royal Palm	Tree	E								f	d	
Asteraceae	*Chromolaena odorata*		Shrub	N								a		
	Tagetes lemmonii	Bush marigold	Shrub	I			f		f		f	f		
Berberidaceae	*Berbertis thonbergii DC*		Shrub	I		r								r
Bignoniaceae	*Cresentia cujete*	Calabash	Tree	N		r								r
Bombacaceae	*Ceiba pentandra*	Silk Cotton	Tree	N										
Bromeliaceae	*Tillandsia recurvata*	Tillandsia	Epiphyte	N										
Cactaceae	*Opuntia ficus-indica*	Tuna/Prickly Pear/ Barbary Fig	Tree-like	I		r								r
Caesalpiniaceae	*Delonix regia*	Poinciana	Shrub	I								o		
	Haematoxylum campechianum	Logwood	Tree	Inv			a					a	r	
Combretaceae	*Terminalia catappa*	Almond	Large tree	I		r						o	o	r
Convolvulaceae	*Ipomoea batatas*	Sweet Potato	Vine	I			a	a	a					
	Ipomoea pandurata	Wild Potato Vine, Wild Sweet Potato	Vine	I	f			f		f		f	o	
Cucurbitaceae	*Citrullus lanatus*	Watermelon	Vine	I	a		a	a						
	Cucumis sativus	Cucumber	Vine	I				a						

Family Name	Species Name	Common Name	Growth habit	Provenance	Mixed Woodland and Cropland							Riparian/Wetland		
					PS3+R 2	PS4+R 3	R2	R1A	R1B	R1C	R4	Pipe1	Pipe2	PS1
	Cucurbita maxima	Pumpkin	Vine	I		a		a						a
Cycadidae	*Zamia spp*		Shrub	U										
Cyperaceae	*Cladium jamaicensis*	Saw Grass	Grass	N									a	
Dryopteridaceae	*Athyrium filix-femina*	Lady Fern	Fern	I							r			
Fabaceae	*Cajanus cajan*	Pigeon Peas	Shrub	I			f	r			o			
	Ceratonia siliqua	Carob	Shrub	I				r						
	Clitoria ternatea	Bluebellvine	Herb	I						f				
	Mimosa pudica	Shama macka	Herb	N	f		f	f	f	f		f		
Fabroniaceae	*Ficaria verna mattis*	Fig butter cup	Herb	I										
Hydrangeaceae	*Philadelphus coronarius*		Shrub	I										
Lamiaceae (mints)	*Ocimum basilicum*	Basil	Herb	I		a								a
Lauraceae	*Laurus nobilis*	Bay Leaf	Herb	I			r	r				r		
	Octea spp.	Sweetwood	Tree	N						r				
Magnoliaceae	*Magnolia sp.*		Small tree	U							r			
Malvaceae	*Abelmoschus esculentus*	Okra	Herb	I			o							
	Hibiscus sp.	Hibiscus	Shrub	N				o						
	Shaeralcea ambigua	Desert globemallow/Apricot mallow	Shrub	I	f			f		f				
	Theobroma cacao	Cocoa	Tree	I								a		
Mimosaceae	*Acacia tortuosa*		Small tree	N	r		o					o		
	Adenanthera pavonina	Red Bead Tree	Tree	I										

Family Name	Species Name	Common Name	Growth habit	Provenance	Mixed Woodland and Cropland							Riparian/Wetland		
					PS3+R2	PS4+R3	R2	R1A	R1B	R1C	R4	Pipe1	Pipe2	PS1
	Samanea saman	Guango	Large tree	N			a					a		
Moraceae	*Artocarpus altilis*	Breadfruit	Tree	I									o	
	Artocarpus heterophyllus	Jackfruit	Tree	I		o								o
	Cecropia peltata	Trumpet	Tree	N								f		
Musaceae	*Musa campestris*	Swamp banana	Shrub	I									a	
	Musa sp.	Banana and Plantain	Shrub	I	o	f	o	o				o	o	f
Nephrolepidaceae	*Nephrolepis biserrata*	Giant Sword Fern	Fern	U								a		
Nyctaginaceae	*Bougainvillea sp.*	Bougainvillea	Scrambler	I		r								r
Oleaceae	*Fraxinus excelsior*		Tree	I	f									
Palmae (Arecaceae)	*Sabal jamaicensis*	Bull Thatch Palm	Tree	N									a	
	Thrinax radiata	Thatch palm	Tree	N										
Papaveraceae	*Argemone mexicana*	Mexican Poppy	Herb	N		o								o
Papilionacea	*Robinia pseudoacacia*	False acacia	Tree	I								o		
Passifloraceae	*Passiflora edulis sims*	Common Passion Fruit	Tree	I								r		
Phyllanthaceae	*Phyllanthus acidus*	Otaheite gooseberry	Tree	I		r								r
	Phyllanthus emblica	Indian Gooseberry	Tree	I		r								r
Poaceae	*Arundo donax*	Giant Reed	Grass	I									a	
	Bambusa vulgaris	Bamboo	Shrub	Inv									o	
	Cynodon dactylon	Bermuda grass	Herb	I			a		a		f	a		
	Digitaria sanguinalis	Crab grass	Grass	I								f		
	Panicum maximum	Guinea grass	Grass	Inv	f	d	d	d	f	d		a		d

Family Name	Species Name	Common Name	Growth habit	Provenance	Mixed Woodland and Cropland							Riparian/Wetland		
					PS3+R 2	PS4+R 3	R2	R1A	R1B	R1C	R4	Pipe1	Pipe2	PS1
	Cynodon nlemfuensis	African Star Grass	Grass	I										
	Eleusine indica	Yard grass	Herb	I										
Polygonaceae	*Antogonon leptopus*	Coralita	Vine	I										
	Cocoloba uvifera	Seagrape	Shrub	N		r								r
Pontederiaceae	*Eichhornia crassipes*	Water hyacinth	Herb	Inv									f	
Pteridoideae	*Acrostichum aureum*	Swamp Fern	Fern	N									f	
Rhamnaceae	*Paliurus spina-christi*	Jerusalem thorn	Shrub	I	o									
Sapindaceae	*Blighia sapida*	Ackee	Tree	I	r									
	Melicoccus bijugatus	Guinep	Tree	I		r								r
Sapotaceae	*Chrysophyllum oliviforme*	Wild-star apple	Tree	N										
	Manilkarra sapota	Naseberry	Tree	I		r								r
Smilacaceae	*Smilax aspera*	Jamaica Sarsaparilla	Vine	N				f						
Solanaceae	*Solanum lycopersicum*	Tomato	Vine	I						f				
Turneraceae	*Turnera ulmifolia*	Ram Goat Dashalong	Shrub	N										
Typhaceae	*Typha domingensis*	Reed/ Bulrushes	Grass	N							f	f	d	
Urticaceae	*Urechites lutea*	Nightshade	Vine	N	o	o	r	r	r			r		o
	Virtica dioica	Common nettle	Herb	U										
Verbenaceae	*Lantana reticulata*	Lantana	Shrub	N										
	Lantara camara	Lantana	Shrub	N						f				
	Priva lappulacea	Clammy bur	Grass	U										
	Lantana camara	Lantana	Shrub	N										

Family Name	Species Name	Common Name	Growth habit	Provenance	Mixed Woodland and Cropland							Riparian/Wetland		
					PS3+R 2	PS4+R 3	R2	R1A	R1B	R1C	R4	Pipe1	Pipe2	PS1
	Lippia nodiflora	Turkey tangle frogfruit	Herb	I										
	Stachytarpheta jamaicansis	Vervine	Herb	N										
	Verbena officinalis	Common verbena	Herb	I	f		f	f	f	f	f	f		
Zingiberaceae	*Hedychium spicatum*	Ginger lily	Shrub	Inv									f	
Zygophyllaceae	*Guaiacum officinale*	Lignum vitae	Tree	N			r							

Table 53 - List of bird species observed during survey period of project area (October 2019)

#	Family groups	Family	Common Name	Scientific Name	Status	Habitat observed		DAFOR
						Woodland + Cropland	Riparian + Wetland	
1	**Swifts**	**Apodidae**	Antillean Palm Swift	*Tachornis phoenicobia*	b	x	x	A
2	**Swifts**	**Apodidae**	Black Swift	*Cypseloides niger*	b	x	x	D
3	**Bitterns and Herons**	**Ardeidae**	Great Egret[w]	*Ardea alba*	b	x	x	F
4	**Bitterns and Herons**	**Ardeidae**	Cattle Egret[w]	*Bulbicus ibis*	b		x	F
5	**Bitterns and Herons**	**Ardeidae**	Snowy Egret[w]	*Egretta thula*	b		x	O
6	**Bitterns and Herons**	**Ardeidae**	Green Heron[w]	*Butorides virescens*	b		x	O
7	**Bitterns and Herons**	**Ardeidae**	Black-crowned Night-Heron[w]	*Nycticorax nycticorax*	b		x	O
8	**Bitterns and Herons**	**Ardeidae**	Great Blue Heron[w]	*Ardea herodias*	b		x	R
9	**Bitterns and Herons**	**Ardeidae**	Little Blue Heron[w]	*Florida caerulea*	b		x	O
10	**Bitterns and Herons**	**Ardeidae**	Tri-colored Heron[w]	*Egretta tricolor*	b		x	O
11	**Jacanas**	**Jacanidae**	Jacana[w]	*Jacana spinosa*	b		x	R
12	**Nightjars & Allies**	**Caprimulgidae**	Antillean Nighthawk	*Chordeiles gundlachii*	bs		x	R
13	**New World Vultures**	**Cathartidae**	Turkey Vulture	*Cathartes aura*	b	x	x	D
14	**Pigeons & Doves**	**Columbidae**	Rock Dove	*Columba livia*	b	x	x	F
15	**Pigeons & Doves**	**Columbidae**	White-crowned Pigeon	*Patagioeanas leucocephala*	b	x		R
16	**Pigeons & Doves**	**Columbidae**	Mourning Dove	*Zenaida macroura*	b	x	x	F
17	**Pigeons & Doves**	**Columbidae**	Zenaida Dove	*Zenaida aurita*	b	x	x	F
18	**Pigeons & Doves**	**Columbidae**	White-winged Dove	*Zenaida asiatica*	b	x		F
19	**Pigeons & Doves**	**Columbidae**	Common Ground-Dove	*Columbina passerina jamaicensis*	bes	x		F

#	Family groups	Family	Common Name	Scientific Name	Status	Habitat observed		DAFOR
						Woodland + Cropland	Riparian + Wetland	
20	**Cuckoos and Anis**	**Cuculidae**	Mangrove Cuckoo	*Coccyzus minor nesiotes*	bes		x	R
21	**Cuckoos and Anis**	**Cuculidae**	Smooth-billed Ani	*Crotophaga ani*	b	x	x	F
22	**Bananaquits**	**Emberizidae**	Bananaquit	*Coereba flaveola faveola*	bes	x	x	O
23	**Grassquits**	**Emberizidae**	Yellow-faced Grassquit	*Tiaris olivacea*	b	x	x	O
24	**Grassquits**	**Emberizidae**	Black-faced Grassquit	*Tiaris bicolor*	b	x	x	R
25	**Emberizids**	**Emberizidae**	Grasshopper Sparrow	*Ammodramus savannarum*	bes	x	x	O
26	**Emberizids**	**Emberizidae**	Greater Antillean Grackle	*Quiscalus niger*	bes	x	x	F
27	**Emberizids**	**Emberizidae**	Shiny Cowbird	*Molothrus bonariensis*	b	x	x	F
28	**Emberizids**	**Emberizidae**	Jamaican Oriole	*Icterus leucopteryx leucopteryx*	bes	x	x	O
29	**Falcons & Caracaras**	**Falconidae**	American Kestrel	*Falco sparverius*	b	x		R
30	**Finches and Hawaiian honeycreepers**	**Fringillidae**	Jamaican Euphonia	*Euphonia jamaica*	be	x	x	F
31	**Mockingbirds & Thrashers**	**Mimidae**	Northern Mockingbird	*Mimus polyglottos*	b	x	x	D
32	**Woodpeckers & Allies**	**Picidae**	Jamaican Woodpecker	*Melanerpes radiolatus*	be	x	x	F
33	**Parrots, Macaws & Allies**	**Psittacidae**	Jamaican Parakeet	*Eupsittula nana*	be		x	R
34	**Rails, Gallinules and Coots**	**Rallidae**	Common Moorhen	*Gallinula chloropus*	b		x	O
35	**Ibises and Spoonbills**	**Threskiornithidae**	Glossy Ibis	*Plegadis falcinellus*	b		x	O
36	**Hummingbirds**	**Trochilidae**	Red-billed Streamertail	*Trochilus polytmus*	be		x	R
37	**Hummingbirds**	**Trochilidae**	Vervain Hummingbird	*Mellisuga minima minima*	bes	x	x	O
38	**Hummingbirds**	**Trochilidae**	Mango Hummingbird	*Anthracothorax mango*	be	x	x	O
39	**Tyrant Flycatchers**	**Tyrannidae**	Gray Kingbird	*Tyrannus dominicensis*	bs	x	x	F
40	**Tyrant Flycatchers**	**Tyrannidae**	Loggerhead Kingbird	*Tyrannus caudifasciatus jamaicensis*	bes	x	x	F
41	**Barn-Owls**	**Tytonidae**	Barn Owl	*Tyto alba*	b			R

#	Family groups	Family	Common Name	Scientific Name	Status	Habitat observed		DAFOR
						Woodland + Cropland	Riparian + Wetland	
42	**Vireos & Allies**	**Vireonidae**	Black-whiskered Vireo	*Vireo altiloquus*	bs	x	x	O
43	**Vireos & Allies**	**Vireonidae**	Jamaican Vireo	*Vireo modestus*	be	x	x	O
44	**Thrushes & Allies**	**Turdidae**	White-chinned Thrush	*Turdus aurantius*	be		x	R
45	**Swallows and Martins**	**Hirundinidae**	Cave Swallow	*Petrochelidon fulva*	b		x	O
46	**Wood Warblers**	**Emberizidae**	Northern Parula	*Parula americana*	m	x	x	R
47	**Wood Warblers**	**Parulidae**	Black-throated Blue Warbler	*Dendroica caerulescens*	m	x	x	R
48	**Wood Warblers**	**Parulidae**	Prairie Warbler	*Dendroica discolor*	m	x	x	R
49	**Wood Warblers**	**Parulidae**	Palm Warbler	*Dendroica palmarum*	m	x	x	R
50	**Wood Warblers**	**Parulidae**	American Redstart	*Setophaga ruticilla*	m	x	x	R
51	**Wood Warblers**	**Parulidae**	Northern Waterthrush	*Seiurus noveboracensis*	m	x	x	R

Classification based on H. Raffaelle "Birds of the West Indies."
Status according to Downer and Sutton "Birds of Jamaica."
Note Score determined by numbers of points where each species occurs
Key Abundance
b → breeding species [Very common - seen/heard at >50% 0f observation points in suitable habitat]
be → Jamaican endemic species [Common - seen/heard at 25-50 of observation points in suitable habitats]
bes → Jamaican endemic sub-species [Locally common - found at >50% of points but habitat type very restricted in area]
bs → summers and breeds [Uncommon - seen/heard at <25% of points in suitable habitats]
D Dominant 10 +

A	Abundant	5 to 10
F	Frequent	1 to 5
O	Occasional	0.1 to 1
R	Rare	0

Table 54 - List of macro-invertebrates observed during survey period for project area (October 2019)

Common Name	**Scientific Name**	**Species/Sub-Species Range**
Apricot Sulphur	*Phoebis argante comstocki*	Mexico to Paraguay and West Indies
Julia Longwing	*Dryas julia iulia delila*	Southern US to Brazil & Bolivia
Jamaican Suphur	*Eurema nise*	Jamaica, Cuba, southern Bahamas, southern Florida
Gulf Fritillary	*Agraulis vanillae*	Bahamas, Bermuda and Greater Antilles
West Indian Buckeye	*Precis evarete zonalis*	Florida and the Caribbean, Mexico, Central America, to tropical and subtropical South America
Zebra Longwing	*Heliconius charitonius*	Jamaica
Jamaican White Peacock	*Anartia jatrophae jamaicensis*	Greater Inagua, Hispaniola, Jamaica, Puerto Rico
Tropical Checkered skipper	*Pyrgus oileus*	Southern US to Argentina
Cloudless Sulphur	*Phoebis sennae*	Southern US to Argentina
Little Blue	*Hemiargus ceraunus ceraunus*	Hispaniola, Jamaica
Jamaican Albatros	*Appias drusilla jacksoni*	Northern Brazil to Souther Florida Peninsula

Table 55 - Other fauna observed/noted in literature as common to the area

Scientific name	**Common name**	**Status**
Trichecus manatus	West Indian Manatee	Native
Crocodylus acutus	American Crocodile	Native
Aristelliger praesignis	Croaking Lizard	Native
Anolis sp.		2 species observed
Pseudemys terrapen	Freshwater Turtle	Endemic
Chrusemys terrapen	Edible Freshwater Turtle	Introduced
Eleutherodactylus luteolus		Endemic
Eleutherodactylus gossei		Endemic
Eleutherodactylus johstonei		Endemic
Bufo marinus	Cane Toad	Introduced (also *Rhinella marina*)
Rana catesbiana	American Bullfrog	Introduced
(from Ramsar Information Sheet and McLaren, 2016)		
Pterygoplichthys pardalis	Suckermouth catfish	Introduced
Centropomus unidecimalis	Snook*	Native
Oreochromis mossambicus	Perch*	Introduced
Caranx hippos	Jack*	Native
Mugil curema	Mullet*	Native
Elops saurus	Lady fish*	Native
Megalops atlanticus	Tarpon*	Native
Gerres cinereus	Yellow fin morjarra*	Native
Ctengraullis edulens	Sprat*	Native
Hoplosternum littorale	Amour-plated catfish	Introduced
Syacium micrurum	Flounder	Native
Gobiomorous dormitor	Mud fish*	Native
Platybelone argalus argulus	Gar fish*	Native
Anguilla rostrata	Eel*	Native
Cyprinus carpio	Carp	Introduced
Gambusia melapleura	Ticki Ticki	Endemic
Callineltes sapidus	Blue crab*	Native
Macrobrachium acanthurus	Shrimp	Native
Macrobrachium carcinus	Shrimp	Native
Macrobrachium faustinum	Shrimp	Native
Xiphocaris elongata	Shrimp	Native
Atyidae sp	Shrimp	Native

McLaren, 2016 and Ramsar Information Sheet - Table modified from Prospere (2016). * denotes species previously recorded in the Black River Lower Morass (NEPA, 2016)

5.3 NATURAL HAZARDS AND CLIMATE CHANGE

Major natural hazards considered as being potentially relevant to the project are discussed in the following paragraphs.

As most of the project infrastructures is buried (pipelines) and somehow protected, main potential impacts concern structures such as the pumping station, the photovoltaic plant and the reservoirs.

5.3.1 SEISMICITY

Seismicity has been estimated from the paper « Probabilistic Seismic Hazard Assessment for Jamaica » from W. Salazar, L. Brown and G. Manette (2013). This study compiled high magnitude events from 1551 to 2010 and concluded to a horizontal peak ground acceleration (expected on stiff ground with a 475 years return period) around 0.18g for the western part of Jamaica.

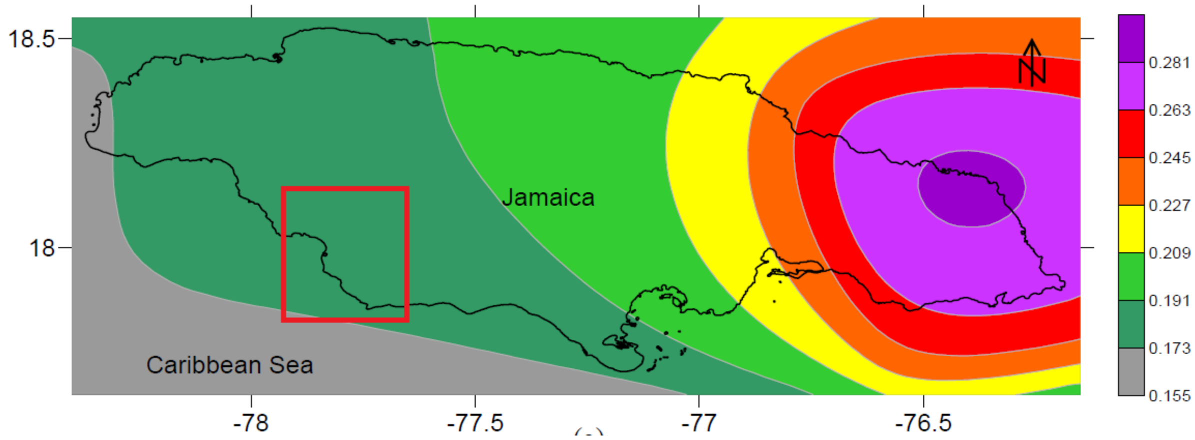


Figure 81 - Seismic hazard map for the peak ground acceleration (g) and 475 years return period (Salazar, Brown, Manette, 2013)

The Jamaican Building Code gives a peak rock acceleration of 0.3g for the whole country.

Considering that:

- Studies and code characterize western part of Jamaica as medium seismic hazard place,
- Project will be composed of low buildings and underground infrastructures, vulnerability of the system to seismic event is assumed to be low,
- Consequences of irrigation system failure can also be considered as minor on a short term basis,

The infrastructure will be built in order to respect National Building Code considering seismic hazard.

5.3.2 HURRICANES

According to the "The State of Jamaican Climate 2015", the North Atlantic (Atlantic Ocean, Caribbean Sea, and Gulf of Mexico) hurricane season runs **from June 1 to November 30**. This coincides with the period when the **Caribbean Sea is most conducive to convective activity** and with **Jamaica's rainfall season**. However, some storm or hurricane can occur in **May**. The **peak season is from mid-August to late October** as seen in Figure 82, although a deadly hurricane may occur **at any time during the season**.

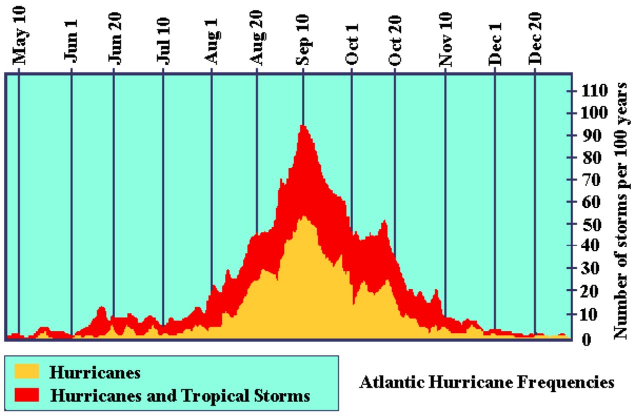


Figure 82 – Data of hurricane frequency for the Atlantic Ocean hurricane season. Source: NOAA (Mona_Climate_Studies_Group, October 2017)

The

Table 56 below shows the number of storms and hurricanes by category passing within 200 km of Jamaica over the period 1842-2016. The Table suggests that the frequency of tropical storm and hurricane activity in the proximity of Jamaica **peaks between August and October**. The most active months are August (29 storms and hurricanes) and September (25 storms and hurricanes) while the **least active months are May** (1 event) **and June** (7 storms and hurricanes). When the categories are considered separately, **hurricane activity** (H1-H5) near Jamaica peaks in August, while **tropical storm activity** (TS) peaks in September.

Table 56 - Number of tropical storms (TS) and hurricanes (H) passing within 200 km of Jamaica over the period 1845-2015 sorted by month. Hurricanes are also categorized by strength (H1-H5). Data source: NOAA reconstructed Hurricane Reanalysis database (Mona_Climate_Studies_Group, October 2017)

Month	Number of Storms and hurricanes (by strength)						
	TS	H1	H2	H3	H4	H5	Total
May	1						1
June	1	1					2

July	3	-			1		4
Aug	7	8	3	4	2	1	25
Sept	14	3	2		1	1	21
Oct	6	4	2				12
Nov	4	1	1	1			7

Most of the hurricane activity measures in the Atlantic show a substantial increase since the early 1980s, when measurements were enhanced by satellite data (measurements of intensity, frequency, duration and number of category 4 and 5 storms). However, **climate change is not unanimously considered as the main cause of this increase in activity**.

In addition, **some of the variability in hurricane activity depends on the occurrence of the "El Niño"** (ENSO) events in the North Atlantic:

- ❖ During "El Niño" events fewer hurricanes occur in the Caribbean Basin
- ❖ During "La Niña" events, the result is the opposite.

Finally, "El Niño" and "La Niña" also **influence the genesis location of Atlantic hurricanes**:

- ❖ During "El Niño" events, fewer hurricanes are formed in the tropics, ie close to Jamaica.
- ❖ When "La Niña" occurs, the number of hurricanes increases in these areas.

The

Figure *83* illustrates the historical trajectories of tropical storms and hurricanes past 200 km from Jamaica between 1950 and 2015. The

Figure *83* (a) shows that Jamaica was hit by 12 **hurricanes** during this period. :

- ❖ 2 in the 1950s (King 1950, Charlie 1951),
- ❖ 2 in the 1960s and 1970s (Cleo 1964, Carmen 1974),
- ❖ 2 in the 1980s (Allen, 1980, Gilbert 1988),
- ❖ 6 since the 2000s (Iris 2001, Iva 2004, Charley 2004, Dennis 2005, Dean 2007, Sandy 2012)

The

Figure *83* (b) shows 18 **tropical storms** during the same period.

The preferred trajectory of hurricanes hitting Jamaica ranges from southeast to northwest (

Figure *83*). The **south coast of Jamaica** (including the "**Pedro Plains**" project area) **is therefore more vulnerable to strong winds and rains** associated with hurricanes. The

Figure *84*, which represents the data in Table 57, illustrates this sensitivity for different grid boxes of Jamaica (probability that a storm center passes less than 50 km from each mesh of the grid).

- ❖ The central and northern regions of the islands (boxes 1 to 14 of the grid) are affected by fewer storms than those in the south (boxes 15 to 23 of the grid).
- ❖ The grid box No. 16 that contains the area of the "**Pedro Plains**" project presents approximately the same situation than Jamaica as a whole.

Finally, most of the storms or hurricanes that hit the island of Jamaica are in categories 3 and 4 (Table 57). This probably reflects Jamaica's position downstream of the tropical Atlantic hurricane development center, east of the Lesser Antilles.

(a) *hurricanes*

(b) *Tropical Depressions and Tropical Storms*

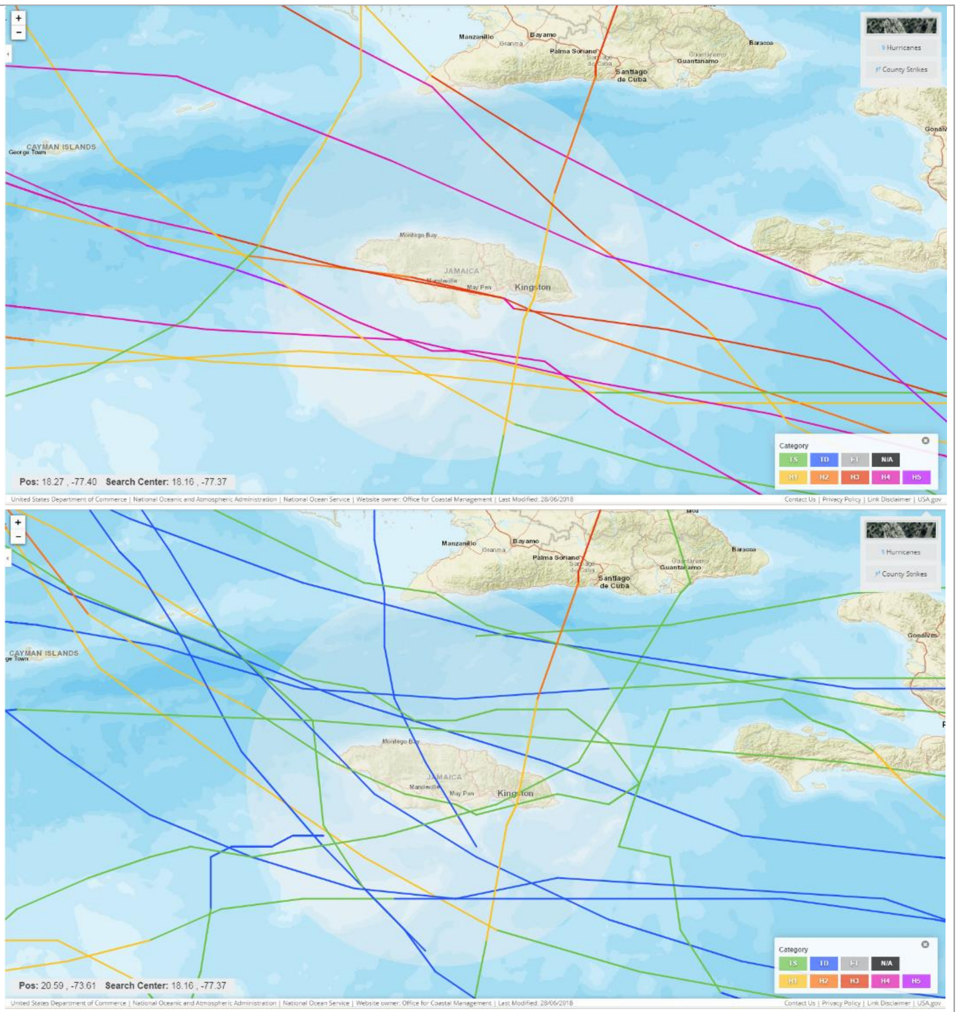


Figure 83 – (a) All hurricanes impacting the Caribbean basin between 1950 and 2015. (b) Tropical Depressions and Tropical Storms (Source: http://coast.noaa.gov/hurricanes/) (Mona_Climate_Studies_Group, October 2017)

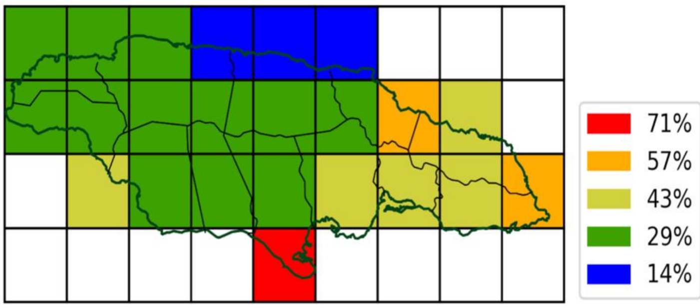


Figure 84 –Map showing the probability of a hurricane passing within 50km (over period 1950-2015)

(Mona_Climate_Studies_Group, October 2017)

Table 57 - Number of Hurricanes Impacting Jamaica's grid box (by category) within 50, 100, 150 and 200-km (over the period 1950 to 2015)
(Mona_Climate_Studies_Group, October 2017)
*NB : No. 16 grid box includes the "**Pedro Plains**" project sector*

50-km

	Grid Box	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Category	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	1	1	1
	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	3	1	2	2	0	0	0	1	2	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1
	4	0	0	0	1	1	1	0	0	0	0	0	1	2	1	1	0	0	1	1	1	1	1	3
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**4**	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**3**	**4**	**5**

100-km

	Grid Box	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Category	1	2	0	0	0	1	1	2	2	1	0	1	1	1	1	3	3	4	3	3	2	2	2	4
	2	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0
	3	2	2	2	1	2	1	2	2	2	1	1	2	1	1	2	1	1	1	1	1	1	1	1
	4	2	2	1	2	2	2	2	3	3	4	4	4	2	1	2	3	4	4	4	3	3	3	3
	5	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0
Total		**6**	**4**	**3**	**3**	**5**	**5**	**6**	**7**	**6**	**5**	**6**	**7**	**6**	**5**	**7**	**7**	**9**	**8**	**8**	**8**	**8**	**8**	**8**

150-km

	Grid Box	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Category	1	5	5	5	4	3	2	5	5	4	4	4	4	3	3	5	4	4	4	4	4	5	5	4
	2	0	0	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1	0
	3	2	2	3	2	1	1	2	1	2	2	1	1	1	1	1	1	2	1	1	1	1	1	2
	4	3	4	4	5	5	4	3	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4
	5	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0
Total		**10**	**11**	**12**	**11**	**10**	**9**	**10**	**10**	**10**	**10**	**11**	**11**	**10**	**10**	**10**	**9**	**10**	**10**	**10**	**11**	**12**	**12**	**10**

200-km

	Grid Box	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Category	1	7	6	6	6	5	5	6	6	6	6	5	4	6	8	6	6	5	4	4	6	7	8	4
	2	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	0	0	1
	3	2	1	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1
	4	7	6	6	5	5	5	6	7	7	5	5	5	4	4	5	6	5	5	4	4	4	4	5
	5	0	0	0	1	1	1	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1
Total		**17**	**14**	**14**	**14**	**12**	**12**	**13**	**14**	**14**	**13**	**12**	**11**	**13**	**14**	**13**	**14**	**13**	**12**	**11**	**13**	**13**	**15**	**12**

Concerning the impact of climate change, the projections described here are taken from the latest reference document "The State of Jamaican Climate 2019 (Climate Studies Group Mona" 2021). The following main conclusions summarize the multiple works available worldwide on the predicted evolution of tropical cyclones in the Atlantic of the northern hemisphere. These conclusions take into account in particular the reference synthesis published in 2020 by Thomas Knutson of the NOAA (National Ocean and Atmospheric Administration, USA).

The climate scenario taken into account corresponds to a global warming of +2°C, but is not associated with one of the SSP or RCP typologies.

The main conclusions are detailed below, and the figure illustrates the following summary: The North Atlantic and Caribbean regions will likely experience **more intense rain rates** associated with tropical cyclones and storms, with **greater intensity of the wind**. However the projections are quite unclears with regard to the frequency of cyclones, and are inconclusive regarding their location, extent and duration in the North Atlantic.

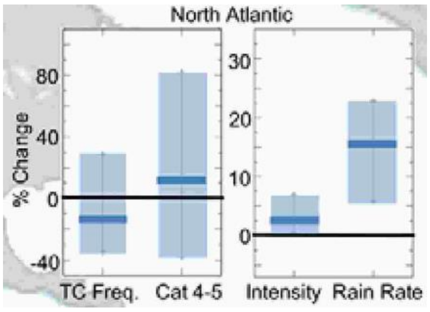


Figure 85 - Tropical Cyclone projections for a 2°C global warming: Frequency for all cyclones, Frequency for Category 4-5, Intensity & Near-storm rain rate (Knutson 2020)

Moreover, it is noted that **sea level rising will augment the impact of tropical cyclones** in terms of storm surge, that is to say higher inundation levels over coastal regions.

Finally, the hurricane development may also prove **more difficult to be forecasted** in the future. Indeed, as tropical cyclone track and size become more variable under global warming, it will become more uncertain to predict when and where a storm will intensify and make landfall.

Location of Tropical Cyclone genesis, tracks, duration, and areas of impact

The various works do not indicate a clear signal concerning a future modification of the parameters of location (origin, displacement and extent) and duration of tropical cyclones in the North Atlantic.

Rainfall rates of tropical cyclones

It is likely that tropical cyclone related rainfall rates will increase between 5 to 25% for the North Atlantic basin (see figure below).

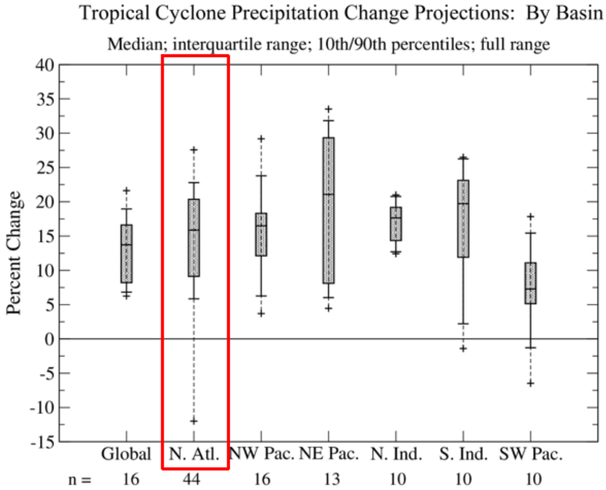


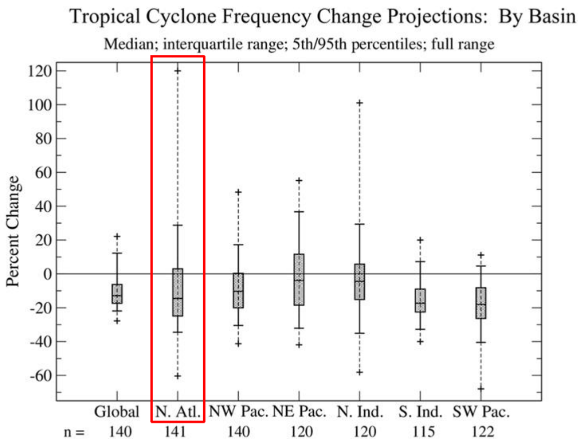
Figure 86 - Projection changes in tropical cyclone rainfall rates (%) – North Atlantic highlighted in red (Knutson 2020)

Note : (n) is the number of separate estimates for the geographical basin

Frequency of tropical cyclones

It is likely that tropical cyclone frequency in North Atlantic will decrease (up to -30%) or remain essentially unchanged. Regarding to the most intense cyclones (category 4 or 5), the signal of their evolution in the North Atlantic is not clear because the increase in the median is marginal (+7%), despite the trend of increase for the other oceans (see figures below).

All cyclones



Very intense cyclones (category 4-5)

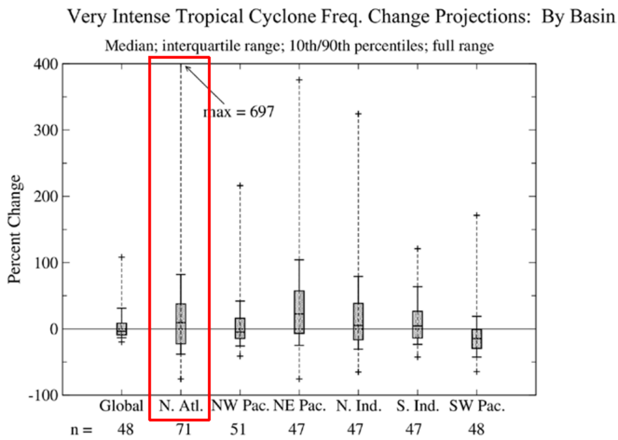


Figure 87 – Projection changes in tropical cyclone Frequency (%)North Atlantic highlighted in red (Knutson 2020)

Tropical cyclone intensities

Most models indicate +1% to +10% increase in global intensity of tropical cyclones. Intensity is quantified based on two key variables: the maximum sustained wind speed and the minimum central pressure. The higher the maximum wind speed and the lower the minimum central pressure, the more intense the storm.

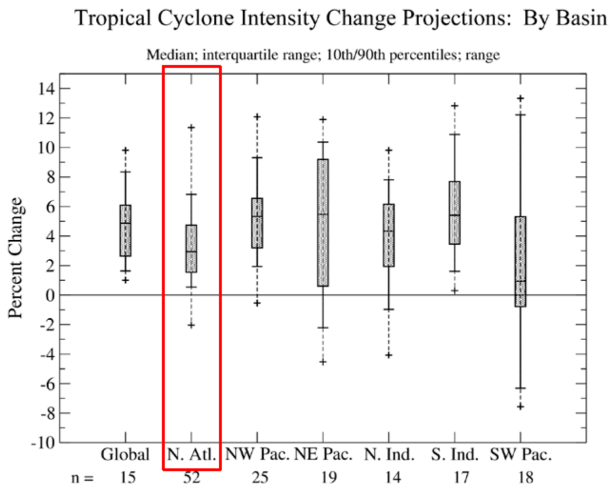


Figure 88 – Projection changes in tropical cyclone Intensity (%) – North Atlantic highlighted in red (Knutson 2020)

5.3.3 DROUGHTS

From 1970 to 2012, 12-month droughts (characterized by the SPI-12 standardized precipitation index) appeared in similar ways in 3 of Jamaica's 4 rainfall zones, including the "**Pedro Plain**" project area. "(Interior [1], west [3] and coasts [4], see *Table 58 - Number of dry periods as determined by SPI3 and SPI12 in each rainfall zone*):

- A major drought in the first half of the 1970s.
- Serious drought centered on the year 2000 then in 2010, which represents two recent droughts on the scale of the island.
- There are other periods (for example, in the early 1980s) when the coasts and the interior zones are experiencing drought conditions that the western zone has not known.

In addition, eastern Jamaica (zone 2, which has a different mechanism of underlying forcing) experienced a prolonged drought period from 1985 to 1995, while the other 3 zones experienced varying degrees of moisture and drought.

Finally, since the 2000s, all 4 areas of Jamaica show more interannual fluctuations between extreme conditions than in previous decades (more floods and droughts).

The Table 58 presents the number of occurrences of drought over the period 1970-2012 for each zone, for both the 3-month seasonal drought (SPI-3) and the annual drought (SPI-12). We make the following observations:

- The number of seasonal (short-term) droughts is logically higher than the number of droughts at an annual scale.
- The middle part of the island including interior and coasts zones (zones 1 and 4) is much more exposed to short-term droughts than the western and eastern zones.
- The coasts zones (zone 4), which include the area of the project "**Pedro Plains**" were **much more prone than the rest of the island to drought at the scale of the year**.

Table 58 - Number of dry periods as determined by SPI3 and SPI12 in each rainfall zone

- *El Nino (Left) and La Nina (Right)*

SPI	Interior (zone 1)	East (zone 2)	West (zone 3)	Coasts (zone 4)
3	34	23	25	36
12	6	6	5	11

The SPI index has been calculated for the 4 rainfall zones over the period up to 2012.

A meteorological drought is a period of well below normal rainfall, lasting for a few months (annual dry season) or a few years. This is why the standard Precipitation index (SPI) is calculated on these two time scales, in order to characterize the scarcity of drought episodes (or in contrast to wetter periods than the average): SPI12 = interannual variability, and SPI3 = variability over the dry season.

- Values greater than +1 indicate above average humidity.
- Values less than -1 indicate more than normal dryness.
- Values below -2 are considered extremely dry and values above +2 are extremely wet.

5.3.4 IMPACT OF “EL NINO” AND “LA NINA” EVENTS ON CARIBBEAN CLIMATE

“El Niño” event refers to periods when the eastern Pacific Ocean of the coast of Peru and Ecuador is unusually hot. The "La Niña" envent corresponds to the opposite conditions, with an abnormally cold eastern Pacific Ocean.

The “El Niño” event, which lasts about a year, peaks in December and goes out the following spring. El Niño events tend to occur every 3 to 5 years, although increases in the frequency, severity and duration of events have been observed since the 1970s. This recent increase in activity "El Nino" is NOT unanimously attributed to climate change, however projections tend to predict a further increase in frequency.

During an “El Niño” event, the Caribbean tends to be **drier and warmer** than usual and especially during the late rainy season from August to November. There is also a **tendency to reduce hurricane activity**. Recent droughts in the Caribbean in 2010 and 2014-15 coincide with the “El Niño” events. However, during the year following an "El Niño" event, the early rainy season (May to July) tends to be wetter than usual.

The impact of “El Niño” on the drought period in the Caribbean (from January to March) produces opposing signals to the north and south of the Caribbean:

- Significant drying up in the southern Caribbean,
- and wetter conditions on Jamaica and countries further north.

In general, a "La Niña" event produces the opposite conditions for the the late rainy season (conditions are wetter than average) and the dry season (the northern Caribbean being drier than my average).

In the sentence that follows the effect of "La Nina" is indicated in parentheses as opposed to the effect of "El Nino".

Rainfall conditions in the northern Caribbean are also conditioned by the low-level wind component blowing over the Caribbean Sea. A west (east) anomaly decreases the low altitude jet, bringing more moisture to the wetter (drier) northern Caribbean. The low-level jet is strongly controlled by Sea Surface Temperature (SST) gradients between the Pacific and the Atlantic, which are in turn modulated by “El Niño” / “La Niña” events.

5.3.5 SEA LEVEL RISE

Sea level rise projections for the coast of St. Elizabeth Parish are used here that are consistent with the projections for the Caribbean as a whole, published in the 6th Climate Change Assessment Report.

Figure 89 – Sea level rise projections for West Indies relative to a 1995–2014 baseline(IPCC AR6 – Interactive Atlas)

For Caribbean as a whole, the projections at 2050 and 2090 are 0.2 and 0.6 m for the SSP2-4.5 scenario, and 0.3 and 0.7 m for the SSP5-8.5 scenario (IPCC6, see figure above).

More local values are available from the CMIP6 HighResMIP project (High Resolution Model Intercomparison Project) and released by the Copernicus Climate Change Service. According to this latter source, the projected elevation for the coast of St. Elizabeth Parish is **0.27 m in 2050 for the SSP5-8.5 scenario**, with reference to 1986-2005 (see figure below). The local projection is not available for other horizons and scenarios.

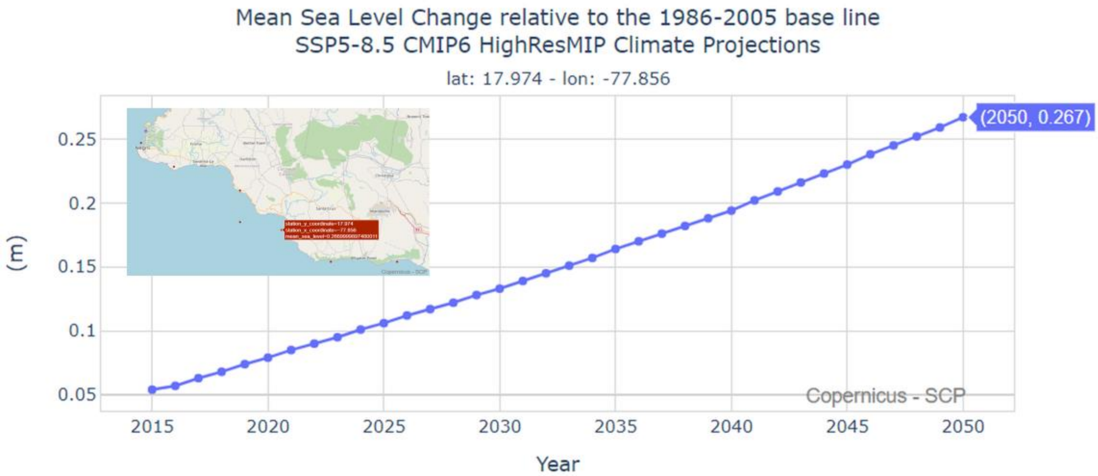


Figure 90 – Sea Level Rise projections for St Elisabeth coast relative to 1986-2005 (HighResMIP)

5.3.6 GENERAL CONCLUSIONS CONCERNING CLIMATE CHANGE OVER THE AREA

The 2 climate scenarios considered here correspond to moderate or high greenhouse gas emissions (ssp2-4.5 or ssp5-8.5).

The projections indicate an increase in **mean temperatures** for all months of the year. By 2050 the projected increase is +1.7 or +2.0°C depending on the scenario, compared to the period 1970-2000. The difference between the two scenarios is much greater by 2090 (+2.5 or +3.9°C). Moreover, observations already show an increase of +0.5°C between the reference period 1970-2000 and the more recent period 2001-2018.

With regard to **average precipitation**, the projections show a downward trend in central values. However, this trend is not very significant and not very certain. The less weak trend is for the 2090 horizon for the high emission scenario (ssp5-8.5). However, some models predict an upward trend in precipitation in all cases. Moreover, observations show that the recent period 2001-2018 has a rainfall 10% higher than the period 1970-2000.

Regarding **heavy precipitation**, the projections are in the direction of an increase, and this is particularly the case for those associated with **cyclones**. Regarding cyclones, wind intensities could increase, while projections are not clear regarding their frequency. The storm surge impacts of cyclones will therefore be stronger, and furthermore increased by **sea level rise**.

5.4 HERITAGE

The Jamaican National Heritage Trust was questionend concerning possible Site and Monuments in the area. Their presence not being excludes, the JNHT recommends a two day archeological survey.

5.5 SOCIO-ECONOMIC & CULTURAL ENVIRONMENT

5.5.1 SOCIAL BASELINE OF THE STUDY AREA

5.5.1.1 DATA SOURCES AND LIMITATIONS

Community profiles[29] constitute one of the key entry data for the social assessment of the Pedro Plains Project area. The relevant reports collected have been analyzed and summarized. Information on these profiles come from surveys of about 10 % of households in each community.
While these documents display useful information, a certain number of limitations appear to have significant impacts on the quality of this assessment. In increasing order of importance, the following limitations were identified:

- Few inconsistencies have been noted between the data presented in the summary and those in the text. Numbers showcasing a statistical feature ("40 % of the land use area is dedicated to agriculture") are frequently inconsistent with the same feature stated further in the report ("Agriculture = 60 % of the land use area").

- Some irrelevancies of displayed data appear for example instead of displaying the distribution of household's members' employment status (employed/unemployed) per age class, the reports present the distribution of unemployed members of the household per age class. The latter provides no interesting information and gives no element on the share of employed/unemployed household members.

[29] Social Development Commission, Community profiles, 2010

- In many aspects, data is often misinterpreted in terms of information level. A confusion was observed regarding the different level of information. Reports sometime picture community features, sometimes address respondents' characteristics, and, more rarely, give information on household members. Despite this multi-scale approach, no logical link is made among these elements.

- The profile "Burnt Savanah" is incomplete, only 15 pages on spatial data, demographic data, educational, housing.

- Most importantly, the choice of the survey's target doesn't seem to be relevant. Most information focus on household's heads, and consequently, do not give interesting indication on the situation of the entire sample of the population, simply because household heads are far from being representative of the project area's population. Household heads could have been identified as key informant without necessarily providing personal information when responding to the survey. The key respondent should have been the spokesperson of his/her housing unit (household members). By providing household heads-related information, the exploitability of community profiles is compromised, all the more so as the selected key-respondents (household heads) are likely to have rather different personal profiles than other household members (better access to education, more income, higher social power, etc.).

The second source of information comes from shapefiles dataset, called "povertymap". This files give community based geographical information on community names and locations, number of households, population, percentage of poverty level, GINI[30] coefficient, acreages in different units and population densities. It also gives information about "consumption" but unit used for this is not clear. Moreover metadata wasn't received, no sources or years are attached with this information.

The third source of information come from the survey conducted in March 2019 for two weeks in the area. The sampling was determined in order to over represent farmers as we needed to characterize them precisely.

The sampling was designed according to the following criteria, to be representative of the population:

- The proportion of woman
- The types of profiles (farmers, higglers, cattle breeders, etc.)
- The geographic location

According to the statistics from RADA extracted from the ABIS database, at least 40 % of registered farmers are woman. According to the figures, we effectively reached 38 % of women interviewed.

The breakdown of the profiles of interviewers proportions that we aimed to achieve for each category are the following:

Category of interview	Total number in the area	Sampling expected	Sampling achieved	Proportion expected	Proportion achieved
Crop farmers	Around 4000	214	161	63%	47 %
Livestock farmers	50 to 60	5	14	1%	4 %
Higglers	Around 100	20	43	6%	13 %
Individuals who are not farmers nor higglers (including laborers)	No data available	100	124	29%	36 %
Total		**340**	**342**	**100 %**	**100 %**

The sampling was based on the following sources:

- The total number of livestock farmers and higglers are provided as gross estimations from extension officers of the Parish

[30] GINI coefficient = measure of statistical dispersion intended to represent the income or wealth distribution of a nation's residents, and is the most commonly used measurement of inequality

- The total number of farmers is calculated as follows: based on the ABIS database, the total number of active farmers calculated within the study area are 3300. If we consider that around 80 % of farmers are registered, then it means that there are around 4100 farmers;
- The sum of the people actively involved with farming and marketing represent 70 % of the sample and the rest of the interviewees should represent around 30 % of the sample

In terms of number of surveys, the calculation was made as follows: the number of households per commune is an entry data. Then the proportion of the commune present in the study area was calculated. In addition, **4.3 % rate was applied** to know how many interviews would be conducted per community and this is how we obtain the following target figures.

N°	Community	Population of the community	Number of surveys expected	Number of surveys really achieved
1	Barbary Hall	866	10	7
2	Bigwoods	1 859	23	26
3	Burnt Savannah	3 243	40	49
4	Mountainside	2 952	37	35
5	Newell	814	10	25
6	Parottee	1 629	19	16
7	Pedro Plains	3 227	38	45
8	Pondside	506	8	5
9	Potsdam	2 484	31	48
10	Southfield	4 323	57	25
11	Treasure Beach	3 435	41	26
12	Watchwell	2 184	26	35
	Total	**27 522**	**340**	**342**

The survey conducted is therefore globally satisfactory as the targets per community were globally met.

5.5.1.2 POPULATION PROFILES

See map 012 - Population density

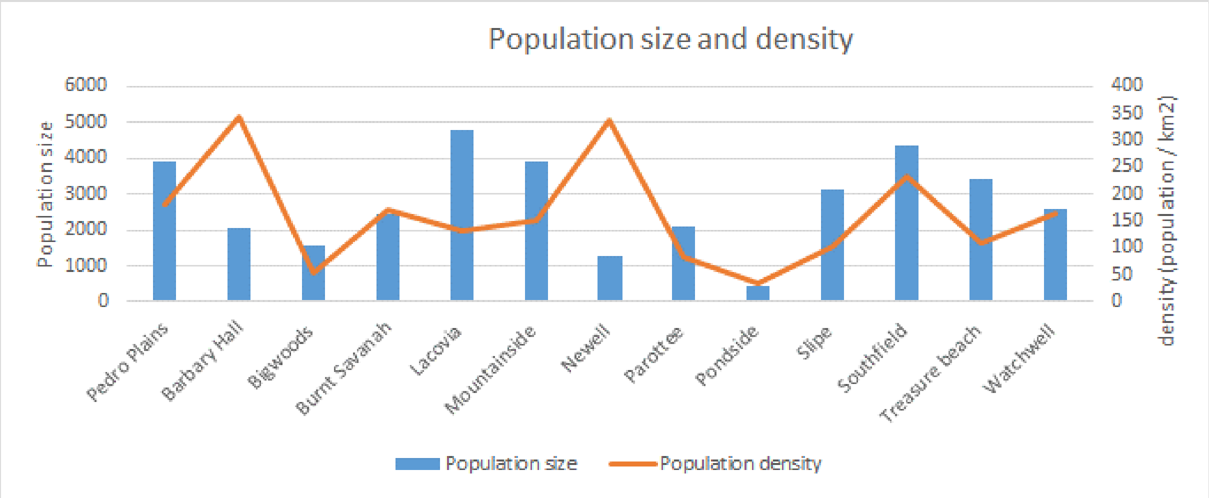
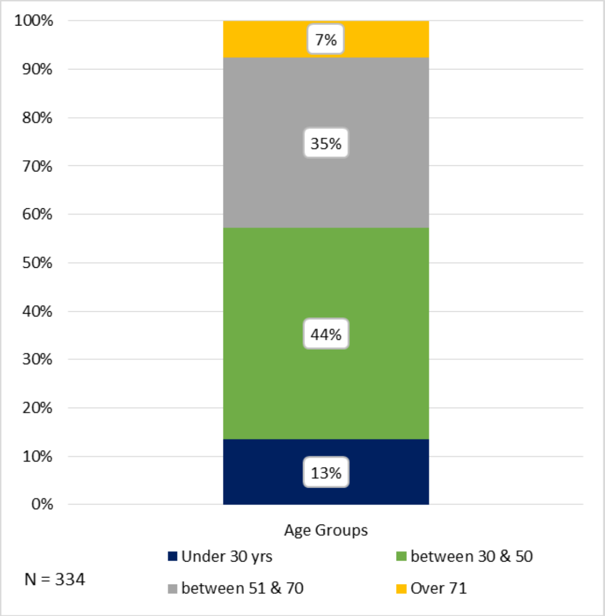


Figure 91 - Population size and calculated density (SDC data)

The most populated communities are Lacovia, Southfield and Pedro Plains, and the highest population density are in **Barbary Hall, Newell and Southfield.**

The average household size (3.8 persons per households) is not significantly different between communities except for Bigwoods, where it is lower (3.0). Gender ratio of population is quite equilibrated everywhere. Nevertheless, the gender of households's heads is in majority Male, apart from Newell where it is observed than 58 % of households's heads are Females. Burnt Savanah and Newell have the higher proportion of the age group 20-39 years compared to others age groups.

In terms of age groups, most of the people interviewed are persons from 31 to 50 years, followed by people aged from 51 to 70 years. The following graph shows the age groups represented in the survey conducted by ESL and SCP.



5.5.1.3 POVERTY LEVEL PROFILES AND HEALTH, EDUCATION AND DRINKING WATER ACCESS

☞ ***See map 013 – Poverty rate***

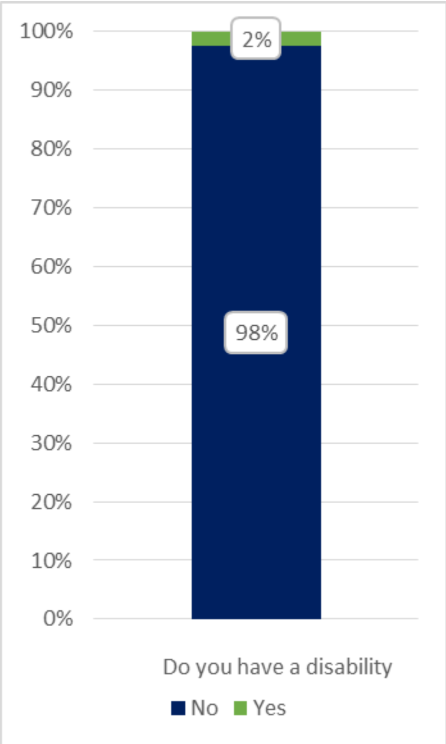
Community	Level of medical facilities/ services (P/B/G)[31]	Poverty rate[32]
Burnt Savanah	no data	**43,42**
Barbary Hall	B	**41,57**
Mountainside	P	**40,49**
Newell	B	**37,29**
Slipe	B	**27,99**
Watchwell	B	**22,28**
Lacovia	B	**20**
Pondside	P	16,25
Bigwoods	B	16,17
Parottee	P	15,83
Southfield	G	15,66
Pedro Plains	P	15,16
Treasure beach	G	14,02
Potsdam	no data	10,99

Table 59 - Level of medical facilities (SDC data) and Poverty rate (data from shape files received from NIC)

Communities with poverty rates above national rate are all along the proposed main pipeline location and in the north of study area. They are in bold in the table above. It appears also that NIC equipped areas are mainly not within the communities with highest poverty rates.

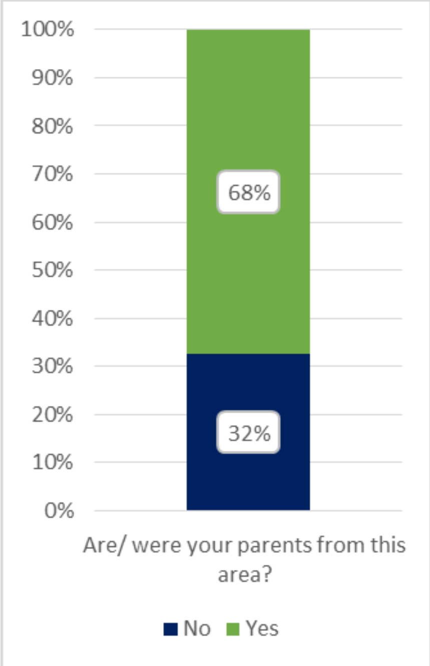
Communities with estimated poor access of medical facilities are Mountainside, Pondside, Parottee, and Pedro Plains.

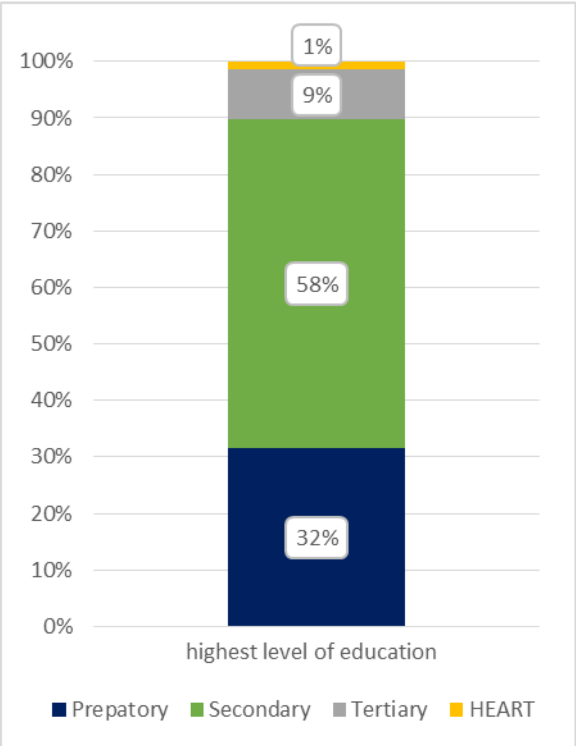
Amongst the people interviewed, only 2 % declare to present a disability. The following graph summarizes these results.



[31] P = Poor ; B = Basic ; G = Good
[32] Percentage of population whose income falls below the poverty line. National rate in 2017 is 17,6 %.

68 % of the people established in the area have parents who come from the area. This shows that migrations within Jamaica are significant as 32 % come from other parishes.





Access to education within the study area is mainly preparatory (32 %) and secondary (58 %) as shown in the following graph. Very rarely people extend the studying period to the tertiary education (9 %).

5.5.1.4 WATER SUPPLY SERVICE LEVEL AND SOCIAL CHALLENGES

☞ ***See map 014 – access to water and map 15 – medical facilities***

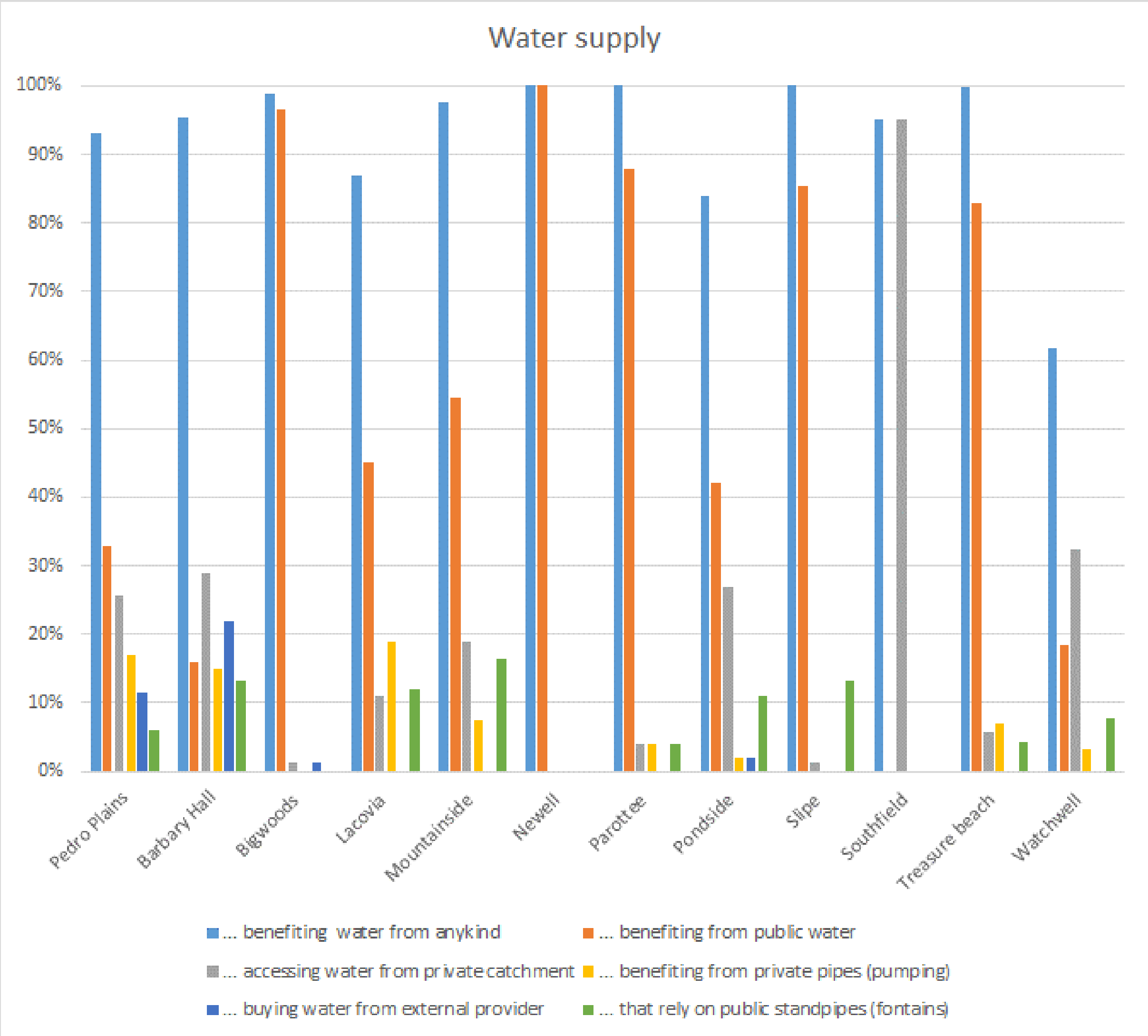


Figure 92 - Water supply access to surveyed Households (SDC data)

Among the surveyed households, the lower rate of water accessibility from any kind is in Watchwell. On the field, it was indeed observed that this community is one of the most landlocked. Water supply from public service is quite low (between 19 and 55 %) in 6 communities: **Barbary Hall, Watchwell, Pedro Plains, Pondside, Lacovia, and Moutainside**. Data does not exist for Burnt Savanah.

Reported social challenges faced by the communities are ranked by importance in the charts below and counted by occurrences of concerns for communities.

This data was completed by the information provided by the survey conducted by ESL and SCP. The question "what is the source of drinking water in your house?", interviewees answered:

What is the source of drinking water in your house?		
	N	%
NWC	311	91%
Tank	21	6%
Bought water	4	1%
Irrigation Water	2	1%
Catchment, Purchase	1	0%
NIC	1	0%
Rainfall	1	0%
River	1	0%
Total	342	100%

Table 60 - Answers to the question "What is the source of drinking water in your house?". Source: survey conducted by ESL and SCP

The water supply in the area is estimated at around 90 %. The rest of the households buy water, drink irrigation water from NIC or uses tanks or collects water directly from the river. Even if the access to drinking water is of 90 %, around 30 % of the interviewees would be interested in benefiting from another source of water.

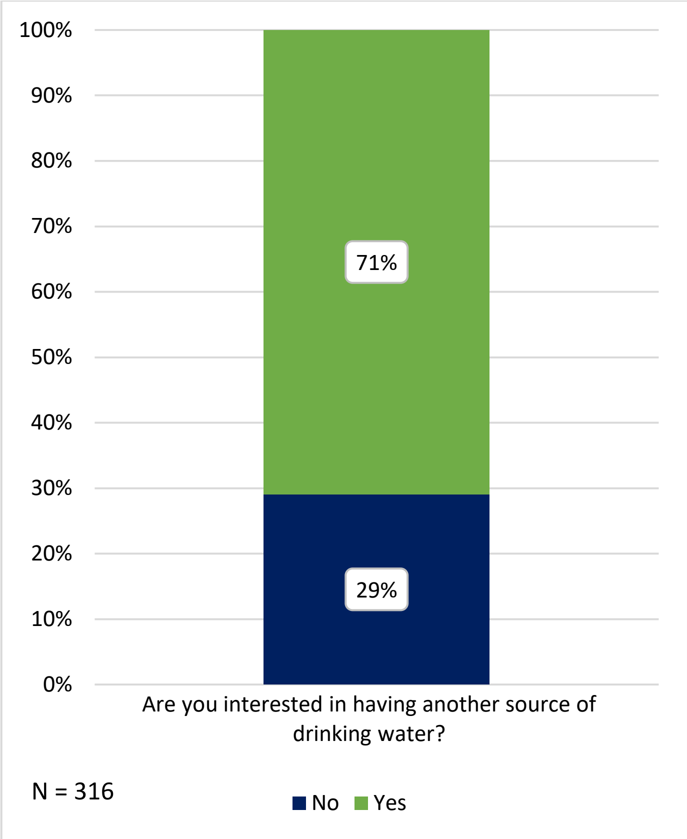


Figure 93 - Answers to the question "are you interested in having another source of drinking water?". Source: survey conducted by ESL and SCP

On average, what do you spend monthly on drinking water?		
	N	**%**
Less than $JMD500	56	16,4
$JMD500-$1000	35	10,3
$JMD1000-10,000	144	42,2
$JMD10,000-50,000	13	3,2
Don't Know	39	11,4
Missing	55	15,5
Total	**342**	**100,0**

Table 61 - Answers to the question "On average, what do you spend monthly on drinking water?". Source: survey conducted by ESL and SCP

The water rates to access to drinking water are highly variable depending on the level of service (hydrants or tap water), the number of people within the household and the location.

☞ ***See map 16 – social challenges***

Figure 94 - 3 main reported challenges (ranked by importance) among communities (SDC data)

Finally social challenges are classified in 5 topics and shown in the chart below. Topics are unemployment, water supply (including access and low pressure problem), education, flooding and roads.

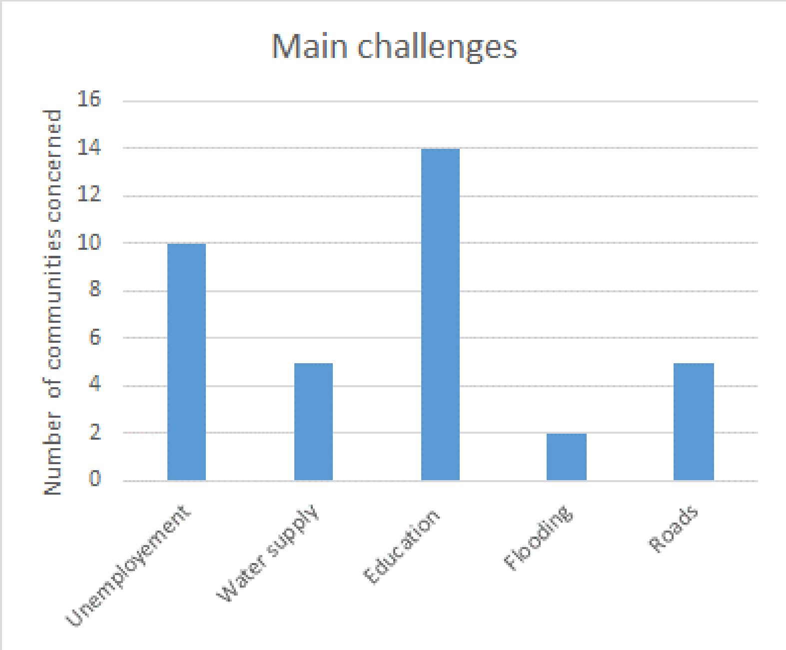


Figure 95 - number of communities who have quoted the main ranked challenges (SDC data)

Water supply challenges (kind of use, domestic or irrigation, is not indicated) has been quoted by 4 communities, **Pedro Plains, Bigwoods, Pondside and Southfield. Water supply** is the first and second challenge ranked by importance for **Pondside.**

5.5.1.5 HOUSEHOLDS PROFILES

According to the interviews conducted, in the area 2/3 of the households are comprised of one to four people; 25 % of five to seven people and 10 % of more than seven people.

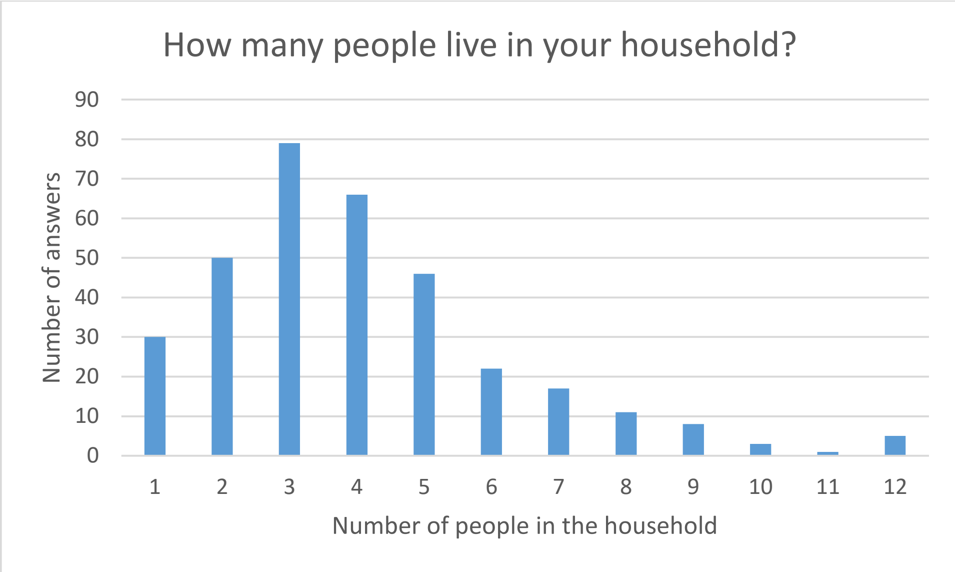


Figure 96 - Number of people comprised within households. Source: survey conducted by ESL and SCP

Out of the 342 interviews, only 35 households (10 %) do not comprise at least one person who has a farming related job. Even if the interviewee is not necessary a farmer him/herself, he/she has one to two people in a faring related job (71 % of the households) and more than three people in a farming related job (less than 20 %).

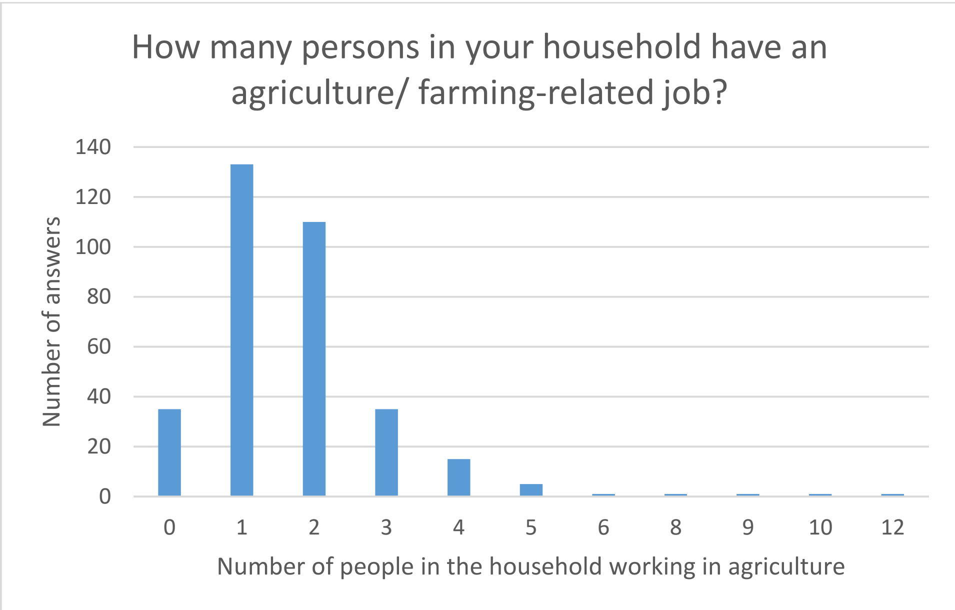
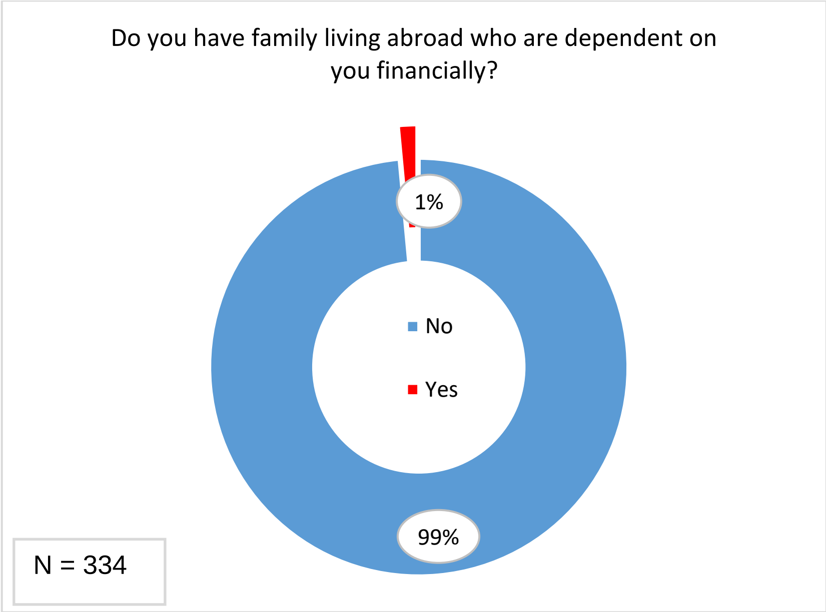


Figure 97 - Number of people within households whou have a farming related job - Source: survey conducted by ESL and SCP

Most families do not have anyone abroad that would be financially dependent on them (for example children studying) as the following graph shows.



5.5.2 AGRICULTURAL BASELINE OF THE STUDY AREA

5.5.2.1 LAND OCCUPATION IN THE COMMAND AREA

Land occupation in the project area has already been studied and modelled (in the 2019 SCP report during the feasibility phase of the project) in order to assess crop water requirements.

☞ ***See map 17 – Land use in the project area***

The hydraulic levels 1 to 4 have been divided into sectors, to show specific crop diversity at local scale.

Sectors 1 to 6 are connected to the first hydraulic level and their peak flow demand supplied by pumping station PS1 and reservoir R1. Sectors 7 to 9 are connected to the second hydraulic level and peak flow demand supplied by pumping station PS2 and reservoir R2. Sectors 10 and 11 are connected to the third hydraulic level and peak flow demand supplied by pumping station PS3 and reservoir R3. Sector 12 is connected to the fourth hydraulic level and peak flow demand supplied by pumping station PS4 and reservoir R4. Sector 13 is close to the uptake point at Lacovia.

In the “without project” scenario, the land occupation per hydraulic sector is:

Hydraulic sector	(2) SCP feasibility irrigable area - ha	(2) SCP feasibility irrigated area - ha	Cereals	Condiments	Fruits	Legumes	Tubers	Vegetables	Pastures and guinea grass
1	290	170	6,82	27,33	22,02	28,96	10,63	38,28	35,78
2	415	243	9,76	39,11	31,51	41,44	15,22	54,77	51,21
3	124	73	2,92	11,69	9,41	12,38	4,55	16,37	15,30
4	719	421	12,62	63,11	47,33	63,11	24,35	84,14	126,22
5	305	180	3,46	13,72	20,59	31,98	32,39	46,83	30,97
6	233	138	5,72	11,44	11,44	22,89	22,89	34,33	28,80
7	276	163	3,13	12,41	18,63	28,94	29,31	42,37	28,02
8	684	404	16,80	33,59	33,59	67,18	67,18	100,78	84,56
9	409	244	1,25	42,88	7,28	3,65	14,02	150,79	24,19
13	73	42	1,69	6,79	5,47	7,19	2,64	9,50	8,88
Total	**3528,00**	**2076,49**	**64,17**	**262,07**	**207,26**	**307,72**	**223,17**	**578,16**	**433,94**

Table 62 - Gross surface distribution amongst crops per hydraulic sector. Source: SCP

In the without project situation, the intensification rates considered are per crop:

	Cereals	Condiments	Fruits	Legumes	Tubers	Vegetables	Pastures and guinea grass
Number of crop cycles cultivated per year - WITHOUT project situation	1	1,5	1	1,5	1,5	1,5	1

Considering intensification rates[33] the land occupation is:

Hydraulic sector	With Intensification rate (ha)	Cereals	Condiments	Fruits	Legumes	Tubers	Vegetables	Pastures and guinea grass
1	290	13,64	41,00	44,03	57,92	21,26	76,55	35,78
2	415	19,52	58,67	63,01	82,88	30,43	109,55	51,21
3	124	5,83	17,53	18,83	24,77	9,09	32,73	15,30
4	684	25,24	94,66	94,66	126,22	48,70	168,29	126,22
5	322	6,93	20,58	41,18	63,95	64,77	93,65	30,97
6	240	11,44	17,16	22,89	45,77	45,77	68,66	28,80
7	291	6,27	18,62	37,26	57,87	58,62	84,75	28,02
8	706	33,59	50,39	67,18	134,37	134,37	201,55	84,56
9	442	2,50	64,31	14,55	7,31	28,04	301,59	24,19
10	211	1,19	30,66	6,94	3,48	13,37	143,79	11,53
11	253	1,43	36,80	8,33	4,18	16,04	172,55	13,84
12	334	1,89	48,59	11,00	5,52	21,19	227,85	18,28
13	72	3,39	10,18	10,93	14,38	5,28	19,01	8,88
Total	**4386**	**132,84**	**509,15**	**440,79**	**628,62**	**496,93**	**1700,50**	**477,59**

Table 63 - Gross surface distribution amongst crops per block and considering intensification rates. Source: SCP

5.5.2.2 TYPOLOGY OF FARMS IN THE COMMAND AREA

Thanks to the survey, we were able to collect significant data from the people living in the area and specifically from farmers. A simplified portrait of farmers coming from the survey will be presented as follows.

[33] Intensification rate: number of crops per year on the same plot.

Out of the 342 interviews, we can deduce that:

- All of them live in the project area
- The main source of drinkable water is NWC with 91 % answers; 6 % of the people drink water from tanks and 3 % drink water from irrigation, a catchment and a river.
- Most of them spend between $ 1000 and $ 10 000 Jamaican dollars to access to water
- 71 % of the interviewees declare to be interested in benefiting from another source of water
- The main source of information is the television (89 % of people mention it), followed by the radio (73 %); Internet (29 %), the newspaper (26 %) and training from RADA (5%)

Out of the 167 people who declared not to be farmers, **108 - 64 % - declared to be interested in farming**, which could be interesting to reduce unemployment in the area which is the main concern today, 28 said they were not interested (17 %) and the rest did not know.

To the question "what would you need to start a farm", people answered[34]:

More land	45 answers
Ensured market	29 answers
Training	20 answers
Higher prices	13 answers
Credit	18 answers
Water	12 answers

Figure 98 - Answers to the question "what would you need to start a farm" for people who do not farm yet. Source: survey conducted by ESL and SCP

Water comes at 5th position, the main constraints identified are economic issues (ensured market, higher prices and credit), the difficulty to access to land and the need for training. This

[34] Interviewees had the possibility to choose many answers.

confirms the assessment made in the agricultural assessment phase that identified four major topics to work on:

- Marketing
- The use of inputs to improve economic results and limit environmental consequences
- Farmers' structuration in order to improve economic results (by improving marketing and decreasing costs of production) and facilitate access to credit and
- Irrigation technics

From the 161 farmers interviewed:

- 34 are women that is 21 %;
- 6 present a disability, that is 3.7 %
- All of them live in the area
- 46 of them had parents who were not from the area and who immigrated to the area, that is 28 %
- 63 went to preparatory school (39 %), 85 to secondary school (53 %) and 11 to tertiary education (7%), 2 did not answer; this means that farmers are in average less educated than the global sample of the survey
- Slightly more than a half are registered farmers within RADA
- Around 70 % work in agriculture fulltime, 14 % work in agriculture seasonally and 17 % work part-time
- 31 % have land in an irrigation scheme (Beacon or Hounslow)
- 37 % of them have been victims of praedial larceny
- Only 26 % of them are members of a farmers' association

According to the survey, farm sizes are split as follows:

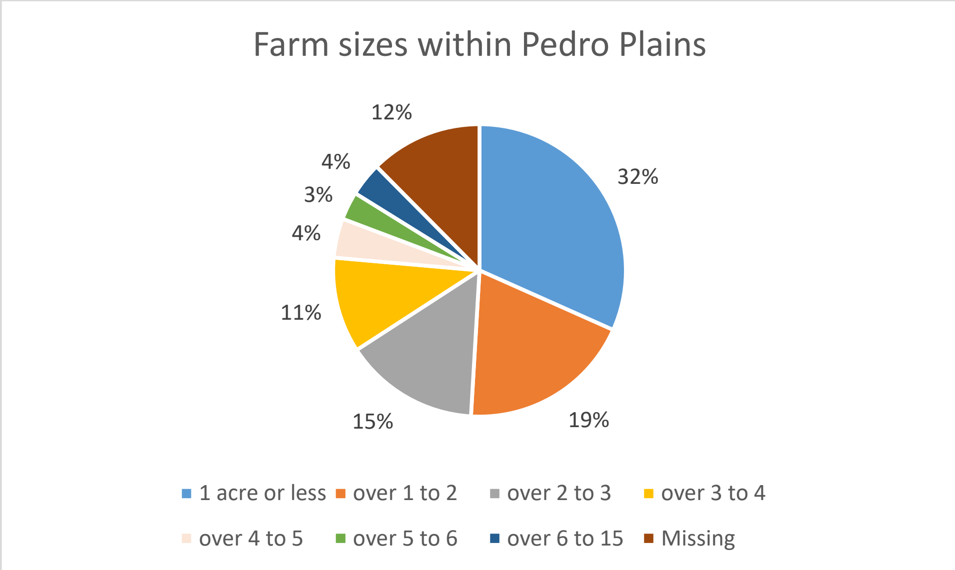


Figure 99 - Farm size typology. Source: survey conducted by ESL and SCP

1/3 of farmers have one acre or less, another 1/3 have 1 to 3 acres and only 6 farmers (4%) have more than 6 acres. 20 farmers do not know or did not want to answer this question (missing category).

In order to simplify the model, we chose as a farm baseline a farm of 1 hectare which represents 2.47 acres of land.

These are the crops farmers declare to grow:

Which vegetables do you grow irrigated?	
	N
Beans, Hot Pepper	2
Beet Root , Onion , Tomatoes , Watermelon	1
Beet Root, Lettuce	1
Beet Root, Tomatoes , Watermlon , Canteloupe	1
Beetroot, Tomato, Canteloupe, Watermelon, Cucumber, Sweet pepper	1
Brocolli , Lettuce, Mushrooms, Cabbage	1
Cabbage, Corn, Yam, Tomato, Lettuce, Sweet Pepper, Hot pepper, Pumpkin	1
Cabbage, Lettuce, Sweet pepper, Sweet potato, Hot pepper, Corn, Pumpkin, Yam, Cassava , Cho-cho	1
Calallo, Sweet Pepper,Pumpkin	2
Calaloo, Marijuana, Sweet Pepper	1
Calaloo, Pumpkin , Peanut	2
Califlower , Peanut, Pumpkin	1
Califlower, Cucumber	2
Canteloupe, Honey Due, Watermelon, Cucumber	1
Carro, Sweet Pepper, Cabbage, Corn, Pokchoi, Pumpkin	1
Carrot , Cabbage , Lettuce, Sweet Potatoes	1
Carrot, Cucumber, String beans,Sweet potatoes	1
Carrot, Sweet pepper, Cho- Cho, Irish Potatoes	1
Cassava , Peas, Corn, Pumpkin , Banabis Bean , Sorrell, Running bean	1
Coorn, Ockra, Bean, Sweet Peppers , Hot peppers, Pumkin, Cucumber	1
Corn	1
Corn , Peanut , Cassava	1
Corn, Peaanut, Sweet Pepper, Calaloo, Cassava, Beet Root, Pok Choi, Hot Pepper	2
Corn, Peanut , Pumpkin, Cassava , Peas , Sorrell	1
Corns, Cassavas, Pumpkin,Sweet Potatoes, Beans	1
Cucumber , Watermelon	1
Cucumber and Watermelon	1
Cucumber, Bean, Peas,Corn, Watermelon, Pumpkin, Sweet Pepper	1
Cucumber, Beet Root, Sweet Pepper , Watermelon, Canteloupe	1
Cucumber, Cabbage, Tomatoes, Melon, Canteloupe	1
Cucumber, Melon , Cabbage, Tomato	1
Cucumber, Pumkin, Peanut , Sweet Pepper, Corn, Cassava	1
Cucumber, Squash , Watermelon , Escallion	1
Cucumber, Watermelon	1
Cucumber, Watermelon , Sweet Pepper, Canteloupe, Beet Root, PumpKIN	1
Cucumber,Beetroot, Watermelon, Escallion, Sweet Pepper, Tomato	1
Cumcumber Pumpkin Callaloo	1
Escallion, String beans , Cucumbers,Thyme , Watermelon, Marijuana , Carrots	1
Escallion, Thyme, Peanuts, Pumpkin	2
Escallion, Tomatoes , Garden egg , Sweet Pepper	1
Lettuce, Cabbage,Yam, String Bean, Cho-cho, Corn, Sweetpepper, hot pepper, squash	1
Lettuce, Carrot, Sweet Pepper, Watermelom	1
Lettuce, Pok Choi, String Beans, Cabbage	1
Lettuce, Pokchoi, Carrot, Sweet Pepper, Escallion, Cabbage ,	1
Lettuce, Sweet Pepper, Pak Choi, Calaloo	1
Marijuana, Tomato	1
Melon , Canteloupe, Cucumber, Tomato	1
n/a	1
Onion , Escallion , Tomatoes , Beet root , Canteloupe	1
Onion, Escallion , Watermelon , Beet Roo , Tomato , Carrot	1
Peanut , Cauliflowr , Tomato, Pepper , Escallion , Onion	1
Peanut , Pupmpkin, Red Peas, Canteloupe, Honey Dew	2
Peanut Pumkin	1
Peanut Pumkin , Irish, Papayas	1
Peanut Tobacco Corn	1
Peanut, Calallo, Sweet pepper, Watermelon, Canteloupe, Cassava, Pumpkin, Beans, Sweet Potato	1
Peanut, Corn, Escalion, Tyme, Pumpkin, Cucumber, Sorrell, Carrot, Peas	1
Peanut, Corn, Peas, Sweet Potato . Coco, Pumkin	1
Peanut, Corn, Pumpkin, Peas	1
Peanut, Garden Bean	1
Peanut, Pumkin, Cucumber , Water Melon , Sweet Pepper, Cantaloupe, Cauliflower	1
Peanut, Pumpkin	1
Peanut, Pumpkin and Corn	1
Peanut, Pumpkin, Bean, Calallo, Corn	1
Peanut, Sweet pepper, Tomato, Pumpkin, Hot pepper, Calallo, Cassava, peas, Papaya	1
Peanut, Watermelon, Canteloupe, Pumpkin, Sweetpepper	1
Peanut. Bean, Pumpkin	1
Peanuts	1
Penuts	1
Pumkin, Irish, Peanut, Melon, Cucumber, Sweet Potato	1
Pumkin, Peanut, Cucumber, Sweet pepper	1
Pumpkin	1
Pumpkin , Cassava, Bean, Corn	1
Pumpkin , Corn, Cassav, Bean, Okra, Tobacco	1
Pumpkin , Corn, Peas	1
Pumpkin, Bean , Calallo, Sorrel, Pepper	1
Pumpkin, Bean , Cassava , sweet Pepper	1
Pumpkin, Cabbage, Lettuce , Sweet pepper, Sweet Potato, Yam, Hot Pepper	1
Pumpkin, Christmas tree, Cauliflower , String beans , Sweet Pepper, Cabbage, Scotch Bonnet	1
Pumpkin, Cucumber	1
Pumpkin, Escallion	2

Table 64 - Half of the answers to the question "which crops do you grow irrigated?". Source: survey conducted by SCP and ESL

The number of crops grown per farm and per year varies also greatly:

- 30 farmers (19 %) declare to grow 3 to less crops,
- 91 farmers (57 %) grow four or more crops per year
- 40 farmers did not answer the question 25 %

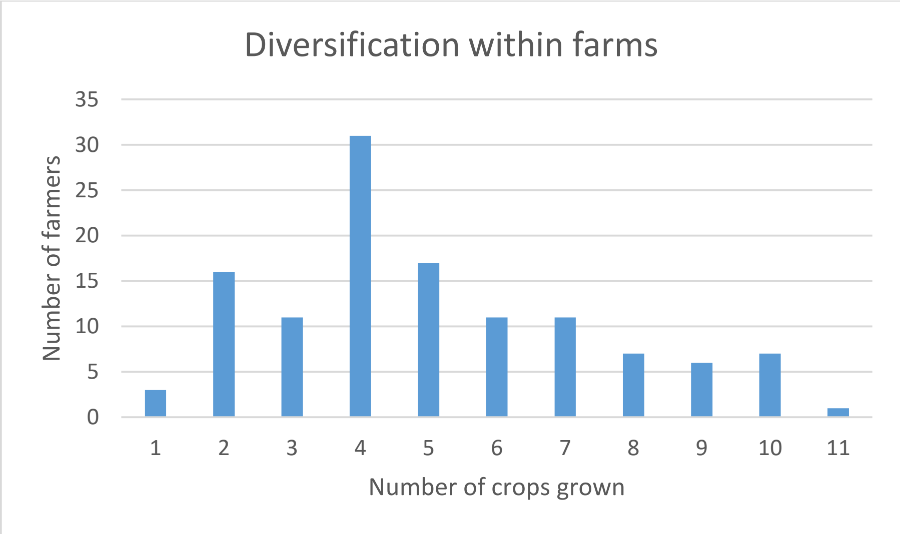


Figure 100 - Number of crops grown within farms. Source: survey conducted by SCP and ESL

Concerning financial data, farmers were asked which was their most profitable crop and here are the answers:

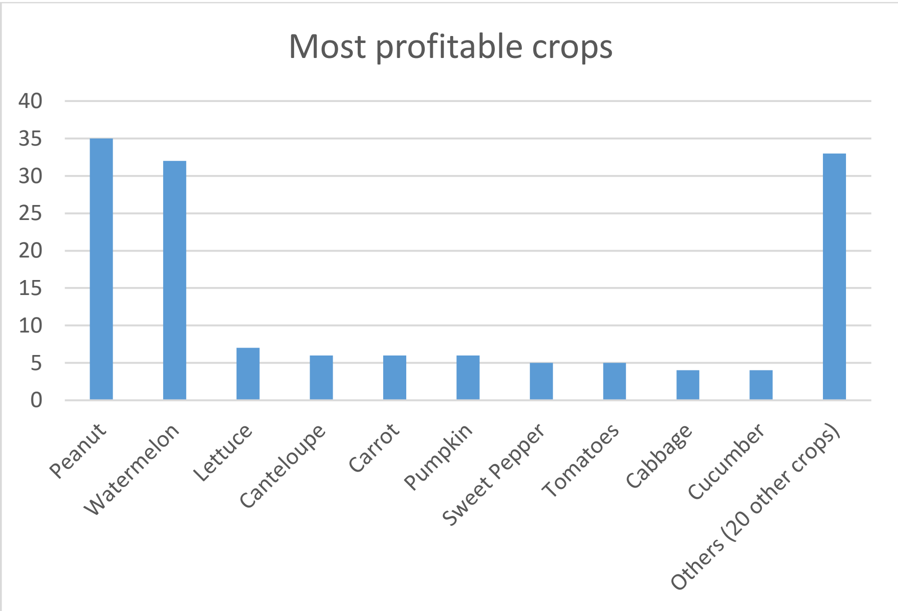


Figure 101 - Most profitable crop according to farmers. Source: survey conducted by SCP and ESL

These results show that:

- The crops that come on top of the answers are peanut (35 answers) and watermelon (32 answers)
- Nevertheless, 109 farmers mention other crops as being most profitable

- Therefore, the profitability of a crop is highly dependent on the individuals: if they have access to market or not, if they have family labour at home or not, if they have access to inputs or not.

- **These results conduct us to be extremely cautious on the interpretation of the figures of the financial and economic results; the models that we built cannot reflect the high diversity of situations that we can see here. We had to simplify this very complex situation in order to obtain the results but they are highly dependent on the hypothesis that we chose.**

Finally, the number of farmers included in the targeted area is about 4,000 who are potential future customers. **They are about 3,100 customers more than currently**. The total amount of expected hydrants would be between 3,800 and 5,000 (currently 1,400 hydrants).

5.5.3 GLOBAL PERCEPTION OF THE PROJECT

During the survey, a quick presentation of the project was exposed to the interviewees. They were asked the question "does this project meet your approval?" The answers are summarized in the following diagram: 96 % of the 342 people interviewed approve the project, only 2 % does not approve the project and 2 % does not know or prefer not to say.

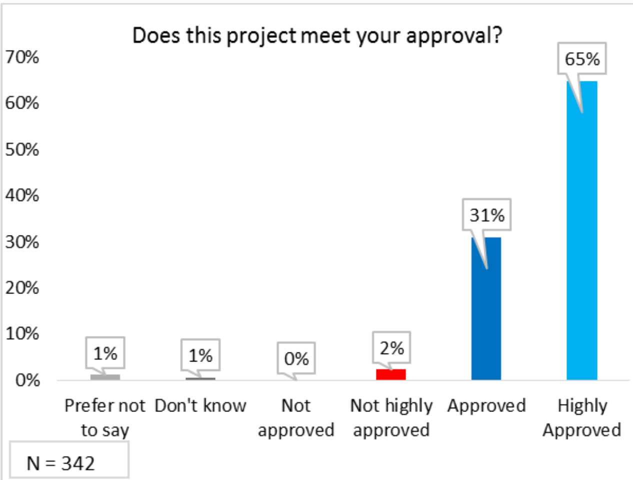


Figure 102 - Answers to the question "does this project meet your approval".
Source: survey conducted by ESL and SCP

Details on public participation to the project are presented in chapter 4.

Interviewees were also asked “Do you think that this project would meet the community's approval?”

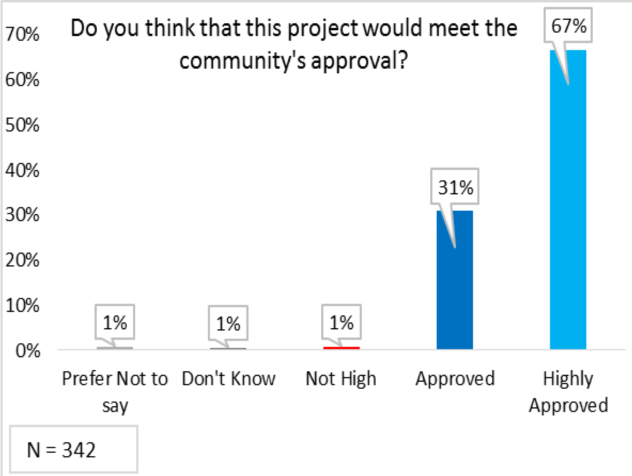


Figure 103 - Answers to the question “do you think this project would meet the community’s approval?”.
(Source: survey conducted by ESL and SCP)

The answers are summarized in the following diagram: 98 % of the 342 people interviewed think that the community would approve the project, only 1 % does not think they would approve the project and 2 % does not know or prefer not to say.

The following question was “do you think your community will view this project as being: …”. For this question, interviewees preferred not to speak in the name of the community and 32 % of them answered they preferred not to say and 63 % they did not know.

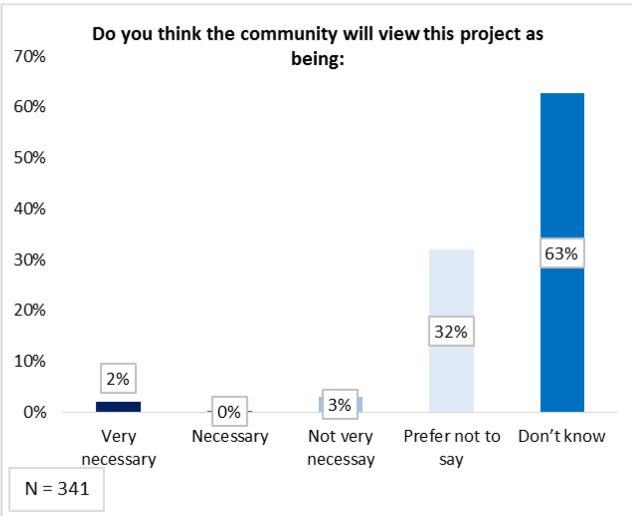


Figure 104 - Answers to the question “do you think the community will view this project as being: …?”.
Source: survey conducted by ESL and SCP

This question was completed by the fommowing question "How do you think your community will perceive this project?". The answers are summarized in the following table:

Positive answers	323
Negative answers (not that important)	3
N/A	15
Missing	1

Figure 105 - Answers to the question "How do you think your community will perceive this project?".
Source: survey conducted by ESL and SCP

⇨ This reveals the high approval of the project by the people surveyed in the area.

The following question was an open-ended question "What benefit do you think your community will gain from this project?". Interviewees had the possibility to express and mention many different ideas, this is why the total does not reflect the number of answers. 10 people out of the 342 did not answer the question. The project is therefore perceived as a **lever to community development in general** and agriculture and farming in particular. The answers are summerized in the following table:

Community development	315
Employment	180
Increase farming	104
Increase income	61
Improvement of agriculture	14
Missing	10

summ

Figure 106 - Answers to the question "What benefit do you think your community will gain from this project?". Source: survey conducted by ESL and SCP

Next answers show that communities are willing to help the project to be realized. They are OK in offering labour mainly, security, store equipment, land space to park and store, etc. Some people are even willing to offer voluntary service.

What do you think your community can offer this project?		
	N	**%**
Labour	85	24,9%
Help	59	17,3%
Security	44	12,9%
Store Equipments	42	12,3%
Land space to park machinery	23	6,7%
Storage	23	6,7%
Support	13	3,8%
Voluntary service	11	3,2%
Investment	4	1,2%
Land space	3	0,9%
Nothing	1	0,3%
Don’t Know	1	0,3%
Missing	33	9,6%
Total	**342**	**100,0**

Figure 107 - Answers to the question “What do you think your community can offer this project?”. Source: survey conducted by ESL and SCP

In terms of historical heritage, people declare the following:

Do you know any cultural heritage/ historical sites in this area?		
	N	**%**
No	296	86,5
Lovers Leap	15	4,4
Munro College	14	4,1
Southfield Historical Site	4	1,2
Pedro Plains Anglican Church	3	,9
Memorial of Donald Sangster	1	,3
Tombstone	1	,3
Missing	8	2,3
Total	**342**	**100,0**

Figure 108 - Answers to the question “Do you know any cultural heritage/ historical sites in this area?”. Source: survey conducted by ESL and SCP

Most of the people do not identify any particular heritage nor historical site except for Lovers leap (which is not included in the project area), Munro College, Southfiled historical site, Pedro Plains Anglican Church, the memorial of Donald Sangster and a cemetery.

What are your main environmental concerns regarding this project?		
	N	**%**
No concern	158	46%
Dust nuisance	88	26%
Digging of the road	67	20%
N/A	23	7%
Road concerns	2	1%
Missing	2	1%
High concerns	1	0%
Pipelines turned off	1	0%
Total	**342**	**100,0**

Figure 109 - Answers to the question "What are your main environmental concerns regarding this project?". Source: survey conducted by ESL and SCP

Nearly half of the interviewees do not have concerns about the project. The rest are concerned especially on the works phase (not on the operation phase) about:

- Dust nuisance
- Digging of the road and road concern
- Pipelines turned off
- And one person expressed to be highly concerned but did not explain the reasons why.

6 PUBLIC PARTICIPATION

Public participation takes places along the project life at several stages: during the feasibility and preliminary project design, in order to collect field data and quantify the need; then during the public consultation once that the environmental and social impact assessement are done, in order to present to the population and stakeholders the project, (including the mitigation measures) and collect their feedback to ensure optimal adaptation and acceptability of the project.

6.1 FEASIBILITY AND PRELIMINARY DESIGN PHASE SURVEYS

Several surveys were carried on in order to adapt the project to local needs and specific issues.

During the feasibility studies, conducted in 2018 and 2019, several surveys were conducted.

Thanks to the survey, data from the people living in the area and specifically from farmers were collected. A simplified portrait of farmers coming from the survey is presented below.

Here are the figures of the achievement of the survey compared to the objectives:

Table 65 - Sample of the survey and results. Source: SCP

Category of interview	**Total number in the area**	**Sampling expected**	**Sampling achieved**	**Proportion expected**	**Proportion achieved**
Crop farmers	Around 4000	214	161	63%	47 %
Livestock farmers	50 to 60	5	14	1%	4 %
Higglers	Around 100	20	43	6%	13 %
Individuals who are not farmers nor higglers (including laborers)	No data available	100	124	29%	36 %
Total		**340**	**342**	**100 %**	**100 %**

Out of the 342 interviews, we can deduce that:

- All of them live in the project area
- The major age group represented is people between 31 and 50 years but all of the other group ages are represented as well
- 38 % are women
- 2 % suffer from a disability
- 108 went to preparatory school (32%), 199 to secondary school (58.2 %) and 30 to tertiary education (9%), 2 did not answer
- The main source of drinkable water is NWC with 91 % answers; 6 % of the people drink water from tanks and 3 % drink water from irrigation, a catchment and a river.
- Most of them spend between $ 1000 and $ 10 000 Jamaican dollars to access to water
- 71 % of the interviewees declare to be interested in benefiting from another source of water
- The main source of information is the television (89 % of people mention it), followed by the radio (73 %); Internet (29 %), the newspaper (26 %) and training from RADA (5%)

Out of the 167 people who declared not to be farmers, 108 declared to be interested in farming 64 %, 28 said they were not interested (17 %) and the rest did not know. To the question "what would you need to start a farm", people answered[35]:

[35] Interviewees had the possibility to choose many answers.

Table 66 - Answers to the question "what would you need to start a farm" for people who do not farm yet. Source: survey by SCP and ESL

More land	45
Ensured market	29
Training	20
Higher prices	13
Credit	18
Water	12

Water comes at 5th position and the other constraints are economic issues (ensured market, higher prices and credit), the difficulty to access to land and the need for training.

This confirms the assessment made in the agricultural assessment phase that identified four major topics to work on:

- Marketing
- The use of inputs to improve economic results and limit environmental consequences
- Farmers' structuration in order to improve economic results (by improving marketing and decreasing costs of production) and facilitate access to credit and
- Irrigation technics

From the 161 farmers interviewed:

- 34 are women that is 21 %;
- 6 present a disability, that is 3.7 %
- All of them live in the area
- 46 of them had parents who were not from the area and who immigrated to the area, that is 28 %
- 63 went to preparatory school (39 %), 85 to secondary school (53 %) and 11 to tertiary education (7%), 2 did not answer; this means that farmers are in average less educated than the global sample of the survey
- 31 % have land in an irrigation scheme (Beacon or Hounslow)
- 50,3 % of farmers are registered farmers
- 37 % of them have been victims of praedial larceny
- Only 26 % pf them are members of a farmers' association

According to the survey, farm sizes are split as follows:

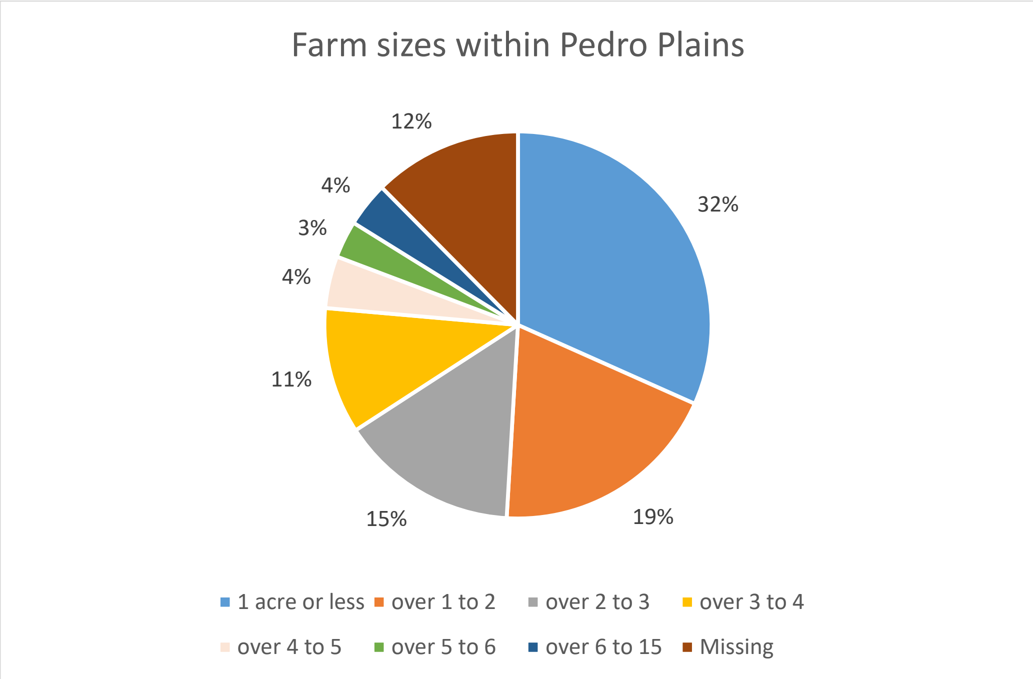


Figure 110 - Farm size typology (source: SCP's survey)

1/3 of farmers have one acre or less, another 1/3 have 1 to 3 acres and only 6 farmers (4%) have more than 6 acres. 20 farmers do not know or did not want to answer this question (missing category).

In order to simplify the model, we chose as a farm baseline a farm of 1 hectare which represents 2.47 acres of land.

If they had access to irrigation, farmers would use it to:

Table 67 - If they had access to irrigation, farmers declare they would use it to…. Source: survey by SCP and ESL

a□ Increase crops' yields	111
e□ Improve your incomes	78
b□ Diversify the crops you farm	46
c□ Grow crops that need plowing	6
d□ Stage your crops' harvesting	1
f□ Decrease the diversity of crops (grow less but with higher yields)	0
g□ Other (please specify):	0
Missing	36

Even if water was not available on demand but only twice a week, 95 % of the farmers would still be interested in benefiting from it.

These are the crops farmers declare to grow:

Table 68 - Half of the answers to the question "which crops do you grow irrigated?". Source: survey by SCP and ESL

Which vegetables do you grow irrigated?	N
Beans, Hot Pepper	2
Beet Root , Onion , Tomatoes , Watermelon	1
Beet Root, Lettuce	1
Beet Root, Tomatoes , Watermlon , Canteloupe	1
Beetroot, Tomato, Canteloupe, Watermelon, Cucumber, Sweet pepper	1
Brocolli , Lettuce, Mushrooms, Cabbage	1
Cabbage, Corn, Yam, Tomato, Lettuce, Sweet Pepper, Hot pepper, Pumpkin	1
Cabbage, Lettuce, Sweet pepper, Sweet potato, Hot pepper, Corn, Pumpkin, Yam, Cassava , Cho-cho	1
Calallo, Sweet Pepper,Pumpkin	2
Calaloo, Marijuana, Sweet Pepper	1
Calaloo, Pumpkin , Peanut	2
Califlower , Peanut, Pumpkin	1
Califlower, Cucumber	2
Canteloupe, Honey Due, Watermelon, Cucumber	1
Carro, Sweet Pepper, Cabbage, Corn, Pokchoi, Pumpkin	1
Carrot , Cabbage , Lettuce, Sweet Potatoes	1
Carrot, Cucumber, String beans,Sweet potatoes	1
Carrot, Sweet pepper, Cho- Cho, Irish Potatoes	1
Cassava , Peas, Corn, Pumpkin , Banabis Bean , Sorrell, Running bean	1
Coorn, Ockra, Bean, Sweet Peppers , Hot peppers, Pumkin, Cucumber	1
Corn	1
Corn , Peanut , Cassava	1
Corn, Peaanut, Sweet Pepper, Calaloo, Cassava, Beet Root, Pok Choi, Hot Pepper	2
Corn, Peanut , Pumpkin, Cassava , Peas , Sorrell	1
Corns, Cassavas, Pumpkin,Sweet Potatoes, Beans	1
Cucumber , Watermelon	1
Cucumber and Watermelon	1
Cucumber, Bean, Peas,Corn, Watermelon, Pumpkin, Sweet Pepper	1
Cucumber, Beet Root, Sweet Pepper , Watermelon, Canteloupe	1
Cucumber, Cabbage, Tomatoes, Melon, Canteloupe	1
Cucumber, Melon , Cabbage, Tomato	1
Cucumber, Pumkin, Peanut , Sweet Pepper, Corn, Cassava	1
Cucumber, Squash , Watermelon , Escallion	1
Cucumber, Watermelon	1
Cucumber, Watermelon , Sweet Pepper, Canteloupe, Beet Root, PumpKIN	1
Cucumber,Beetroot, Watermelon, Escallion, Sweet Pepper, Tomato	1
Cumcumber Pumpkin Callaloo	1
Escallion, String beans , Cucumbers,Thyme , Watermelon, Marijuana , Carrots	1
Escallion, Thyme, Peanuts, Pumpkin	2
Escallion, Tomatoes , Garden egg , Sweet Pepper	1
Lettuce, Cabbage,Yam, String Bean, Cho-cho, Corn, Sweetpepper, hot pepper, squash	1
Lettuce, Carrot, Sweet Pepper, Watermelom	1
Lettuce, Pok Choi, String Beans, Cabbage	1
Lettuce, Pokchoi, Carrot, Sweet Pepper, Escallion, Cabbage ,	1
Lettuce, Sweet Pepper, Pak Choi, Calaloo	1
Marijuana, Tomato	1
Melon , Canteloupe, Cucumber, Tomato	1
n/a	1
Onion , Escallion , Tomatoes , Beet root , Canteloupe	1
Onion, Escallion , Watermelon , Beet Roo , Tomato , Carrot	1
Peanut , Cauliflowr , Tomato, Pepper , Escallion , Onion	1
Peanut , Pupmpkin, Red Peas, Canteloupe, Honey Dew	2
Peanut Pumkin	1
Peanut Pumkin , Irish, Papayas	1
Peanut Tobacco Corn	1
Peanut, Calallo, Sweet pepper, Watermelon, Canteloupe, Cassava, Pumpkin, Beans, Sweet Potato	1
Peanut, Corn, Escalion, Tyme, Pumpkin, Cucumber, Sorrell, Carrot, Peas	1
Peanut, Corn, Peas, Sweet Potato . Coco, Pumkin	1
Peanut, Corn, Pumpkin, Peas	1
Peanut, Garden Bean	1
Peanut, Pumkin, Cucumber , Water Melon , Sweet Pepper, Cantaloupe, Cauliflower	1
Peanut, Pumpkin	1
Peanut, Pumpkin and Corn	1
Peanut, Pumpkin, Bean, Calallo, Corn	1
Peanut, Sweet pepper, Tomato, Pumpkin, Hot pepper, Calallo, Cassava, peas, Papaya	1
Peanut, Watermelon, Canteloupe, Pumpkin, Sweetpepper	1
Peanut. Bean, Pumpkin	1
Peanuts	1
Penuts	1
Pumkin, Irish, Peanut, Melon, Cucumber, Sweet Potato	1
Pumkin, Peanut, Cucumber, Sweet pepper	1
Pumpkin	1
Pumpkin , Cassava, Bean, Corn	1
Pumpkin , Corn, Cassav, Bean, Okra, Tobacco	1
Pumpkin , Corn, Peas	1
Pumpkin, Bean , Calallo, Sorrel, Pepper	1
Pumpkin, Bean , Cassava , sweet Pepper	1
Pumpkin, Cabbage, Lettuce , Sweet pepper, Sweet Potato, Yam, Hot Pepper	1
Pumpkin, Christmas tree, Cauliflower , String beans , Sweet Pepper, Cabbage, Scotch Bonnet	1
Pumpkin, Cucumber	1
Pumpkin, Escallion	2

The number of crops grown per farm and per year varies also greatly:

30 farmers (19 %) declare to grow 3 to less crops,
91 farmers (57 %) grow four or more crops per year
40 farmers did not answer the question 25 %

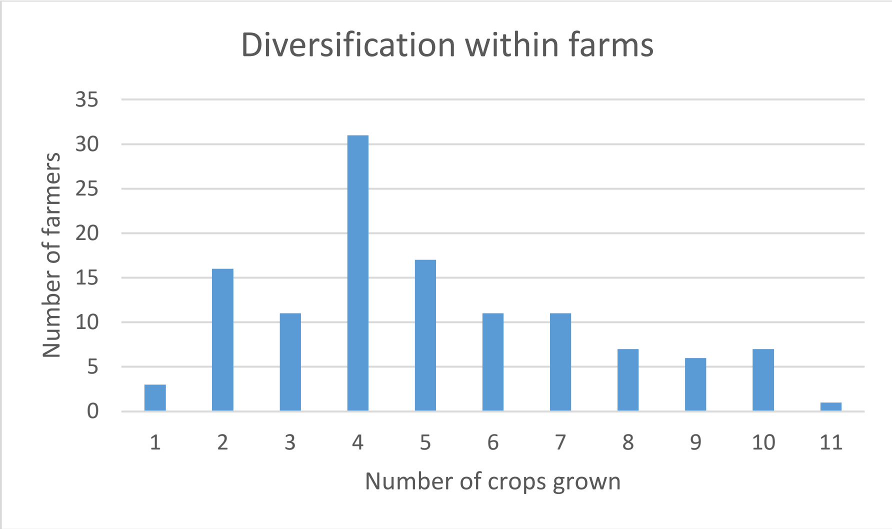


Figure 111 - Number of crops grown within farms. Source: survey conducted by SCP and ESL

Concerning financial data, farmers were asked which was their most profitable crop and here are the answers:

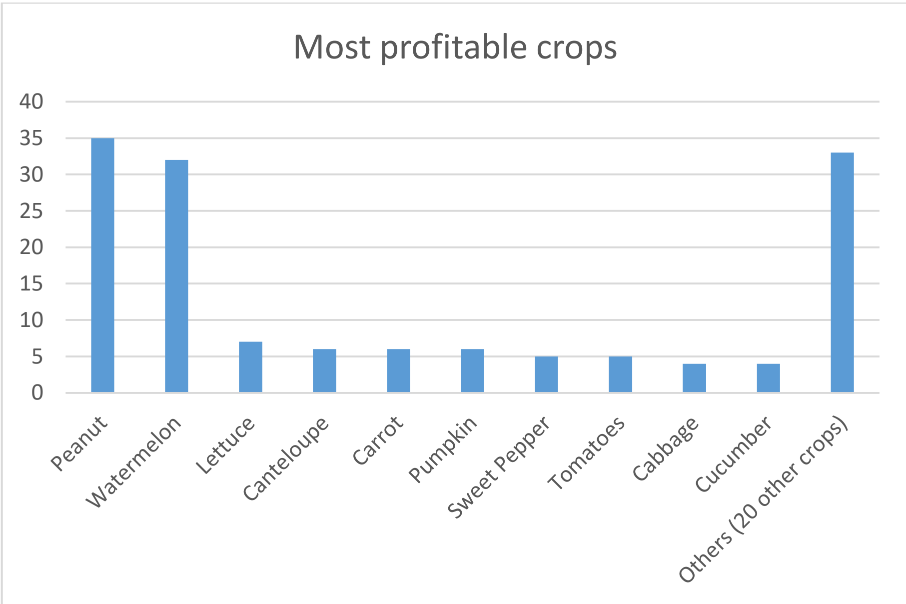


Figure 112 - Most profitable crop according to farmers. Source: survey conducted by SCP and ESL

These results show that:

The crops that come on top of the answers are peanut (35 answers) and watermelon (32 answers)

Nevertheless, 109 farmers mention other crops as being most profitable

Therefore, the profitability of a crop is highly dependent on the individuals: if they have access to market or not, if they have family labor at home or not, if they have access to inputs or not

- **These results conducts us to be extremely cautious on the interpretation of the figures of the financial and economic results; the models that we built cannot reflect the high diversity of situations that we can see here. We had to simplify this very complex situation in order to obtain the results but they are highly dependent on the hypothesis that we chose.**

Finally, the number of farmers included in the targeted area is about 4,000 who are potential future customers. **They are about 3,100 customers more than currently**. The total amount of expected hydrants would be between 3,800 and 5,000 (currently 1,400 hydrants).

Specifical agriculture-oriented field visits and value chains' interviews were done, with the following objectives:

- To draw a baseline of the current stakeholders intervening in the value chain in the area
- To identify elements of history impacting the agriculture production of the area
- To characterize the main stakes of agriculture in the area, the strengths and weaknesses.

Value chain interviews consisted mainly in interviewing the following categories of stakeholders:

- Input suppliers: 1 farm store
- Farmers: 15 interviews amongst which 2 organic farmers were interviewed
- Higglers: 2 interviews (buyers/distributors) ;
- Processing: Grace factory

Picture 26 - Field visits, focus groups and farmers' interviews. Source: SCP, ESL and NIC

Four focus groups were held in 2019, aiming to:

- Engage a collective discussion on the main stakes faced by agriculture in the area
- Build the "with irrigation network" scenario,
    - "What would you do if you had access to cheapest water?" for farmers who do not yet have access to the irrigation network
    - "What are the changes identified when you accessed to the irrigation network operated by NIC?" for farmers who benefit from the irrigation network in Hounslow and Beacon / Little Park
- Characterize the current levels of water service and start a discussion of alternative levels of service for farmers who are far from the main pipeline and on hilly locations
    - "What are the different level of services and their tariffs that you are ready to consider?" for farmers who do not yet have access to the irrigation network
    - "Describe the level of service supplied by NIC? What do you think about it? What are the strengths and what can be improved?" for farmers who benefit from the irrigation network in Hounslow and Beacon / Little Park

The following focus groups were organized thanks to RADA intervention:

- Tuesday 29th January 2019, Farmer's groups in Southfield with farmers who do not benefit from NIC network
- Wednesday 30th January 2019, Water Users' Association in Hounslow with farmers who benefit from NIC network
- Wednesday 30th January 2019, Farmers' group in Mountainside / Knoxwood with farmers who do not benefit from NIC network
- Thursday 31st January 2019, Water Users' Association in Beacon with farmers who do not benefit from NIC network => this focus group was canceled because of the lack of availability of farmers and was replaced by individual interviews.
- Thursday 31st January 2019, Farmers' group in Flagaman with farmers who do not benefit from NIC network.

6.2 PUBLIC ENQUIRY

People will be invited to express their opinion about the project during the public enquiry that will be held in the next months, after NEPA's screening phase of the environmental and social assessment. A public presentation in accordance with the Guidelines for Conducting Public Presentation is held during the environmental permit process. The date of the presentation will be announced in local newspapers during 3 notices within 21 days. . Public submits comments in writing within 21 days after the public presentation.

7 IDENTIFICATION OF POTENTIAL IMPACTS

The aim of this chapter is to identify major environmental and public health issues of concern. The projet impacts are divided into:

- preparation and construction related
- operation phase related.

The evaluated areas of impact deal with the physical environment (changes in drainage pattern, surface and groundwater parameters), the ecological features (ecosystem, flora and fauna...), natural hazards, heritage and also socio-economic and human impacts (e.g. agriculture, income...).

According to NEPA directions, project activities and impacts are represented in matrix form with separate matrices for pre and post mitigation scenarios.

7.1 IMPACTS DURING PREPARATION AND CONSTRUCTION PHASE

7.1.1 IMPACTS RELATED TO PHYSICAL PARAMETERS

Impacts on physical parameters related to preparation and construction of the pipeline network, reservoirs, pumping station and photovoltaic plant can be summarized as following :

- site cleaning, trench excavation, storage of soil aside during pipe laying or during construction of reservoirs or pumping station can create increased air pollution because of dust. Noise and vibrations can also occur but will be limited in time.
- Gas emissions will increase due to traffic of heavy duty vehicles.
- Generally, fuel recharge of vehicles or any other machine can imply surface water pollution, Sewage system can also have a negative impact on water quality.
- Buildings (pumping station) or reservoirs can imply a modification of drainage patterns, but this will occur very locally and will not increasy flooding risk. Surface water quality can be also affected by contruction works, because of increased erosion or drainage of water with a high rate of suspended solids.

All the possible impacts listed above are considered neglectable or minor negative, and can be mitigated (cf. suggested mesures, chapter 8).

7.1.2 ENVIRONMENTAL AND SOCIAL IMPACTS

The main potential environmental impacts associated to pre-operation phases are the loss of flora and fauna over the project area.

The fact that the pipeline will lay underground implies a higher impact during construction phase, but a better cicatrisation of the ecosystem afterwards : in fact, once the pipeline is laid, vegetation can grow above the area, and this linear infrastructure will not cause habitat loss or fragmentation. The only permanent impacts on habitat loss will likely be associated with the permanent and above-ground infrastructures, which are the pumping stations, photovoltaic plants and reservoirs. Only two of these infrastructures lay in the Morass area, close to the Black River and to an existing farm, which is an area with some anthropogenic influence.

The projected land acquisition in Lacovia corresponds to the surface that will host the photovoltaic farm (PV1), and the pumping station (PS1) at the intake from the Black River.

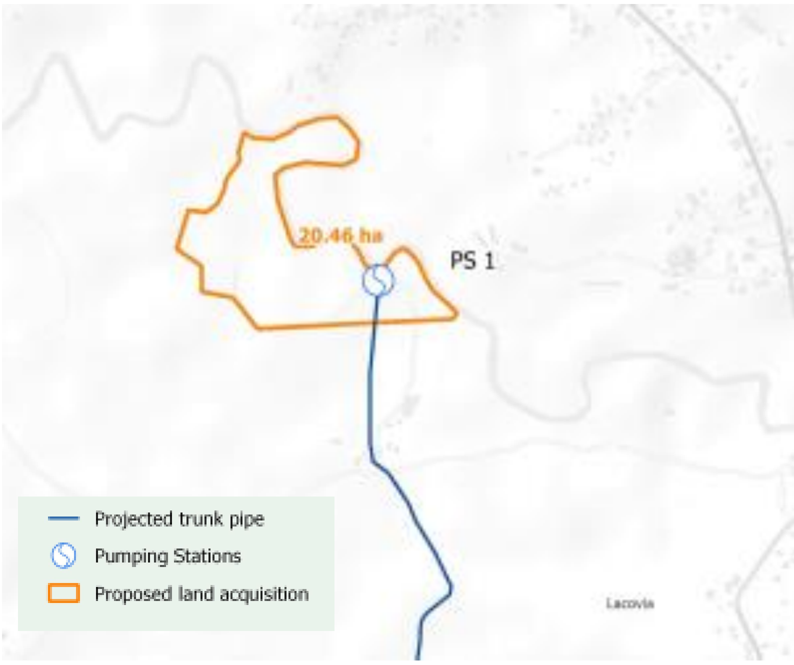


Figure 113 - Projected land acquisition, along the Black River at Lacovia

The construction of the uptake infrastructure will also have possible impact on water quality, mainly due to turbidity increase.

The environmental impacts of the proposed activity on vegetation and wetland ecosystem are evaluated as major negative impacts, because of the sensitivity of the Morass ecosystem. These potential impacts can be considered minor on the fauna, because of their capacity to move to other areas during disturbances.

The second photovoltaic farm (PV2) will be located on an agricultural ground. The land acquisition will include the surface required for the farm and the pumping station (PS2). The remaining land acquisitions corresponding to a land use change are located at the sites that will host the remaining reservoirs and pumping stations.

☞ ***See maps 18 and 19 – Projected land acquisition areas***

Figure 114 - Projected land acquisition along the future infrastructure south of Lacovia

These sites are located in areas that have a mix of croplands and woodand. The immediate surroundings of the pumping stations and reservoirs shown in Figure 91 are open grass areas and some farms. These areas are not ecologically sensitive and so the ecological impact is considered negative but minor in these instances. However, based on the location of some of the farms, the loss of individual farm lots will potentially be a negative and major social impact.

Additionally, during construction, it is anticipated that the excavation and construction activities will likely result in temporary but significant dust and noise nuisance to neighbouring residents and businesses and as such appropriate mitigation measures will need to be applied during construction to minimize this.

Health and safety concerns, although temporary can also arise as major issues during the construction period. Accidents, unwanted injuries and even death can potnetially occur to workers as well as visitors and nearby residents and road users. Good construction practices would need to be employed during the contruction periods to minimize these major potential impacts.

During the construction phase, the project will have an impact on the population due to the acquisition of land for the construction of superstructures (reservoirs, pumping stations, solar farm, backfill…) and the temporary occupation of land for the laying of the pipeline. The land acquisition and easement will result in a possible reduction in crop production (less land for agriculture) that will have to be compensated (see § 8.).

7.2 IMPACTS DURING OPERATION PHASE

Operation phase impacts can be of 3 types :

- impacts due to water uptake: these impacts are both physical (impact on water discharge and level, see paragraph 7.2.1.) and environmental (paragraph 7.2.2)
- impacts due to the infrastructure itself (mainly environmental, paragraph 7.2.2)
- impacts resulting from the use of water for irrigation: these impacts are generally indirect and are linked to the consequences of providing water for agriculture. They imply positive consequences (benefits for social and production aspects) but also possibly negative impacts due to increased use of pesticides, overproduction etc. All these aspects are discussed in paragraph 7.2.3.

7.2.1 IMPACTS RELATED TO PHYSICAL PARAMETERS

During operation phase most of the infrastructure will be "invisible", i.e. pipes being buried in trenches, and the only visible part of the project will be related to the pumping stations, reservoir and photovoltaic plants. These components of the project, once built, have no significative impact on compartiments such as air quality, noise, or gas emissions.

The main identified impact is the water abstraction from the Black River, described in the paragraph hereafter for what related to physical parameters.

7.2.1.1 IMPACT OF WATER ABSTRACTION OF THE FLOW OF THE BLACK RIVER

As previously mentioned, the amount of abstracted water was calculated in order to **respect the ecological flow** of the Black River. This value was calculated using the rule defined by WRA as:

Ecological flow = 60% of the stream flow on 7 days minimum – period of ten-year return

7.2.1.1.1 Statistical determination on the basis of daily flows

Data collected from the Jamaican discharge database over the period of 1963 to 2017 have allowed statistical calculation of the main discharge parameters at Lacovia.

- Minimum flow rate over 7 consecutive days of ten-year return: **5.77 m^3/s** (refer to chart of)
- Ecological flow : **3.46 m^3/s**

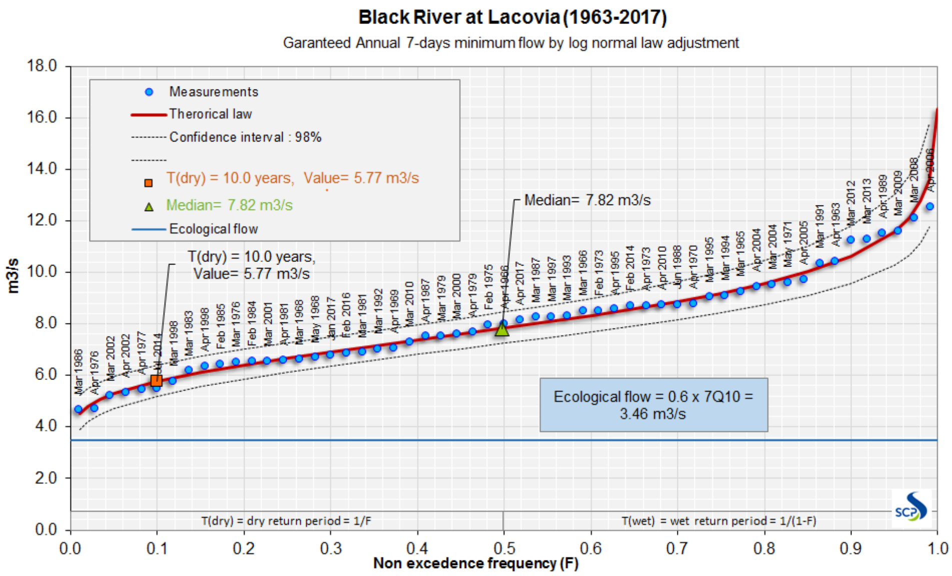


Figure 115 - Annual minimum 7 days Stream flow statistics

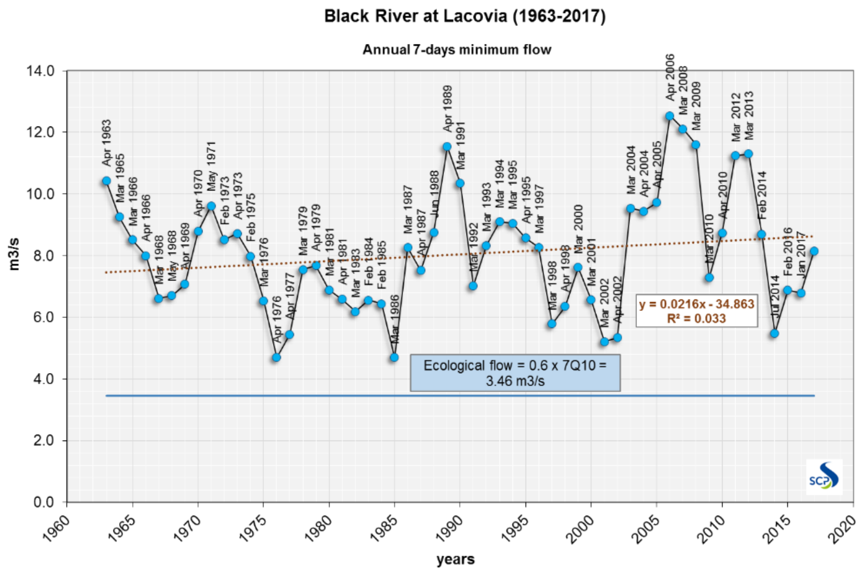


Figure 116 - Annual minimum 7 days Stream flow historical

7.2.1.1.2 Simulation f the impact of an uptake of 2.2 m^3/s

A simulation has been carried on to model the impact of a constant uptake of 2.2 m3/s. This simulation in the most defavourable case, because the value of 2.2 m3/s is the maximum uptake over 18 consecutive hours. In the simulation the uptake is considered constant over 24h. This scenario meets WRA demand, to show the worst possible impact on water flow.

The value of the "ecological flow" (**3.45 m³/s**) is reached during the 6 driest years (see Figure 20), for periods of 2 to 32 consecutive days. It is recalled that in reality, the flow of the river has never reached this value in the past.

<u>... Impact on the minimum annual flow over 7 days (7Q)</u>:

- The median (7Q2) drops by 28% (7.8 to **5.65 m³/s**) see figure below,
- The ten-year dry value (7Q10) drops by 34% (from 5.77 to **3.83 m³/s**), which comes close therefore the value of the "ecological flow" (defined as 60% of the current decadal dry value).

<u>... Impact on the average Black River average annual flow</u>: the impact is significant since the value drops by 11% (from 20.3 to **18.0 m³/s**)

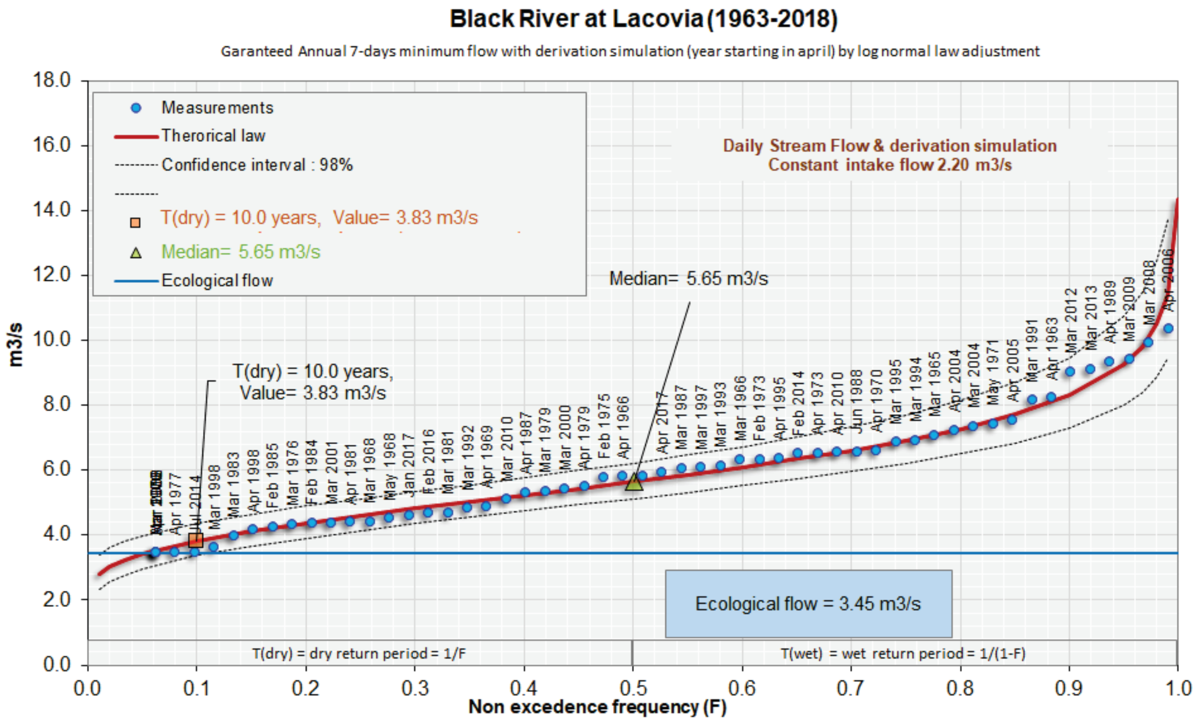


Figure 117 - Annual minimum 7 days simulated stream flow statistics (River intake 2.2 m3/s)

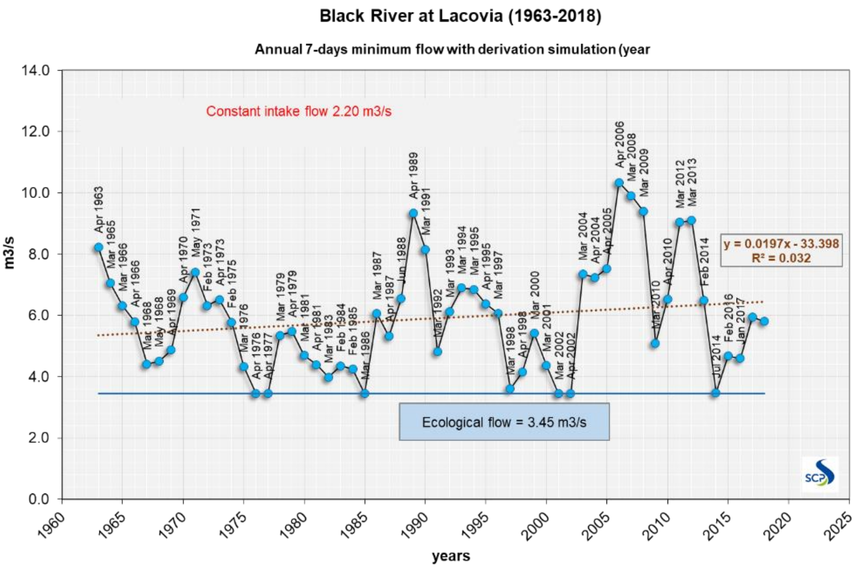


Figure 118 - Annual minimum 7 days simulated stream flow historical (River intake 2.2 m^3/s)

.... Impact on all daily flows (sorted flows)

The changes in the daily debit regime, illustrated below, can be commented as follows:

- The current value of the median daily flow (i.e. 16.8 m^3/s exceeded 50% of the time), is only exceeded 44% of the time with the simulated diversion (i.e. a reduction in duration of 7%, and 260 days in 10-year average)
  At the same time the median value of the daily flow would drop from 16.8 to 14.6 m^3/s (a decrease in flow of 13%)
- The flow rate exceeded 80% of the time in a natural situation (10.6 m^3/s) is only exceeded 70% of the time in the simulation (a reduction in duration of 10%, and 365 days on average over 10 years)
  At the same time, the flow value exceeded 80% of the time would become 8.5 m^3/s (i.e. a flow drop of 20%)
- The flow rate exceeded 90% of the time in a natural situation (8.7 m^3/s) is only exceeded 80% of the time in the simulation (a reduction in duration of 10%, and 365 days on average over 10 years)
  At the same time, the value of the flow exceeded 90% of the time in a natural situation, become 6.5 m^3/s in the simulation (i.e. a reduction in flow of 25%)

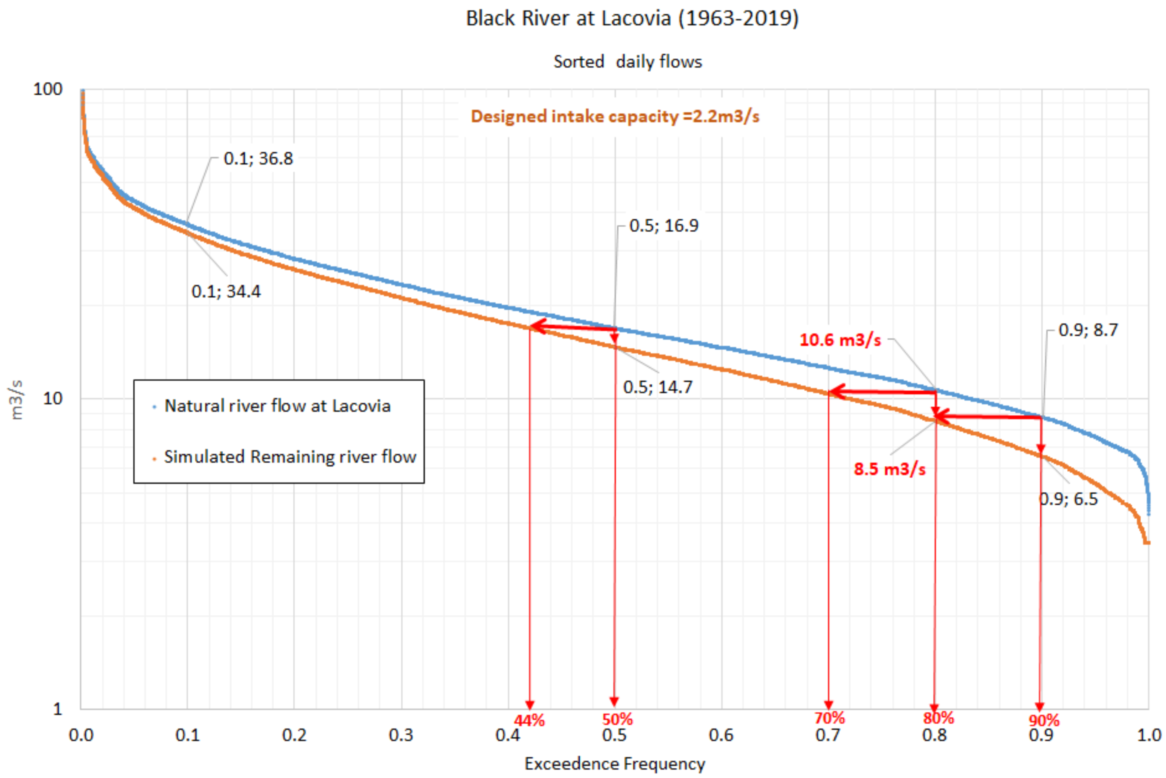


*Figure 119 – Frequency distribution of daily streamflows (*original flows and remaining flows according to intake simulation)

7.2.1.2 INDIRECT IMPACTS OF SURFACE WATER ABSTRACTION

A positive indirect impact of the project is the fact that providing water from the Black River will avoid overexploitation of the underground water resource, which is already used at its maximum capacity.

Another positif impact will be that the raw water for agriculture will be provided through a pipeline distribution system instead of private truck transport, current practice, expensive and responsible for greenhouse gazes emissions.

An indirect negative impact will be the necessity of maintanance operations once the infrastructure will be in operation phase : flushing of the pipe will be needed periodically, depending on sediment accumulation in the infrastructure. Possible impact on the receiving environment is to be considered.

7.2.2 ENVIRONMENTAL IMPACTS

The potential environmental impacts of the operation phase of the project, as discussed above (paragraph 5.2), are associated with the the water uptake and the maintenance of the infrastructure.

Water uptake impact has been modelled conservatively, using the peak season uptake value as a permanent uptake. The environmental consequences of such an uptake can imply a local disturbance of fauna habitats close to the uptake point. This could include disturbing fish life if water levels were to reduce, or simply by human activity. This fish population would only be negatively impacted if updake were to occur leaving less than required for the environmental flow. At this point the quality of the water would be compromised and can lack the biological oxygen demand requreiment for a healthy fish population.

The ESL survey performed in 2019 in order to describe the ecological baseline of the site has not shown any crocodile nests close to the uptake point. The crocodiles witin the BRLM often nest on the coastal beaches and swim upstream. Their numbers are greater in the brackish areas of the BRLM. Crocodile nesting is not charactersitic of the intake area.

The impact of water uptake is evident on water flow and on water depth : the water column can decrease of 15 cm according to modelling of the uptake impact. Such an impact can be visible for 2km dowsteam from the uptake point. Further downstream there is no mode influence of water depth variation, just the water flow will be lower.

The construction and operation of the pumping stations, photovoltaic plant and reservoir sites will result in the permanent loss of vegetation in these locations. These areas did not possess any species of ecological significance and although negative can be considered minor. Improtantly, these areas also had private crop farms and as such the is negative, major loss for these farms. Socially, these lands would need to be acquired to facilitate the construction.

Despite this, the development of these structures will result in the ability of the project to supply the wider communities with irrigation network to support the farming activities that are characteristic of the area. Communities such as: Queensbury, Beacon, Pedro Plains, Flagaman, Ballard's Valley, Newcombe Valley, Watchwell, Bigwoods, Berlin, Top Round Hill, Bethany District, Claremont Park, Southfield, Bull Savannah and Treasure Beach, will be positively impacted by the supply in irrigation water. This is both a major social and economic impact.

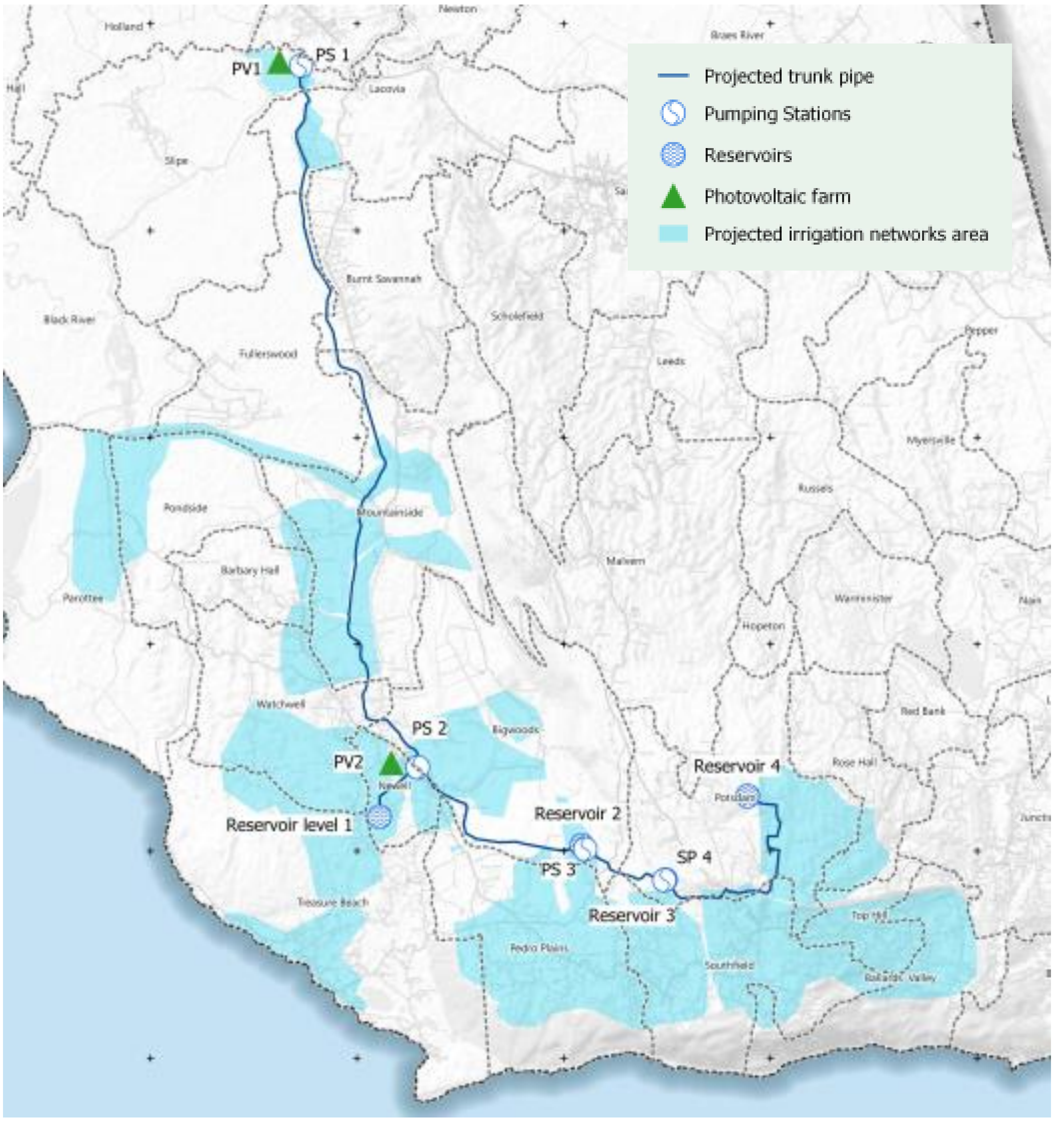


Figure 120 – Projected irrigable areas

Ponctual flushing maintainance will be also done during operation of the infrastructure. These flushing will be done periodically, in order to clean the pipeline from the suspended matter that can accumulate in it. The release of this water will be done through a management plan that will imply the respect of water quality standards, and avoiding low water season.

Furthermore, pipe flushing will occur every some years. Rejection points will be identified during the project final design.

7.2.3 SOCIO-ECONOMIC AND AGRICULTURE RELATED IMPACTS

7.2.3.1 CHANGES IN AGRICULTURAL PRODUCTION THANKS TO THE PROJECT

During the feasibility studies, out of the 161 farmers interviewed, 1/3 of the farmers have already access to irrigation. The other 2/3 buys water from trucks which are very expensive (water price ranging from 100 Jamaican $ to 1 000 Jamaican $).

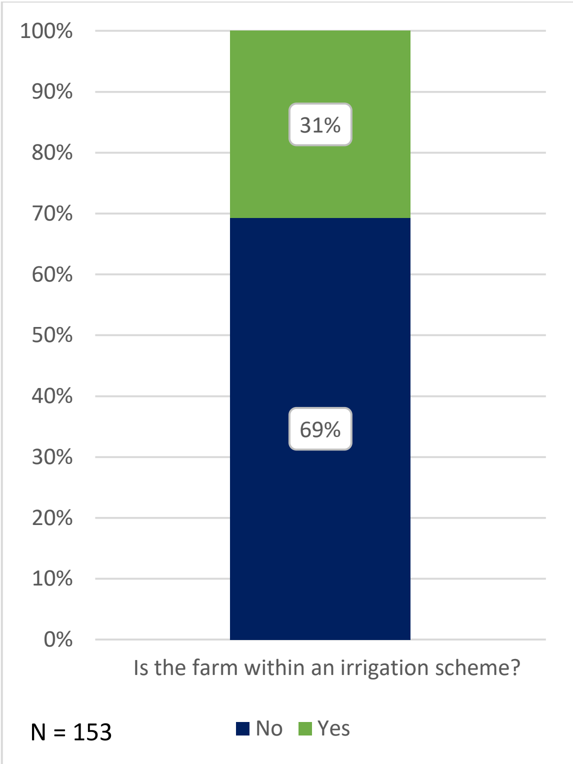


Figure 121 - Current access to irrigation within farms in Pedro Plains according to the survey results. Source: survey conducted by ESL and SCP

Most farmers in the irrigation scheme irrigate thanks to sprinklers especially for the seedlings and drip irrigation for the vegetables and fruits.

Farmers within and without irrigation schemes also practice small irrigation thanks to drums.

⇨ **The project would therefore increase the water consumption at a global scale as most of the farms want to develop thanks to the access to water.**

The project will have a major impact on agriculture as it should ensure the transition of a rain-fed agriculture to an irrigated agriculture. This transition has to be done in the best conditions to preserve agro-ecological practices that already exist in the area and also promote new one.

Considering only the 114 farmers who do not benefit from water from NIC, most of them are interested in accessing to irrigation water as shown in the table below.

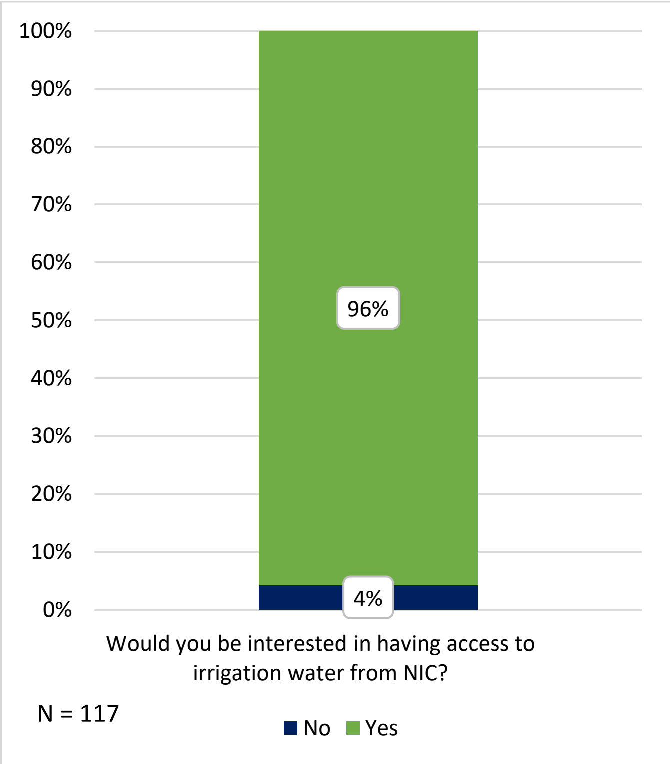


Figure 122 - Answers to the question "Would you be interested in having access to irrigation water from NIC?". Source: survey conducted by ESL and SCP

Even if water were not available on demand but only twice a week, **95 % of the farmers** would still be interested in benefiting from it.

⇨ **The project would certainly impact the development of agriculture in the area: new farmers want to seize this opportunity to start a farming business**

Farmers declare that they would use the irrigation water to:

Increase crops' yield	111 answers
Improve your incomes	78 answers
Diversify the crops in your farm	46 answers
Grow crops that need plowing	6 answers
Stage your crops harvest	1 answers
Decrease the diversity of crops	0
Other	0
Missing	36 answers

Table 69 - Answers to the question "if you had access to irrigation, how would you use it?". Source: survey conducted by ESL and SCP

⇨ **According to the table above, access to water would have potentially the following impacts: farmers expect to improve their income thanks to the increase of the yields.**

⇨ **Nevertheless, around one third of farmers also would like to use water as a lever to diversify the crops' production, this is very interesting from a resilience and agro-ecological perspective as it improves the global efficiency of the farm (economic but also environmental)**

Increasing yields means also an increase in the use of fertilizers. If not done properly, the use of fertilizers could become a major source of pollution for the water resources in the area, including the ocean.

Developing an agriculture based on inputs consumption presents also the following risks related to irrigation:

- Irrigation can increase the risk of moisturizing the air around the crop and thus developing fungi
- Irrigation can facilitate the germination of weeds and thus the increase of weed killers

⇨ **Weed killers and fungicides are powerful pollutants for the soil and the water, a special focus has to be made in order to prevent this sources of pollution by promoting agro-ecological technics**

The last risk related to agricultural practices would be that farmers prefer to abandon the use of mulch which is very expensive, and prefer just to apply irrigation that is much cheaper.

This situation could also lead to over irrigation and thus the waste of water resources.

⇨ **Specific actions are proposed in the accompanying measures action plan to prevent this situation**

The development of irrigated agriculture in the area is a great economic opportunity for farmers. Nevertheless, they are very concerned about the marketing of agricultural products: if the structures currently in place do not evolve, the marketing of the surplus of production related to the development of irrigation could overstretch the economic results at farm level

⇨ **There is a significant risk that the expansion of irrigation leads to higher periods of over production exacerbating the marketing issues. This is why the project includes several "accompanying measures" to mitigate this risk.**

7.2.3.2 PERMANENT CHANGES IN LAND OCCUPATION

As mentioned in the project description, some of the projected infrastructures will lead to a permanent land use change: reservoirs, pumping stations, solar farms will be object of land acquisitions in order to modify the land use. On the other hand, the easements along the pipelines mean that the land used to access the pipelines will have to be kept clear of vegetation. Mitigation measures will allow farmers to compensate for the loss of production on these small areas.

7.3 IMPACT MATRIX (POTENTIAL IMPACTS WITHOUT MITIGATION MEASURES)

The impacts described in the paragraphs above can be resumed in the following matrix.

Note that these impacts correspond to the potential impact of the project if no mitigation measure is suggested.

A second version of this matrix, after application of mitigation measures, is presented in chapter 8, paragraphe 8.3.

Impact Typology

	Major negative
	Minor negative
	Neglectable
	Minor positive
	Major positive
T	Temporary (or seasonal)
AM	Application of Measures*

* See Mitigation measures chapter

	Potential impacts of <u>preparation & contruction phase</u> without mitigation measures						**Potential impacts of <u>operation phase</u> without mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
GENERAL AND/OR PHYSICAL PARAMETERS											
Change in drainage pattern /flooding											
Noise											
Vibration											
Gas emissions											
Air quality											
Surface water quality											

	Potential impacts of <u>preparation & contruction phase</u> without mitigation measures						**Potential impacts of <u>operation phase</u> without mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Surface water quantity							AM				
Groundwater quality											
Groundwater quantity											
ENVIRONMENTAL PARAMETERS											
Terrestrial ecosystem											
Wetland ecosystem				AM							
Aquatic ecosystem							AM	AM			

	Potential impacts of preparation & contruction phase without mitigation measures						**Potential impacts of operation phase without mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Vegetation				AM							
Birds											
Crocodiles and turtles				AM							
Other fauna											
AGRICULTURAL AND SOCIO-ECOMOMIC PARAMETERS											
Decrease in agricultural drudgery thanks to the access to pressurized water networks											

	Potential impacts of preparation & contruction phase without mitigation measures						**Potential impacts of operation phase without mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Job creation (as contruction employes or farmers)											
Higher cost to access to land									AM		
Increase in the farmers' income thanks to the decrease of the costs of production related to cheaper water									AM		
Increase of the issues related to the marketing of agricultural products									AM		

	Potential impacts of preparation & contruction phase without mitigation measures						Potential impacts of operation phase without mitigation measures				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Land use change due to acquisition or land easement for access lanes or pipeline laying	AM	AM	AM	AM				AM			
Improved standard of living											
Generation of soil pollution due to an increased use of pesticides									AM		
Generation of water pollution related to pesticides									AM		
Generation of water pollution related to fertilizers									AM		
Opportunity to develop agro-ecological practices									AM		

	Potential impacts of preparation & contruction phase without mitigation measures						**Potential impacts of operation phase without mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Over irrigation and waste of water resources											
Landscape aesthetics											

8 MITIGATION

Most of the impacts identified in the previous chapter can be reduced thanks to mitigation measures. As for the impact matrix, they are considered accordingly to the project phase they refer to: preparation - construction or operation phase.

8.1 MITIGATION MEASURES DURING PREPARATION AND CONSTRUCTION PHASE

8.1.1 GENERAL PRINCIPLES

Several mesures can be applied in order to diminish the impacts of the project.

- Sprinkling will -be regularly done over all the surfaces that can generate dust, especially during the phase of trench preparation.
- The recharge of fuel of all engines will be done in an impermeable area, to avoid any seepage.
- Only vehicles respecting gas emission standards will be allowed to circulate, and their speed will be limited to avoid dust dispersion.
- Temporary chemical toilets will be located throughout the work sites. They will be placed in an impermeable area.
- Solid waste generated during the project construction phases will end into approved disposal centres.
- The JNHT will be immediately alerted in case of discovery of any ancient monuments or sites.
- Works will avoid cyclonic season, especially in places where flooding can occur.

- Land easement will include, when applicable, compensation for lower crop production. Land acquisition negotiation have started for the grounds that will be used to build the permanent surface infrastructures (intake, pumping station, solar farms, reservoirs).

  The Environmental and Social Management Plan (chapter 10) contains the exhaustive list of measures that are recommended.

8.1.2 ECOLOGICAL MEASURES

Concerning habitats, flora and fauna preservation, the following measures are proposed:

- Soils will be sorted in order to separate the surface layer (about 30 cm, but varies locally), which is especially rich of seed, and which will be backfilled over the trench as top layer, in order to favorize land cicatrisation.
- All works having possible impact on the river's water quality (creation of the intake channel) will benefit from an intermediate filtration system (e.g. sheet pile wall and/or straw bale filtration) to avoid direct sediment weathering into the river.
- Wherever possible, preserve the trees along the pipeline route, paying special attention to trees that are used for bird nesting.
- Vegetation clearance should only be done in areas that are needed. A wider area than necessary should not be cleared to prevent leaving unwanted areas of soil open.

Specific additional measures concerning the protected area of the Morass are:

- Manual clearing of the area: in order to better identify eventual nests of birds, crocodiles or any other specific fauna.
- Presence of an ecologist during sensitive phases of the project: the ecologist will ensure awereness of the workers to environmental issues, will check that the environmental mitigation measures are applied and respected, will provide advice when specific situations occur.
- Invasive species: if encountered during the work, will be isolated to avoid spreading them in other sites. In particular, the recently completed project for "Mitigating the Threat of Alien Species in the Insular Caribbean" (MTIASIC) Project (2016) note the following invasive alien species of particular concern in the BRLM:
    - Water Hyacinth (Eichornia crassipes) – floats on the water and has been present for many years;

- Wild Ginger (Alpinia allughas) – spreading along riverbanks and appears to be a recent invader;
- Paperbark Tree (Melaleuca quinquenervia) – spreading throughout the Morass and is a recent invader;
- Australian Red-claw Crayfish (Cherax quadricorinatus) – in the lower Morass and considered a threat to the pepper shrimp industry;
- Suckermouth Catfish or Pond Cleaner (Pterygoplichthys pardalis) – in the lower Morass and is a threat because it is generally not considered edible;
- Armour-plated Catfish (Hoplosternum littorale) – in the lower Morass and is a threat because it is generally not considered edible;
- Perch (Oreochromis mossambicus) – has been in the Morass since at least the 1980s;
- Carp (Cyprinus carpio) – appears to be a newly introduced species."

The ecologist assisting the works in the BRLM will pay particular attention to the identification of these species.

8.1.3 HEALTH AND SAFETY MEASURES

- The contractor must have a health and safety policy that is known and understood by all workers. It must be visible to the workers on site.
- Provide safe and acceptable working conditions, including securing workers health and safety.
- Inform the employees of the occupational risks and preventative measures that must be taken to address these risks.
- Ensure all workers have the required personal protective equipment required of them to work on the Project and to regularly monitor to ensure compliance.

- Perform routine checks of health and safety equipment to ensure that they are functioning properly.
- Assign an officer with the responsibility to oversea workers health and safety.
- Construction areas should be clearly demarcated with safety signs and barriers to prevent possible incidents.
- Workers should be properly trained in how to operate construction equipment.
- All workers must be trained to properly use all health and safety equipment.
- All workers must be trained in the proper handling and management/ disposal of all types of waste.
- The contractor EHS Manager/ Officer shall maintain a register of all EHS related incidents that have occurred as a result of the activities associated with the contract. EHS incidents that should be recorded include: fires, accidents, spills of hazardous materials that contaminate soil or water resources, stop-order notices issued by any Regional Corporation or any other relevant agency, non-compliance with the Environmental Management Plan.
- Each EHS related incident will be investigated by the client's EHS officer and an incident report forwarded to the contractor. An incident report will be presented within five working days.
- EHS incident reports will include at a minimum: a description of the incident, actions taken to contain any damage to the environment, personnel or the public, and the corrective actions to repair/remediate any damage;
- All construction plant and equipment, tanks and machinery shall be maintained in a good state of repair throughout the construction period.
- Equipment maintenance will be carried out on an impermeable surface.
- Leakage from equipment will be prevented by conducting regular inspection and repair.
- Areas under construction should be clearly demarcated.
- Emergency medical supplies must be available and easily accessible in the case of an incident.

- In the event that the onsite medical supplies are not adequate, the incident needs to be escalated to the hospital.
- In the event that a worker is exposed to hazardous material they should immediately be taken for medical attention.

8.1.4 SOCIAL MEASURES

Land easement will include, when applicable, compensation for lower crop production. Land acquisition negotiation will start for the lands that will be used to build the permanent superstructures (intake, pumping stations, solar farms and reservoirs).

8.2 MITIGATION MEASURES IN OPERATION PHASE

8.2.1 ECOLOGICAL MEASURES

Concerning environmental issues, two potential impacts have been identified during operation phase:

- Possible impact of water abstraction (especially during dry seasons). For that issue, a water flow monitoring programme will be engaged and coupled with remote control of the uptaken water, in order to guarantee environmental flow to the river section downstream from the intake point: riverine discharge will be measured at Lacovia bridge upstream from the uptake channel.

  The following rule will be applied: the uptake of water will be stopped if,

  "upstream flow at Lacovia"- "uptaken flow" value < ecological flow

  This measure will allow to adapt (reduce) water abstraction during exceptionally dry seasons, ensuring the ecological flow.

- Suspended solid flows during pipe maintainance operations: specific rejection points should be identified during final design phase. The main rejection point will be the Black River. The mitigation measures associated to this kind of maintainance (that will occur every few years) are:
  - to reject water into a stabilisation basin that will reduce water pressure. The water overflowing the basin will return to the Black River.
  - To do the maintainance during wet season, when the river has naturally a high content of suspended solids.

8.2.2 SOCIAL MEASURES

As mentioned in the impact section, some infrastructures will need permanent access lanes etc. This kind of land use will imply land easement that will have to be fairly and adequately compensated. Financial compensation for subsoil easements (pipeline corridor), lateral access lanes along the main pipeline, and simple easement along minor pipelines will have to be identified.

Furthermore, the accompanying measures described in paragraph 4.3.2 are designed to maximise the socio-economic benefits of the project for farmers and the Communities.

8.3 IMPACT MATRIX AFTER APPLICATION OF MITIGATION MEASURES

The impacts listed in the matrix of paragraph 7.3 have been evaluated once more after taking into account the mitigation measures applied to the project.

Impact Typology

	Major negative
	Minor negative
	Neglectable
	Minor positive
	Major positive
T	Temporary (or seasonal)

	Potential impacts of preparation & contruction phase after application of mitigation measures						**Potential impacts of operation phase after application of mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
GENERAL AND/OR PHYSICAL PARAMETERS											
Change in drainage pattern /flooding											
Noise											
Vibration											
Gas emissions											
Air quality											
Surface water quality											

	Potential impacts of preparation & contruction phase after application of mitigation measures						**Potential impacts of operation phase after application of mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Surface water quantity											
Groundwater quality											
Groundwater quantity											
ENVIRONMENTAL PARAMETERS											
Terrestrial ecosystem											
Wetland ecosystem											
Aquatic ecosystem											

	Potential impacts of preparation & contruction phase after application of mitigation measures						**Potential impacts of operation phase after application of mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Vegetation											
Birds											
Crocodiles and turtles											
Other fauna											
AGRICULTURAL AND SOCIO-ECOMOMIC PARAMETERS											
Decrease in agricultural drudgery thanks to the access to pressurized water networks											

	Potential impacts of <u>preparation & contruction phase</u> after application of mitigation measures						**Potential impacts of <u>operation phase</u> after application of mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Job creation (as contruction employes or farmers)											
Higher cost to access to land											
Increase in the farmers' income thanks to the decrease of the costs of production related to cheaper water											
Increase of the issues related to the marketing of agricultural products											
Improved standard of living											

	Potential impacts of preparation & contruction phase after application of mitigation measures						**Potential impacts of operation phase after application of mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Land use change due to acquisition or land easement for access lanes or pipeline laying											
Generation of soil pollution due to an increased use of pesticides											
Generation of water pollution related to pesticides											
Generation of water pollution related to fertilizers											
Opportunity to develop agro-ecological practices											
Over irrigation and waste of water resources											

	Potential impacts of preparation & contruction phase after application of mitigation measures						**Potential impacts of operation phase after application of mitigation measures**				
	Site clearance	Site access	Material transport	Construction works	Solid waste disposal	Sewage treatment	Water abstraction	Pipe maintainance	Water withdrawall and increased irrigated area	Solid waste disposal	Sewage treatment
Landscape aesthetics											

9 PROJECT ALTERNATIVES

9.1 No action alternative

The scenario without the project entails continuing to use the groundwater resource, without being able to satisfy the current water demand, nor the increased demand necessary to face climate change aleas or to simply develop the Pedro Plains area.

Additionnaly, the current situation implies the continued use of vehicles to provide water to areas that are not served by the NIC network, which implies also higher gas emissions, and a negative impact on the water price paid by farmers.

The risk of such a scenario is possible saline intrusion linked to the rise of water level in the future and to the overexploitaion of the water resource. The no action alternative will also imply not coping with the objectives of the roadmap of Vision 2030 Jamaica - National Development Plan. One objective of the latter is to increase the local food production, and Pedro Plains is a key area for the success of such an objective.

9.2 PROJECT ALTERNATIVES

Several alternative were taken into account before choosing the best option, meeting development goals, and having the lowest environmental impact.

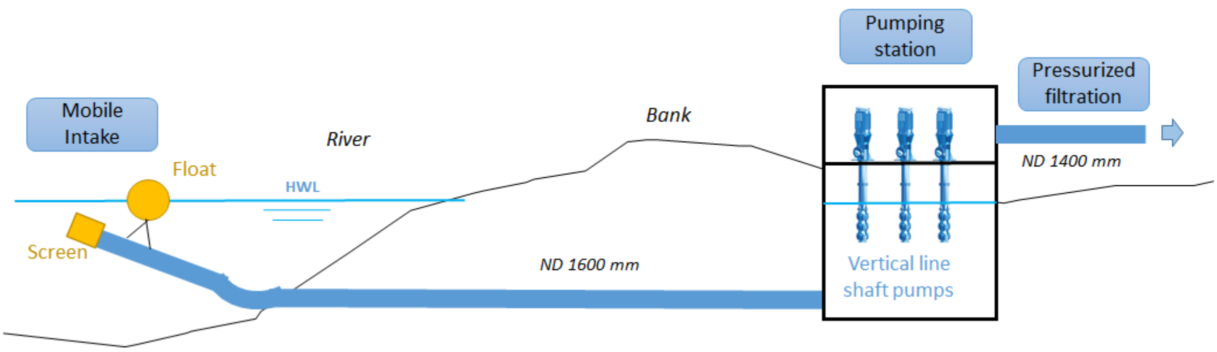
9.2.1 TECHNICAL WATER INTAKE OPTIONS

Concerning the intake, three technical options were examined.

- Option A: **open intake chanel;**
- Option B: **immersed strainers;**
- Option C: **mobile intake** (see figure below)

In all cases the first pumping station has the same design, and water filtration will be ensured by pressure sieve filters with a **cut-off point at 80 µm** to fit with drip irrigation systems.

Open channel is the most suitable option: it is the most respectful solution for aquatic fauna, and moreover there is not enough water level for strainers all over the year, and not enough water level variation for the mobile device.



Scheme of mobile intake (option C)

9.2.2 WATER INTAKE AND PHOTOVOLTAIC PLANT ALTERNATIVES

Further to the first land procedures carried out by the NIC, it was decided to lead a prioritization analysis on the following sites to locate the phovoltaic plant PV1 and the intake and pumping station PS1:

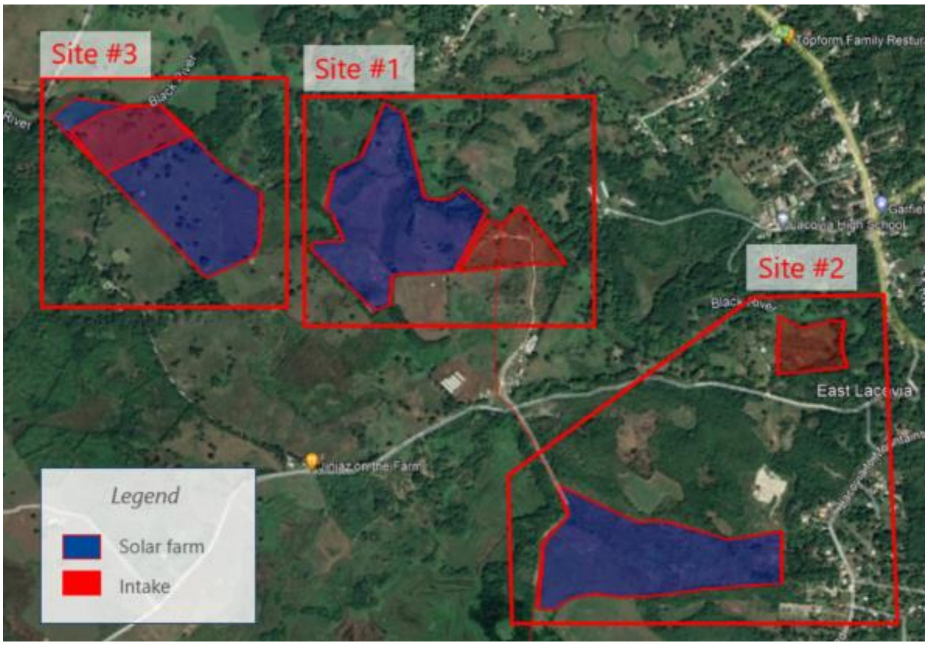


Figure 123 - Intake and solar farm location map

This analysis is carried out on the current state of knowledge of each site and on their technical and economic impact on the project.

9.2.2.1 SITE #1

Site #1 is the "historical" site of the project. It is located 1350 m (as the crow flies) to the West downstream from the old Lacovia Bridge and north of a pig farm.

The site is shown below:

Picture 27 - Views of site #1

Its location in a bend of the Black River makes it a favorable site for setting up an intake.

In terms of surface area, this site has a gross area of more than 30 ha. It can therefore be considered favorable for the main infrastructures. In addition, this site is flat, and the elevation is between 5.0 and 7.0 meters[36] .For a reminder the Highest Water Level for facilities design is set at 5.9 m EGM 08 (for a flow in Black River of 100 m^3/s), and the apron of the room of pumps motors is set at 7.0 m EGM08. Therefore the site is suitable for the intake facilities.

It can also be noted that there is enough space in one piece to locate the solar farm in direct proximity. The site has also a good orientation for solar radiation.

Regarding the trunk pipe, as shown below, in order to avoid rocky and swampy areas, there is only one viable passage at the level of the old dyke. So the shortest way for the trunk pipe is from site #1 with a linear of 600 m from the intake to the dyke.

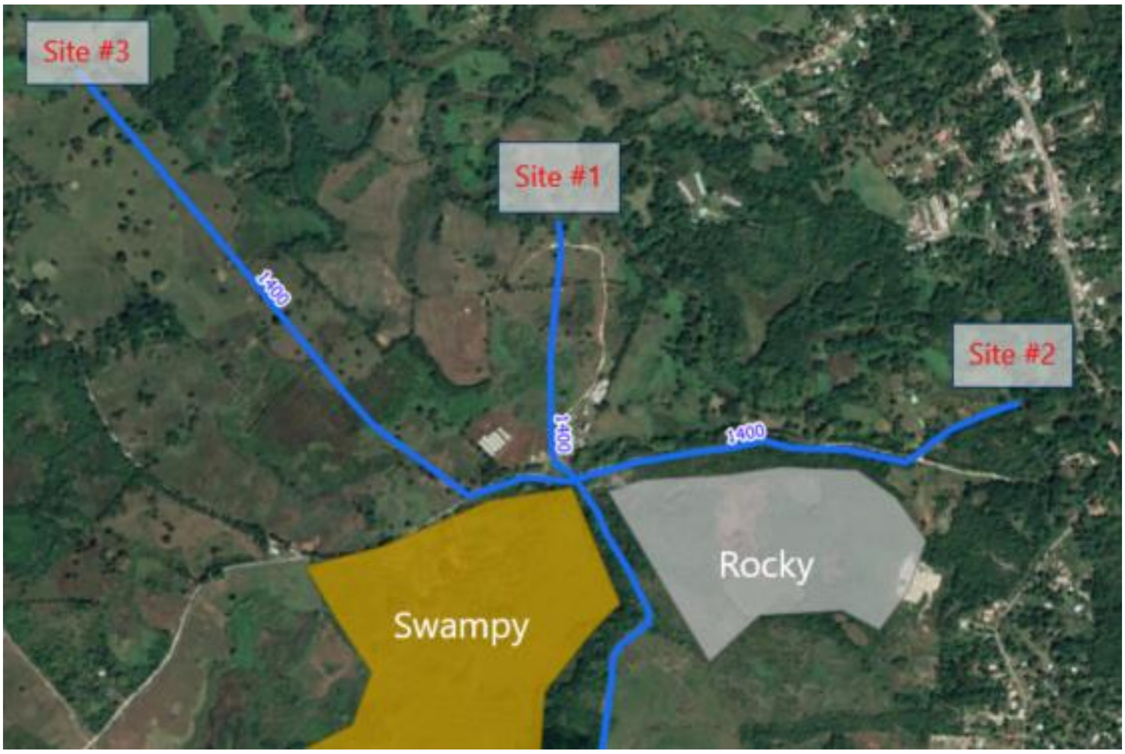


Figure 124 - Main trunk pipe for each site

The site is also easily accessible with a paved road less than a kilometer away.

Moreover at this stage this site is the only one fully investigated with a geotechnical survey with drillings carried out in 2020.

[36] All elevations are given in the geoid reference EGM08

Among the 30 hectares of the site, the parcel proposed for acquisition shown below measures 20 ha (orange boundaries), including non-suitable fringe.

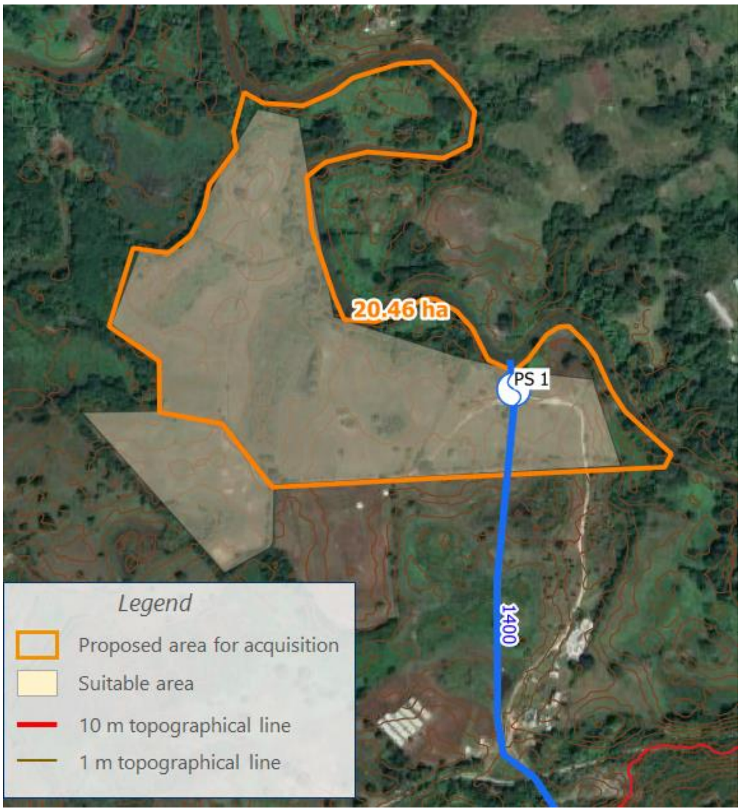


Figure 125 - Projected land acquisition for PV1 and PS1

9.2.2.2 SITE #2

The site #2 is located 260 m to the West downstream from the old Lacovia Bridge. As for site #1, this site is also located in a favorable bend of the Black River for setting the intake.

The site is shown below:

Picture 28 - View of site #2

For the trunk pipe, the location of the intake involved the implementation of an additional 450 m of DN1400, so an extra cost in this configuration (+ 500k USD only for pipe). In terms of accessibility, this site is close to paved roads.

At this stage, no geotechnical studies have been carried out on these sites. The elevation is estimated between 5 and 8 meters which is favourable for facilities regarding the flooding.

The suitable area is about 2.5 ha. This surface is not sufficient to accommodate the solar panels. This therefore led to the search for another site nearby.

In the south west the following site has been identified (see figure below):

Picture 29 - View of the land from the south (potential solar farm)

This site has the advantage of having an interesting surface, but has the disadvantage of being hilly. The average level of the site is between 5 and 15 m.

This other picture shows the site from the top point.

Picture 30 - Other view of the hilly part (potential solar farm)

Another disadvantage is that the solar farm site is 600 meters far from the intake site, which will result in additional costs for bringing the energy produced to the pumping station 1.

9.2.2.3 SITE #3

The site #3 is located 2500 m to the West downstream from the Old Lacovia Bridge. In the same way as for site #1 and site #2, this site is also located in a favorable bend of the Black River for setting the intake.

The following picture shows the site:

Picture 31 - View of site #3 for the intake

The location of the intake involves an additional 950 m compared to site #1, so it's the costly site option regarding the trunk pipe part (additional cost of almost 1M USD for the pipe). For the accessibility, this site is also near a paved road.

The elevation of the site is between 3 and 5 meters which means the entire site can be flooded (the highest water level for facilities design set at 5.9 m EGM 08) and thus requires a protection dyke all around.

In terms of surface available for the solar farm, there is approximately 25 ha of gross surface suitable around, allowing to have solar production close to the intake and so next to pumping station 1.

9.2.2.4 COMPARISON

Table 70 - Site comparison for the intake

	Technical suitability	***Geotechnical survey done***	**Flooding**	**Access**	**Solar farm area**	**Cost (trunk pipe)**	**Ranking**
Site #1	+	+	+	+	+	+	1
Site #2	+	-	+	+	-	-	2
Site #3	+	-	-	+	+	--	3

The site #1 remains the most suitable for the intake and other projected facilities around. The main disadvantage of site #3 is the lack of area for the solar farm, and the disadvantage of site #2 is its low elevation and the elongation of the trunk pipe

The final suggested location at site #1, has several advantages:

- Space is available for main facilities (intake, channel, pumping station), but also for related facilities as the filtration plant, the sludge drying bed, the bleed pipe and the different buildings for operation (warehouse, life base…). Moreover there is also space next to the site for photovoltaic panels ;

- This site location shortens the 1400mm pipe length compared to other sites ;
- Locally the river bend is favorable to install the intake on the river extrados. Moreover the back of the bank is sufficiently elevated to be above the historical highest water level measured of Black River.

A topographical and bathymetric survey was carried out by SPC between June and August 2020.

Instructions were to survey 16 cross-sections between the Old Bridge of Lacovia and 1000 m downstream the proposed river intake. The chosen site is the one that will have less impact on the modification of river profile.

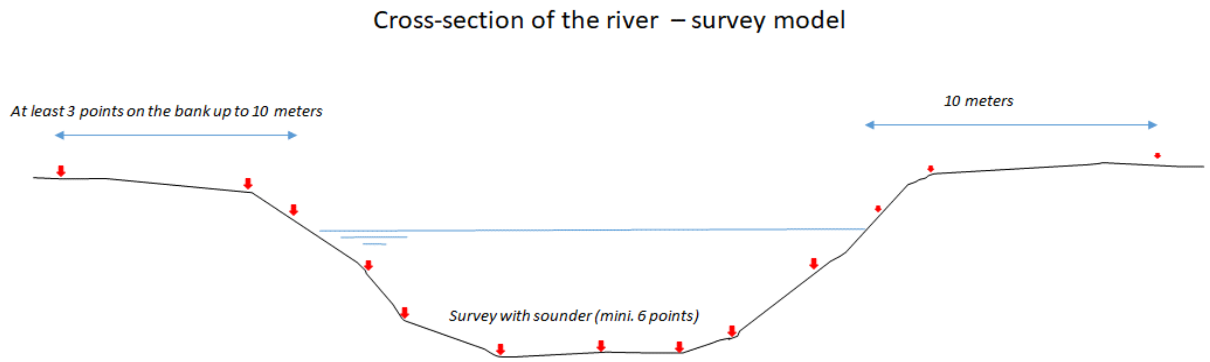


Figure 126 - Direction for the Black River cross-section bathymetric survey

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9.2.3 PIPELINE ALTERNATIVE DESIGN

Pipeline design will be adapted locally to avoid, where possible, trees and other sensitive sites (e.g. graveyards).

Between Mountainside and Newell Pen there are two possible alternatives. The two alternatives presented below were examined. Both cross similar habitats, and the less impact scenario that has been chosen (blue line) is the one that minimizes the land easement procedures.

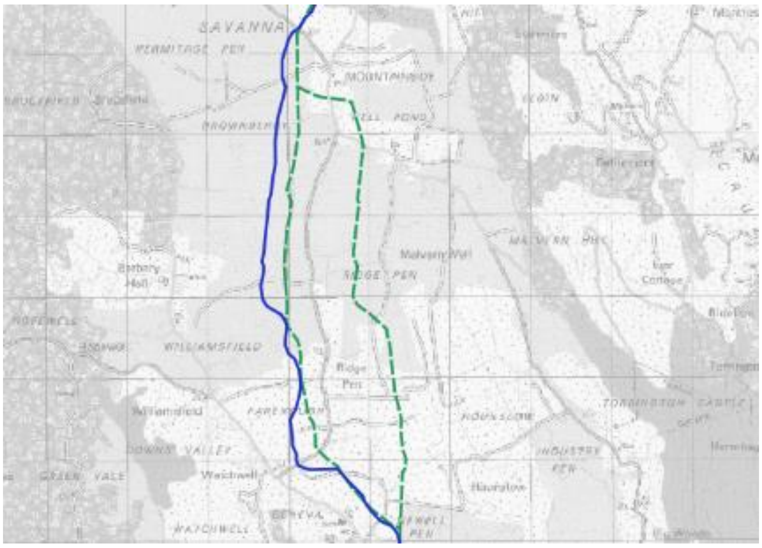

Figure 127 - Alternatives (in green) for the main pipe

9.3 RESERVOIR ALTERNATIVES

For the 4 projected reservoirs different sites were considered. They are listed in the table below.

Table 71 - Synthesis of recommended site for each facilities

Facilities	Site identification	Observation	Conclusion
Reservoir 1	Site B in Newcombe Valley	Issue regarding free space (presence of housings and graves)	**Not suitable**
	Site C in Little Park	High cost	**Challenging**
	Site D in Newcombe Valley	Suitable	**Recommended site**
Reservoir 2	Round Hills	Suitable	**Recommended site**
Reservoir 3/SP4	Site #1 in Queens burry	**Multiple landowners**, houses too close, presence of **graves**	**Challenging**
	Site #2 in Queens burry		**Recommended site**
Reservoir 4 –	Site #1 in Berlin	Area too **narrow, difficult access** (slope)	**Not suitable**
	Site #2 Upper Berlin		**Recommended site**

For Reservoir 2, the recommended site was easily identified. For Reservoir 1 and 4, some alternative sites were considered, but the choice was rather straightforward because of technical or social issues (presence of housings, or slope for ex.). For reservoir R3 there was a site comparison analysis. The reservoir R3 next to the pumping Station 4 will be located in Queensbury area. Following the various meetings during the field visit of the first site identified, a second site was identified for these infrastructures. The analysis therefore covers two sites.

9.3.1 SITE #1 FOR R3

The site # 1 was identified during the first design studies. The elevation of the site is between 554 and 563 m.

The map below shows the initial proposed layout of facilities.

Figure 128 - Proposed facilities layout in site 1 for R3 / SP4

The issue is the presence of two graves, visible on the picture below on the left.

Picture 32 - Site #1 view for reservoir 3 and pumping station 4

The area is slightly sloping in a north east- southwest direction, but this is not problematic for the location of these infrastructure.

The area suitable of the site is about 0.85 hectares, lightly less than the surface proposed to acquire (1 hectare) for the facilities.

9.3.2 SITE #2 FOR R3

The site #2 was identified thanks to a NIC operating officer working in Hounslow. The elevation of the site is between 548 and 558 m, so it's slightly lower than the site #1.

The map below show the suitable area and the proposed parcel for acquisition. The capacity of this reservoir will be of 8 000 m^3.

Figure 129 - Suitable area and proposed parcel

The site is shown on pictures below.

Picture 33 - Site#2 view for reservoir R3 and pumping station PS4

The area is slightly sloping in an east- west direction, implying terrain cutting in the slope (picture 2). The flat area (picture 1), lower, is suitable for the pumping station.

The parcel proposed for acquisition measures about 1 hectare.

9.3.3 COMPARISON OF SITES FOR R3

Both sites have drawbacks, nevertheless **site #2 seems more suitable** especially thanks to the absence of housings, graves, etc. nearby.

Previous observations for each sites are synthetized in the table below, and the options in green are the ones that are projected.

Table 72 – Site comparison for R3

	Technical suitability (elevation / slope)	Number of parcels	Surface of suitable area	Obstacles	Access	Cost	Ranking
Site #1	+-	-	+- (0.85ha)	-(graves and close housings	+	=	2
Site #2	+	+	+- (0.85ha)	+	+-	=	1

9.4 DEVELOPMENT SCENARIO SIZES

Two scenarios were considered before choosing the projected one:

Scenario 1: irrigation of 3,450 ha under an elevation of 200 m asl, with the possibility to extend hydraulic development later. This scenario concerns hydraulic levels 1 and 2.

Scenario 2: irrigation of the complete targeted area of 4,200 ha until 700 m asl. This scenario concerns hydraulic levels 1 to 4.

In the end, scenario 2 was chosen, as it serves a larger agricultural area, and therefore meets the needs of the region.

9.5 SUGGESTED DESIGN AND JUSTIFICATION OF PREFERRED ALTERNATIVE

The suggested design is the one described in chapter 4, and corresponds to the best compromise between environmental, technical, and costing issues.

10 ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

10.1 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

On the basis of the environmental and social impacts identified for the project the Environmental and Social Management Plan (ESMP) is presented in the table below. The objectives of the Environmental and Social Management Plan (ESMP) are to:

a) Propose mitigation measures minimizing the magnitude of impact generation due to project implementation.

b) Recommend measures which will reduce each environmental and social impact considered to be significant enough to require a degree of control.

c) Comply with all the environmental applicable laws and regulations.

d) Develop a monitoring plan which will:

- Establish baseline conditions for comparison purposes.
- Monitor the performance of the Project and effectiveness of mitigation measures.
- Determine compliance with regulatory framework.
- Provide for remedial actions in cases where monitoring identifies a shortfall in targets for which corrective action is possible.

e) Achieve sustainable, environmentally and socially acceptable development of the Pedro Plains Irrigation Expansion Project.

Table 73 – Environmental and Social Management Plan

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
DETAILED DESIGN PHASE						
Detailed Design Measures	• Design to incorporate environmental and social management and mitigation measures as indicated in the present EIA and any possible updates, using optimum, international best practice and most stringent mitigation measures in detailed design. • Set up protocols for a follow-up of the cleaning (bleedind) operation after pipeline is commissioned. • Take account of public consultation for environment, and other areas of concern within the community. • Design to minimize impact on activities, e.g. choose pipe alignment (for distribution network) which do not directly impact businesses and which during construction will cause minimal obstruction for access to them; • Design to minimize impact to agriculture and traffic disruption during construction, e.g. lay pipes within existing way-leaves, etc.	Detailed Designers	NIC	GOV	Design cost	During design

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Define some general measures to ensure road and public safety and accessibility, both during construction and operation, within the constraints of project budget. The future contractor will define the practical measures to be applied. • Design for maximum recycling of existing excavated materials to both reduce the requirement to exploit and transport new materials and also to minimize waste (cut/fill used in the dyke along the first kilometers of the main pipe, cut/fill balance of the reservoirs). • Design for use of locally available materials. • Make minor adjustments to the alignment to eliminate possible damage or degradation of historic and cultural sites. • Incorporate reuse of waste materials and use of designated disposal sites in the detailed design, as much as possible.					
Bidding and Contract Documents	• Ensure all relevant provisions of the ESMP in terms of implementation of environmental mitigation measures, monitoring activities, supervision and	Detailed Designers	NIC	GOV	Design cost	During design

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	reporting are included in the contract documents and construction supervision. • Incorporate particular requirements into the Specification, e.g. protection of flora and fauna, etc. • Make explicit that compliance with all environmental provisions is to be incorporated into the Bill of Quantities unit rates for work items.	Consultant/ Detailed Designers				
Land acquisition or land easement	• Provide detail how individuals are to be fairly and adequately compensated.	Easement Consultant	NIC	GOV	Design cost	During design
CONSTRUCTION PHASE						
Inadequate environmental awareness of workers	• Conducting special briefings and/or on-site training for the contractors and workers on the environmental requirements of the project. • Contractors to provide workers with social sensitivity training, which may be conducted at the same time as HIV awareness in which the problems and issues	Contractor	Contractor	NIC	Construction Cost	Before start of construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	will be explained (elements of training may be provided Contractor) • Conducting other such briefing sessions as and when required.					
Flora and fauna	• Do not clear vegetation or damage vegetation outside of the worksite, do not cut trees, damage	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	**Mitigation Measures**	**Institutional Arrangements**			**Cost Estimate**	**Timing**
		Implementing	**Responsible**	**Supervising**		
	root system or lop branches without prior consent of NIC / Work Supervisor. • No tree cutting during the nesting season. • If rare, endangered, threatened or endemic species are identified, the Contractor will follow instructions of NIC (after consultation of NEPA). • Avoid stock piling of materials on vegetated sensitive areas. • Monitor stockpiling. • If needed, plant appropriate seedlings, indigenous to the area to regenerate vegetation to pre-project state. • Use of soil reinforcement where necessary to promote establishment of vegetation cover, biodegradable soil reinforcements can be used. • Works contractor responsible for vegetation until established.					
Spoil and construction	• Topsoil to be stripped on construction site and stockpiled for reinstatement post-construction. • Estimate the amounts and types of spoil and construction waste to be generated by the project.	Contractor	Contractor	NIC / Work	Construction Cost	During construction

Environmental /social concern	**Mitigation Measures**	**Institutional Arrangements**			**Cost Estimate**	**Timing**
		Implementing	**Responsible**	**Supervising**		
waste disposal	• Investigate whether the waste can be reused in the project or by other interested parties. • Document reuse and safe disposal of spoil and construction waste; including disposal sites and volumes for hazardous or contaminated waste. • Identify, in coordination with NIC / Work Supervisor, potential safe disposal sites close to the project. Investigate the environmental conditions of the disposal sites and prepare a recommendation for most suitable and safest site(s). • Designate disposal sites to be used in the project. • Provide guidelines for proper and safe spoil and construction waste disposal.			Supervisor		
Quarrying and Borrow pits and temporary access roads	• Estimate amounts/types of materials to be used in project. • Assess whether spoil materials are suitable for the construction. • Identify potential borrow sites and investigate the environmental conditions and if they have the required permits and licenses.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Opening, use of and closure of access roads in compliance with all relevant provisions for quarries and borrow pits. • The clearing of trees and other desirable vegetation shall be discouraged. • Temporary ditches and/or settling basins shall be dug to collect runoff water and to prevent erosion and contamination of surface water. • The site is to be restored after construction activities have ceased. The site shall be left in a stable condition, without steep slopes. Stripped material shall be spread to stable contours in order to promote percolation and there shall be a regeneration programme with endemic species of natural vegetation and natural drainage. • Extraction of rocks, gravel and sand from small rivers or streams is forbidden. • The depth of material removal at any one location shall be limited and extraction areas shall be selected where there is little fine material to be carried downstream.					

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
Dust, air, noise and vibration	• Apply Jamaican Standards for noise. Stockpiled materials such as sand and soil shall be lightly wetted before loading, particularly in windy conditions. • All heavy equipment and machinery shall be fitted with air pollution control and noise dampening devices that are operating correctly • Vehicles transporting easily windblown materials such as sand and soil shall be covered with a tarpaulin. • The operation of heavy equipment shall be conducted only in daylight hours; damages to building or other property as a result of such activities are to be rectified by the works contractor at the contractor's cost. • Washing of tires and lower body of vehicles when moving out from the construction site, regular sweeping of sealed roads which must be kept free of mud from vehicle tires and spilt materials. • Spraying of bare areas of ground with water while taking appropriate actions to negate sheet or rill erosion or sediment transportation into drains.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Strict adherence to speed limits during all vehicle operations • Construction site will be kept clean and tidy, with materials optimally stored and covered. • Storing cement and other such fine-grained materials if need to be delivered in bulk shall be in closed silos fitted with a high-level alarm indicator; weigh hoppers shall be vented with a suitable filter. • Employing fuel-efficient and well-maintained haulage trucks with proper exhaust baffles to minimize exhaust emissions. • Turning off the engines for all vehicles, while parked on the site. • Providing barriers in locations where strong winds are likely to blow away dust and debris.					
Soil Erosion	• Fill should be compacted properly in accordance with the Specification. • Unsuitable and surplus excavated materials shall not be disposed to locations or in a way that it will subsequently be prone to erosion.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Protect slopes from erosion, where bare slopes are exposed as a consequence of the works limit the period of exposure to water or wind erosion and provide temporary or the designed slope protection at the earliest opportunity. • Minimize or protect areas of bare soil throughout the rainy season. • Precautions as necessary to prevent erosion of areas under construction throughout the rainy season including excavation/fill/etc. any areas that cannot be completed prior to the rains. • Planting with indigenous species or restore agricultural areas to same or better standards that pre-project					
Siltation	• Stockpile of earth fill and other material shall be kept covered at all times when not being accessed to protect against wind or water erosion. • Do not stockpile any materials over a water course or in depressions or valleys which are water paths. • Avoid stock piling of materials on the banks of watercourses or in any area prone to flooding.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Use of silt fencing to catch any sediments eroding off pipeline and material stockpile and construction areas.					
Works contractor's temporary operational sites and locations	• Identify location of temporary operational sites in consultation with NIC. The location shall be subject to approval by NIC and Government authorities. • Water and sanitation facilities shall be provided sufficient for all users of temporary operational sites. Sanitation facilities will be located appropriately so as not to affect surface or ground water sources nearby and human health impacts • Managing solid waste and sewage according to Jamaican laws and regulations. • Ensuring the Contractor organizes and maintains a waste separation, collection, and transportation system. • Ensuring that all liquid and solid hazardous and non-hazardous waste are separated, collected, and disposed of according to international laws, standards, conventions and Jamaican laws and regulations.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• At conclusion of the project, removing all debris and waste, as well as all temporary structures. • At conclusion of the project, all wreckage, rubbish or temporary works that are no longer required shall be removed or given to local residents. All temporary structures, including office buildings, shelters and latrines, shall be removed. The site shall be restored to near natural and stable conditions. • Exposed areas shall be planted with indigenous vegetation as far as practical as existed prior to clearing the site. • The Engineer shall report in writing that the temporary operational site has been vacated and restored to pre-project conditions before acceptance of the works. • Gender separate latrines and ablutions will be required.					
Health Sanitation	• Construct separate male and female toilet facilities for workers to at least Jamaican acceptable standards.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Adopt system for garbage collection, separation and disposal/treatment. • Disposal and treatment of hazardous waste and materials from any necessary demolition and excavations has to be carried out according the Jamaican Laws and Regulations and International best practices (whichever is most stringent. • Disposal sites are to be selected respecting the minimum specified distances form water protection zones, buffer zones of natural parks, settlements, abstraction facilities for water supply, while taking into consideration prevailing geological conditions.					

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
Health and Safety of Workers	• Provide adequate warning signs. • An Emergency Management Plan shall be prepared to cope with all foreseen emergency incidents including medical, hazardous waste spill, fire and other emergencies, and will consider and consult with emergency services, community and workers and other stakeholders within the plan • Provide training and briefings for workers on safety their responsibility for their safety and the safety of others • Allocate responsibilities to ensure that these arrangements are in place. • Arrange for regular safety checks of vehicles and material, and allocating responsibility for checking. • Establish procedures and provide instructions about emergency evacuations and providing a list of 24 hours emergency contacts.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
Worker Welfare	• The contractor will develop and follow an equal opportunities employment policy, allowing employment of all working age applicants who are qualified for the position, regardless of race, religion, gender. • Additional skills training for women interested in pursuing construction related employment. •	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction
Water Quality	• Proper construction management including, training of operators and other workers to avoid pollution of water bodies by the operation of construction machinery and equipment • Storage of lubricants, fuels, and other hydrocarbons in either double skinned tanks or bounded areas of capacity at least 110% the stored volume. • Disposal of water and waste products arising from the site via a suitably designed temporary drainage systems in a manner that will not cause pollution problems or other nuisance	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Covering the construction material and spoil stockpiles with a suitable material to reduce material loss and sedimentation. • No disposal to surface or groundwater bodies and wetlands of, solid waste such as discarded packing, and excavated material. • Do not stockpile any materials over a water course or in depressions or valleys which are water paths. • Providing sanitation arrangements at work sites, offices and temporary accommodation which collect or treat all wastewater and sewage ensuring that contaminated wastewater or sewage cannot be released to water bodies.					
Handling, Storage and disposal of Hazardous Materials	• Storing hydrocarbons and hazardous materials on impervious ground under cover and constructing the storage area as a spill tray to avoid spread of accidental spills. • Providing safe ventilation for storage of volatile chemicals. • Restricting and controlling access to areas containing hazardous substances.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Site all material processing plants, workshops, depots, and temporary workers accommodation facilities in approved locations. • Document safe disposal of hazardous or contaminated waste; including disposal sites and volumes. • Identify, in coordination with Jamaican authorities, as required, potential safe disposal sites for hazardous or contaminated waste. Investigate the environmental conditions of the disposal sites and prepare a recommendation for most suitable and safest site(s). • Designate disposal sites to be used in the project. • PCBs, asbestos, lead paint residues and any other hazardous materials to be handled and disposed to recognized Jamaican legal requirements					
Disposal of Hazardous Materials	• Estimate the amounts and types of hazardous construction waste to be generated by the project. • Document reuse and safe disposal of spoil and hazardous construction waste; including disposal sites and volumes.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Identify, in coordination with Jamaican Government authorities, as required, potential safe disposal sites close to the project. Investigate the environmental conditions of the disposal sites and prepare a recommendation for most suitable and safest site(s).					
Damage to Archaeology or Cultural Resources	• Cease work as soon as an archaeological or cultural find is encountered during earthworks or other construction activities • Provide relevant information to NIC for contacting appropriate GOV authorities (NHTF) for instruction and action.	Contractor	NIC	NIC and GOV authorities	Construction Cost	During construction
Traffic and Pedestrian Management During Construction	• Formulate and implement a construction-related traffic management plan. • Install traffic warning signs, and enforce traffic regulations during transportation of materials, equipment, and machinery. • Conduct awareness programs on safety and proper traffic behavior in densely populated areas near the construction sites. • Assign traffic control personnel/flag men. • Provide alternative access to pedestrians.	Contractor	Contractor	NIC	Construction Cost	Before starting construction and During Construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
	• Provide safe pedestrian access for businesses. • Repair damages to roads caused by haulage of construction materials, spoil and equipment, and machinery. • Obtain approval from local authorities' use of local roads for transportation.					
General Social Impacts	• A works monitoring committee must be set up in each part of the parish; the committee will be the contact for the works manager. The NIC, in conjunction with the contractor, will set up a complaints and grievances management mechanism. • Workers will be employed locally, where possible, without discrimination of gender, race, religion, and for unskilled positions for low literate. • Avoid conflicts with local communities by providing resources for worker requirements at works contractor's temporary operational sites. • Inform the affected community of the schedule if utilities have to be moved or services are interrupted.	Contractor	Contractor	NIC / Work Supervisor	Construction Cost	During Construction

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
OPERATIONAL PHASE						
Air Quality	• Maintenance of emission control equipment on pumping stations.	NIC / Technical support consultant	NIC	GOV	TBD	During Operation
Noise Level	• Maintenance of silencers where present on the infrastructure.	NIC / Technical support consultant	NIC	GOV	TBD	During Operation
Use of new infrastructure	• Recruitment and training of NIC staff for state-of-the-art operation and maintenance of the infrastructure.	NIC / Technical support consultant	NIC	GOV	TBD	Before Operation
Maintenance requirements of infrastructures	• Prepare a Maintenance Plan, with cleaning protocols program • Install continuous water quality management system to provide water quality monitoring in selected areas. • Waste management planning will include sediment cleaned from the pipeline or the drying bed.	NIC / Technical support consultant	NIC	GOV	TBD	Before and during Operation

Environmental /social concern	Mitigation Measures	Institutional Arrangements			Cost Estimate	Timing
		Implementing	Responsible	Supervising		
Hydraulics variations during pipeline Maintenance operations	• Prepare a plan in order to release flows from the pipeline according to the capacity of the receiving water streams • Implement the plan	NIC / Technical support consultant	NIC	GOV	TBD	Before Operation
Water quality reduction due to cleaning pipeline maintenance operations	• Prepare a Maintenance Plan, including stages and rates of opening valves for water release from pipeline, water quality requirements and quality measurement parameters.	NIC / Technical support consultant	NIC	GOV	TBD	During Operation
Water flow and flood risks	• Prepare a management plan for water uptake from the Black river, with a protocol that will stop uptake if the minimum discharge in the river is not guaranteed. • Prepare a management plan in case of flood events.	NIC / Technical support consultant	NIC	GOV	TBD	During Operation

10.2 ENVIRONMENT AND SOCIAL MONITORING PLAN

Based on the EIA and ESMP, this section presents a proposed Environmental and Social Monitoring Plan (ESMoP). At the time of construction contractor recruitment, a site specific ESMoP shall be prepared, based on the requirements below.

Environmental and social monitoring is an essential component of the ESMP. It is necessary to ascertain whether the mitigation measures are implemented properly and whether the implemented measures can mitigate the adverse impacts as intended or need adjustment.
The Environmental and Social Monitoring Plan (ESMoP) provides the general guidance on the monitoring requirements of the ESMP. Monitoring will be implemented during construction and operational phases of the project. Environmental and social monitoring is mainly compliance and impact monitoring.
The following table presents the Environmental and Social Monitoring Plan, including indicators, methods, frequency, costs and responsibilities.

The Contractor hired for installing the pipeline and constructing the various assets will carry a great responsibility in implementing environmental managment plan and monitoring schedule. It is advisable that the contractor take on an Environment, Health and Safety Officer or Manager to ensure the measures are being implemented. Monitring activiites can be conducted by a reputable Consultacy firm that has the capacity to monitor according to the recommended requirements.

Table 74 – Environmental and Social Monitoring Plan

<table>
<tr><th>Environmental Aspect</th><th>Monitoring Standard</th><th>Key Performance Indicators</th><th>Data Analysis and Reporting</th><th>Roles and Responsibilities</th><th>Cost Estimate</th><th>Frequency</th></tr>
<tr><td colspan="7">CONSTRUCTION PHASE</td></tr>
<tr><td>Air Quality</td><td><table>
<tr><th>Pollutant</th><th>Averaging time</th><th>Standard (Maximum concentration in µg/m³)</th></tr>
<tr><td>Total Suspended Particulate Matter (TSP)(a)</td><td>Annual
24 h</td><td>60
150</td></tr>
<tr><td>PM_{10} (b)</td><td>Annual
24 h</td><td>50
150</td></tr>
<tr><td>Lead</td><td>Calendar Quarter</td><td>2</td></tr>
<tr><td>Sulphur Dioxide</td><td>Annual
24 h
1 h</td><td>80 Primary; 60 Secondary (c)
365 Primary; 280 Secondary
700</td></tr>
<tr><td>Photochemical oxidants (ozone)</td><td>1 h</td><td>235</td></tr>
<tr><td>Carbon Monoxide</td><td>8 h
1 h</td><td>10,000
40,000</td></tr>
<tr><td>Nitrogen Dioxide</td><td>Annual</td><td>100</td></tr>
</table></td><td>Equipment maintenance log and schedule
Notices to stakeholders
Air quality parameters within NEPA standards
Log of wetting frequency
Use of personal equipment gear</td><td>The Certificate of Analysis (COA) obtained from the laboratory should contain at least the
following information:
i. Sample identification/information and description
ii. Sample collection date and time
iii. Sample submitting information (temperature and condition of sample, time and date of
submission)
iv. Analysis date
v. Test results with units of measurement
vi. Test methods
vii. Notes regarding anomalous tests results
viii. Applicable standard
ix. QA/QC documentation
x. Signature of authorized persons</td><td>Contractor.
Results to be presented to NIC, the Implementing Agency</td><td>US$6,000 /monitoring event</td><td>Monthly during Construction or as indicated in NEPA Permit
This will involve continuous monitoring for a 24-hour period along the length of the proposed site.</td></tr>
<tr><td>Noise</td><td><table>
<tr><th></th><th colspan="2">NRCA (NEPA) Standard</th></tr>
<tr><th></th><th>Day (7am – 10pm)</th><th>Night (10pm – 7am)</th></tr>
<tr><td>Residential</td><td>55dBA</td><td>50dBA</td></tr>
<tr><td>Commercial</td><td>65dBA</td><td>60dBA</td></tr>
<tr><td>Industrial</td><td>75dBA</td><td>70dBA</td></tr>
</table></td><td>Equipment maintenance log and schedule
Notices to stakeholders
Noise parameters within NEPA standards
Log of complaints
Use of personal equipment gear on inspection record</td><td>The results from the sampling exercise will need to be compared to NEPA noise pollution standards and included in the environmental monitoring report prepared and submitted to NEPA at the prescribed frequency.
If there are any exceedances, this should be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.</td><td>It is the responsibility of the Contractor to ensure that all mitigation measures are carried out and that monitoring reports are prepared. The Contractor should ensure that an Environment, Health and Safety Manager is employed to
oversee the specific requirements of this plan.</td><td>US$3,000 / monitoring event</td><td>Monthly during Construction or as indicated in NEPA Permit
The noise level readings should be taken over a minimum period of 24 hours or as stipulated by the NEPA permit and the average (geometric mean) noise level recorded in decibels (dBA).</td></tr>
</table>

<table>
<tr>
<td>Water Quality</td>
<td>Draft Jamaica National Ambient Water Quality Standard –Freshwater, 2009
<table>
<tr><th>Parameter</th><th>Measured as</th><th>Standard Range</th><th>Unit</th></tr>
<tr><td>Calcium</td><td>(Ca)</td><td>40.0-101.0</td><td>mg/L</td></tr>
<tr><td>Chloride</td><td>(Cl^-)</td><td>5.0- 20.0</td><td>mg/L</td></tr>
<tr><td>Magnesium</td><td>(Mg^{2+})</td><td>3.6- 27.0</td><td>mg/L</td></tr>
<tr><td>Nitrate</td><td>(NO_3^-)</td><td>0.1- 7.5</td><td>mg/L</td></tr>
<tr><td>Phosphate</td><td>(PO_4^{3-})</td><td>0.01 - 0.8</td><td>mg/L</td></tr>
<tr><td>Potassium</td><td>(K^+)</td><td>0.74- 5.0</td><td>mg/L</td></tr>
<tr><td>Silica</td><td>(SiO_2)</td><td>5.0- 39.0</td><td>mg/L</td></tr>
<tr><td>Sodium</td><td>(Na^+)</td><td>4.5- 12.0</td><td>mg/L</td></tr>
<tr><td>Sulfate</td><td>(SO_4^{2-})</td><td>3.0- 10.0</td><td>mg/L</td></tr>
<tr><td>Hardness</td><td>($CaCO_3$)</td><td>127.0-381.0</td><td>mg/L (as $CaCO_3$</td></tr>
<tr><td>Biochemical Oxygen Demand</td><td>(O)</td><td>0.8- 1.7</td><td>mg/L</td></tr>
<tr><td>Total Dissolved Solids</td><td></td><td>120.0-300</td><td>mg/L</td></tr>
<tr><td>pH</td><td></td><td>7.00- 8.40</td><td></td></tr>
<tr><td>Conductivity</td><td></td><td>150.0-600</td><td>µS/cm</td></tr>
</table>
</td>
<td>Sediment traps
Logs indicating when any
incidents and when work
was halted
Water Quality Results from a certified lab.
Spot Checks/ Self Audits</td>
<td>All samples collected during the monitoring exercise should be analysed using verified/validated analytical
methods at an EHU approved laboratory. The Certificate of Analysis (COA) obtained from the laboratory
should contain at least the following information:
i. Sample identification/information and description
ii. Sample collection date and time
iii. Sample submitting information (temperature and condition of sample, time and date of
submission)
iv. Analysis date
v. Test results with units of measurement
vi. Test methods
vii. Notes regarding anomalous tests results
viii. Applicable standard
ix. QA/QC documentation
x. Signature of authorized persons</td>
<td>Contractor.
Results to be presented to NIC, the Implementing Agency</td>
<td>US$13,000 / monitoring event</td>
<td>Monthly during Construction or as indicated in NEPA Permit</td>
</tr>
<tr>
<td>Ecology</td>
<td>• Monitoring is necessary when construction is being undergone in the BRLM. Areas outside of this are not sensitive and would not need to be examined in this detail.
• Sensitive ecological species that are on the list of endemic species should be removed and placed in a nursery for replanting post construction.
• Efforts should be made to retain some of the larger trees at each site (i.e. with a diameter at breast height (DBH) greater than 25cm). Locations for tree retention should be selected deliberately with trees falling along the boundaries of each plot.
• NEPA should be contacted if there is a sighting of any species of concern (especially the endangered crocodiles) and this should be fully communicated to all workers. Workers should be properly advised on the presence of species of concern.
• Where possible, vegetation clearance and construction activities should take place outside of the March to September breeding season for birds. Where construction must proceed during this period, activities that could disturb or destroy nests should be avoided, adapted, rescheduled or relocated.
• Contractors should consider sensitivity/awareness training on local and migrant avifauna to mitigate risks. Additionally:
o Active nest searching is not recommended as the ability to detect nests is very low while the risk of disturbing or damaging active nests is high</td>
<td>Inspection records for no major losses of priority species based on list in Section 5.2.2
Signage
No training and awareness session</td>
<td>Reports of sitings of endemic species of flora and fauna should be recordning during the construction monitoring period. If there are any violations to the monitoring standard, this will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.</td>
<td>Contractor.
Results to be presented to NIC, the Implementing Agency</td>
<td>US$5,000 per event</td>
<td>Monthly during Construction – particularly for those areas located in the BRLM or as indicated in NEPA Permit</td>
</tr>
</table>

	o If an active nest is encountered during construction activities, all activities should be halted in the nesting area and persons should move away as quickly and quietly as possible. o Appropriate setback should be established (species dependent) and a qualified ecologist/NEPA consulted. If the status of the nest cannot be confirmed, or if a nest is found outside of the breeding season, an appropriate setback distance should be implemented until such time that the nest status can be confirmed. • Cleared vegetation should be disposed of in a suitable manner. Burning should not be permitted. • Proper storage and disposal of construction waste and the management of stockpiles to minimize/avoid sedimentation of waterways and surface water bodies at each site should be practiced.					
Health and Safety	• The Contractor must have a health and safety policy that is known and understood by all workers. It must also be visible to the workers on site. • Construction areas should be clearly demarcated with safety signs and barriers to prevent possible incidents. • Workers should be properly equipped with health and safety equipment and trained in the proper use of construction equipment. • All workers must be trained in the proper use of all health and safety equipment. • All workers must be trained in the proper handling and management/ disposal of all types of waste. • The contractor EHS Manager/ Officer shall maintain a register of all EHS related incidents that have occurred as a result of the activities associated with the contract. EHS incidents that should be recorded include fires, accidents, spills of hazardous materials that contaminate soil or water resources, stop-order notices issued by NEPA, the WRA or any other relevant agency, noncompliance with the environmental management plan.	Health and Safety Policy Health and Safety Signs Inspection of the site Training log and schedule Register of all EHS related incidents Equipment maintenance log and schedule Emergency Kit	Health and Safety Monitoring Reports to be prepared. If there are any violations, this will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.	The contractor EHS Manager/ Officer shall maintain a register of all EHS related incidents that have occurred as a result of the activities associated with the contract. EHS incidents that should be recorded include fires, accidents, spills of hazardous materials that contaminate soil or water resources, stop-order notices issued by NEPA, the WRA or any other relevant agency, noncompliance with this EMP.	US$3,000 per monitoring event	Monthly during Construction or as indicated in NEPA Permit
Solid waste management	To reduce the possible negative impacts of improper waste disposal and management, the EHS Manager or Operations Manager is to ensure that during operations, every effort is made to adhere to the mitigation measures outlined in the environmental management plan for proper solid waste management.	Inspection record of site garbage management/evidence of littering etc. Location of a storage site away from roadway, waterways, ponds or pedestrian walkways for construction waste No leakages or spills records and management Record of reuse of waste (construction, organic etc) where possible Record of Disposal Certificate Approved Contractors for Disposal	Monitoring Reports of site cleanliness and soild waste disposal management. If there are any exceedances, these will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.	Contractor. Results to be presented to NIC, the Implementing Agency	US$3,000 per monitoring event	Monthly during Construction or as indicated in NEPA Permit.
OPERATION PHASE						

<table>
<tr>
<td>Water Quality</td>
<td>
Draft Jamaica National Ambient Water Quality Standard –Freshwater, 2009
<table>
<tr><th>Parameter</th><th>Measured as</th><th>Standard Range</th><th>Unit</th></tr>
<tr><td>Calcium</td><td>(Ca)</td><td>40.0-101.0</td><td>mg/L</td></tr>
<tr><td>Chloride</td><td>(Cl^-)</td><td>5.0- 20.0</td><td>mg/L</td></tr>
<tr><td>Magnesium</td><td>(Mg^{2+})</td><td>3.6- 27.0</td><td>mg/L</td></tr>
<tr><td>Nitrate</td><td>(NO_3^-)</td><td>0.1- 7.5</td><td>mg/L</td></tr>
<tr><td>Phosphate</td><td>(PO_4^{3-})</td><td>0.01 - 0.8</td><td>mg/L</td></tr>
<tr><td>Potassium</td><td>(K^+)</td><td>0.74- 5.0</td><td>mg/L</td></tr>
<tr><td>Silica</td><td>(SiO_2)</td><td>5.0- 39.0</td><td>mg/L</td></tr>
<tr><td>Sodium</td><td>(Na^+)</td><td>4.5- 12.0</td><td>mg/L</td></tr>
<tr><td>Sulfate</td><td>(SO_4^{2-})</td><td>3.0- 10.0</td><td>mg/L</td></tr>
<tr><td>Hardness</td><td>($CaCO_3$)</td><td>127.0-381.0</td><td>mg/L (as $CaCO_3$</td></tr>
<tr><td>Biochemical Oxygen Demand</td><td>(O)</td><td>0.8- 1.7</td><td>mg/L</td></tr>
<tr><td>Total Dissolved Solids</td><td></td><td>120.0-300</td><td>mg/L</td></tr>
<tr><td>pH</td><td></td><td>7.00- 8.40</td><td></td></tr>
<tr><td>Conductivity</td><td></td><td>150.0-600</td><td>µS/cm</td></tr>
</table>
</td>
<td>Sediment traps

Logs indicating when any incidents and when work was halted

Water Quality Results from a certified lab.

Spot Checks/ Self Audits</td>
<td>All samples collected during the monitoring exercise should be analysed using verified/validated analytical

methods at an EHU approved laboratory. The Certificate of Analysis (COA) obtained from the laboratory

should contain at least the following information:

i. Sample identification/information and description

ii. Sample collection date and time

iii. Sample submitting information (temperature and condition of sample, time and date of

submission)

iv. Analysis date

v. Test results with units of measurement

vi. Test methods

vii. Notes regarding anomalous tests results

viii. Applicable standard

ix. QA/QC documentation

x. Signature of authorized persons</td>
<td>Contractor.

Results to be presented to NIC, the Implementing Agency</td>
<td>US$13,000 / monitoring event</td>
<td>Annually, or as indicated in NEPA Permit</td>
</tr>
</table>

11 CONCLUSIONS AND RECOMMENDATIONS

The expansion of the Pedro Plains Irrigation network is a major challenge for local development and for Jamaica as well, in order to meet the goal of increased food production in the country.

The area of interest for the proposed pipeline network can be classified as disturbed to highly disturbed. The portion that falls within the northern sections of the Black River Lower Morass (BRLM) show signs of significant anthropogenic influence, particularly the site identified for the intake and pumping station #1 as is located on a vast animal farm where natural vegetation has been cleared. Similarly, the pipeline route and sites for Pumping Stations #2 to #4 and Reservoirs #1 to #4 cross lands that have been historically cleared for conversion for use in agriculture, residential settlements and supporting infrastructure.

Appropriate mitigation measures have been considered for the identified impacts of the development, and the residual negative impacts of the project are evaluated to be minor or neglectable.

On the other side the project will bring several positive impacts in the area of Pedro Plains, and indirectly for the whole country.

The social positive impact of the project is to increase from 900 to 4000 the number of farms connected to at least one private hydrant for agricultural use, and multiply by 4 water delivery (from ground resource) to NWC for domestic and touristic use.

At the same time, thanks to resource substitution of ground water by surface water, the project is expected to divide by 2 the volume of water abstraction from the aquifer, with a positive effect on the latter.

Finally positive impacts are also expected for agriculture : an increase by at least 20 % the added value of marketable production of the area, thanks to the increase of yields, of the number of crop cycles per year, and of the irrigation rate.

12 APPENDIX

12.1 STUDY TEAM AND METHODOLOGY

List of experts having collaborated to produce this EIA.

Table 75 – List of expert having worked on this EIA

Name	Affiliation	Domaine of expertise
Jacques BERAUD	SCP	Water quality
Loic DUFFAR	SCP	Hydrology and climate
Yohann GRISARD	SCP	Sismology and civil engineering
Jean-Claude LACASSIN	SCP	Geology
Paola POMMIER	SCP	Agro-economy
Sylvain SAUVIAT	SCP	General project design
Agata SFERRATORE	SCP	Environnemental sciences & final EIA
Aurélie SHEIK-CASSIM	SCP	Energy
Anne-Lise VICTOIRE	SCP	GIS data treatment and maps
Annmarie GOULBOURNE	ESL	Environmental assessment and management
Danielle A. NEMBHARD	ESL	Ecology
Rashidah KHAN-HAQQ	ESL	Environmental chemistry and occupational health and safety
Jaidene Webster-JONES	ESL	Environmental chemistry

The Consultants conducted the studies for the Ecological Assessment (component of the Environmental Impact Assessment, EIA) based on the Terms of Reference (TOR) received from the Client, and which represented the agreed TOR between the National Environment and Planning Agency (NEPA) and National Irrigation Commission (NIC).

A multidisciplinary team of experienced scientists and environmental professionals was assembled to conduct the required generation and analysis of ecological baseline data.

The team utilized the Charette-style approach to data gathering, analysis, and presentation, whereby team members conducted the reconnaissance investigations together to determine critical elements for analysis and the issues to be highlighted for the design and planning process. Team meetings were used to discuss the progress of investigations and analyses and to facilitate integration of data toward an understanding of the systems at work in both the natural and built environment.

Baseline data for the study area were generated using a combination of research approaches:

- Analysis of maps, plans, aerial photos
- Review of reports and background documents
- Structured interviews (surveys)
- Field samplings.

For soil investigations and samplings, using manual augers, drilling locations were chosen randomly to allow the survey of the whole study area within the given time between January 22 and January 31, 2019. Auger drilling allows to collect soil samples between 0 and 25 cm deep for analysis in a laboratory in Kingston. The field reconnaissance associated with sampling allowed an overview of the organization and characteristics of soil cover.

Community profiles were use as entry data for the social assessment of the Pedro Plains Project area. The relevant reports collected have been analyzed and summarized. Information on these profiles come from surveys of about 10 % of households in each community. A second source of information were shapefile datasets, called “povertymap”. This files give community based geographical information on community names and locations, number of households, population, percentage of poverty level, GINI coefficient, acreages in different units and population densities. It also gives information about “consumption” but unit used for this is not clear. Moreover metadata wasn’t received, no sources or years are attached with this information.
A third source of information for rural development were surveys conducted in March 2019 for two weeks in the area. The sampling was determined in order to over represent farmers as we needed to characterize them precisely.

Water quality samples were collected from the Black River upstream and downstream, within approximately 1km, of the proposed abstraction location in 2023. Data from previous surveys were also used. Information on the description, location and GPS co-ordinates of all water samples was all documented, along with the ambient conditions at the time of collection or at the beginning of the sampling exercise.

The quality control procedures used in the laboratory for the analyses of water samples included the testing of blanks, reference standards and duplicates, as well as the utilisation of verified standard analytical methods. In all cases, appropriate CoC records were prepared and maintained for analytical samples. All containers were properly labelled, individually packaged, stored, and transported in a cooler maintained at the appropriate temperature.

Where parameters were not analysed in-house, labs with similar QA/QC programmes were used and monitored to ensure that data of the highest quality was received.

The locations for the air quality and noise level sampling stations were selected based on the requirements of the terms of reference (TOR) received which indicated that the study area should include at least the area within a 1 km radius of the abstraction and storage points, as well as 250 m on either side of the route of the pipeline point of the proposed project area.

For the air quality assessment and noise survey, all equipment were calibrated prior to use and where applicable, field blanks were used for quality control purposes. Monitoring devices were placed away from any known sources to prevent bias in the data collected.

Detailed observations were made at all sampling stations which were georeferenced for traceability and for all monitoring requirements.

12.2 SAMPLING POINTS AND ASSOCIATED HABITAT TYPES

Table 76 – Location of sampling points and associated habitat types in the project area (October 2019)

Site #	Site	Location	Habitat Type	Land Use	Date	Time	Longitude	Latitude	Elevation
1	Pumping Station #4 + Reservoir #3	Queensbury	Mixed Woodland and Cropland	Secondary shrub, grassland, rocky soil, crop field, limestone outcrop, developed low intensity	October 10, 2019	08.30	-77.682571	17.899677	250m ASL
2	Reservoir #1 Option A	Pedro Plains Road	Mixed Woodland and Cropland	Secondary shrub, grassland, rocky soil, crop field, limestone outcrop, developed low intensity	October 10, 2019	10.45	-77.726507	17.893611	110-125m ASL
3	Reservoir #1 Option C	Beacon	Mixed Woodland and Cropland	Secondary shrub, grassland, rocky soil, crop field, limestone outcrop, developed low intensity	October 10, 2019	12.00	-77.716055	17.901838	110-125m ASL
4	Pumping Station #3 + Reservoir #2	Round Hill	Mixed Woodland and Cropland	Secondary shrub, grassland, rocky soil, crop field, limestone outcrop, developed low intensity	October 10, 2019	13.30	-77.702938	17.908812	250m ASL
5	Reservoir #4	Berlin	Mixed Woodland and Cropland	Secondary shrub, rocky soil, crop field, developed low intensity	October 10, 2019	15.30	-77.663521	17.921206	740m ASL

Site #	Site	Location	Habitat Type	Land Use	Date	Time	Longitude	Latitude	Elevation
6	Intake and Pumping Station #1 (Lacovia, Black River)	Lacovia	Riparian/Wetland	Grassland, pasture, field, riparian, freshwater aquatic	October 11, 2019	06.45	-77.768535	18.079684	7m ASL
7	Lacovia Bridge (1.8km upstream from Intake and Pumping Station)	Lacovia	Riparian/Wetland	Riparian, freshwater aquatic	October 11, 2019	07.15	-77.756707	18.075939	7m ASL
8	Black River (1.2km downstream from Intake and Pumping Station)	Lacovia	Riparian/Wetland	Riparian, freshwater aquatic	October 11, 2019	07.30	-77.771726	18.083498	7m ASL
9	Pipeline Route #1	PS1 to Burnt Savannah	Marshland	Marshland, secondary shrub, crop field, limestone outcrop	October 11, 2019	08.00	-77.767331	18.071296	
10	Pipeline Route #2	PS1 to Burnt Savannah	Marshland	Marshland, secondary shrub, crop field, limestone outcrop, developed low intensity	October 11, 2019	8.30	-77.756707	18.075939	

Site #	Site	Location	Habitat Type	Land Use	Date	Time	Longitude	Latitude	Elevation
11	Reservoir #1 Option B	Newcombe Valley	Mixed Woodland and Cropland	Secondary shrub, rocky soil, crop field, developed low intensity	October 11, 2019	10.30	-77.757771	17.916100	110m ASL
12	Pumping Station #2	Claremont Park	Mixed Woodland and Cropland	Secondary shrub, rocky soil, crop field, developed low intensity	October 11, 2019	11.00	-77.730227	17.911725	50m ASL

12.3 REFERENCES

12.3.1 SCIENTIFIC BIBLIOGRAPHY

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12.3.2 OTHER REFERENCES

The following documents were consulted before, during and after the field mission:

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- FAO, Review of agricultural sector support and taxation, 2014
- IDB, EAC consult and Martin associates, Jamaica logistics chains study, 2013
- Ministry of Industry, Commerce, Agriculture and Fisheries, Annual performance report 2016-2017
- Ministry of Industry, Commerce, Agriculture and Fisheries, Strategic Business Plan 2017-2021
- Ministry of Agriculture and Fisheries and Ministry of Health, Food and nutrition security policy, 2013
- Ministry of Agriculture and Fisheries, National food safety policy, 2013
- Ministry of Industry, Commerce, Agriculture and Fisheries, National Seed Policy and Action Plan 2018-2028
- NIC, Annual reports, 2011-2012; 2012-2013 and 2013-2014
- National Land Agency, Executive agencies act
- National Land Agency, Land Valuation act
- National Land Agency, Land acquisition act, 1947
- National Land Agency, National Land Policy in Jamaica, 1997
- National Land Agency, Registration act and registration of titles
- National Land Agency, The crown property act
- National Land Agency, The land surveyors act
- SDC, community profiles of Barbary Hall, Bigwoods, Burnt Savannah, Lacovia, Mountainside, Newell, Parrottee, Pedro Plains, Pondside, Slipe, Southfield, Treasure Beach and Watchwell
- IDB, Feasibility Studies and Final Designs for Essex Valley and St. Dorothy Project Areas, 2012
- RADA, Cost of production estimates in 2011
- RADA, Cost of production estimates in 2015
- SCP, Feasability study for the expansion of the Pedro Plains irrigated area, 2019.

The following databases were also mobilized:

- ABIS database
- JAMIS database
- NIC's customer database

The following websites were consulted:

- NIC http://www.nicjamaica.com/
- RADA https://rada.gov.jm/
- NLA http://www.nla.gov.jm/
- JOAM http://www.joamltd.org/
- SDC https://sdc.gov.jm/
- Jamaica Climate https://www.jamaicaclimate.net/

12.3.3 INSTITUTIONAL AND STAKEHOLDER INTERVIEWS

The main stakeholders involved in agricultural and rural or local development were interviewed namely:

- RADA at national level:
  - Marina Young, Principal Director of Technical Services
  - Winston Shaw, Senior Director – technology, training and technical information
  - Vaughn Barnaby – coordination of projects within RADA
- RADA at Parish level:
  - Nathan Samuels, Parish Manager of RADA for St Elizabeth
  - Mark Lee, Deputy Parish Manager
  - Jermaine Wilson, Extension officer
  - Hortense Forrester, Extension officer
  - Odain Williams, Extension officer
  - Christopher Blake, Extension officer
  - Oneil Aikens, Extension officer
  - Joseph Alde, Marketing officer
  - Hopeton Panton, Livestock officer
- NIC at national level:
  - Milton Henry, project director
  - Andria Whyte Walters, monitoring and evaluation specialist
  - Wayne Barrett, Director, Commercial Operations
- NIC in Hounslow:

  - Rohan Stewart, engineering director
  - Imran Singh, Manager of Hounslow and Beacon irrigation system
  - Dwayne Dunkley, system operator
  - Carlington Darby, Officer for Hounslow
  - Emile Myers, energy engineer
  - Jason German, Responsible for demonstration site and president of the WUA of Beacon/Little Park
- NLA:
  - Royston Loutin, regional manager
- SDC:
  - Alrick Miller, responsible of SDC at the Parish level
  - Stephanie Lewis Brown, Research, in charge of database
- Treasure Beach touristic resorts
  - Jason Hentzell, owner of Jakes' hotel.

The purposes of the institutional interviews were:

- To draw a baseline of the current stakeholders intervening in the rural and agricultural development of the area
- To understand the agricultural policy in which the project will evolve
- To identify the main stakes of agriculture / tourism in Jamaica and in the area
- To start a discussion on recommendations and on an accompanying measures program.

12.4 MAP LIST

The maps cited in the present document are included in the annexed EIA Cartographic Atlas and are numbered according to the table below. They are in A3 printing format.

Table 77 – List of the maps of the Cartographic Atlas

Map number	Title
001	EXISTING IRRIGATION INFRASTRUCTURES
002	FUTURE EQUIPPED AREAS
003	DISTRIBUTION SECTORS
004	GENERAL INFRASTRUCTURE MAP
005	GENERAL INFRASTRUCTURE MAP – ZOOM NORTH
006	GENERAL INFRASTRUCTURE MAP – ZOOM SOUTH
007	PHOTOVOLTAIC PLANT PV1 MAP
008	PHOTOVOLTAIC PLANT PV2 MAP
009	GEOLOGY OF THE AREA
009A	HYDROSTRATIGRAPHY MAP
009B	SOIL ROOT LIMIT MAP
009C	PEDOLOGICAL MAP
009D	SOIL MOISTURE MAP
009E	SOIL EROSION MAP
009F	SOIL DRAINAGE MAP
010	WATER QUALITY SAMPLING POINTS
011	AIR AND NOISE LEVEL SAMPLING POINTS
012	POPULATION DENSITY
013	POVERTY RATE
014	WATER SUPPLY
015	MEDICAL FACILITIES
016	SOCIAL CHALLENGE FOR THE COMMUNITY
017	LAND USE MAP
018	PROJECTED LAND ACQUISITION - NORTH
019	PROJECTED LAND ACQUISITION - SOUTH