CARRYING CAPACITY REPORT FOR BLACK RIVER AND ITS TRIBUTARIES

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REVISED DRAFT

esl environmental SOLUTIONS

Carrying Capacity Report for Black River and its tributaries

REVISED DRAFT

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List of Abbreviations and Acronyms

BOD	Biochemical Oxygen Demand
BR	Black River
CC	Carrying Capacity
COD	Chemical Oxygen Demand
ESL	Environmental Solutions Limited
GTBSDP	Greater Treasure Beach Sustainable Development Plan
JNHT	Jamaica National Heritage Trust
LDUC	Land Development and Utilization Commission
LM	Lower Morass
NEPA	National Environment and Planning Agency
JNHTA	Jamaica National Heritage Trust Act
NRCA	Natural Resources Conservation Authority Act
NLA	National Land Agency
RRA	River Rafting Authority
TCPA	Town and Country Planning Authority
TDS	Total Dissolved Solids
TEF	Tourism Enhancement Fund
TOR	Terms of Reference
TPDCo	Tourism Product Development Company
TSS	Total Suspended Solids
UM	Upper Morass
WRA	Water Resources Authority

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Executive Summary

The Black River (BR) basin situated primarily in the parish of St. Elizabeth, supports many ecological functions and accommodates Jamaica's largest wetland. The River actually rises in Manchester as the Hector's River, sinks into Cockpit Country from where it emerges as the One Eye River, travels for a distance before sinking again to emerge as the Black River at Siloah in St Elizabeth. The BR and its tributaries (the study area) provides a diverse range of economic, recreational and agricultural benefits to the local population as well as for overseas visitors/tourists primarily through the Upper and Lower Morass, names given to the major divisions of the expansive wetland . This study area continues to be an important wetland and habitat for flora and fauna and for the members of the BR community and the Greater Treasure Beach Development Area (GTBDA).

Public interest in nature and landscapes has increased the number of visitors, both local and international, to Black River. The increased visitation may have already caused a negative impact on ecosystems and various resources within the BR Basin. Conservation, management and protection of these areas are extremely important. A carrying capacity assessment of these areas is therefore required to define a balance between maintaining ecological function and the use of these areas.

The consultants have been asked to assess the status of the environment through various ecological, recreational and socio-economic indicators in order to determine the carrying capacity of the area and the level of stress imposed upon the environment. A series of presentations, written reports, focus groups and review of literature were undertaken to further guide the consultant.

The Black River basin currently supports numerous activities including shrimping, boating, farming and fishing. These activities are all able to co-exist adequately without much negative impact. However, patrolling of the area is needed to enforce and restrict non permitted activities.

Findings reveal that even though healthy flora and faunal populations still exist within the study area, agricultural and tourism activities such as burning of the morass and bout tours respectively, have led to a decline in the species numbers observed as well as variances in chemical and ecological parameters. Despite these changes, the overall environment does not seem to have undergone any significant irreversible impacts and remains in a stable condition.

After critical analysis of the study area and application of the indicators through a holistic lens, it has been determined that the carrying capacity of the study area has not been surpassed based on the ecological, hydrological and socio-economic assessments. However a Zoning and Land Use Management Plan is needed to monitor activities and prevent any further human-induced degradation overtime.

1 Introduction

1.1 Purpose and Objectives

The Tourism Enhancement Fund (TEF) has provided funding to the National Environment and Planning Agency (NEPA) to conduct a carrying capacity study of the Black River (BR) and its tributaries, St. Elizabeth, Jamaica, an area of ecological importance. Environmental Solutions Limited (ESL) has been contracted to undertake this recreational and ecological carrying capacity study to:

1. Ascertain the current levels of recreational and associated activities in the study area;
2. Identify existing and potential impacts of recreational and associated activities and limits of acceptable change for the study area; and
3. Provide recommendations for:
    - Optimal carrying capacity for recreational and associated activities and limits of acceptable change for the study area; and
    - Guidelines, strategies and actions for the effective management of recreational and associated activities in the study area.

This assessment is important because the BR area is a major eco-tourism asset, which is highly used and biologically rich. The study will be carried out to define a balance between maintaining ecological function and human use.

1.2 Consultancy Outcome

On completion of the consultancy, it is expected that the information garnered from the carrying capacity studies will:

1. Guide the NEPA in its review of applications received regarding ecotourism projects and tours along the Black River and its tributaries;
2. Guide the River Rafting Authority in its determination of licenses for river rafting and boating activities on the Black River and its tributaries; and
3. Inform the preparation of zoning and management plans for the proposed protected area.

This report constitutes the seventh deliverable: ***Draft Report on Carrying Capacity for Black River and its Tributaries*** as outlined in the Terms of Reference (TOR). The report details and outlines the research processes, field work and all findings retrieved to date by the consultant, as well as, challenges encountered in accessing the carrying capacity of the study area. Recommendations and conclusions regarding the use of the study area have also been presented.

Deliverables that have been submitted to date to NEPA are presented in Table 1:1

Table 1-1: Deliverables for NEPA and status update

TITLE	***STATUS***
Work Plan	*Submitted*
Review of Technical Information Report (Draft and Final)	*Submitted*
Preliminary Stakeholder Consultation Report (Draft and Final)	*Submitted*
Carrying Capacity Report for Black River and its Tributaries (Draft and Final)	*Due January 25, 2016*
Report on Consultancy (Draft and Final)	*Due January 25, 2016*
Stakeholder Consultation Report (Draft and Final)	*Due February 8, 2016*
Monthly Progress Reports (10 reports)	*8 Submitted*

1.3 Defining Carrying Capacity

In order to successfully execute the objectives of this study, it is important that the term Carrying Capacity (CC) be defined in the context of the study.

According to Sustainable Measures, 2010, "the carrying capacity of an ecosystem is the size of the population that can be supported indefinitely upon the available resources and services of that ecosystem."

Limits of acceptable change have been defined as the variation that is considered acceptable in a particular component or process of the ecological character of a wetland, without indicating change in ecological character, that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (Phillips 2006).

Living within the limits of an ecosystem depends on three factors:

- The amount of resources available in the ecosystem,
- The size of the population, and
- The amount of resources each individual is consuming.

It must be noted that both terms: Carrying Capacity and Limits of acceptable change are similar in meaning with little variation. It has and will therefore be used interchangeably within this report.

1.4 Contextual Background

The BR is described as the largest river system in Jamaica. It is situated in the southwestern section in the parish of St. Elizabeth. The drainage basin covers 67,341 hectares (166,403.23 acres) and consists of two distinct sub-basins: the Upper Morass (UM) (Maggoty to Lacovia) and Lower Morass' (LM) (Lacovia to the sea); both of which have surface and ground water (Webber, 2010). The river originates in Colleyville, Trelawny (in the Cockpit Country as Hector's River) and discharges in BR Bay, St. Elizabeth covering a distance of 70.4km (43.74 miles) (Webber, 2010). From its origins, it travels in a westerly direction before disappearing and re-surfacing from numerous sinkholes. From these sinkholes, the river flows through a narrow gorge before entering the UM. The river meanders into another narrow gorge at Lacovia before entering the LM. Its tributaries include One Eye, Maggotty, Elim, Grass, Y.S., Middle and Broad Rivers.

The project area is dominated by an expansive morass, which occupies an alluvial plain with riverine strands dissected by the BR. Ponds, marshlands and swamps are general features of the landscape. The

BR LM extends southwards of BR to the Parottee Point. The upper and lower Morasses are ecologically significant freshwater wetlands at local, national and international levels.

The BR LM was designated a Ramsar Site in 1997 and was the first wetland in Jamaica to be designated under the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat. It has been so designated due to the numerous habitats it provides for both plants and animals, and for their critical ecological functions with respect to drainage and coastal stabilization and others. The BR LM also helps to protect the marine environment from sediment and nutrient runoff from the land into the sea. This greatly reduces the negative impact of sediments on the coral reefs, which play a significant role in fostering habitats for commercially important fish, on which many fishermen depend.

In addition, the BR LM and UM have been designated as a Game Sanctuary/Reserve under the *Wild Life Protection Act*. Other Reserves within the parish of St. Elizabeth include: Stanmore Hill Game Reserve and Great Morass Parottee Game Reserve, Parottee.

Due to the significant and unique characteristics of the BR Morass, the BR is able to support many activities in which the demand for resource use and space on the river steadily increases. It is therefore imperative that the area is properly managed and regulated, so that the existing and potential benefits derived, remain sustainable and within the river's carrying capacity (CC) with any further human degradation.

This project will therefore seek to determine a suitable carrying capacity by assessing its current features and proposing mitigation measures and a management plan to ensure that the environment remains in a good and resilient condition.

1.5 Legislative, Policy and Institutional Responsibilities

In Jamaica, there are fifty-two (52) statutes that have direct or indirect jurisdiction over matters of the environment. These range from the public health to physical planning and land use, with many instances of overlapping responsibilities among Ministries. The enactment of the Natural Resources Conservation Authority Act of 1991 (NRCA Act), began the process of rationalization and prioritization of these statutes. This Act binds the Crown as well as the people; therefore enforcement can be applied to Public Sector entities as well as private citizens.

In addition to the several statutes, there are system and area plans that are relevant to management of the BR basin and have been drafted to assist the process of conservation and protection of valuable ecosystems and services. These plans include the Draft Protected Areas System Master Plan: Jamaica 2013-2017 and The Greater Treasure Beach Sustainable Development Plan 2013.

Draft Protected Areas System Master Plan: Jamaica 2013-2017

The aim of the Protected Areas System Master Plan (PASMP) is to develop a comprehensive and representative system of protected areas including landscape, seascape and natural and cultural heritage. The Master Plan is in keeping with the Vision 2030 Jamaica- National Development Plan and will be the primary national policy document for strengthening management and extending protected area coverage.

Jamaica's protected areas include a wide range of categories that are subject to different protective regimes, based on management objectives. They are governed by a complex amalgam of legislation, policies, management authorities, and management actors. The effective management and planning of the protected areas therefore requires a coordinated approach with respect to the various units within the system and with other land uses and management activities.

The PASMP which covers the five year period 2013 – 2017, sets out guidelines for establishing and managing a comprehensive system of protected areas that is intended to support national development by contributing to long-term ecological viability; maintaining ecological processes and systems; and protecting the country's natural and cultural heritage. The PASMP also sets out strategies and activities that will lead to the establishment of a system of protected areas that is effectively managed and sustainably financed.

The Greater Treasure Beach Sustainable Development Plan

The Greater Treasure Beach Sustainable Development Plan (GTBSDP) prepared by the St. Elizabeth Parish Development Committee and the St. Elizabeth Parish Council, was developed to align with Vision 2030 Jamaica: National Development Plan, as well as with other local, national and regional policies, regulations and conventions (GTBSDP, 2013). It is intended as a policy document to provide strategic guidance for sustainable development and economic growth in the Greater Treasure Beach Development Area (GTBDA).

The GTBDA stretches from the Great Pedro Bluff to the town of BR and the surrounding LM. This region comprises of eight communities: BR, Treasure Beach, Pedro Plains, Watchwell, Newell, Barbary Hall, Pondside and Parottee (Figure 1:1). Of these, BR is recognized as the primary commercial center, and according to the GTBSDP, there is very little scope for expansion of the town due to the ecologically sensitive areas to the north and west of the town and the coastline to the south. (GTBSDP, 2013).

Ecotourism is at the center of the sustainable development plan for the BR and Parottee communities as the areas seek to achieve social, economic and community development while protecting the resources of the natural environment. The developments proposed for these areas take advantage of the natural environmental assets, such as, the large ponds, wetlands and the long navigable BR.

Table 1-2 below summarizes all the Acts, Policies, Treaties and key Institutions relevant to the study area. A more detailed explanation of each is provided in **Appendix 1** of this report

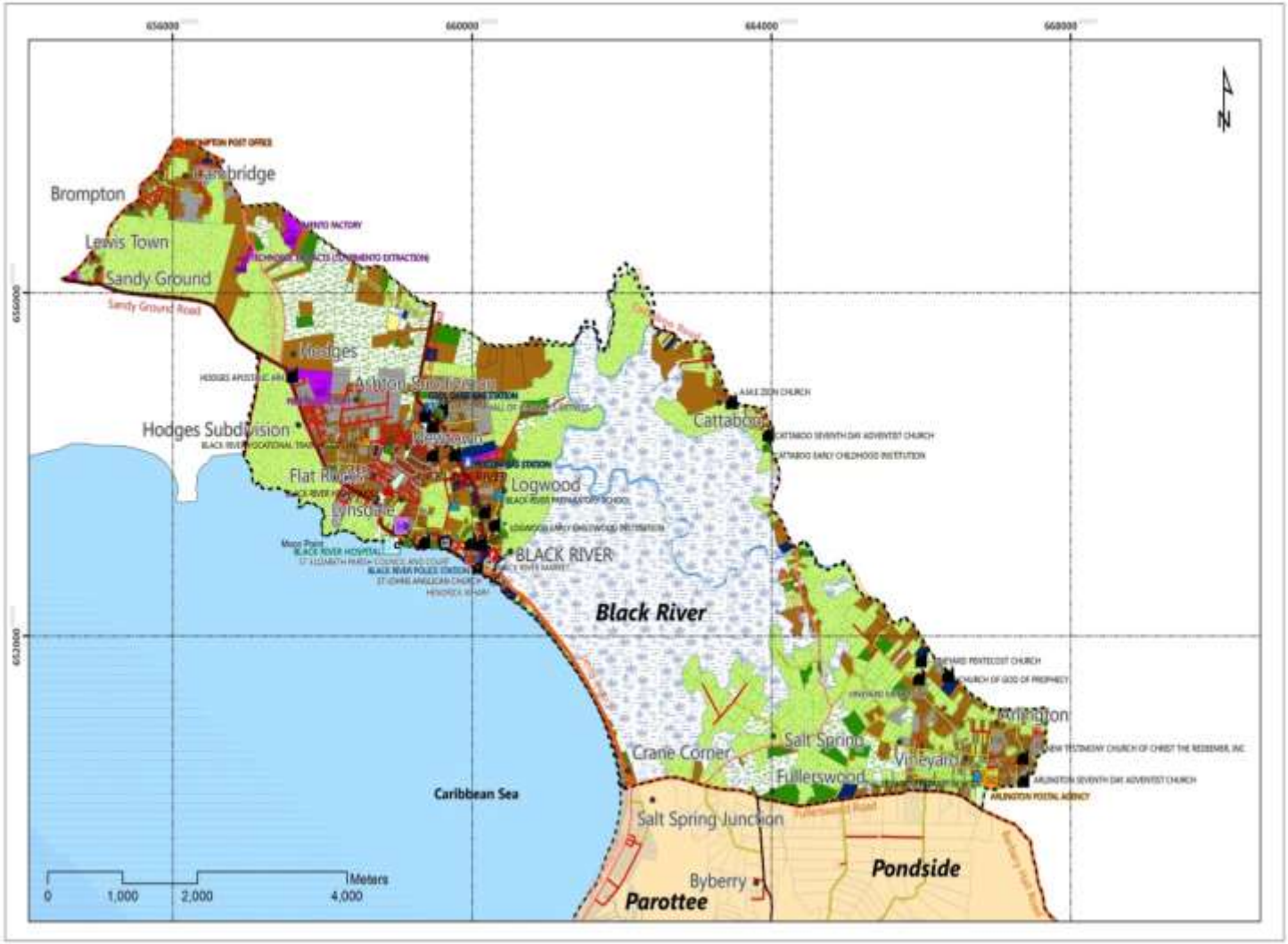


Figure 1:1: Greater Treasure Beach Development Area within St. Elizabeth

Source: Social and Environmental Assessment Report: ESL: August 2013

Table 1-2: Relevant Acts, Policies, Treaties and Institutions to the study area

CATEGORIES	ACTS	POLICIES/ REGULATIONS	TREATIES	INSTITUTIONS
Natural Resources	The Wild Life Protection Act (1945) Amended 1991 The Endangered Species (Protection, Conservation and Regulation of Trade) Act (2000) The Tree Preservation Order Conservations of Natural Resources	The National Land Policy (1996) Policy for Jamaica's System of Protected Areas (1997) Mangrove and Coastal Wetland Protection Draft Policy and Regulations (1996)	Convention on Biological Diversity, Rio de Janeiro (1992) Convention on Wetlands of International Importance especially as Waterfowl Habitats (Ramsar Convention) Protocol on Specially Protected Areas and Wild Life (SPAW) to the Cartagena Convention on the Protection of the Marine Environment of the Wider Caribbean Region	Forestry Department The National Environment and Planning Agency (NEPA)
Agriculture and Fisheries	The Fishing Industry Act (1975) Fishing Industry (Special Fishery Conservation Area) Regulations (2012)			The Fisheries Division
Heritage and Tourism	River Rafting Act Historic Sites and Building			River Rafting Authority Jamaica National

CATEGORIES	ACTS	POLICIES/ REGULATIONS	TREATIES	INSTITUTIONS
				Heritage Trust (JNHT)
Health	Public Health Act (1976)	The Natural Resources Conservation (Permits and Licenses) Regulations (1996)		Tourism Product Development Company (TPDCo)
Land Management and Planning	The Town and Country Planning (St. Elizabeth Parish) Provisional Development Order (1976)			Parish Councils National Environment and Planning Agency (NEPA) National Land Agency (NLA)
Water Resources		Ambient Water Quality Standard (Marine) The Natural Resources Conservation (Wastewater and Sludge) Regulations (2013)		Water Resources Authority (WRA)

2 Approach/Methodology

2.1 Desk Research and Document Review

The consultants conducted a desk review of past approaches and data, including referenced literature, agency reports, maps and photographs. The following were the main source categories:

- Ecological assessments within the area
- Past carrying capacity assessments of the area
- Historical water quality data
- Socio-economic studies conducted
- Documents related to key industries within the area.

Table 2-1 below highlights information/literature that has been reviewed to date.

Table 2-1: Documents and literature reviewed to date

Document	Prepared by
Towards the Management of the Black Rover Morass (RAMSAR Site): Gathering Biological, Social and Economic Data (2010)	Webber *et al*
Recreational Carrying Capacity Assessment for BR (2005)	Smith Warner International
BR Managed Resource Protected Area; Management Plan (1999)	Technical Support Services Limited, Inc.
The BR; Waterway, Wetlands and a Way of Life	Barry Wade
Study of the Carrying Capacity of the BR Morass for Water Sport Activities (Phase 1 Report) (1985)	Environmental Solutions Limited
Study of the Carrying Capacity of the BR Morass for Water Sport Activities (Phase 2 Report) (1997)	Environmental Solutions Limited

Document	Prepared by
The BR Morass: Valuing Ecosystem Services in a Ramsar Protected Area (2013)	Maurice Mason
Local Sustainable Development Plan 2030 and Beyond (Greater Treasure Beach, St. Elizabeth)	Environmental Solutions Limited
The Negril and BR Wetlands, Jamaica	Sven Bjork and Gunner Digerfeldt
Protected Areas System Management Plan, Legal Framework Final Report (2004)	Winston McCalla
BR Morasses Reclamation Project; Report of Consultants to the GOJ. (1964)	Grontmij
Convention on Wetlands of International Importance especially as Waterfowl Habitat (2007).	J. Heinen

2.2 Land Use Mapping and Site Description

Satellite imagery was assessed for the project area and land use was mapped based on recent imagery and ground truthing data. Land use was described and mapped for the recreational and associated activities inclusive of buildings and infrastructure/facilities in the study area and surrounding land uses.

A profile of recreational and other uses of the study area was completed.

2.3 Physical and Ecological Assessment

Field visits were undertaken to investigate the health and use of the ecosystems within the area. Field visits included the Black River, Middle Quarters, Lacovia and Broad Rivers, which make up the greater portion of the Lower Morass and YS and Maggoty of the Upper Morass.

2.3.1 Ecology

2.3.1.1 Avifaunal Census

Fixed Radius Point Count Census Method

The Fixed Radius Point Count method was utilized. This method is based on the principle of counting birds at a defined point or spot and determining the distance of each bird identified. A point was selected along the BR and then all bird contacts (seen and heard) were recorded with a determination of distance given (< 25m or >25m) for each contact. This was done for a predetermined time (10 minutes), before moving to another point at a specified distance away Points for this survey were at most 50m apart. Each spot coincided with the water sampling sites shown in Table 2-2.

2.3.1.2 Other Faunal Surveys

Other faunal surveys were conducted through direct observation of species within a randomly selected area. The use of burrows, nests and tracks were also included to ensure a complete assessment of all the fauna.

2.3.1.3 Vegetation Assessment

For tree and plant assessment, a vegetation description was done for the major vegetation patches surrounding the survey site (heavy use impact areas in the UM and LM). A list of tree and plant species inclusive of trees, endemics and native plants, was generated.

2.3.2 Water Quality Assessment and Profiles

Water quality samples were collected both in the dry (June) and wet (November) seasons and were taken to the ESL lab for analyses and interpretation. The methodology used to analyze the water samples is provided in Appendix II

Water samples were taken from seven (7) previously identified sites/stations along the BR (Table 2-2). One water sample was taken at each station during both the dry season and wet season. A total of fourteen (14) water samples were collected (one sample, per station, per season).

These points are illustrated in Figure 2:1.

The samples were analyzed for the following parameters:

1. Nitrates
2. pH
3. Conductivity
4. Salinity
5. Total Dissolved Solids (TDS)
6. Phosphates
7. Sulphate
8. Chloride
9. Total Coliform
10. Faecal Coliform
11. Biochemical Oxygen Demand (BOD)
12. Chemical Oxygen Demand (COD)
13. Total Suspended Solids (TSS)
14. Oil and Grease
15. Copper
16. Cadmium
17. Iron
18. Arsenic

Table 2-2: Sampling points along the Black River

STATION	NAME	GPS Coordinates	
		N	W
1	½ way point from mouth of BR	18.02626	077.84251
2	Intersection of Broad River and BR	18.03363	077.83967
3	Salt Spring River (underneath Bridge)	18.02573	077..80929
4	Cheese Rock	18.02425	077.80388
5	Middle Quarters River	18.04988	077.83368
6	YS River (at stream gauge station)	18.11333	077.81036
7	Black River at Lacovia	18.07582	077.75675

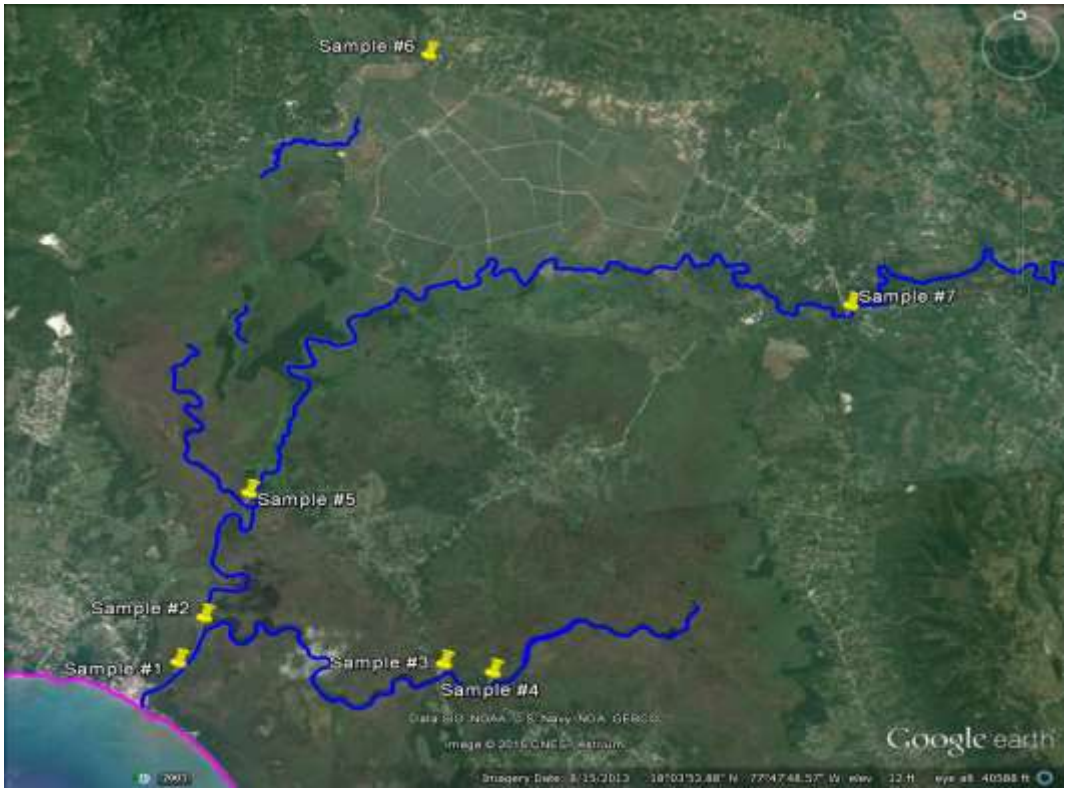


Figure 2:1: Sample points on the Black River

(Environmental Solutions Limited: June 3, 2014)

2.3.3 Hydrogeology

The hydrological assessment of the Black River and its tributaries was carried out using the following methodology:

a) A Geological Map of the Black River and its tributaries was generated to record and illustrate the major rock types, structural features and the drainage network as seen from field observations. A topographic map was used as the base and placement of key features was helped by use of a clinometer and GPS. Rock samples were collected to facilitate analysis of the mineralogy as well as the fossil assemblage to ascertain the age of the different formations. Field data were then plotted on CANVAS software to create the Geology Map for the study area.

b) Review of existing reports on Black River, Jamaica's Water Sector Policy, Water Resources Master Plan 1990 and the Draft Water Resource Master Plan, 2008, available literature on flooding and water resources in Jamaica.

c) The drainage basin was delineated using the USGS freely available ASTER DEM. The DEM utilized a horizontal resolution of 30m and vertical resolution of 1m, as the base layer for determining the topography that would be used for the delineation of the flow direction, drainage lines, points of flow accumulation or confluence of tributaries and sub-catchments for the watershed. The Aster DEM was smoothed using 9x9 grid filter, and sinks were filled to eliminate areas of artificial depression in the DEM. This was based on the recommended procedure commonly used before performing any hydrological analysis with DEM (Zhu et al, 2013).

d) Field visits to observe the different areas of abstraction of water from the Black River. Email and personal communications with WRA on the abstraction of water for different industrial and tourism uses, amount abstracted and the present status was also done.

e) Discharge data was made available from WRA including Webmaps for all the stream gauge stations for the Black River and its tributaries. The data was plotted to show the average yearly and mean monthly variation to detect any seasonal changes if any observed. Flow duration curves and flows for different percentiles (5, 10, 25, 50, 75, 90 and 95) as well as the 7day low flow values were constructed to determine the nature of the drainage basin, changes in flow due to any abstraction if any.

f) Abstraction data obtained from two users were analyzed to see their yearly and seasonal variation. Streamflow for corresponding years was also noted to see if there is any abrupt or drastic change in flow level due to abstractions.

2.4 Socioeconomic Assessment

A socioeconomic assessment was conducted with the use of surveys, interviews, focus group sessions and public meetings. Questionnaires were administered to major investors in the tourism product, staff members in businesses, tourists, farmers, fishermen, shrimpers, other casual users of the river and management agencies.

Stakeholders were identified and the relevant consultations were used for data gathering and for presenting the project.

The following data that related to recreational and associated activities on the Black River were collected:

1. Occurrence
2. Numbers
3. Patterns
4. Concentration

Data was captured from the consultations to determine perceptions of crowding, risk and safety, natural resource and economic impacts, quality and degree of satisfaction with recreational and associated activities, implementation of mitigation measures and or management strategies in the area. Customer surveys were also conducted to ascertain opinions on the activities within the area. Detailed questionnaires were developed and issued under the project. The questionnaires that were utilized are presented in Appendix III.

The indicators to reflect existing socioeconomic conditions and changes in recreational use for the study area were determined. An inventory of the existing socioeconomic conditions, using indicators, was prepared to determine existing status.

A small consultation with relevant representatives (government and non-government) was held on January 13, 2013 at the offices of the Ministry of Water Land Environment and Climate Change in Kingston. The consultants presented the preliminary findings and recommendations to date, fielded questions and solicited feedback to further inform the CC analysis. Another public consultation with a larger group of stakeholders is scheduled to take place in Black River on February 2, 2016. Information gathered from these meetings will help to guide the consultants into determining the appropriate CC for the study area.

2.4.1 Boat Counting

A boat survey was conducted to determine the level of boating activity (traffic) on the river. Both canoes and pontoon vessels travelling up and down the river were counted over a three day

period for 8 hours each day. Boat counts were taken on Tuesday, Thursday and Saturday. The number of occupants in each vessel was also counted.

2.5 Institutional Authorities and Capacity

Key overarching institutions governing the Black River area were identified and interviewed. Their mandate and ability to fulfill their mandate was determined through consultations and document review.

The results of the assessment informed recommendations for the standards development, alternative and carrying capacity, as well as the implementation and monitoring plans developed under this project.

2.6 Recommendations and Standards of Development

Following an assessment of the status of the ecological environment and existing socioeconomic setting, the potential range of recreation opportunity zones in the study area were identified. Standards for each zone were developed in accordance with international best practice and to suit the local environment.

2.7 Assessment of the Alternatives

Alternative opportunity zones based on needs, interests, values and concerns were identified and the costs and benefits for these alternatives were determined. These alternatives were informed by the physical, ecological and social assessments conducted. Management strategies/ interventions required for each alternative opportunity zone were developed. All the recommended alternatives were assessed and the preferred alternative(s) were decided.

2.8 Determination of Carrying Capacity

In order to determine the carrying capacity for the area, the following were identified based on the assessments:

1. All resources: ecological, physical socioeconomic, heritage
2. The most vulnerable indicator/ sensitive elements in the short and long term;

3. How these relate to one another and in the inter-linkages;
4. Potential impact on the vulnerable elements including recreational activities, socioeconomic activities like settlement, commercial activities etc.

The consultants formulated indicators to effectively and holistically determine the state of the environment in both the Upper and Lower Morass and to inform the CC of the study area. Based on the type of study undertaken; Physical, Ecological and Socio-economic, the respective indicators were applied.

The indicators used are illustrated below in Tables 2-3: 2-5

Table 2-3: Ecological Indicators

Indicators
Density and Distribution of Mangroves
Flowering pattern of Red Mangroves
Density of occurrence of water hyacinth (Black River)
Water Hyacinth occurrence (Broad River)
Occurrence of agricultural plants within the floral composition of the wetland
Monitoring of swamp communities inclusive of *Sabal jamaicensis* and *Roystonea princeps*
Crocodile observations noting age and location
Bird species monitoring along all rivers and tributaries
Monitoring of the occurrence of commercially important fish species
Monitoring of shrimp and crab sizes captured

Table 2-4: Physical Indicators

Indicators
Daily Mean Flow
Average Yearly Flow
Mean Monthly Flow
Flow Duration Curves
7day low flow
Q90 flow (flow that exceeds 90% of the time)
Parameters are within ambient standards of NEPA

Table 2-5: Socio-economic Indicators

Indicators
Expanse of population
Housing and other development
Source of Water
Changes in shrimp catch
Changes in fish catch
Burning
Boat traffic – numbers and wave action
Chemicals
Deforestation

A summary of the approach and its components that would ultimately feed into determining the carrying capacity of the study area is shown below in Figure 2:2.

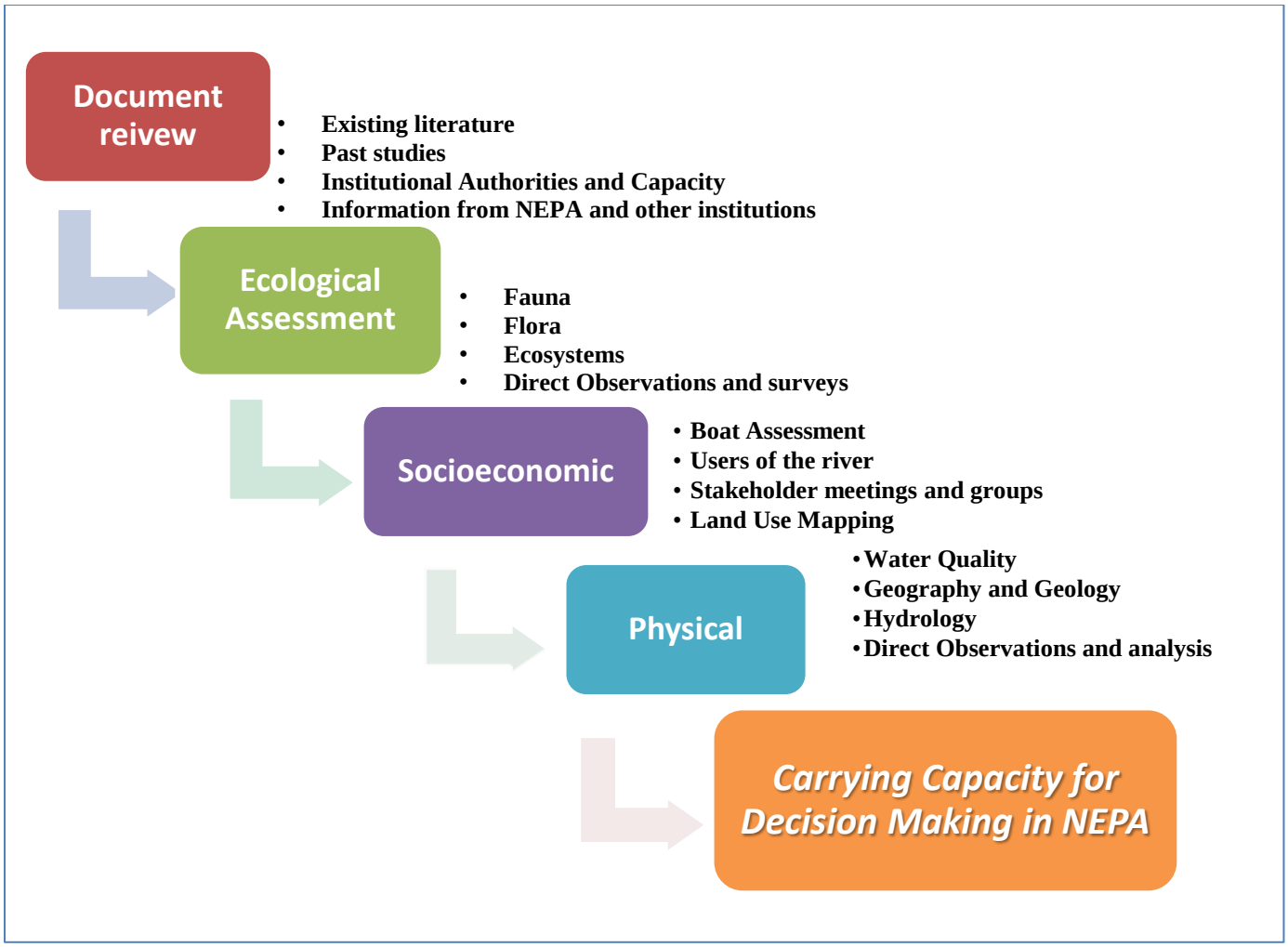


Figure 2:2: The Approach

2.9 Statistical approach for Carrying Capacity Assessment

Areas suitable for recreational boating activities as well as optimal boating activities have been determined based on international best practice. There is a growing interest for recreational activities in the BR LM and research has shown that increasing boat densities have the potential for negative ecological impacts (SWIL, 2005).

Recreational carrying capacity considers several key issues including physical characteristics of the area, environmental impacts, boating density and potential buffer areas which determine usable and non-usable areas (Rajan et al, 2011).

Recreational carrying capacity for this BR LM study was determined by applying limits of acceptable change for boating activities in a lake environment. This method has been utilized in several countries including the United States and Jamaica in not only lake environments but river systems which are of a similar nature.

The general equation for determining recreational carrying capacity is as follows:

Recreational Carrying Capacity = Area suitable for recreation ÷ desired density

(SWIL, 2005; Rajan et al, 2011; Boslev, 2005)

To determine recreational carrying capacity, optimum boating density needs to be calculated. Optimum boating density is the recommended space for various boat categories, measured in square metres per boat (Lorenz and Pusch, 2012). There are some studies that have determined the optimum boating densities based on user groups, activities, safety and user perceptions. The table below (Table 2-6) outlines some of these that have been considered for the study.

Table 2-6: Optimum boating densities

Source	Recommended Density	Watercrafts / Uses Prescribed
Jackson et al, 1989	20 acres/boat (81,000m^2/ boat)	Waterskiing & motor Cruising
	8 acres/boat (32,000m^2/boat)	Kayaking & Sailing
	10 acres/boat (40,500m^2/boat)	Fishing
	10 acres/boat (40,500m^2/boat)	All uses combined
Warren and Rea, 1989	9 acres/boat (36,000m^2/boat)	Motorboats
	1.3 acres/boat (5,260.91 m^2/boat)	Fishing from boat
	4.3 acres per boat (17,401.5m^2/boat)	Sailboats
	1.3 acres per boat(5,260.91 m^2/boat)	Canoes/kayaks
	12 acres/boat (49,000m^2/boat)	Waterskiing boats
Duke Power, 1999	4 acres/boat (17,000m^2/boat)	Fishing, Sailing & Jet Skiing
	1 acre/boat (5,000m^2/boat)	Canoe/Kayak
	9 acre/boat (36,000m^2/boat)	Motor Boating
	12 acres/boat (49,000m^2/boat)	Water Skiing

Florida Department Of Environmental Protection Division Of Recreation And Parks, 2005	5-10 acres /boat	Limited Power (10 HP or less)
	10-20 acres /boat	Unlimited Power
	20-50 acres /boat	Water-skiing
	5-10 acres /boat	Sailing
	5-10 acres/boat	No Power, Still Water

For the BR Area, the optimum boating densities that have been adopted are listed below. These have been adopted based on the similarities shared in terms of the size watercraft and wave effect resulting from these watercraft.

1. Fishing canoes (motorized and non-motorized) = 4 acres/boat (17,000m^2/boat
2. Kayaks and rafts (non-motorized) = 1 acre/boat (5,000m^2/boat)
3. Pontoons (motorized) = 9 acre/boat (36,000m^2/boat)

In order to determine desired boating density for activities in the BR LM, surface water area (usable and non-usable), types of watercraft used, the natural topography and setting, safety conditions, and on-water crowding perceptions were considered.

The water surface area traversed along the river in the LM was calculated by multiplying the measured length of the river traversed by the measured width of the river. A non-usable area was also estimated so as to provide a needed 10m buffer on either side of the river. This buffer is considered for ecological sensitivity of the wetland flora and fauna, which was estimated by SWIL, 2005, and was retained for this study.

Areas suitable for boating recreation in the BR LM are presented below in Table 2-7. These areas have been determined based on site assessments, interviews as well as past studies

undertaken within the area. Chapter 7 of this report presents the results of the calculated boating density based on type of watercraft recommended for the LM using the formula outlined above for recreational carrying capacity.

Table 2-7: Suitable recreational areas for boating within the LM

Areas	Total Water Area (m^2)	Non-usable area (m^2)	Usable Area (m^2)
From the main Docking Area, along Broad River to Salt Bridge (Pontoons)	325,000	130,000	195,000
From the main Docking Area, along Broad River up to 2km past the Salt Bridge (Canoes)	318,750	170,000	148,750
From the Docking Area, along Black River up to the Intersection with Middle Quarters River (Canoes)	60,000	10,000	50,000
From the Black River / Middle Quarters River intersection along Middle Quarters river up 2km (Rafting)	60,000	40,000	20,000

3 Existing Environment

3.1 The Project Area - Black River Catchment

The BR rises as the Hector's River in the Cretaceous volcanic rocks in the northwest section of the Central Inlier. It sinks below the Tertiary limestones at Oxford and re-emerges as the One-Eye River, which cascades through several travertine covered waterfalls and rapids, sinks again at Wallingford Cave and re-emerges for a second time at Mexico Cave (Nassau Valley) as the BR. It then enters the western side of the BR Upper Morass, flows through a narrow fault-controlled 'gap' at Lacovia where it enters the lower morass.

The BR has several tributaries within the upper morass, the largest ones being the Smith River, Blake River and Island River, all of which rise from springs within the immediate vicinity. Figure 3:1 shows the topography of the basin as well as the different tributaries of the BR and the Y.S River. It shows the rise of the BR as Hectors river, location of the Nassau Mountains and the location of the UM and LM as well as the gap at Lacovia.

The most important tributary is the Y.S. River, which originates ultimately in the Cretaceous rocks of the Marchmont Inlier, sinks and re-emerges in the Ginger Hill-Merrywood area and then flows south towards Redgate, forming several cascades and waterfalls through a fault controlled 'valley'. It then continues to flow through a broader valley to the west of the Lacovia Mountains and drains into the LM near to Middle Quarters, forming a confluence with the BR near Holliday Pen. Within the BR LM, the Middle Quarters and Broad Rivers (Salt Spring River) arise from springs to form important tributaries, before it empties into the Black River Bay.

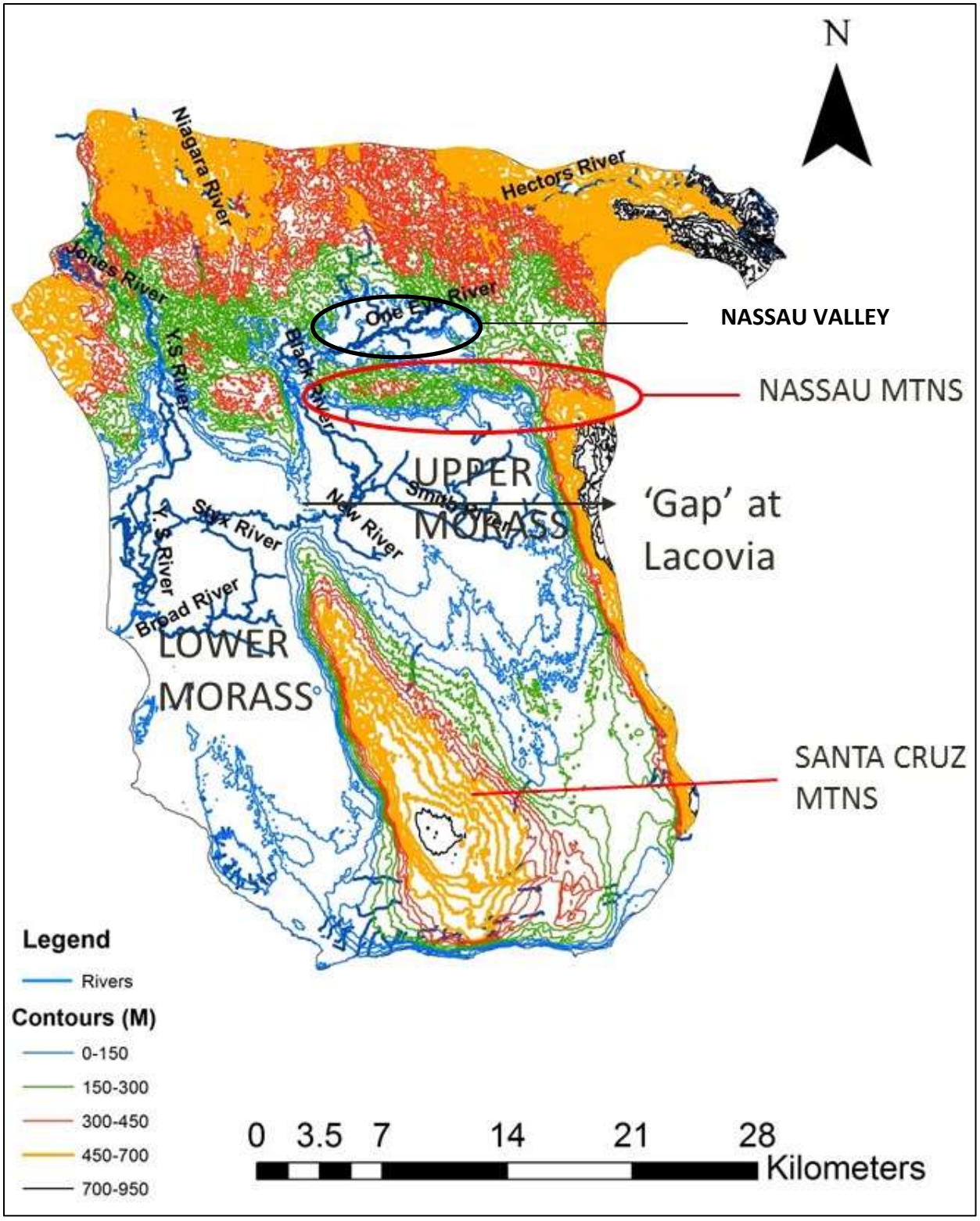


Figure 3:1- BR basin showing the topographic contours, drainage, network and the location of the Upper and Lower Morasses

3.1.1 Upper Morass

In the past, The UM has functioned as a settling basin for the BR after it passed through the Newton Gorge. Attempts at drainage and flood control were first undertaken primarily to facilitate the growing of cane. Rice cultivation was also initiated and small scale practices are still evident today (Webber et al, 2010). With the completion of engineering works in the UM, 2,023 hectares (5,000 acres) of usable agricultural land was reclaimed, including areas reserved for aquaculture. The agricultural activity in the UM and upper reaches (Maggotty, Newton, Appleton) has severely affected the LM. Since the river has been dyked, it has been unable to shed its heavy silt load over the UM before passing through the Lacovia gorge and entering the LM, therefore resulting in heavy siltation downstream. The downstream impacts of the physical works, particularly on the LM include siltation, and high levels of chemical fertilizers and other pollutants washed into the river (Wade, 1985).

Observations of the activities conducted in the UM reveal characteristic changes in the water quality and flow of the BR as it travels down to the LM. As the BR passes through Bartons and Newtons, the water flow is heavy, highly silted and turbid and the area is covered in dense vegetation. Numerous cane and agricultural fields have been observed with cattle and goat farming evident in various sections of Bartons (Figure 3:2). Also evident are large areas of coconut farming and aquaculture in which rainwater harvesting initiatives are implemented (Figure 3:3). Other major land uses of the UM include tourist attractions, such as, Bubbling Springs, YS Falls and Apple Valley Park.

Sluice gates are also observed along the BR UM as shown in Figure 3:4 in very close proximity to agricultural fields in which they (gates) are used for flood control and irrigation purposes. Further investigation and analysis has been conducted so as to determine the effect of this activity on water levels in the morass and its impacts downstream. In addition, the certainty as to whether or not these farmers have been licensed by the relevant institutions to extract water from the BR will be discussed.

Figure 3:2 Cattle farming in the UM

Source: Environmental Solutions Limited, 2015

Figure 3:3 Aquaculture in the UM and Rainwater harvesting drums for water collection in the fields

Source: Environmental Solutions Limited, 2015

Figure 3:4 Sluice gates observed on the BR UM used to control flooding and irrigation purposes

Source: Environmental Solutions Limited, 2015

The burning of sugarcane and other forms of vegetation is still very active within the morass and large volumes of smoke have been observed, which could have a possible impact (directly and indirectly) on air quality, biodiversity and overall ecology of the area (see Figure 3:5).

Figure 3:5- Smoke emitted from burning vegetation and cane fields in the UM

Source: Environmental Solutions Limited, 2015

The water flow observed from the different tributaries in the UM, such as, Maggotty, flowing down to Lacovia passing Bartons and Newton is significantly different from the water flow arising from YS entering New Holland. Even though both tributaries (Maggotty and YS) enter the BR, the water stream from YS is characteristically cleaner and more transparent than that of Maggotty, which appears turbid and highly silted. This may be a result of the high agricultural activities occurring in the Appleton, Siloah and Maggotty region.

3.2 Lower Morass

As indicated above, the BR LM is the most diverse and largest wetland in Jamaica covering an area of approximately 6,075 hectares (15,000 acres) (Webber, 2010). It is bounded on the west and north by the major roads linking the towns of BR, Middle Quarters and Lacovia, on the east by the Santa Cruz Mountains and on the south by the coastline (Wade, 1985) (Figure 3:6).

The sub-basin consists of shallow estuaries, marshland and mangrove swamps, providing a rich and diverse ecological environment. The BR LM is a complex area of shallow brackish lagoons, limestone islands, tidal marshes, mudflats and mangroves near the coast, and extensive freshwater marshes with peat formations. Historically, the area has been 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. In addition, the river and its tributaries provide water for the various uses in the area, such as the JPS Hydro Plant (Webber, 2010).

Influenced by the surrounding water and nature of the soil, the LM is made up of many different types of vegetation and habitats. Wade, 1985 reported that the LM is home to 92 species of flowering plants, 23 of which are considered rare, and eight of which are endemic to Jamaica. 10% of the plants found in the morass are rare in Jamaica, which include the Night-Blooming Water Lilies, the Royal Palm and the Alligator Pear plant (Kenning and Hayes-Sutton, 1999 in The Greater Treasure Beach Sustainable Development Plan, 2013).

However over the years there have been significant changes in both the ecology of the area such as vegetative cover and agricultural and industrial uses of the LM and UM. This can be attributed to the increase in activities within the morass as well as environmental changes, such as,

deforestation, burning of the morass and farming activities. Other major land uses of the LM include safari/boat tours on the river, swimming, picnicking (Cheese Rock), kayaking, fishing and shrimping. Figures 1, 2 and 3 in Appendix IV highlight changes in vegetation in the upper and lower morass between 2000-2010 as well as the current land use and agricultural activities in the study area.

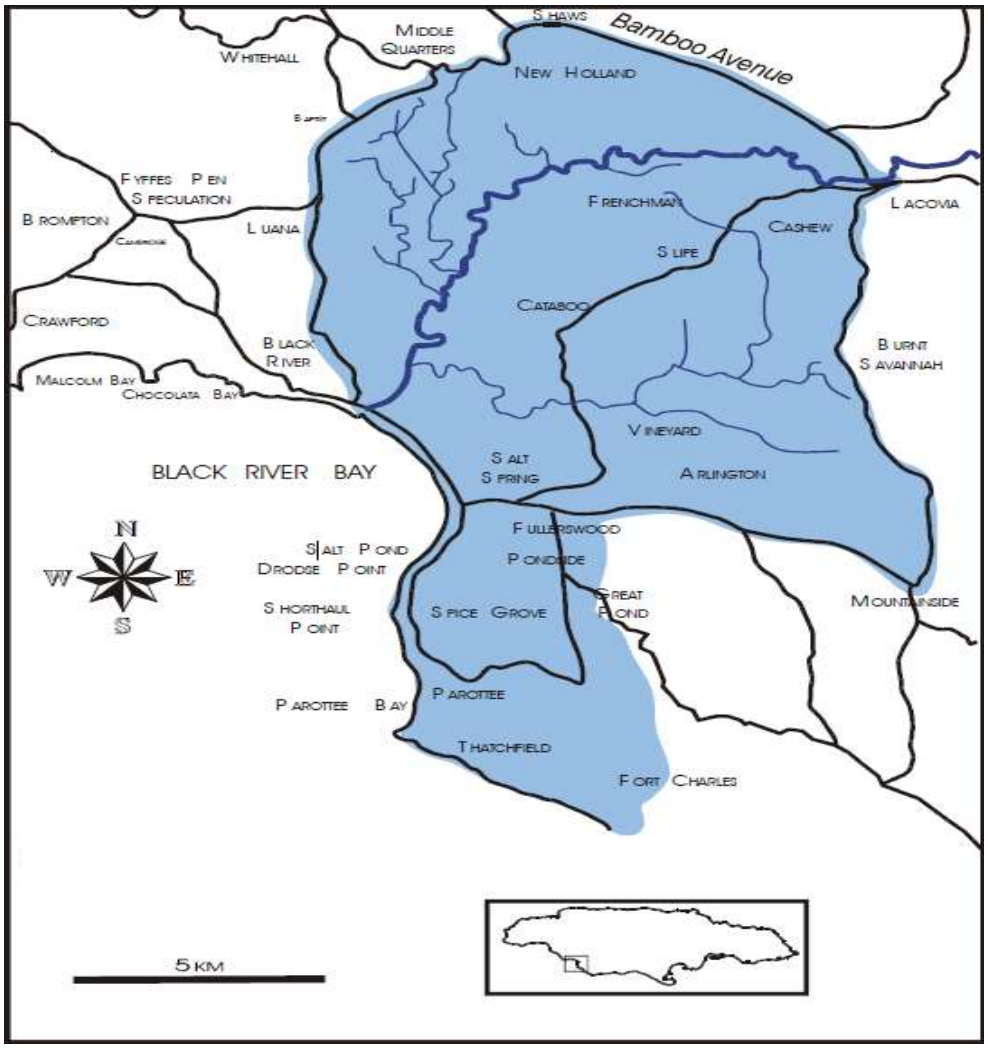


Figure 3:6: The Lower Morass (LM)

Source: Towards the Management of the Black River Morass Report, 2010

3.3 Ecology

Fauna

A large number of vertebrate and invertebrates depend on the BR LM. The area is ecologically diverse with species of global concern observed. Over 150 vertebrate species have been recorded including endangered species, and just below 50% of the island's avian species have been identified in the morass (Information Sheet on Ramsar Wetlands Black River Lower Morass, 1997). Avian species include: *Casmerodius albus* (the Great Egret), *Bubulcus ibis (Cattle Egret), Egretta thula* (Snowy Egret) *Egretta tricolor* (the tri-coloured Heron), *Patagioenas leucocephala* (White Crowned Pigeons), *Zenaida asiatica* (White-Winged Doves) and *Pandion haliaetus* (Ospreys) (The Greater Treasure Beach Sustainable Development Plan, 2013). Other faunal species of interest observed in the LM include:

- *Crocodylus acutus* (American crocodile)
- Trichechus manatus (West Indian Manatee)
- Marine turtles: *Eretmochelys imbricate (*Hawksbill Turtle), *Chelonia mydas* (the Green Turtle) and *Caretta caretta* (Loggerhead Turtle:- occur between BR and Savanna-la-Mar) (Webber, 2010)
- Freshwater turtles: *Trachemys terrapen* (The Jamaican Slider turtles)

Flora

The LM flora plays an ecologically important role in removing nutrients received from the BR exiting from the UM (Garrick, 1986), as well as, controlling floodwaters from the YS and BRs. The LM functions as a genetic reserve consisting of over 92 species of flowering plants, of which 25% are rare 9% endemic to Jamaica (Garrick, 1986).

A unique relationship exists between the soils of the Morass and the vegetation (Grontmij, 1964).

- In the presence of peat- *Cladium jamaicense* (sawgrass), *Typha augustifolia*, *Sabal jamaicensis* and *Roystonea princeps* were mainly identified.
- In the presence of Clay- a swamp forest

- In the presence of alluvial clay - mangroves, especially *Rhizophora mangle* (Red mangrove), was dominant as well as *Phragmites communis* (reeds). *Nymphaea ampla* (Water Lily) and *Eichhornia crassipes* (Water Hyacinth) dominated the waterways.

An ecological assessment of the major rivers within the BR Basin was done to determine the status and ecological features. The main rivers examined included:

1. YS Falls River
2. Maggotty River
3. Black River
4. Middle Quarters River
5. Broad River

3.3.1 YS Falls River

YS Falls located in the UM of BR was noted to be fairly shaded with several mature trees (Figure 3:7). Even though numerous agricultural and recreational activities were evident, such as, livestock rearing and nature tours, the area was in a generally good condition. In addition, the river has a fairly rich riparian area. Noted also was the fact that YS Falls attractions limited the amount of visitors daily, therefore controlling the usage and amount of traffic in and out of the area.

Figure 3:7- Section of the YS Falls River: Large trees form part of the Riparian Zone

Source: Marlon Beale, 2015

3.3.2 Maggotty River

The Maggotty River (Figure 3:8) was surveyed from the main road and along the road leading to the JPS Hydropower sub-station: the major industrial activity that occurs along the river. In general, the riparian area (Figure 3:9) is fairly degraded in most areas and the water tends have a high turbidity on most occasions. However it is recognized that several emergent trees (trees greater than 10m) occur along the banks of the river and provide stability for soil and reduce erosion effects during high rainfall periods.

Figure 3:8- Section of the river by the Hydropower Substation

Source: Marlon Beale, 2015

Figure 3:9- Riparian Zone of the Maggotty River

Source: Marlon Beale, 2015

3.3.3 Black River

The lower reaches of BR are predominantly vegetated by Red Mangroves on the western banks, and wild cane on the eastern banks (Figures 3:10 to 3:12). Small clumps of Water Hyacinths were observed floating along the river as well as in amongst the Red Mangrove roots. The mangroves were noted to be fruiting as several young red mangroves were seen on attached to trees. Tree heights ranged from 3 – 4m. The water was noted to be fairly silted or turbid in the lower reaches of the Back River.

Figure 3:10- Lower reaches of the BR showing Red Mangroves and Wild Cane

Source: Marlon Beale, 2015

Figure 3:11- Red Mangroves along BR

Source: Marlon Beale, 2015

Figure 3:12- Wild Cane on the eastern banks of the BR

Source: Marlon Beale, 2015

The upper section of the Black River was significantly different with respect to dominance of water hyacinths which affected the full width of the river (Figure 3:13). Similar mangroves species were observed as in the lower reaches of the study area. There were a number of avifaunal species observed along the banks of the river, predominantly in the Wild canes and reeds (see species list for details). Similar to the lower reaches, the upper areas of the Black River had a dirty brown turbid coloration to it.

Figure 3:13- Upper reaches of BR where Water Hyacinths dominate and "choke" the river

Source: Marlon Beale, 2015

3.3.4 Middle Quarters

This area is similar to the upper reaches of the Black River with predominantly herbaceous species and no mangroves species observed. Additionally, there was an increase in presence in the number of Water Hyacinths floating along the river in several areas; most likely, eventually reaching the mouth of the Black River. Also noted in this area, was the presence of two types of submerged plant species (Figure 3:14).

Figure 3:14- Submerged plants species observed

Source: Marlon Beale, 2015

3.3.5 Broad River

Broad River appears fairly pristine with clear waters observed throughout. Mangroves (predominantly Red Mangrove) as tall as 15m were observed along sections of the river ("Mangrove Avenue"). The presence of Wild cane and Reeds were noted in areas where mangroves were absent. Also observed in some sections were water lilies. This was especially dominant where the water was shallow. This part of the river is the most trafficked by the tour operators, fishers and some shrimpers. The Broad River includes areas such as Salt Spring River and Cheese Rock.

3.3.6 Other Key Areas: Confluence (merging of Broad and Black Rivers)

This area is the point of merger of both the Black and Broad Rivers. The area is dominated by Reeds and Wild Cane. However, a few patches of White and Black Mangroves were observed. Also observed were small areas of Water Hyacinth. It was noted, that it was fairly shallow in certain areas as large patch of reeds were seen growing detached from the main swamp area.

3.4 Tree Species Observed

Numerous species of trees and vegetation were observed along the BR. These included mangroves, shrubs, grasses, mango and coconut trees among many others, partially and fully submerges plants, etc. The names of each species identified (common and scientific name), their location observed and their DAFOR ratings are presented in Appendix V.

3.5 Faunal Observations

3.5.1 Avifauna

A total of 25 species of birds were observed during the assessment period and these comprised both wetland and terrestrial based species. It must be noted that the time of sampling would have limited the number of birds (especially terrestrial species) seen in the study area.

A list of the wetland and terrestrial bird species that were found along the BR including their numbers and location observed are presented in Appendix VI.

3.5.2 Crocodiles

Historically, the American Crocodile (*Crocodylus acutus*) was found on the south coast, with Font Hill and Black River being the most important places in Jamaica for crocodiles until the early 1990's. The current status and population is unknown especially within the Black River Morass due to migration and nesting variation and patterns. However, the National Environment and Planning Agency (NEPA) has undertaken national surveys to determine distribution and status of crocodiles (personal comm. Y. Strong, 2016). It is important to note that the availability of undisturbed nesting habitat is the most important limiting factor.

Site visits conducted on June 24, 2015 and November 18, 2015 had the following observations. These are presented in table 3-1 below:

Table 3-1: Number of crocodiles observed on Black, Middle Quarters and Broad River

June 24, 2015			
	Black River	Middle Quarters	Broad River
Number of crocodiles	2	1	1
November 18, 2015			
Number of crocodiles	2 (juveniles)	1	1

3.5.3 Indicators

The status of the existing environment (ecology) was determined using various floral and faunal indicators. The level of stress imposed on the environment as then evaluated to effectively determine the levels of acceptable change.

3.5.3.1 Floral Indicators

- Density and Distribution of Mangroves along the two major Rivers (Black and Broad)
- Flowering pattern of Red Mangroves, which are crucial to river bank establishment and habitat for several faunal species
- Density of occurrence of water hyacinth especially along the upper sections of the Black River
- Water Hyacinth occurrence along the Broad River (monitoring for increased occurrence)
- Occurrence of agricultural plants within the floral composition of the wetland, noting replacement of wetland/swamp species with more hardwood trees
- Monitoring of swamp communities which include tree species such as *Sabal jamaicensis* and *Roystonea princeps*
- Distribution of other alien invasive species e.g. Wild Giber (*Alpinia allughas)*

3.5.3.2 Faunal Indicators

- Crocodile observations noting age and location of observation
- Bird species monitoring along all rivers and tributaries with a focus on areas of high mangrove density and those with high water lily density – key species are Herons and Jacanas
- Monitoring of the occurrence of commercially important fish species
- Monitoring of shrimp and crab sizes captured especially by fishers along the Black and Broad Rivers and those which venture close to the headwaters (example above Cheese Rock).
- Monitoring distribution of known invasive alien species within the main rivers of the Upper and Lower Morass. Species of note:
    1. Red Claw Lobster (*Cherax quadricarinatus*)
    2. Suckermouth Catfish (*Hypostomus plecostomus*)
    3. Cascadura or New Type fish (*Hoplosternum littorale*)

Table 3-2 below summarizes the various indicators and outlines the current status of the description provided.

Table 3-2: Ecology Indicators

Indicator	Description of Status	Direction (Positive, Negative, Stable)
Floral		
Density and Distribution of Mangroves	Density seems stable especially along the two major tributaries	Stable
Flowering pattern of Red Mangroves	Mangrove flower at a specific time of the year	Stable
Density of occurrence of water hyacinth (Black	Density along the Black River seems high, with the	Negative

Indicator	Description of Status	Direction (Positive, Negative, Stable)
River)	possibility of increasing based on nutrient input from upstream	
Water Hyacinth occurrence (Broad River)	Occurrence along Broad River is very low	Positive
Occurrence of agricultural plants within the floral composition of the wetland	Based on burning activities within the wetland, there has been a steady increase in observed species	Negative
Monitoring of swamp communities inclusive of *Sabal jamaicensis* and *Roystonea princeps*	Swamp communities occur throughout the wetlands, however burning activities for agriculture have decreased their presence	Negative
Faunal		
Crocodile observations noting age and location	Numbers of crocodiles observed was lower than previous records, however this isn't a clear indication that numbers have decreased	Stable
Bird species monitoring along all rivers and tributaries	Numbers of bird species observed was lower than previous records, however this isn't a clear indication that numbers have decreased	Stable
Monitoring of the occurrence of commercially	Fish catch reports are that numbers are decreasing	Negative

Indicator	Description of Status	Direction (Positive, Negative, Stable)
important fish species		
Monitoring of shrimp and crab sizes captured	Catch reports are that numbers are decreasing, as well as the presence of invasive(shrimp) species	Negative
Monitoring distribution of known invasive alien species within the main rivers of the Upper and Lower Morass. Species of note: 1. Red Claw Lobster (*Cherax quadricarinatus*) 2. Suckermouth Catfish (*Hypostomus plecostomus*) 3. Cascadura or New Type fish (*Hoplosternum littorale*)	The distribution of these alien invasive species is noted across both upper and lower sections of the morass, with higher densities of each observed at particular locations within the Black River Morass	Negative

3.6 Physical Setting

3.6.1 Hydrology

The BR hydrological basin is one of the ten hydrological basins in Jamaica. Hydrological basins in Jamaica as defined by the Water Resources Authority Master Plan (1990) are geographical areas drained by a surface and or groundwater. The basin boundaries are normally surface water divides but groundwater divides are also used specially in the karstic areas. Figure 3:15 and Figure 3:16 shows the different hydrological basins and watershed management units in Jamaica. The BR basin, however, as noted previous sections, can be sub-divided into two sub-basins: The Upper Sub-basin comprising the Nassau Valley, Upper Morass and Essex Valley agricultural areas and the Lower Sub-basin comprising the Lower Morass and the Pedro Plains.

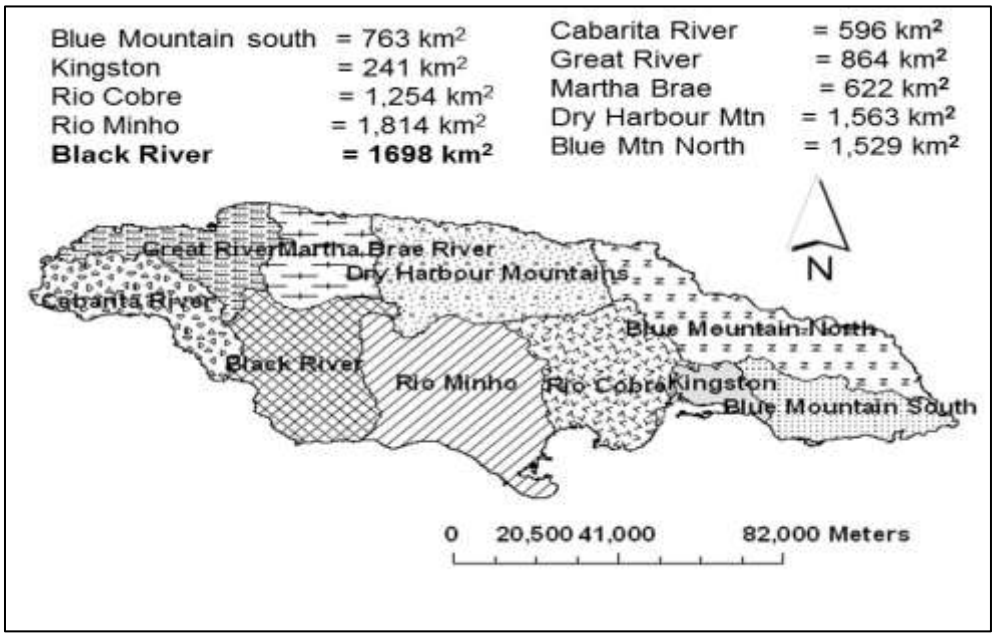


Figure 3:15- Map of Jamaica showing the different hydrological basins and their corresponding areas

Source: WRA, 2015

Figure 3:16- Map of Jamaica showing the 26 watershed management units with the BR

Source: WRA, 2015

The WRA Master Plan, 1990 reports that the main areas which were identified for suitable irrigated agriculture are the Upper Morass, Lower Morass and the Pedro Plains. Irrigation scheme plans were identified for the Upper Morass, which consisted of diverting water from the BR for irrigating a total net area of 3570 hectares (9266 acres), growing rice, sugarcane, bananas and vegetables. Diversion of water from the BR for agriculture has also been reported in the WRA Master Plan, 1990 for the Lower Morass for growing rice. However, at present no data is available on the amount of water abstracted for irrigation from the river systems. The latest information from communications with NIC and WRA on irrigation system in the BR basin showed presence of a few groundwater wells for irrigation in southern St. Elizabeth at Hounslow and the Pedro plains, which are operated by the National Irrigation Commission. These, however, are outside the areas of the Upper and Lower Morass and hence do not supply water for any agriculture in the Morass. Based on literature and information received from these institutions (WRA, NIC) it was noted that there is not much irrigable agriculture in the northern section of the basin or northern St Elizabeth where the rainfall is high.

The landuse map seen from Figure 3.17 created from the landuse data of 1998 as available from the Forestry Department of Jamaica's, identifies the different landuse types for the BR basin. The latest 2013 data was not available for this study hence the description of the landuse types and their spatial variation are based on the available 1998 data. It is seen in Table 3:3 and Figure 3.17 that the landuse type "fields" which includes herbaceous crops, cultivated vegetables are seen to occupy ~ 52% of the total land area followed by "disturbed broadleaf forest" . There are very few industrial/urban areas and majority of the agriculture is in the areas covered by the Upper and Lower Morass and southern St Elizabeth.

Table 3-3: Landuse types for the BR Basin

LANDUSE TYPE	AREA (HECTARES)	% OF THE TOTAL AREA
Bamboo and Fields and Secondary Forest	977.35	0.67%
Bare Rock	164.86	0.11%
Buildings and Other Infrastructures	1629.94	1.11%
Closed broadleaved forest (Primary Forest)	6783.96	4.62%
Disturbed broadleaved forest (Secondary Forest)	21961.12	14.97%
Herbaceous Wetland	7832.45	5.34%
Mangrove Forest	390.37	0.27%
Open dry forest - Tall (Woodland/Savanna/Shrubland/Bushland)	5253.92	3.58%
Plantation: Tree crops, shrub crops, sugar cane, banana	5581.01	3.80%
Swamp Forest	150.46	0.10%
Water Body	279.81	0.19%
Fields and Secondary Forest	9507.87	6.48%
Fields: Herbaceous crops, fallow, cultivated vegetables	76219.35	51.96%
Secondary Forest and Fields	9954.33	6.79%

(Source: http://www.forestry.gov.jm/?q=resources/maps-gis)

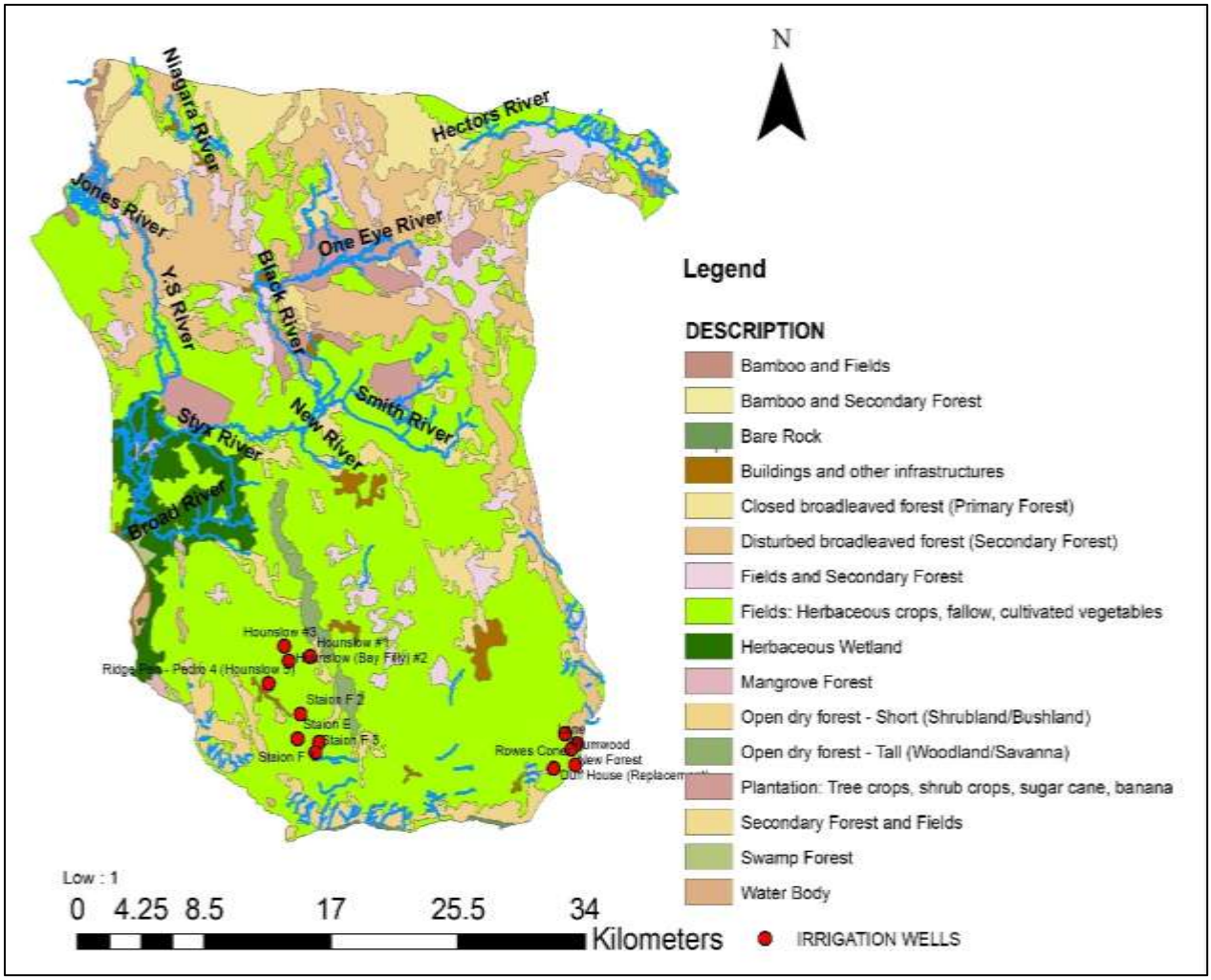


Figure 3:17- Landuse types for the BR basin

(Source: http://www.forestry.gov.jm/?q=resources/maps-gis)

Much of the agriculture is seen to be concentrated in the UM with a few in the LM near Slipe, Holland, Middle Quarters and areas near the mouth of the river. Agriculture in the Morass is believed to be rain fed but there is no reliable data available on the consumption of water per farms, hence a detail analysis of consumption and demand per farm was limited in this present study. **Data was not available on the amount of water abstracted from the river for agriculture both for the present and historical time series. Hence it was not possible to**

quantify at this stage the amount of water abstracted if at all from the river and if it has affected the flow /discharge capacity of the river.

3.6.1.1 Soils and Geology

The BR drainage basin is situated in south-central Jamaica on the southwestern part of the Clarendon Block and the extreme south-easterly part of the Montpelier-Newmarket Trough (Figure 3:18). The blocks and troughs are physical areas of Jamaica, largely separated by major faults with differing successions of White Limestone (late Eocene to early Miocene) age. A simplified geological map is shown in Figure 3:19.

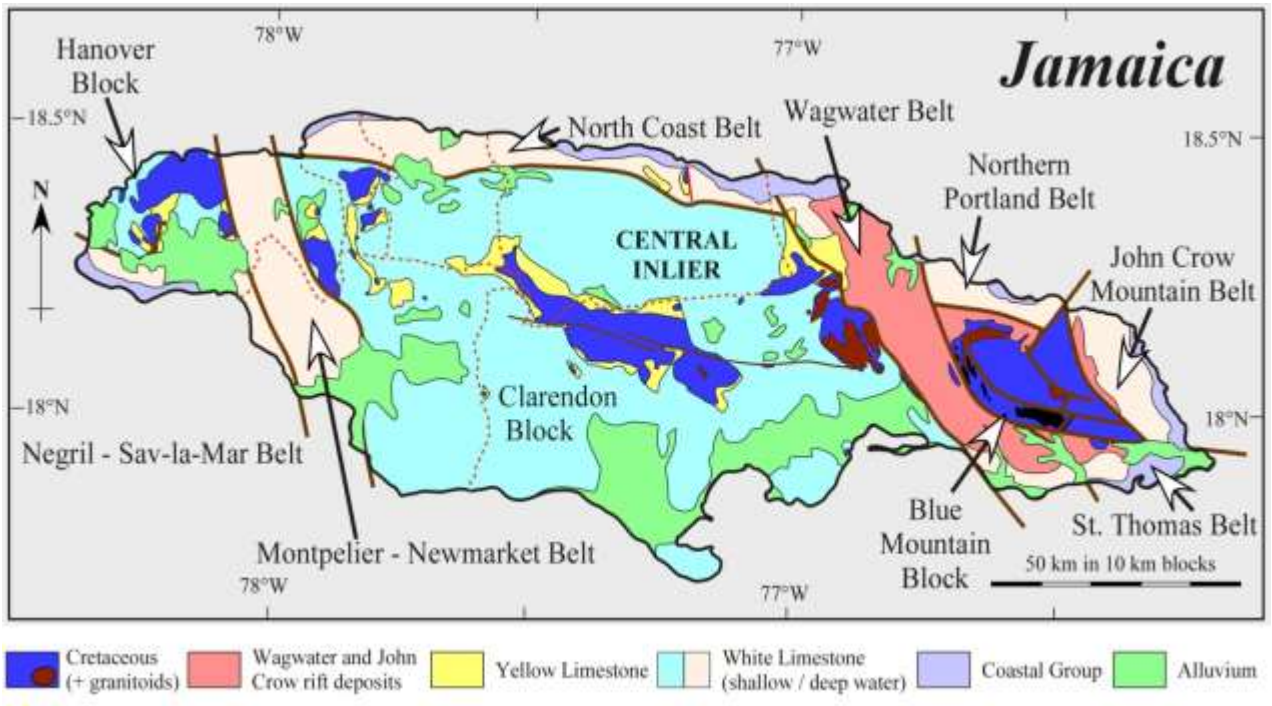


Figure 3:18- Blocks and troughs in Jamaica

Source: Mitchell, 2013

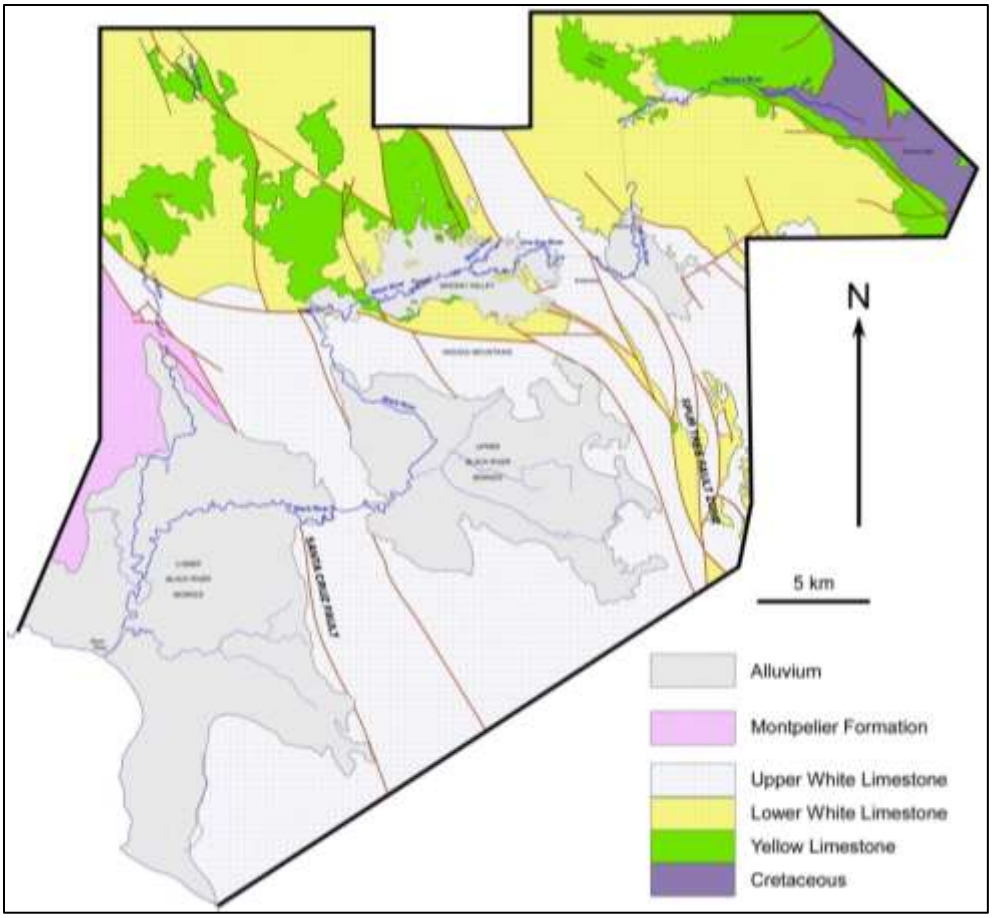


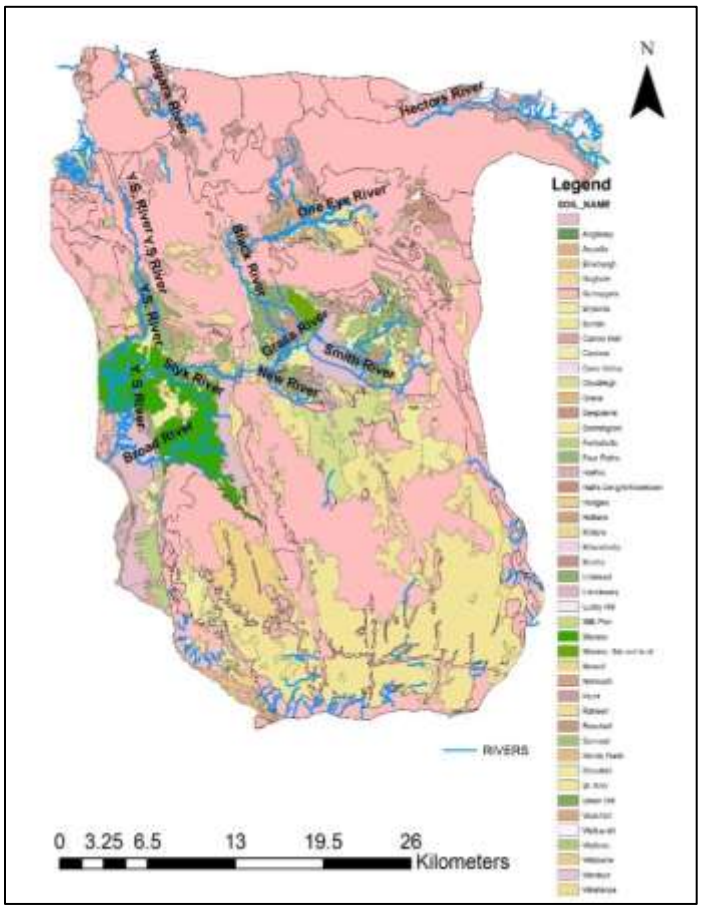
Figure 3:19- Simplified Geology of the BR drainage basin

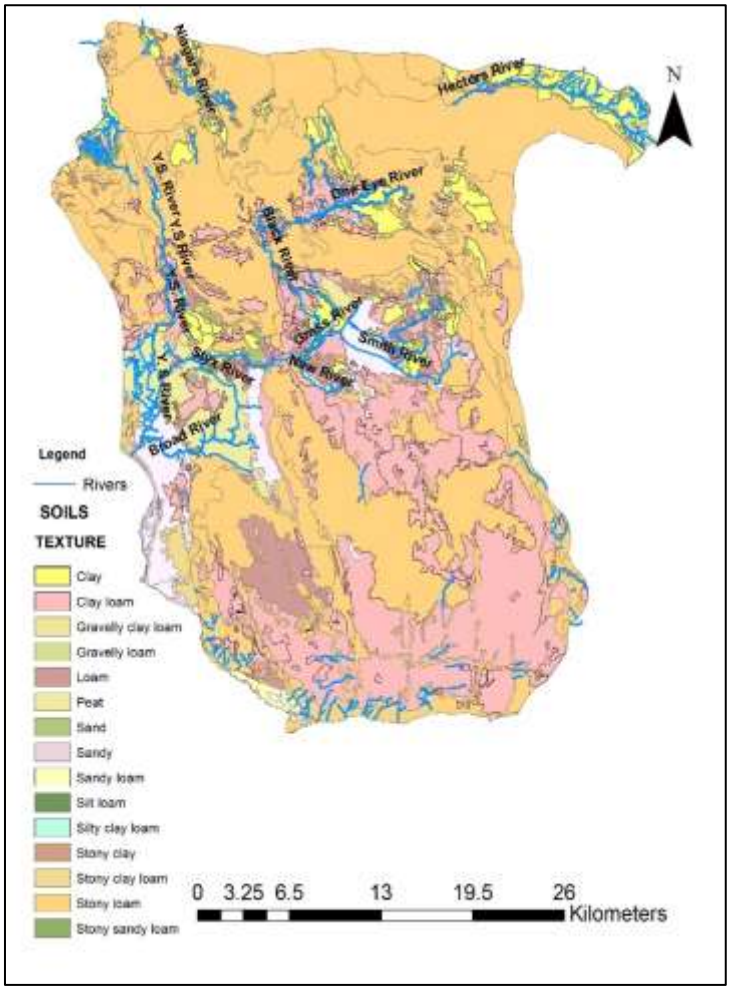
Source: Mitchell, 2016

The oldest rocks found within the BR drainage basin are of Cretaceous-Paleocene age. They occur within the Cretaceous inliers of the BR's tributaries in Trelawny, Manchester and St. Elizabeth. The largest area occurs around Hectors River (part of the Central Inlier) and consists of tuffaceous sandstones and conglomerates of the Maastrichtian-Paleocene Mahoe River Formation of the Summerfield Group (Mitchell and Blissett, 2001; Mitchell, 2003). Small inlers of Cretaceous rocks are also found near Aberdeen (volcanic conglomerates) and to the northwest in the Marchmont Inlier (Maastrichtian sandstones, shales and limestones).

The soil map for the BR basin is shown in Figures 3:20 (a-c). Figure 3:20 shows the different soil types as described by their names /terminologies based on the location and parent material. Figures 3:20 b) and c) shows the soil types classified based on texture and internal drainage or

maximum infiltration capacity. The soils developed over alluvium (Four Paths Loam, Brysons Clay loam, Cashew Clay Loam) are associated with old alluvial or colluvial deposits (Webber et al, 2010). The drainage in these areas as seen from Figure 3:20b seems to be very rapid (marked in yellow). Soils with very rapid drainage are seen to cover majority of the basin with exception of the areas of the Upper and Lower Morass. The soils developing on the limestone areas and the surrounding upland region are undifferentiated are in general Bonnygate Stony Loam and Clay Loam. As mentioned by Webber et al., 2010, the Bonnygate Stony Loam is a shallow, stony soil that develops on limestone slopes steeper than 20 degrees. Drainage is generally rapid, resulting in a poor moisture supplying capacity. The areas surrounding the Upper and Lower Morass are composed of both drained and soils with low internal drainage. Texturally these are composed of clay loam (Figure 3:20b), clay and peat soils. The presence of soils with low internal drainage near Lacovia, New River and the surrounding areas does indicate accumulation of surface water/ponding leading to flooding.





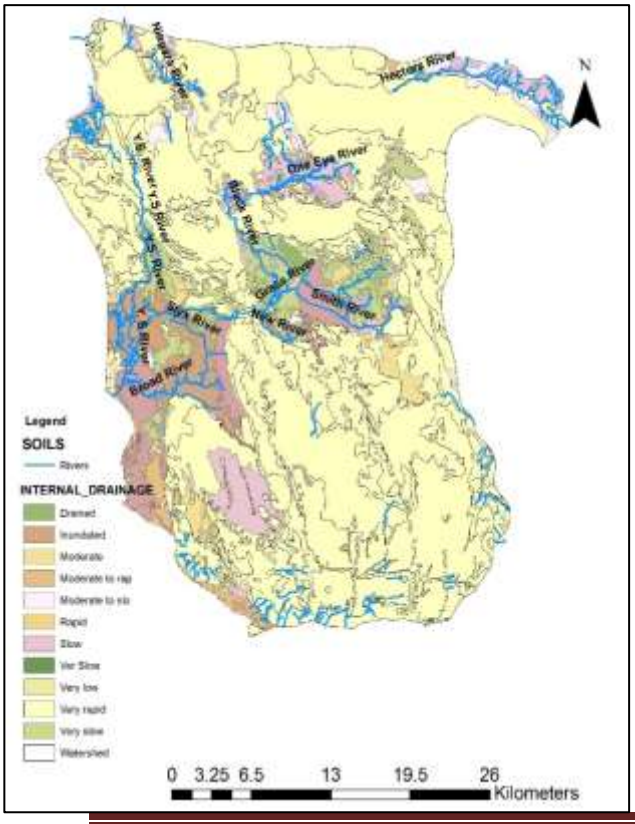


Figure 3:20 - Soil map of Black River basin showing the different soil types b) Soil map showing the different textures and c) Soil map classifying the soils based on internal drainage.

****Note when compared to the map showing flood prone areas, most of the flooding takes place in the Upper and Lower Morass, along the banks of the main channel (Black River) and its tributaries consisting of soils with low internal drainage and of clay and stony loam texture.**

3.6.1.2 Coastal Geomorphology

Much of the immediate coastline from Starve Gut Bay through Parottee Point and north into Black River Bay is characterised by a low-lying coastal plain, containing a 'barrier beach' system separating the sea from a coastal morass. The coastal geomorphology of the BR study area is characterised by an extensive area of morass wetland, which is low-lying and where the water table is close to or at sea level. Geomorphologically, the morass represents land that has been 'reclaimed' from the sea by mangrove vegetation acting as sediment traps. Both the BR Lower and Upper Morasses probably initially developed as a structurally controlled karst polje that formed during and after the Pliocene and early Pleistocene block-faulting event.

The Newport Formation under the morasses is poorly consolidated, sandy in parts and generally with a high argillaceous content (Wright 1971:56) and in the BR Lower Morass forms several outcrops in the central area of the depression, forming nine isolated 'limestone islands' in the wetland between the districts of Cataboo and Slipe. The limestone islands, which are weakly cemented, sandy and marly in texture and composition, are subject to deep solution weathering and show no apparent relationship to the present drainage pattern (Bertrand 1983). The islands were probably formed as a result of local uplift, where the buried karst surface becomes exposed, while the surrounding areas were subject to down faulting and inundation by sea-level-rise in the early Holocene.

The morass basins and particularly the BR LM consist of swamp deposits with thick alluvial clays and silt. The alluvial clays cover most of the floor of the BR LM resting directly on the underlying Newport Formation (Bertrand 1983). Peat covers almost all of the wetland areas and in the lower morass has a thickness varying between 5m to 12m. Grontmij (1964) suggests that during the early Pleistocene, the drainage in the morass may have been fully subterranean, but during the Holocene sea-level rise conditions favoured peat development and the formation of wetlands due to an increase in rainfall and water-table rise. The occurrence of subterranean drainage within the BR morasses in the Pleistocene is further supported by Wright (1971), who suggested that there may be as many as 18 sinkholes in the bed of the Broad River, most being no longer part of the modern hydrogeological system but perhaps older conduits for subterranean flow to the sea.

Along much of BR Bay, between the shoreline and the morass inland is a 'barrier-beach' system, which can become inundated during storm events and has been subject to coastal erosion for a number of years leading to the damage and destruction of many beach properties, particularly south of the town of BR and towards Parottee Point. In addition to this 'barrier-beach', the mangroves and swamps within the BR LM contain quite distinct beach ridges, particularly in the Parottee area. These ridges may have formed by a range of processes, including, storm wave run-up and longshore drift, while in the BR Bay some may have formed by wave winnowing of fine sediments.

Jamaica's largest freshwater pond, the Wallywash Great Pond, although not a coastal feature is found close to the coast in the Pondside area, located at an elevation of about 7m above present sea level and 3km from the coast. The maximum depth of the pond is about 5 m (Street-Perrott et al. 1991), the average depth being about 2.8m (4.2m above present sea level)

Palaeo-dunefields occur to the south of the BR Lower Morass and are particularly well-developed immediately landwards of the modern beach system between Starve Gut Bay and Parottee Point where they are up to 7m to 8m high. Occasionally they are re-activated on their seawards margins by strong onshore winds, while they are currently being mined for their siliciclastic sands.

Additional information on the Geomorphological features of the study area including Karst; Slope, and Fluvial geomorphology is presented in Appendix VII in great detail.

3.6.1.3 Water Holding Capacity and Supply

The BR Basin as mentioned earlier is one of the ten hydrological basins in Jamaica located in the southwestern section of the island. The hydrology of the basin is discussed with respect to the drainage basin analysis using the topography, soil and land use as well as with the analysis of the flow data for the BR and its tributaries. The hydrostratigraphy of the basin shows (Figure 3:21) the different rock types based on their water holding capacity i.e. as aquifers and aquicludes. The BR basin is dominantly composed of the Limestone aquifer which is predominantly found in the areas of the Upper and Lower Morasses hosting the shallow alluvium wells. Figure 3:21 also shows the presence of the basal aquiclude which are primarily the impermeable rocks of the

Cretaceous volcanics, tuffaceous sandstones and conglomerates as well as the rocks of the Yellow Limestone Group primarily seen as outcrops around the Hectors River, Niagara River and in the northern section of the basin. These are marked by location of surface water systems such as rapids, waterfalls and springs. Apart from this there are also surficial alluvium deposits which are found in the flood plain of the One Eye River and comprise the alluvium aquifer.

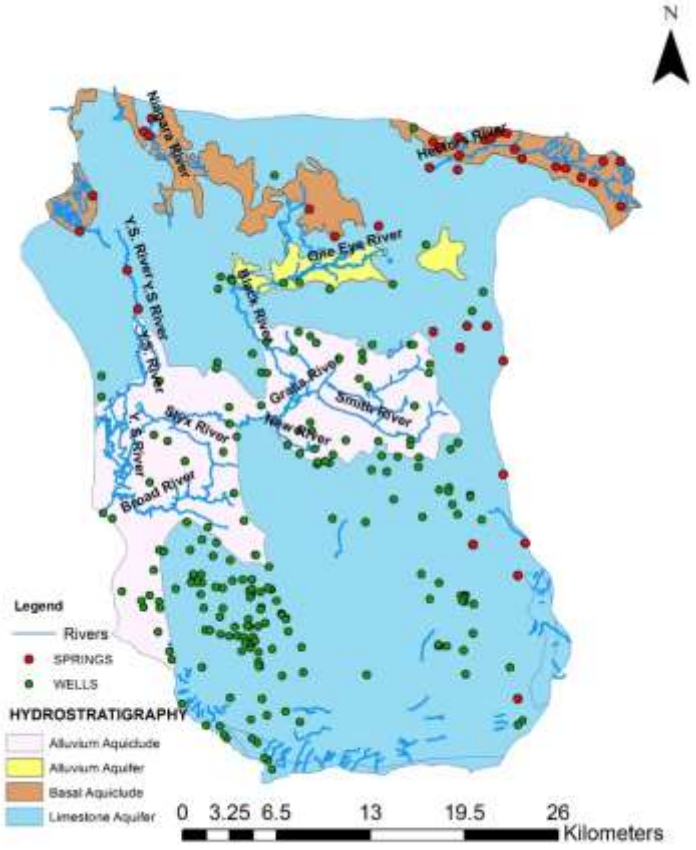


Figure 3:21- Hydrostratigraphic units of the BR Basin showing the location of the wells and springs

Source: WRA Jamaica

A brief demand and supply analysis has been done for the study area in comparison to the other basins of the island. The analysis is based on data achieved from Water Resources Authority Master Plan (1990) and the draft WRA Master Plan (2008). The demand distribution is based on location of irrigated lands, population distribution and water consuming industries. The main sectors of water consumption and demand in Jamaica are: Agriculture, Domestic, Industrial and Tourism. Table 3-4 outlines the water supply for the different sectors for the different basins in Jamaica. Agriculture is the dominant sector consuming the highest amount of water per year in most of the basins with exception of the Kingston and the Great River basin where maximum consumption is seen in the domestic sector.

The Black River basin ranks third in terms of consumption of water in the agriculture sector with minor consumption in the domestic and tourism sectors.

Table 3-4: Water Supply (MCM/yr) in the different basins for the different consumer sectors

Basin		Water Supply				
No.	Name	Agriculture	Domestic (Rural)	Domestic (Urban)	Industrial	Tourism
I	Blue Mountains South	12.2	1.1	1.7	1.0	0.0
2	Kingston	2.0	0.0	61.8	10.0	0.5
3	Rio Cobre	259.8	1.9	29.0	14.0	0.0
4	Rio Minho	329.0	7.6	12.5	19.0	0.1
5	Black River	31.5	2.8	2.5	1.0	0.2
6	Cabarita River	23.5	1.3	2.4	6.0	1.1
7	Great River	2.2	1.9	14.6	4.2	4.9
8	Martha Brae River	0.0	1.3	2.0	4.2	0.9
9	Dry Harbour Mountains	9.3	0.7	4.0	2.4	1.5
10	Blue Mountains North	12.0	2.6	8.0	0	0.9

Source :WRA Master Plan, 1990

The use/supply of water for different sectors is shown in figure 3:22 below which are based on the study conducted in 1997 by US Army Corps of Engineers on the Water Resource Assessment of Jamaica. The basin wise and sectorial analysis of water supply and demand shows that the major supply of water for the **BR** basin is obtained from underground water resources from the Limestone aquifer as opposed to the supply from surface water sources. It also ranks as the second largest basin in terms of supply of groundwater from the limestone aquifer. It is worth mentioning here that although the data below show a surplus of water supply in the BR basin where the irrigated agriculture demand is 24.30 MCM/yr and the non-agriculture is 27.77MCM/yr, the effects of drought are felt by the agricultural sector severely in this parish. This could be due to the fact that most of the agricultural areas in the southern areas of the basin St Elizabeth experience low rainfall.

Basin	Supply				Demands				Surplus or Deficit	Import
	Surface Water[1]	Ground Water		Total	Non-Agricultural	Agricultural	Export	Total		
		Limestone Aquifer	Alluvial Aquifer							
Blue Mountain South	101.80	18.60	44.30	164.70	9.88	21.05	26.50	57.43	107.27	0.00
Kingston	10.20	15.30	20.90	46.40	89.90	0.00	0.00	89.90	-43.50	67.00
Rio Cobre	11.40	378.40	25.40	415.20	49.94	314.41	32.50	396.85	18.35	0.10
Rio Minho	26.70	361.00	78.00	465.70	42.00	260.45	8.30	310.75	154.95	9.00
Black River	48.90	624.60	--	673.50	27.77	24.30	8.30	60.37	613.13	1.2
Cabarita River	0.00	451.00	--	451.00	15.22	6.61	3.95	25.78	425.22	0.00
Great River	58.60	315.60	5.50	379.70	20.96	0.26	0.15	21.37	358.33	9.90
Martha Brae River	19.70	150.60	--	170.30	9.32	11.06	10.30	30.68	139.62	0.20
Dry Harbour Mountain	27.60	691.00	--	718.6	15.55	1.18	1.80	18.53	700.07	0.40
Blue Mountain North	333.00	270.20	7.30	610.50	12.27	5.26	28.10	45.65	564.85	1.10
Total	**637.90**	**3276.30**	**181.40**	**4,095.60**	**292.81**	**644.60**	**119.90**	**1,057.31**	**3,038.29**	**88.9**

[1]The value in the surface water column is the reliable yield, which is the amount of water expected 90 percent of the time.

Note:
Supply minus demands; positive means surplus, and negative means deficit. "Supply" means the available water resources including reliable yields of streams and safe yields of various aquifers.
Dash indicates information is not available or is not applicable.

Source:
Harza Engineering Company International L.P., Annex A-Water Resources, *Preparation of a National Irrigation Development Plan and Preparation of an Irrigation Investment Project, Master Plan*, Vol. 2, Kingston, October 1997.

Figure 3:22: Average water demand and supply per hydrological basin (Mm3/yr) for Jamaica

Source: WRA, Jamaica

Flow Analysis of the BR and its tributaries from the Streamflow Data from gauging stations

The BR is monitored for daily streamflow measurements at three stations: Appleton, Newton and Lacovia. The Y.S River is monitored at Middle Quarters for daily flow recordings. Figure 3:23 shows the locations of the different streamflow gauging stations for the BR basin. WRA is in charge of monitoring all three stations. The entire 60 years of daily flow from 1955-2015 for

Black River at Appleton and Y.S River at Middle Quarters as well as 52 years of daily flow from 1963-2015 for Black River at Newton and Lacovia was downloaded from the WRA Webmap and used in the present study. The flow data for all the stations were analysed to show the variation in mean annual flow, mean monthly variation for each decadal cycle as well as Flow Duration Curves and the different flow indices such as Q95, Q90, Q50, Q75, Q10 and Q5 which are used for different flow conditions and for estimating yields for agriculture, domestic supply.

The mean daily flow were also plotted to show the daily time series and estimate the average baseflow in the river. **Baseflow** (also called drought flow, groundwater recession flow, low flow, low-water flow, low-water discharge and sustained or fair-weather runoff) is the portion of streamflow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow. It is the minimum flow which is sustained in the river during low flow season and contributes to long term sustainability of the river system. Extreme flows or high flows are event based for example for the tropics it is related to extreme rainfall from tropical storms, hurricanes, troughs or fronts. These are not the average flow and although they contribute to the storage capacity of the river they are not consistent over time. The average annual time series for the Black River at Appleton, Lacovia and Newton and for the Y.S River at Middle Quarters are shown in Figure 3:24 (a-d) below.

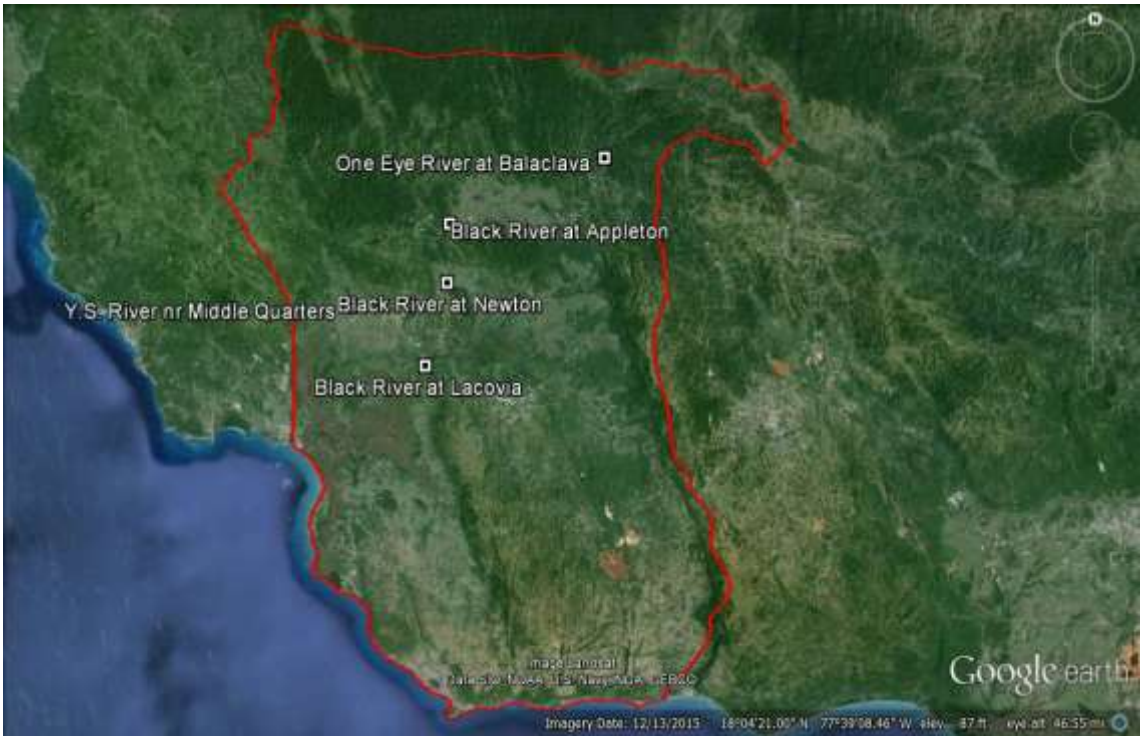
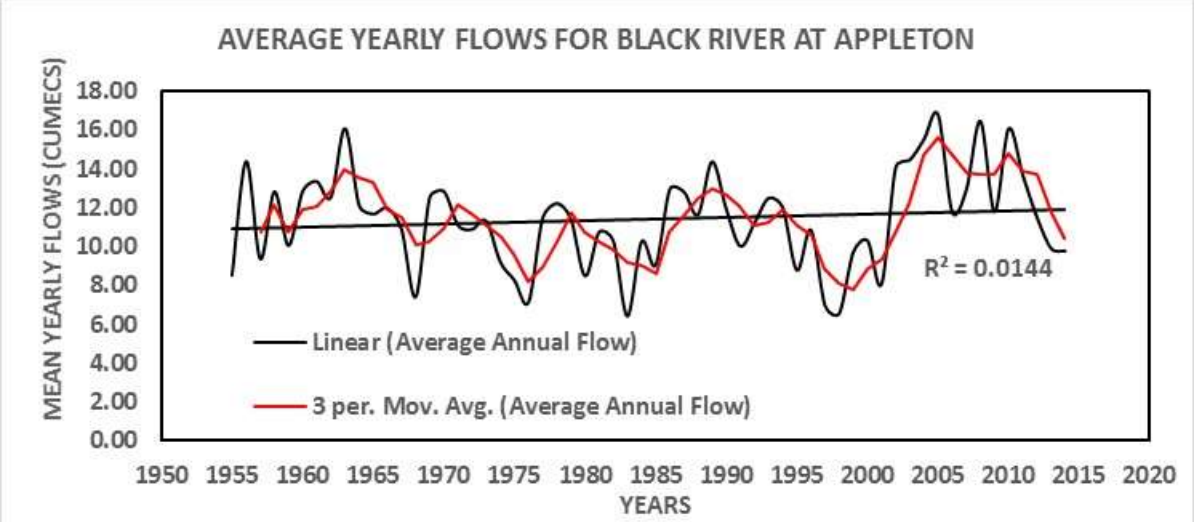
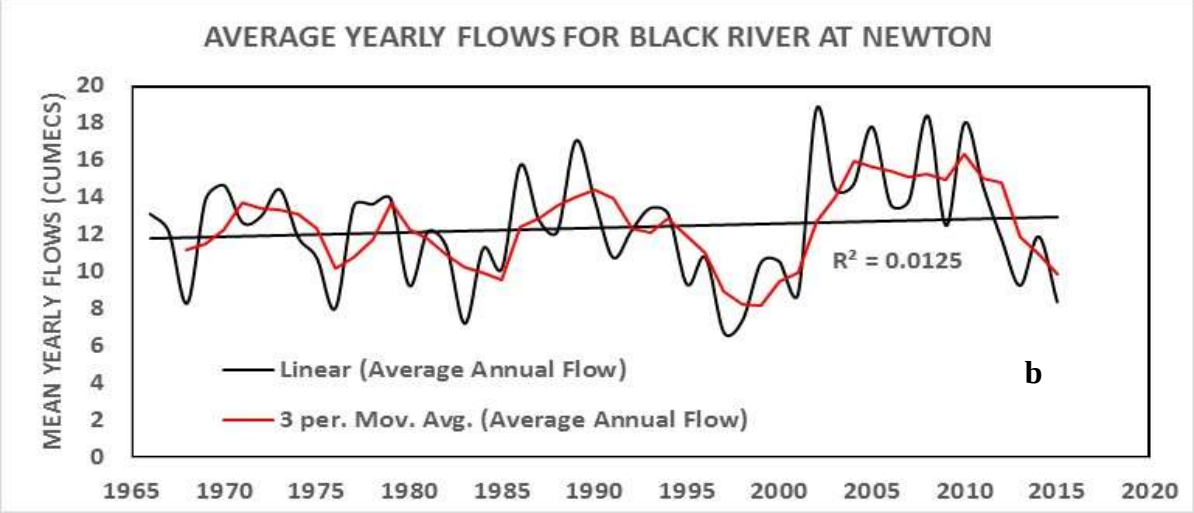
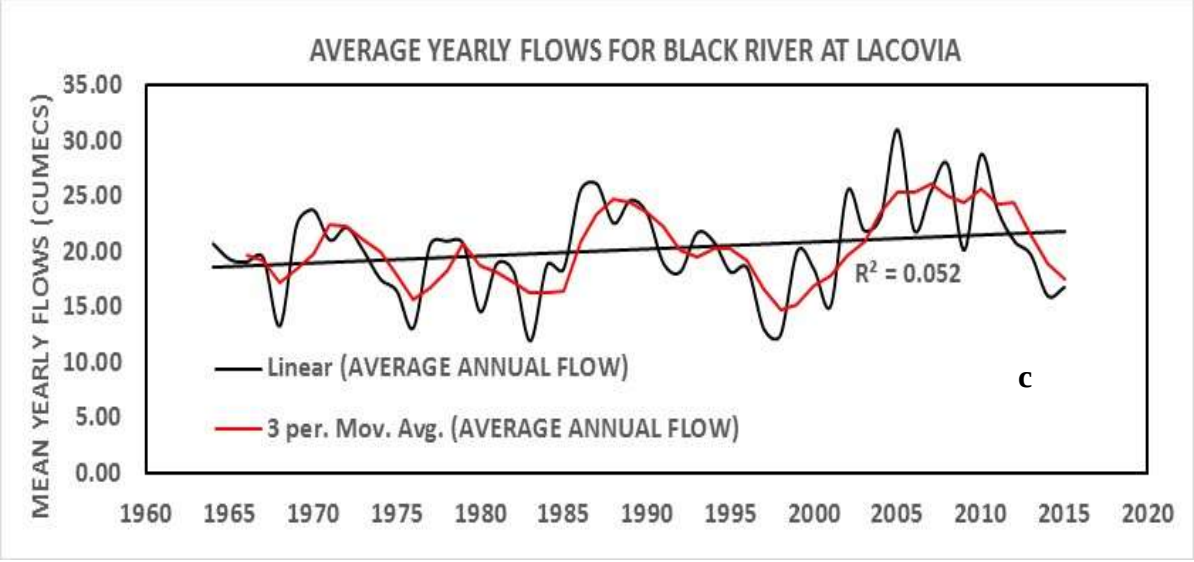


Figure 3:23-The different stream gauge stations for BR and its tributaries

Source: Google, 2014


AVERAGE YEARLY FLOWS FOR BLACK RIVER AT APPLETON
MEAN YEARLY FLOWS (CUMECS)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
YEARS
R² = 0.0144
Linear (Average Annual Flow)
3 per. Mov. Avg. (Average Annual Flow)


AVERAGE YEARLY FLOWS FOR BLACK RIVER AT NEWTON
MEAN YEARLY FLOWS (CUMECS)
20
18
16
14
12
10
8
6
4
2
0
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
R² = 0.0125
Linear (Average Annual Flow)
3 per. Mov. Avg. (Average Annual Flow)
b


AVERAGE YEARLY FLOWS FOR BLACK RIVER AT LACOVIA
MEAN YEARLY FLOWS (CUMECS)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
R² = 0.052
Linear (AVERAGE ANNUAL FLOW)
3 per. Mov. Avg. (AVERAGE ANNUAL FLOW)
c

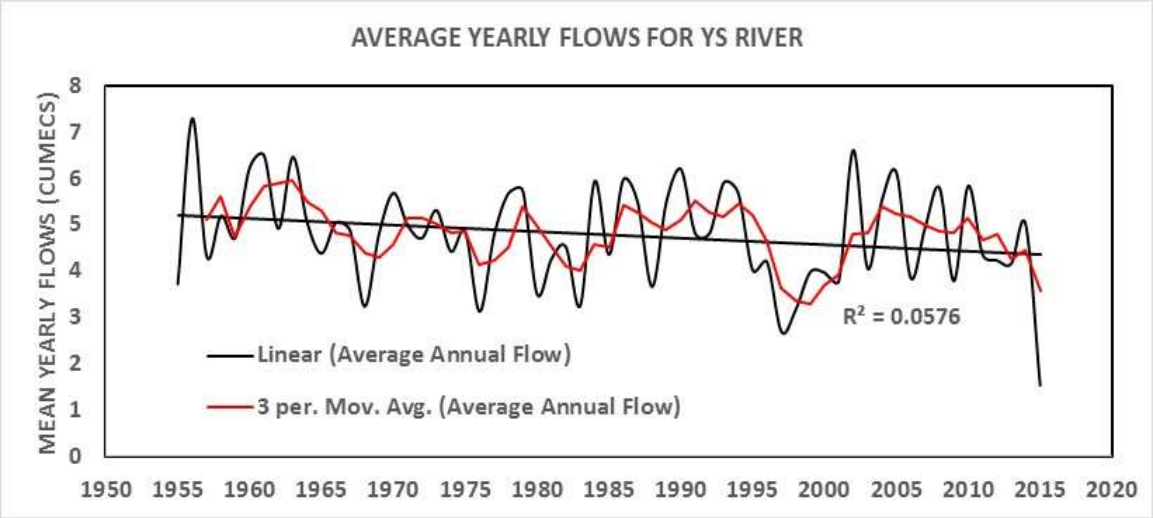


Figure 3:24 (a-d): Average Annual Flow for BR, Appleton, Newton, Lacovia and for Y.S. River at Middle Quarters

The average annual flow for the BR for all the stations as well as for the Y.S River show a weak increasing trend for the flows recorded at Appleton, Newton and Lacovia followed by a weak declining trend for the Y.S River. Alternating high and low flow values are seen to be present for all the stations which could be associated with corresponding high and low rainfall values. Flow values are maximum for the station at Lacovia where a maximum yearly average of 35 cumecs was recorded for the year 2005. Corresponding values for the similar year were 18cumecs for Newton and 17 cumecs for the station at Appleton. Flow values are lower for the Y.S River as compared to the Black River. The higher discharge values for the station at Lacovia agrees with the drainage network as delineated from the Digital Elevation Model where the flows from the Black River at Appleton and its tributaries join with the tributaries draining through the Upper Morass (New River and Smith River). Hence the flow at Lacovia is a combination of all the flows from all the channels upstream. The three year moving average for all the stations show an overall steep declining trend from 1995 which was followed by a period of higher flow from 2003- 2009 followed by a declining trend for the years 2010-2015. This could be due to the impact of drought in 2013, 2014 and 2015 which caused lowering of the mean daily flow. Further analysis is needed to correlate with rainfall values for corresponding years to validate the above assumption.

Flow Duration Curve and the different flow indices for BR and its tributaries

Hydrological analysis of river discharges often needs analysis of different low flow indices which are also referred to as measuring environmental flow. Environmental flow is referred as the minimum flow that is required in the rivers to maintain ecological balance and existence of habitats in river. There are different methods of measuring the environmental flow. One of the common method is the hydrological method where the flows for different probability of exceedances are measured. These are Q90, Q95, Q50 which implies flow which exceeds 95%, 90 and 50% of the time. The other common types of flow indices are the 7Q2, 7Q5, 7Q10 of which 7Q10 is the most commonly used low flow index. It has been widely used in the United States from 1974 as and an index to measure stream contamination based on the minimum flow for a continuous 7 day period for a recurrence interval of 10 years (Singh, 1974).). It has also been used to license abstraction of water from river systems based on the value for different abstraction purposes. Communication with WRA, Jamaica indicates that WRA grants licenses to authorities for abstraction of water from surface water systems if, the 7day minimum flow as well as a few other flow indices (Q90, Q95) are used to calculate the exploitable yield. The Development of a National Water Sector Adaptation Strategy to address climate change in Jamaica (2009) also refers to the flow indices Q90 which is used for calculation of reliable river yield. The report refers River Safe Yield = Q90 low flow, which is the flow that occurs 90% of the time. Hence it is important to understand the different low flow indices for the Black River and its tributaries, its variation at different locations and if there has been any variation of the low flow with time. In the present study the 7 day low flow values were obtained from WRA for the three gauging stations of the Black River (Appleton, Lacovia and Newton) and the flow duration curves for the 7day low flow was determined.

The flow duration curves for the daily discharge for the Black River at the three locations, Y.S River at Middle Quarters and the 7 day low flow values are shown in Appendix VIII.

The mean 7 day low flow for the Black River at Appleton, Lacovia and Newton are 3.59, 8.57 and 3.50 respectively. As discussed before the highest flow values are seen for Lacovia as compared to the other stations due to its location with respect to the drainage network with combined inflows from Newton and Appleton section as well as drainage from the Upper

Morass. The flow duration curves for the 7day low flow show a gentle flat slope for all the stations with the Lacovia station having the gentlest slope as compared to the rest. There flow duration curves are however not very smooth as compared to those created from the average daily flows. This could be due to the time period chosen (4months in each year) where discharges could be erratic due to low rainfall and less recharge. Overall the pattern remains the same for all the gauging stations.

The mean daily flow for the BR and its tributaries also shows the station at Lacovia recording higher discharge than the rest of the stations. The flow duration curves for all the stations show a smooth gentle curve implying gentle topography, less rapid surface runoff and less affected by fluctuations in rainfall and more sustained flow from underground sources. This has been explained earlier and also evident from the location of the stations with respect to the topography, geology, soil type. The Q90 values which imply low flow /baseflow index as well as the Q95 which is more reliable for domestic yield shows a higher value for the Lacovia station as compared to the rest due to combined inflows from upstream. The flows at 10 and 5 percentile of exceedance which would indicate high flows or flows exceeded 5% -10% of the time are often used for estimating flood events. Discussions on flooding in the BR shows areas near Lacovia prone to flooding which can also be evidence by the higher rate of discharge for the BR at Lacovia for 5 and 10% probability of exceedance.

The BR has also been noted for abstraction of water for various industrial and agricultural practices. The commonly used abstraction as observed from field and records from WRA, Jamaica are as follows:

a) JPS Hydro Dam at Magotty: has a license to abstract 553,493.70 cubic metres per day from the Black River for hydropower purposes. This is non-consumptive usage; the water is returned to the river after diversion
b) Appleton Estate has a license to abstract and use 53,420 cubic metres per day from the Black River for industrial/cooling purposes.
c) Aquaculture Jamaica at Barton Isle: had a license to abstract 604,800 cubic metres per day from the Black River for aquaculture purposes. According to WRA, Jamaica this

license has expired but recent field visits have shown that the abstraction is still continuing.

d) Additional minor abstractions: Barkeith Ltd was granted 55 cubic metres per day for irrigation (never used), Mark Lee was granted 630 cubic metres per day for a water park which is not currently operational, and Dean Powell was granted 75 cubic metres for bottling (never used).

Figure 3:25 shows the locations of the different abstractions in the Black River. Apart from this there are some tourism activities in and around the Upper and Lower Morass. These include the Apple Valley Farm, Bubbling Spring, Y.S Falls, Cashew Park, Goshen Sports Club and the Black River safari. However there is no data on the amount of water if at all used from the river for these activities. The Bubbling Spring is mainly underground water which is coming from the limestone and is a continuous inflow and outflow from a pool which is used for bathing. There is not net use of the river water. As noted earlier there is no record of water used for irrigation in the Upper and Lower Morass currently from WRA. Hence, it cannot be quantified if water is abstracted from the river for any irrigation uses.

It must be mentioned however, that based on the information received from the Rural Agricultural Development Authority, water is actually being abstracted for irrigation purposes (for farms) but the amount taken from the river is not documented or communicated to WRA.

Further studies will have to be done to determine the level and extent of abstraction from other users in the study area such as farmers based on type of crop, land space, etc.

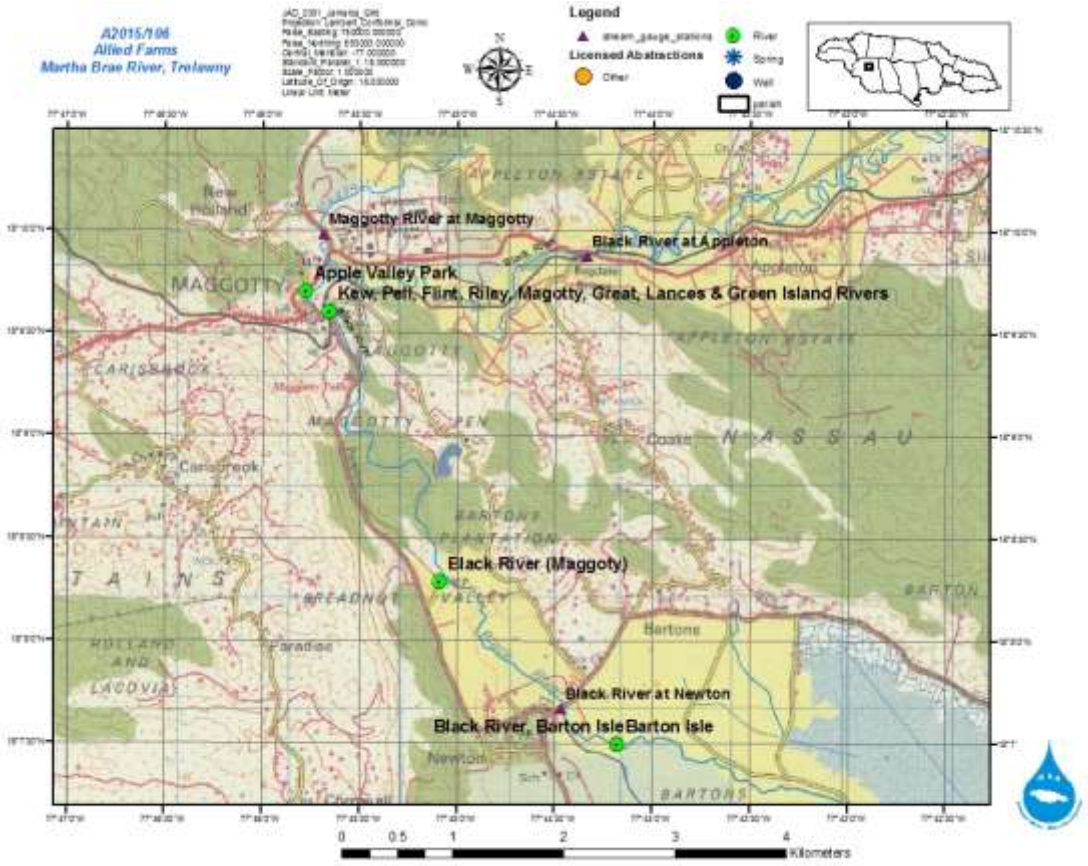


Figure 3:25- Stream gauge stations and the areas of abstraction from the BR

Based on a lack of information, an attempt was made to analyze the data obtained from WRA, Jamaica on the abstraction at Barton Isle, Aquaculture and Hydro dam at Maggotty. The data that was available was for a very short period (2007-2014) for Barton Isle (monthly totals) and from 2012-2014 for the Maggotty hydro dam (yearly totals available). The data plots for the abstraction for the above mentioned sites are presented in Appendix IX with further analysis.

3.6.2 Water quality

The results indicate that there is a general absence of contaminants in the samples collected at the identified points along the course of the Black River.

TDS and Conductivity were high and above the noted standard. This is due primarily to the proximity of the sampling points on the BR to the sea as the value of both these parameters

significantly decreases with distance from the river's mouth. There was also a noted decrease in the values of these parameters for samples collected in November (Figure 3:26).

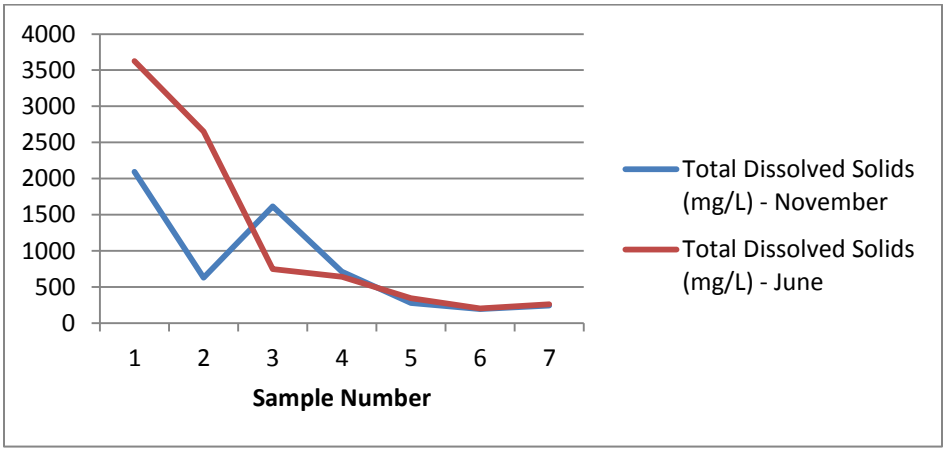


Figure 3:26- Variation in TDS over two sampling periods: June (dry period) and November (wet season)

Sulfate and chloride were concomitantly high as expected based on the TDS values and may be attributable to the weathering of the underlying limestone rock formation that is prevalent throughout that region as well as contributions from the mixing of sea water closer to the estuarine region, where these concentrations are highest. The concentrations of these parameters follow a similar trend to the TDS and Conductivity (Figures 3:27-3:30).

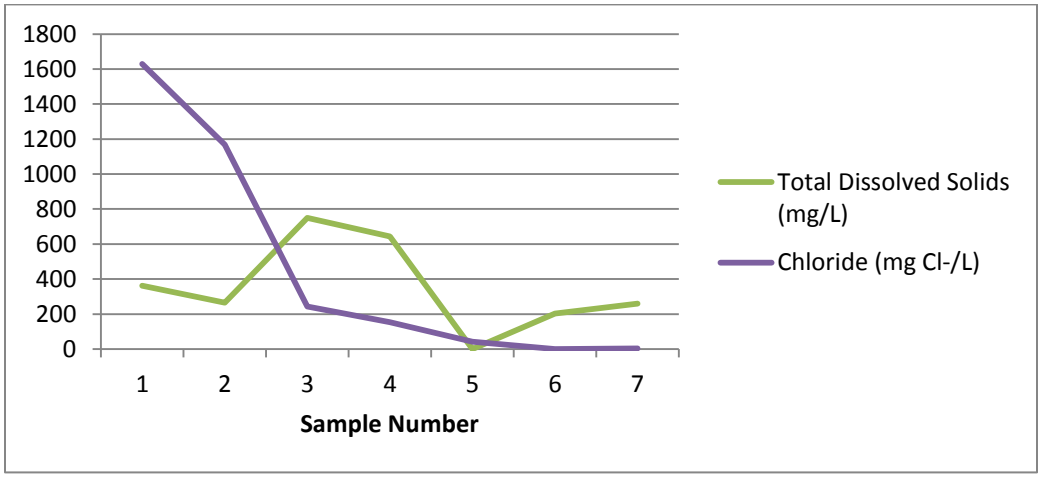


Figure 3:27- Distribution of Chloride and TDS along the course of the BR (June)

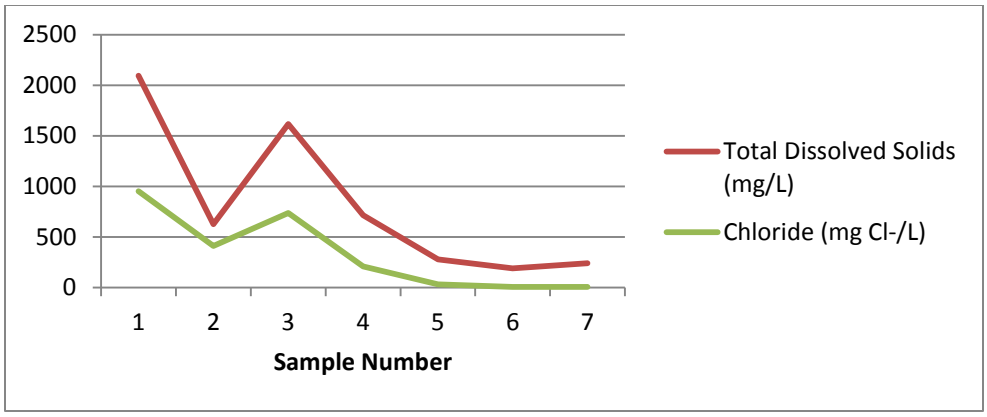


Figure 3:28- Distribution of Chloride and TDS along the course of the BR (November)

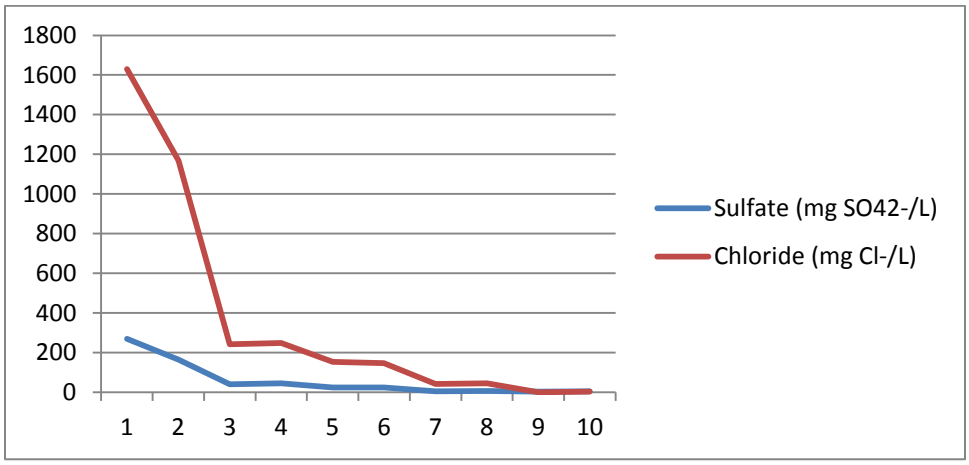


Figure 3:29- Distribution of Chloride and Sulfate along the course of the BR (June)

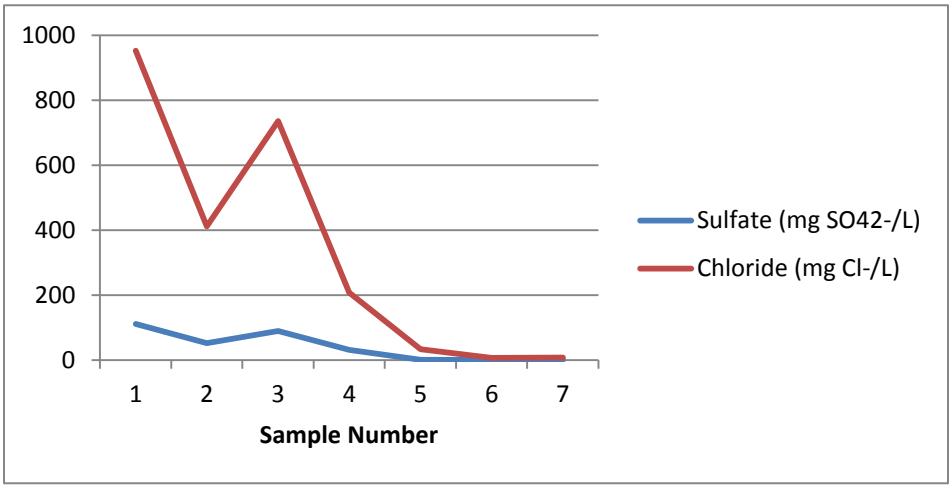


Figure 3:30- Distribution of Chloride and Sulfate along the course of the BR (November)

TSS was anomalous in that at the time of sampling, there was heavy rainfall upstream of the sampling site (at YS River at the stream gauge station and BR at Lacovia). This rainfall resulted in an increase in a higher flow rate and hence increased turbulence of the river which caused and unsettling of sediments which showed up as TSS (Figures 3:31-3:32)

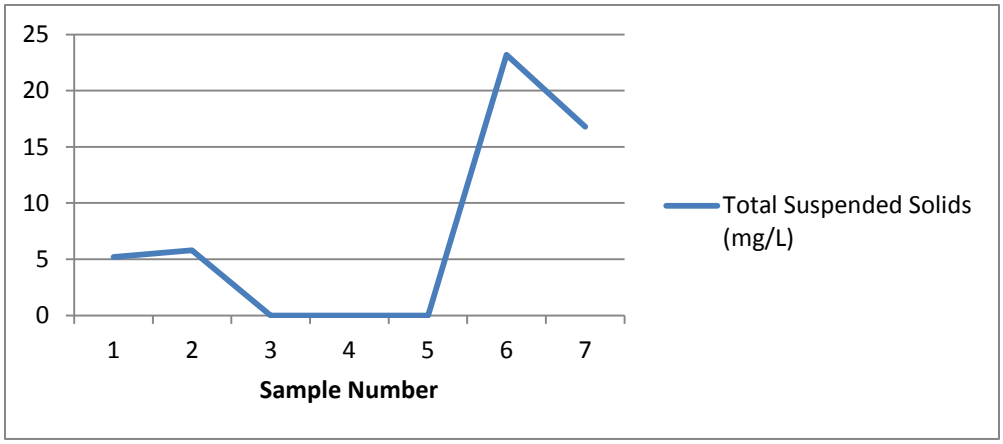


Figure 3:31- Distribution of TSS along the course of BR (June)

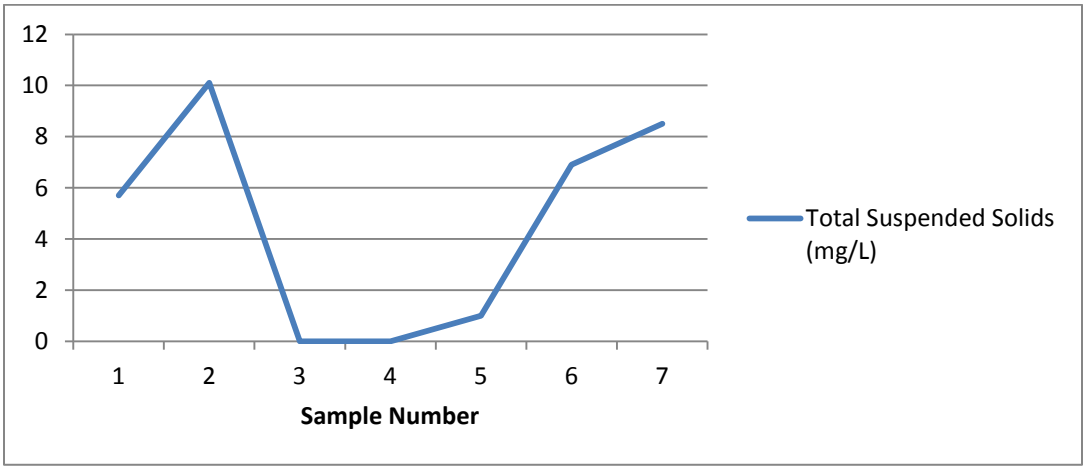


Figure 3:32- Distribution of TSS along the course of the BR (November)

COD and BOD values were highest for samples collected inland on the BR (Figures 3:33-3:34). These values are due mostly to decaying vegetation. The darkness of the black river is due to the thick layers of decomposing vegetation that has lined the river bed. Similarly so, the organics as

estimated by COD and BOD are influenced by the decomposition of vegetation.

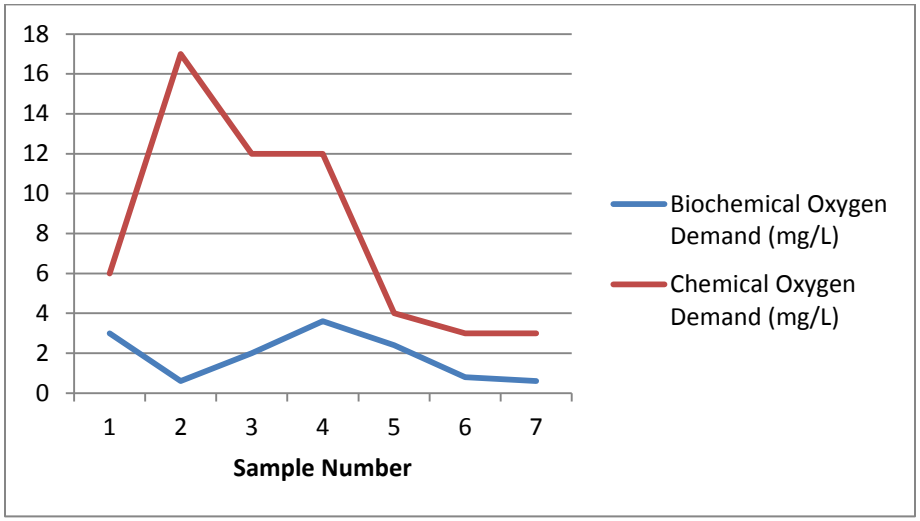


Figure 3:33- Distribution of BOD and COD along the course of BR (June)

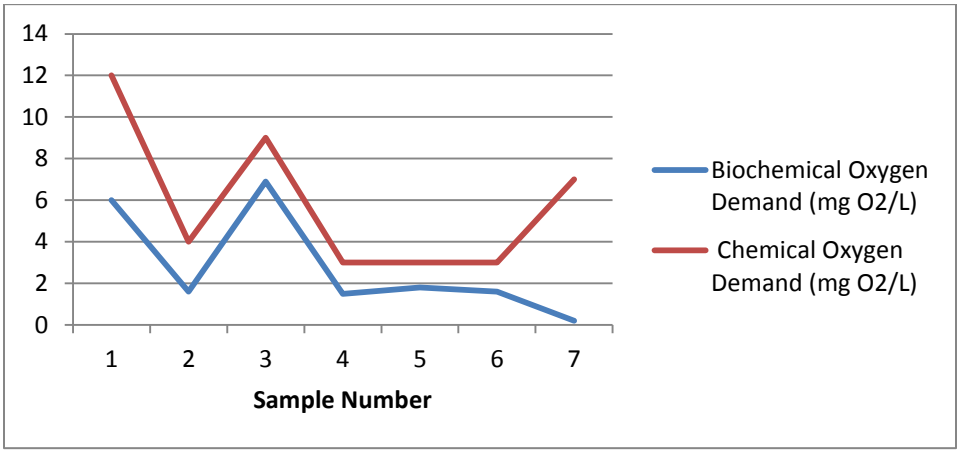


Figure 3:34- Distribution of BOD and COD along the course of the BR (November)

There is an increase in the levels of coliform bacteria moving towards the more densely populated areas (Samples 6 and 7) (Figures 3:35-3:36) with high occurrences of human use. The presence of faecal coliform indicates recent faecal contamination. STATIN reports that only 37% of households in the parish of St. Elizabeth use pit latrines and a 3% has no toilet facilities. Even though 57% of the households in the parish use water closet, this number may not represent all the households connected to central sewerage system. Lack of a proper sewer network can cause a proliferation of coliform organisms in the environment and this can be further compounded if

there is a prevalence of livestock farming, as these can only survive in the intestines of warm blooded mammals.

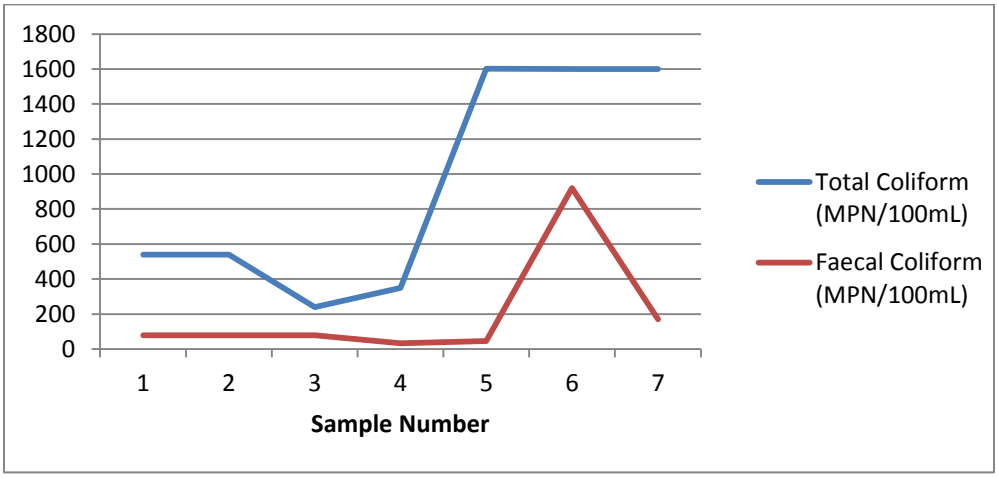


Figure 3:35- Distribution of Coliform Microorganisms along the course of the BR (June)

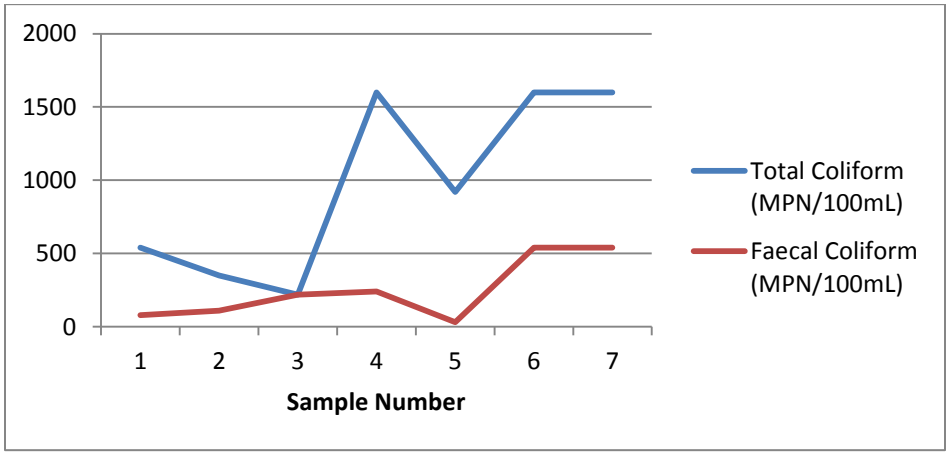


Figure 3:36- Distribution of Coliform Microorganisms along the course of the BR (November)

Metals as well as Oil and Grease are usually not regulated in surface waters. Nonetheless, there was an absence of oil and grease which also indicates an absence of pollution. Organics do not occur naturally in high concentrations in surface waters and so there absence is an indication of a water body being in good condition. The only metal that was detected at all locations was iron and this is expected due to the underlying geology of the river.

Due to the fact that the riparian zones of the black river are only sparsely populated and dependence of the black river is minimal (less than 1% of the population in the parish depends

on rivers for domestic water), the dilution effect of the river would be significant and would facilitate various pollutants being washed downstream and not allow for their accumulation in any particular place/site. The dilution power of the river is further augmented by rainfall, as seen in the lower values obtained for samples collected in the rainy period.

As the use of this water resource increases there should be a concomitant increase in the frequency and rigor of monitoring so as to maintain the health of the riverine environment.

The technical analysis and results obtained from the water sampling are provided in Appendix X.

3.6.3 Indicators

Based on the Physical setting, the following parameters were identified as key indicators.

Table 3-5 outlines the current status of the description

1. Daily Mean Flow
2. Average Yearly Flow
3. Mean Monthly Flow
4. Flow Duration Curves
5. 7 Day Low Flow
6. Q90 flow (flow that exceeds 90% of the time)
7. Parameters are within the water quality standards (NEPA)

Table 3-5: Indicator and Physical Assessment

Indicator	Description of Status	Direction (Positive, Negative, Stable)
Hydrology		
Daily Mean Flow	Shows a weak increasing trend. 30 day moving average shows decadal high and low values.	Average daily flow for all stations stable
Average Yearly Flow	Weak increasing trend. Fluctuations in yearly values could be due to variation in rainfall and recharge	Stable
Mean Monthly Flow	Seasonal variation, high during wet months (Sep-Nov) and low during the dry season.	Stable
Flow Duration Curves	Shows the flows for different probability of exceedance.	Smooth flat gentle slope , stable over the 50-60 yr record
7day low flow	Varies corresponding to years of drought	Stable
Q90 flow (flow that exceeds 90% of the time)	Low flow or baseflow, consistent with variation in average yearly flow. No decline corresponding to the years for which abstraction data available.	Stable
Water Quality		
Parameters are within ambient standards of NEPA	General water quality is within general standards with few irregularities. Key paramters include: nitrates, phosphates, fecal coliform, TDS, TSS	Stable

3.7 Socioeconomic

3.7.1 Demographics

The Black River Drainage Basin as defined in earlier chapters represents much of the Parish of St. Elizabeth in addition to a small section of southern Trelawny. As such, demographics for the BR drainage basin utilised the St. Elizabeth parish figures from the most recent population census in 2011 as a best fit for the project area.

The population of St. Elizabeth is 150,205 according to the 2011 census with 149,153 living in private dwellings and 1,046 living in non-private dwellings (STATIN, 2014). The parish had a 2.60% (3,801 persons) increase in the population since 2001. The population is approximately 51% (76,530) male and 49% (73,675) females and is fairly youthful as 53% of persons are less than age 30 (See Figure 3.37). The urban population is 22,585, which represents 15% of the total population. Much of the parish population resides in the rural areas.

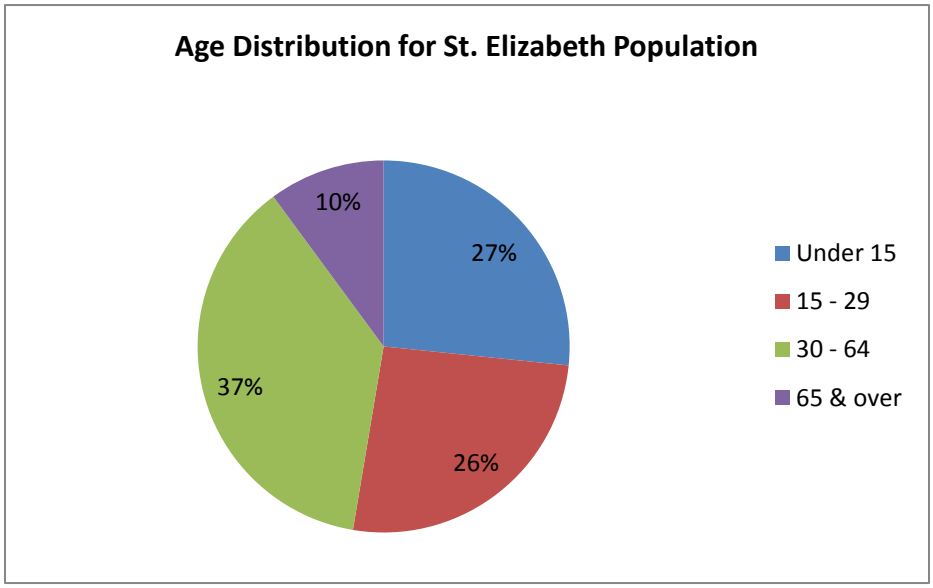


Figure 3:37: Age Distribution for St. Elizabeth Population

(Source: STATIN, 2014)

St. Elizabeth has a total of 48,067 dwelling units and 49,388 households both with an average of 15.5% located in urban areas and 84.5% located in rural areas. The total number of dwelling

units has increased from 40,701 in 2001 to 48,067 in 2011 (STATIN, 2014). The parish has an increasing rate of housing development, which is expected to continue to increase. Table 3-5 below shows the total number of dwelling units in special town areas of St. Elizabeth.

Table 3-6: Number of Dwellings, Special Areas of St. Elizabeth

Special Areas of St. Elizabeth	Number of Dwellings
Black River	1,788
Santa Cruz	3,071
Balaclava	898
Junction	1,690
Maggotty	599
Lacovia	1,301
New Market	787
Bull Savanna	1,117
Nain	1,018
Mountainside	566
Southfield	1,144
Newell	635
Malvern	788
Siloah	865

Special Areas of St. Elizabeth	Number of Dwellings
Rest of Parish	31,804

(Source: STATIN, 2014)

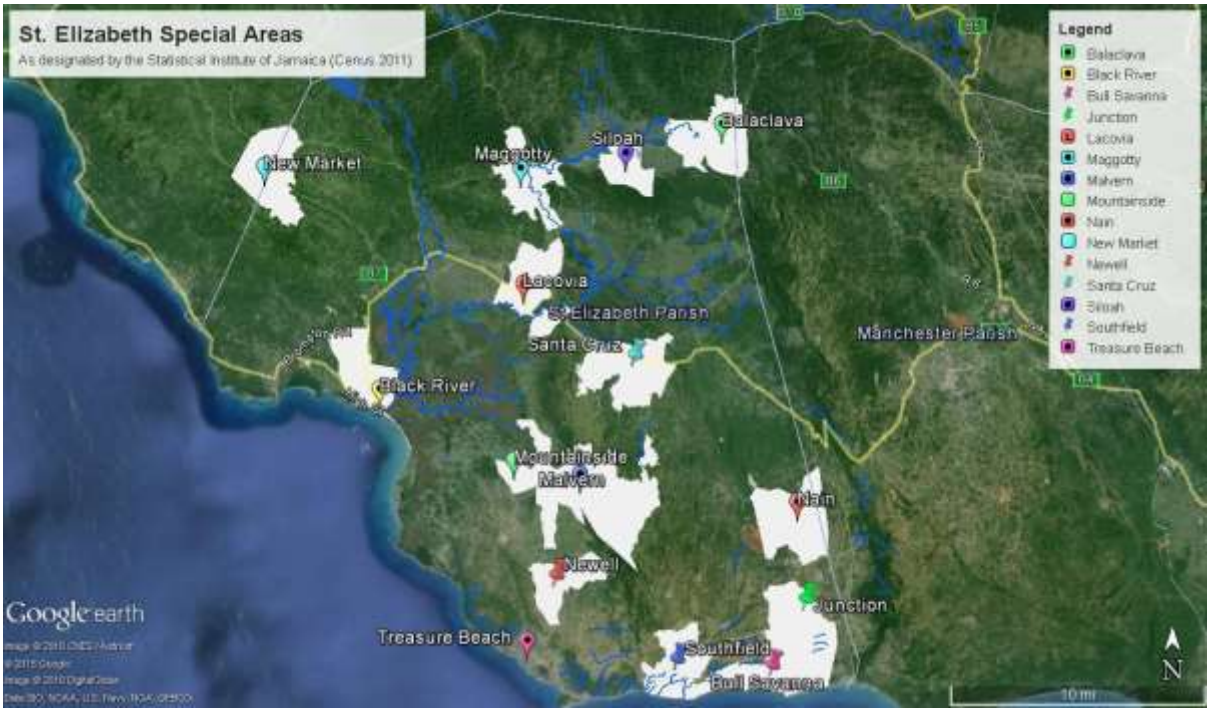


Figure 3:38: Location of Special Areas in St. Elizabeth

Source: Google, 2016

Based on Figure 3:38 above, the Special Town Areas that are key to the BR drainage basin include: Black River, Lacovia, Maggotty, Siloah, and Balaclava, which together has a total of 5,451 dwellings. A point of note is also Balaclava, Siloah and Maggotty and Lavovia are situated in the Upper Morass and are significant areas for both crop and animal farming. Additionally, large acres of sugar cane production predominate in the area.

3.7.1.1 Garbage Disposal

Figure 3:39 below illustrates the method of garbage disposal for all the households in St. Elizabeth. While 50% of the population benefit from regular garbage collection, 43% burn their garbage because of the absence of available a formal collection system.

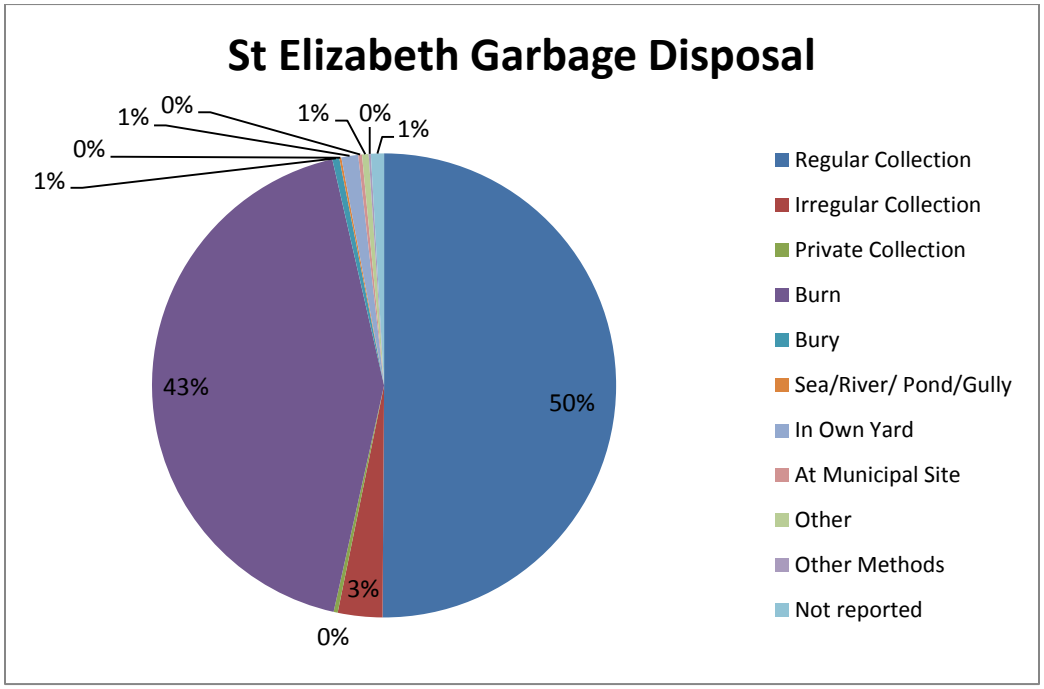


Figure 3:39: Method of Garbage Disposal, St. Elizabeth

(Source: STATIN, 2014)

3.7.1.2 Domestic Water Supply

Figure 4:40 below shows water supply to the various households. Much of NWC's public water supply is from underground and they supply 45% of households either through water piped into their dwelling, yard of a public standpipe or catchment. 31% of the population has their own water catchment largely relying on rainwater. Only 1 % of households access domestic water from springs or rivers.

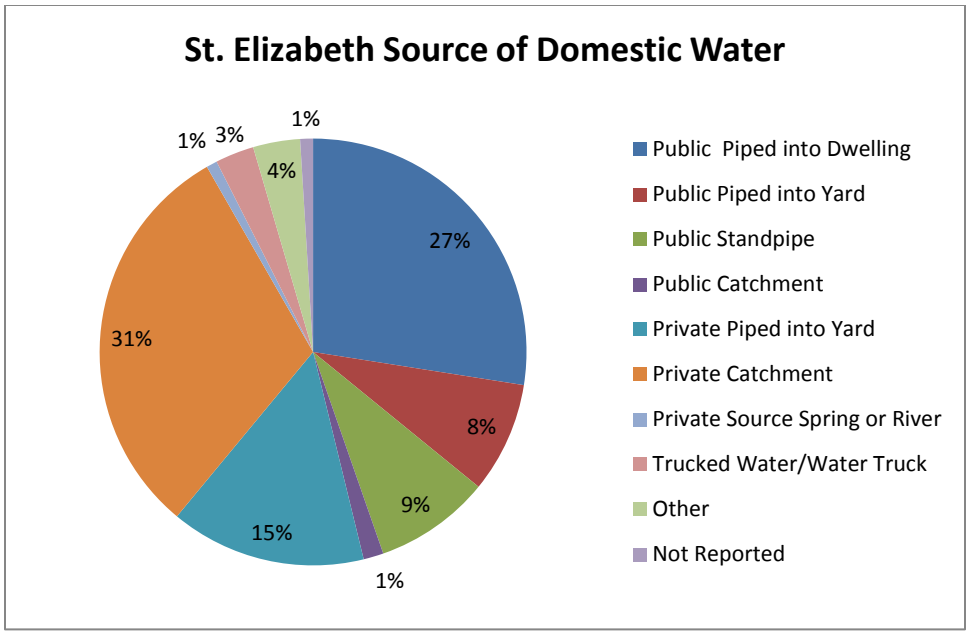


Figure 3:40: Source of Domestic Water, St. Elizabeth

(Source: STATIN, 2014)

3.7.1.3 Fuel Used for Cooking

Approximately 67% of the households in the parish rely on LPG for cooking. 28% relay on wood and 2% from charcoal. This means that tree cutting for wood or charcoal is still the source of fuel for many (Figure 3:41).

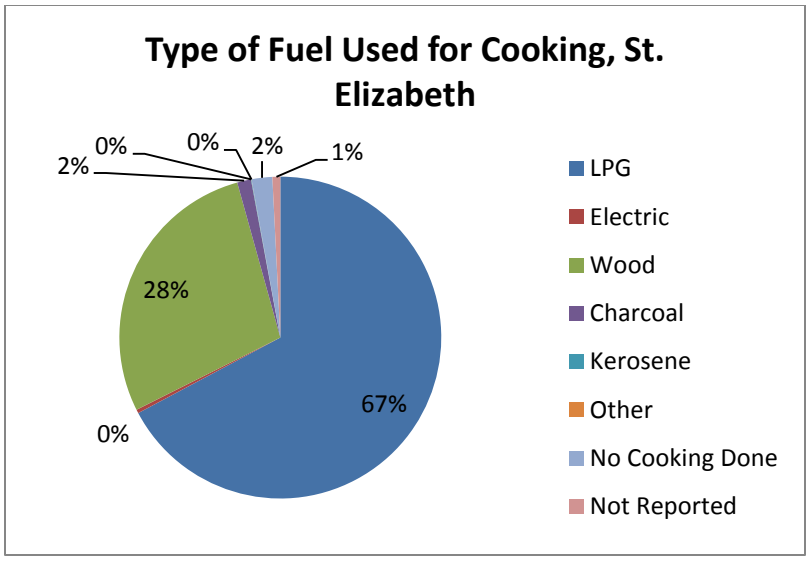


Figure 3:41: Type of Fuel Used for Cooking, St. Elizabeth

(Source: STATIN, 2014)

3.7.2 Heritage

Several unique pockets of heritage assemblages[1] have been retained in the BR area. Elements of these retentions are found scattered throughout the project area ranging from the late 19th century through early 20th century; architectural styles found in the waterfront buildings of BR; to the Taino settlement sites scattered in the southern beaches and highland areas of St. Elizabeth. In 1999, the town of BR was designated by the Jamaica National Heritage Trust as a Protected National Heritage District. Some notable structures within the Protected National Heritage District include Magdala House, Lacovia tombstone (Figure 3:42), Waterloo Guest House, Ashton Great House and Invercauld Hotel.

[1] Heritage assemblages refers to a collection/array of historical and heritage icons dispersed within Black River (JNHT, 2015).

Figure 3:42: Showing structure of Heritage importance; Lacovia Tombstone

(Environmental Solutions Limited: June 3, 2014)

3.7.3 Road Transportation and Traffic

The transportation and road network in BR is quite extensive with a number of taxis available to take passengers (school children and working people) to and from home each morning. Peak hours have been noted to be between 6:30-8:30am and 4-7pm from Mondays-Fridays (Social Development Commissions, 2009). There are also quite a number of private vehicle owners in the community of BR.

The various modes of transportation to and from and within the districts of BR such as Middle Quarters, Parottee, Treasure Beach, Slipe, Pondside, etc. include taxis (licensed and unlicensed); buses, and private motor cars. A study done by the Social Development Commission in 2009 indicated that the main means of transportation is the licensed taxi which is used by 33% of the households, followed by private motor car (19%) and taxi and private motor car which is used by 14%. Approximately 22% use all available types of transportation.

Updated information for 2015-2016 regarding the road transportation and traffic in the study area has been requested from STATIN and will be provided in the Final Carrying Capacity Report.

3.7.4 Economic Drivers

Agriculture, fishing and tourism are the main economic drivers for the communities within the GTBDA. The BR LM alone is a vital economic resource for an estimated 20,000 people. Jamaica's south coast and, in particular, the BR area, has been the center of increased interest in recent years as an alternative tourism destination, with its tourism ventures focused on ecotourism (ESL, 1997). Eco activities include nature tours, hiking, mineral baths, etc.

Current agricultural activities within the BR area include the cultivation of sugar cane, rice, dasheen and other food crops (Mason, 2013). Fishing and the harvesting of shrimp are very important economic activities and for some people, this is the only means of livelihood.

Palm fronds are also harvested for construction material and for the weaving of baskets for sale.

3.7.4.1 Boating

The boat tours, more commonly known as "safari" boat tours, are the most prominent water based activities within the LM. This activity is a huge income earner for the operators and other community members such as local fishermen. There are currently 3 major boat operators on the BR who use Pontoon boats to conduct their tours. There is also 1 small operator who utilizes canoes to conduct their tours. All operators are registered with the River Rafting Authority and include:

- BR/South Coast Safari – Mr. Charles Swaby (4 vessels)
- Jacana Aqua Tours (Irie Safari) – Mr. Lloyd Linton (3 vessels)
- St. Elizabeth Safari – Dr. Donovan Bennett (5 vessels)

All vessels noted above are motorized. The small operator is identified as **BREDS Treasure Beach**, and they have in total 7 canoes, all of which are non-motorized (River Rafting Authority, 2015, pers. comm., 16 September).

All river rafting activities conducted on the BR are boat tours. No other activity is approved for this river (River Rafting Authority, 2015, pers. comm., 16 September).

A total of 19 vessels are registered with the River Rafting Authority. This number has increased since the last study conducted by Smith Warner International in 2005, in which a total of 16 vessels (8 motorized and 8 un-motorized) were registered at the time of study.

The route taken by most tours is usually up the BR to Broad Water (where the two rivers meet), then up the Broad River to the bridge at the village of Salt Spring (see Figure 3:43). Along the way, numerous stops are made to highlight the various environmental and biological features of the BR: mangroves, crocodiles, Cattle Egrets (nesting sites), aquatic vegetation and the Broad River waters. Crocodiles are the main attraction here and tour guides ensure that visitors are given a look while on the river. Some tour operators turn around before they actually reach to Salt Spring, while others allow guests to disembark and walk around the village of Salt Spring. Information is lacking regarding the economic and cultural significance of the latter activity (Salt Spring), however, there has been some tension among community members of Salt Spring who believe that the economic opportunities of the BR are seldom passed on to them.

Figure 3:43: Map Showing Route taken by tour operators on the BR

(Google, 2014)

In addition to the formal tours offered by the named operators listed above, there are also informal tours given by fishermen as shown below in Figure 3:44, who travel from as far as Belmont and Treasure Beach (see Figure 3:45). These tours usually take their visitors past the bridge at Salt Spring to Cheese Rock where they can engage in associated activities, such as, swimming and refreshments (Environmental Solutions Limited, 1997)

Figure 3:44: Boat used by informal tour operators along the BR

(Source: Environmental Solutions Limited: August 18, 2015)

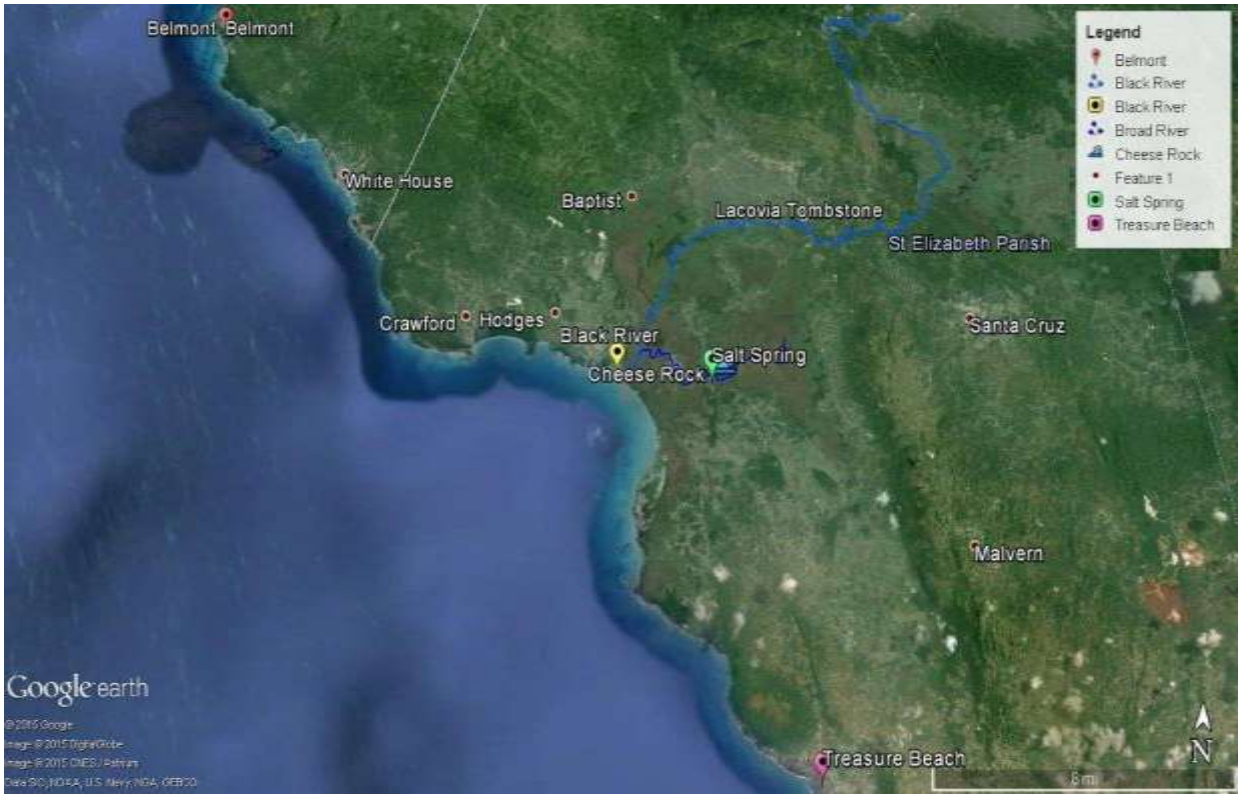


Figure 3:45: Key Communities in the parish of St. Elizabeth that is influenced by the features of BR

(Google, 2014)

This high level of boating activity on the river is a contributing factor to the negative environmental impacts observed, such as, depletion of river banks and decrease in biodiversity of the area. In addition, the tours are conducted in great proximity to the wildlife, such as, tour guides feeding crocodiles, and in showcasing environmental features, such as, bird life. It has been observed that operators travel in very close proximity to bird mating and nesting areas.

In general, the tour operators seem to have a good working knowledge of the environment (BR) although some scientific and historical inaccuracies are evident. All formal operators have safety features present during tours. These range from first aid kits, life jackets and general boat rules, such as, no feeding of animals, no standing on boats and no smoking. Most operators are also trained in cardio-pulmonary resuscitation (CPR). They also practice the "rules of the river" in which keeping to the left and slowing down in the presence of another vessel is practiced. This is

not observed by informal operators who lack safety devices and training, and usually speed on the river.

In a recreational carrying capacity report conducted by Smith Warner International in 2005, it was suggested that the BR can accommodate between 2-3 vessels at a time without compromising safe use, aesthetic enjoyment and/or environmental quality. This number, which is based on fast moving vessels is well below the number of vessels that were observed in operation at a given time on the river. Based on these figures, a total of 15 tours can be accommodated (5 tours per operator), if each tour conducted by an individual vessel was to last for an hour and a half between the hours of 9:00am and 4:30pm. It should be noted that the above determination was done based on several assumptions, and based on the existing characteristics of the BR and tours on the River.

3.7.4.2 River Rafting

River Rafting is another source of income for the members of the BR community, as well as, a recreational activity for locals and visitors (tourist attraction). Rafting activities occur mostly on the Middle Quarters River. Based on a report from ESL in 1997, a river rafting operator saw this activity as a low impact, special interest attraction, catering to no more than 30 persons per day, and an activity that will be conducted solely on property that is owned by himself. The consultants are of the view that the ecological consequences likely to result would be minimal, if the attraction turned out to be as proposed. There has been no recent data on river rafting activities in the study area to determine if any negative impacts on the ecology and of BR and its tributaries have occurred. However, recent discussions and interviews with River Rafting Authority (RRA) and other stakeholders in the area indicate that no river rafting activities have been observed on the river or are currently being conducted.

3.7.4.3 Fishing and Shrimping

Wetlands are important to Jamaica's fishing industry. Mangroves, a major feature of the wetlands, provide a diverse habitat for these aquatic organisms as they offer protection and food resources. Due to the high productivity of Mangroves, a high concentration of biota can be found (Webber, 2010).

The BR LM is particularly rich in wildlife. Both marine and freshwater fish feed actively, and the young find shelter. Within the lower morass, numerous crabs can be found within the mangrove forests, particularly within their prop roots. In times past, there was a considerable sport fishery within the BR, with species, such as, snook, snapper and mullet amongst the sport fishermen's catch. Today, fishing and shrimping in the morass remains one of the most important activities and is done both for economic and recreational purposes.

In a report prepared by Webber in 2010, it has been noted that 35 species of fish were recorded from the BR Morass, 3 of which are endemic and the others of commercial importance. Fishing in the morass is both an economic and recreational activity and is primarily artisanal conducted from canoes with basic fishing equipment. In the same report, it was observed that most of the fish that were caught comprised primarily marine fish that used the mangrove habitats as some part of their lifecycle. These fish included commercially important fish such as jack, snapper and snook. However, it is important to note that fishermen have reported that there has been a decline in the catch over the years. This may be as a result of overfishing and/or an increase in juvenile fishing, depleting the ability for the stock to renew itself. The fishing industry especially within the morass, constitutes a significant portion in the livelihoods of the fishermen and others members of the BR community. It is therefore important that careful management is exercised to ensure that the industry remains viable and sustainable. Figure 3:46 below illustrates a fisherman and his catch that was obtained from spear-fishing in the upper reaches of the morass. His catch will be sold to local communities as a source of income.

The Black, Broad, and Middle Quarters Rivers are well known for their shrimp. However, Middle Quarters is the most famous outlet for which shrimp is sold and caught. The shrimp live primarily among the roots of aquatic plants in the streams and rivers of the morass in which 7 species of shrimp are commonly caught. The most common, is the species *Macrobrachium acanthurus.* Shrimping in the LM is an important industry. Webber et al in 2010 estimated that on average, the annual income per shrimp man was between JA$24,960 and $624,000, with the vendors making up to JA$2,340,000 per vendor per annum. Even though the industry has been valued at about J$3miilion per annum (Wade, 1985), this value may have been significantly reduced due to pollution and overfishing. Wade (1985) wrote that the shrimping industry in the

LM employed about 200 shrimp men, and an equal number of other persons in boat making, pot and basket weaving, and vending. Proper management of this industry as well as cooperation of the shrimp men could be used to increase efficiency and productivity within the area. Even though fishing is an activity done in conjunction with shrimping, it is not as lucrative. Regardless, it is still an income earner for fishermen and provides food to many families.

Figure 3:46: Fisherman and his catch for the day in Broad River

(ESL: June 24, 2015)

3.7.5 Stakeholder Engagement

Numerous stakeholders depend on the proper management and functioning of the Morass, to ensure sustainability of the activities in the area and their own economic survival. Activities include fishing, shrimping, agricultural pursuits and Safari tours of the BR. Consultation with stakeholders is germane to carrying capacity studies and in that regard the consultants have embarked on phased consultations to inform their conclusions and recommendations.

This following section provides the results obtained from various consultations with eight main groups of stakeholders:

1. Tour operators/Tour guides
2. Tourists/visitors of the "safari" tours
3. Community members (Cheese Rock and Salt Bridge Community)
4. Shrimpers
5. Fishers
6. Farmers
7. Informal tour guides
8. Institutions

3.7.5.1 Tour operators

The tour companies have been developed (initially starting with Charles Swaby) as a tourism product of the country to provide tourists with a different attraction on the south coast. They have been geared towards meeting the needs for eco-tourism type attractions and they have become increasingly popular. It provides an opportunity for visitors locally and internationally to learn and observe different aspects of Jamaica's largest wetland, the BR Morass.

Three managers/tour guides from 4 of the tour companies identified were interviewed. These included:

- BR/South Coast Safari
- Jacana Aqua Tours (Irie Safari)
- St. Elizabeth Safari

A total of 6 people were interviewed using a structured survey.

The responses received from each person were very similar and only varied in a few instances. The tour operators receive visitors from all over the island as well as overseas. Most of the visitors however are international tourists and travel from areas such as Negril, Ocho Rios, Treasure Beach and Westmoreland. 86% of the respondents (Managers, tour guides) strongly believe that there is a serious lack of management and regulation in regards to activities within the BR. This specifically relates to the use of the river by fishermen who "unconcernedly" utilize the river for personal uses, without any consideration for the other tours. That is, they use the rive rto conduct personal tours and other activities that in some way affect the operation of the

other formal tour operators. In addition, the canoes used by the fishermen from Treasure Beach tend to pose a significant safety threat on the river, as they travel at rapid speeds with their "bows in the air" and are therefore unable to see properly up or down the river. Many times, the larger boats owned by the operators mentioned above have to "stand clear" of the area so as to avoid any serious accidents from occurring. The respondents indicated that they are unable to observe any constant monitoring of the area by the respective regulatory bodies and Marine Police, to ensure that users of the BR are licensed and activities are occurring in a safe and sustainable fashion. In addition, the hunting of the crocodiles and burning of the Morass continues to pose a serious threat to the ecological value of the BR as well as the aesthetics of the area. Only 1 of the respondents from St. Elizabeth Safari believed (15%) that regulatory issues in the area is not bad and there is constant patrolling of police, issuing of licenses, checks for safety equipment, etc.

All tour companies interviewed agreed that their busiest season (peak season) is in the winter (October –March), and remain open 7 days a week, 8:30am-4:30pm. Closing of the tours only happens twice a year that being, Christmas and Good Friday. It should be noted that on weekends, mainly on a Saturday, the number of tours decreases greatly.

Tours range from anywhere between 5-10 per day but can significantly decrease to even 1-2 per day in the low season.

The Black River/ South Coast Safari and St. Elizabeth Safari conduct their tour in excess of an hour (usually an hour and a half depending on the time their visitors had available and the demand). Jacana Aqua Tours (Irie Safari) was the only tour company that indicated that their tour lasts anywhere between 45 minutes to an hour.

Both Irie Safari and Charles Swaby conduct "special tours" that goes beyond the Salt Spring Bridge. St. Elizabeth Safari indicated that they do not offer this because of security issues.

100% of the respondents indicated that the most popular attraction on the Safari were the crocodiles and thus is the focus of marketing. Mr. Charles Swaby made reference to the fact that this has changed drastically as the tours were originally marketed to Europeans as a bird watching botanical experience. However, despite the change in interest, there are often bird

watchers and "environmentalists" who take the tours and often request a closer look at the mangroves and birds so that they can take pictures.

All tours implement safety features on the tour itself such as life jackets, no standing on boats, no hands in water, CPR training, etc. This is expressed verbally by the tour guides to the visitors before riding up the river.

Even though strong competition exists between the tour companies, a similar route is taken (BR, Mangrove Alley, Broad River, etc.). This however, creates a lot of tension on the river as many of the boats from the different tour companies compete for space on the river and sighting opportunities for viewing crocodiles. This may have negative effects on the ecology due to high wave action (speeding) and erosion of river banks.

The reduction in the number of crocodiles seen on the tour has also been noted and may be as a result of human activities/us on the BR. This slightly skews the level of satisfaction of the visitors. Only 4 crocodiles were spotted in a 4 hour period (11:30am -3:30pm) when a comprehensive tour of the BR was taken by the consultants.

Some of the tours offered by each company shorten the length of the return leg. This is done not only to keep the tours "short and quick," but rather in an effort of ultimately providing a quick turnover time of the boats.

Not all boats are filled to capacity each time the boat goes up the BR. Pontoon capacity ranges from 10-12 seater boats to about a 40 seater. Whether or not boats are filled to capacity, it departs and this is to ensure that none of the visitors wait for an extended period of time and to ensure that boats are available and ready for the arrival of other guests. 7 Pontoon boats were observed on the river in a 4 hour period and 3 canoes (fishermen). Passengers varied in numbers ranging from 5-20 persons per boat. As shown in Figure 3:47 below, a 25 seater Pontoon vessel was observed on the BR returning to base with about 15 passengers inside.

The Marine Police patrolling the Black River for an unlicensed fishermen/tour guides was also spotted (Figure 4:48).

In regards to solid waste disposal, waste on the boats such as food and water containers are usually collected by the captain and disposed of on land at an identifiable garbage site after each

tour. Restroom facilities are also available on land at each tour company and the use of soak-a-way pits are utilized for the disposal of waste.

Tour vessel spotted on the BR on its return leg

Figure 3:47- Vessel used by a tour operator traveling back to base (the return leg)

(ESL: August, 18, 2015)

Police vessel found patrolling the BR

Figure 3:48- Marine Police patrolling the BR

(ESL: August 18, 2015)

3.7.5.2 Visitor Expectations and Satisfaction

The BR Safari Tours is still considered one of the biggest tourist attractions and an important recreational activity on the South Coast of St. Elizabeth. In terms of popularity and usage, the BR has been ranked second in Jamaica, the first being Dunn River Falls, Ocho Rios. Current data suggests that visitor satisfaction is above average and many, if not all visitors have indicated that it had exceeded their expectations and that they would return to do the tour again. Even though pre-booking is recommended, many visitors are still allowed to take the tour if space is available throughout the day where advanced booking was not done. No customer will be turned away and this has been done to increase customer experience, convenience and business. This form of business appears to be consistent with all tour operators along the Black River.

3.7.5.3 Knowledge of Tours

Most of the visitors of the tours when interviewed indicated that they were informed of the tours via travel brochures and travel packages that were offered by their respective hotels/travel agents including cruise ships. The Safari Tour and a trip to YS Falls are just two of the many attractions that are offered in the packages. The majority of the respondents interviewed were overseas visitors (95%) and only a small percent (5%) were locals who were taking their children to see crocodiles on the BR tours (summer holidays).

3.7.5.4 Visitor Review

In total, 29 visitors were interviewed comprising persons from the St. Elizabeth Safari, Irie Safari and Charles Swaby BR Safari.

100% of the respondents indicated that they believed that the environment was in good condition and that they could not identify any debris or ecological degradation of the area. The environment was in a satisfactory state and at often times reminded them of the Everglades.

Out of the 29 respondents, only 10% indicated that they wished the tour was longer and included more activities along the way. These respondents however, did not express that they felt as if the return leg of the trip was faster and rushed compared to the first leg up the River.

90% of the respondents felt as if the length of the journey was perfect and took note of the fact that they had other stops to make and thus could not stay any longer on the safari.

All respondents also indicated that they did not feel as if their safety was compromised on the Pontoon boats, even though most boats were filled to capacity. They actually preferred a larger group to travel with as it increased their overall experience.

The tour guides were given high scores by the visitors who they said contributed to their overall experience. The tour guides were described as "fun" and very knowledgeable of the Morass and ensured that each person on the tour understood what they were seeing and was observing. 1 of the respondents added that they would return if they got the same tour guide.

As described before, 100% of the respondents felt "good" about the tour and in most cases, the tour exceeded their expectations. However, 21% of the respondents indicated that the tour could have been improved by providing bins on board for garbage, a fridge for water as it can get very hot, walking the Morass itself (mangrove area), be given the opportunity to come off the boats and explore communities and forest areas and also be given the opportunity to touch the crocodiles. These respondents described themselves as "naturists."

Even though the tour provides an opportunity for people to observe nature, bird watch, and see wildlife, many of them came particularly to see the crocodiles. Some were even a bit disappointed as they did not see as many crocodiles as anticipated. However, this did not affect their overall experience on the river.

None of the respondents indicated that they felt any form of tension or confusion on the river due to the presence of other tour companies or fishermen.

86% of the respondents said they would return and recommend the tours to other people. However 14% said even though they would strongly recommend the tour, they would not do it again. This was due to the fact that they did it already and would want to experience new things. If the tour offered more activities then they would strongly consider returning the next time.

3.7.5.5 Community Benefits and Response (Salt Bridge and Cheese Rock)

Members of the Salt Spring Community as well as Cheese Rock were interviewed to determine their perspective on the use of the River in relation to economic and recreational activities. It is the shared consensus of the communities that the benefits from the tours given on the BR are limited. Interviews were conducted in small focus groups and ranged from 3-5 persons (Cheese Rock and Salt Bridge respectively). 100% of those interviewed indicated that benefits received to their business or their communities are very limited. Cheese Rock and Salt Spring receive a limited number of visitors from the Safaris. The majority of their clientele are local residents from BR and the surrounding communities that pass through the area. However, they do occasionally get a few visitors from the tours, but these visitors are mostly from the Treasure Beach area transported by local fishermen. This number is very dependent on the season of year as well. The tour companies do offer specialized tours that stop at the bridge and at Cheese Rock. However, the occurrence of this is low. It appears that Cheese Rock receives more visitors than Salt Spring and may be solely due to security issues such as theft and the range of activities offered. 100% of the respondents at Cheese Rock said that they do get some visitors and occasional sales from the tours (mainly informal and tours from Treasure Beach). The members of the Salt Spring are “annoyed” and feel a sense of “being robbed,” as they have an assortment of craft and souvenirs to offer. In addition, they believe, that if given the opportunity, they would be able to offer a service to the visitors (educational, cultural and recreational) that would in return contribute to the economic success and enhancement of the community.

100% of the respondents at both Cheese Rock and Salt Spring strongly believe that economic development and increased recreational activities in these areas could provide a “new source of income and attraction to Jamaica.”

3.7.5.6 Shrimping

The BR and its Tributaries, namely Broad River, Middle Quarters and Maggotty play an integral role, providing a means of income and food to citizens of the BR area.

Shrimping is one of the major fishing activities in the area. Both shrimp vendors and shrimpers were interviewed.

3.7.5.7 Shrimp Vendors

7 Shrimp vendors were interviewed via face to face discussions. All of the respondents indicated that this was their main source of income and that their busiest period occurs during the holiday season. Currently, business is low (June-July). They all obtain their shrimp from shrimpers as far as Cataboo, Slipe and Clarendon and then re-sell to their customers. Even though the majority of their clients are locals, they also receive business from tourists especially those going to YS Falls.

100% of the respondents indicated that activities within the morass do affect the volume of shrimp collected and sold. One of the respondents strongly felt that the hydroelectric power plant located in the upper morass (Maggotty) has greatly affected the numbers of shrimp within the Morass since it began operating in 2014. She indicated that due to the reduction in water flow and with the continued drought, the size and number of shrimps/prawn caught has been greatly reduced. In most cases, many of the shrimpers are forced to buy shrimp from Rainforest and then re-sell to visitors.

The price of the shrimp ranges for many of the vendors. However, bag price ranges from $50 bags to $700 bags depending of the size of the bag and shrimp. In the high season 43% (3) of the respondents indicated that they can sell up to 25 bags of shrimp a day, while in the low season, they sometimes sell none. Even though there appears to be no tension, competition or animosity expressed among the vendors, all respondents have indicated the need for more activities in the BR area so as to generate more traffic and customers to them.

100% of the respondents indicated that they purchase their goods from licensed fishermen only throughout the year and they are of the opinion that the fishermen are constantly monitored and regulated by the Marine Police.

3.7.5.8 Shrimpers

Shrimpers are defined in this context as those stakeholders who actively catch shrimp within the morass and sell it to various vendors as their primary source of income. They are approximately 120 shrimpers in the BR morass area.

Nine (9) shrimpers were interviewed within the Slipe area and there was a consensus on the overall shrimping activity within the morass. The shrimpers indicated that they primarily sell their shrimp to vendors in Middle Quarters, on the beach and community members. They also deliver to homes who then sell to people in Mandeville, Kingston and Negril. Shrimping is done every day (5am-10:30am) and is primarily caught from the BR Morass (Mangroves and bushy areas). Even though shrimping is their primary source of income, during the off season (December-March), many of them farm. During the rainy season, the shrimp yields are high and are sold in abundance. However in the dry season, the shrimp yield decreases significantly and results in an increase in the cost of shrimp.

All respondents agreed that the activities in the BR do not significantly affect their ability to catch shrimp in the river. However, the large waves created by larger vessels, do have an impact on their fish traps and safety and suggested that if any more activities were to be introduced on the BR, that wave action be strictly monitored.

Competition among the shrimpers is minimal as every person has their own designated space on the river.

Challenges experienced by the Shrimpers include:

1. They strictly depend on the BR for their shrimp
2. In the dry season, shrimp is scarce and expensive
3. High pollution of the river and its tributaries
4. Drainage of the land
5. Lack of management in the area and of the activities
6. The large waves created by the boats disturb traps and shrimping activities

3.7.5.9 Fishing

The BR is utilized by fishermen who quite often fish (net/spear/line fishing) in the upper and lower reaches of BR and also at sea. It is sold to local communities and businesses. Other fishermen catch fish for domestic and recreational purposes. Some of these fishermen come from as far as Treasure Beach and use the BR as a secondary source when their primary source (the sea) is compromised either due to weather conditions, season or productivity of fish.

Fish commonly caught in the river (mainly the UM) includes the Jamaican mudfish (fresh water), Tilapia, Mullet and Perch. This is mostly done by traps, but other fishermen engage in spear fishing in the shallower areas in the upper reaches. They are able to access this area via walking through the morass. Even though fishing is done all year round, peak season tends to be around March-April while the low season is July-September.

The use of the BR has become increasingly popular and also appears to be creating tension and challenges between the tour companies and the fishermen. Lack of monitoring and regulation in the area, creates safety issues and competition for resources on the river. Most of the tour companies expressed the view that the fishermen do not obey the "rules of the river" nor do they cooperate in using the river for tours. This is causing more and more tension with respect to conflicting use on the river. In addition many activities occurring upstream such as agriculture and other recreational activities have a great impact on the environmental conditions downstream. Oil leakage from boats, domestic uses of the river (washing of clothes), chemicals from other activities and agriculture does impact catch yields at sea. One respondent suggested that management of the UM is critical to the livelihood of the fisher folks downstream.

100% of the respondents indicated that fishing was their primary source of income and in the low season, they would conduct tours along the BR to compensate. However this is not very lucrative as many do not have the correct licenses.

One respondent suggested the use of fish sanctuaries and conservation areas within the morass to help protect vulnerable fish species and prevent overexploitation.

Challenges include:

1. Downstream activities are greatly affected by upstream activities, thus better management is needed.
2. Problems such as pollution from boats and agriculture, affect their ability to catch good yields.
3. There are currently no fish sanctuaries or conservation areas within the Morass.

3.7.5.10 Farming

Farming is a significant aspect of agriculture and a major use of the BR morass. Nine (9) farmers were interviewed for the purpose of this study.

Most of the farms indicated by the respondents are located in the Upper Morass of BR. Namely Pointe, Diligent and Giddy Hall. Middle Quarters is used for bee farming. Crops grown include Callaloo, peanut, pumpkin, plantain, banana, yam, cocoa and peas. Livestock is also reared and include goats, cows and chickens. The size of farms varies from 0.4-0.6 hectares (1-1.5 acres) and many are unable to expand, as they lack the materials and resources to increase the capacity of land usage. Currently none of the farmers especially in the UM use machines to irrigate land. It is strictly rain-fed and water is stored in tanks for livestock and future use. During times of drought and little rainfall, 80% of the farmers indicated that they lose most of their crops and would therefore prefer if they could access the river for irrigation purposes. 100% of the respondents indicated that currently they do no extract any water from the morass for irrigation.

Like the shrimpers and fishers, farming is their main source of income and rely on the proper functioning of the morass. Peak season is usually in sync with the rainy season and results in high productivity and yield of fish.

60% of the farmers use fertilizers and pesticides regularly on their crops. 40% of the farmers only apply as necessary as it is very expensive and leaching of chemicals into the morass has become a problem (but only during heavy rainfall).

The burning of the morass has also become a common activity among the famers. Agricultural land is burnt to clear the land, dispose of water and kill pesticides.

It is the common consensus that there is a lack of management in the area. Stricter enforcement is needed along with better implementation programs and plans. It has been expressed that accountability and qualified personnel in the study area is greatly lacking. The role of the Parish Council has been questioned.

Challenges include:

1. Death of crops during drought. They are unable to use the BR to irrigate crops due to lack of tools and resources.
2. The pollution of the morass and its tributaries
3. Poor drainage which results in flooding of land areas
4. Leaching of fertilizers into the river
5. Lack of regulation and monitoring
6. Inability to access the BR for irrigation

Table 3-7 below shows the current information available on the farming activities in St. Elizabeth from the Rural Agricultural Development Authority. There are currently 1,692 registered farmers within the parish of St. Elizabeth. Despite numerous conversations with farmers that say that they do not use water from the BR, the data indicates that water is currently being abstracted from the BR for farming and irrigation purposes.

Table 3-7- Farming in St. Elizabeth

Number of Farmers	1692
Location of farms	Siloah, Elim, Braes River, Black River, Luana, Maggotty, YS, Holland, Middle Quarters, Barton, Newton, Barton Isle, Middlesex, Lacovia, Breadnut Valley, Slipe, Parottee, Catterboo, Knoxwood, Burnt Savannah, Farbas
Size of farm plots	0.04 ha. - over 100.00 ha.
Type of Agriculture	Aquaculture (fish farm); livestock (cattle, goats poultry & pigs); Crops (sugar cane, papaya, dasheen, banana, plantain, peanut and vegetables)
Source of water for irrigation	River, blue hole

Source: Rural Agricultural Development Authority, 2015

3.7.5.11 Informal Tour Guides (Treasure Beach)

Informal tour guides refers to licensed fishermen and tour guides, some of whom are registered with RRA but are not formally associated with a tour company such as the ones mentioned above. These "tour guides" act independently and offer tours along the BR to both locals and international visitors.

Currently, there are about 10-12 boats that operate from Treasure Beach, Calabash, Frenchman and Billy's Bay. Brief discussions with a few of the fishermen from the Treasure Beach area indicate that they receive little to no help from hotels or travel agencies and have to seek business opportunities themselves. Most of them operate from Jakes in Treasure Beach and utilize the BR tour as a means of income especially in the low season of fishing. 100% of them indicated that during this time (off season for fishing), the boat tours become their only source of income and it can become highly competitive as they compete with the other tour company in Treasure Beach – BREDS.

BREDS Tour Company receives most of their customers from Jakes Hotel and their visitors are mainly from hotels within St. Elizabeth area and as far as Negril and Ocho Rios. During the peak season, 100% of the respondents indicate that they conduct 2 tours per day as each tour last 4-5hours. In low season they may only conduct 1 tour per day and sometimes 1 per week. The route/sites taken by these fishermen include Treasure Beach, Pelican Bar and Cheese Rock, in which visitors are encouraged to shop, swim, eat and engage in other activities offered along the BR by the local communities such as Salt Bridge Community. Visitors are given safety instructions before departure and each person is required to wear a life jacket. The crew consists of 2 crew members (1 being the captain) and each boat can comfortably accommodate up to 10 individuals. Along the tour, information about the ecology, vegetation, topography and other ecological features are discussed and explained. The main attraction for these tours however is the dolphins and these are often observed at sea. The crocodiles along the BR are also highlighted and bird watching is a common activity observed. 50% of the respondents indicated that they would be grateful if more opportunities were given to them and if they could be involved in more tourism development activities in BR. They expressed their challenges in obtaining the necessary permits as the process is very lengthy, stressful and expensive. The

remaining 50% however indicated the opposite. They expressed their satisfactory relationship with NEPA and TPDCo and have encountered no problems to date.

Improvements that they would like see include:

- More business oriented people in Treasure Beach area (hence training activities offered),
- Treasure Beach has great potential and therefore more marketing is necessary to position the area as a tourist destination.

Challenges include:

1. High competition in Treasure Beach
2. Lack of marketing in the area to help develop their business opportunities
3. Obtaining a license to conduct tours

3.7.5.12 Institutions (St. Elizabeth Parish Development Committee)

Even though the St. Elizabeth Parish Development Committee does not include the BR study area under its purview, the committee does have some degree of influence regarding activities occurring within the area. The committee acts more as a facilitator (to NEPA and Royal Life Saving Society) and helps to provide recommendations for people who wish to utilize different aspects of the area.

The respondents did indicate that they believe that the upper and lower morass, have the capacity and economic potential to be further developed allowing for more eco-tourism activities such as nature trails through the morass, etc. to occur. However, it is the general consensus that there is a lack of regulation and management in the area, and if these developments do occur without proper management, it will eventually lead to the ecological degradation of the morass.

Invasive species of fauna and flora (such as Catfish, crabs and prawns; Ginger Lilly) have been identified as being a nuisance/invasive to the area. The Catfish for example digs into river banks and weakens the structure greatly.

The committee overall acknowledges that “things are changing” in regards to the environment and would like to extend their scope of work to include proper environmental management of the Morass. They see great potential of the Morass both economically and recreationally for the

communities in Black River and would like to see the "wealth" spread beyond the tour companies and extend to the surrounding communities.

The respondents also expressed their concern in regards to the growing of crocodiles (Charles Swaby) and its suitability/sustainability. Parottee Bay has been identified as an area with a high population of crocodiles and poor drainage. During the rainy season, there is serious flooding, a huge build-up of garbage and infestation of mosquitoes. This has resulted in lack of development and a decline in the tourism activities undertaken in this area.

3.7.5.13 Boat counting

The results obtained from the boat traffic survey have been summarized in Table 3-8 below.

Table 3-8: Results obtained from the Boat Traffic Survey

DATE	CANOES		PONTOONS		TOTAL	
	B*	O*	B	O	B	O
17/11/2015 (Tuesday)	12	38	41	620	53	658
19/11/2015 (Thursday)	22	250	35	320	57	570
21/11/2015 (Saturday)	17	57	18	160	35	217

*B- Boat; O- Occupants

The results indicate that the peak day observed was a weekday (Thursday) with a total of 57 boats moving up and down the river and a total of 570 occupants. Tuesday was identified as the second peak day even though on this day, more occupants were on the river than on Thursday.

The lowest day observed was the weekend (Saturday), in which only 35 boats traversed the river and had a low occupant count of 217. The results also indicated that the peak period for the tour operations on each day occurs within the two hour period between 10:00am and 12:00noon. Over 30 tours carrying passengers were observed during that period (per day observed) after which the numbers declined sharply.

3.8 Socio-economic Indicators

Based on the socioeconomic setting, the following parameters were identified as key indicators. Table 3-9 outlines the current status of the description

1. Expanse of population – increase or decrease in population
2. Housing and other development – evidence of unapproved development, proposed sites for new developments
3. Source of Water – domestic purposes, irrigation, industry, other
4. Changes in shrimp catch - increase, decrease/stable
5. Changes in fish catch - increase, decrease/stable
6. Burning – garbage disposal, land clearing for farming
7. Boat traffic – numbers and wave action
8. Chemicals – use of pesticides and fertilizers
9. Deforestation – evidence of tree removal

Table 3-9: Indicators and Socioeconomic Analysis

Indicator	Description of Status	Direction (Positive, Negative, Stable)
1. Expanse of population	Population increasing based on census but not a direct link as a negative impact on BR	Stable
2. Housing and other development	Evidence of a few unapproved development	Stable

Indicator	Description of Status	Direction (Positive, Negative, Stable)
	Existing use of soakaways impact WQ in population areas	
3. Source of Water	Use of river for domestic purposes, few industry and irrigation. Extraction based on hydrologic analysis indicates minimal impact on the existing flow	Stable
4. Changes in shrimp catch	Stable catch; however, issue with invasive lobster, which has outgrown the local shrimp breed. Reproduction of invasive species is independent of the BR and it's uses	Stable
5. Changes in fish catch	Decreasing catch, may be attributed to overfishing/ fishing of juvenile fishes	Negative
6. Burning	Burning for garbage disposal and land clearing for farming, fires sometimes get out of control	Negative
7. Boat traffic – numbers and wave action	Traffic numbers have increase but can be tolerated on the river, wave action	Stable
8. Level of Chemicals in BR and tributaries	Pesticides and fertilizers used by farmers… impacts evident on BR (water hyacinths) but not evident on other tributaries… WQ within NEPA ambient standards	Negative

Indicator	Description of Status	Direction (Positive, Negative, Stable)
9. Deforestation	Tree removal for charcoal and wood indicated in Census report and based on observation tree loss when land is burned.	Negative

The negative changes for the indicators in Table above are reversible with proper management.

4 Potential Impacts

4.1 Climate

Jamaica is located in the Tropics at approximately latitude 18ºN and longitude 77ºW, which is about 4.5 degrees south of the Tropic of Cancer or about midway between the southern tip of Florida and the Panama Canal (Meteorological Service of Jamaica, 2014).

Among the most important climatic influences are the Northeast Trade Winds, the range of mountains which runs east-southeast to west-southwest along the centre 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 (Meteorological Service of Jamaica, 2014). The cold fronts are usually weak after migrating from the North American continent and evident from mid-October to mid-April. The overall climate of Jamaica affects rainfall patterns within the study area which in turn impacts the dynamics of BR and its overall hydrology.

4.1.1 Rainfall

Figure 4.1 below shows that St. Elizabeth falls within the annual rainfall average of 180 to 200mm/month. Seasonal patterns show that August, September and October have the highest rainfall averages 220 to 300mm monthly. November, December and January are the driest months with rainfall averaging 120 to 150mm/month (Figures 4.1 and 4.2).

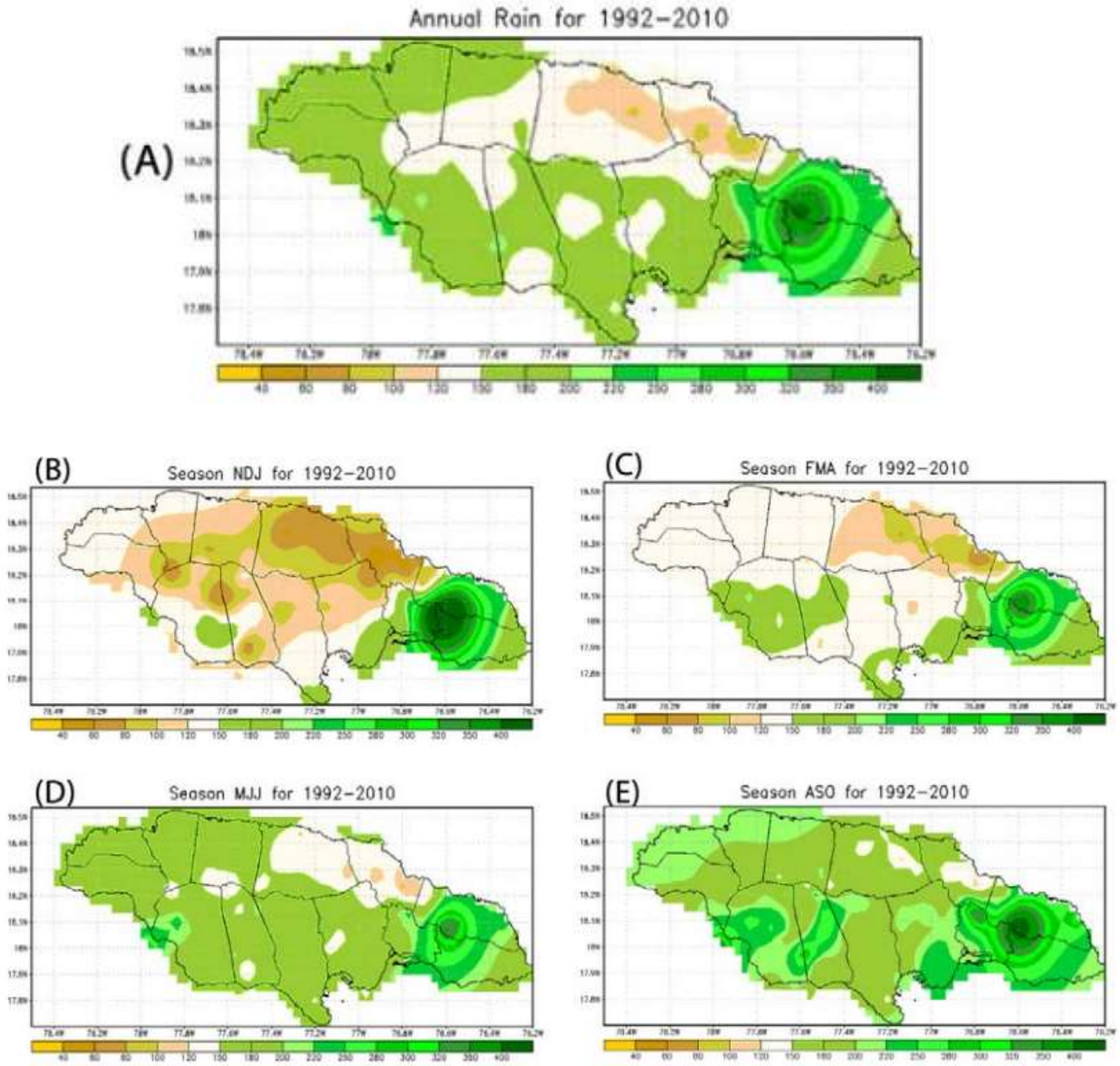


Figure 4:1: Annual Rainfall for 1992-2010 and Monthly Patterns

(Source: UWI Climate Studies Group, n.d.)

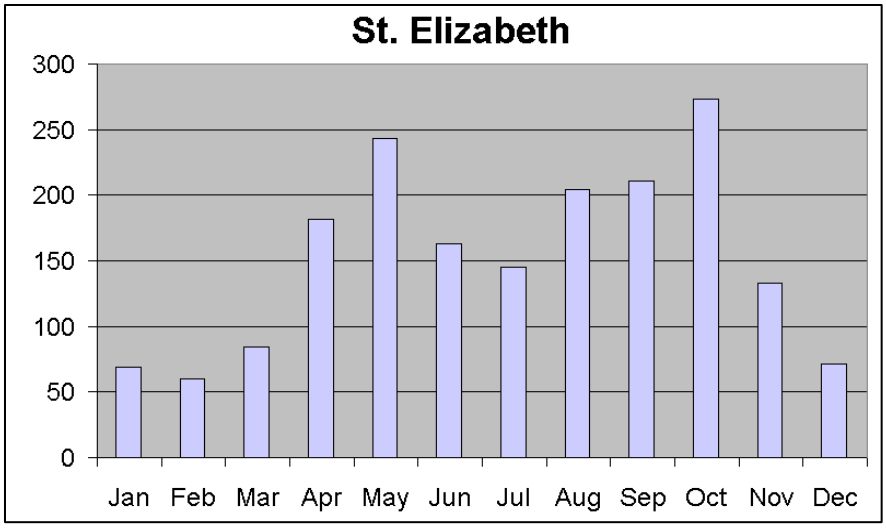


Figure 4:2: Rainfall Estimates (mm)

(Source: Meteorological Service of Jamaica, 2014)

4.2 Natural Hazards

4.2.1 Tropical Cyclone and Flooding

Jamaica is located within the hurricane belt, and the hurricane season is experienced during the six month period, June 1 to November 30. During this season, Jamaica is prone to easterly waves which frequently mature into tropical weather systems such as: tropical disturbances/ tropical waves, tropical depressions, tropical storms, and hurricanes. With conditions such as these, lightning storms, thunder-storms, strong winds, and floods are often associated hazards.

Some of the recent tropical storm/hurricane activity, significantly affecting the south coast of Jamaica, includes the following:

1. Hurricane Gilbert - 1988
2. Hurricane Ivan - 2004
3. Hurricane Dean – 2007
4. Tropical Storm Gustav – 2008
5. Tropical Storm Nicole – 2010
6. Hurricane Sandy – 2012

Figure 4.3 below shows the many storms and hurricanes which have passed across or within Jamaica over the past sixteen decades. It therefore means that climatic factors influence drought and flood incidences on the Black River. In order to determine carrying capacity, uses which are impacted by climatic factors must be considered.

Figure 4:3: Paths of Storms and Hurricanes passing Major Hurricane History 1851-2010

(Source: Climate Studies Group, 2012)

Flooding is a common phenomenon in the Black River area during these events. During the rainy season, anecdotal information suggests that flooding always occurs within the Lower Morass and sections of the Upper Morass. Communities, such as Slipe, in the Lower Morass experience flooding whenever there is heavy rainfall.

In 2011, The Office of Disaster Preparedness and Emergency Management commissioned a consortium of consultant's including ESL, led by Smith Warner International to conduct the project: ***Risk Assessment and the Development of Risk Management Plans for Ocho Rios, BR and Savanna-La-Mar, Jamaica.*** Under this project ESL conducted a vulnerability and risk assessment which showed that the most vulnerable areas to flooding included the houses along

the road parallel to the river. Additionally the most vulnerable economic centers included the town market and the river side attractions (Figure 4:4). It was recognized that the BR which flows through the LM when flooded, overflows into the morass and prevents wide spread flooding into the town.

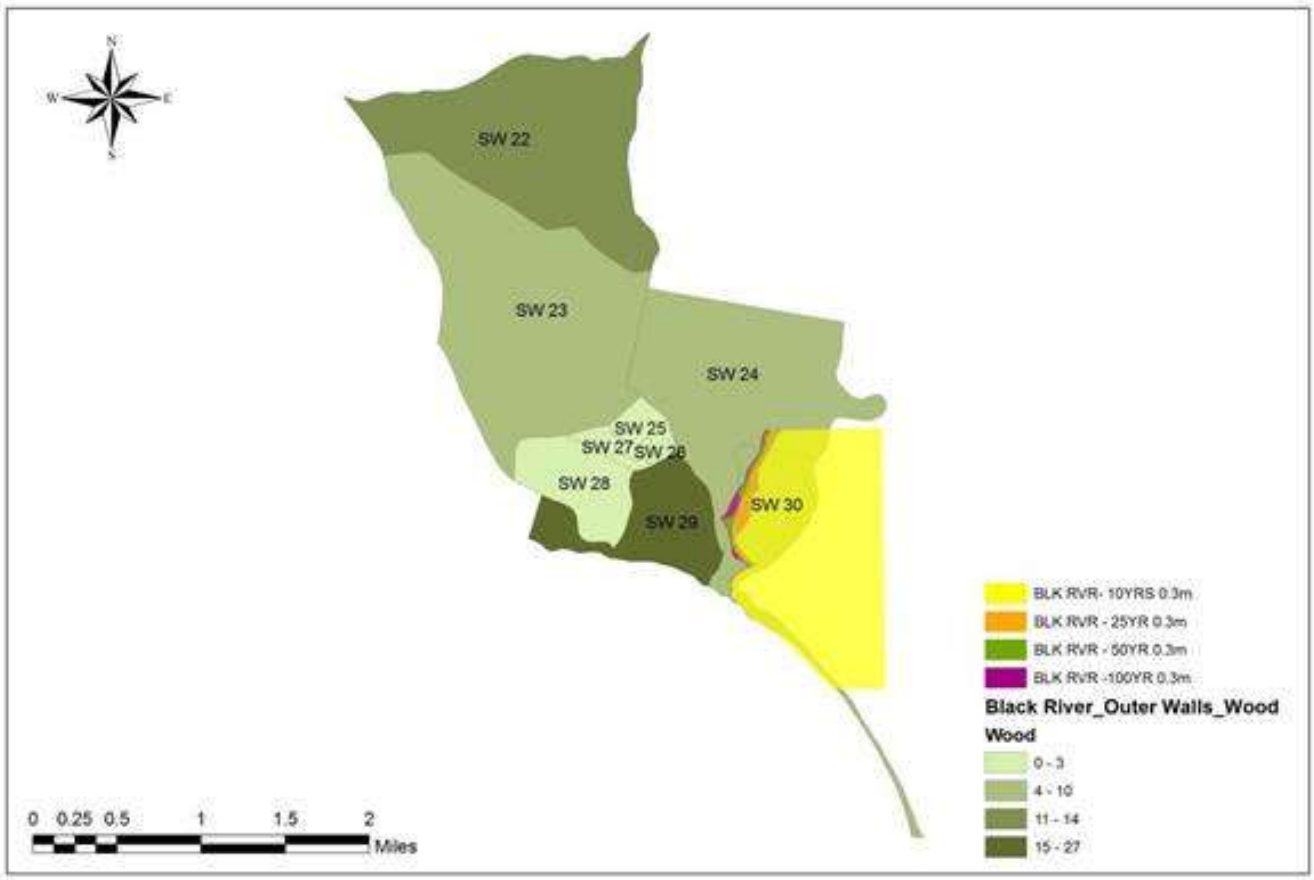


Figure 4:4: Riverine flooding and distribution of wood as an outer wall material in Black River

(Source: ESL, 2011)

4.2.2 Earthquakes

Figure 4:5 below illustrates the cluster of epicentres recorded during the period of 1997-2007. There are a number of faults in the BR drainage basin. The general area is seismically active and is situated on unconsolidated alluvial deposits. Alluvium is known to amplify seismic ground motions.

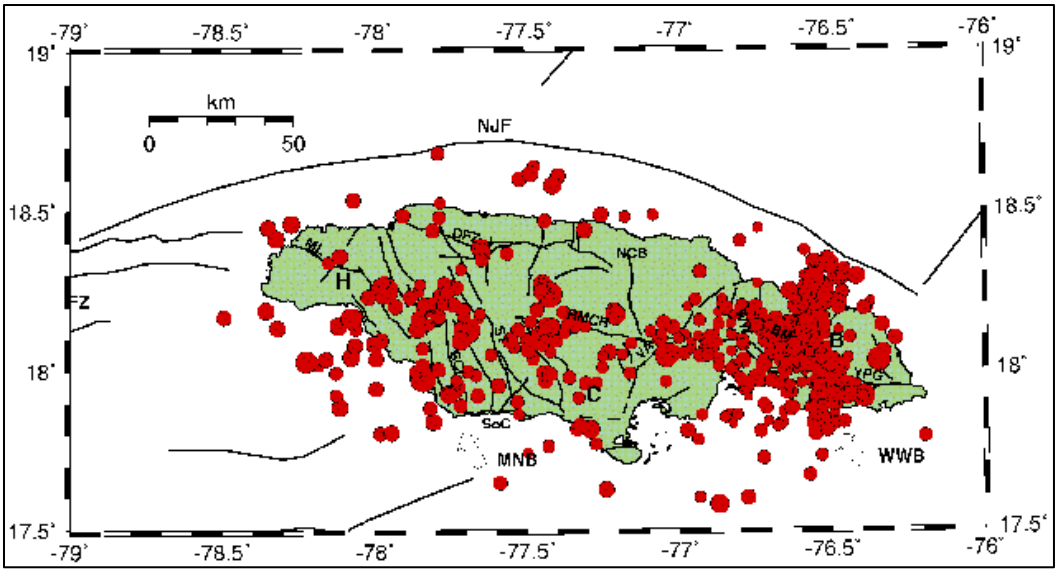


Figure 4:5: Jamaica Seismicity 1997 – 2007

Figure 4:5 above illustrates Seismicity for Jamaica. The red dots represent the epicentres of earthquake/earth movements in the past.

4.2.3 Climate Change

Climate change impacts on small Islands like Jamaica have significant impacts on climatic conditions and seasonal patterns, namely, temperature and rainfall. Sea level rise also has an impact on Jamaica and the project area. The rise in sea level increases the possibility of saline intrusion, disrupting the chemical and physical components of the morass. In addition, an increase in sea level increases the risk of flooding within the morass and on neighbouring communities and also interrupts the balance of vital ecosystems. The State of the Jamaican Climate (2012) indicates that the mean annual temperature for Jamaica is projected to increase between the range of 0.7 to 1.8˚C by the 2050s and 1.0 to 3.0˚C by the 2080s. There will be continuing increases in sea-surface temperatures for Jamaican waters with projected increases ranging between +0.9˚C and +2.7˚C by the 2080s. Projected rainfall changes range from -44% to +18% by the 2050s and -55% to +18% by the 2080s (ibid). Figure 4.6 illustrates predicted drying in the western part of Jamaica which includes the project area due to lower rainfall averages.

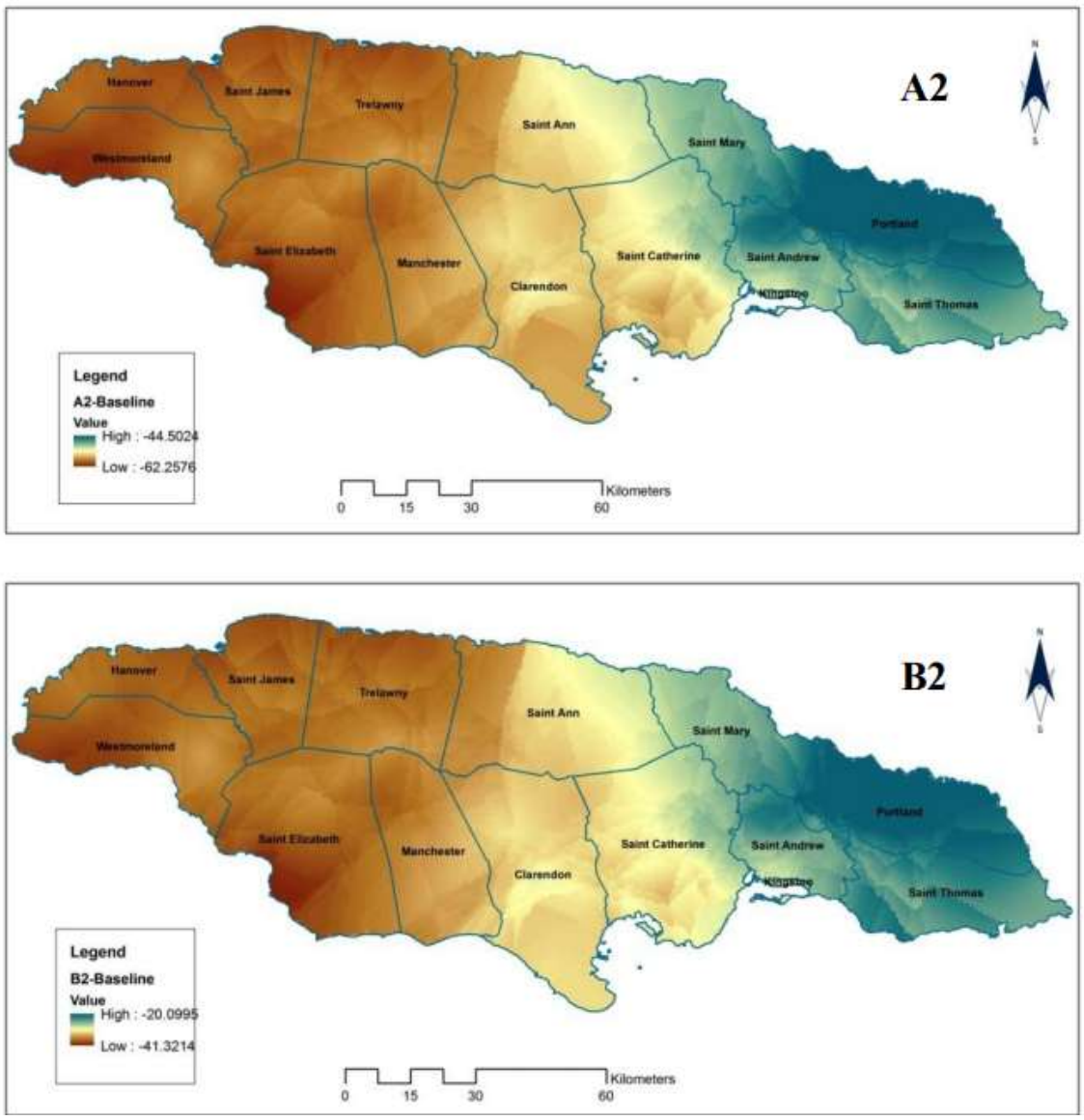


Figure 4:6: Change maps showing projected precipitation changes over Jamaica for the A2 (top) and B2 (bottom) simulations comparing baseline to 2071-2099

(Source: Climate Studies Group, 2012)

Increased sea levels and changes in the severity or frequency of storms are likely to result in changes to the frequency or magnitude of storm surges on Jamaica's coast. The likelihood of more severe hurricanes will increase, although the overall frequency of hurricanes remains uncertain. There may be increased frequency of category 4 and 5 storms by the end of the 21st century while there may be an overall decrease in the frequency of tropical cyclones. The sea

level is projected to rise between 0.18-0.59 m by 2100. Figure 4.7 below illustrates the impact of a 1m rise and above on Jamaica coastal areas.

Figure 4:7: Coastal Vulnerability Topographically Low-Lying Regions and Sea Level Rise

(Source: Mona Geo-informatics Institute, 2012)

4.3 Environmental

4.3.1 Ecological

Most ecological impacts on the area have been derived from human activities. The sources of these impacts are noted to occur from throughout the entire wetland area. There are noted agricultural impacts from the upper reaches especially through nutrient enrichment in most tributaries. In the middle and lower sections of BR, fires, invasive and introduced floral and faunal species, livelihood and tourism related activities have impacted the ecology upon the lower areas of the wetland.

4.3.2 Existing Impacts:

Upper Wetland areas:

- Nutrient additions through fertilizers result in overgrowth of plants (Water Hyacinths) resulting in blocked rivers;
- The effluent water released from the hydropower plant as a part of the electricity generation along the Maggotty River will impact faunal composition within the river especially below the power plant and where the inflow will have the greatest impact.
- Burning and cutting of areas to facilitate agricultural activities is impacting both floral and faunal species, and has possibly resulted in loss of several rare, endemic and potentially important economic species.

Lower Wetland areas:

- Cleaning and detergent agents (highly caustic) from boats which cause lower of water pH, and well as dissolved oxygen within the water
- Pollution from engine oils from boats (motorized tour and fishing). This usually results in fish kills and impacts roots of trees such as mangroves as well as reeds and other water plants that occur.
- Upstream nutrient additions result in uncontrolled growth of species such as water hyacinths and for areas such as middle quarters and extreme reaches of the

Broad River, increased presence of algal species within the river resulting in blocked tributaries and rivers.

- Burning and cutting of the wetland floral and faunal species. Similarly to the upper areas of the wetland these activities result in loss of rare, endemic and potentially important economic species. Also it must be noted that such plant species as Mangroves are heavily impacted and removal of these trees, further impact several faunal species who use it for nesting and roosting (especially for birds) and habitat for fish and crocodiles.

4.3.3 Potential Impacts

Further decline of Bird Species (especially on Broad River)

Environmental Solutions Limited report on the Carrying Capacity for BR (1997), noted that there was a decline in avifaunal species observed on the Broad River. Recent site visits (November 2015) to the study area supported this observation of 1997 as there was very limited observation of bird species along the length of the river traversed. This was somewhat odd as the health of the wetland along the river seemed fairly good and by far better than that of the BR. This may be as a result of the increase human and recreational activities on the Broad River.

Reduced observations of Crocodiles

The rate of boat tours or boating activity in generally on the BR will have increased impacts on the crocodile population. The constant boating activity on the river hinders the crocodile's ability to regulate their body temperature and aerate their lungs as they are unable to stay for long periods above water (basking) without being disturbed. It was noted also that observed crocodiles were fairly young. However, upon further discussion, it was noted that there was a release programme undertaken which would account for this observation. Further studies are needed to determine the ages of the various crocodiles, whether or not the older members of the population are dying or migrating further out of the wetland for less disturbance and if the older crocodiles are displacing the younger ones thus reducing survival.

Destruction of vegetation and Erosion of the River Banks

Fires are the primary source of vegetation destruction. These fires are primarily for the preparation of lands for agricultural activities. Over time, fires will increasingly impact species composition based on loss of vegetation, and also impact faunal composition due to the loss of needed habitat.

Additionally, the wave action from boats (due to speeding) leads to further destruction of river banks. It is noted that some areas are fairly vulnerable to such excessive action.

Alterations to flow regimes

Even though in the case of the BR LM there has been no observation of waterway barriers, the potential for this exists especially if there are any further infrastructural developments along the path of both the Black and more so the Broad River.

Upon further discussions with stakeholders, it has been indicated that within the UM, waterway barriers natural and/or man-made do exist in certain locations. Such barriers over time may decrease flow regimes of the rivers, which in turn, have greater impact on floral and faunal composition (especially of fish and other aquatic species). Extraction of water from tributaries and the major rivers also impact flow regimes. It is also important to note that climate change can exacerbate these impacts in the future.

Further introduction of Non-Native or Invasive Alien Species (Flora and Fauna)

Over time there exists the possibility of introduced flora and fauna to the ecosystem of the Black River Morass.

Often times, aquatic faunal species are introduced as part of schemes or strategies to improve food stock. However, either through natural disasters or human activities, there is release of these species into the natural environment. These introduced species then proliferate in number and out-compete native and or endemic species (based on the lack of a natural predator). This has been seen in the case of the *Cherax quadricorinatus* (Red-claw lobster) and its extreme prevalence in the shrimp harvesting areas.

Similarly, aquatic plant species have the possibility of out-producing naturally occurring species. This then leads to rivers and tributaries being blocked or impassable by boat etc., based on their presence. The most obvious example is that of the Water Hyacinth and its proliferation especially in the Black River.

4.4 Physical

4.4.1 Hydrological Impacts

The present condition of the capacity of the river can be discussed from the time series of the daily flow data for the three stations (Appleton, Lacovia and Newton) and estimating the average base flow. Plots of the same are shown in the Figures 4:8-4:10 below.

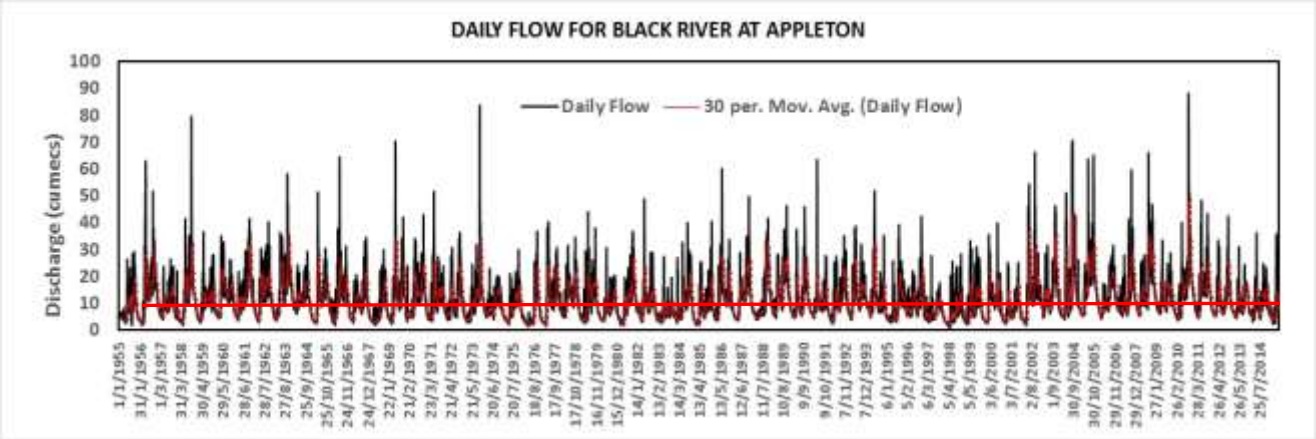


Figure 4:8- Time series plot of daily flow for Black River at Appleton showing baseflow marked with red line.

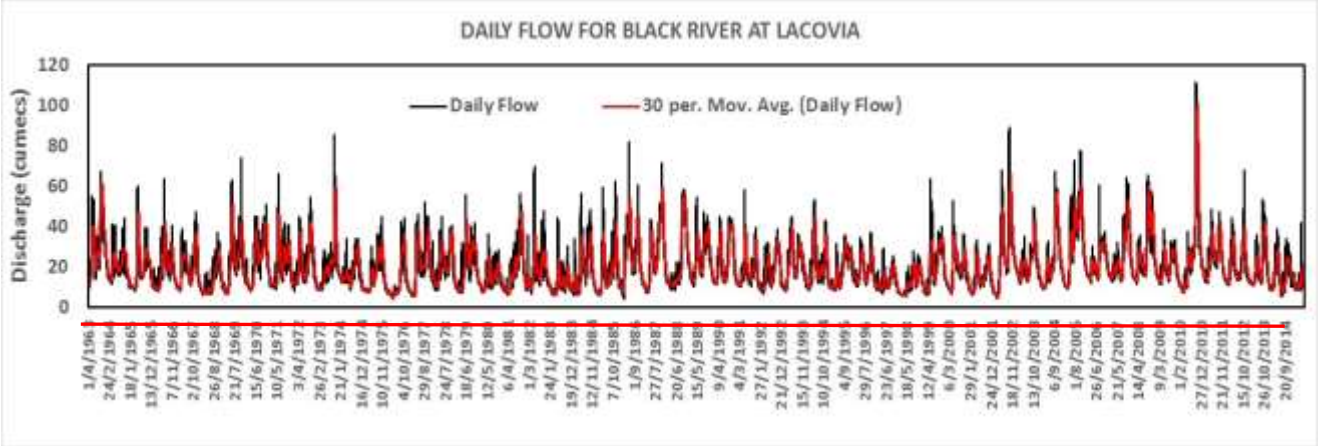


Figure 4:9- Time series plot of daily flow for Black River at Lacovia showing baseflow marked with red line.

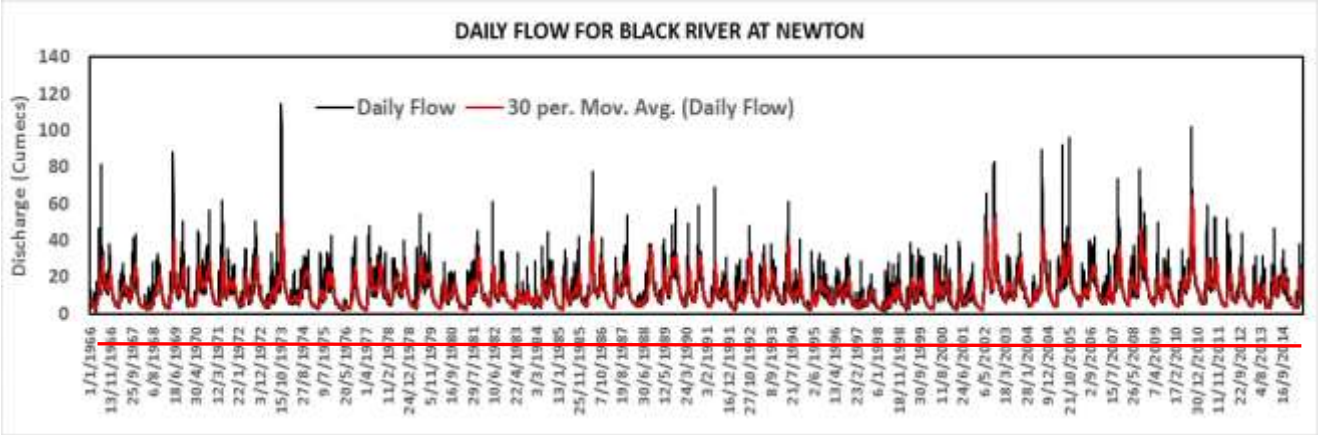


Figure 4:10- Time series plot of daily flow for Black River at Newton showing baseflow marked with red line.

The above plots show that the river shows a consistent baseflow for all the locations of measurements, which correspond to different sections of the river where different levels of abstractions are in operation. Overall, the baseflow values which are low flows and roughly estimated here by drawing a line joining the points of inflection (changes in curvature) of the rising and declining limb of a hydrograph (discharge vs time plot). The 30 day moving average smoothens the hydrograph and shows the extreme flows which are greater than the average and could be due to extreme rainfall which needs to be studied with corresponding rainfall data. Further work is needed to do baseflow separation from daily discharge using computational program. Overall, the baseflow values are higher for the station at Lacovia which as discussed earlier has inflows from the tributaries upstream. The Barton Isle abstraction is located near Newton, hence the trend in baseflow for Newton can be used as a proxy to comment on the sustainability of the river. Data shows that with the present and historical rate of abstraction for aquaculture at Barton Isle, the baseflow and low flow values at Newton has remained consistent and the average Q90 flow is 3.99. Similar is the value for the environmental flow and low flows for the river at Appleton, where abstraction is presently being conducted. Hence, based on the present study with limitations, it can be said that the continued abstractions have not affected the capacity of the river. However further work needs to be conducted on a rainfall-runoff analysis as well as on other possible sources of inflows to the river such as underground resurgences. Additionally if new tourism or agricultural activities are to be conducted in the Morass, and if water for these areas to be abstracted from the river, question arises on the sustainability of the river. This needs to be studied with respect to the type of abstraction, as different rates of abstraction depend on the usage. If tourism is to be centered on new possible discovered waterfalls, it will still not affect the capacity of the water as it will be water from springs, or resurgence from caves etc. There is no direct usage/input of the BR water for this.

If agricultural activities are to be increased in the Upper and Lower Morass and if all the new farms were to use water from the river as irrigation, it is pertinent to study what effect this would have on the capacity of the river. This will depend on the size of the farm and most importantly the type of crops. A study was conducted by JICA in 1984 on the Feasibility of the Lower Morass for Agriculture. It was based on a detailed analysis on the uptake of water by different crop types. The study showed the construction of canals for irrigation and the amount of water to

be diverted from the river through the canals to water the various crops. This needs to be studied in detail and can be extended as a further continuation of the present work. Additionally climate impacts needs to be considered. Any factor affecting the rainfall such as El Nino, climate model predictions of increase in dry spells, low rainfall, etc. will affect the recharge and eventually may cause a decline in the discharge of the river and its capacity.

At present, with the current rate of abstraction, rainfall and recharge, the river is sustainable showing no drastic decline and has maintained the environmental flows.

It is important to note that climate change can also exacerbate the impacts of the hydrology in the future on the area.

Climate change can also change the hydrological equilibrium of the area. Increase in weather conditions such as rainfall or drought will have significant changes on the flow, river level (rise), and temperature of the river. All these changes both directly and indirectly affect flora and faunal composition and a changes in the suitability of activities conducted on the river. To address these challenges, it is important to integrate the issues of climate variability and climate change into resource use and development decisions. In this way the vulnerability of our river basins and other key resources can be greatly reduced.

4.4.2 Water Quality

The effect of water quality on river systems can have both direct and indirect impacts. Based on the properties of water, water is free flowing and therefore its impacts can be widespread and far reaching. Mismanagement and irresponsible land management practices, such as in agriculture and development type activities (tourism activities and waste disposal), can lead to serious negative impacts on not only the ecology, but the socio-economic dynamics of the area. Even though the results indicate that the water obtained from the various sites along BR and its tributaries are within the ambient water quality standards of NEPA, changes in the quality of water (negative) can lead to the following impacts. These impacts will be felt in both the upper and lower reaches of the morass.

1. **Fish kill**

Excessive amounts of nitrates, phosphates (chemical species) and other chemical species can severely disrupt fish populations in any given area. Even though these chemical species occur in the natural environment, they can be enhanced greatly by human activities and interventions. Fish have a limited ability to adapt to changes in these factors and thus their environment. A decrease in the level of dissolved oxygen by an increase in vegetation and/or organic material in the river, or the increase in the level of nutrients and/or chemicals can significantly reduce fish populations whether by death or change in breeding habitats. The indirect impacts of fish kill affect not only the ecology of the area (food chain processes) but the livelihood of various stakeholders such as the fishermen.

2. **Pollution – (water hyacinths)**

An increase in nitrates and other nutrients into the river system can lead to an increase in vegetation and other intrusive plant species (Water Hyacinths). Water Hyacinths have been noted to choke waterways and limit the water surface available on the river for other ecological processes especially along BR and on the Middle Quarters River. A surplus of water hyacinths on the surface also decreases the level of sunlight penetrated and oxygen content beneath; resulting in death and decomposition of submerged flora and fauna. This plant species- the Water Hyacinth (most noted one the river), displaces other plant species and may introduce other invasive species into the ecosystem.

3. **Health and safety- Fecal coliform**

An increase in pollutants in the river (especially in highly populated areas) can lead to serious health and safety issues on the human population. An increase in fecal coliform caused by inappropriate waste disposal practices and inefficient sewage treatment systems results in highly contaminated waters. When the river is used for domestic purposes such as cooking, drinking and other recreational and economic activities such swimming and farming, outbreaks in diarrhea and gastroenteritis can occur.

4.5 Socioeconomic Impacts

As with the ecological impacts, most of the socio-economic impacts on the study area are derived from human based activities from the major users of the river. The impacts imposed on the environment are from activities such as farming (agriculture), fishing, boating, shrimping and other recreational/economic activities. These impacts occur both in the upper and lower morasses, some being more concentrated in a particular region such as shrimping in the LM. The socioeconomic impacts on the river relate directly to the user and are presented below.

4.5.1 Fishing and shrimping in the morass

Overexploitation

Unsustainable practices of fishing and shrimping in the morass can lead to over exploitation of the resources; those that are needed to adequately support the population (human and animal) and the livelihoods of many of the users. Without the proper management and correct guidelines, excessive fishing activities within the morass can lead negative impacts on the resilience of fish populations and the ability of juvenile populations to mature and reproduce. This will result in a further decline in fish catch and yield. Controlling and maintaining the number of fishers and shrimpers who fish within the morass is necessary, including monitoring the amount of species caught per day. Currently, the number of fish caught and sold is sustainable with room for further growth (as fishing is done both at the river and sea). Designated zones for specific fishing activities will be needed to reduce negative impacts and stress on the river system and fish populations and to also prevent overexploitation.

4.5.2 Farmers

Deforestation

The clearing of vegetation and land for farming via the removal of trees/vegetation has many irreversible economic and ecological implications. The illegal and unsustainable removal of trees disturbs natural habitats, often displacing or killing critical species in the area. Both the bird population and the biodiversity of BR have been reduced since studies done by Wade in 1997. Deforestation also drives climate change. Deforestation destroys the quality of the land and quickly dries out the natural soil (loss of tree cover to keep soil moist). Former forest lands can

also quickly become barren deserts as they distort water cycle processes preventing water from returning back into the atmosphere. Soil erosion and landslides are also noted impacts. A few areas within BR have already been identified as an area susceptible to flooding and other environmental impacts (especially in the southern areas) due to the lack of protection from trees and other types of vegetation.

Irrigation and fertilizer use

Excessive use of fertilizers and other pesticides for agricultural purposes significantly affects the water quality and fish yields in the river. During heavy rainfall, chemicals from the soil are leached into water systems resulting in high pollution levels and contaminated waters. The indirect impacts of this include impacts on fish and other aquatic populations (death or populations become displaced) and health and safety risks on the human population. Unsustainable irrigation practices can lead to changes in supply and demand and the availability of water from the river. Uncontrolled and unmanaged irrigation practices can also change ecological and hydrological process currently existing in the BR.

Burning

As mentioned in section 5.1.3, fires are the primary source of vegetation destruction. These fires are primarily for the preparation of lands for agricultural activities. Over time, fires will increasingly impact species composition based on loss of vegetation, and also impact faunal composition due to the loss of needed habitat. Prolonged burning of the morass can also lead to significant air quality health concerns and the impacts associated with this activity will become irreversible.

4.5.3 Boating Activities

Boat Tours

The most popular activity on the BR is the safari tours. The data indicates that on an average day, there are about 15-20 tours at least, traversing up and down the river. Currently there is no significant impact caused by these tours on the river. However, increased activity on the river without the proper management and strategy in place, can lead to crowding on the river. It was observed that there were occasional "bunching" of the boats at areas of interest (Mangrove Avenue and whenever a crocodile was spotted) which led to increased tension among the tour operators. This possibility of congestion on the river can also affect various ecosystems due to increased wave action from the boats and the disruption of nesting sites for animals (fumes and noise from vessels).

The current number of licensed tour operators and fishermen operating motorized and non-motorized vessels can be increased substantially. However, this should be done on the basis that there are strict regulations and management of the area and scheduling of the tours is done so that only a certain amount of boats are present on the river on any particular day.

Speeding

The boats have been noted to travel at a speed of about 10mph going up the river and about 15-20mph on the return leg of the tour. The increase in speed on the return led is mainly due to the fact that boats are encouraged to return quickly to pick up the next set of visitors before they are lost to the competitors. Speeding on the river results in high noise levels and the creation of large waves on the river that degrade river banks and dislodge fish traps set by other users of the river such as the fishermen and shrimpers.

Risk and safety

Even though they are no recorded incidents or catastrophic events on the river, risk and safety issues are of prime concern. The increase number of activities on the river as well as speeding by both the tour operators and informal tour guides greatly increases the risk factor especially as the interaction between human and wildlife (crocodiles) increases. Most of the occupants of the

informal tours were also seen without life jackets on the river. Drowning and other unfortunate incidents are likely to occur if safety on the river is not strictly enforced.

Increase in spills and solid waste on the river (garbage disposal and boat washing)

The increase in activities on the river can lead to a greater possibility of spills on the river (oil from vessels) and pollution from solid waste. Both fishers and shrimpers have suggested that boat washing activities near the mouth of the BR and oil leakage from boats have led to a serious decline in fish catch and in the quality of water. Tributaries are blocked with debris and affect smaller boating activities. As the number of persons in the area increases (visitors/tourists), the chances of pollution due waste and chemicals will also increase.

4.5.4 Other recreational/ economic activities

Other recreational and economic activities such as swimming, picnicking (by Cheese Rock) and kayaking (in designated areas on the BR) can have potentially negative impacts on the environment and carrying capacity of the area in the short and long term. An increase in activities on the river without proper management can lead to risks of overcrowding and health issues (inappropriate waste disposal practices). Even though, the current status indicates that there are no obvious unsanitary practices and there were only a limited number of persons observed swimming at Cheese Rock, growth in development of the area over time, without setting the appropriate management strategies, can lead to tension and competition of space on the river by the different users. The effect on an increase in population on the river due to increased activities can also disturb migratory and nesting habitats for faunal species. The safety of the human population also poses a serious concern. Human and crocodile contact via activities such as swimming should be greatly considered. Zoning of the areas for recreational use is therefore of critical importance.

4.5.5 Lack of interest from the local community

Recent studies reveal that it is the perception of the members within various communities, notably BR, Cheese Rock and Salt Spring, that they are deliberately excluded from sharing in any benefits derived from the increased tourism activities on the river. This has resulted in much tension and animosity among communities and the various tour operators. This is consistent with

the studies that were done by ESL in 1997. Communities continue to feel “abandoned” and a poor relationship exists between the community members and other users of the river, mainly the tour operators. An increase in activities on the river without inclusion of the surrounding communities will lead to further tension and annoyance from the local population on development and future tourism activities in the area.

5 Mitigation Measures

The following mitigation measures are proposed to alleviate the range of impacts (existing and potential) experienced on the morass:

1. Scheduling of the tours
2. Public education and training
3. Institution of a rest day. On this day no tours will be allowed on the river
4. Speed limits for boats on the river
5. A regulatory official/warden to monitor activities and enforce rules and laws
6. Abstraction limits and regulated use of the river
7. Disposal facilities and regulated farming and boat washing activities
8. Community involvement

Table 5-1 below describes the mitigation measures in more detail.

Table 5-1: Impacts and Mitigation Measures for BR and its tributaries

Impact	Current level of intensity (low, medium, high)	Mitigation Measures
Ecological		
Over exploitation of resources	High	• Limit the amount of catch per day • Fish sanctuaries and conservation areas be declared within the morass • Strict rules regarding fishing practices such as no net fishing and the release of fish smaller than 15cm depending on species.
Burning of the morass/vegetation	High	• Institution of a warden to patrol the area to ensure that sustainable practices are enforced and maintained. • Areas restricted to any form of agricultural or farming practices. Zoning of the morass.
Alternation of flow regimes	Medium	• Monitoring and removal of all barriers which are currently impacting waterways in both the upper and LM • Long-term rehabilitation (tree planting) activities to reduce siltation in the LM
Deforestation	Medium	• Patrolling of the area by a warden to ensure sustainable practices

Impact	Current level of intensity (low, medium, high)	Mitigation Measures
		• Areas restricted to any form of agricultural or farming practices. Zoning of the morass
Pollution (solid waste and chemical pollutants)	Medium	• Increase in the amount of disposal facilities and units available on boats and at other recreational centres. • Designated areas for boat washing, mechanical servicing (oil changes), etc. that does not interact directly with the river system
Decrease in species number observed (birds and crocodiles)	High	• Scheduling of tours – it is suggested that departure times should be between 8:00am-11:00am and then from 1:00pm-4:00pm. This will allow intrusion on wildlife within a particular time frame only and restrict the constant interaction. • Maintenance and long-term restoration of the Morass habitat • Tours scheduled 10-15 min apart to prevent congestion and rush to get visitors on to another tour. Less congestion on the river reduces likelihood of accidents, reduces noise and fume levels and disturbance of habitats. This 10min break should be controlled by a site warden. • Only birdwatching tours and fishing activities should be allowed on the river

Impact	Current level of intensity (low, medium, high)	Mitigation Measures
		before 8:00am. • Research and monitoring of crocodile populations and distribution • No evening tours or activities on the river. • A rest day should be implemented- it is proposed that no tours should be allowed on the river on Mondays. This is one of the lowest days for tours and would allow ecosystems to recover such as birds and crocodiles • Training of tour guides to be better informed on the ecology of the area. Guides will be aware of migratory patterns and nesting seasons.
Further introduction of non-native/invasive alien species		• Monitoring of identified non-native and invasive alien species: distribution and density • Determination of a suitable treatment and management strategy specific to each species identified.
Hydrological		
Excessive abstraction from the BR	Low	• Limits on the amount of water abstracted from the BR. • Licences and permits required for all abstractors.

Impact	Current level of intensity (low, medium, high)	Mitigation Measures
Deteriorated water quality over time (increase in fecal coliform etc.) – ***Pollution***	Medium	• Designated areas for boat washing, mechanical servicing (oil changes), etc. that does not interact directly with the river system • Increase in sanitary facilities and practices (education and provision of resources)
Socio-economic		
Crowding on the river	Low	• Only birdwatching tours should be allowed on the river before 8:00am. • No evening tours or activities on the river. • Scheduling of tours between tour operators and informal tour guides. Informal tour guides should start from 9:00am and end at 1pm. • Tours scheduled 10-15 min apart to prevent congestion and rush to get visitors on to another tour.
Risk and safety	Medium	• Each tour scheduled 10-15 min apart to prevent congestion and rush to get visitors on to another tour. Less congestion on the river reduces likelihood of

Impact	Current level of intensity (low, medium, high)	Mitigation Measures
		accidents, reduces noise and fume levels. This 10min break should be controlled by a site warden. • A complete band on the use of jet-skis and restrictions on other vessels that have not been formally approved by RRA and NEPA. • Operators should abide to the "rules of the river" which includes speed limits, all boats keeping on the left of the river and boats reducing speed when passing each other. • Patrolling and enforcement of rules by wardens (Duties and roles are presented in Appendix XI) • Training of tour guides. CPR certified
Speeding	High	• Speed limits be implemented and strictly enforced by assigned wardens • Speed on both legs of the tour should remain the same (12-15mph)
Lack of interest from local communities	High	• Involvement of local communities in activities on the BR (craft selling, vending of food and drinks for visitors, heritage tours. • Visitors should be given at least 15min to walk around the BR while waiting

Impact	Current level of intensity (low, medium, high)	Mitigation Measures
		on tours or after. This should be offered as a package. • Visitors should be given time to engage in heritage tours as a part of the BR safari package. This should be offered as a package. • A craft selling arcade should be developed near the tour operators. • Areas such as Salt Spring and Cheese Rock should be developed more and marketed properly so that visitors are knowledgeable of the area and can support local markets. • Activities should be developed by Salt Spring to allow visitors to experience more than just the tour.
Use of fertilizers and other chemicals	High	• Improved agricultural practices to ensure better application of fertilizers. • Restricted use on fertilizers and pesticides based on location and proximity to the river. • Engagement of RADA in the introduction of integrated pest management strategies to reduce the use of pesticides on farms.

6 Opportunity Zones/Alternative Activities

With respect to opportunity zones, the suggestion is to maintain all current activities at their current locations. However, other zones have been identified within the study area that present additional opportunities/alternatives aimed at reducing the pressure of activities and level of traffic (human and vessels) on existing routes/zones (see section 6.1.1). There would be need to monitor, based on current findings, the number of tours whether through formal tour companies or through informal means (fishers), the number of daily tours as well as the possible establishment of closed or non-tour periods. Figure 6:7 illustrates the proposed designated zones within the study area.

6.1 Identified zones

1. **Recreation docking area:**
    - Boats of varying sizes will be allowed to dock in the vicinity of the mouth of the Black River up to 0.7km up the river.

2. **Recreation and Livelihood Zone – motorized boats/pontoons:**
    - Motorized vessels including pontoons will be allowed up the Black River to the intersection of the BR and Broad River and then along the Broad River up to the point of Salt Spring.

3. **Recreation and Livelihood Zone – non & small motorized boats:**
    - Only small motorized boats (e.g. canoes) and non-motorized vessels will be allowed on the Broad River beyond the Salt Spring Bridge and up to Cheese Rock.

4. **Conservation Zones:**
    - These areas include: YS River, Middle Quarters River, Styx River, Cashew River, and Broad River from Cheese rock up to its source. This area will be designated as Ecological Sanctuaries and Limited Take areas. As such, limited extraction for shrimping and fishing activities will be allowed.

5. Research and Management Intervention Zone:

- Wetland areas surrounding all rivers of the Lower Morass
- Agricultural lands and rivers of the Upper Morass

Rivers are:

1. Elim River
2. Blake River
3. Horse Savannah
4. Smith River
5. Braes River
6. Foster River
7. Mt. de Los Uvas River

6.1.1 Opportunity for Development

Opportunities for development exist in the ***Cascades area*** where a number of small waterfalls are present. Smaller tourism attractions can be allowed within this area. See Figure 6:8.

Other opportunities for development/additional activities have been identified on the BR and Middle Quarters River, where the area seems to be "underutilized" in terms of current activities and usage. These opportunities include introduction of low impact activities such as kayaking, bird watching, canoeing and river rafting (similar to the Rio Grande rafting) along the BR and Middle Quarters River. Bird watching has been considered a viable option for this area due to high biodiversity observed (as compared to Broad River). In this way, traffic on the Broad River could be greatly reduced. Due to the low ecosystem impacts generated from these activities (such as low wave action, reduced speed, little interaction with fauna and flora), these activities can be conducted in this area within the Research and Management Intervention Zone (see Figure 6.7).

River rafting and kayaking activities can occur along the Middle Quarters River strictly while motorized canoes can traverse up the BR to the intersection of the Middle Quarters River. River Rafting and kayaking will be allowed 2km up the Middle Quarters River measured from the intersection of the BR and the Middle Quarters River. Here both bird watching and boat tours can be accommodated. A rafting facility can also be accommodated at this intersection (BR-

Middle Quarters River) where small boats can transport passengers for rafting and kayaking activities (Figure 6.1).

The size of the river rafts allowed can be modelled based on best practices observed on the Martha Brae River in Trelawny.

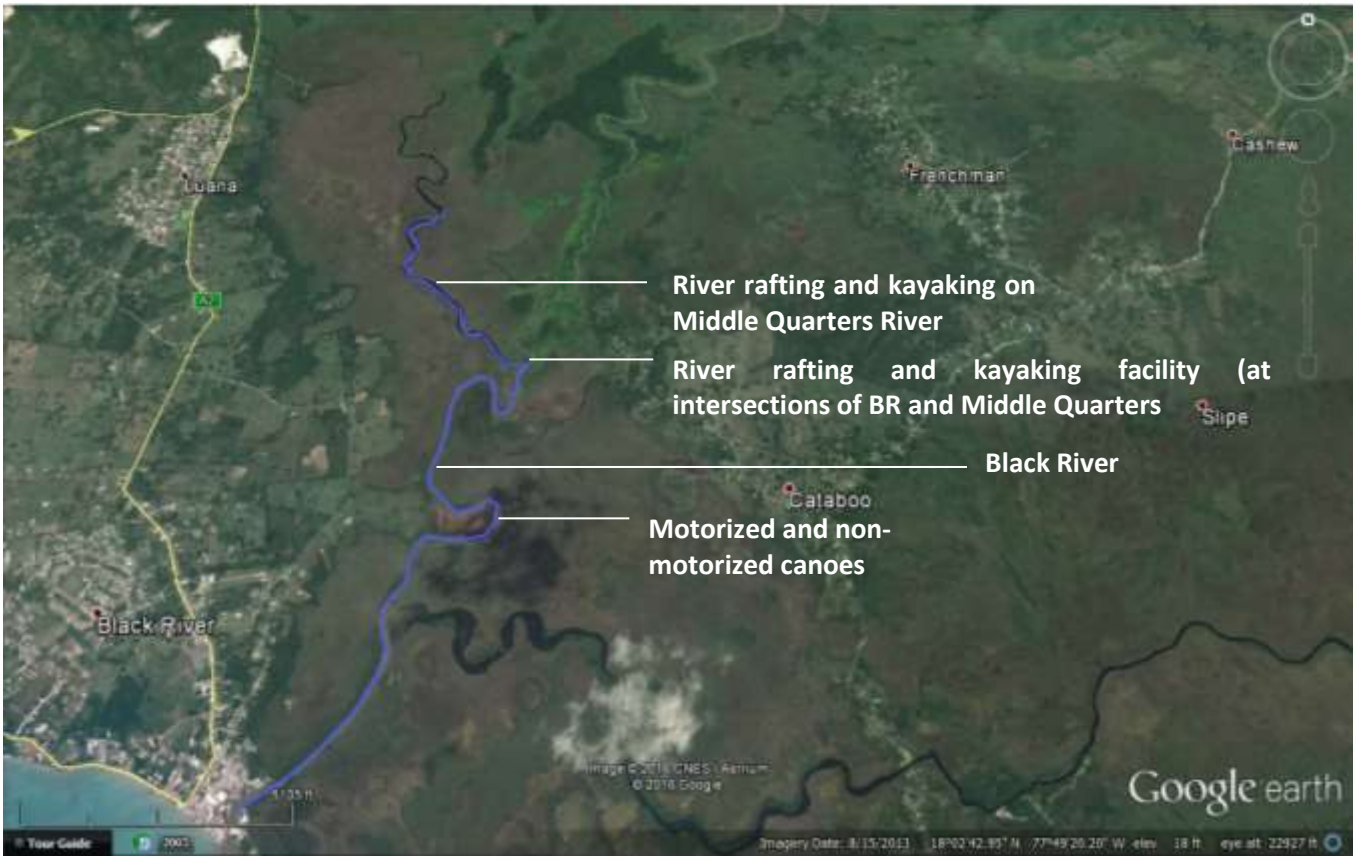


Figure 6:1 Alternative Activities for BR and Middle Quarters River

Source: Google, 2016

However, it must be recognized that:

1) Only low impact activities will be allowed to operate within the designated conservation and research areas.
2) Some shrimpers do utilize regions of Middle Quarters River for their livelihood. Therefore, any additional activity on this river should not compromise the shrimper's ability to catch in this area. Additionally, there should be consultations with these current

users prior to any form of formal implementation to avoid tension and possible crowding on the river. Involvement of the local community in these activities is crucial and essential.

Even though it has been recommended that current activities remain in their existing locations, opportunities still exist on the BR and its tributaries that do not involve the direct and physical contact by humans with the river and its ecosystems. Infrastructure such as trails and boardwalks can be utilized so that the BR is not the primary medium of transport to from activities and experiences (bird watching and observations of the mangroves and crocodiles, swimming). In this way, visitors and locals can experience and interact with the environment and surrounding communities without being in direct contact with sensitive ecological and hydrological processes. Alternative opportunity zones have been identified which are intended to relieve the growing demand presently being exerted on the river and which is expected to increase. The zones identified include;

1. The town of BR
2. The Ponds at Parottee
3. Parottee Beach
4. Land access areas at Cheese Rock and Salt Spring

As is, the main stressor on the river is the passage of motorized boats and canoes (fishing, shrimping and tours) which results in the creation of waves and disruption of ecological habitats. While any one of those activities does not in itself necessarily have a significant negative impact on the river, the combined activities need to be managed to minimize the cumulative impacts.

The Town of BR

The town of BR has a rich history. The main street along the coastline provides a potential zone for redevelopment of the Georgian and Victorian structures that essentially creates a particular character to that stretch, and if restored, would become an attraction in its own right. This would increase the income opportunities to local residents and not leave the river as the only source of income from the growing tourism product. The Jamaica National Heritage Trust has already

declared the area along High Street and a section of Crane Road and this would then be the core of the development area.

"The town has many important historic sites and structures and the buildings are of varying architectural styles. You will find examples of Georgian, Jamaican Georgian, British Colonial and Jamaican Vernacular architectural styles. The predominant ones however, are Georgian and Victorian, which reflect the different periods in the history of the town's development."
Jamaica National Heritage Trust, 2015

The Pond at Parottee and the Wally Wash Pond

The Pond at Parottee (Figure 6:2) is in itself a beautiful and scenic location as is the Wally Wash Pond (Figure 6:3). However, they are known only to the local residents, occasional visitors to Parottee and some adventurous locals and foreigners who enjoy "being of the beaten track." The areas around the ponds have a great potential for low density sustainable development, and as the crocodiles also occupy the ponds, it would provide another location to see them in the wild without having to traverse the river.

Figure 6:2: Parottee Pond

Source: Environmental Solutions Limited, 2015

Figure 6:3- Wally Wash Pond

Source: Google, 2016

The type of access that could be considered could provide an intimate experience without impacting directly upon the natural conditions. One alternative is to have an access to a section of the pond by way of a track/trail/boardwalk which provides a controlled access where the pond can be viewed and would traverse areas occupied by the crocodiles. This could also enhance the attractiveness of the area. An example of this type of interaction is at Shark Valley in the Florida Everglades where access is by a tram on a dedicated roadway only used by park vehicles, bicycles or pedestrians. The erection of a viewing tower is also an option which would again provide an interaction that does not degrade the location. The tower/s for the Parottee Pond would be located in the east so as not to impact on the visual beauty of the pond from its western bank where there are now local residents and small scale developments. These concepts would all be subject to test in the preparation of a development plan.

Figure 6:4 below illustrates an example of a viewing tower that could be implemented in the Parottee Wally Wash Pond area.

Figure 6:4- Viewing Tower

If a visitor's center is located on the eastern side of the Parottee Pond, it would also provide a small economic enterprise within the community near to Spice Grove and it would then be located in between both pond systems extending north to the community of Pondside.

Parottee

The beach at Parottee (Figure 6:5) is somewhat like the Negril beach of 30 years ago and it provides an excellent location for development but with the lessons learnt from the development and growth of Negril and Ocho Rios. The lessons learnt from the small scale low impact tourism of the Treasure Beach area would also be a valuable tool in the development planning for these areas as is presented in the St. Elizabeth Sustainable Development Plan.

Figure 6:5- Parottee Beach

Source: Environmental Solutions Limited, 2015

Land Access

At present the means of accessing the river system is primarily by boat traversing the river from BR up to Salt Spring for the pontoons and Cheese Rock for the canoes. The rudimentary rest stop that was established at Salt Spring should be seen as the potential location for a land based tour where a trail along the river could be established for trams, bicycles and pedestrians. This trail could be extended to areas where there are crocodiles (or where crocodiles are introduced), thereby allowing for an increase in visitor interaction without increasing the river traffic.

Tours would start at the Salt Spring Bridge area and the visitors would be brought to this location which would now expand the ability to absorb more visitors to the area without increasing direct impact on the environment. This could be modelled from the Negril Royal Palm Reserve as illustrated in Figure 6:6 below.

Figure 6:6- Negril Royal Palm Reserve

Source: Ian Gage, 2015

As is recommended above, breeding sites for fish should be established to mitigate against the effects of the waves generated by the boats on the river and faunal populations. This would not only enhance the breeding sites of fish in the river system, but also, increase the birdlife on the river (wading birds and the visiting Ospreys), due to the increased availability of fish (as a food supply) in these areas. Consequently, the fishers would be able to increase their catch with less risk to the sustainability of the fish stock. If this is done in conjunction with conservation efforts in the marine zone, it will lead to a long term enhancement of the fish stock.

All of these developments should be a part of a wider conservation concept, where built into the facilities and tours, would be a conservation theme and financing for conservation. This would be generated from the proposed activities above.

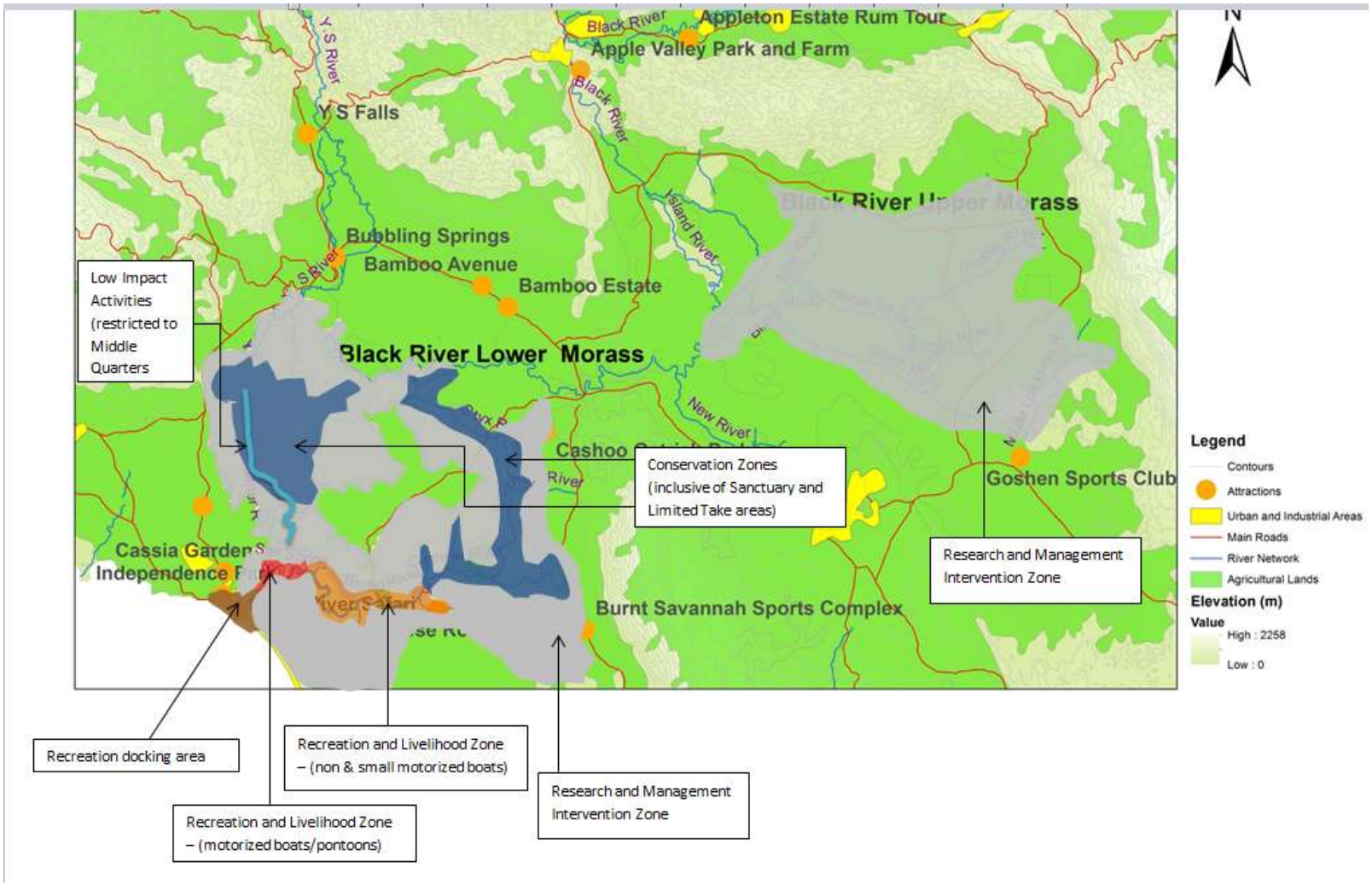


Figure 6:7- Areas of Opportunity for various activities within the study area

Figure 6:8: Opportunity area for small scale tourism

Source: Google, 2015

7 Determining the Carrying Capacity of BR and Recommended Management Strategies and Implementation Plan

7.1 Limits of acceptable change

As stated before in section 1.3, *Limits of acceptable change* can been defined as the variation that is considered acceptable in a particular component or process of the ecological character of a wetland, without indicating change in ecological character, that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (Phillips 2006).

It is useful for managers of a site to understand and describe the ecological character of the wetland, so as to enable site monitoring, identification of management actions and then determine limitations to activities to maintain the ecological character and balance of the site. These monitoring activities will help inform over the long term, the health and status of the wetland.

In order to set limits of acceptable change for the conditions of any area the following are necessary:

1. Determination of ecological character and adequate information to form a baseline against which change can be measured
2. Sufficient information to characterize variability
3. Determination of areas and indicators that can be monitored

In the case of the Black River Morass, the limits of acceptable change would have to be set on two levels, the first in relation to the overall ecology of the wetland and second in relation to direct eco-tourism and livelihood related activities. It is important to recognize that these limits would have to stretch across both the Upper and Lower Morass with possible separation of both areas to have distinct standards. For the upper areas of the wetland, limits of acceptable change should be linked to established indicators. The most probable indicators for the limit of acceptable change would be:

1. Faunal composition (freshwater) within the Maggotty River below the hydropower plant as compared to those below, similarity range should be within 80%.
2. Agricultural encroachment within the morass/wetland must be maintained at or exceed 5% of current levels.
3. Water Quality profiles especially physio-chemical nature remains within 5 – 10% of current standards over a period of 10 years (inclusive of YS falls/river and Maggotty rivers)

For the lower areas of the wetland

1. Mangrove and wetland community densities remain at current levels without acceptable loss of 1% over a period of 5 years
2. Levels of crocodile observation and numbers remain or increase by 10% over a period of 5 years
3. Occurrence of invasive species such as Water Hyacinth decrease by 5% over a period of 5 years
4. Levels of avifaunal species, numbers and observations remain at current levels or increase by 10% over a period of 5 years

Table 7-1 illustrates the combination of the various indicators that were applied for the purposes of this study.

Table 7-1: Ecological. Physical and Socio-economic indicators used in this study

Indicator	Description of Status	Direction (Positive, Negative, Stable)
Ecology - Floral		
Density and Distribution of Mangroves	Density seems stable especially along the two major tributaries	Stable
Flowering pattern of Red Mangroves	Mangrove flower at a specific time of the year	Stable

Indicator	Description of Status	Direction (Positive, Negative, Stable)
Density of occurrence of water hyacinth (Black River)	Density along the Black River seems high, with the possibility of increasing based on nutrient input from upstream	Negative
Water Hyacinth occurrence (Broad River)	Occurrence along Broad River is very low	Positive
Occurrence of agricultural plants within the floral composition of the wetland	Based on burning activities within the wetland, there has been a steady increase in observed species	Negative
Monitoring of swamp communities inclusive of *Sabal jamaicensis* and *Roystonea princeps*	Swamp communities occur throughout the wetlands, however burning activities for agriculture have decreased their presence	Negative
Ecology - Faunal		
Crocodile observations noting age and location	Numbers of crocodiles observed was lower than previous records, however this isn't a clear indication that numbers have decreased as fishers indicated an increase	Stable
Bird species monitoring along all rivers and tributaries	Numbers of bird species observed was lower than previous records, however this isn't a clear indication that	Stable

Indicator	Description of Status	Direction (Positive, Negative, Stable)
	numbers have decreased (could be due to time and day of sampling)	
Monitoring of the occurrence of commercially important fish species	Fish catch reports are that numbers are decreasing	Negative
Monitoring of shrimp and crab sizes captured	Catch reports are that numbers are decreasing, as well as the presence of invasive(shrimp) species	Negative
Physical - Hydrology		
Daily Mean Flow	Shows a weak increasing trend. 30 day moving average shows decadal high and low values.	Average daily flow for all stations stable
Average Yearly Flow	Weak increasing trend. Fluctuations in yearly values could be due to variation in rainfall and recharge	Stable
Mean Monthly Flow	Seasonal variation, high during wet months (Sep-Nov) and low during the dry season.	Stable
Flow Duration Curves	Shows the flows for different probability of exceedance.	Smooth flat gentle slope , stable over the 50-60 yr record
7day low flow	Varies corresponding to years of drought	Stable
Q90 flow (flow that exceeds 90% of the time)	Low flow or baseflow, consistent with variation in	Stable

Indicator	Description of Status	Direction (Positive, Negative, Stable)
	average yearly flow. No decline corresponding to the years for which abstraction data available.	
Water Quality		
Parameters are within ambient standards of NEPA	General water quality is within general standards with few irregularities. Key parameters include: nitrates, phosphates, fecal coliform, TDS, TSS	Stable
Socio-economic		
Expanse of population	Population increasing based on census but not a direct link as a negative impact on BR	Stable
Housing and other development	Evidence of a few unapproved development Existing use of soakaways impact WQ in population areas	Stable
Source of Water	Use of river for domestic purposes, few industry and irrigation. Extraction based on hydrologic analysis indicates minimal impact on the existing flow	Stable
Changes in shrimp catch	Stable catch; however, issue with invasive Red Claw	Stable

Indicator	Description of Status	Direction (Positive, Negative, Stable)
	lobster, which has outgrown the local shrimp species. Reproduction of invasive species is independent of the BR and it's uses	
Changes in fish catch	Decreasing catch, may be attributed to overfishing/ fishing of juvenile fishes/disruption of breeding sites	Negative
Burning	Burning for garbage disposal and land clearing for farming, fires sometimes get out of control	Negative
Boat traffic – numbers and wave action	Traffic numbers have increased but can be tolerated on the river at or near the present levels, wave action	Stable
Level of Chemicals in BR and tributaries	Pesticides and fertilizers used by farmers… impacts evident on BR (water hyacinths) but not evident on other tributaries… WQ within NEPA ambient standards	Negative

Indicator	Description of Status	Direction (Positive, Negative, Stable)
Deforestation	Tree removal for charcoal and wood indicated in Census report and based on observation tree loss when land is burned.	Negative
Customer satisfaction	Customers review on the ecological, physical and social aspects of the tours.	Positive

7.2 Analysis and Application of Carrying Capacity

Figure 7:1 below illustrates areas recommended for recreational boating activities in the BR LM. Sections 7.2.1 to 7.2.3 which follow, outline the recommended Carrying Capacity for recreational boats.

Figure 7:1- Recommended areas of activity

Source: Google, 2016

7.2.1 River Rafting

It is recommended that no more than twenty-four (24) river rafting trips be made in this area (along Middle Quarters) per day with a total of three (3) licensed operators. This means that each operator can facilitate approximately eight (8) trips per day at a maximum. The results based on the monitoring activities over the next three to five (3-5) years can be used to guide whether or not this number can be increased based on cumulative impacts observed.

CALCULATION:

Length along Middle Quarters River = 2000m

Total Area: 2000m X 30m wide = 60,000m^2

Usable area = 10m wide X 2000m = 20,000m^2

Non-usable area = 20m X 2,000m = 40,000m^2

Estimation of raft needs = 5000m^2/raft

Carrying Capacity = 20,000/5000 = 4 rafts X 8hrs per day = 32 raft trips/day

With an average of 32 river rafting trips per day, approximately one hundred and twenty eight (128) visitors could be accommodated daily estimating a maximum of four (4) passengers per trip (excluding the raft captain).

7.2.2 Canoes

Canoes should be allowed to conduct tours along the BR up to the intersection with the Middle Quarters River, as well as along the Broad River up to two thousand meters (2000m/2km) past the Salt Spring Bridge.

Tours by owners of canoes will be allowed to traverse the BR to the Middle Quarters intersection, a total of five thousand meters (5000m/5km) from the main docking area.

It is recommended that a total of twenty-four (24) trips per day can be accommodated in this area. It is estimated that individual operators may conduct two (2) trips per day therefore a total of 12 operators can be accommodated to traverse this route. The primary attraction in this area would be bird watching. Permits and licenses granted should specify the route that is allowed.

CALCULATION:

Length along BR = 5000m

Total Area= 5000m X 30m wide = 60,000m^2

Usable area = 10m wide X 5000m = 50,000m^2

Non-usable area = 20m X 5,000m = 10,000m^2

Estimation of canoe needs = 17,000m^2/canoe

Carrying Capacity = 50,000/17,000 = 3 canoes X 8hrs per day = 24 canoe trips/day

Canoes traversing the Broad River up to the general Cheese Rock area would be allowed to traverse approximately 8.5km (8,500m) of the river from the main docking area. A total of 64 trips per day are estimated. It is further estimated that individual operators may conduct two (2) trips per day therefore a total of 32 operators can be accommodated to traverse this route at maximum. The primary attraction in this area would be crocodiles, mangroves and swimming (at Cheese Rock only).

CALCULATION:

Length along Broad River up to Cheese Rock area = 8500m

Total Area: 8500m X 37.5m wide = 318,750m^2

Usable area = 17.5m wide X 8500m = 148,750m^2

Non-usable area = 20m X 8,500m = 170,000m^2

Estimation of canoe needs = 17,000m^2/canoe

Carrying Capacity = 148,750/17,000 = 8 canoes X 8hrs per day = 64 canoes trips/day

With an average of 64 canoe trips per day, approximately five hundred and twelve (512) visitors could be accommodated daily estimating a maximum of eight (8) passengers per trip (excluding boat captain and second).

7.2.3 Pontoons

Pontoons will be allowed to conduct tours from the main docking area along the Broad River to the Salt Bridge. This is approximately six thousand five hundred meters (6500m/6.5km) in length. A total of forty (40) trips per day are recommended. With individual operators conducting a maximum of seven (7) trips per day, a total of 6 tour operators may be allowed to conduct such tours.

CALCULATION:

Length along Broad River up to Salt Bridge = 6,500m

Total Area: 6500m X 50m wide = 325,000m^2

Usable area = 30m wide X 6500m = 195,000m^2

Non-usable area = 20m X 6,500m = 130,000m^2

Estimation of pontoon needs = 36,000m^2/pontoon

Carrying Capacity = 195,000/36,000 = 5 pontoons X 8hrs per day = 40 pontoon trips/day

With an average of 40 pontoon trips per day, approximately 800 visitors could be accommodated daily estimating a maximum of twenty (20) passengers per vessel per trip.

7.3 Recommended Management Strategies and Implementation Plan

This section details the management strategies/recommendations for each alternative opportunity zone identified in section 6 above, as well as for the general study area. Table 7-2 also describes those entities responsible for carrying out the recommended strategies and prescribed standards in the implementation plan (Table 8-1).

It should be noted that on-going monitoring should take place to determine impacts of activities and usage of the BR overtime. Monitoring activities to determine level of impact imposed in the environment by existing and additional activities should focus on the ecological and hydrological aspects of the river in particular, fish population, bird population, crocodile population, shrimp/crustaceans population, mangrove density and water flow analysis.

Collaboration with other institutions such as UWI should also be done to ensure on-going monitoring and research in the area.

Table 7-2: Management strategies for opportunity zones and Implementation Plan

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
Recreational Docking Zone	1. No washing of boats and disposal of oil in river or near by 2. All waste materials (solid or liquid) produced by the boats or other sources should be discarded in appropriate garbage receptacles on land away from waterways.	1. All users of the river should have a certified license and relevant permits from the RRA, NEPA, Fisheries Division and TPDCo to use the river and conduct any form of activity. 2. An adequate number of garbage receptacles must be visually present at each safari tour for visitors and other individuals to dispose of solid waste. This waste must be collected from these receptacles and disposed of at a an approved solid waste disposal site.	River Rafting Authority and Marine Police, Fisheries Division	On-going
Recreational and Livelihood Zone	1. The number of boat tours per day and other recreational	1. Making permits and licences more accessible to users/fishers. 2. Proper scheduling of tours and a	TPDCo, River Rafting	Scheduling should be

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
(motorized boat and pontoons)	activities are as outlined in section 7.2 with possible merger of smaller fisher non-motorized tours. 2. A "rest day" should be implemented (Monday). No activity on the river should take place on this day as to allow the various ecosystems to recoup. 3. Boats are not allowed to remove or rest crafts along mangroves or any other vegetation during tours.	break period where no tour activities are allowed on the river for that time period each day. This is to ensure that faunal species especially crocodiles have time for crucial physiological habits e.g. temperature regulation. 3. All boats should maintain a distance of 2m or more from ecological resources, fauna and flora. This is to ensure that there is minimal direct contact between the environment and the human population 4. Constant monitoring and patrolling by Marine Police and wardens to ensure that users abide by the safety rules. Permission for arrest	Authority and Marine Police	phased in over a 1-year period and implemented/ monitored over subsequent years.

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	4. Feeding of animals is strictly prohibited 5. Rest and food areas for tours are to implement strict pollution control measures including, liquid and solid wastes. 6. Removal of plant specimens is strictly prohibited along tours (especially mangrove seedlings and any other endemic species) 7. Safety protocols are to be developed	if warranted (based on illegal activities or disturbance) and the issuing of fees due to violation of rules should be granted.		

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	procedures are to be implemented for operations on and along the river			
Recreational and Livelihood Zone (small motorized non-motorized boats)	1. The number of small boat tours per day should be limited to 64 tours (Broad River-Cheese Rock) with no more than 8 visitors per boat. 2. The number of small boat tours per day should be limited to 24 tours (Black River to Middle Quarters intersection) with no more than 8 visitors	1. Tours starting at 8:00am-11:00am and then from 1:00pm-4:00pm.A break period between 11:00am-1:00pm should be enforced where no activities are allowed on the river for that time period each day. This is to ensure that faunal species especially crocodiles have time for crucial physiological habits e.g. temperature regulation. 2. Generation and monitoring of registered tour guides and operators, with categorisation in small motorized and non-	TPDCo, River Rafting Authority and Marine Police	Scheduling should be phased in over a 1 year period and implemented in subsequent years

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	per boat. 3. Proper scheduling of tours between small tour guides. 4. A rest day should be implemented (Monday), that is no activity on the river so as to allow the various ecosystems to recoup. 5. Boats should not remove, or rest crafts along mangroves or any other vegetation during tours. 6. Feeding of animals is strictly prohibited 7. Rest and food areas	motorized. 5. All boats should maintain a distance of 2m or more from ecological resources, fauna and flora except when swimming at Cheese Rock. This is to ensure that there is minimal direct contact between the environment and the human population 3. Constant monitoring and patrolling Marine Police and wardens to ensure that safety rules are abided by. Permission for arrest and the issuing of fees due to violation of rules should be granted		

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	for tours should be kept free of all possible chemical pollutants and that there is no seepage into the river (especially through soil leeching) 8. Avifaunal tours are conducted during peak observation periods of wetland birds (mid-morning) and should coincide with other safari tours identifying specific locations where the activity can occur.			

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	9. Removal of plant specimen is strictly prohibited along tours (especially mangrove seedlings) 10. Life vests should be worn at all times along the river			
Conservation Areas (Shrimping, Fishing)	1. Catch weight should be no more than XX lbs per day. An amount to be determined by the Fisheries Division/NEPA 2. Fishers and Shrimpers are limited to 5 catch days per week	1. Monitoring schedules for shrimp, fish and other identified macro vertebrates developed and implemented. 2. Generation and monitoring of registered tour guides and operators, with categorisation in small motorized and non-motorized. 3. Weekly reports on catch number	NEPA,UWI and Marine Police	Scheduling should be phased in over a 1 year period and implemented/ monitored over subsequent

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	3. Shrimp pots must be of a standardised mesh size. 4. Fishing methods must be through the use of line fishing. The use of large nets and trawling as methods of catch is strictly prohibited. 5. The designated no-take zone/sanctuary (fish, shrimp and all other macro vertebrates (e.g. crabs) is strictly enforced.	and size should be generated by a team leader for each area. 4. Research programme developed and implemented for indicator species. Key studies would be long-term population distribution and density of these species (endemic flora, birds and crocodiles) 5. Research programme developed and implemented for invasive species. Key studies would be long-term distribution and density of species such as Water Hyacinth and Red Claw Lobster.		years

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
Research and Management Intervention Zone	1. Research programme and protocols developed 2. Best Management Practices developed and implemented (Conservation and Agricultural) 3. All other activities in this area is strictly prohibited with the exception of river rafting and other low impact activities as identified in section 7.	1. Research programme developed and implemented for indicator species. Key studies would be long-term population distribution and the dynamic distribution of these species (endemic flora, birds and crocodiles) 2. Research programme developed and implemented for invasive plant and animal species. Key studies would be long-term distribution and density of these species	NEPA, UWI	Scheduling should be phased in over a 1 year period and implemented in subsequent years
Recreational Waterfalls	1. Visitor numbers should be kept below 100 visitors per day	1. Monitoring and evaluation schedule developed and implemented	TPDCo, River Rafting	Scheduling should be phased in over

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
Swimming and picnicking	for a period of 5 years, with possible review for increase after this period. Environmental and ecological processes must have been maintained during the monitoring period; 2. All national health safety standards are adhered to; 3. Physio-chemical levels of water (pre and post the site) are maintained at current levels for a period of 5 years, and in		Authority	a 1 year period and implemented in subsequent years

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	accordance with international and/or national measures for such recreational establishments.			
Farming	1. Best Management and Agricultural Standards developed and implemented 2. Use of pesticides and fertilizers should be applied as required or a maximum of 4 times yearly. 3. Irrigation of agricultural land from the BR should be done under the correct	1. Monitoring of agricultural practices 2. Sensitization and Training sessions conducted 3. Patrolling of the area by wardens and enforcement officers to ensure that farming practices are maintained and practiced and there are no illegal activities such as burning of the morass and the cultivation of other plants occurring.	RADA, NIC, WRA	This should be done over a period of 3-4 months. This includes training and sensitization programs.

Opportunity Zone	Prescribed Standard	Management Strategy/Recommendations	Responsible Entity	Time Frame
	permits and licenses 4. Disposal of waste into tributaries and other waterways is prohibited. 5. The burning of the morass is prohibited unless permission has been granted from the relevant institutions.			

8 Implementation Plan/Schedule

Table 8-1: Implementation Plan and Schedule for the study area

Management Intervention	Year 1	Year 2	Year 3	Year 4	Year 5
Recreational Docking Area					
All users of the river should have a certified license and relevant permits from the RRA, NEPA, Fisheries Division and TPDCo to use the river and conduct any form of activity.					
Recreational and Livelihood Zone (motorized boat and pontoons)					
Control of boat traffic and numbers as outlined in 7.2					
Bird watching Proper scheduling of tours and a break period where no activities are allowed					

Management Intervention	Year 1	Year 2	Year 3	Year 4	Year 5
on the river for that time each day. Bird watching activities should take place before 9am everyday on the Black and Middle Quarters River. Pontoons will be able to conduct bird watching tours on the Broad River					
Recreational and Livelihood Zone (small motorized non-motorized boats)					
Tours starting at 8:00am-11:00am and then from 1:00pm-4:00pm. A break period between 11:00am-1:00pm should be enforced where no activities are allowed on the river for that time each day.					
Conservation Areas (Shrimping, Fishing)					

Management Intervention	Year 1	Year 2	Year 3	Year 4	Year 5
Monitoring schedules for shrimp, fish and other identified macro vertebrates developed and implemented	Schedule Development				
		(Implementation)			
Generation and monitoring of registered tour guides and operators, with categorization into small motorized and non-motorized.	Schedule Development				
		(Implementation)			
Research programme developed and implemented for indicator species. Key long term studies for both upper and lower morass) of population distribution and density of (endemic flora, birds and crocodiles).	Schedule Development				
		(Implementation)			
Research programme developed and implemented for control and/or	Schedule Development				

Management Intervention	Year 1	Year 2	Year 3	Year 4	Year 5
removal of invasive species. Key studies would be long-term distribution and density of these species.		(Implementation)			
Research and Management Intervention Zone					
Research programme developed and implemented for indicator species. Key studies would be long-term population distribution and dynamic of these species (endemic flora, birds and crocodiles)	Schedule Development				
		(implementation)			
Research programme developed and implemented for invasive plant and animal species. Key studies would be long-term distribution and density of these species	Schedule Development				
		(Implementation)			

Management Intervention	Year 1	Year 2	Year 3	Year 4	Year 5
Monitoring and evaluation schedule for BMP developed and implemented	Schedule Development				
		(Implementation)			
Recreational Waterfalls Swimming and picnicking					
Monitoring and evaluation schedule developed and implemented	Schedule Development				
		(implementation)			
Farming					
Mapping and Monitoring of agricultural practices/activities	Schedule Development				
		(Implementation)			
Sensitization and Training sessions conducted re: Best Management					

Management Intervention	Year 1	Year 2	Year 3	Year 4	Year 5
Practices and Land Husbandry techniques					

9 Conclusion

The results from this study indicate that the ecology, hydrology and socio-economic conditions of the study area have not undergone any significant changes since studies that were done in 1997 and 2010. However, activities that were once impacting the environment such as speeding on the river, burning of the morass or other types of vegetation and cutting of the trees have continued and may have increased, resulting in changes in the environmental and social conditions of the BR morass.

One very noticeable change/impact is the reduction in avifaunal species observed on the river particularly on the Broad River. Due to the increased boating activities and human encroachment on the area, the number of species observed have declined as nesting habitats have been removed or disturbed and the loud noise and fumes from boating and burning have displaced many.

Apart from changes in avifaunal numbers and small changes in nutrients levels in the water primarily along the BR (resulting in numerous Water Hyacinths), the consultants have been unable to detect any other critical effects on the Ecology of the wetland from tour operators and other activities such as fishing and shrimping. However, concern has been raised in regards to the creation of waves along the river and the speeding of boats which results in increased turbidity and destruction of habitats. All users of the BR appear to co-exist harmoniously, utilizing the river as best as possible.

In regards to community members especially from the Salt Spring Community and Cheese Rock and other operators from the Treasure Beach area, tension and animosity still exists as they feel that benefits of the BR are not extended to them. It is the view of the consultants that unless the communities in the area are involved in existing and future activities (tours along BR, vending, etc.) of BR, then these operations will not remain sustainable.

Numerous management issues have been identified, resulting in many of the problems along the river. Lack of regulation and enforcement has impacted the overall operations of the river and it is essential that these issues be solved before there is any increase in activities along the BR and

its tributaries. If not, current and future levels of activities will be in jeopardy of falling a apart, as competition, conflict and congestion in the area becomes unbearable.

Additional activities can be included in the study area such as river rafting along BR, Cascades recreational centers (waterfalls) and an increase in the number of fishermen granted permission for conducting tours along the river if careful planning and management takes place.

Based on ecological, physical and socio-economic studies conducted on BR and its tributaries, it is the opinion of the consultants that the carrying capacity of the study area has not been surpassed. However, to ensure that the area remains within its carrying capacity and that there is on-going sustainable use of the resources, strict regulations and management of the area is needed and a defined management authority is to be established with the appropriate rules and legislation to provide them with the authority and resources to carry out their management function.

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Appendix I (Legislative, Policy and Institutional Responsibilities)

Relevant Legislation

The following legislations have been considered relevant to this project:

The Natural Resources Conservation Authority Act (1991)

The Natural Resources Conservation Authority Act (NRCA) provides for the management, conservation and protection of the natural resources and is the chief Environmental Act for Jamaica. The Act NRCA is tasked with the role of effectively managing the physical environment of Jamaica. A noted provision of this Act is that it gives the NRCA the power to directly request as a condition for receiving a permit, an Environmental Impact Assessment, if the activities are likely to have an adverse impact of the environment. This is also for existing projects undergoing expansion. NRCA's powers and responsibilities include the following:

- Establishing and enforcing pollution control and waste management standards and regulations;
- Guiding environmentally appropriate development through such tools as prescribing areas;
- Requiring environmental impact assessments, and granting permits and licenses;
- Maintaining a system of national parks and protected areas. It is important to note that NEPA is responsible for the protected areas that are declared/ designated under Acts it administers such as the NRCA Act, Wild Life Protection Act and the Beach Control Act.
- Promoting broad public awareness through information, environmental education and outreach activities;
- Monitoring and enforcing environmental laws and regulations, especially those including in the NRCA, Beach Control, Watershed Protection, and Wild Life Protection Acts;
- Providing national environmental leadership and support local, non-government efforts at protecting and enhancing the environment;

The Wild Life Protection Act (1945) *Amended 1991*

This Act is primarily concerned with the protection of specified species of fauna and precludes the hunting of any protected species. The Act also stipulates the periods for hunting; prescribes the conditions for such activities and the penalties for going in contravention of these provisions. The Act prohibits the removal, sale, or possession of protected animals and the use of dynamite, poison or other noxious material to kill or injure fish. It also prohibits the discharge of trade effluent or industrial waste into any harbour, stream, river canal etc. However, it has been superseded by the NRCA Act which provides for permits or licenses for the discharge of trade effluent into waters. There is also Draft Trade Effluent and Sewage Regulations promulgated under the NRCA Act and these regulations incorporate trade effluent standards which specify limits for discharges of trade effluent and draft ambient water quality Standards.

The Fishing Industry Act (1975)

This Act is the main piece of legislation that provides for the regulation of the fishing industry in Jamaica. Along with this Act are the Fishing Industry (Exemption) Order, 1976; The Fishing Industry (Declaration of Closed Season) (Lobsters) Order, 1987 and the Fishing Industry Regulations, 1976. The Act (1975) gives the Fisheries Division responsibility for licensing fishermen and fishing boats, protection of the fishery by establishment of closed seasons, creation of special fishery conservation areas, and penalties for landing or sale of illegally caught fish. The Director of Fisheries, is empowered by the Act to issue licenses, and is required to keep a register of all licenses issued. In addition to the license to fish, every boat used for fishing whether for business, recreation or sport, must be registered under the Act and the owner of the boat must possess a license authorizing the boat to be used for fishing.

Fishing Industry (Special Fishery Conservation Area) Regulations (2012)

The Fishing Industry Regulations Legislation states that no person shall fish in a special fishery conservation area except in accordance with a:

a) License issued by the Licensing Authority under the provisions of the Act and
b) The provisions of the directions issued by the Minister under regulation 5.

Special Fishery Conservation Areas are reserved for the reproduction of various fish populations. Their nature reserve statuses are declared by the Agricultural Minister under the Fishing Act (1975) and therefore punishable by law to engage in any unauthorized fishing activities in the designated areas. Therefore, any person who contravenes this legislation or commits an offense against it will be liable on summary conviction before a Resident Magistrate to a fine not exceeding one thousand dollars. There are 14 declared marine protected areas and of these include: Galleon Harbour, that is located within St. Elizabeth.

This Act establishes the Central Health Committee with the local bodies being resident under the Parish Council of respective parishes. The functions and powers of the local boards are also outlined under this Act for the enforcement of all regulations and orders. There are provisions under section 14 which empowers the designated Minister to make regulations relating to air and soil pollution, occupational diseases and employment health hazards and for the control and destruction of rodents, mosquitoes and other insects, termites, and other vermin.

The Public Health Regulation (1976) aims at controlling, reducing, removing or preventing air, soil and water pollution in all possible forms. The Environmental Control Division (ECD) in the Ministry of Health administers the Public Health Regulations under which air, soil and water pollution standards are established and monitored.

The Endangers Species (Protection, Conservation and Regulation of Trade) Act (2000)

This Act serves to provide for the protection, conservation and management of endangered species of wild fauna and flora and for the regulation of trade in such species and for connected matters. The objectives of the Act are to facilitate Jamaica's compliance with its obligations under the Convention on International Trade in Endangered Species of Wild Fauna and Flora and to further the protection, conservation and management of endangered species of wild fauna and flora of Jamaica and other countries by regulating –

i. The exportation of specimens that are or are derived from indigenous Jamaican animals or plants;
ii. The exportation and importation of specimens that are or are derived from animals or plants which
    a. Are threatened with extinction and are or may be affected by trade

b. May become so threatened if international trade in specimens of such species is not subject to strict regulation;
c. Require or are likely to require protection or the corporation of other States in order to prevent or restrict exploitation'

iii. The importation of animals or plants the introduction of which has or is likely to have an adverse effect on the habitats and species of indigenous Jamaican animals or plants;

iv. The exportation or importation of specimens that is difficult to distinguish from specimens (live or dead plant or animal specimens).

River Rafting Act

The River Rafting Act serves to govern river rafting and its activities in Jamaica. The Authority under this act functions to carry out the following:

1. Regulate and control river rafting in Jamaica.
2. To develop, within the limits of its resources, river rafting in Jamaica, and to promote the efficient operation of river rafting in Jamaica;
3. To offer, by way of trade or business, or to encourage others so to offer, any goods, equipment, entertainment, transportation, food, drink or service to patrons of river rafting, where it considers it is desirable so to do;
4. To encourage, by such measures as it thinks fit, the attainment and maintenance of the highest standards of service by rafts men and other persons who offer or provide by way of trade or business any goods, equipment, entertainment, transportation, food, drink or service to patrons of river rafting;
5. To perform such other functions in relation to river rafting in Jamaica as the Minister may from time to time determine;
6. To make all such enquiries and to collect all such information as it may think necessary or desirable for the purpose of carrying out its functions, and to examine, in consultation with such organizations and persons as it considers appropriate, problems affecting the) operation of river rafting in Jamaica; and

7. Generally to take all such other lawful measures as it may consider likely to assist it in carrying out most effectively the purposes of this Act.

The Town and Country Planning (St. Elizabeth Parish) Provisional Development Order (1976)

The intentions of this Order is to make provision for the orderly and progressive development of the Parish of St. Elizabeth and to enable the St. Elizabeth Parish Council as local planning authority, to regulate general developments within the entire Parish. BR has been considered the principal urban community within St. Elizabeth. The provision of basic infrastructure, social services and amenities will be given priority for its development. Local commercial centers are expected to develop in these places and it is important that proper siting and other considerations be observed. Urban development will occur in the following areas relevant to the study area:

- BR
- Middle Quarters
- Lacovia
- Maggotty
- Siloah and
- Balaclava

The Tree Preservation Order

This order falls under the Town and Country Planning Act. The order provides for the protection of all trees from destruction or mutilation of any kind, except with the express permission of the local planning authority under the National Land Policy (1996).

Conservation of Natural Resources

Under the NRCA, areas that require controlled management of development have been clearly outlines. These areas are those of outstanding landscape beauty, areas of outdoor recreational potential, areas of special scientific interest due to the presence within the area of unique flora or fauna, areas with vulnerable watersheds, National parks or access along coastlines. No

development will be permitted in these areas which would conflict with the policies being followed by the NRCA or any other such authority.

Historic Sites and Building

BR and Lacovia Tombstones are protected by the provisions of the Jamaica National Heritage Trust Act (JNHTA) and have been listed as monuments by the Jamaica National Heritage Trust. It is hoped that owners of property on which there are historic relics will restore and preserve them to cause them to be preserved and restored within a compatible environment and within the context of viable development where this is contemplated.

Relevant Policy and Regulations

The following policies and regulations have been considered relevant to this project:

The National Land Policy (1996)

The goals and objectives of this Policy are to ensure the sustainable, productive and equitable development, use and management of the country's natural resources. It is comprehensive in order to achieve complementary and compatible development which is in harmony with the socioeconomic development initiatives of the country. It allows for the development and implementation of a rational set of strategies, programs and projects to facilitate stable and sustainable development. Chapter 3 of the National Land Policy includes rural development and the protection of watershed and fragile areas, exploitation of mineral resources, and crop and livestock production.

Policy for Jamaica's System of Protected Areas (1997)

Jamaica has a rich and diverse natural heritage created by its geographical location and its varied topography, geology and drainage. In the face of deteriorating environmental conditions, a system of protected areas provided the means to conserve and ensure the sustainable use of Jamaica's biological and cultural resources. The NRCA is the organization charged by the Government with responsibility for overall environmental management. It has the pivotal role in the establishment of a National System of Protected Areas. NEPA along with other governmental

organizations such as The Forestry Department, Fisheries Division and Jamaica National Heritage Trust also have an important role to play in the establishment of the system.

Mangrove and Coastal Wetland Protection Draft Policy and Regulations (1996)

Government has developed the mangrove and coastal wetlands protection policy and regulation in order to promote the management of coastal wetlands to ensure that the many benefits they provide are sustained. The policy sets the following five goals in support of the overall aim of sustainable use of wetlands:

i. Establish the guidelines by which wetlands can be developed in order to ensure their continued existence;
ii. Bring to an end all activities carried on in wetlands which cause damage to these resources;
iii. Maintain the natural diversity of the animals and plants found in wetlands;
iv. Maintain the functions and values of Jamaica's wetland resources;
v. Integration of wetland functions in planning and development of other resource sectors such as agriculture, forestry, fisheries, ecotourism, and waste management;

The policy specifically seeks to:

- Provide protection against dredging, filling, and other development;
- Designate wetlands as protected areas;
- Protect wetlands from pollution particularly industrial effluent sewage, and sediment;
- Ensure that all developments planned for wetlands are subject to an Environmental Impact Assessment (EIA);
- Ensure that traditional uses of wetlands are maintained;

The Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013

Because of the existing damage and threats to water quality in various basins, it is vital that steps are taken to arrest or reverse the pollution and to remove the threats posed to water quality by human activities. These measures require reduction in the amounts of untreated sewage, trade effluent and industrial sludge that contaminate water basins. The Regulations address sewage

and trade effluent, industrial and sewage sludge, and provide regulatory means to manage wastewater releases from human activities in Jamaica.

The regulations, inter alia:

- Identify facilities that need to obtain licenses;
- Specify monitoring and reporting obligations;
- Promulgate various standards (trade effluent, sewage effluent and sludge) that the licensees' effluent or sludge must meet; and
- Specify sampling and analytical methods that are to be used to monitor effluent and sludge quality.

The Natural Resources Conservation (Permits and Licenses) Regulations (1996)

Under the NRCA Act of 1991, the NRCA is authorized to issue, suspend and revoke permits and licenses if facilities are not in compliance with the environmental standards and conditions of approval stipulated.

Ambient Water Quality Standard (Marine)

Table 1 highlights the Ambient Water Quality Standard for Marine Ecosystems as stipulated by NEPA.

Table 1- Draft Jamaica National Ambient Water Quality Standard – Marine Water, 2009

Parameter	**Measured as**	**Standard Range**	**Unit**
Phosphate	P*	0.001-0.003	Mg/L
Nitrate	N**	0.007-0.014	Mg/L
BOD_5	O	0.0-1.16	Mg/L
pH		8.00-8.40	
Total Coliform		2-256	MPN/100ml
Faecal Coliform		<2-13	MPN/100ml

*Reactive phosphorus as P

**Nitrates as Nitrogen

Relevant International Treaties

Jamaica is signatory to a number of international treaties and conventions that obligate signatories to take wide ranging measures in support of environmental protection and sustainable development, including enacting enabling legislation. Those relevant to this project include:

Convention on Biological Diversity, Rio de Janeiro, 1992

The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has 3 main objectives. The objectives of this Convention include conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

Convention on Wetlands of International Importance especially as Waterfowl Habitats [Ramsar Convention]

The Convention on Wetlands of International Importance especially as Waterfowl Habitat is an international treaty for the conservation and sustainable utilization of wetlands, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. The Convention came into force in 1975. The mission of the convention is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world" (Ramsar site, 2015).

Parties who sign of the Ramsar agreement commit to working towards the wise use of all their wetlands; cooperate internationally on transboundary wetlands, shared wetlands systems and shared species; and designate suitable wetlands for the list of Wetlands of International Importance and ensure their effective management.

The Black River Morass has been identified as a Ramsar site under the Ramsar Convention.

Protocol on Specially Protected Areas and Wild Life [SPAW] to the Cartagena Convention on the Protection of the Marine Environment of the Wider Caribbean Region

The Protocol Concerning Specially Protected Areas and Wild Life (**SPAW Protocol**) was adopted in 1990, and entered into force in 2000. The SPAW Protocol seeks to "Take the necessary measures to protect, preserve and manage areas that require protection to safeguard their special value, and threatened or endangered species of flora and fauna," in a sustainable way.

The objectives of the SPAW Sub-Program are to assist Governments in meeting the provisions of the Protocol and to:

1. Significantly increase the number, and improve the management of, protected and/or managed areas in the Wider Caribbean Region (WCR), including support to national and regional conservation management strategies and plans.
2. Support the conservation of threatened and endangered species and sustainable use of natural resources to prevent them from becoming threatened or endangered.
3. Develop strong regional capability for information exchange, training and assistance, in support of national biodiversity conservation efforts; Coordinate activities, and develop synergies, with the Secretariat of the Convention on Biological Diversity (CBD)**,** as well as other biodiversity-related treaties and initiatives, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora(CITES), the Convention on Wetlands/Ramsar Convention, the Convention on the Conservation of Migratory Species of Wild Animals (CMS)/Bonn Convention, the Western Hemisphere Conventions, the Inter-American Convention for the Conservation of Sea Turtles (IAC), the International Coral Reef Initiative (ICRI) and the Western Hemisphere Migratory Species Initiative (WHMSI).

Functions and Roles of Key Government Stakeholder Institutions

Key stakeholder institutions viewed to be integral to the BR study area include: The Forestry Department, the Fisheries Division, Fishing Industry (Special Fishery Conservation Areas), Jamaica National Heritage Trust, River Rafting Authority, Tourism Product Development fund, and the Parish Councils.

Forestry Department

The main function of the department is "*aimed at managing forests on a sustainable basis to maintain and increase the environmental services and economic benefits they can provide*" (Forestry Department, 2015). Many of the mandates for the Forestry Department are outlined in the Forest Act of 1996. These mandates correlate very closely with those of the NRCA and include (but not limited to):

a. Declaring Forest Reserves, "protected areas" and Forest Management areas;
b. preparing management and conservation plans;
c. Providing recreational facilities;
d. protecting biological diversity, and
e. Enforcing compliance to laws and regulations

Fisheries Division

A Fish Sanctuary according to the Fisheries Industry Act is simply an area where no fishing is allowed to take place. With the invasion of Lionfish in particular there was a need to be able to fish or cull lionfish within Fish Sanctuaries. Under the law however this act would not be possible. The Fisheries Division therefore decided to change the designation of Fish Sanctuaries and instead put in place as a temporary measure (until the new Fisheries Act is in place) **Special Fishery Conservation Areas (SFCA)**, which would allow for special permitted activities such as lionfish culling and appropriate research activities that may require the removal of fish. This name and designation change occurred in 2012.

The Fisheries Division within the Ministry of Agriculture and Fisheries plays a major role in regards to the Protected Area System in Jamaica. The BR LM has been declared a protected area and therefore fishing activities within this area is regulated and monitored. The Fisheries

Division is guided by the Fishing Industry Act and the Fishing Industry Regulations (1976) which regulate and monitor fishing activities in Jamaica.

a. The Division manages 14 designated areas known as the Special Fishery Conservation Areas (regulated under the Fishing Industry Regulations).
b. Provides important guidance to marine protected area managers in setting up replenishment zones and regulating fishing activities;
c. Facilitates active stakeholder engagement with fishermen in marine protected area planning and management activities; and
d. Helps fishermen participate as effective stakeholders in marine protected area planning and management activities.

In 2009, the coastal area between Crawford, Galleon Beach, Malcolm Bay and Hodges Bay (St. Elizabeth) was declared a Fish Sanctuary by the Ministry and Agriculture and Fisheries.

Fishing Industry (Special Fishery Conservation Area) Regulations (2012)

The Fishing Industry Regulations Legislation states that no person shall fish in a special fishery conservation area except in accordance with a:

c) License issued by the Licensing Authority under the provisions of the Act and
d) The provisions of the directions issued by the Minister under regulation 5.

Special Fishery Conservation Areas are reserved for the reproduction of various fish populations. Their nature reserve statuses are declared by the Agricultural Minister under the Fishing Act (1975) and therefore punishable by law to engage in any unauthorized fishing activities in the designated areas. Therefore, any person who contravenes this legislation or commits an offense against it will be liable on summary conviction before a Resident Magistrate to a fine not exceeding one thousand dollars. There are 14 declared marine protected areas and of these include: Galleon Harbour, that is located within St. Elizabeth.

Jamaica National Heritage Trust (JNHT)

The JNHT has the responsibility of protecting both Jamaica's cultural and natural heritage. This includes sites representing manmade or natural objects, as well as any "species of plant and animal life." (McCalla, 2004). Other functions of the JNHT include:

a. Promoting the preservation of national monuments and anything designated as protected national heritage for the benefit of the island
b. To carry out development as it considers necessary for the preservation of any national monuments or anything designated as protected national heritage;
c. To record any precious objects or works of art to be preserved and to identify and record any species of botanical or animal life to be protected.

Many buildings, landmarks, and sites on JNHT's National Historic Register are located within existing Protected Areas. Buildings such as Invercauld and BR Court House located in BR are on the National Register.

The Jamaica National Heritage Trust Act has been in operation since 1985 with the overarching objective of preserving and protecting national heritage in Jamaica. This act is the overarching legislation and outlines the functions and responsibilities of the Trust among other components such as the types of designations and declarations that are made under the Act.

River Rafting Authority

The River Rafting Act serves to govern river rafting and its activities in Jamaica. *River rafting* as defined under the River Rafting Act is the use of any raft (boat or other vessel) as a river raft. *River Raft* refers to a raft used or to be used for carrying passengers for reward on a river, not being a prescribed boat or vessel.

The River Rafting Authority (RRA) under this act functions to carry out the following (Ministry of Justice, 2015):

8. Regulate and control river rafting in Jamaica.
9. To develop, within the limits of its resources, river rafting in Jamaica, and to promote the efficient operation of river rafting in Jamaica;
10. To offer, by way of trade or business, or to encourage others so to offer, any goods, equipment, entertainment, transportation, food, drink or service to patrons of river rafting, where it considers it is desirable so to do;
11. To encourage, by such measures as it thinks fit, the attainment and maintenance of the highest standards of service by rafts men and other persons who offer or provide by way of trade or business any goods,

equipment, entertainment, transportation, food, drink or service to patrons of river rafting;

12. To perform such other functions in relation to river rafting in Jamaica as the Minister may from time to time determine;
13. To make all such enquiries and to collect all such information as it may think necessary or desirable for the purpose of carrying out its functions, and to examine, in consultation with such organizations and persons as it considers appropriate, problems affecting the) operation of river rafting in Jamaica; and
14. Generally to take all such other lawful measures as it may consider likely to assist it in carrying out most effectively the purposes of this Act.

All river-based tourism attractions and tours within the study area are required to fulfill certain legal obligations under the River Rafting Regulations (1970) in order to be licensed (Ministry of Justice, 2015). All river-based attractions must be registered and licensed in order to operate legally in the area.

BR is one of the seven navigable river systems in Jamaica in which the RRA has approved for the issuing and granting of licenses for rafting and other river based recreational activities.

Tourism Product Development Company (TPDCo)

TPDCo, is a specialized planning and implementation agency under the Ministry of Tourism and Entertainment, and is responsible for the development of tourism through establishment of standards, licensing, training and implementation of special projects.

The TPDCo works with local operators through the Tourism Resort Boards to enhance tourism products. BR and its tributaries fall under the South Coast Resort Board, in which tourism product offerings are developed, managed and regulated. If any of the river-based activities conducted along the study area would like to advertise their activity as an attraction, they must consult and register with TPDCo.

Within the region, the South Coast Resort Board set up in 1994, has been a positive vehicle for community involvement in tourism marketing and product development issues.

Parish Councils

Parish Councils play an important role in the identification, establishment and management of protected areas and parish-wide protected area planning. Parish Councils do have the potential to exercise management authority for protected areas (either solely or in partnership with other community-based organizations) provided that they are effective at providing community services and expanding their levels of responsibility.

They aim among other things to:

a. Develop, manage and maintain infrastructure and public facilities such as water supplies, recreational centers, parks, markets, etc.
b. Spearhead plans and initiatives for the orderly, balanced and sustainable development of the parish as a whole,
c. Boost economic activity and local wealth creation,
d. Support national policies and development programs at the local level and
e. Regulate building, planning approvals and development control, licensing of trades and businesses, and control of public vending.

The St. Elizabeth Parish Development Committee works very closely with the Parish Council of St. Elizabeth (major partner). The St. Elizabeth Parish Council is a NGO and is made up of the entire development area chairpersons. There are six (6) in total for St. Elizabeth and other representatives from civil society. Some of the Committee's priorities include:

a. Rural development
b. building local and citizen partnerships
c. promotion of social equality
d. Balancing environmental sustainability and economic growth for the area.

National Environment and Planning Agency (NEPA)

NEPA is responsible for executing and carrying out the technical, functional and administrative mandate of three statutory bodies:

- The Natural Resources & Conservation Authority (NRCA)
- The Town & Country Planning Authority (TCPA)

- The Land Development & Utilization Commission (LDUC)

Their work includes conservation and protection (Natural Resources Management), Environmental Management, Public Education, Compliance and Enforcement among many others (NEPA, 2015). NEPA plays a very important role in the management and regulation of various environmental resources including protected areas such as the Black River so as to ensure sustainable development by protection of the environment (NEPA, 2015).

NEPA has management responsibility for Ramsar Sites (Black River) designated by the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) to which Jamaica is a party (NEPA, 2015) .

Water Resources Authority (WRA)

WRA is responsible for the management, protection and controlled allocation and use of Jamaica's water resources (WRA, 2015). A hydrological database is maintained by WRA so that institutions requesting any kind of information, data or technical assistance can be provided. It is the mission of WRA to ensure the sustainability of Jamaica's water resources through assessment, monitoring, proper management, promotion of conservation and protection and sustainable use of these resources (WRA, 2015). In addition, WRA aims to ensure rational and equitable allocation of the water resources to reduce conflict among water users.

National Land Agency (NLA)

NLA is an executive agency under the Ministry of Water, Land, Environment and Climate Change (NLA, 2015). The agency in essence aids to support national development. The NLA brings together the core land functions of the government under one roof and includes Land Titles, Surveys and Mappings, Land Valuation and Estate Management.

Among many others, the mission of NLA includes optimal use of government owned lands and to ensure that a basic infrastructure on which to build a modern spatial information system designed to support sustainable development (NLA, 2015).

Regulatory Framework Gap Analysis

Policy Inadequacies

Key policies affecting critical areas remain in draft and are therefore not binding or implemented. Changes in management and environmental systems have warranted a revision on policies that governed these areas so as to maintain sustainability of the resources.

The Mangrove and Coastal Wetlands Policy is a draft document and needs to be approved by Cabinet as well as the necessary regulations to implement this Policy when and if it is approved by Cabinet. The effect is that in this critical area there is no policy or effective regulatory framework.

Insufficiencies in Local Laws/Regulations

A number of the laws and regulations are outdated and are in need of revision. These include the Natural Resources Conservation Authority Act (1991), the Town and Country Planning Act, the Wild Life Protection Act (1945), amended in 1991), (amended in 1991), the Fishing Industry Act (1975) and the Public Health Act (1976).

Environmental Management

Over the years there have been several attempts to revise and reform the major legislation in this area. For example: the level of fines and penalties under the Natural Resources Conservation Authority (NRCA) Act. Proposals have been put forward for major revisions to this Act, but so far these proposals have not been implemented. More significant fines and sanctions would greatly enhance the effectiveness of this Act.

There is also a need to ensure that international standards for the management control and monitoring of key environmental parameters are reflected in a new environmental act as well as the appropriate regulations.

The enforcement of environmental regulations is a pervasive problem and is evidenced by the fact that despite the existence of the National Trade (Industrial) Effluent Standard and Sewage

Effluent Standard, several sewage and industrial waste treatment facilities continue to discharge substandard effluent to the environment.

Fisheries

A new Fisheries Act is pending and this will provide a major overhaul to the existing Fisheries Industry Act, 1975. This will include strengthening the regulatory framework for fisheries management, increased protection of fish sanctuaries and greater level of fines and sanctions for fishing offences. Whilst this draft Act has been pending for some time, its immediate enactment appears uncertain.

Planning

The Town and Country Planning Act and the Local Improvement Act are both outdated and in need of early reform. An attempt was made to reform the Planning legislation, including the drafting of a revised Town and Country Planning Act, but these proposed legislation reforms were never implemented. The Draft Development Order for St. Elizabeth has been prepared and is currently under review. It is now urgent that steps be taken to undertake a comprehensive reform of planning legislation.

Wildlife Protection

Legislation was proposed some years ago to revise the Wild Life Protection Act to include plants. This legislative framework was never implemented. A major revision of the Wild Life Protection Act is urgently needed especially to enable Jamaica to become a party to the SPAW Protocol.

Conclusion

Even though a number of the legislation and policies that govern our resources is outdated, it still can be used and applied to the management and protection of these areas. However, under the NRCA Act a wide range of Regulations have been promulgated and these provide (in areas where there are regulations) an adequate legislative framework. The critical need is to enforce the existing Acts and Regulations. Once this is put in place, the regulatory framework would be workable.

APPENDIX II - Methodology used in assessing Water Samples Obtained from the BR

Analytical Techniques

Environmental Solutions Limited *QEH* Laboratory will analyze or supervise the analysis of all parameters. All the methods used at the QEHL are approved standard methods. The methodology for each parameter is as follows:

pH

A pH meter is used in conjunction with a combination of glass plus reference electrode, which develops a voltage potential in response to the hydrogen-ion activity without interference from most other ions. The instrument is calibrated regularly using buffer solutions of pH 4, 7, and 10; this ensures proper operation of the instrument.

TDS, Conductivity, Salinity

Conductivity is determined by measuring the resistance in an area of the test solution. A voltage is applied between the two electrodes immersed in the test solution, and the voltage drop caused by the resistance of the solution is used to calculate its conductivity per centimeter. TDS and Salinity are calculated as fraction of conductivity.

Dissolved Oxygen

A light emitting diode (LED) light source excites luminophore substrate in a probe. Excited molecules emit energy (light). DO present in the sample suppresses this reaction, hence the luminescence lifetime is proportional to DO concentration.

Phosphate

Orthophosphate reacts with molybdate in an acidic medium to produce a phosphomolybdate complex which in turn is reduced by ascorbic acid to form a blue coloured analyte which is read by a spectrophotometer as mg/L Phosphates.

Nitrates

Cadmium metal reduces nitrates present in the sample to nitrite. The nitrite ions reacts in an acidic medium with sulphanilic acid to form an intermediate diazonium salt. This salt couples to gentisic acid to form an intermediate diazonium salt. This salt couples to gentisic acid to form an analyte whose concentration is read as mg/L nitrate by a spectrophotometer.

Chloride

The sample is titrated under acidic conditions against mercuric nitrate using diphenylcarbazone as the indicator. As the end point of the titration, the excess mercuric ion complexes with the indicator to form a pink-purple. The concentration of the chloride in the sample is calculated from the volume of mercuric nitrate used.

Total Coliforms

Shake the sample to ensure homogeneity and sanitize the container by wiping it with a clean paper towel saturated with 70% alcohol. Inoculated Lauryl Tryptose Broth with required sample volume is incubated at 35°C for 48 hours. Following incubation all tubes showing growth, acid and or gas production is recorded and submitted to the confirmatory test. To confirm Total Coliforms, Brilliant Green Bile Broth is inoculated and incubated with test sample at 35.5 +/- 0.5°C for 48 hours. Gas production of any quantity in the inverted tube constitutes a positive test. The MPN value is then calculated using the MPN Tables

Faecal Coliforms

Shake the sample to ensure homogeneity and sanitise the container by wiping it with a clean paper towel saturated with 70% alcohol. Inoculated Lauryl Tryptose Broth with required sample volume and incubated at 35°C for 48 hours. Following incubation all tubes showing growth, acid and or gas production is recorded and submitted to the confirmatory test. To confirm Faecal Coliforms, EC Broth is inoculated and incubated at 44.5 +/- 0.2°C for 24 hours. Gas production of any quantity in the inverted tube constitutes a positive test. The MPN value is then calculated using MPN Tables.

Biological Oxygen Demand (BOD_5)

This BOD method measures the amount of oxygen used by bacteria as they oxidize organic matter in the sample. The sample is placed in BODTrack bottles with an ample amount of air left above the sample. As the bacterium uses the dissolve oxygen in the sample, it releases carbon dioxide which is absorbed by a hydroxide causing a drop in the pressure above the sample which is read as milli-gram per litre BOD.

Chemical Oxygen Demand

The mg/L COD is defined as the mg of O_2 consumed per litre of sample under the conditions of the method used. The sample is heated for a period of time with a strong oxidizing agent. Oxidizable organic compounds react, reducing the oxidizing agent. A colorimetric measurement is then used to determine the amount of oxidizing agent remaining which determines the amount of oxygen consumed.

Total Suspended Solids

The determination of TSS is done by filtering a measured volume of sample under vacuum using 0.45 µm membrane or glass fibre filters which has been preconditioned. The residue on the filter is dried to constant weight in an oven set at between 103 -105 ^{o}C. The difference in weight between the final filter weight and the preconditioned weight divided by the volume of sample filtered gives the concentration of suspended sediments in the sample.

Fats, Oils and Grease

Sample is acidified and the oils are extracted using one of the approved extraction methods (sohxlet, N-Hexane etc.). The extraction is concentrated and then gravimetrically treated. The amount of FOG present is then determined from the sample volume used.

Metals

Atomic Adsorption Spectroscopy: This method operates on the principle of wavelength specific method utilizing the adsorption or emission of energy when an analyte is excited by energy. The magnitude of the adsorption or emission is proportional to the concentration of the element in question.

Appendix III- Questionnaires

Questionnaire 1- Administered to Tourists/Visitors of the BR Safari Tours

1) How did you hear about the tours offered at Black River? (Friends, hotel, tour packages, etc.)
2) What is your assessment of the state of the environment? In your opinion, is it used properly and did you notice any form of debris?
3) Do you feel that the carrying capacity of the boat affected your experience of the tour in any way (was it too crowded)?
4) Would you prefer a smaller more intimate tour?
5) What signs of environmental degradation have you noticed that needs to be addressed?
6) Do you wish that the tour was longer or offered more activities/experiences?
7) Do you think that the quality of the tour received was what you expected?
8) In your opinion, what was lacking and what would have been improved?
9) How was the overall journey? What about the return leg (did you think it was too fast, too slow)?
10) Would you do the tour again or recommend it to other people.

Questionnaire 2- Administered to the Tour Operators and Tour Guides of the BR Safari Tours

Date: Conducted by:

Name of Tour Company:

Name of Person Providing Information:

Position or Responsibility in the Company

1) How many boats does your tour operation possess?
2) How many are currently in use?
3) How many tours does your company conduct per day?
   Max……. Minimum…… Average…….
4) How many tours does your company conduct per week?
   Max……. Minimum…… Average…….
5) How many visitors do you take per tour?
   Max……. Minimum…… Average…….
6) How many visitors do you take per week?
   Max……. Minimum…… Average…….
7) What routes do you take during the tour? (Black River, Broad River, Middle Quarters)
8) How long does each tour normally last?
9) What are the main attractions you show along the routes?
10) Before the tour begins, are the visitors informed of what they expect to see?
    Yes……. No……
11) If yes, how is this done? (Verbal, Video, Other)
12) What are the main features that are shown on the tours?
13) Do you explain to them what it is that they are seeing on the tour? (Yes or No)
14) How many boats do you normally see on the river during the tour?

15) How many of these boats are transporting:

Tourists…… Shrimpers…… Jet Skiers…… Other locals……

16) Which of these do your passengers want to do?

Sightsee……. Swim/Snorkel…… Picnic on the shore……

Take Photos…….. Buy craft souvenirs in villages……..

Buy Shrimp or fish…… Use the Bathroom……. Stay longer…….

Dispose of solid waste…….. Other (please specify)…….

17) How do you dispose of waste generate during the tour?

18) What safety features are in place for each tour?

(Talk on safety. Life jackets on boats, so snorkeling rule, no standing on boat, no jumping overboard, no hands in water while travelling, etc.

19) What is the average speed of your boat?

20) Do you observe any particular "rules of the river?" If so, what?

21) What type of boat do your visitors prefer?

22) How are your boats powered?

23) What type of fuel do your boats use?

24) What is the size of your boat?

25) Where is the maintenance work on your boats conducted?

26) How often are the boats serviced?

27) How do you dispose of waste generated by the boat servicing?

28) What are the biggest problems in maintaining your operation?

29) How would you rate the satisfaction level of your customers?

30) What improvement would you like to see?

31) What would you like to see implemented?

Questionnaire 3- Administered to the farmers in the study area

1. Where are your farms located?
2. What kind of crops do you grow/plant?
3. Do you rare livestock? If so what? (pigs, cattle, goat)
4. What is generally size of your farm?
5. How do you irrigate your land?
6. Do you extract water from the Black River or its tributaries?
7. If so, how much?
8. What other means do you use to water your crops, etc.
9. Do you currently experience any problems using the Black River/tributaries?
10. What happens to your farm and crops during periods of drought?
11. Do you use a lot of fertilizers and pesticides? How do you dispose of waste?

Questionnaire 4- Administered to the shrimpers in the study area

1. Where do you primarily sell your shrimp?
2. Where do you get your shrimp from?
3. How often do you sell shrimp and what are the times?
4. How do you sell you shrimp? (per lb, per bag, etc.) and what is the cost?
5. Is this your only source of income?
6. What are your peak seasons for selling shrimp?
7. Who are your primary customers
8. Do you get local support?
9. Do the activities on the Black and its tributaries affect your ability to get shrimp?
10. How do you manage in terms of business with so many other shrimpers? Is it highly competitive?

Questionnaire 5- Administered to the fishers in the study area

1. What type of fish/shrimp do you catch?
2. Where in the area do you normally go for a good catch? (where is fishing usually conducted)?
3. Is your fishing seasonal?
4. What method do you use to retrieve the catch (netting, line fishing)?
5. Is this your only means of income?
6. Would you say that fish/shrimp fishing is a profitable job? If no, why?
7. Do the Black River tours and other activities within the river affect your fishing activity? If so, what and how?
8. Who do you sell your catch to?
9. What changes would you like to see happen to facilitate your livelihood in the Black River?

Appendix IV – Land Use Maps

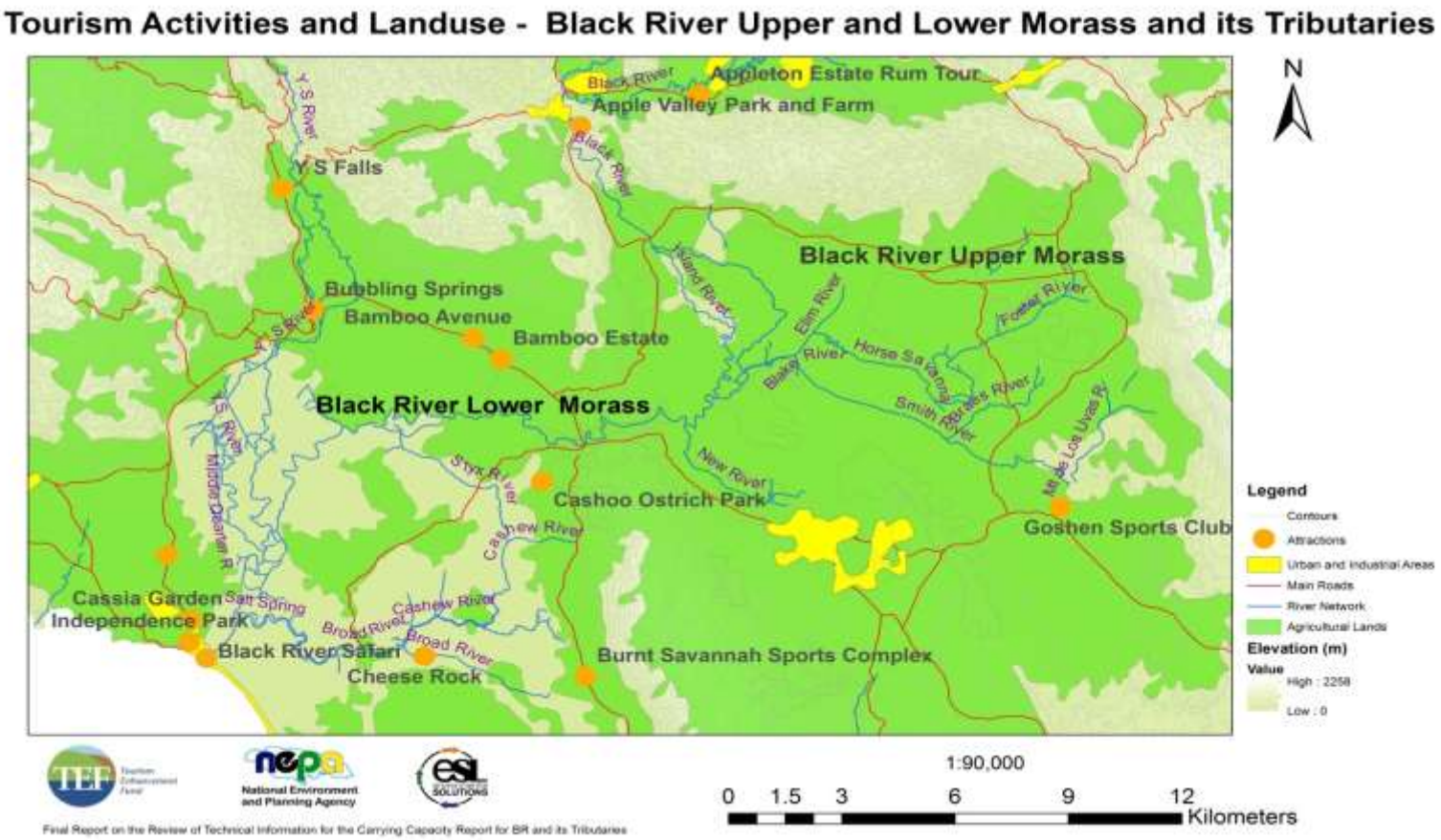


Figure 1: Tourism/recreational activities in the Lower and Upper Morass of BR

Source: Environmental Solutions Limited, 2015

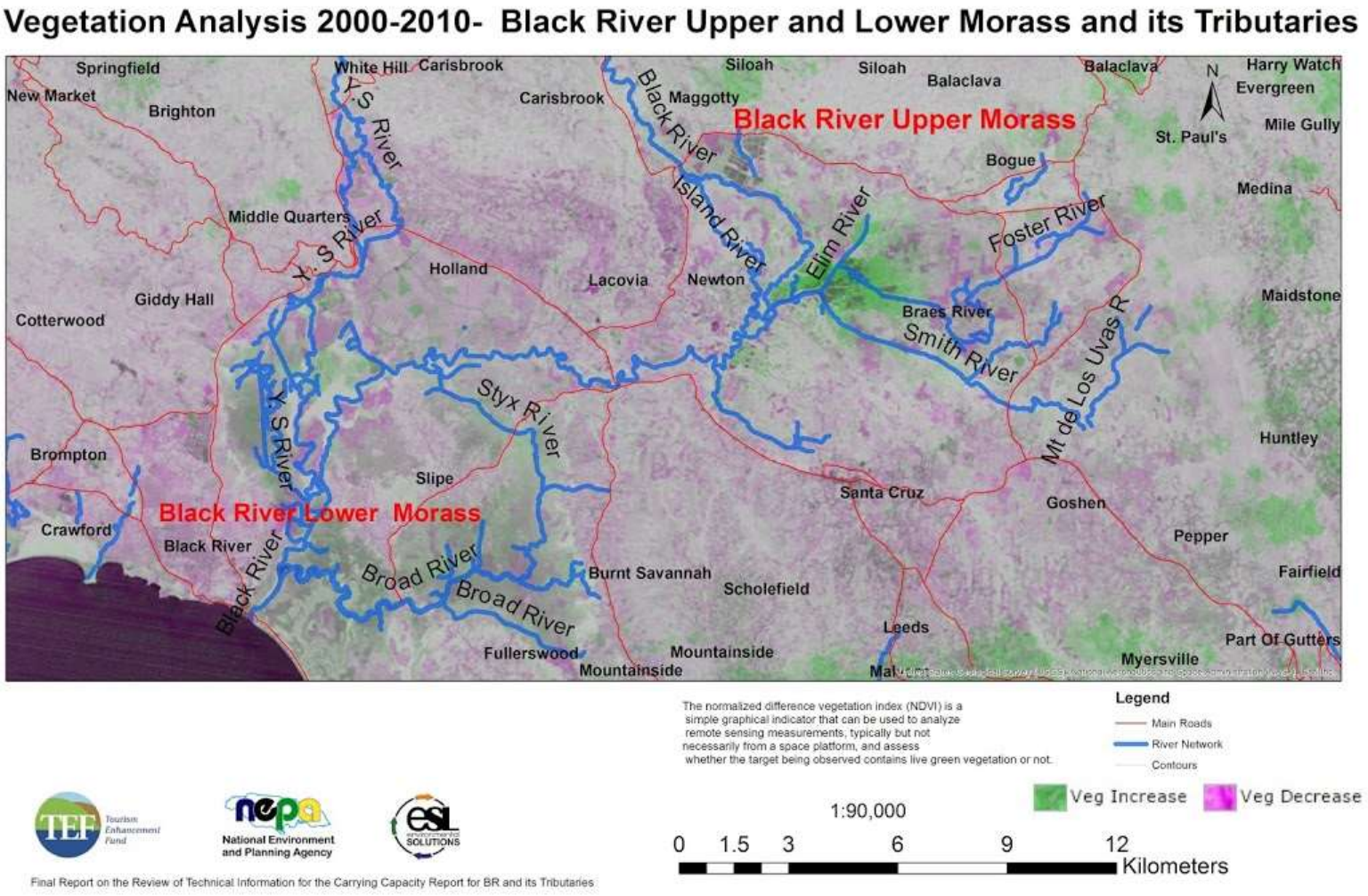


Figure 2: Changes in Vegetation cover in the UM and LM between 2000-2010

Source: Environmental Solutions Limited, 2015

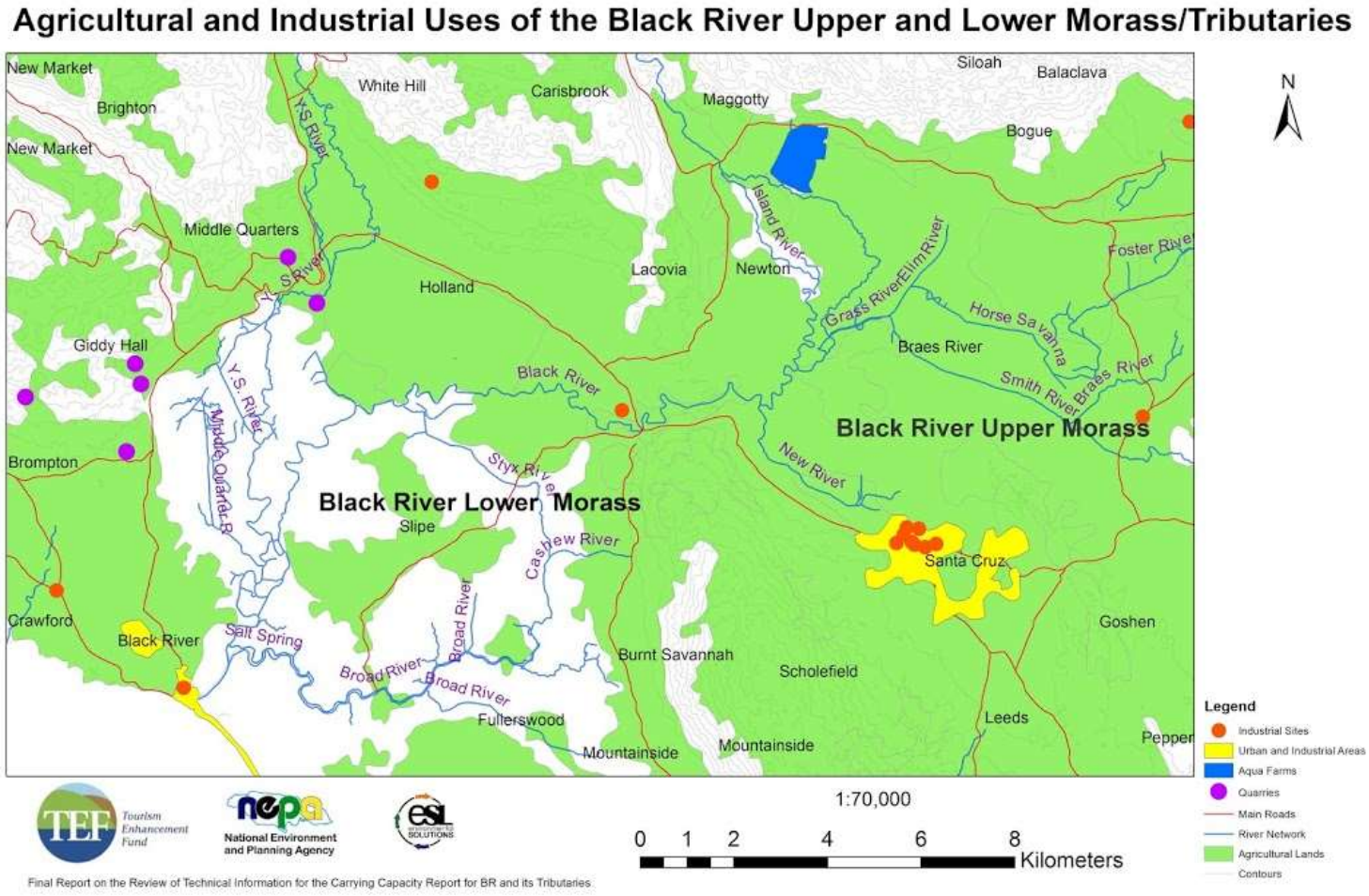


Figure 3: Land Use (Agricultural and Industrial) within the Study Area

Source: Environmental Solutions Limited, 2015

Appendix V- Tree Species Observed

Tables 2, 3 and 4 below highlight the various tree species that were observed on the BR and their specific locations.

Table 2: Observed Tree Species and location observed

COMMON NAME	SCIENTIFIC NAME	LOCATION OBSERVED	*DAFOR
Red Mangroves	*Rhizophara mangle*	BR1; BR2; BrR; Co; CR; SS; YS	F
Black Mangrove	*Avicennia germinans*	BrR; Co	O
Bull Thatch	*Sabal jamaicensis*	BR1; MQ; SS	O
Swamp Cabbage	*Roystonea princeps*	MG; MQ; SS	F
Mango	*Mangifera indica*	MG	O
Coconut	*Cocos nucifera*	CR; YS	R
Red Birch	*Bursera simarouba*	CR; MG; SS; YS	O
Guango	*Samanea saman*	CR; MG; SS; YS	O
West Indian Cedar	*Cedrala odorata*	MG; YS	O
Bastard Cedar	*Guazuma ulmifolia*	CR; MG; SS; YS	O
Star Apple	*Chrysophyllum cainito*	CR; MG; SS; YS	O
Quick Grow	*Gliricidia sepium*	MG; YS	F

COMMON NAME	SCIENTIFIC NAME	LOCATION OBSERVED	*DAFOR
Sweetwood	*Nectandra* sp.	MG	O

Key:

BR1 – Black River (below confluence); BR2 – Black River (above confluence); Co – Confluence; MG – Maggotty River; MQ – Middle Quarter River; SS – Salt Spring River

DAFOR refers to species that are: Dominant, Abundant, Frequent, Occasional or Rare

Table 3: Observed Shrubs and Grasses

COMMON NAME	SCIENTIFIC NAME	LOCATION OBSERVED	DAFOR
Saw Grass	*Cladium jamaicensis*	BR1, BR2;	F
Reed	*Typha domingensis*	BR1; BR2; BrR; Co; MQ	F
Wild Cane	*Gynerium sagittatum*	BR1; BR2; Co; SS	F
Giant Fern	*Acrostichum aureum*	BR1; BR2; Co; BrR	F

Key:

BR1 – Black River (below confluence); BR2 – Black River (above confluence); Co – Confluence; MQ – Middle Quarter River; SS – Salt Spring River

DAFOR refers to species that are: Dominant, Abundant, Frequent, Occasional or Rare

Table 4: Partially or fully submerged plants

COMMON NAME	SCIENTIFIC NAME	LOCATION OBSERVED	DAFOR
	Utricularia foliosa	BrR; SS	F
	Ceratophyllum demersum	BR2	F
Water Lily	*Nymphaea ampla*	BrR	O
Water Hyacinth	*Eichhornia crassipes*	BR1; BR2; BrR; Co	F

Key:

BR1 – Black River (below confluence); BR2 – Black River (above confluence); Co – Confluence; MG – Maggotty River; MQ – Middle Quarter River; SS – Salt Spring River

DAFOR refers to species that are: Dominant, Abundant, Frequent, Occasional or Rare

Appendix VI- Bird Species Observed

Tables 5 and 6 below highlight the various bird species (wetland and terrestrial) that were observed on the BR and their specific locations.

Table 5: Wetland bird species, numbers and location observed

COMMON NAME	SCIENTIFIC NAME	NUMBER OBSERVED	LOCATION OBSERVED
Great Blue Heron	*Ardea Herodias*	1	SS
Great Egret	*Casmerodius albus*	12	Co; BR2
Snowy Egret	*Egretta thula*	2	BR2
Little Blue Heron	*Florida caerulea*	11	BR2
Tri-coloured Heron	*Egretta tricolor*	1	BR2
Osprey	*Pandion haliaetus*	1	BR2
Jacana	*Jacana spinosa*	1	BR2
Reddish Egret	*Egretta rufescens*	1	MQ
Cattle Egret	*Bubulcus ibis*	6	BR1; BR2
Green Heron	*Butorides virescens*	2	BR2

Key:

BR1 – Black River (below confluence); BR2 – Black River (above confluence); Co – Confluence; MQ – Middle Quarter River; SS – Salt Spring River

Table 6: Terrestrial bird species, numbers and location observed

COMMON NAME	SCIENTIFIC NAME	NUMBER OBSERVED	LOCATION OBSERVED
Common Ground Dove	*Columbina passerina*	1	BR1
Magnificent Frigatebird	*Fregata magnificens*	1	BR1
Jamaican Oriole	*Icterus leucopteryx*	2	BR1; MG
Cave Swallow	*Petrochelidon fulva*	2	BR1
Antillean Palm Swift	*Tachornis phoenicobia*	2	BR1; BR2
Loggerhead Kingbird	*Tyrannus caudifasciatus*	3	YS; CR; SS
Zenaida Dove	*Zenaida aurita*	1	YS
American Kestrel	*Falco sparverius*	1	YS
White-chinned Thrush	*Turdus aurantius*	1	MG
Jamaican Woodpecker	*Melanerpes radiolatus*	1	MG
Red-Billed Streamertail	*Trochilus polytmus*	2	MG; CR

COMMON NAME	SCIENTIFIC NAME	NUMBER OBSERVED	LOCATION OBSERVED
Jamaican Euphonia	*Euphonia jamaicensis*	1	MG
Jamaican Tody	*Todus todus*	1	MG
Greater Antillean Grackle	*Quiscalus niger*	1	MG
Bananaquit	*Coereba flaveola*	2	CR

Key:

BR1 – Black River (below confluence); BR2 – Black River (above confluence); CR – Cheese Rock; MG – Maggotty River; SS – Salt Spring River; YS – YS River

Appendix VII – Geomorphology of the Study Area

Geomorphological Overview

The broad-scale geomorphology within the BR study area is controlled by upfaulted blocks forming highlands and plateau surfaces interspersed with alluvial plains and interior valley systems. The upfaulted blocks mainly contain Oligocene to Miocene age limestones and dolostones that have been moderately to intensely karstified. The BR contains relatively thin (compared to other south flowing river systems to the east) alluvial deposits, built over downfaulted blocks of White Limestone, which often breaks the surface to form low-lying plains of hummocky terrain and karstic surfaces with ponds. The plains of the BR also contain distinct wetlands and low-lying morasses which extend from Parottee Point northwards, especially the BR LM

The overall geomorphology is controlled by faulting and by the occurrence of numerous limestone massifs. The eastern boundary of the Black River Upper Morass is dominated by the NNW-SSE Spur Tree Fault, marking the western boundary of the Manchester Plateau; the fault forms a 400m high prominent escarpment from the south at Alligator Pond, through Spur Tree Hill to the Don Figueroa Mountains. The northern boundary of the Upper Black River Morass is marked by the Nassau Mountains, forming a similar uplifted and karstified limestone block, while at its southern boundary is another prominent upfaulted limestone limestone block forming the Malvern Plateau and Santa Cruz Mountains. This karstified 'plateau' surface is over 400m above sea level extending to 689m immediately south of Malvern.

The western limit of the Santa Cruz Mountains and the Malvern Plateau is terminated by the Santa Cruz Fault, which also marks the eastern boundary of the Black River Lower Morass. The Santa Cruz Fault is another prominent NNW-SSE trending scarp, at Malvern the scarp is over 600m high, but it is only 180m high at Burnt Ground, south of Lacovia, and becomes indistinct as a geomorphological feature at the community of Lacovia. To the west of the Santa Cruz Fault, the landscape is characterised by a relatively low-lying, poorly karstified block, extending to a maximum elevation of about 140m above sea level well to the south at Pedro Cross, though it becomes less distinct northwards and terminates at Salt Spring in the south of the lower morass. The western limit of this low-lying block is a similar NNW-SSE trending fault, called the

Newcombe Fault; forming a low escarpment about 100m high between Pedro Pen and Treasure Beach in the south, but diminishing in height towards Hopewell and Williamsfield in the north.

West of this is a narrow karstified block extending from Fort Charles in the south, to east of Wallywash Great Pond in the north. Similarly to the low-lying block east of the Newcombe Fault, this karstified block also becomes lower and less distinct northwards towards the lower morass and is characterised by 'hummocky' limestone topography and buried karst surfaces. This block is also terminated to the west by the Fort Charles Fault, again trending NNW-SSE and forming a 40m to 60m high scarp from Fort Charles in the south to Wallywash Great Pond in the north. Low-lying morasses occur to the west and north from Parrottee Point to Black River, forming a southern extension of the Black River Lower Morass.

The Black River Lower Morass is therefore situated at the low northern end of two tilted fault blocks. Depressions and sinkholes are common along the edge of the morass and under the basin fill. Similar upfaulted limestone blocks bounded by WNW-ESE trending faults mark the northern boundary of the Lower Black River Morass north of Middle Quarters to Newmarket in the northwest and the Lacovia Mountains to the north. The northern section of the Black River Drainage Basin is similarly dominated by uplifted and heavily karstified limestone blocks, forming well-developed karst terrain, with occasional downfaulted blocks forming interior valleys or poljes, the largest being the Nassau Valley.

The geomorphology of the study area can be subdivided into two major types; *karst geomorphology*, and *slope and fluvial geomorphology*, while there are coastal geomorphological features within the Black River Bay itself.

Karst Geomorphology

Much of the drainage basin to the north of Maggotty, including the southern part of the Cockpit Country, the Maggotty Mountains and the terrain around Ipswich and to west of Elderslie, comprises well-developed karst terrain in the form of cockpit karst, Cockpit Country being the type locality. The Nassau Mountains similarly have well-developed karst terrain. The Lacovia Mountains and the hills to the north and west of Middle Quarters are also karstic, but the residual

hills are less apparent and the landscape has a more 'hummocky' appearance, though cockpit karst reappears south of Newmarket.

The uplifted and tilted limestone 'plateaus' forming the Santa Cruz Mountains and the Fort Charles Block are also kartified, but not in the form of well-developed cockpit karst, rather the landscape comprises hummocky limestone topography with relatively low residual hills, closed depressions, small shallow dry valley systems and ridge karst terrain.

Karst is terrain with distinctive hydrology and landforms, arising from a combination of high rock solubility and well developed secondary permeability (Ford and Williams 2007), leading to the formation of closed depressions, residual hills and the progressive replacement of surface by underground drainage. This leads to the normal stream network being broken up by the development of small, centripetal drainage basins and accounts for the sinking and re-emergence of the Black River drainage system. The karst terrain within the area can be subdivided into a number of morphogenic types. The classical karst terrain in the northern part of the drainage basin falls into three main subjective classifications, namely:

Cockpit Karst – typified by polygonal depressions with conical hills;

Doline Karst – dominated by simple basin forms of closed depressions with small residual hills; and

Tower Karst – characterised by upstanding residual hills, often vertical in their lower parts, surrounded by planed limestone, non-carbonate rock, often covered by a variable thickness of alluvium and other superficial debris.

Cockpit karst is widespread in the northern section of the drainage basin and can be further classified based on the presence or absence of an integrated surface drainage pattern across the terrain, on the size and shape of the intervening residual hills, particularly whether they are circular or elongated in plan, and on the extent of the closed depressions, especially whether or not they contain a residual soil infill.

Doline karst, comprising more 'hummocky' limestone terrain is common in the Lacovia Mountains and in the hills west of Middle Quarters. Similar terrain can be found on the 'plateau' surfaces and uplifted limestone blocks to the south of the Black River morasses. Dolines are

circular to elongated closed depressions varying in diameter from a few metres to over 1km. Their sides range from gently sloping to vertical and they have variable depths. There is a wide spectrum of forms within the area from saucer-shaped hollows to deeper funnels and cones. A basic fourfold division of dolines can be determined within the area, based on the character of their associated residual hills in terms of whether they are conical in shape, subdued hills, elongate hills and ridge karst.

Tower karst is a landscape of residual hills scattered across a relatively flat plain. The most common types seen in the area are residual hills protruding from alluvium that may be burying a pinnacle or planed surface. This tower type is well developed within the Nassau Valley and formed by laterally directed solution at, or near to, the water table, coupled with aggressive floodwaters from the Black River crossing the alluvial plain. A second common type of tower karst is where towers occur above a non-carbonate rock, or a less-karstic carbonate rock, particularly where tower karst within the White Limestone Group Troy Formation lies above doline karst within the Yellow Limestone Group Chapelton Formation. This type of tower karst is well developed to the western margins of Cockpit Country from Maroon Town to Elderslie and in the landscape around Troy and Heading on the southern margins. The towers can also be classified based on whether they are circular or elongated in plan.

The hills and uplifted limestone blocks to the south of the Black River morasses are also karstic, but they do not generally display classical karst, apart from in a few locations. Rather the terrain has a more hummocky appearance with low residual hills and broad depressions. One noteworthy landscape feature here is the occurrence of several karst limestone ridges which occur across a variety of geomorphic settings in the terrain to the south of the Black River morasses. Ridege karst are limestone ridges, up to 4km long, but more commonly 0.5km to 2 km in length, and from <50m to 300m wide and heights ranging from <5m to 30m to 40m. They occur on plateau surfaces, slopes, broad depressions and valley floors of southern St. Elizabeth. Within the immediate study area, limestone ridge karst occurs in low-lying settings to the east of Santa Cruz on the south side of the Black River Upper Morass around Brighton, Longwood and Lovely Point, where the disappear northwards beneath the swamps of the morass. Ridge karst is also common south of the Black River Lower Morass in the Fort Charles, Grand Valley,

Hopewell and Pondside Districts. Most of the ridges are aligned NNW-SSE to NW-SE in response to major fault and joint trends.

The other main karst features within the Black River area are poljes and karst surfaces of low relief (buried karst). Poljes are large flat-floored enclosed depressions with steeply rising marginal limestone slopes. The floor of the polje generally is in alluvium across which a river flows. Within the area there are two distinctive poljes in the Nassau Valley and to the west around Newmarket, both of which are frequently flooded by heavy rainfall. Within the margins of Black River morasses there are extensive karst surfaces of low relief in dotted by ponds, the surfaces being a legacy of a former polje, now buried by alluvium and morass (Grontmij 1964)

Slope and Fluvial Geomorphology

For the most part the Black River is dominated by karst features. There is however a range of fluvial and related mass movement features within the area. The drainage network of the Black River has already been described and there are a range of fluvial erosion and depositional features associated with it, including river sinks and resurgences, cave systems and underground rivers, cascades and waterfalls, and alluvial floodplains. There are also some mass movement phenomena within the area, but they are largely no longer active and confined to steep escarpments along major faults, comprising paleao-landslides and inactive alluvial fans. There are also a number of dry valley and gully systems within the study area, but are largely inactive elements of the landscape, though some may have ephemeral flow.

There is one large landslide within the study area on the northern section of the Spur Tree Fault within the study area that has not been appreciably degraded at Georges Valley, beneath the Don Figueroa Mountains on the eastern margins of the Black River Upper Morass, the slide mass being about 4km^2 in area, while the length of the scar is about 3km.

Within the study area large coalescing vegetated, and therefore inactive, alluvial fans can be seen at the base of the Don Figueroa Mountains, where fluvial processes have reworked the landslide deposits, previously noted. At least 25 fans occur at the base of the Santa Cruz Fault scarp, many of them occurring within the study area around Lacovia.

Other Geomorphological Features

Numerous caves exist in the limestone regions of the study area formed by groundwater percolating through the limestone along cracks and faults, gradually dissolving the rock to form caves and passages. A list of known caves within the study area can be found in the compilation of caves, sinkholes and underground rivers in Jamaica (Fincham 1998). Noteworthy caves within the study area are:

Oxford Cave- in the cockpit hills near Auchtembeddie. It is a dry passage about 765m in length, about 10m wide and 8m high with a muddy floor. This was once a visitor attraction or 'Show' cave and appears in many journals and newspapers dating back to the early 1900's.

Wallingford River Cave- occurs at Wallingford which forms the sink of the One Eye (Coffee River). It is a large gently graded river passage where water flows over shallow gour pools to a sump.

Mexico Cave- this is the rising of the One Eye River which reappears on the surface having sunk below ground at Wallingford River Cave, and is therefore a resurgence cave.

Coffee River Cave- also in the Auchtembeddie area, it is a river cave over 2.8km long, having a main underground river passage but with several complex parallel passages.

There are many more cave systems within the area, none more complex that the Hector's River Sinks and drainage in the Auchtembeddie area, which comprises Coffee River Cave. Numerous caves occur in the Merrywood area associated with the Y.S. River drainage, while the landscape around Ipswich is dotted with many cave systems.

Appendix VIII- Flow Duration Curves

Table 7: Mean Daily Flow and the flow values for different flow indices or probability of exceedances for the Black River and its tributaries

				Discharge in cumecs					
	LENGTH OF DATA	MEAN DAILY FLOW (CUMECS)	Q95	Q90	Q75	Q50	Q25	Q10	Q5
BLACK RIVER AT APPLETON	1955-2015	11.41	3.28	3.99	5.94	9.57	14.32	21.40	26.26
BLACK RIVER AT LACOVIA	1963-2015	20.46	7.61	8.83	11.79	17.05	26.02	36.94	43.72
BLACK RIVER AT NEWTON	1966-2015	12.47	3.15	3.95	5.94	9.90	15.73	24.65	30.29
YS RIVER AT MIDDLE QUARTERS	1955-2015	4.81	0.51	0.7	1.32	3.14	6.46	11.21	0.7

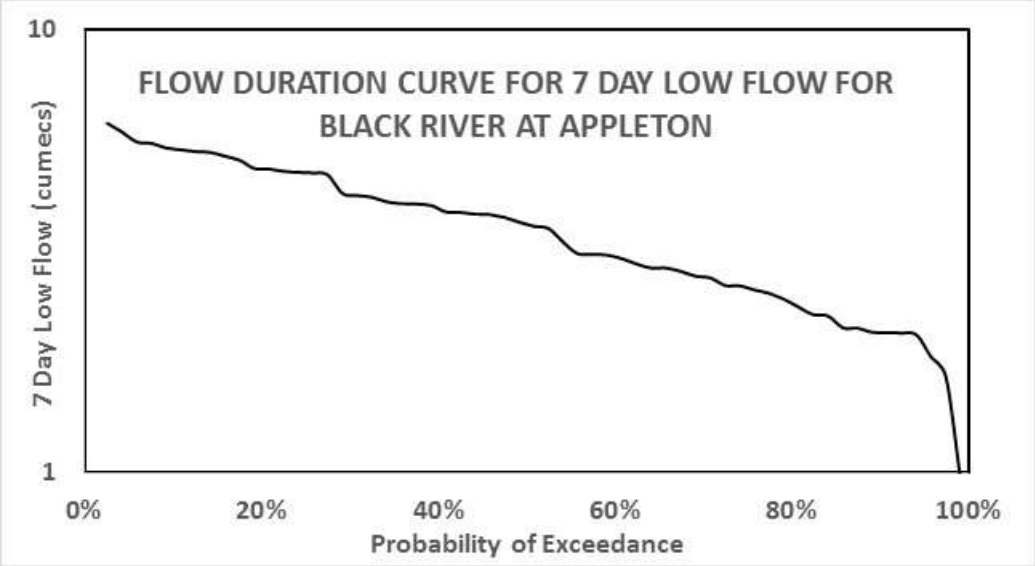


Figure 4a: Flow Duration Curve for 7dat low flow for BR at Appleton

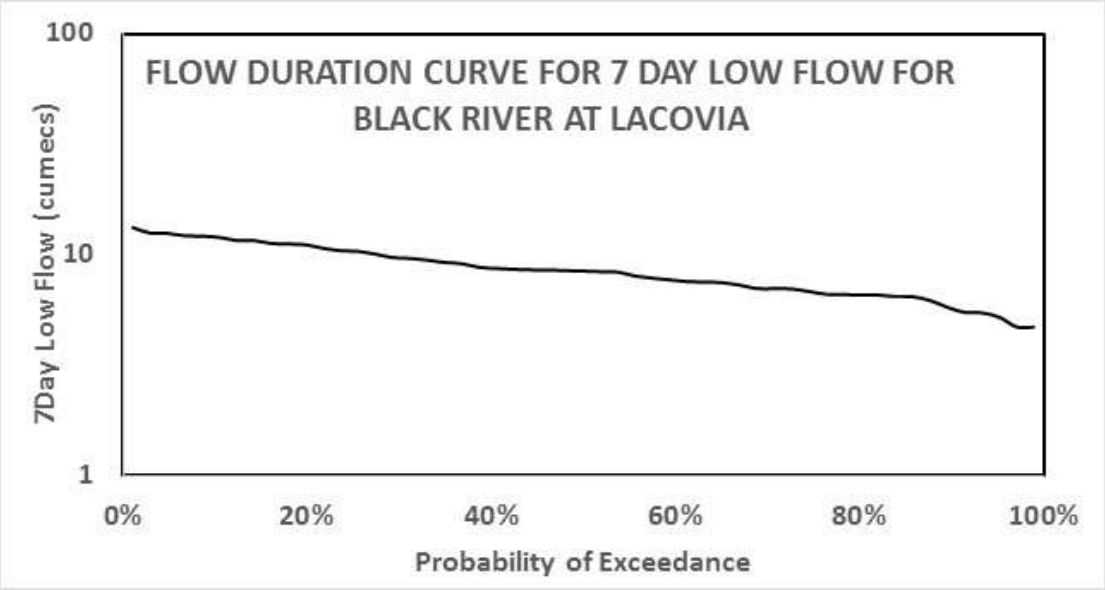


Figure 4b- Flow Duration Curve for 7day low flow for Black River at Lacovia

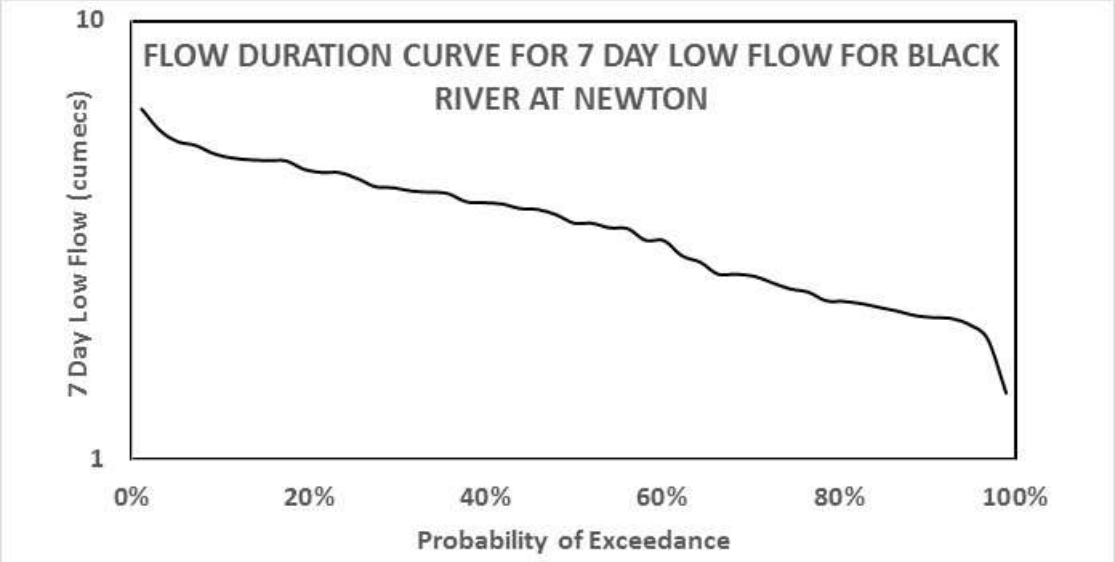
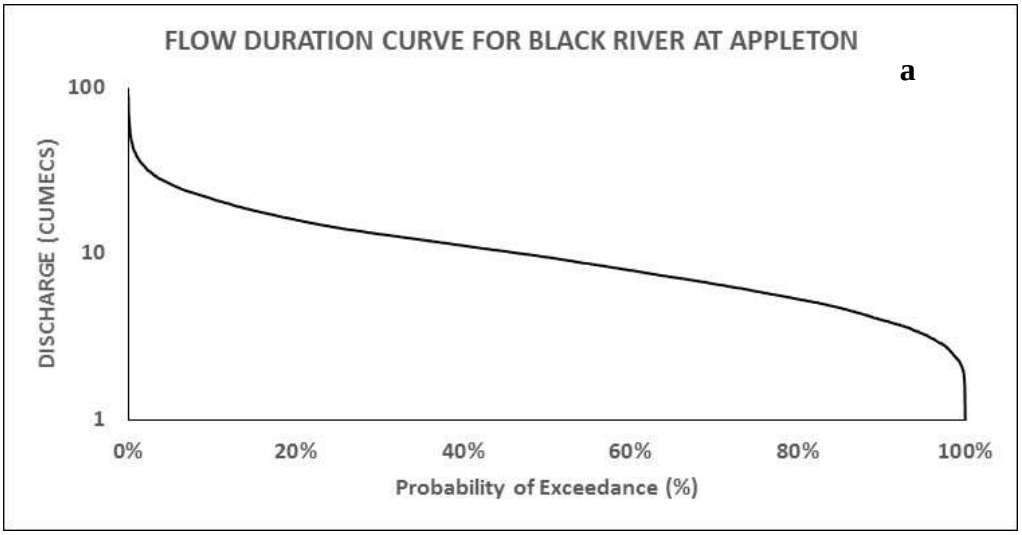
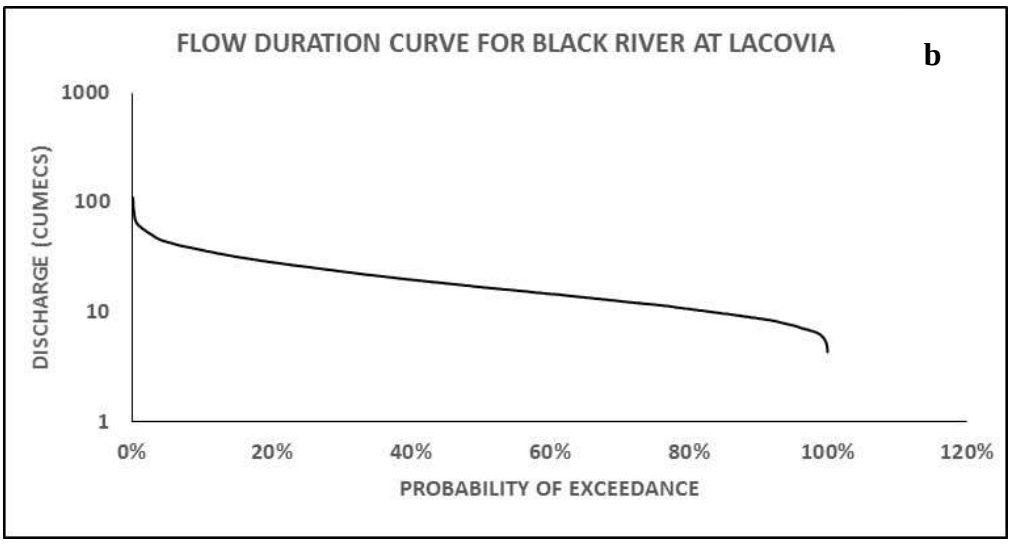
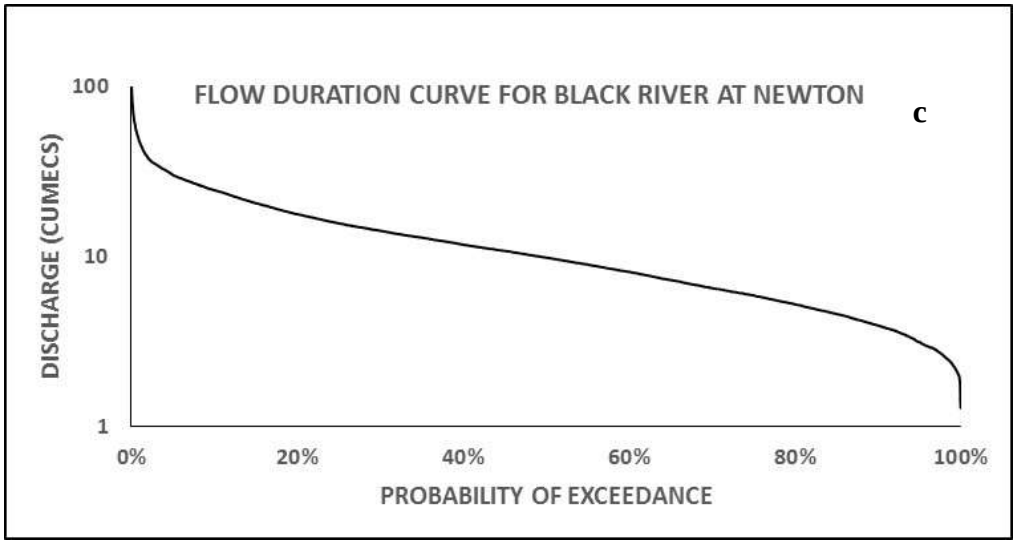


Figure 5- Flow duration Curve for 7 day low flow for BR at Newton


FLOW DURATION CURVE FOR BLACK RIVER AT APPLETON
a
100
10
1
DISCHARGE (CUMECS)
0%
20%
40%
60%
80%
100%
Probability of Exceedance (%)


FLOW DURATION CURVE FOR BLACK RIVER AT LACOVIA
b
1000
100
10
1
DISCHARGE (CUMECS)
0%
20%
40%
60%
80%
100%
120%
PROBABILITY OF EXCEEDANCE


FLOW DURATION CURVE FOR BLACK RIVER AT NEWTON
c
100
10
1
DISCHARGE (CUMECS)
0%
20%
40%
60%
80%
100%
PROBABILITY OF EXCEEDANCE

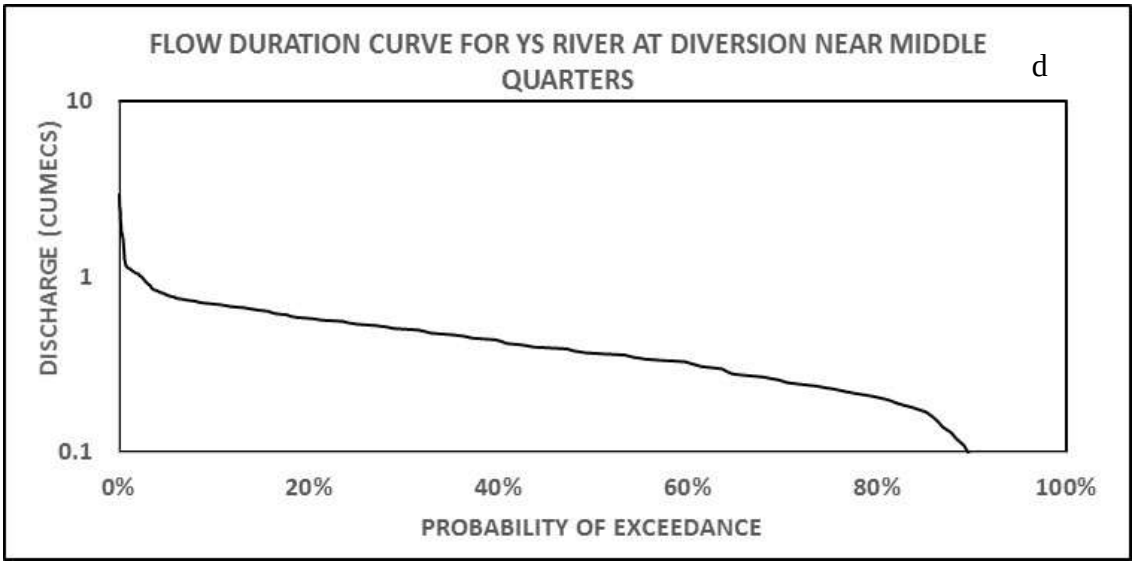


Figure 6: a-d Flow Duration Curve for 7day low flow for BR and its tributaries

Appendix IX- Abstraction of water from BR at various sites

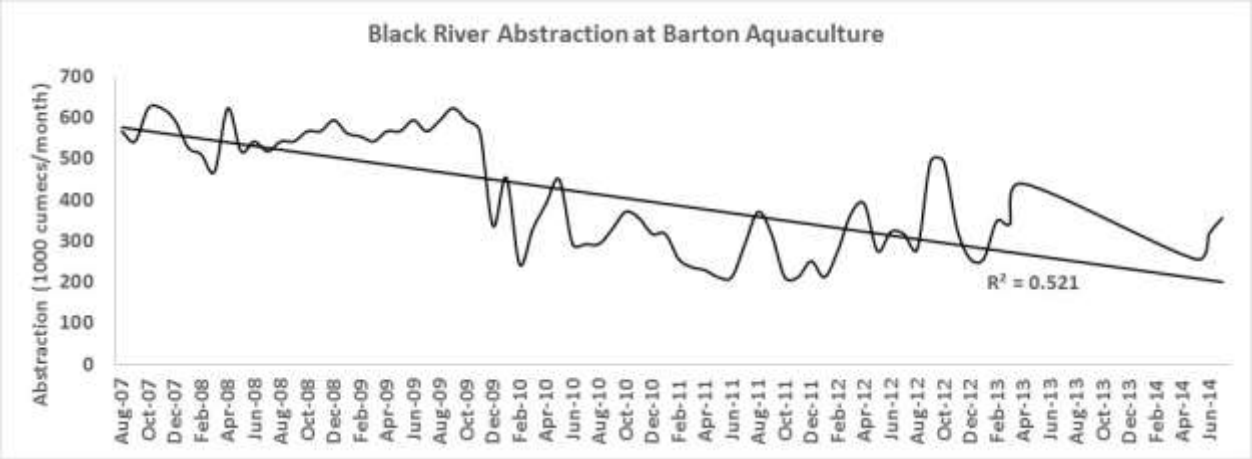


Figure 7- Abstraction for BR at Barton Isle (monthly totals)

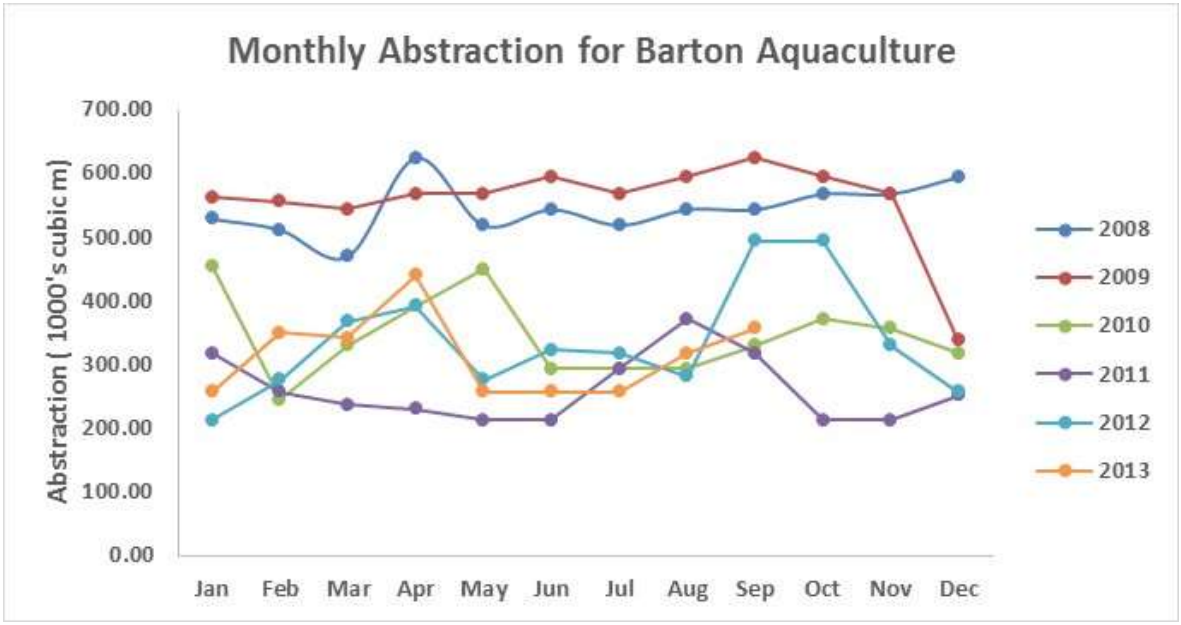


Figure 8- Abstraction for Black River at Barton Isle (mean monthly)

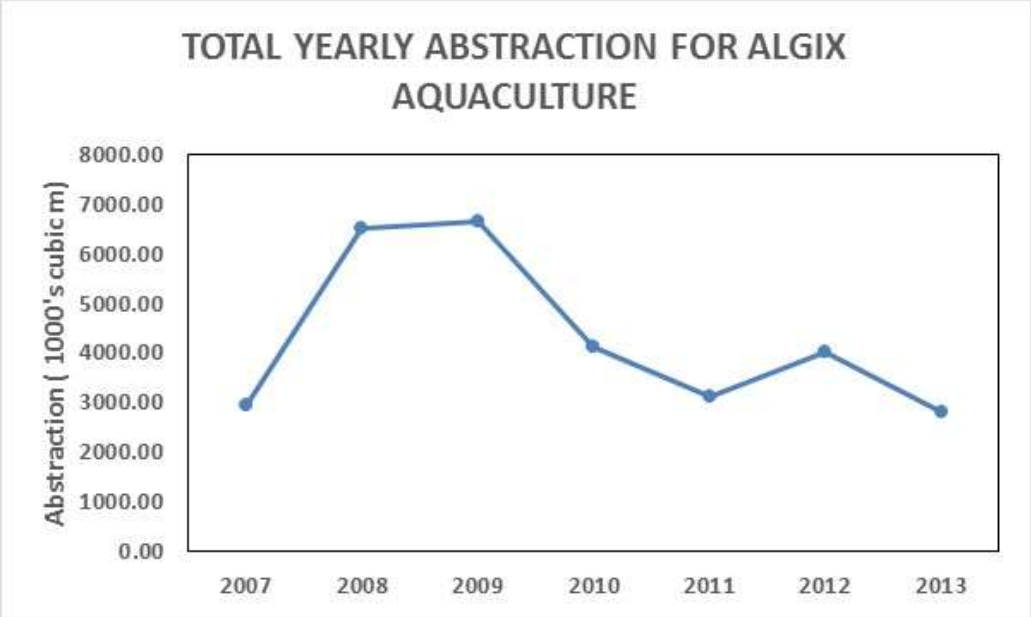


Figure 9- Abstraction for Black River at Barton Isle (yearly totals)

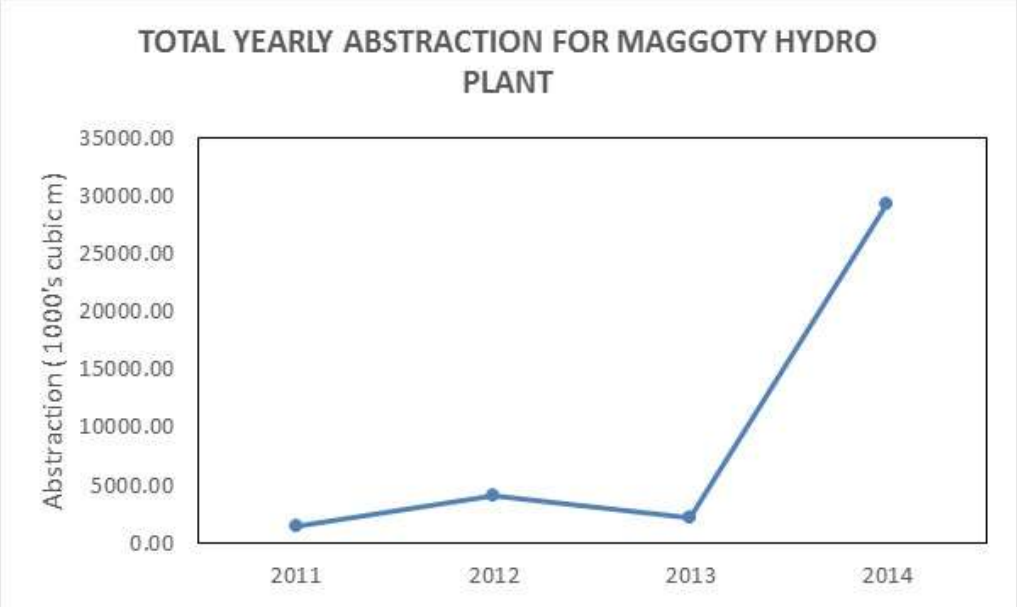


Figure 10- Abstraction for Black River at Maggotty (yearly totals)

The abstraction data available are very spotty and not consistent over a longer period of time (10yrs minimum). This could be either due to no abstraction, no recording of data and submission to WRA. Available data shows that the abstraction for aquaculture at Barton Isle,

close to Newton shows that abstraction shows a steady decline from 2007-2014. Average abstraction was 13608000 cumecs per day for the 7 year period. Decline in abstraction was however unknown. Maximum abstraction seemed to occur in the years 2007-2008 after which there was a steady decline. A decline in 2009 onwards could be due to the drought of 2009, 2013 and 2014 provided all other conditions remained same i.e. demand remained the same. The hydro dam at Maggotty which is located near to Appleton however showed a steep increase in abstraction from 2013 to present. However as noted earlier based on personal communication with WRA, most of the water abstracted from the river at Maggotty and Appleton is returned back to the river, there is not much effect on the discharge capacity of the river. Hence there will not be much effect on the low flow (Q90) and other flow indices. The Q90 flow values for the three stations are shown for each year to see the overall trend and if any excess abstraction has caused any significant lowering of the flow values. It is seen that there is a weak increasing trend which mirrors the trend seen in average yearly flow data shown earlier. There is no significant decrease in trend of flow and for the periods for which abstraction data were available corresponding years also showed a steady trend similar to the average yearly flows. The year 2009 has shown steep decrease in average yearly flows, Q90 as well as abstraction data. Similar was also noted for the years 2013-2014. These are the years the island experienced the effect of drought which may have impacted the inflows in the river and thus the abstraction. Further work is needed on determining the various factors causing variation in the flow indices over time, rainfall runoff relation, quantifying discharge from underground sources and if any water is consumed from the river for farming, thus quantifying it.

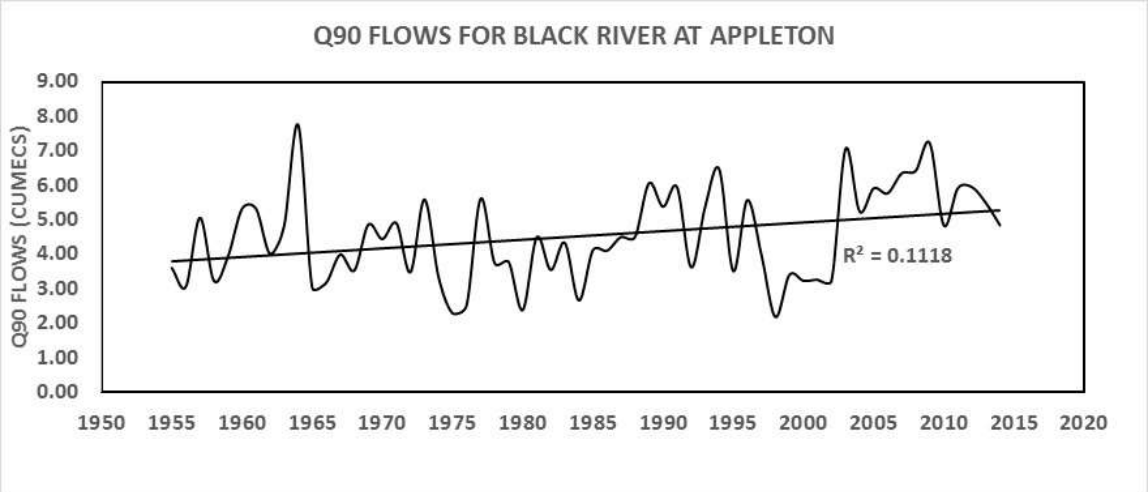


Figure 11: Q90 flow values for Black River at Appleton

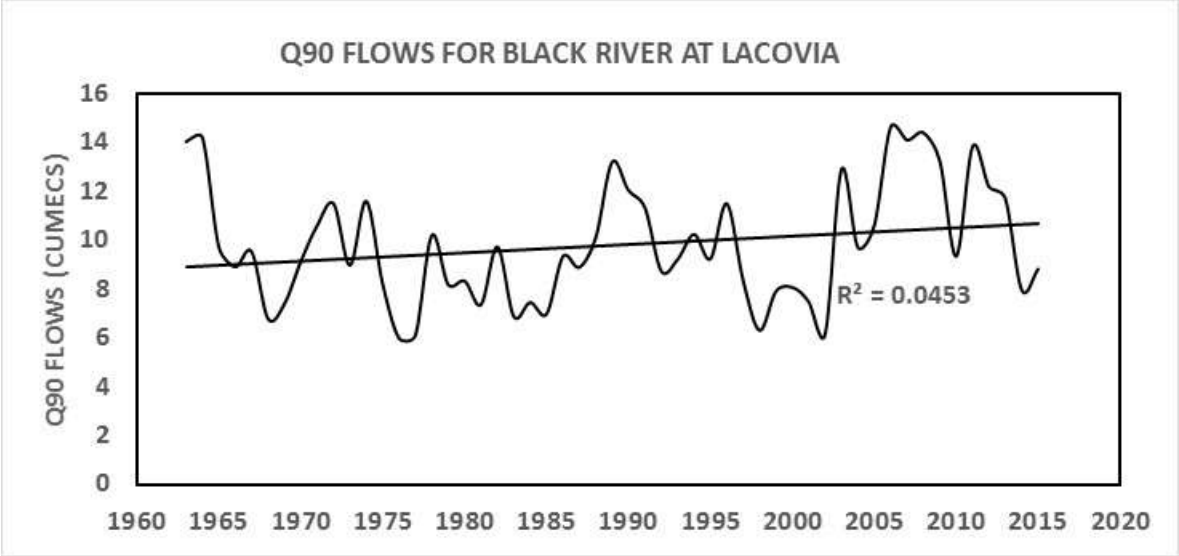


Figure 12: Q90 flow values for Black River at Lacovia

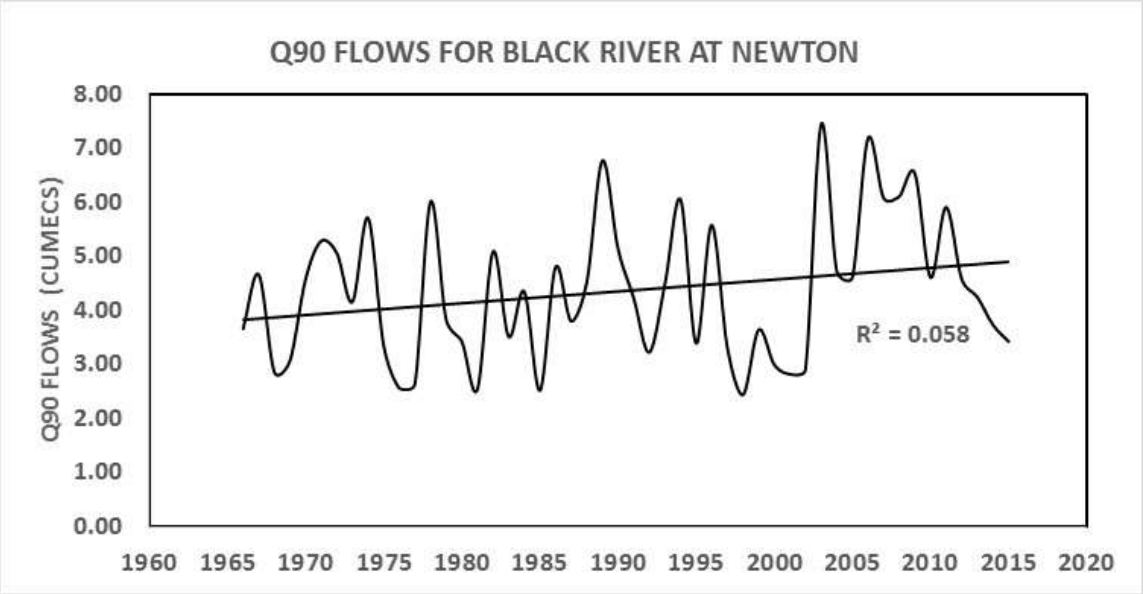


Figure 13: Q90 flow values for Black River at Newton.

Appendix X - Results from the Water Quality Sampling

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

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ENVIRONMENTAL & FOOD
TESTING LABORATORY

89 Hope Road
Kingston 6, Jamaica
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Fax: (876) 946-3745
E-mail:envirsol@cwjamaica.com

Certificate of Sample Analysis

Cert. #: ESL-ECS 15111901-07

Attention:

Ms. Nalini Jagnarine
ESL- Environmental Consultancy Services
Environmental Solutions Limited
89 Hope Road
Kingston 6

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Sample(s) Information

Job Number:	**15111901-07**
Date of Report:	07/01/2016
Sample(s) Collected:	18/11/2015
Sample(s) Submitted:	18/11/2015
Condition on Arrival:	3.6˚C
Number of samples:	7
Specific Handling:	None
Analysis Started:	18/11/2015
Analysis completed:	07/01/2016
Prepared By:	**Lesa Lemmie, Technical Assistant**

Special Comments:

None.

Verified by: ……
Mario Christie, Technical Manager

Approved By: …….
Rashidah Khan-Haqq, QEHL Manager

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

A division of

Parameters	Method	Sample ID			NRCA AMBIENT WATER STANDARD
		Sample #1	Sample #2	Sample #3	
pH[b]	DR	8.39	8.40	6.64	
Conductivity[b] (mS/cm)	DR	3.33	1.091	2.551	**0.15 – 0.6**
Dissolved Oxygen[b] (mg/L)	DR	4.65	4.38	4.12	-
Salinity[b] (ppt)	DR	1.69	0.47	1.27	-
Total Dissolved Solids[b] (g/L)	DR	2.095	0.628	1.615	**0.12 – 0.3**
Temperature[b] (°C)	DR	25.66	25.45	26.62	-
Biochemical Oxygen Demand (mg O_2/L)	H-10099	6.0	1.6	6.9	**0.8 – 1.7**
Chemical Oxygen Demand (mg O_2/L)	H-8000	12	4	9	-
Total Suspended Solids (mg/L)	SM-2540-D	5.7	10.1	<2.5	-
Nitrate (mg NO_3/L)	H-8192	0.06	-	0.04	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		-	<0.01	-	-
Phosphate (mg PO_4^{3-}/L)	H-8048	0.07	0.03	0.02	**0.01 – 0.8**
Sulfate (mg SO_4^{2-}/L)	H-8051	112	52	90	**3.0 – 10.0**
Chloride (mg Cl^-/L)	H-8206	952.0	412.0	736.0	**5.0 – 20.0**
Total Coliform (MPN/100mL)	SM-9221	540	350	220	-
Faecal Coliform (MPN/100mL)	SM-9221	79	110	220	-
Oil & Grease[a] (mg/L)	EPA-1664	<1	<1	<1	-
Copper[a] (µg Cu/L)	FAAS	<10	<10	<10	-
Iron[a] (µg Fe/L)	FAAS	109	103	<20	-

Cadmium[a] (µg Cd/L)	FAAS	<10	<10	<10	-
Arsenic[a] (µg As/L)	Col	<10	<10	<10	-
Lead[a] (µg Pb/L)	FAAS	<20	<20	<20	-
Mercury[a] (µg Hg/L)	CVAAS	<0.1	<0.1	<0.1	-
Zinc[a] (µg Zn/L)	FAAS	<10	<10	<10	-

Shaded parameters are ISO/IEC 17025 Accredited
[a] Parameters were subcontracted
[b] Parameter was done in the field

Parameters	Method	Sample ID			NRCA AMBIENT WATER STANDARD
		Sample #4	Sample #5	Sample #6	
pH[b]	DR	6.64	6.70	7.55	
Conductivity[b] (mS/cm)	DR	1.122	0.441	0.290	**0.15 – 0.6**
Dissolved Oxygen[b] (mg/L)	DR	4.04	4.16	8.92	-
Salinity[b] (ppt)	DR	0.54	0.21	0.14	-
Total Dissolved Solids[b] (g/L)	DR	0.714	0.280	0.192	**0.12 – 0.3**
Temperature[b] (°C)	DR	26.12	26.31	24.3	-
Biochemical Oxygen Demand (mg O_2/L)	H-10099	1.5	1.8	1.6	**0.8 – 1.7**
Chemical Oxygen Demand (mg O_2/L)	H-8000	<3	<3	3	-
Total Suspended Solids (mg/L)	SM-2540-D	<2.5	<2.5	6.9	-
Nitrate (mg NO_3/L)	H-8039	-	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		-	<0.3	<0.3	-
Nitrate (mg NO_3/L)	H-8192	-	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		<0.01	-	-	-
Phosphate (mg PO_4^{3-}/L)	H-8048	0.04	0.02	0.07	**0.01 – 0.8**
Sulfate (mg SO_4^{2-}/L)	H-8051	32	<1	<1	**3.0 – 10.0**
Chloride (mg Cl^-/L)	H-8206	208.0	33.6	7.6	**5.0 – 20.0**
Total Coliform (MPN/100mL)	SM-9221	1600	920	>1600	-
Faecal Coliform (MPN/100mL)	SM-9221	240	31	540	-
Oil & Grease[a] (mg/L)	EPA-1664	<1	<1	<1	-
Copper[a] (µg Cu/L)	FAAS	<10	<10	<10	-
Iron[a] (µg Fe/L)	FAAS	<20	<20	35	-

Cadmium[a] (µg Cd/L)	FAAS	<10	<10	<10	-
Arsenic[a] (µg As/L)	Col	<10	<10	<10	-
Lead[a] (µg Pb/L)	FAAS	<20	<20	<20	-
Mercury[a] (µg Hg/L)	CVAAS	<0.1	<0.1	<0.1	-
Zinc[a] (µg Zn/L)	FAAS	<10	<10	<10	-

Shaded parameters are ISO/IEC 17025 Accredited
[a] Parameters were subcontracted
[b] Parameter was done in the field

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Parameters	Method	Sample ID	NRCA AMBIENT WATER STANDARD
		Sample #7	
pH[b]	DR	6.91	
Conductivity[b] (mS/cm)	DR	0.374	**0.15 – 0.6**
Dissolved Oxygen[b] (mg/L)	DR	6.38	-
Salinity[b] (ppt)	DR	0.18	-
Total Dissolved Solids[b] (g/L)	DR	0.242	**0.12 – 0.3**
Temperature[b] (°C)	DR	25.30	-
Biochemical Oxygen Demand (mg O_2/L)	H-10099	0.2	**0.8 – 1.7**
Chemical Oxygen Demand (mg O_2/L)	H-8000	7	-
Total Suspended Solids (mg/L)	SM-2540-D	8.5	-
Nitrate (mg NO_3/L)	H-8039	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		<0.3	-
Nitrate (mg NO_3/L)	H-8192	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		-	-
Phosphate (mg PO_4^{3-}/L)	H-8048	0.04	**0.01 – 0.8**
Sulfate (mg SO_4^{2-}/L)	H-8051	1	**3.0 – 10.0**
Chloride (mg Cl^-/L)	H-8206	8.4	**5.0 – 20.0**
Total Coliform (MPN/100mL)	SM-9221	>1600	-
Faecal Coliform (MPN/100mL)	SM-9221	540	-
Oil & Grease[a] (mg/L)	EPA-1664	<1	-
Copper[a] (µg Cu/L)	FAAS	<10	-
Iron[a] (µg Fe/L)	FAAS	187	-
Cadmium[a] (µg Cd/L)	FAAS	<10	-

Arsenic[a] (µg As/L)	Col	<10	-
Lead[a] (µg Pb/L)	FAAS	<20	-
Mercury[a] (µg Hg/L)	CVAAS	<0.1	-
Zinc[a] (µg Zn/L)	FAAS	<10	-

Certificate of Quality

Parameter: Biochemical Oxygen Demand
QEHL Personnel: M. Betton **Date of Analysis: 19/11/15**

Parameter: Total Suspended Solids
QEHL Personnel: K. Rose **Date of Analysis: 20/11/15**

	Standard Concentration (ppm)	Determined Concentration (ppm)	Recovery (%)	RPD
BD		6.8		2.9
		7.0		
MB		<2.5		

Parameter: Chloride
QEHL Personnel: M. Dawkins **Date of Analysis: 23/11/15**

	Standard Concentration (ppm)	Determined Concentration (ppm)	Recovery (%)	RPD
BD		736.0		0.0
		736.0		
MB		<3.0		
SRS	100.0	100.0	100.0	0.0

Parameter: Nitrate (Low Range)

QEHL Personnel: M. Betton **Date of Analysis: 19/11/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		0.01		
BD		0.04		83.3*
		0.09		
SRS	0.40	0.42	105.0	5.0

***Duplicates accepted based on the sensitivity of the method used.**

Parameter: Nitrate (High Range)

QEHL Personnel: M. Dawkins **Date of Analysis: 19/11/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		0.4		
BD		17.6		0.0
		17.6		
SRS	10.0	9.9	99.0	1.0

Parameter: Sulfate

QEHL Personnel: K. Rose **Date of Analysis: 23&25/11/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		2		
BD		31		3.2
		32		
SRS	70	69	98.6	1.4

Parameter: Phosphate

QEHL Personnel: M. Betton **Date of Analysis: 19/11/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		0.02		
BD		0.05		22.2
		0.04		
SRS	2.00	2.00	100.0	0.0

Parameter: Chemical Oxygen Demand

QEHL Personnel: K. Rose **Date of Analysis: 19/11/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
BD		28		3.5
		29		
SRS	100	103	103.0	3.0

Parameter: Faecal & Total Coliform

QEHL Personnel: M. Mighty **Date of Analysis: 19/11/15**

Media/Test Item (Batch#)	SS LTB (18/11/15)	DS LTB (18/11/15)	EC (10/11/15)	BG (10/11/15)
Sterile (Yes/No)	Yes	Yes	Yes	Yes
Media performance (Typical, not typical)	Typical	Typical	Typical	Typical

Glossary

BD	–	Batch Duplicate
Col	-	Colourimetry
CV-FAAS	-	Cold Vapour Atomic Absorption Spectroscopy
DR	–	Direct Reading
DS LTB	-	Double Strength Lauryl Tryptose Broth
EC	-	E. coli Media
EPA	–	US Environmental Protection Agency
FAAS	-	Flame Atomic Absorption Spectroscopy
H	–	Hach Water Analysis Workbook 7th& 8th Edition
ISE	-	Ion Selective Electrode
MB	–	Method Blank
RED	-	Parameter Non-compliant
RPD	–	Relative Percentage Difference
SM	-	Standard Methods for the Examination of Water and Wastewater 22nd Edition
SRS	–	Standard Reference Solution

End of Report

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ENVIRONMENTAL & FOOD
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Certificate of Sample Analysis

Cert. #: ESL-ECS 15062501-10

Attention:

Ms. Nalini Jagnarine
ESL- Environmental Consultancy Services
Environmental Solutions Limited
89 Hope Road
Kingston 6

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Sample(s) Information

Job Number:	**15062501-10**
Date of Report:	08/09/2015
Sample(s) Collected:	24/06/2015
Sample(s) Submitted:	25/06/2015
Condition on Arrival:	1.1˚C
Number of samples:	10
Specific Handling:	None
Analysis Started:	25/06/2015
Analysis completed:	08/09/2015
Prepared By:	**Lesa Lemmie, Technical Assistant**

Special Comments:

None.

Verified by: ……

Mario Christie, Technical Manager

Approved By: ……

Rashidah Khan-Haqq, QEHL Manager

Results of Sample Analysis

Parameters	Method	Sample ID				NRCA AMBIENT WATER STANDARD
		Sample BR #1	Sample #2	Sample #3s	Sample #3ss	
Conductivity[b] (mS/cm)	DR	5.84	4.23	1.227	1.63	**0.15 – 0.6**
Dissolved Oxygen[b] (mg/L)	DR	4.12	3.45	3.70	3.32	-
Salinity[b] (ppt)	DR	3.00	2.15	0.57	0.77	-
Total Dissolved Solids[b] (g/L)	DR	3.624	2.650	0.749	1.000	**0.12 – 0.3**
Temperature[b] (°C)	DR	27.53	26.9	28.36	28.15	-
Biochemical Oxygen Demand (mg O_2/L)	H-10099	3.0	0.6	2.0	-	**0.8 – 1.7**
	H-8043	-	-	-	4.5	
Chemical Oxygen Demand (mg O_2/L)	H-8000	6	17	12	17	-
Total Suspended Solids (mg/L)	SM-2540-D	5.2	5.8	<2.5	<2.5	-
Nitrate (mg NO_3/L)	H-8192	-	-	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		<0.01	<0.01	<0.01	<0.01	-
Phosphate (mg PO_4^{3-}/L)	H-8048	0.04	0.06	0.06	0.06	**0.01 – 0.8**
Sulfate (mg SO_4^{2-}/L)	H-8051	270	165	41	45	**3.0 – 10.0**
Chloride (mg Cl^-/L)	H-8206	1,630.0	1,168.0	243.0	249.0	**5.0 – 20.0**
Total Coliform (MPN/100mL)	SM-9221	540	540	240	1600	-
Faecal Coliform (MPN/100mL)	SM-9221	79	79	79	130	-
Oil & Grease[a] (mg/L)	EPA-1664	<1	<1	<1	<1	-
Copper[a] (µg Cu/L)	FAAS	<10	<10	<10	<10	-

Iron[a] (µg Fe/L)	FAAS	254	285	125	110	-
Cadmium[a] (µg Cd/L)	FAAS	<10	<10	<10	<10	-
Arsenic[a] (µg As/L)	Col	<10	<10	<10	<10	-
Lead[a] (µg Pb/L)	FAAS	<20	<20	<20	<20	-
Mercury[a] (µg Hg/L)	CVAAS	<0.1	<0.1	<0.1	<0.1	-
Zinc[a] (µg Zn/L)	FAAS	13	<10	<10	18	-

Shaded parameters are ISO/IEC 17025 Accredited
[a] Parameters were subcontracted
[b] Parameter was done in the field

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Parameters	Method	Sample ID				NRCA AMBIENT WATER STANDARD
		Sample #4s	Sample #4ss	Sample #5s	Sample #5ss	
Conductivity[b] (mS/cm)	DR	1.048	1.170	-	0.548	**0.15 – 0.6**
Dissolved Oxygen[b] (mg/L)	DR	3.34	3.9	-	2.57	**-**
Salinity[b] (ppt)	DR	0.48	0.54	-	0.25	**-**
Total Dissolved Solids[b] (g/L)	DR	0.643	0.717	-	0.343	**0.12 – 0.3**
Temperature[b] (°C)	DR	28.19	28.08	-	26.95	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-10099	3.6	-	2.4	-	**0.8 – 1.7**
	H-8043	-	4.6	-	2.2	
Chemical Oxygen Demand (mg O_2/L)	H-8000	12	17	4	<3	**-**
Total Suspended Solids (mg/L)	SM-2540-D	<2.5	<2.5	<2.5	<2.5	**-**
Nitrate (mg NO_3/L)	H-8039	-	-	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		<0.3	<0.3	<0.3	<0.3	**-**
Nitrate (mg NO_3/L)	H-8192	-	-	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		-	<0.01	-	-	**-**
Phosphate (mg PO_4^{3-}/L)	H-8048	0.04	0.05	0.04	0.05	**0.01 – 0.8**
Sulfate (mg SO_4^{2-}/L)	H-8051	24	24	5	7	**3.0 – 10.0**
Chloride (mg Cl^-/L)	H-8206	154.0	148.0	42.8	45.6	**5.0 – 20.0**
Total Coliform (MPN/100mL)	SM-9221	350	540	>1600	540	**-**
Faecal Coliform (MPN/100mL)	SM-9221	33	110	46	130	**-**
Oil & Grease[a] (mg/L)	EPA-1664	<1	<1	<1	<1	**-**
Copper[a] (µg Cu/L)	FAAS	<10	<10	<10	<10	**-**
Iron[a] (µg Fe/L)	FAAS	99	79	141	110	**-**
Cadmium[a] (µg Cd/L)	FAAS	<10	<10	<10	<10	**-**

Arsenic[a] (µg As/L)	Col	<10	<10	<10	<10	-
Lead[a] (µg Pb/L)	FAAS	<20	<20	<20	<20	-
Mercury[a] (µg Hg/L)	CVAAS	<0.1	<0.1	<0.1	<0.1	-
Zinc[a] (µg Zn/L)	FAAS	<10	18	20	<10	-

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[b] Parameter was done in the field

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Parameters	Method	Sample ID		NRCA AMBIENT WATER STANDARD
		Sample #6	Sample #7	
Conductivity[b] (mS/cm)	DR	0.308	0.416	**0.15 – 0.6**
Dissolved Oxygen[b] (mg/L)	DR	8.51	5.83	-
Salinity[b] (ppt)	DR	0.15	0.19	-
Total Dissolved Solids[b] (g/L)	DR	0.203	0.260	**0.12 – 0.3**
Temperature[b] (°C)	DR	24.15	26.78	-
Biochemical Oxygen Demand (mg O_2/L)	H-10099	0.8	0.6	**0.8 – 1.7**
Chemical Oxygen Demand (mg O_2/L)	H-8000	<3	<3	-
Total Suspended Solids (mg/L)	SM-2540-D	23.2	16.8	-
Nitrate (mg NO_3/L)	H-8039	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)		<0.3	<0.3	-
Phosphate (mg PO_4^{3-}/L)	H-8048	0.07	0.09	**0.01 – 0.8**
Sulfate (mg SO_4^{2-}/L)	H-8051	4	6	**3.0 – 10.0**
Chloride (mg Cl^-/L)	H-8206	<3.0	4.2	**5.0 – 20.0**
Total Coliform (MPN/100mL)	SM-9221	>1600	>1600	-
Faecal Coliform (MPN/100mL)	SM-9221	920	170	-
Oil & Grease[a] (mg/L)	EPA-1664	1	1	-
Copper[a] (µg Cu/L)	FAAS	<10	<10	-
Iron[a] (µg Fe/L)	FAAS	646	223	-
Cadmium[a] (µg Cd/L)	FAAS	<10	<10	-

Arsenic[a] (µg As/L)	Col	<10	<10	-
Lead[a] (µg Pb/L)	FAAS	<20	<20	-
Mercury[a] (µg Hg/L)	CVAAS	<0.1	<0.1	-
Zinc[a] (µg Zn/L)	FAAS	<10	20	-

Shaded parameters are ISO/IEC 17025 Accredited

[a] Parameters were subcontracted

[b] Parameter was done in the field

Certificate of Quality

Parameter: Biochemical Oxygen Demand
QEHL Personnel: K. Rose **Date of Analysis: 25/06/15**

Parameter: Total Suspended Solids
QEHL Personnel: M. Betton **Date of Analysis: 30/06/15**

	Standard Concentration (ppm)	Determined Concentration (ppm)	Recovery (%)	RPD
BD		<2.5		-
		<2.5		
MB		<2.5		

Parameter: Chloride
QEHL Personnel: M. Dawkins **Date of Analysis: 30/06/15**

	Standard Concentration (ppm)	Determined Concentration (ppm)	Recovery (%)	RPD
BD		248.0		0.8
		250.0		
MB		<3.0		
SRS	100	98.8	98.8	1.2

Parameter: Nitrate (Low Range)

QEHL Personnel: K. Rose **Date of Analysis: 25/06/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		0.01		
BD		<0.01		-
		<0.01		
SRS	0.40	0.38	95.0	5.0

Parameter: Nitrate (High Range)

QEHL Personnel: M. Betton **Date of Analysis: 25/06/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		0.4		
BD		<0.3		-
		<0.3		
SRS	10.0	10.4	104.0	4.0

Parameter: Sulfate

QEHL Personnel: K. Rose **Date of Analysis: 29/06/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		2		
BD		4		28.6*
		3		
SRS	70	68	97.1	2.9

***Duplicates accepted based on the sensitivity of the method used.**

Parameter: Phosphate

QEHL Personnel: K. Rose **Date of Analysis: 25/06/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
MB		<0.02		
BD		0.36		2.7
		0.37		
SRS	2.00	1.99	99.5	0.5

Parameter: Chemical Oxygen Demand

QEHL Personnel: M. Dawkins **Date of Analysis: 25/06/15**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	Recovery (%)	RPD
BD		4		0.0
		4		
SRS	100	96	96.0	4.0

Parameter: Faecal & Total Coliform

QEHL Personnel: M. Mighty **Date of Analysis: 25/06/14**

Media/Test Item (Batch#)	SS LTB (19/6/15)	DS LTB (23/6/15)	EC (22/6/15)	BG (17/6/15)
Sterile (Yes/No)	Yes	Yes	Yes	Yes
Media performance (Typical, not typical)	Typical	Typical	Typical	Typical

Glossary

BD	–	Batch Duplicate
Col	-	Colourimetry
CV-FAAS	-	Cold Vapour Atomic Absorption Spectroscopy
DR	–	Direct Reading
DS LTB	-	Double Strength Lauryl Tryptose Broth
EC	-	E. coli Media
EPA	–	US Environmental Protection Agency
FAAS	-	Flame Atomic Absorption Spectroscopy
H	–	Hach Water Analysis Workbook 7th& 8th Edition
ISE	-	Ion Selective Electrode
MB	–	Method Blank
RED	-	Parameter Non-compliant
RPD	–	Relative Percentage Difference
SM	-	Standard Methods for the Examination of Water and Wastewater 22nd Edition
SRS	–	Standard Reference Solution

End of Report

Appendix XI- Duties and Roles of Wardens

A minimum of three wardens should be assigned to monitor and regulate activities along the BR and its tributaries. Each warden should be assigned a specific station in which they will monitor the activities in that area. Their stations and duties are outlined below.

Warden 1: 100m from the BR Bridge on the BR

Duties: Regulation of starting time for safari tours

Tallying the number and type of boats using the river

Enforcement of speed limits on the river

Enforcement of the ban on particular water based activities such as jet skiing

Warden 2: At Salt Spring

Duties: Ensure visitor safety (swimming and life vests)

Ensure "rules of the river" are adhered to

Enforcement of ban on burning and cutting in the morass

Enforcement of the ban on particular water based activities such as jet skiing

Warden 3: At Cheese Rock

Duties: Ensure visitor safety (swimming and life vests)

Ensure "rules of the river" are adhered to

Enforcement of ban on burning and cutting in the morass

Enforcement of the ban on particular water based activities such as jet skiing

The warden and their duties should be regulated by the NRCA and NEPA. These wardens or field officers should be given powers of arrest as a method of dealing with violators.