Atlas

Water Quality

JAMAICA

2019

WRA

WATER RESOURCES AUTHORITY

Jamaica's Water ... Every Drop Precious

Foreword

The Government of Jamaica promulgated the Water Resources Act (WRA Act) of 1995 into law on April 7, 1996, legally mandating the Authority in Section 4 of the Act to conserve, protect, allocate and otherwise manage Jamaica's freshwater resources. The Act further states in Section 16 that the Authority should "...prepare and submit to the Minister for approval a draft Water Resources Master Plan for Jamaica." In performing the functions set out above, Section 16(5) sets out items to be considered for inclusion as follows:

- Identifies objectives for development, conservation and use of water resources that factors in: desirability of economic efficiency, protection of health, safety and welfare of persons, protection or encouragement of economic activity, protection of the environment and enhancement of environmental values,
- Identifies, describes and inventories the occurrence, quantity, availability, quality, current uses of water and the activities which are related to water and its uses,
- Identifies and describes the projected needs for water and recommends the projects, programmes and other steps which should be undertaken,
- Indicates objectives in relation to water quality and programmes designed to achieve those objectives,
- Indicates and evaluates the ways in which the objectives will be achieved.

A determination of the status of the water resources and the water quality trends is the first step in the identifying current water quality within the hydrologic basins across the island in a bid to provide the recommended use for each water source. Funding for the production of the Water Quality Atlas was provided by the Government of Jamaica through its 2016-2017 budget subvention to the Water Resources Authority.

PROJECT TEAM:

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List of Abbreviations

WHO	World Health Organization
US EPA	United States Environmental Protection Agency
GSD	Geological Survey Department
FAO	Food and Agriculture Organization of the United Nations
GOJ	Government of Jamaica
UNESCO	United Nations Education, Scientific and Cultural Organization

Background

Groundwater and surface water quality monitoring on a national scale is not a new concept to Jamaica. In 1965, the Food and Agriculture Organization (FAO) of the United Nations and the Government of Jamaica (GOJ) through the Geological Survey Department (GSD) collaborated to establish an islandwide water quality monitoring network and develop an organized system for compiling water quality data. This database focused on physical and chemical (inorganic) parameters and continued for several years. Though there was no consistent monitoring frequency, data was collected islandwide throughout the 1960s and into the 1970s. However, by the early 1970s, with the termination of FAO participation, the comprehensive sampling and data collection effort ended. Thereafter, water quality data was infrequently collected on a reduced scale and largely in response to specific known water quality issues.

The focus of the Authority in the 1970s to 1980s shifted primarily to the monitoring of water quantity i.e. stream-flow measurements of rivers, water level measurements of aquifer systems and the assessment of ground and surface water (quantity) availability. During this period, water quality data was primarily gathered on a needs basis in response to specific pollution issues. This continued throughout the late 1970s until the late 1980s, when the global trends began to place emphasis on environmental issues, which once again brought to the fore, issues of pollution of natural resources. Water quality related issues being high on the international agenda, led to a renewed focus on water quality management here in Jamaica.

Intrinsic to the management of Jamaica's freshwater resources is the assessment of the water quality status of these resources. The WRA undertook the production of the Jamaica's first Water Quality Atlas (2001) through funding provided by the United Nations Education, Scientific and Cultural Organization (UNESC0) under the 1996-1997 budget – ***Major Programme II; Programme II.3.4., Hydrology and water resources development in a vulnerable environment.*** A comprehensive water quality monitoring programme was implemented, taking samples from 505 point sources islandwide for the development of the National Water Quality Atlas (inclusive of several abstraction points). The Water Quality Atlas provided a simple, visibly illustrative, spatial method of depicting the status of Jamaica's freshwater quality. In a bid to provide the current status of the island's water quality, the WRA undertook another islandwide water quality monitoring project in 2016/2017. The analysed data from the points sampled, along with the historical water quality data and those submitted by external agencies (government and private agencies), were synthesized and the data used to provide an updated overview on the status of Jamaica's freshwater quality.

Scope

This Atlas represents an interpretation of the available environmental water quality data both collated for the project period and generated from previous detailed water quality assessments. Based on this interpretation, the atlas indicates the suitability of freshwater resources for the various categories of usage: domestic, irrigation, industrial, recreational. The available data was classified by hydrologic basins, and pollution indicators were selected by the types of pollutants/pollution risks ether known to exist or considered likely to exist in each hydrologic basin. The atlas's sole focus is groundwater and surface water resources, thereby excluding the marine environment.

Limitations

The unavailability and insufficiency of microbiological, organic, heavy metals and pesticide data limited the Atlas to physical and chemical parameters. Collated data included results from samples collected by external agencies and private sources for which the reliability of the sampling techniques, the preservation of the samples or the analysis accuracy cannot be guaranteed. However, these collated data were compared with the results from sampling undertaken by the Authority for which sampling was conducted in accordance with the Standard Method for the Examination of Water and Wastewater (APHA 1998) to assess their reliability.

Methodology/Approach

Groundwater Quality Sampling Points

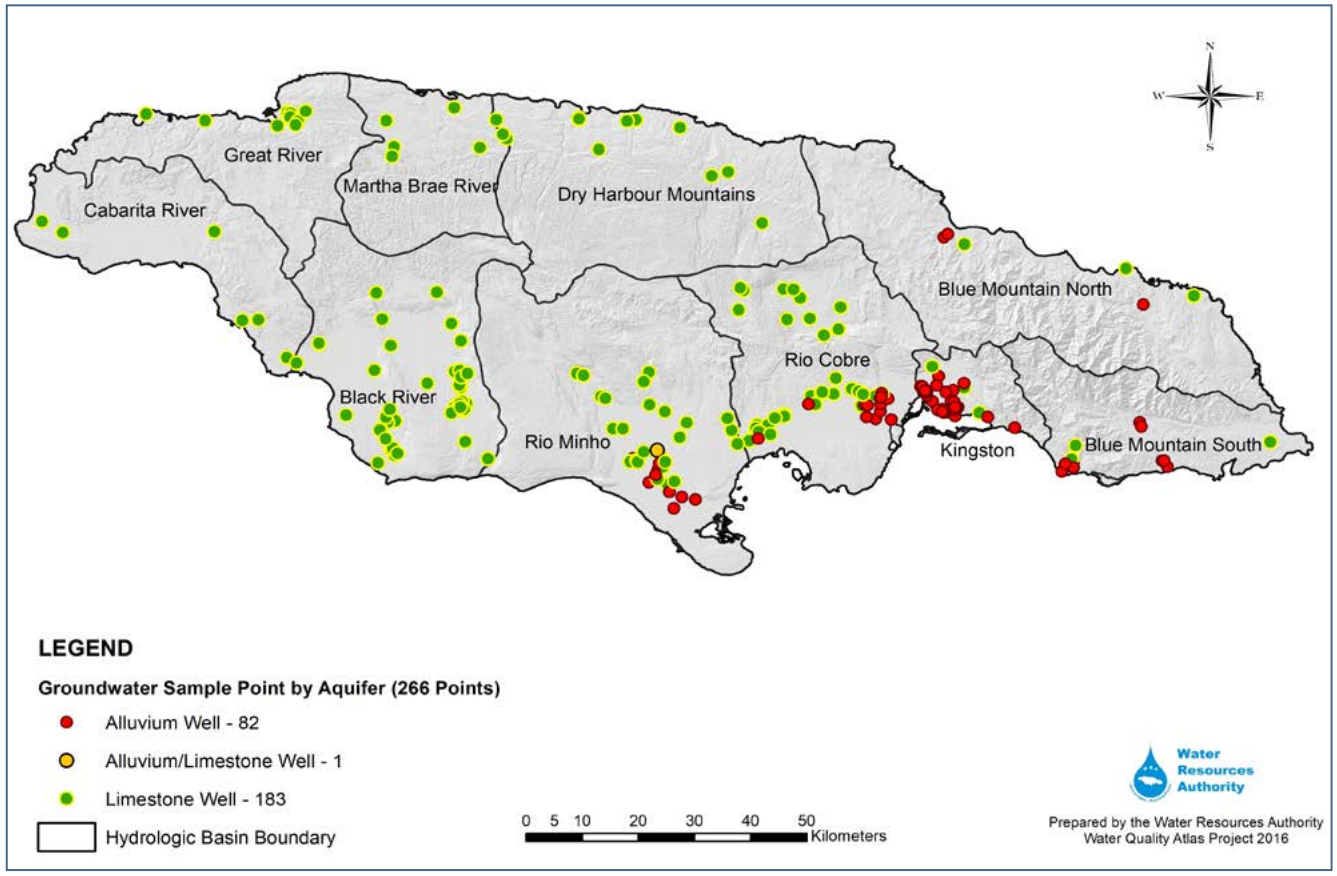


Figure 1: Groundwater Quality Sampling Points, Jamaica

GROUNDWATER MONITORING NETWORK

The groundwater quality monitoring network was selected from existing pumping wells within each hydrologic basin. To ensure greater coverage compared to former years, water quality data from abstractors as well as those sampled by WRA's officers were used for this assessment; this saw an increase of groundwater sample points from 84 in 2001 to 266 sampling points. The samples analysed were obtained over a one year period.

The groundwater sample points (wells), tap either the limestone or alluvium aquifer, as shown in Figure 1 below.

Surface Water Monitoring Network

Surface Water Quality Sampling Points

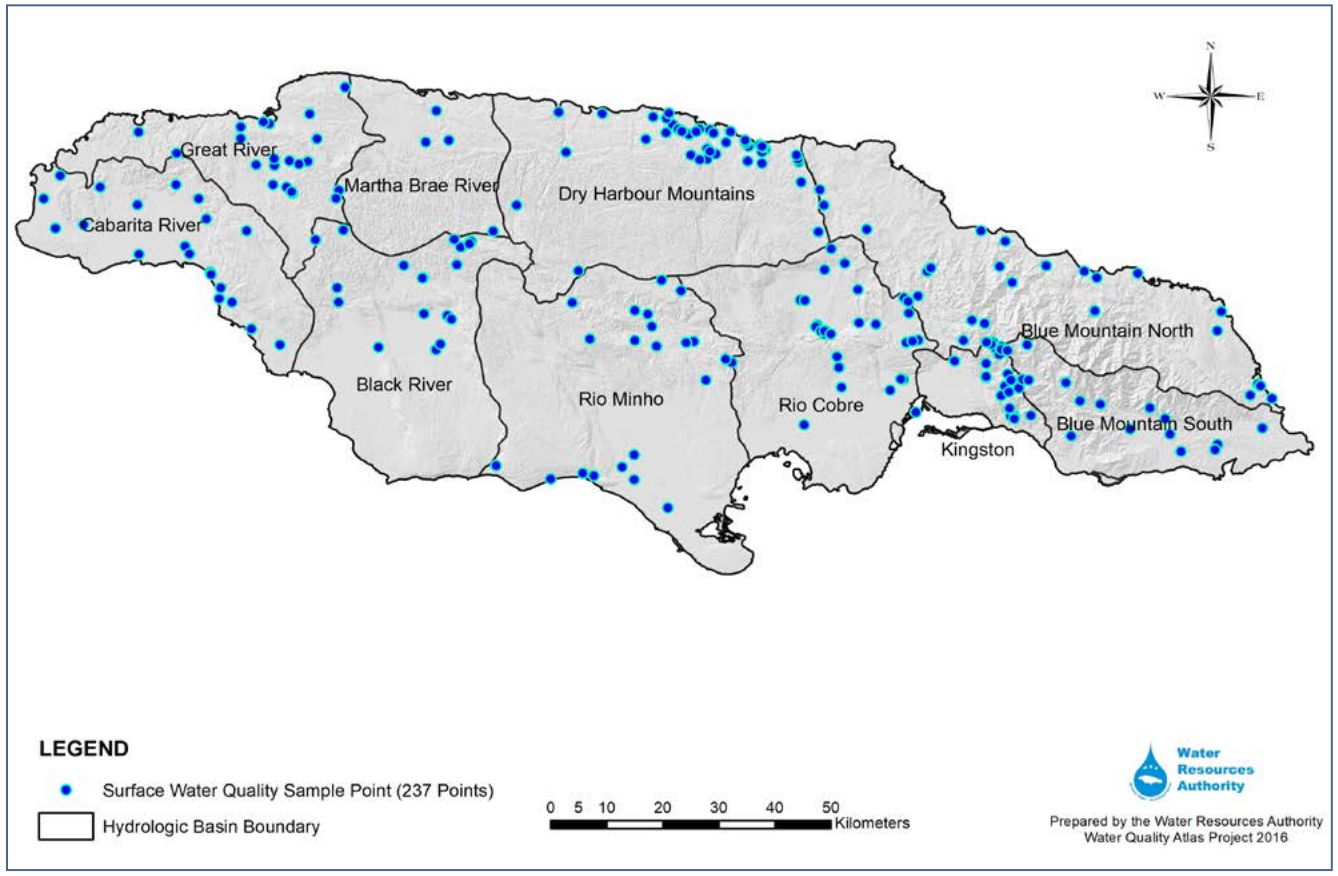


Figure 2: Surface Water Quality Sampling Points, Jamaica

The sample points were primarily:

- rivers that have been are diverted to drinking water treatment plants and
- springs that were entombed as sources of drinking water.

Data was analysed from 239 sample points and are a "snapshot" of water quality at the time the sample was taken.

Spatial Interpolation of groundwater quality sampling points

Spatial analysis of groundwater quality data was done using Geographic Information Systems (GIS) where two methods of spatial interpolation were employed in the assessment of water quality at an islandwide scale. These methods are Inverse Distance Weighting (IDW) and Kriging. Both methods of interpolation use complex mathematical formulas (Kriging more so than IDW) to estimate values at unknown points based on the values at known points (https://docs.qgis.org/2.18/en/docs/gentle_gis_introduction/spatial_analysis_interpolation.html); the interpolation was therefore able to provide estimated values for those areas not sampled. However, IDW was the chosen method of interpolation for most basins based on the number of sample points and how they were distributed. The lack of a geostatistical analysis tool also presented limitations in using the Kriging method effectively.

The basins analysed were: Kingston, Rio Cobre, Rio Minho and Black River. The analysis provided the expected water quality in unknown areas based on the original results.

The Selection of Water Quality Indicators

Table 1: Possible sources of contamination and the parameters that could affect the water quality.

INDICATORS	POSSIBLE SOURCES
Nitrate /Coliform Counts	Sewage Effluent
Sodium Sodium/ Chloride Ratio	Caustic Effluent from: Bauxite/Alumina Processing Sewage Effluent Detergent Industrial Effluent Influence of seawater
Sulphate	Industrial Effluent from Tanneries, Textile Plants, Sulphuric Acid Plants, metal workings, Sulphite Pulp Mills

INDICATORS	POSSIBLE SOURCES
pH	Caustic Effluent from Bauxite/Alumina Processing
Chloride/Bicarbonate Ratio	Influence of Seawater
Total Dissolved Solids/ Conductivity	Representation of salts in a sample Industrial Effluent Influence of seawater Sewage Effluent

The Water Quality Classification System

The colors used in the classification system are presented below.

Table 2: THE COLORS OF THE WATER QUALITY CLASSIFICATION SYSTEM

EXCELLENT/HIGH QUALITY (**Meets** the NATIONAL AMBIENT WATER QUALITY STANDARD)	
EARLY DETERIORATION (Does **NOT** meet the NATIONAL AMBIENT STANDARD but **meets** the WHO Guidelines for Drinking Water)	
POOR QUALITY (**Exceeds** the WHO Guidelines for Drinking Water and is **UNSUITABLE** for drinking without adequate treatment)	

For each basin, water quality classification maps have been presented showing the classification of both ground and surface water sources.

Analytes

NITRATE

Nitrate (NO_3^-) is a nitrogenous compound formed through the chemical combustion of nitrogen and oxygen; a process called nitrogen fixation. It is a vital component of all living things since it is the most readily assimilated form of nitrogen. It is also the most commonly found form of nitrogen found in water resources; a function of the high mobility of its ions. Notwithstanding this, nitrate concentrations have been greatly increased via anthropogenic activities, primarily in groundwater (www. reopure. com/nitrate); the largest contributors being absorption pits and failing septic tanks, runoff from animal manure storage areas, fertilized of croplands (Environmental Protection Agency, 2001). Nitrate levels greater than the drinking water standards is a public health risk as it may cause the condition called methemoglobinemia (hazard to infants above 11mg/l N (50mg/lNO3) (Environmental Protection Agency, 2001), or "blue baby" syndrome. Nitrate groundwater contamination may be associated with wastes from food–processing industries, improper disposal of sewage and animal faeces and poor agricultural practices (Asadi, Vuppala, & Reddy, 2007). Since nitrate and ammonia are both indicative of the same type of contamination; that is, from sewage or industrial waste and ammonia is first derived in the nitrogen-fixation process (as a gas), then nitrate is the preferred parameter for detection of waste contamination.

SODIUM

Sodium (Na) is a naturally occurring element present in natural waters. This is due to most rocks and soils containing sodium compounds, from which sodium readily dissolves in the presence of water. Sodium is often found naturally in groundwater, due to its high solubility (Environmental Protection Agency, 2001). High concentration may be found in some groundwater due to natural occurrence such as high water table in a coastal region. Its threat to humans is that if consumed in excess it may cause hypertension or cause complications for people with heart or kidney diseases. Elevated sodium levels in water may be an indication of either point or non-point sources of pollution or saltwater intrusion. Point pollution sources may include: infiltration of irrigation and rainfall from rich deposits of sodium–containing minerals such as sodium chloride (salts); infiltration of leachate from landfills or industrial sites (including bauxite and alumina processing) and groundwater pollution from improperly treated sewage effluent.

CHLORIDE

Chloride (Cl^-) can be found in all natural waters. In freshwater ecosystems, chloride originates from rock and soil formations and sea spray. Anthropogenic introduction usually comes from waste discharges. A range of 15-35mg/l Cl^- is customary in rivers and other freshwater bodies, free of any anthropogenic influence. Sewage and some industrial wastes are rich sources of chloride. Thus, chloride is often used as an indicator of sewage and industrial contamination of a water body. High levels of chloride in groundwater may be from saline intrusion from over pumping of wells. Chloride does not constitute a health hazard to humans, but rather the consideration is palatability. A concentration of 250mg/l in water causes a salty taste, which intensifies as concentration increases.

SULPHATE

Sulphates formula $SO4^{2-}$ exists naturally, originating from the sulphides of heavy metals (iron, copper, nickel and lead), and enter water resources due to the solubility property of their ions (Asadi et al., 2007). Difference in terrain across a region may regulate sulphate concentration levels (Environmental Protection Agency, 2001). Iron sulphides for

example, present in sedimentary rocks can be oxidized into sulphates which then leach into water sources. It is typical for groundwater to have high concentrations of sulphates. However, elevated levels may be an indication of saltwater intrusion and domestic or industrial waste (https://water.usgs.gov/edu/groundwater-contaminants.html).

TOTAL DISSOLVED SOLIDS

Total dissolved solids (TDS, or Total Filterable Solids) is a representation of salts in a sample; usually of sodium, magnesium, calcium, potassium, chlorides and sulphates. Although the parameter is "total" dissolved solids, the sample is filtered through a defined medium (membrane or glass fibre paper) prior to testing. Many labs take the results of a rapid conductivity test as an estimation of TDS. However, TDS includes ionised and non-ionised matter but conductivity measures only ionised matter. Given that a number of such salts/dissolved solids have been excluded from the list of parameters for sample, TDS then, along with total hardness and electrical conductivity give a good indication of the concentration levels of salts in a sample, therefore eliminating the need to test for each individually. High TDS levels are normally associated with saline waters.

Water Quality Standards

NATIONAL AMBIENT WATER QUALITY STANDARD

The National Ambient Water Quality Standard defines the highest quality of naturally occurring freshwater across the island, i.e. relatively unpolluted freshwater; water that is considered safe and generally suitable for the main beneficial uses and supportive of natural aquatic ecosystems. This standard takes the form of a range, as opposed to a single value for each parameter. The use of ranges is in recognition of the natural and normal variations in the absolute concentrations of specific parameters of our freshwater.

In general, Jamaica's freshwater resources are considered to be of high quality and therefore the National Ambient Water Quality Standard represents the actual quality of water in several locations across Jamaica and as well as an achievable water quality goal for other locations. Therefore, in this context, water classified as Excellent/High Quality, is water which meets the Ambient Water Quality Standard and is suitable for all three beneficial uses.

GUIDELINE FOR DRINKING WATER QUALITY - FOURTH EDITION - WORLD HEALTH ORGANIZATION (WHO) (2011)

The Guidelines for Drinking Water Quality are provided for the protection of public health. It is an international recognized and acceptable standard for drinking water utilizing data from over ninety (90) developing and developed countries. Where drinking water quality standards do not exist (for example TDS), the United States Environmental Protection Agency (US EPA) Safe Water Standard was utilized.

DRINKING WATER CONTAMINANTS - STANDARD AND REGULATION - UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (US EPA)

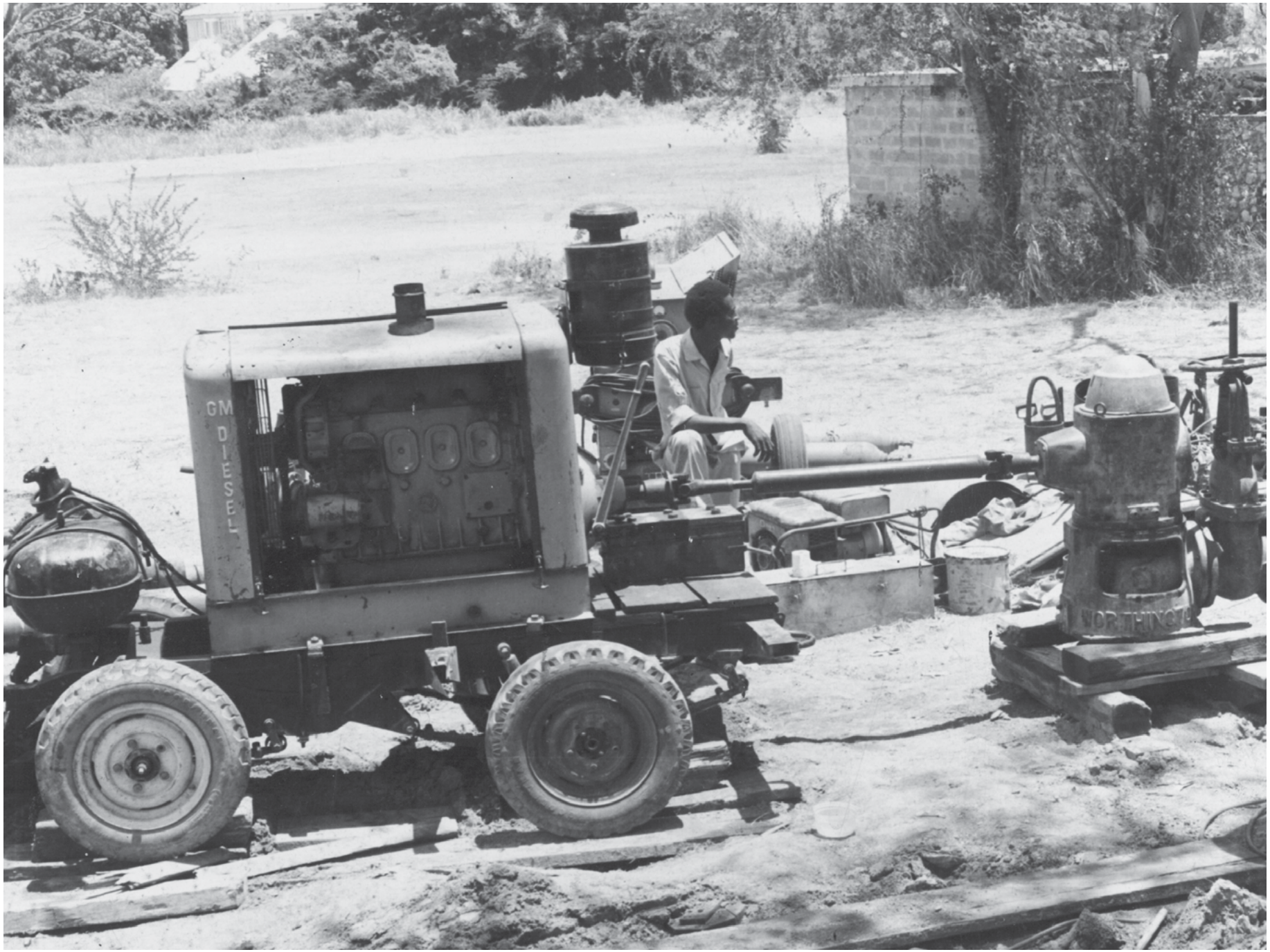
The Environmental Protection Agency (EPA) of the United States through the Safe Drinking Water Act identifies contaminant limits in drinking water.

Under the Safe Drinking Water Act the EPA set standards for drinking water quality to ensure drinking water safety. This standard was included to provide guidance on the limits for total dissolved solids. The total dissolved solids contaminant is neither captured in the National Ambient Standard nor the WHO Standard.

Acceptable Limits for Drinking Water

Table 3: Acceptable Limits for Contaminates in Water

BENEFICIAL USE	PARAMETERS	ACCEPTABLE LIMIT	SOURCE
	Nitrate	< 50 mg/L	World Health Organization Guidelines for Drinking Water, 2011,
	Chloride	< 250 mg/L	
	Sodium	< 200 mg/L	
	Sulphate	< 400 mg/L	
	Total Dissolved Solids	< 500 mg/L	US EPA Drinking Standard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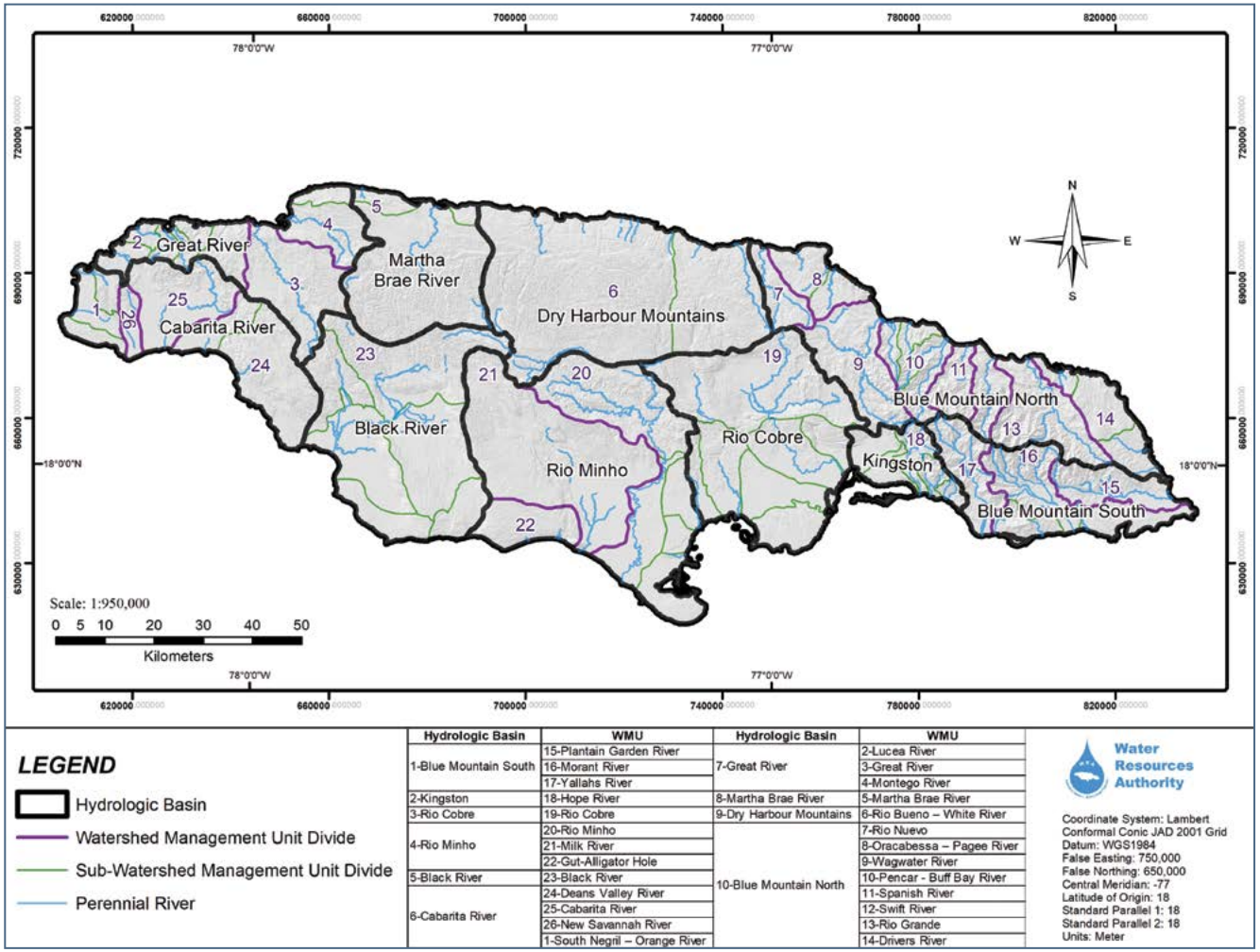
Hydrologic Features of Jamaica

Hydrologic Basins & Watershed Management Units



Hydrologic Basin	WMU	Hydrologic Basin	WMU
1-Blue Mountain South	15-Plantain Garden River	7-Great River	2-Lucea River
	16-Morant River		3-Great River
	17-Yallahs River		4-Montego River
2-Kingston	18-Hope River	8-Martha Brae River	5-Martha Brae River
3-Rio Cobre	19-Rio Cobre	9-Dry Harbour Mountains	6-Rio Bueno – White River
4-Rio Minho	20-Rio Minho	10-Blue Mountain North	7-Rio Nuevo
	21-Milk River		8-Oracabessa – Pagee River
	22-Gut-Alligator Hole		9-Wagwater River
5-Black River	23-Black River		10-Pencar - Buff Bay River
6-Cabarita River	24-Deans Valley River		11-Spanish River
	25-Cabarita River		12-Swift River
	26-New Savannah River		13-Rio Grande
	1-South Negril – Orange River		14-Drivers River

Figure 3: Hydrologic Basins and Watershed Management Units in Jamaica

a. Jamaica has ten (10) hydrologic basins (See Figure 3 and Table 1).
b. Boundaries are surface water divides i.e. no flow across boundaries.
c. Largest basin is Basin IV-Rio Minho with an area of 1814 km^2.
d. Basins are sub-divided into 26 Watershed Management Units (WMUs; see Table 2).
e. The largest WMU is Rio Cobre (basin and WMU has same boundary) with an area of 1257 km^2.
f. Total land area of all 10 basins is 10949 km^2.
g. Limestone aquifers make up ~50% of land area.
h. Alluvium (sand and gravel) aquifers make up ~8% of land area.
i. Aquiclude (non-aquifer) formations make up ~42% of land area.
j. Water type defined by hydrostratigraphy (rock type)
   - Groundwater in aquifer areas
   - Surface water in aquiclude areas
k. Present supply of water is 84% by volume from aquifers (80% limestone-4% alluvium) and 16% from surface water.
l. Water resources reserves are 90% groundwater all in Limestone aquifers.

HYDROLOGIC BASINS	PARISHES COVERED
Blue Mountain South	St. Thomas
Kingston	Kingston and St. Andrew
Rio Cobre	St. Catherine
Rio Minho	Clarendon, Manchester
Black River	St. Elizabeth
Cabarita	Westmoreland
Great River	St. James, Hanover
Martha Brae	Trelawny
Dry Harbour Mountain	St. Ann
Blue Mountain North	St. Mary, Portland

Jamaica Groundwater Quality - Nitrate

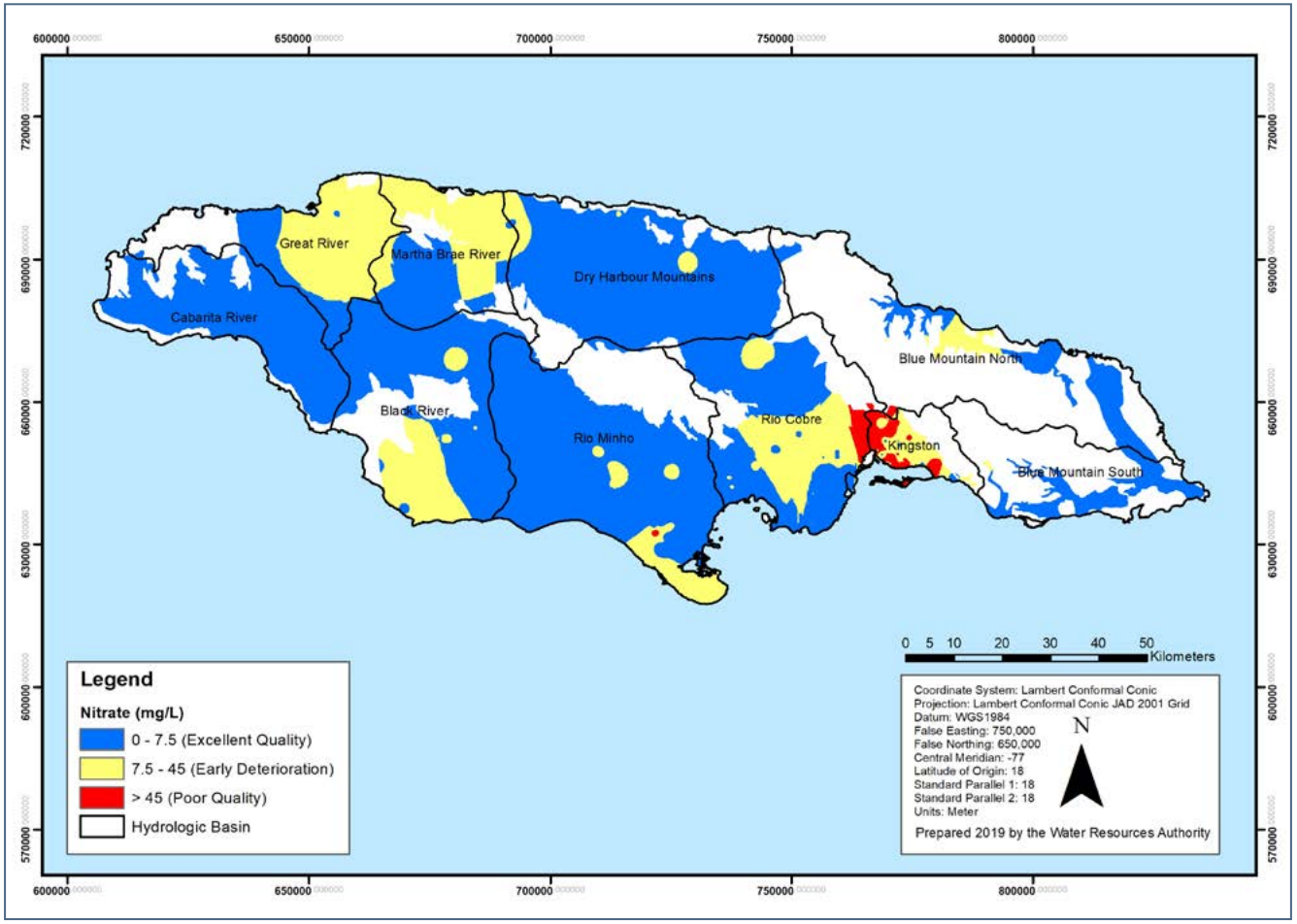


Figure 4: Nitrate Levels in aquifers across the Island

The presence of elevated nitrate indicates seepage of contaminants into the aquifer. Of note, the Kingston Hydrologic Basin (Liguanea Aquifer) shows the poorest quality.

Figure 4 indicates approximately seventy seven percent (77%) of the island's aquifer system having excellent water quality for nitrate. Twenty percent (20%) have indicated early deterioration whilst three percent (3%) have indicated elevated nitrates. Elevated nitrate levels are primarily associated with inadequate sewage treatment and have impacted the quality of the groundwater within the lower sections of the Kingston Basin; primarily in the Liguanea Aquifer. This has resulted in the abandonment of some wells and compromised quality in other domestic wells.

The southern sections of the Rio Cobre Aquifer have also indicated elevated levels of nitrate above the WHO Guidelines for Drinking Water Quality.

Jamaica Groundwater Quality - Sodium

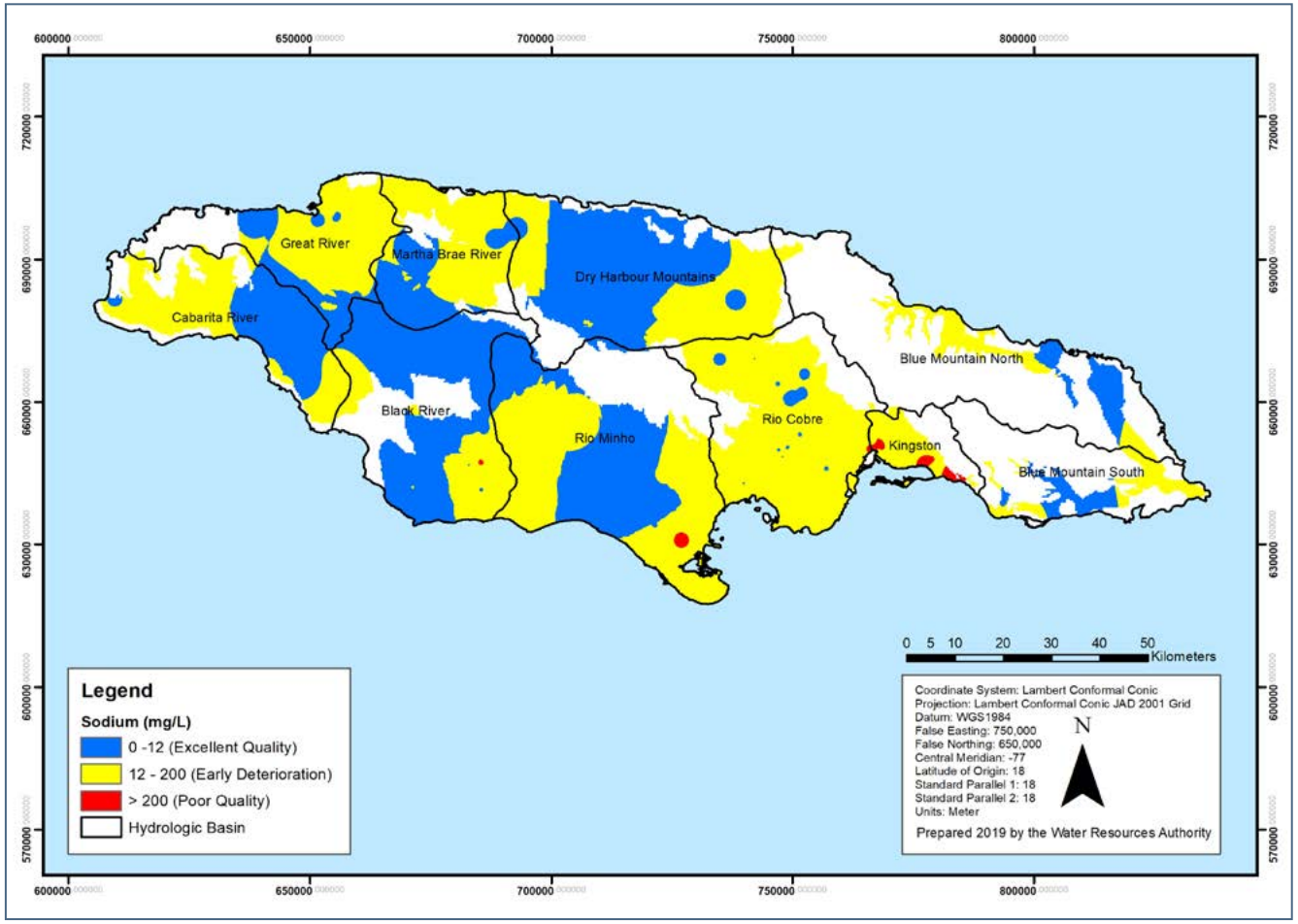


Figure 5: Sodium Levels in underground aquifers across the Island

The most common sources of elevated sodium levels in the groundwater aquifer could be as a result from saline water intrusion, sewage system, salt deposits and sodium bearing rock minerals, and agrochemicals (Sodium and calcium hypochlorite).

Figure 5 indicates approximately forty nine percent (49%) of the island's aquifer systems having excellent water quality for sodium. Fifty percent (50%) have indicated early deterioration whilst less than one percent (1%) have indicated elevated sodium. Pockets of elevated sodium above the WHO Guidelines for Drinking Water Quality have been noted in the Kingston and Rio Minho Basins.

Jamaica Groundwater Quality - Chloride

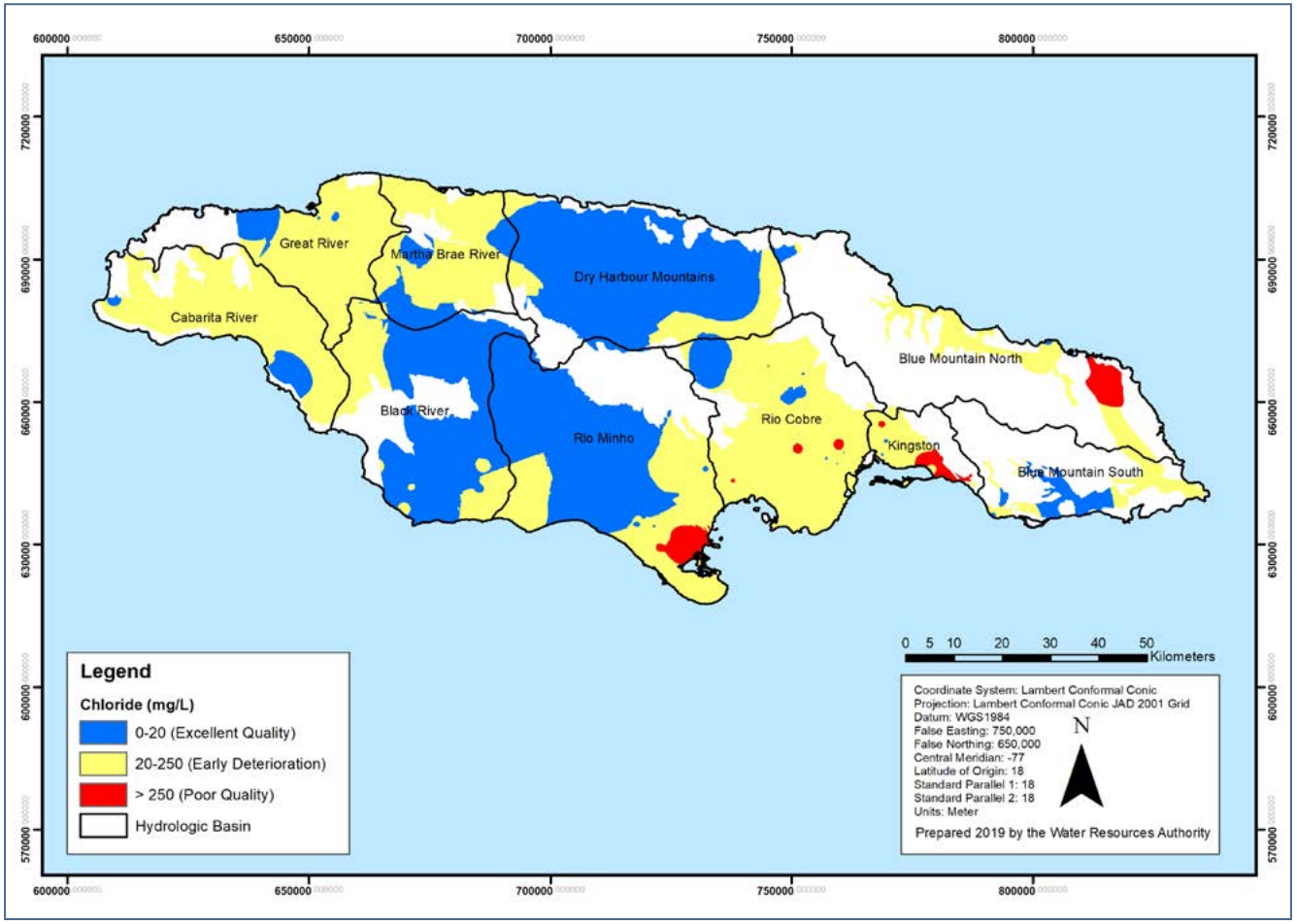


Figure 6: Chloride Level in underground aquifers across the island

The most common sources of elevated chloride levels in groundwater resource is from both natural and anthropogenic sources.

Figure 6 indicates that approximately forty-nine percent (49%) of the island's aquifer systems have excellent water quality for chloride. Forty-nine percent (49%) have indicated early deterioration whilst two percent (2%) indicated elevated chloride levels.

Jamaica Groundwater Quality - Sulphate

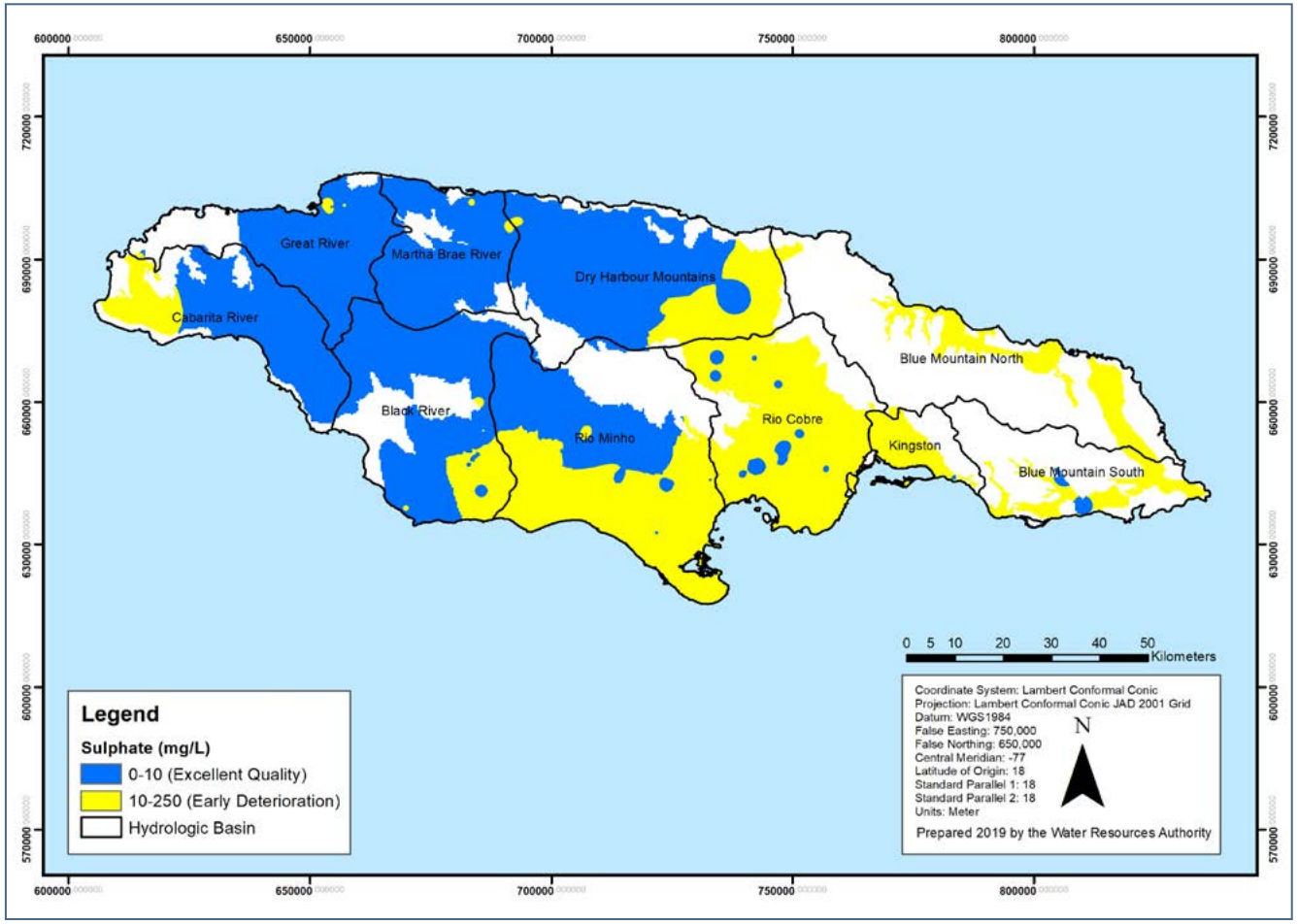


Figure 7: Sulphate levels in underground aquifers across the island

The most common sources of elevated sulphate levels in groundwater resource include atmospheric deposition, sulphate mineral dissolution, and sulphide mineral oxidation.

Figure 7 indicates sixty-five percent (65%) of the island's aquifers having excellent water quality for sulphate whilst thirty-five percent (35%) indicated early deterioration of water quality.

Jamaica Groundwater Quality - TDS

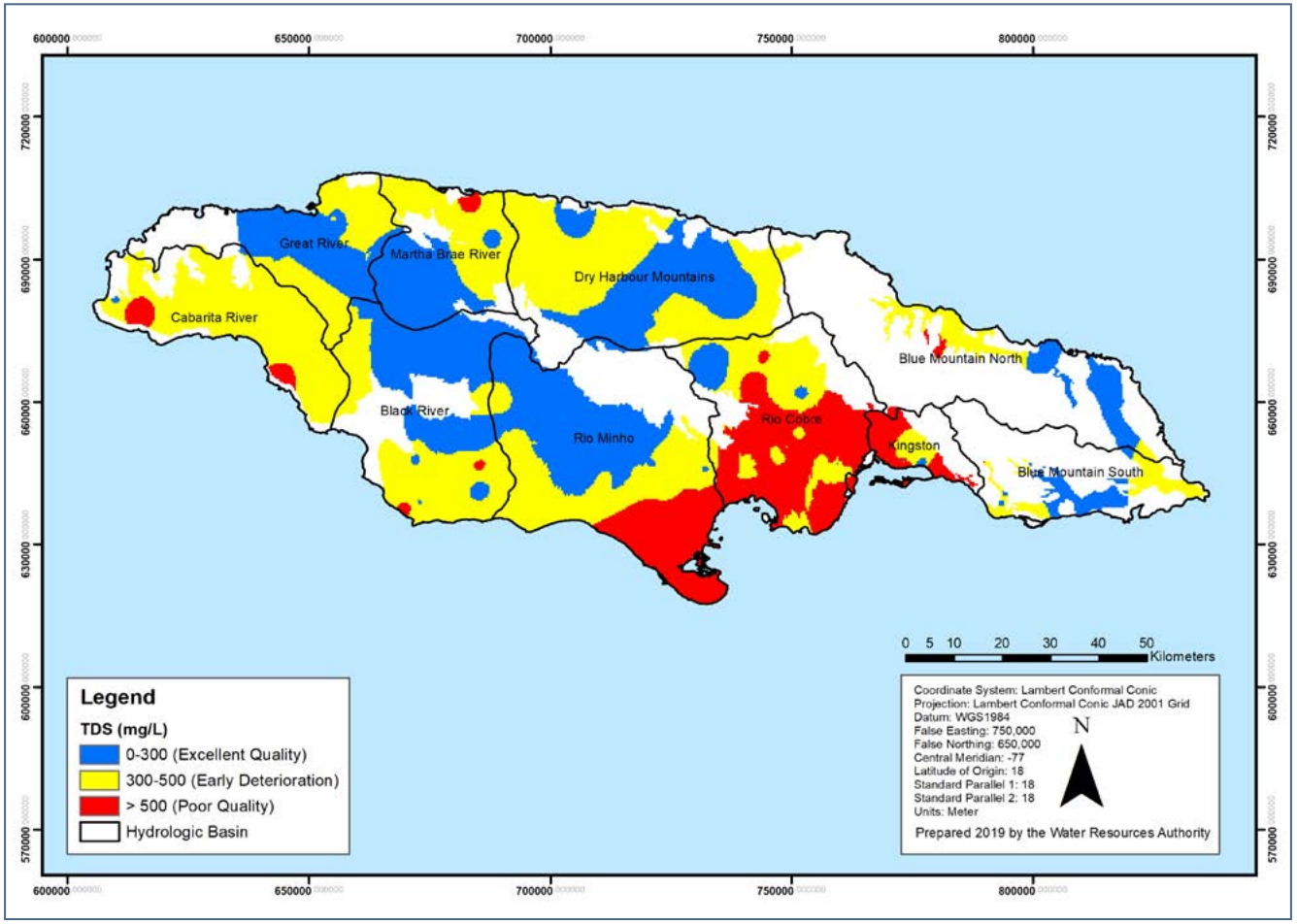


Figure 8: Total Dissolved Solid in underground aquifers across the island

The most common sources of elevated total dissolved solids (TDS) are inorganic compounds that are found in water such as salts, heavy metals and some traces of organic compounds that are dissolved in water.

Figure 8 indicates that thirty-five percent (35%) of the aquifer systems have excellent water quality, forty-five percent experience early deterioration and twenty percent experience poor water quality for TDS. Elevated TDS above the USEPA standard is noted within the southern alluvium aquifers in Kingston, St. Catherine and Clarendon (Kingston, Rio Cobre and Rio Minho Basins? respectively).

Aquifers with elevated TDS experience elevated levels in other compounds such as sulphate, nitrate, heavy metals and sodium.

1.0 Basin I - Blue Mountain South Hydrologic Basin

The Blue Mountain South Hydrologic Basin encompasses the parish of St. Thomas.

The Blue Mountain South Hydrologic Basin has been divided into five sub-basins: Yallahs River, Morant River, White Horses, Plantain Garden River and Port Morant. The basin is drained by a network of rivers traversing the mountains (basement aquiclude – low permeability cretaceous volcanics) in the western, central and eastern sections of the basin, and across the plain towards the southern coast.

The water resources within the Blue Mountain South Basin are comprised of groundwater from alluvium aquifers and surface water from the rivers that drain the five sub-basins.

The main sources of water resource in the Basin are the rivers which emanate in the central mountainous region of the island. These rivers flow south towards the sea with the exception of Plantain Garden - flows east from the Blue Mountains.

The groundwater quality was analysed with the results from thirteen (13) wells (10 alluvium and 3 limestone) and the surface water was done utilizing sixteen (16) sources.

Blue Mountain South Hydrologic Basin Groundwater Sample Locations

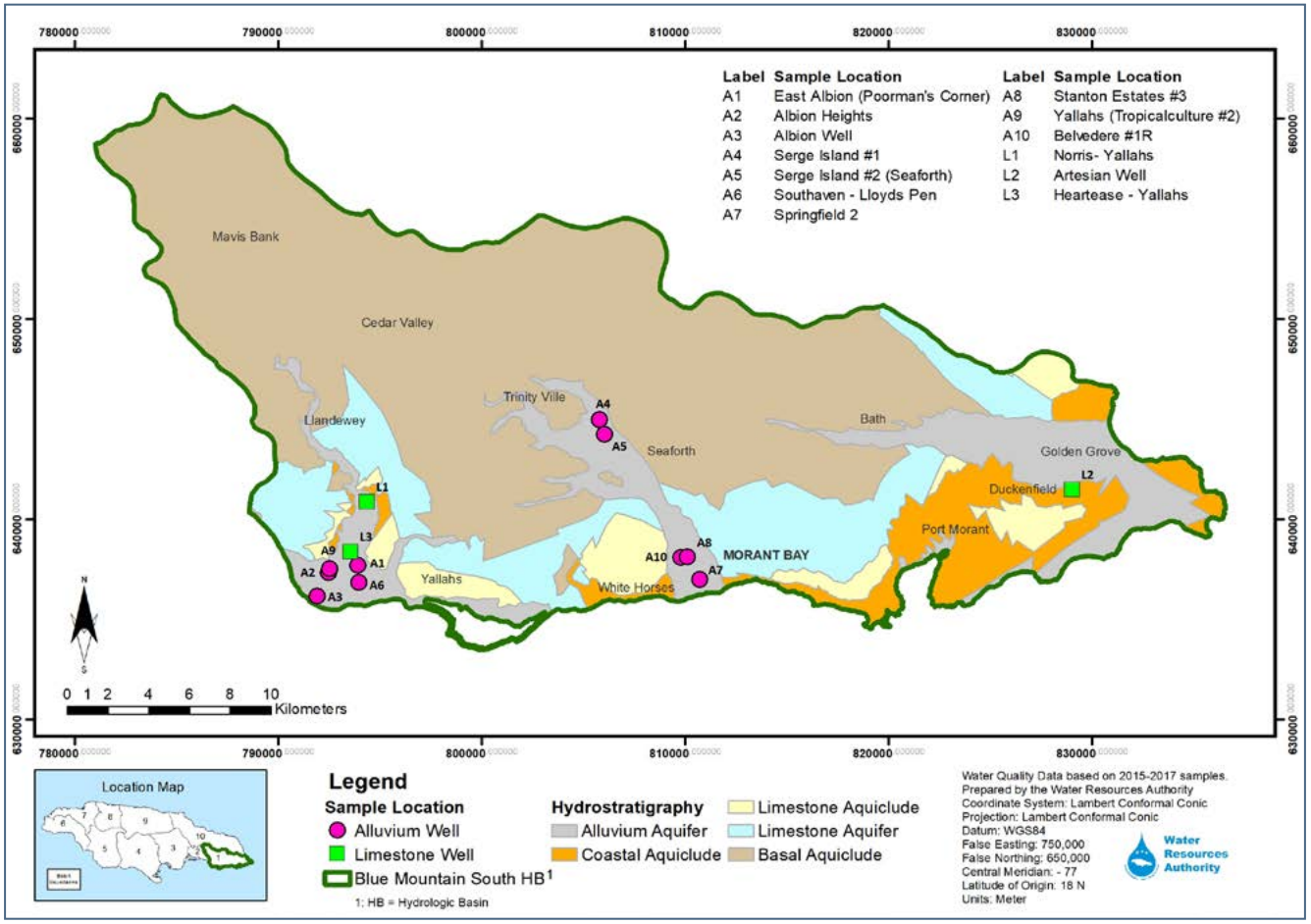


Figure 9: Blue Mountain South Hydrologic Basin Groundwater Sample Locations

Figure 9 indicates the location of the thirteen (13) ground water sampling points utilized in the groundwater analyses for the Blue Mountain South Basin. Ten (10) of the sources are classified as alluvium wells and three (3) limestone wells.

Blue Mountain South Hydrologic Basin Nitrate Levels in Groundwater

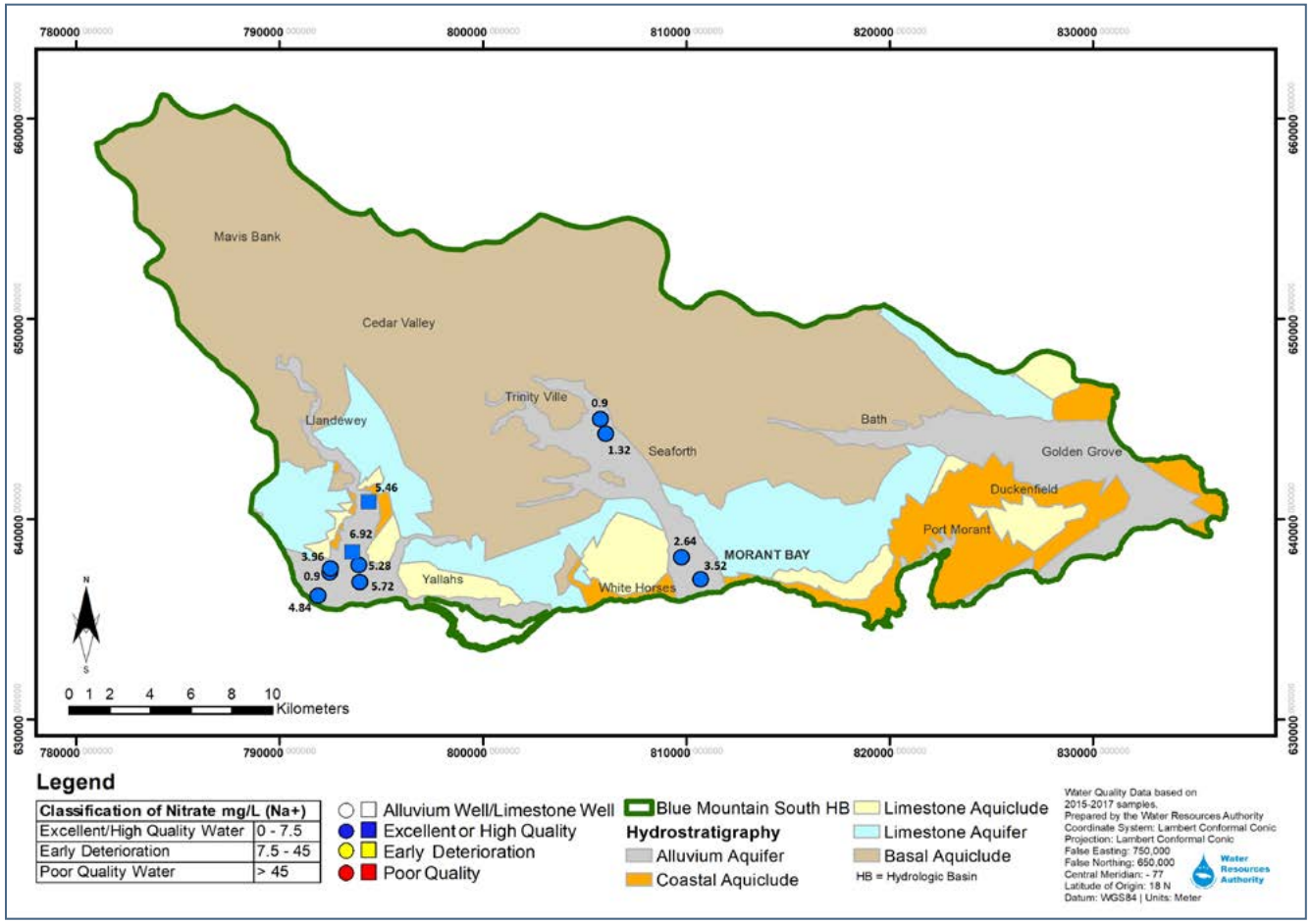
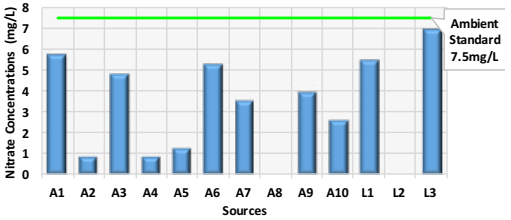


Figure 10: Blue Mountain South Hydrologic Basin Nitrate Levels in Groundwater

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 1: Blue Mountain South Basin Nitrate Levels in Groundwater

The well sources within the basin indicate excellent quality for nitrate as shown in Figure 10 and Graph 1. The water quality for all the sources examined conformed to the National Ambient Water Quality Standard of 7.5mg/L. This indicated that the resource is relatively uncontaminated by sources of nitrates.

Blue Mountain South Hydrologic Basin Sodium Levels in Groundwater

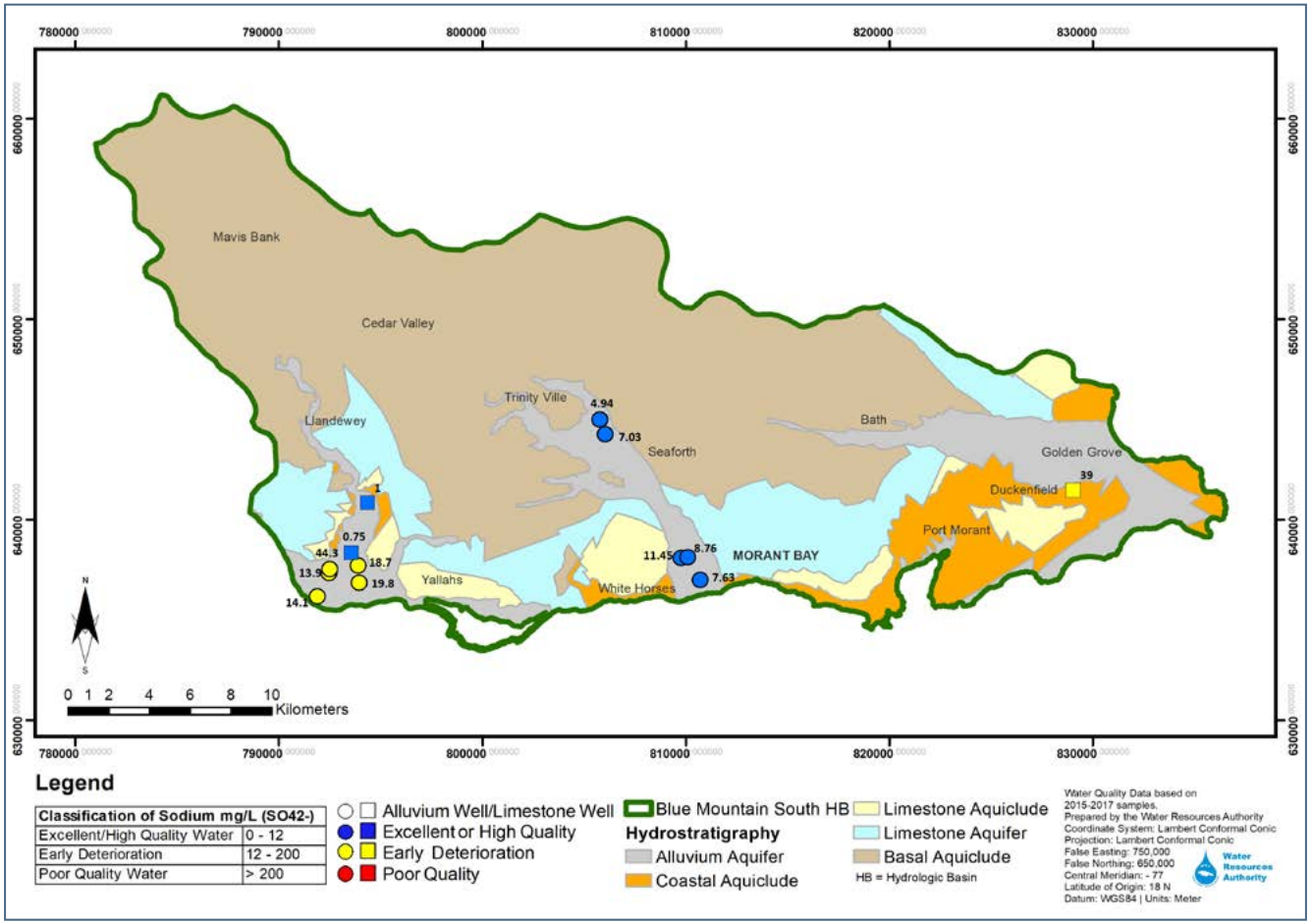
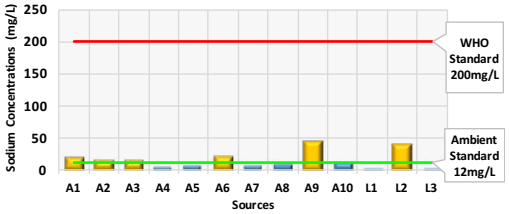


Figure 11: Blue Mountain South Hydrologic Basin Sodium Levels in Groundwater

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 2: Blue Mountain South Basin Sodium Levels in Groundwater

The well sources within the basin indicate excellent quality for sodium with the exception of the alluvium wells located in the Yallahs alluvial fan as indicated in Figure 11 and Graph 2. The Artesian Limestone well labeled L2 has indicated early deterioration, whilst the wells in the Morant Bay alluvial fan have indicated excellent water quality for sodium.

The water quality for forty six percent (46%) of the sources examined conformed to the WHO Guidelines for Drinking Water Quality200mg/L but were elevated above the National Ambient Water Quality Standard of 12mg/L. Sixty four percent (64%)of the sources conformed to the National Ambient Water Quality Standard.

Blue Mountain South Hydrologic Basin Chloride Levels in Groundwater

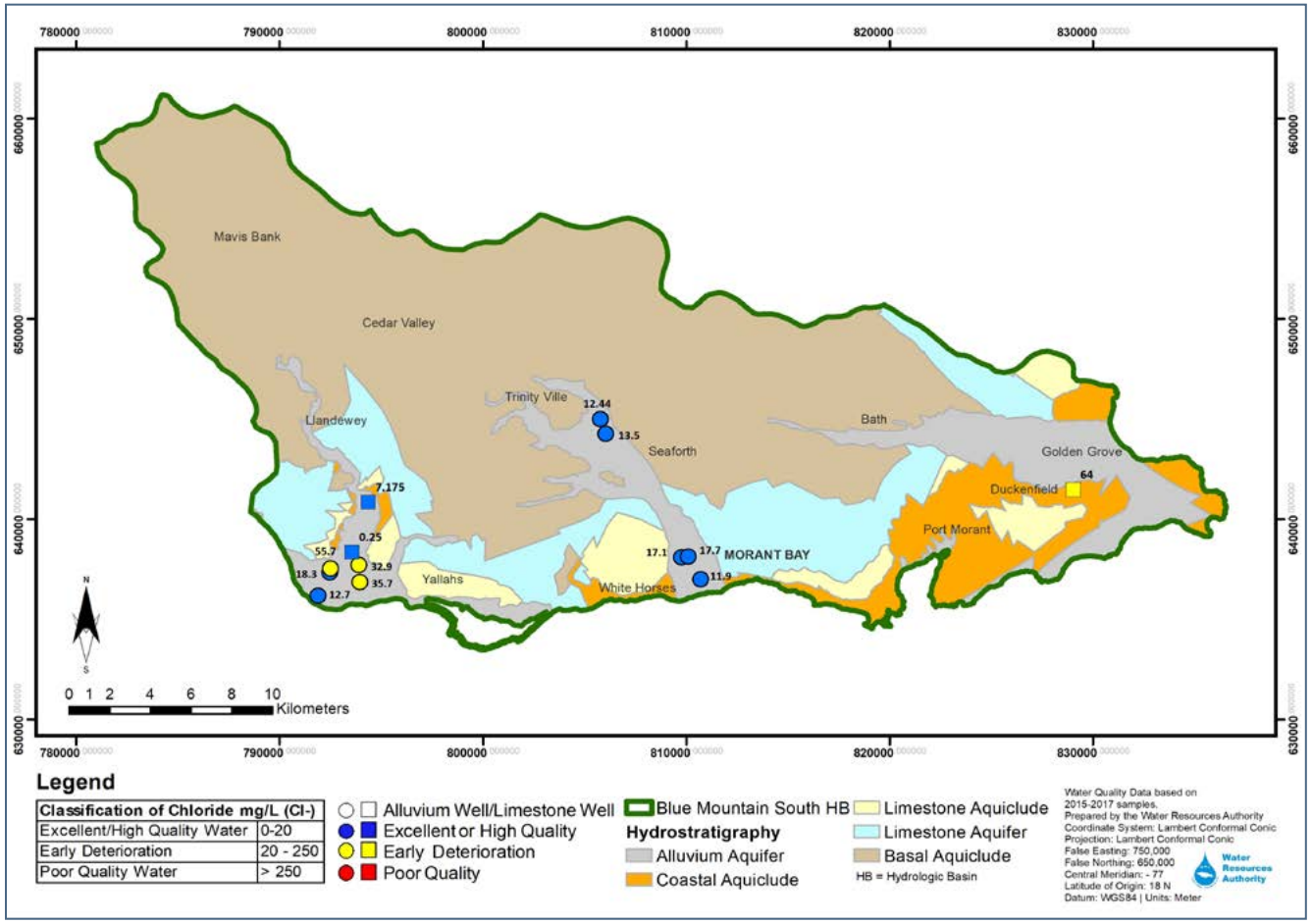
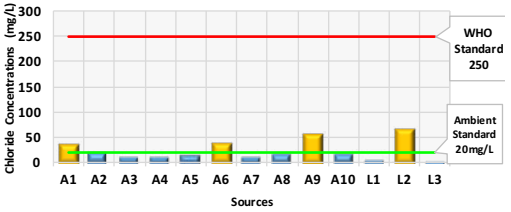


Figure 12: Blue Mountain South Hydrologic Basin Chloride Levels in Groundwater

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 3: Blue Mountain South Basin Chloride Levels in Groundwater

The well sources within the basin indicate excellent quality for chloride with the exception of some of the alluvium wells located in the Yallahs alluvial fan as indicated in Figure 12 and Graph 3.

The water quality for thirty percent (30%) of the sources examined conformed to the WHO Guidelines for Drinking Water Quality 250mg/L but were elevated above the National Ambient Water Quality Standard of 20mg/L. Seventy percent (70%) of the sources conformed to the National Ambient Water Quality Standard.

Blue Mountain South Hydrologic Basin Sulphate Levels in Groundwater

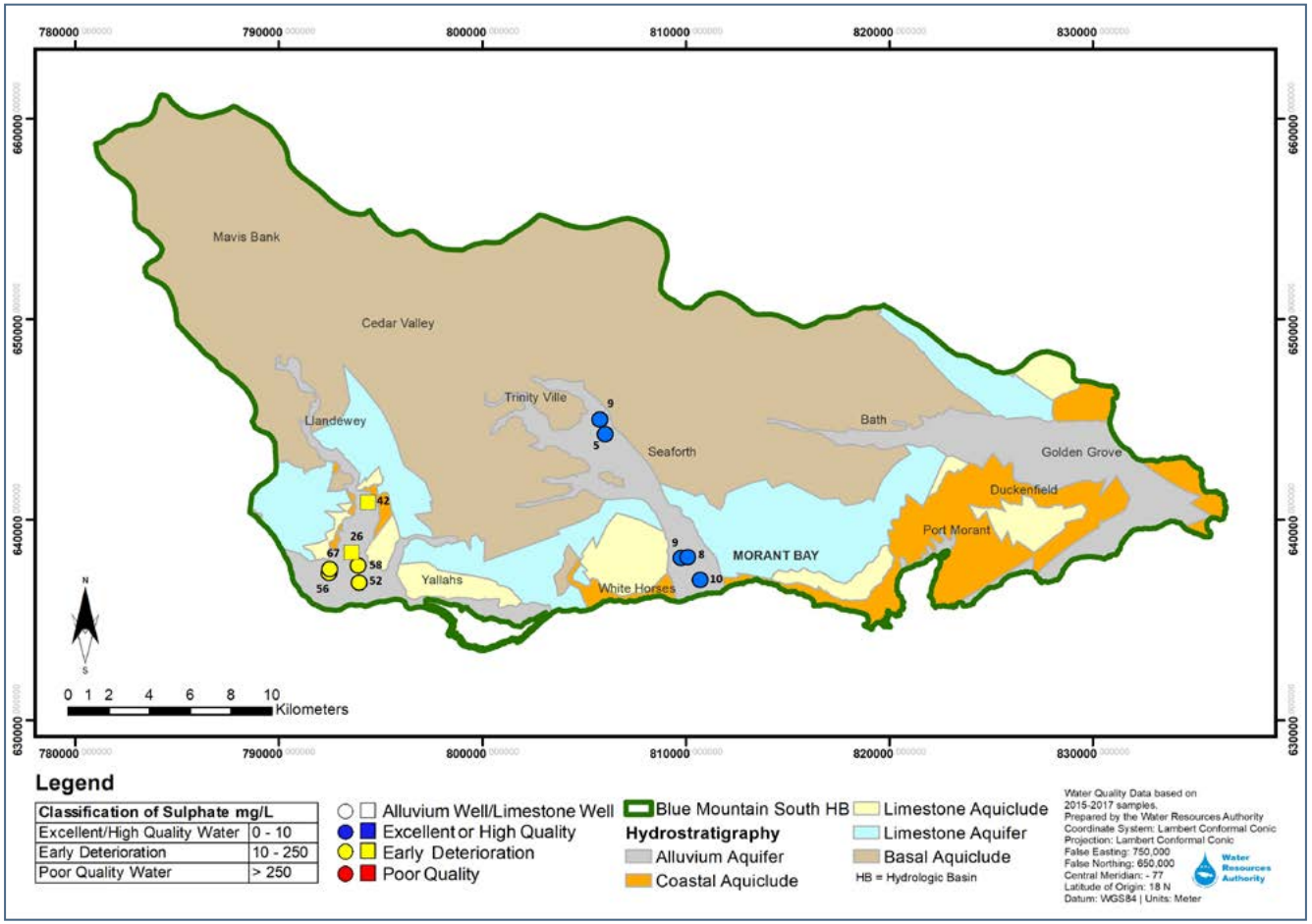
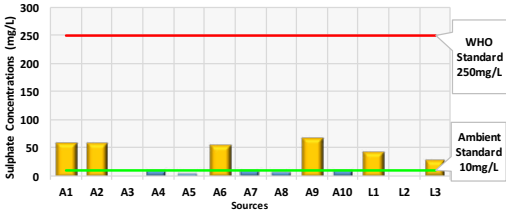


Figure 13: Blue Mountain South Hydrologic Basin Sulphate Levels in Groundwater

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 4: Blue Mountain South Basin Sulphate Levels in Groundwater

The well sources within the basin indicate excellent quality for sulphate with the exception of the alluvium wells located in the Yallahs alluvial fan as shown in Figure 13 and Graph 4.

The water quality for sixty five percent (65%) of the sources examined conformed to the WHO Guidelines for Drinking Water Quality 250mg/L but were elevated above the National Ambient Water Quality Standard of 10mg/L. These are primarily the limestone and alluvium wells located in the Yallahs area. Forty five percent (45%) of the sources examined conformed to the National Ambient Water Quality Standard.

The groundwater points in the Yallahs alluvial fan are located in areas where there are several deposits of gypsum, calcium and sulphate, which are water soluble compounds. The elevated sulphate values are therefore explained by the natural geology.

Blue Mountain South Hydrologic Basin Total Dissolved Solid (TDS) Levels in Groundwater

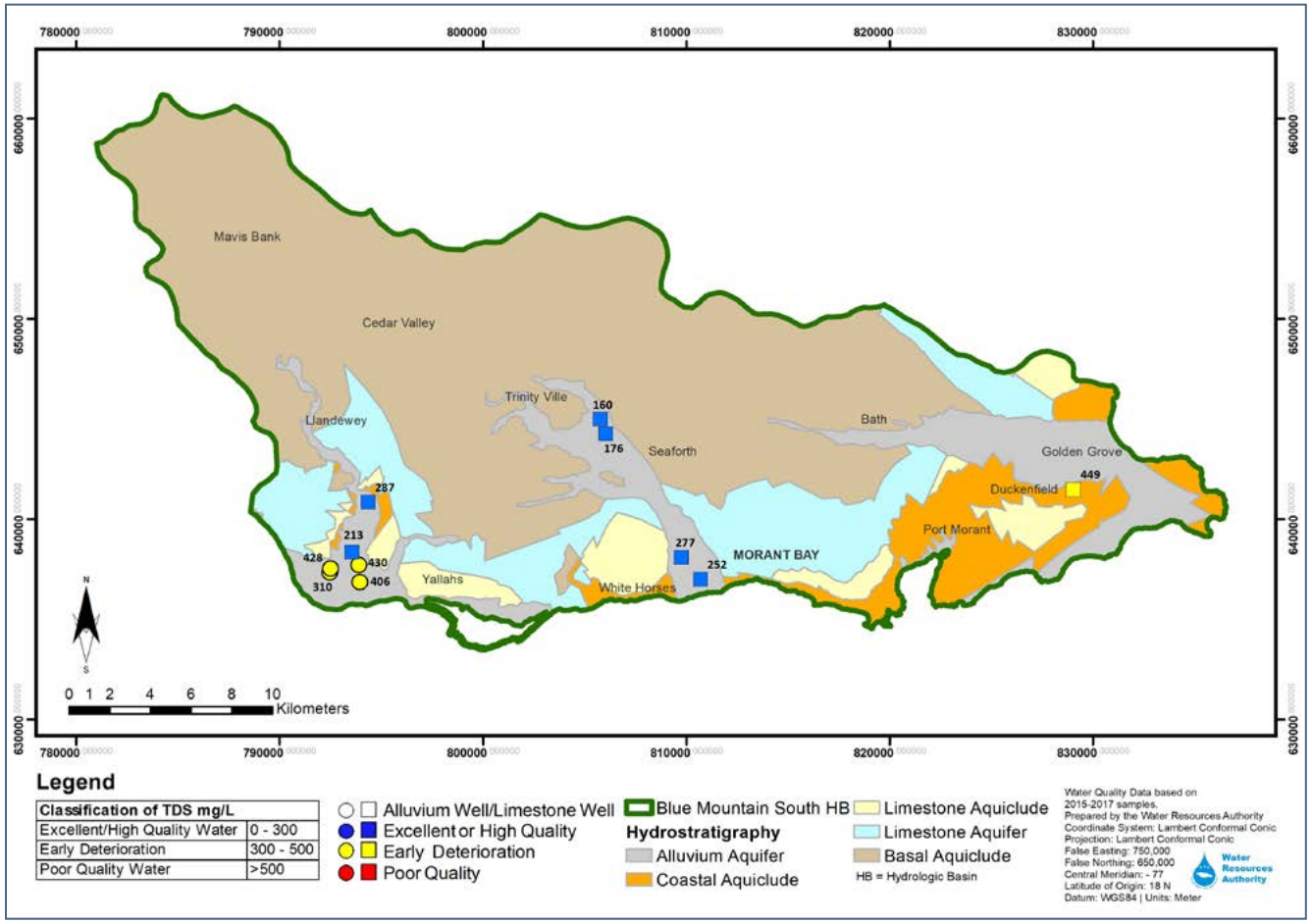
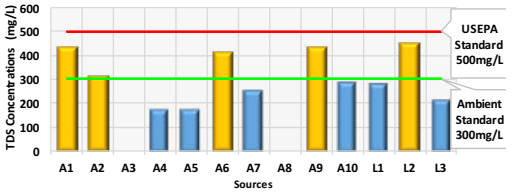


Figure 14: Blue Mountain South Hydrologic Basin Total Dissolved Solid Levels in Groundwater

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN TOTAL DISSOLVED SOLID LEVELS IN GROUNDWATER



Graph 5: Blue Mountain South Basin TDS Levels in Groundwater

The well sources within the basin indicate excellent quality for TDS with the exception of the alluvium wells located in the Yallahs alluvial fan as shown in Figure 14 and Graph 5. The two limestone wells within the Yallahs area indicated excellent quality whilst the alluvium wells indicated early deterioration quality.

The water quality for thirty-one percent (31%) of the sources examined conformed to the US EPA standard of 300mg/L but were elevated above the National Ambient Water Quality Standard of 10mg/L. sixty nine percent (69%) of the sources conformed to the National Ambient Water Quality Standard.

Blue Mountain South Hydrologic Basin Surface Water Sample Locations

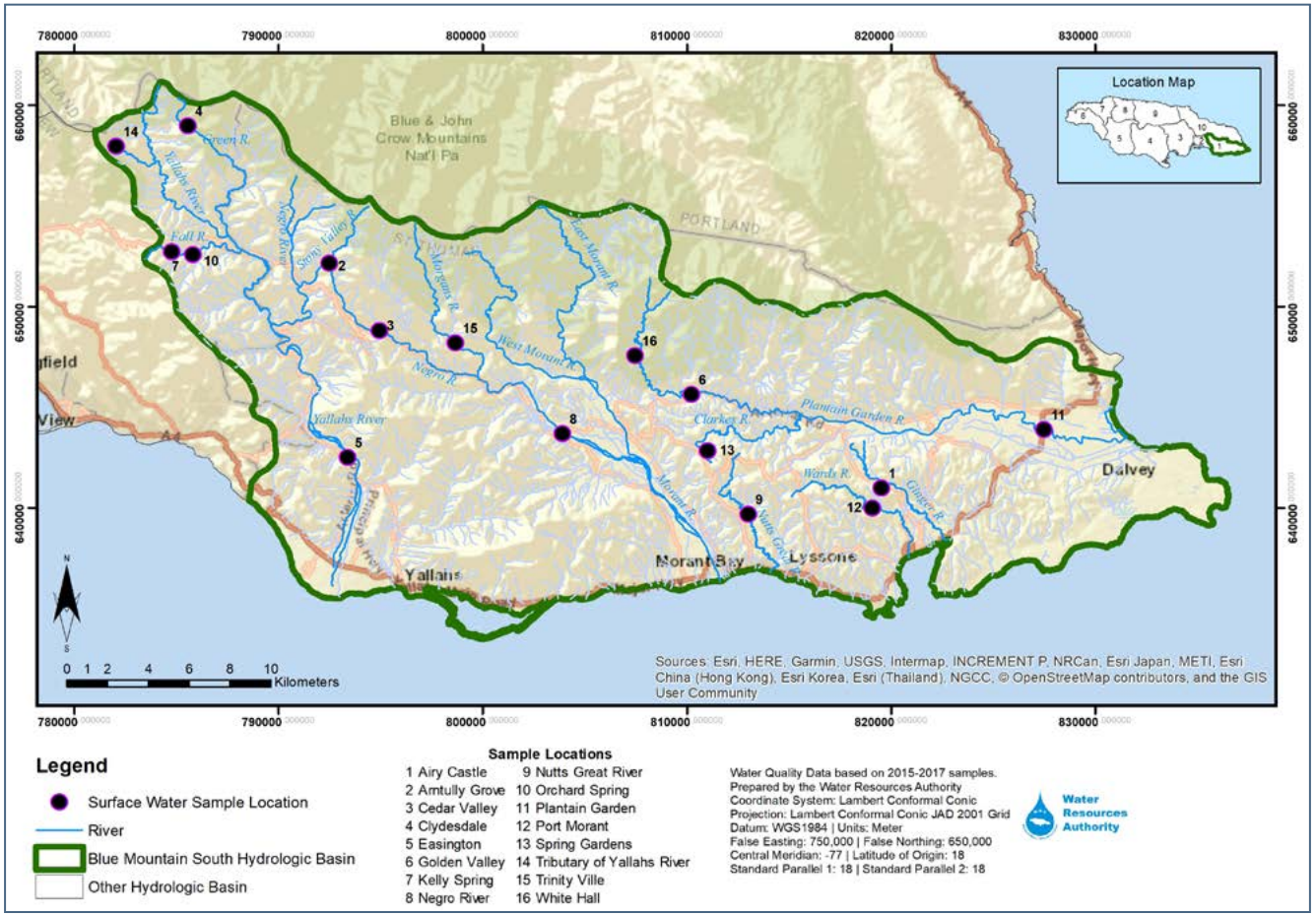


Figure 15: Blue Mountain South Hydrologic Basin Surface Water Sample Points

Figure 15 indicates the location of the sixteen (16) surface water sampling points utilized in the surface water analyses for the Blue Mountain South Basin.

Blue Mountain South Hydrologic Basin Nitrate Levels in Surface Water

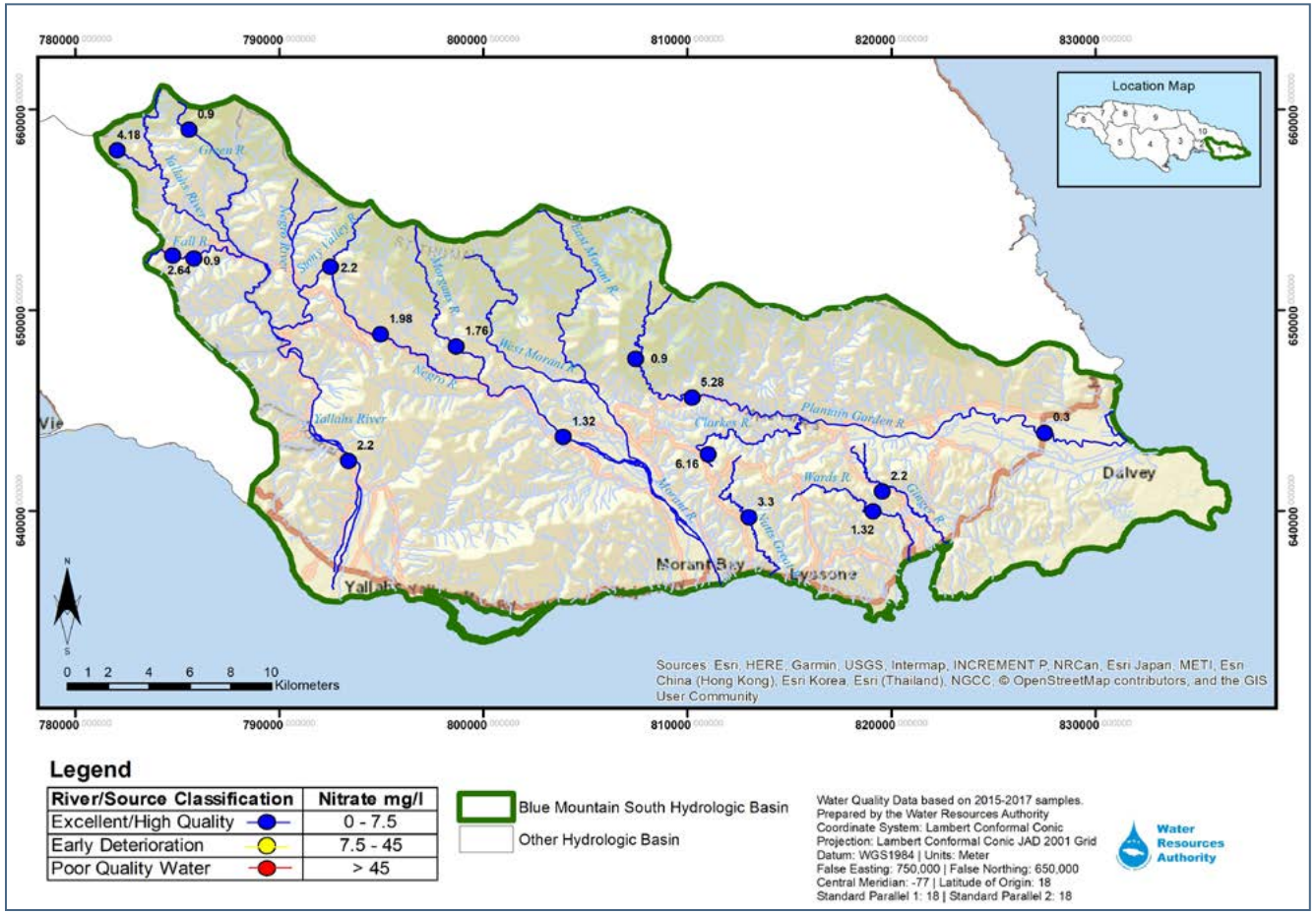
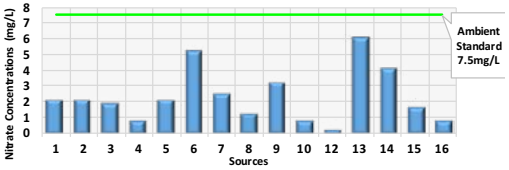


Figure 16: Blue Mountain South Hydrologic Basin Nitrate Levels in Surface Water

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 6: Blue Mountain South Basin Nitrate Levels in Surface water

As shown in Figure 16 and Graph 6, the surface water sources within the basin indicated excellent quality for nitrate. The water quality for all the sources examined conformed to the National Ambient Water Quality Standard of 7.5mg/L. This indicated that the resource is relatively uncontaminated by sources of nitrates.

Blue Mountain South Hydrologic Basin Sodium Levels in Surface Water

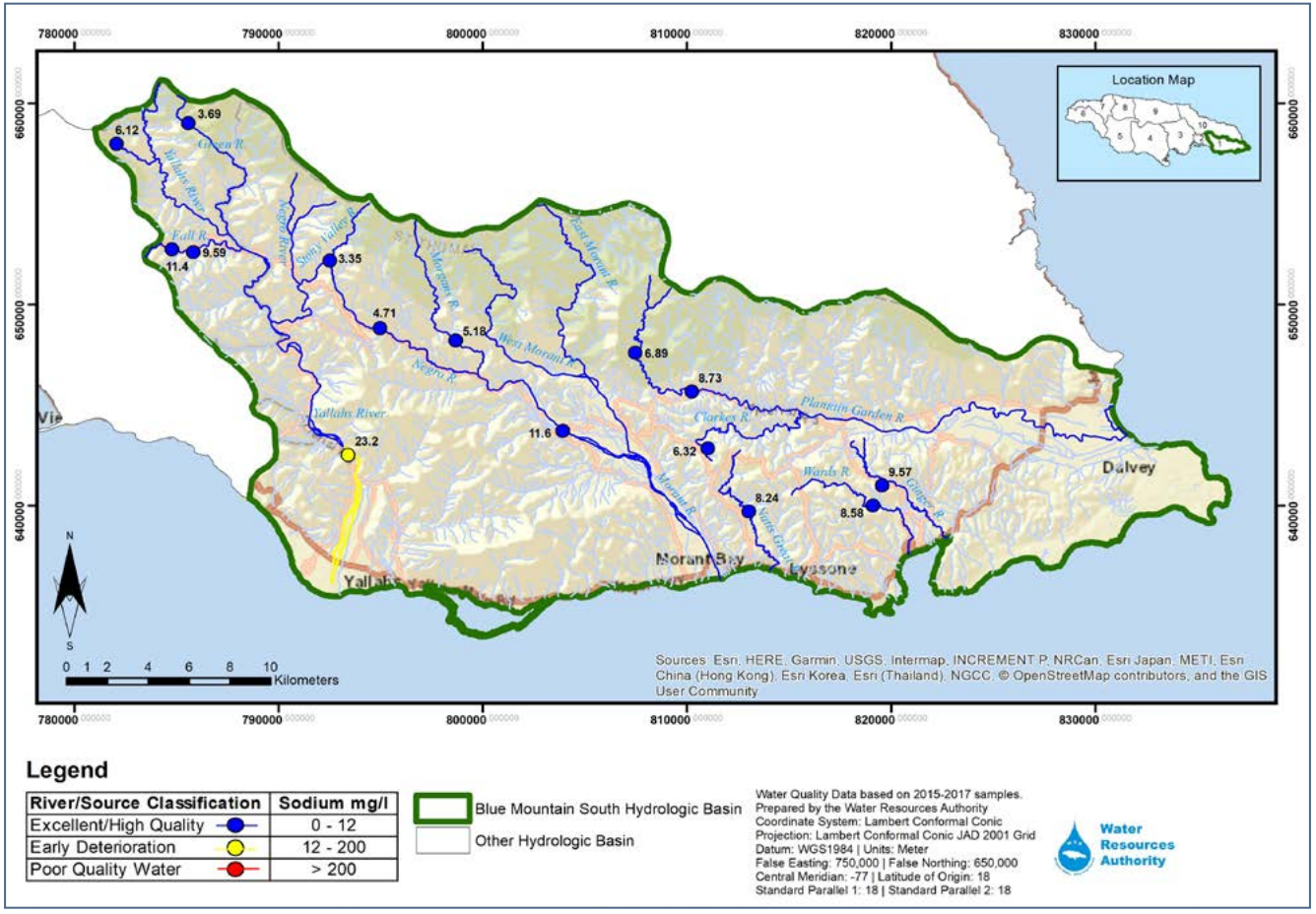
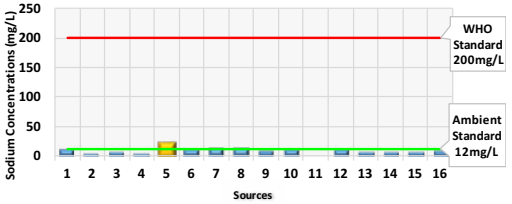


Figure 17: Blue Mountain South Hydrologic Basin Sodium Levels in Surface Water

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 7: Blue Mountain South Basin Sodium Levels in Surface water

As shown in Figure 17 and Graph 7, the surface water sources within the basin indicated excellent quality for sodium which conforms to the National Ambient Water Quality Standard of 12mg/L, with the exception of Easington which recorded sodium levels of 23.2 mg/L which is slightly above the National Ambient Water Quality Standard. The water quality for all the sources examined are excellent.

Blue Mountain South Hydrologic Basin Chloride Levels in Surface Water

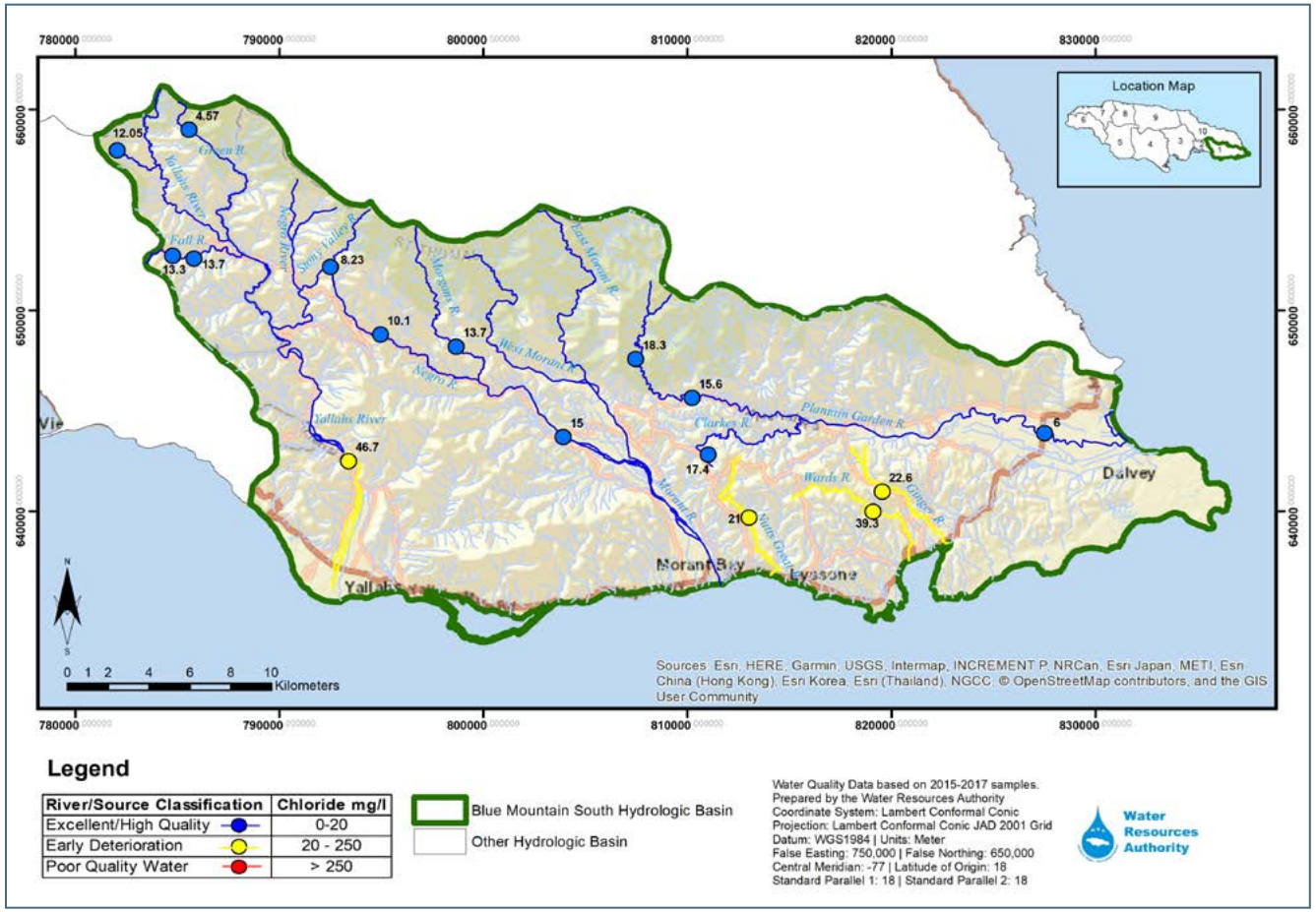
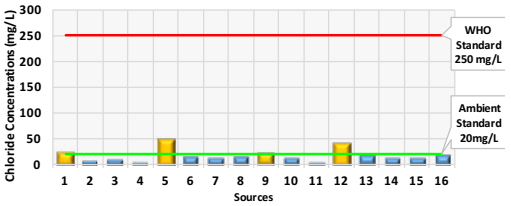


Figure 18: Blue Mountain South Hydrologic Basin Chloride Levels in Surface Water

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 8: Blue Mountain South Basin Chloride Levels in Surface water

As shown in Figure 18 and Graph 8, the surface water sources within the basin indicated excellent quality for chloride with the exception of four sources: Airy Castle, Nutts Great River, Port Morant and Easington surface water sources. The water quality for these sources are slightly elevated above the National Ambient Water Quality Standard of 20mg/L. This indicated that the resource is relatively uncontaminated by sources of sodium.

Blue Mountain South Hydrologic Basin Sulphate Levels in Surface Water

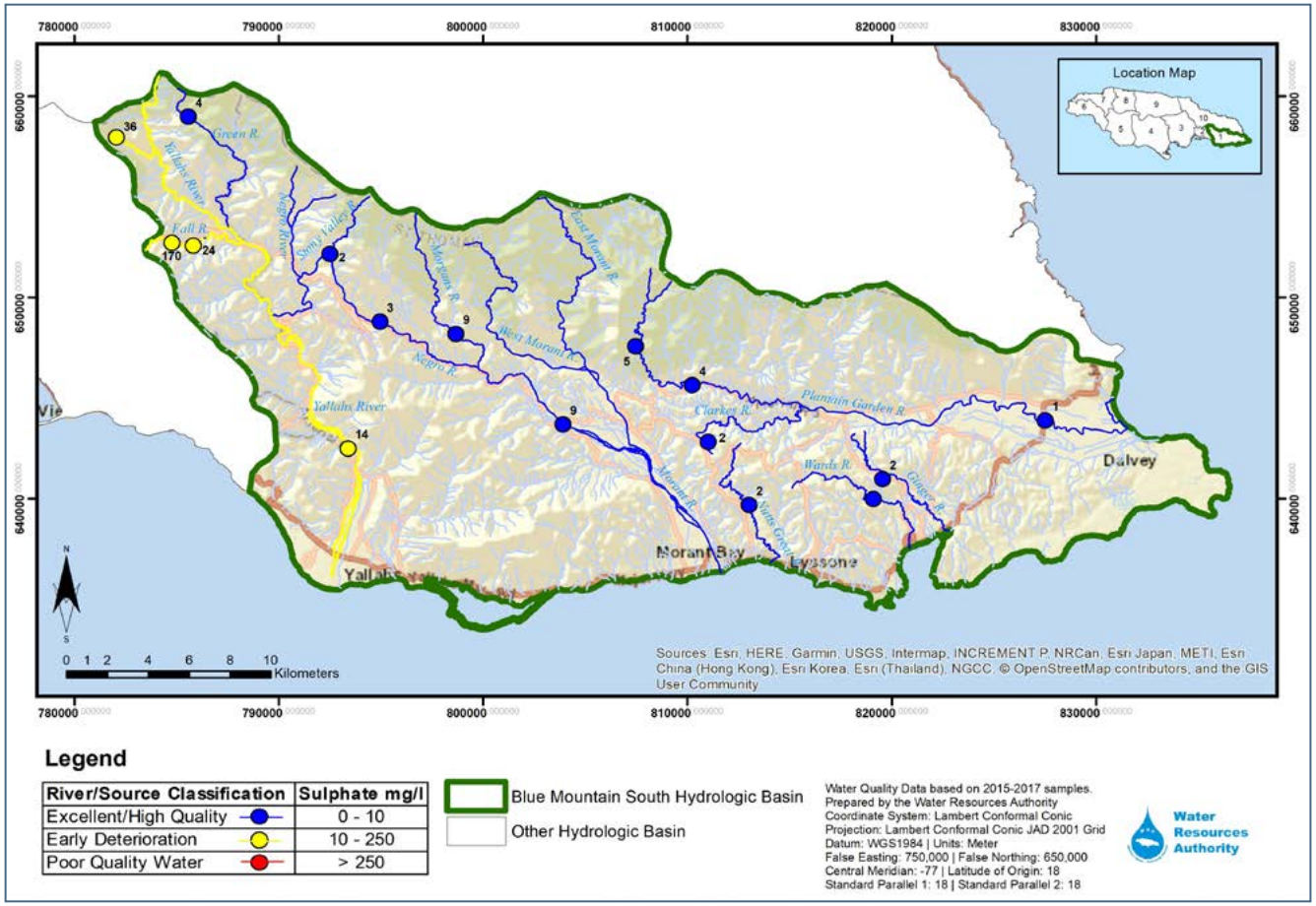
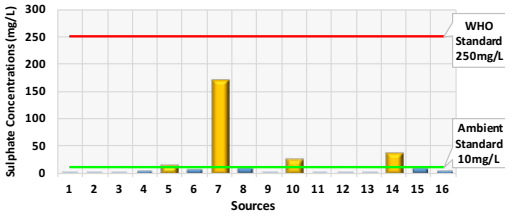


Figure 19: Blue Mountain South Hydrologic Basin Sulphate Levels in Surface Water

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 9: Blue Mountain South Basin Sulphate Levels in Surface water

As shown in Figure 19 and Graph 6, the surface water sources within the basin indicated excellent quality for sulphate with the exception of the surface water sources which drain the mineral rich rock formation. These indicated sulphate levels above the National Ambient Water Quality Standard of 10 mg/L but conforms to the WHO Guidelines for Drinking Water of 200mg/L. This indicated that the majority of the surface water sources are relatively uncontaminated by sources of sulphate.

Blue Mountain South Hydrologic Basin TDS Levels in Surface Water

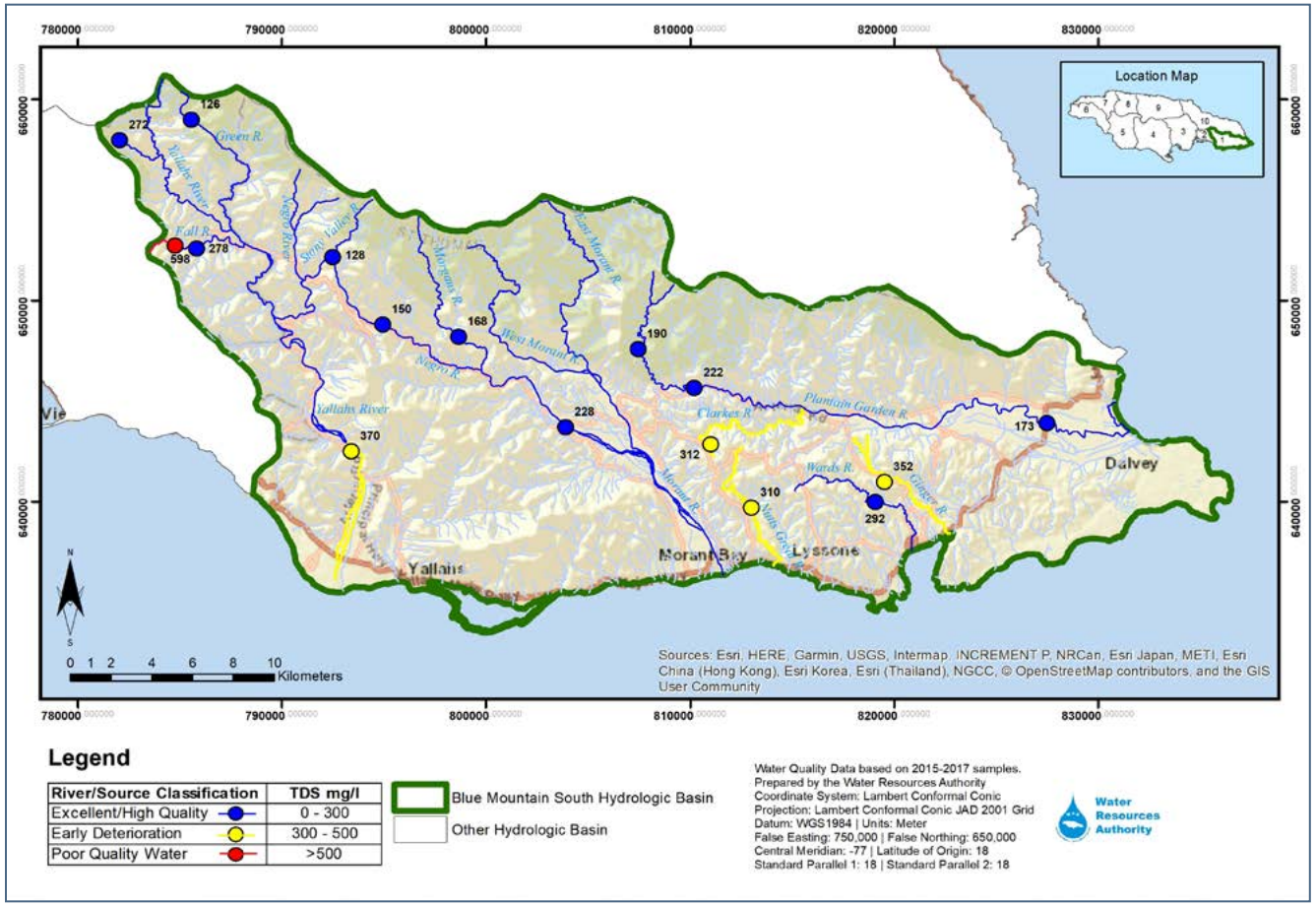
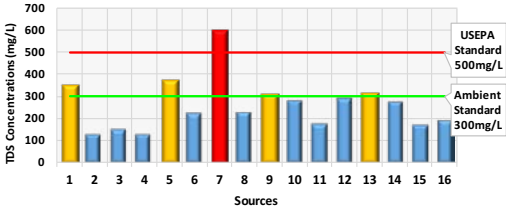


Figure 20: Blue Mountain South Hydrologic Basin Total Dissolved Solids Levels in Surface Water

BLUE MOUNTAIN SOUTH HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 10: Blue Mountain South Basin TDS Levels in Surface water

The surface water sources within the basin indicated predominantly excellent quality for sulphate with the exception of Kelly Spring which drains the mineral rich rock formation as indicated in Figure 20 and Graph 7. There is a strong correlation between salts and TDS. The presence of the parameters sodium sulphate, chloride and nitrates will impact the TDS levels within the surface water sources.

Four sources indicated TDS levels which were above the National Ambient Water Quality Standard of 300 mg/L but conform to the US EPA standard. However, Kelly Spring recorded values above the US EPA standard.

2.0 Basin II- Kingston Hydrologic Basin

The Kingston hydrologic basin includes the parishes of Kingston and St. Andrew, Jamaica's largest and most densely populated urban center. For water management purposes, the Kingston Basin has been divided into four sub-basins; Hope River, Cane/Mammee River, Chalky/Bull Bay and the Liguanea Plains. The basin is drained by a network of rivers flowing over mountains (basement aquiclude – low permeability cretaceous volcanics) in the eastern section of the basin, and by a system of concretized gullies across the plain towards the southern coast.

The water resources within the Kingston Basin comprise of groundwater from the limestone and alluvium aquifers of the Liguanea Plains and surface water from the other three sub-basins: Hope, Cane/Mammee and Chalky/Bull Bay.

Past analysis of the water quality data within the Basin has indicated that there are groundwater contamination[1] and pollution[2] problems in some sections of the Kingston Basin.

The groundwater quality was analysed with the results from thirty four (34) wells (31 alluvium and 3 limestone) and the surface water was done utilizing twenty one (21) sources.

[1] Contamination refers to measurable deterioration in the quality of water without clear evidence of negative impacts or threats to beneficial uses
[2] Pollution refers to deterioration in the quality of water to the point where negative impacts are evident or may become evident if the water is utilized for any beneficial use

Kingston Hydrologic Basin Groundwater Sample Locations

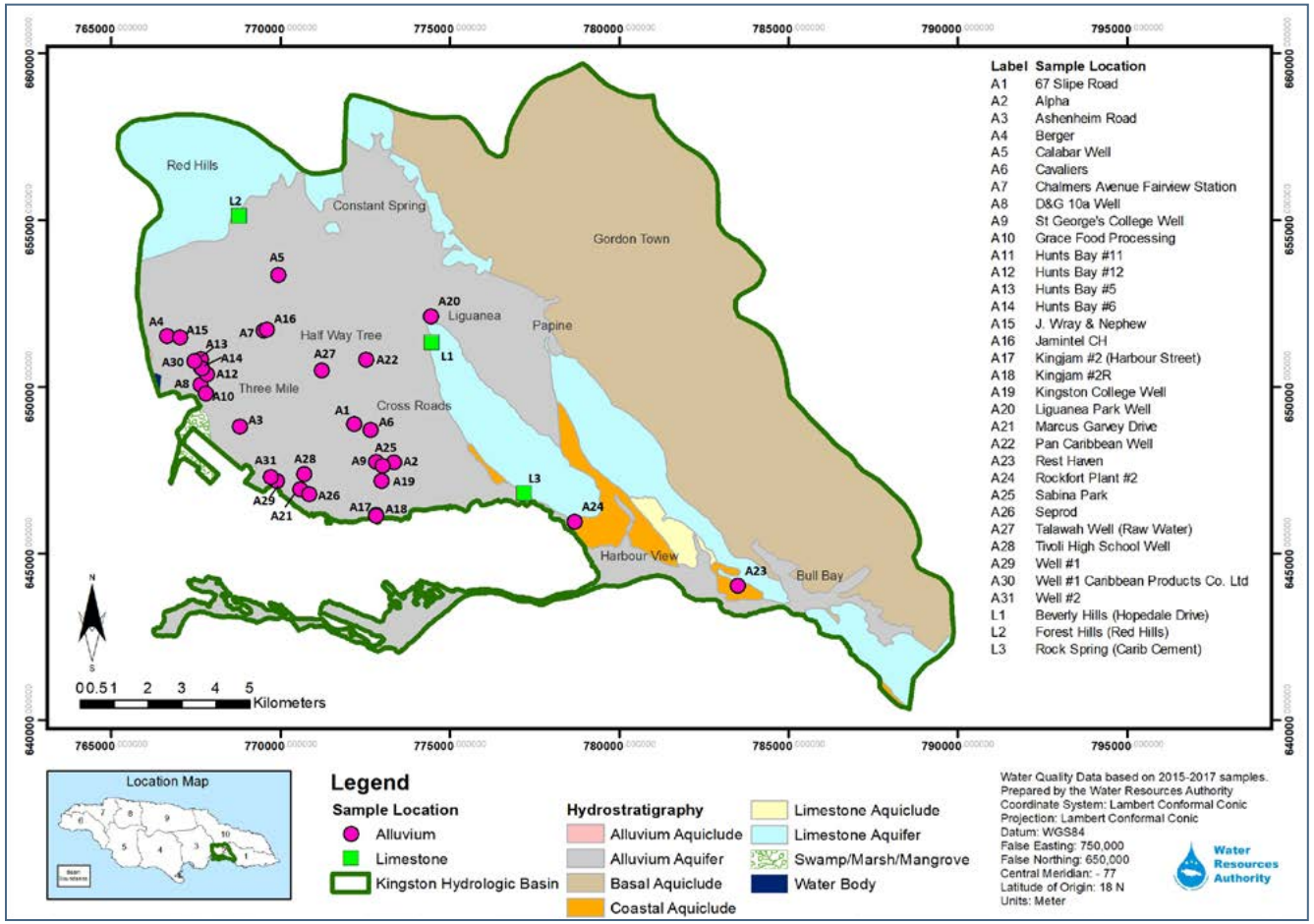


Figure 21: Kingston Hydrologic Basin Groundwater Sample Points

Figure 21 indicates the location of the thirty- four (34) ground water sampling points utilized in the groundwater analyses for the Kingston Basin. Thirty-one (31) of the sources are classified as alluvium wells and three (3) limestone wells.

Kingston Hydrologic Basin Nitrate Levels in Groundwater

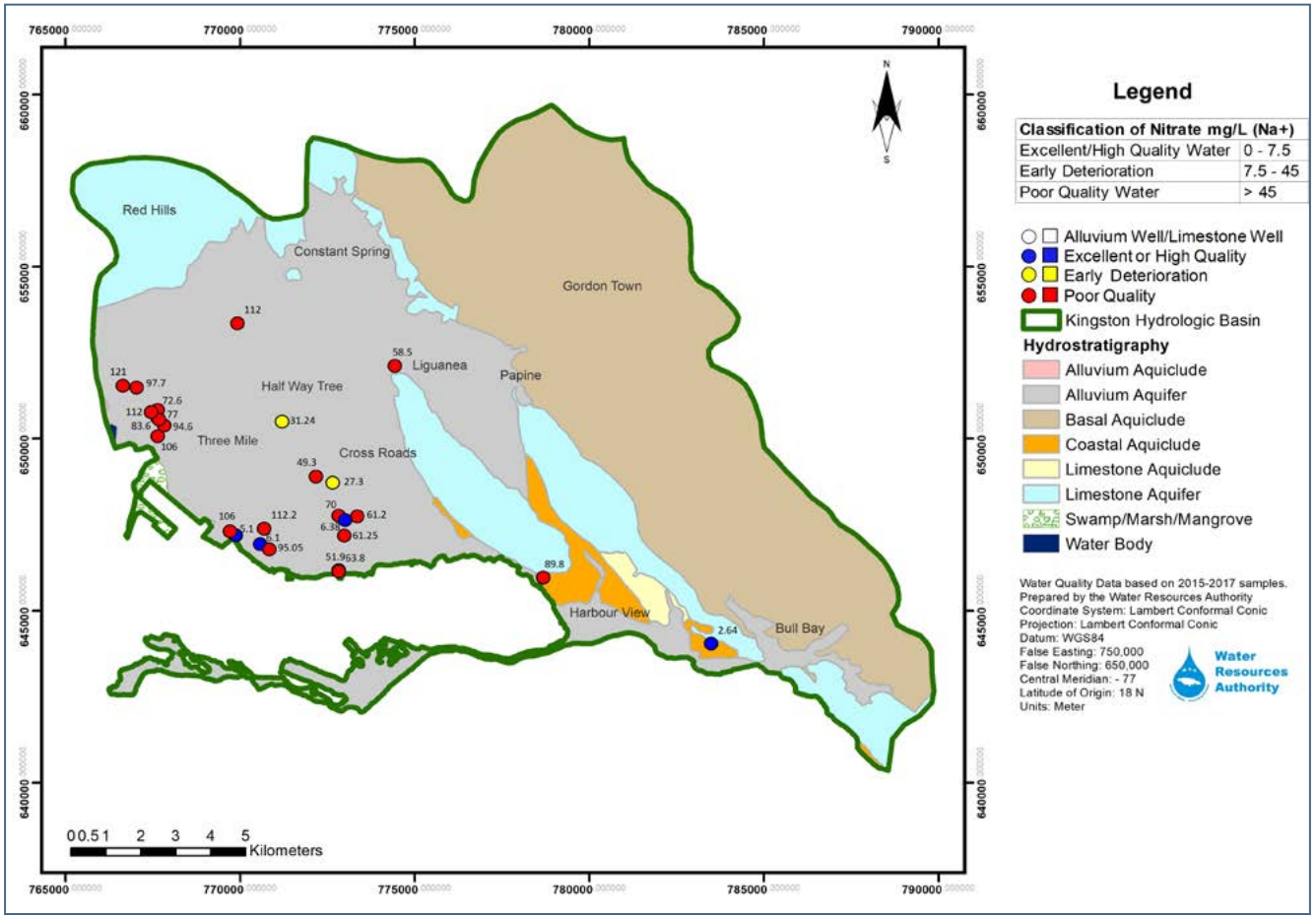
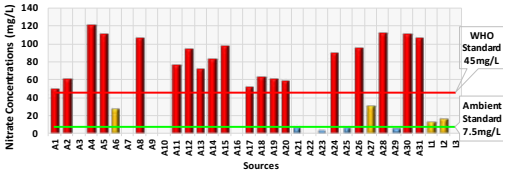


Figure 22: Kingston Basin Nitrate Levels in Groundwater

KINGSTON HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 11: Kingston Basin Nitrate Levels in Groundwater

The well sources within the Kingston basin predominantly indicated poor water quality as indicated in Figure 22 Graph 11.

Fifty six percent (56%) of the wells sampled indicated nitrate level in excess of the WHO Guidelines for Drinking Water Quality. The wells located within the Liguanea Aquifer have indicated contamination from inadequately treated sewage. Eleven percent (11%) of the wells indicated early deterioration having nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L but are within the maximum level of the WHO Guidelines for Drinking Water Quality.

Kingston Hydrologic Basin Nitrate Levels in the Alluvium Aquifer

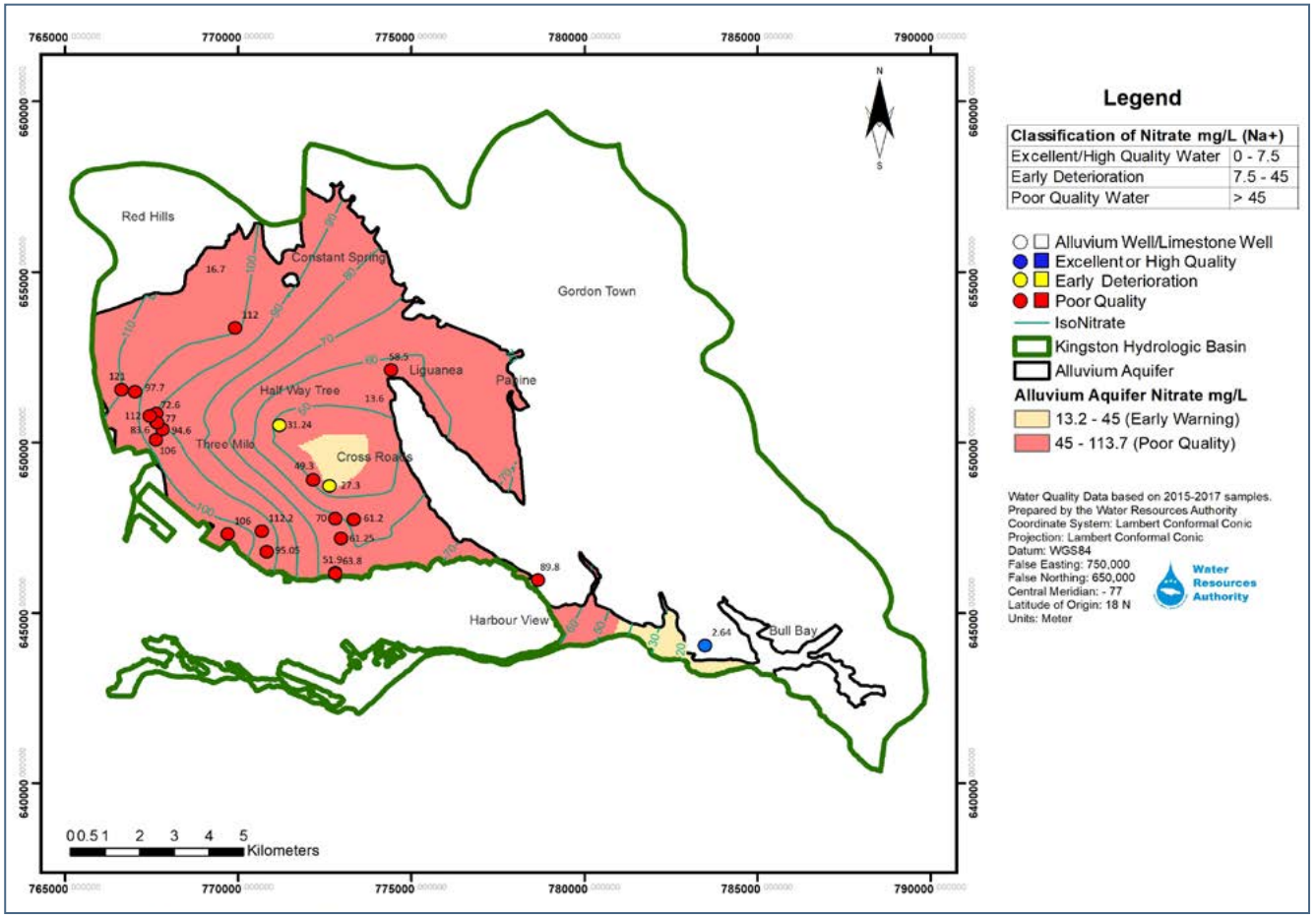


Figure 23: Kingston Hydrologic Basin Spatial Interpolation of the Nitrate Levels in the Alluvium Aquifer

As shown in Figure 23, the well sources within the Kingston basin indicated poor water quality for nitrate for approximately ninety five percent (95%) of the alluvium aquifer. Five percent (5%) of the aquifer indicated early deterioration water quality. Inadequately treated sewage has polluted the aquifer over time resulted in the high nitrate value observed in the wells within the alluvium aquifer.

The nitrates levels in all the alluvium wells from the Berger Paints well in the western section of the basin to the Rockfort well in the eastern section have shown poor quality in nitrates levels ranging from 49mg/L to 141mg/L, with the exception of two wells, the Talawah and the Cavaliers wells showing early detection of 31mg/L and 27mg/L respectively. The limestone well namely Forest Hills and Beverly Hills both have readings of 16 and 13 mg/L respectively. It should be noted that the Rest Haven well in the east is the only sampled well that is within the ambient guideline levels of nitrate within the alluvium.

Kingston Hydrologic Basin Sodium Levels in Groundwater

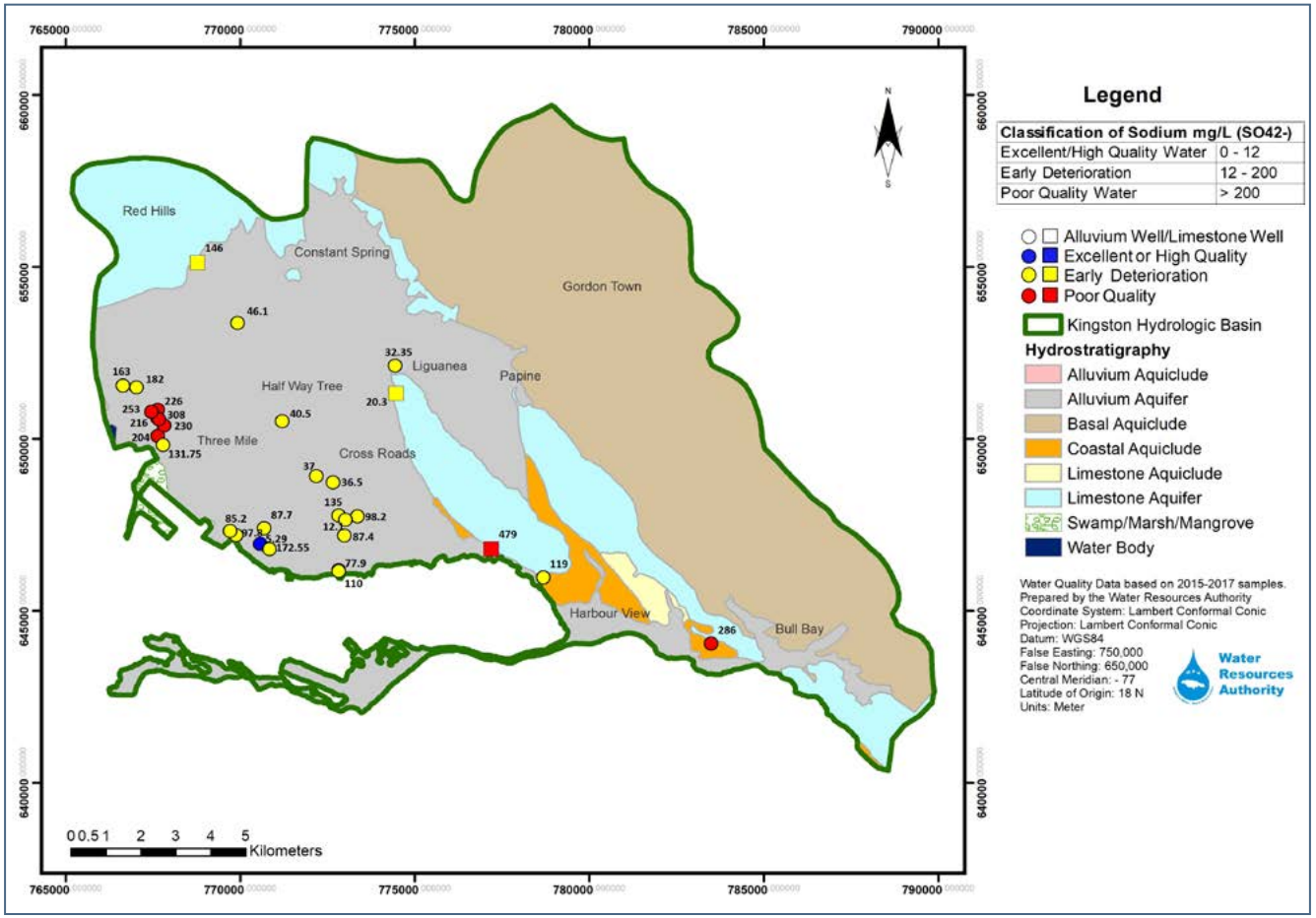
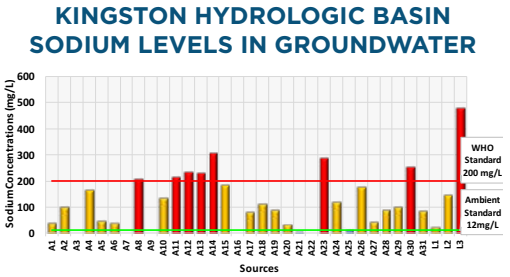


Figure 24: Kingston Hydrologic Basin Sodium Levels in Groundwater



Graph 12: Kingston Basin Sodium Levels in Groundwater

The well sources within the Kingston basin predominantly indicated early deterioration for sodium as shown in Figure 24 and Graph 12. Twenty-four percent (24%) of the wells sampled indicated sodium level in excess of the WHO Guidelines for Drinking Water Quality. Seventy-six percent (76%) of the wells indicated early deterioration, which are sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L but within the maximum level of the WHO Guidelines for Drinking Water Quality.

Kingston Hydrologic Basin Sodium Levels in Alluvium Aquifer

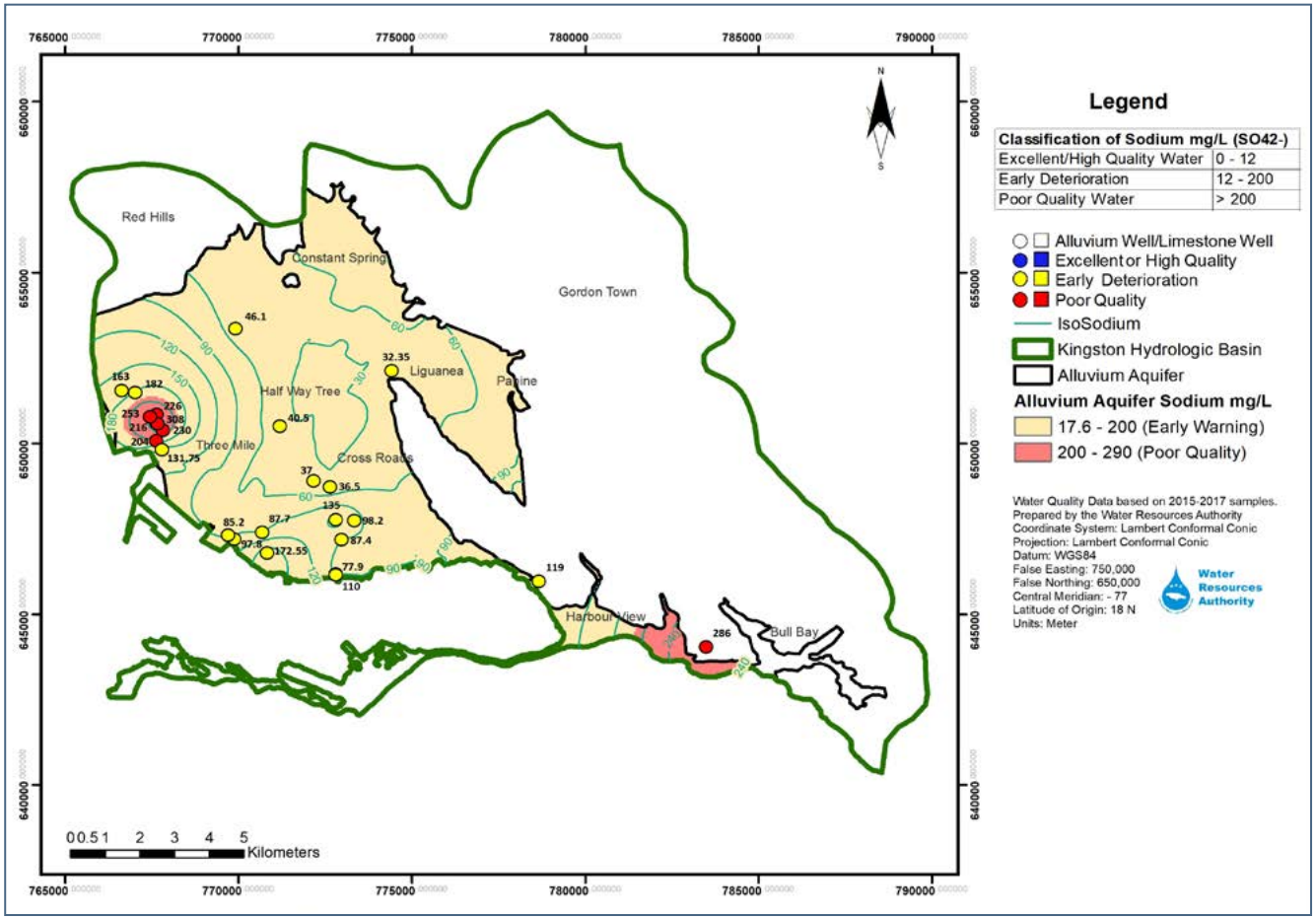


Figure 25: Kingston Hydrologic Basin Spatial Interpolation of Sodium Levels in Alluvium Aquifer

As shown in figure 25, the spatial interpolation of the water quality results indicate that ninety-five percent (95%) of the aquifer had shown signs of early deterioration water quality for sodium. Five percent (5%) of the aquifer indicated poor water quality. The highest level of sodium contamination was concentrated around the wells at Hunts Bay, D&G, Caribbean Products and Rest Haven wells which are located along the south western and south eastern sections of the alluvium aquifer.

Kingston Hydrologic Basin Chloride Levels in Groundwater

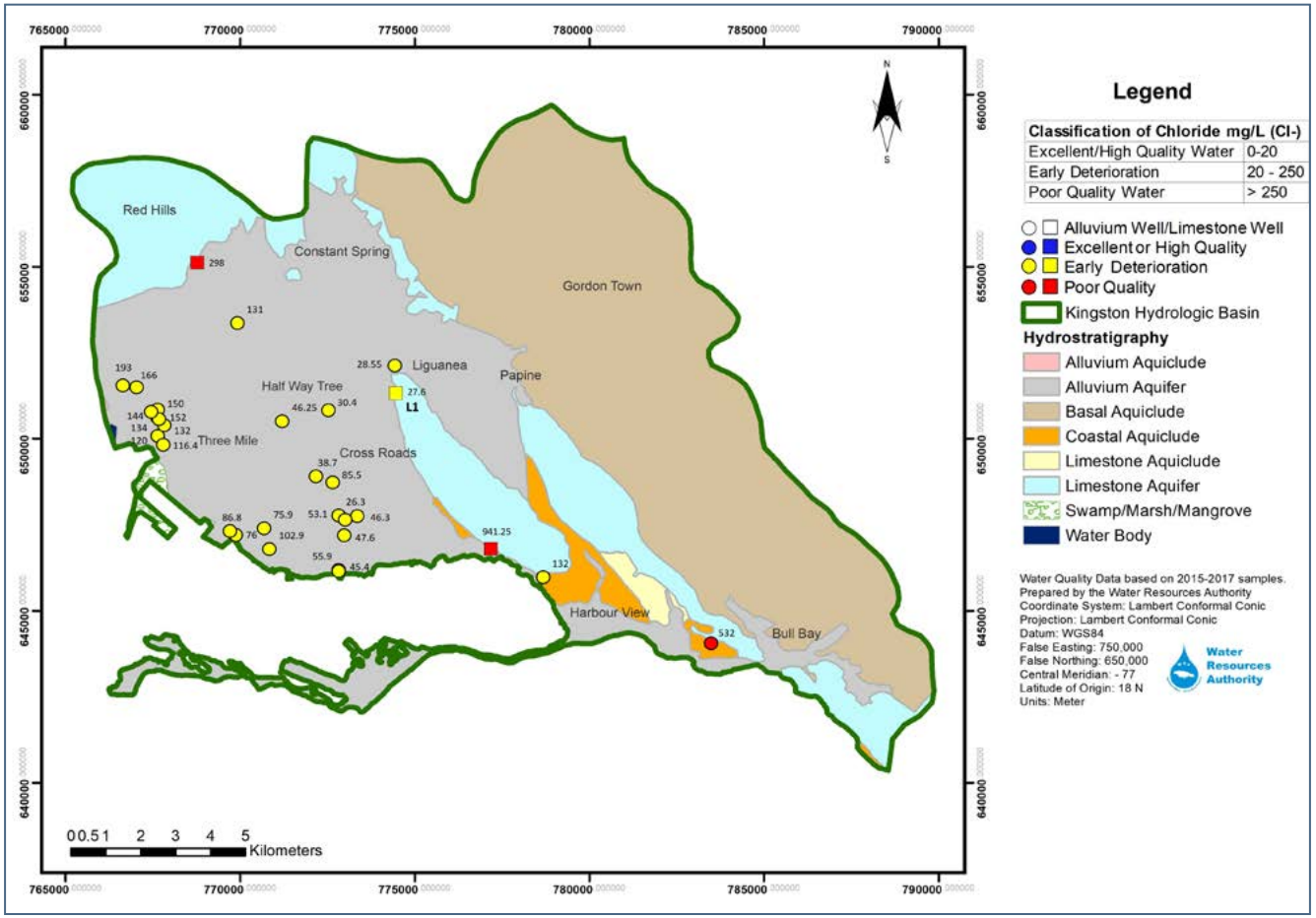
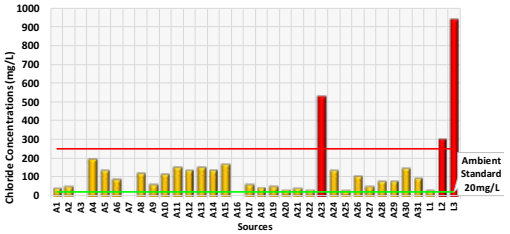


Figure 26: Kingston Hydrologic Basin Chloride Levels in Groundwater

KINGSTON HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 13: Kingston Basin Chloride Levels in Groundwater

As indicated in Figure 26 and Graph 13, the well sources within the Kingston basin predominantly indicated early deterioration for chloride.

Eighty-one percent (81%) of the wells sampled indicated chloride levels in excess of the National Ambient Water Quality Standard of 12mg/L but are within the maximum level of the WHO Guidelines for Drinking Water Quality. Nine percent of the wells sampled indicated poor quality for chloride.

Kingston Hydrologic Basin Chloride Levels in the Alluvium Aquifer

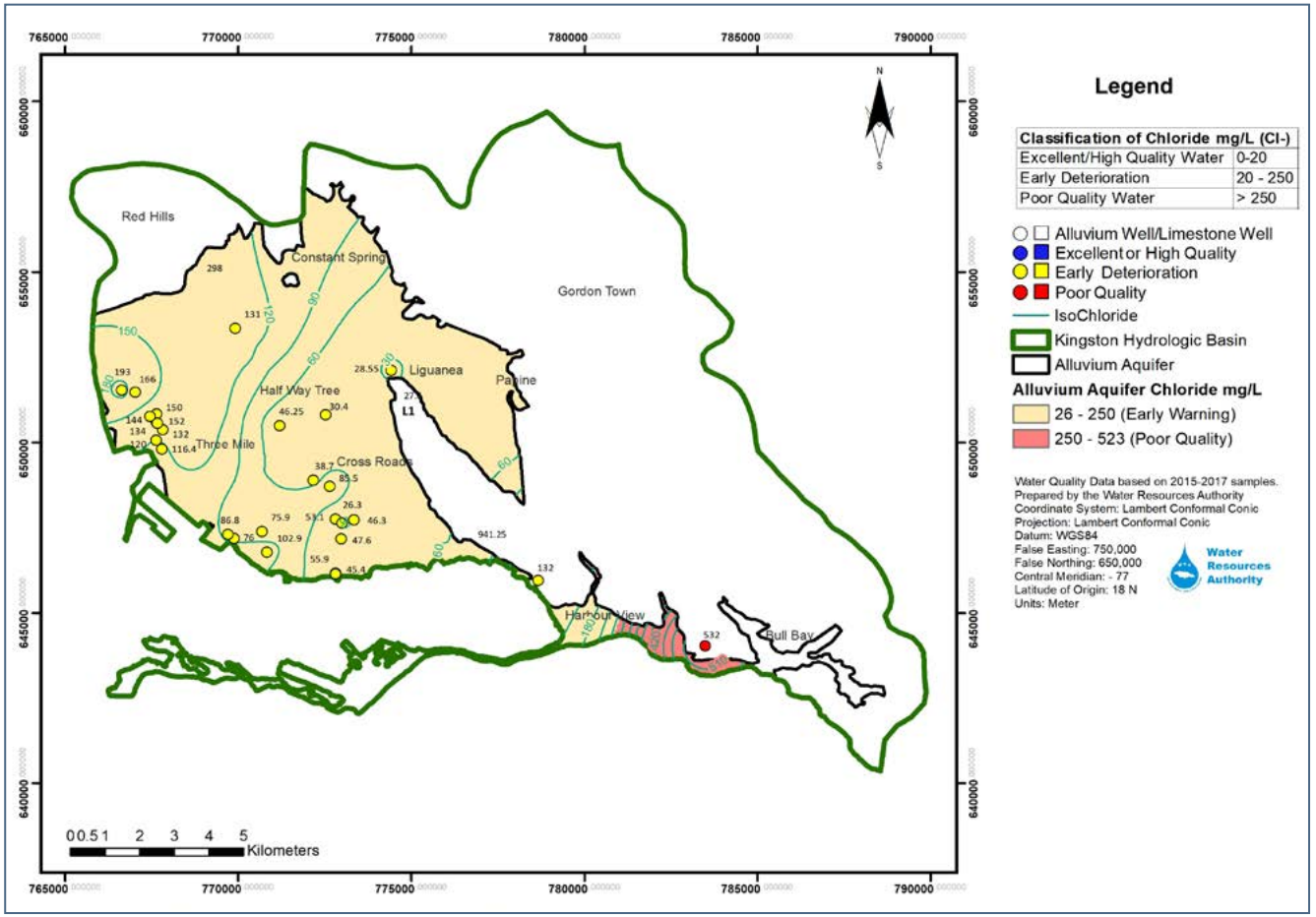


Figure 27: Kingston Hydrologic Basin Spatial Interpolation of the Chloride Levels in the Alluvium Aquifer

As indicated in Figure 27, the spatial interpolation of the water quality results within the Kingston basin has predominantly indicated early deterioration water quality for chloride, with levels in excess of the National Ambient Water Quality Standard of 20mg/L but within the maximum level of the WHO Guidelines for Drinking Water Quality. The Rest Haven well indicated poor quality above the WHO Guidelines for Drinking Water Quality which is 250mg/L.

Kingston Hydrologic Basin Sulphate Levels in Groundwater

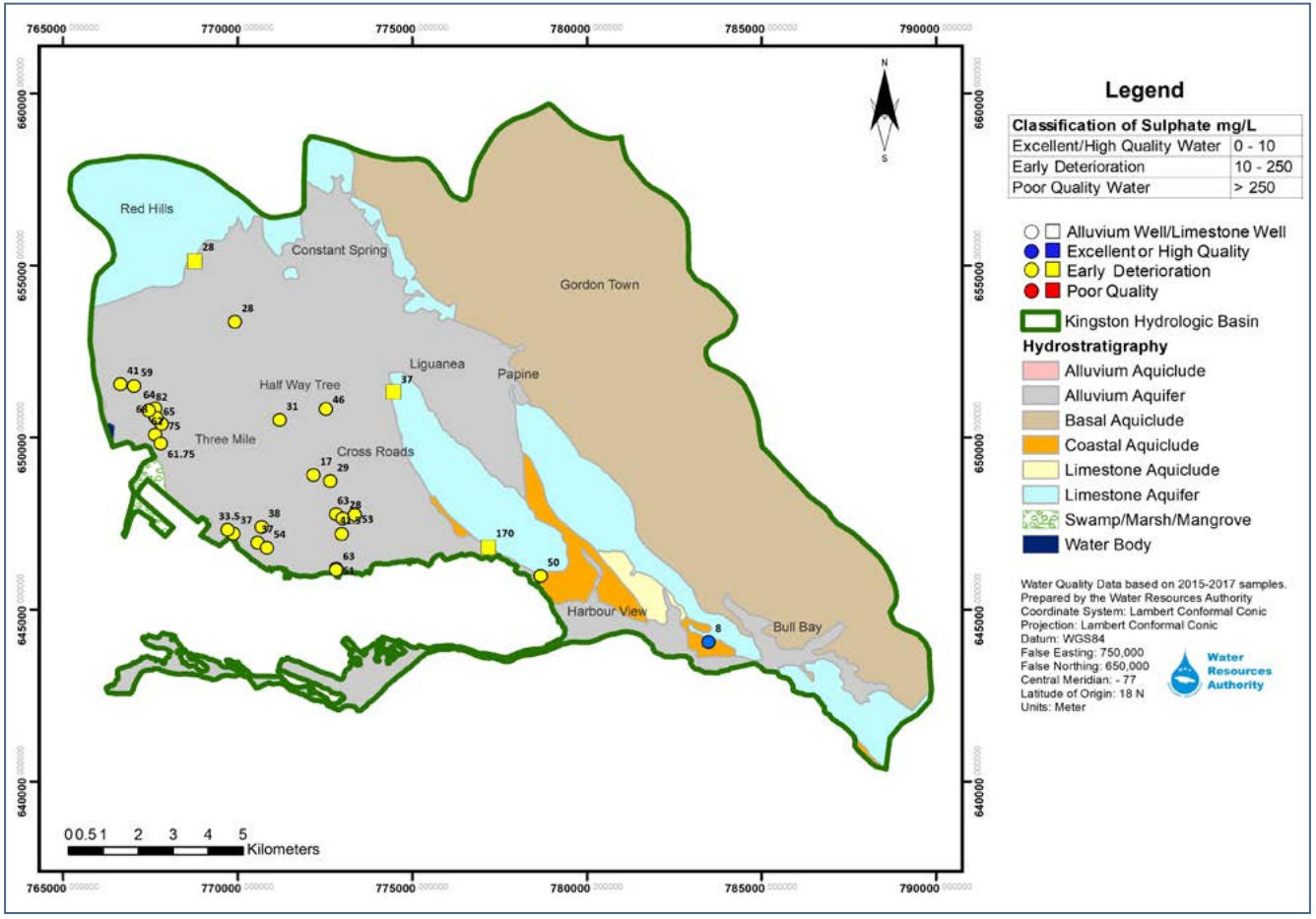
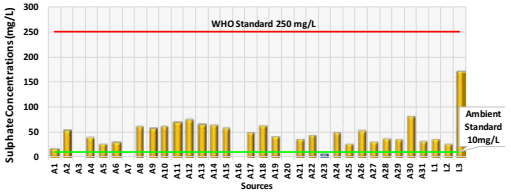


Figure 28: Kingston Hydrologic Basin Sulphate Levels in Groundwater

KINGSTON HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 14: Kingston Basin Sulphate Levels in Groundwater

As shown in Figure 28 and Graph 14, the well sources within the Kingston basin indicated early deterioration for sulphate. All the wells sampled indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L but within the maximum level of the WHO Guidelines for Drinking Water Quality.

Kingston Hydrologic Basin Sulphate Levels in the Alluvium Aquifer

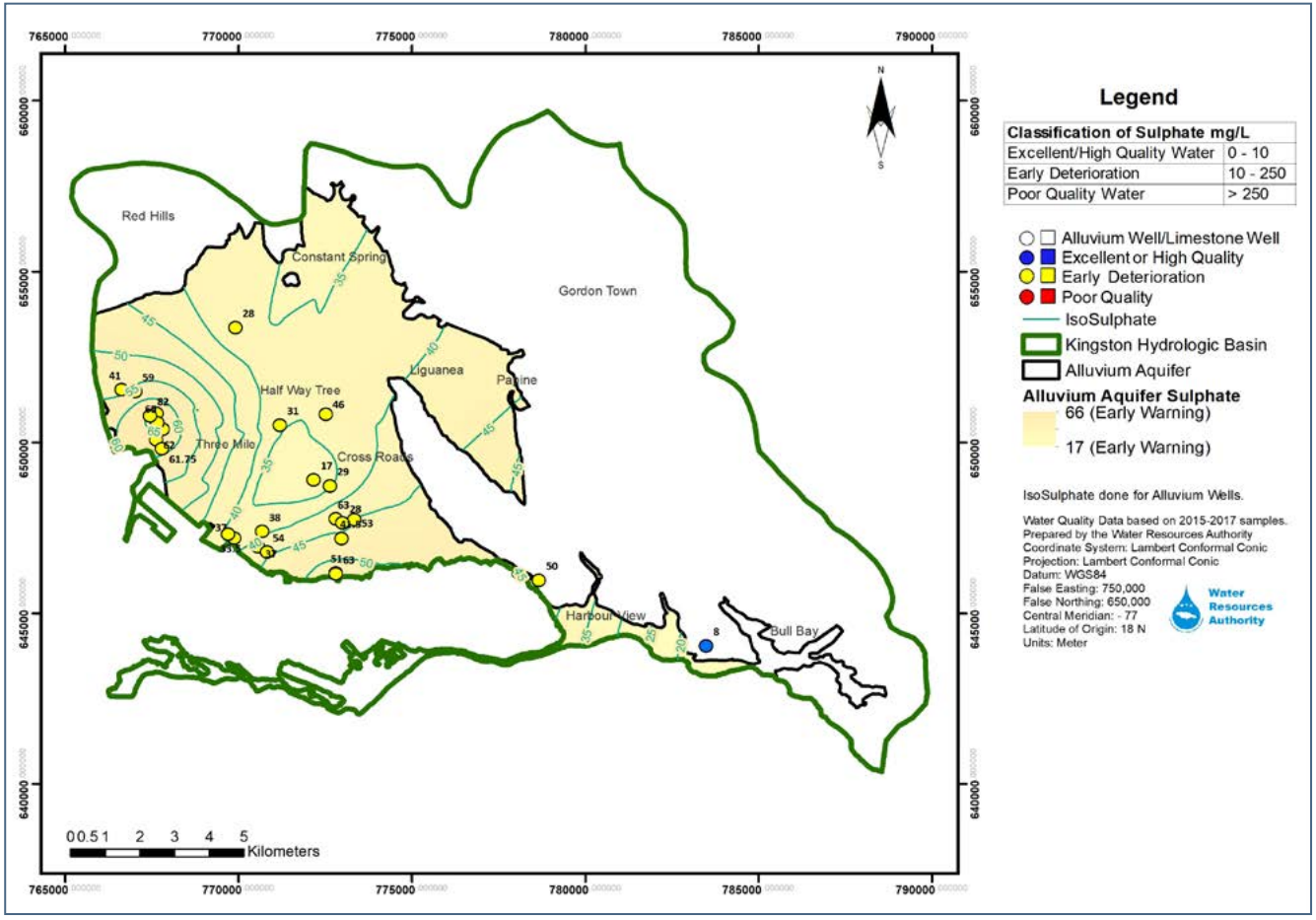


Figure 29: Kingston Hydrologic Basin Spatial Interpolation of the Sulphate Levels in the Alluvium Aquifer

Figure 29 indicates the spatial interpolation of the water quality results within the Kingston basin for sulphate. Based on the interpolated results the basin quality predominantly indicated early deterioration water quality with the exception of Rest Haven well located in the south east part of the basin.

All sources located within the basin with the exception of Rest Haven are expected to have sulphate concentration in excess of the National Ambient Water Quality Standard of 10mg/L, but are expected to conform to the maximum level of the WHO Guidelines for Drinking Water Quality.

Kingston Hydrologic Basin TDS Levels in Groundwater

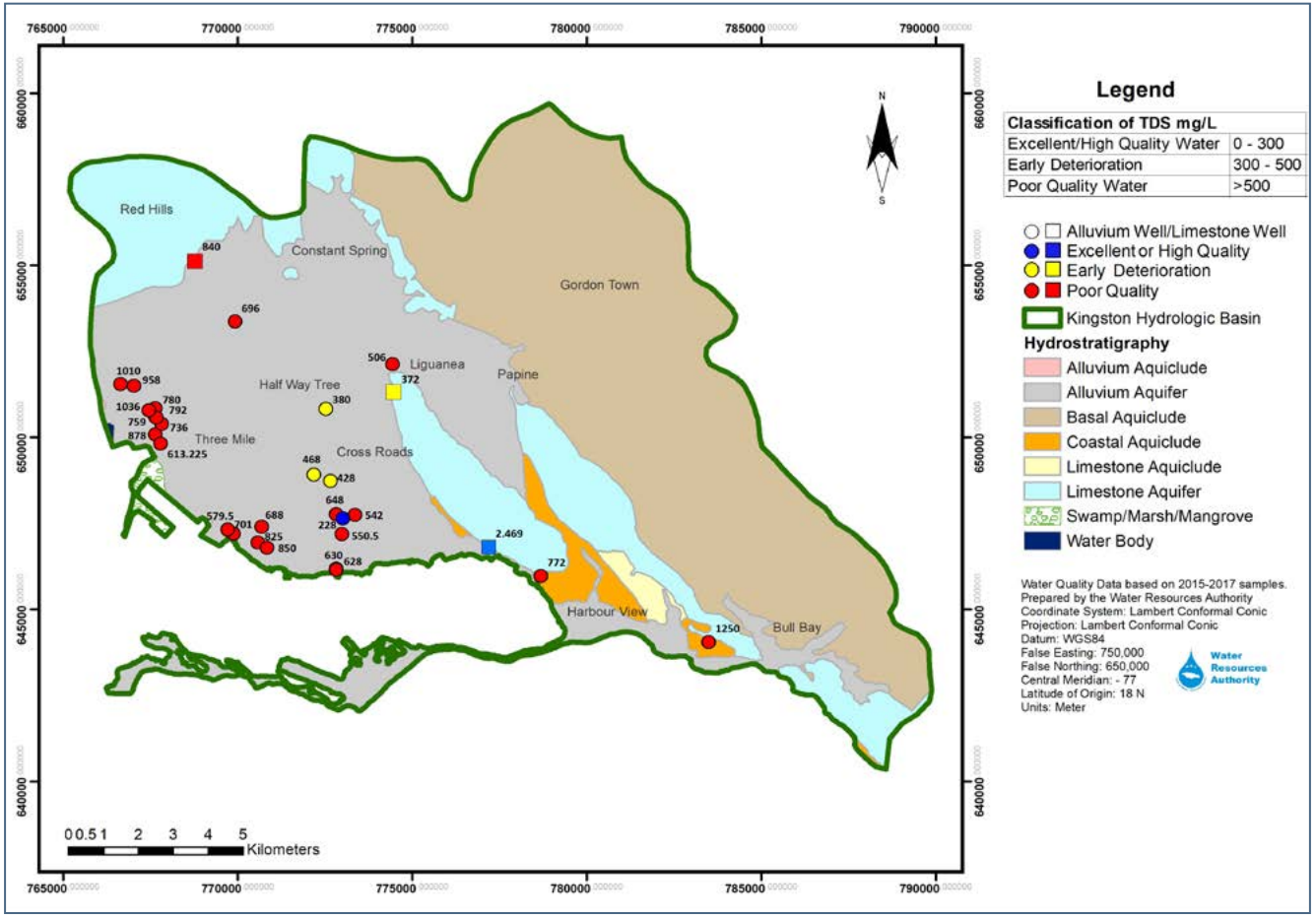
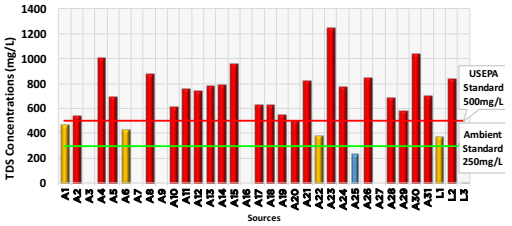


Figure 30: Kingston Hydrologic Basin TDS Levels in Groundwater

KINGSTON HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 15: Kingston Basin TDS Levels in Groundwater

As indicated in Figure 30 and Graph 15, the well sources within the Kingston basin predominantly indicated poor water quality for Total Dissolved Solids (TDS). Eighty-six percent (86%) of the wells sampled indicated TDS level in excess of the US EPA standard. Fourteen percent (14%) of the wells indicated early deterioration, which are TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but within the maximum level of the WHO Guidelines for Drinking Water Quality.

Kingston Hydrologic Basin TDS Levels in the Alluvium Aquifer

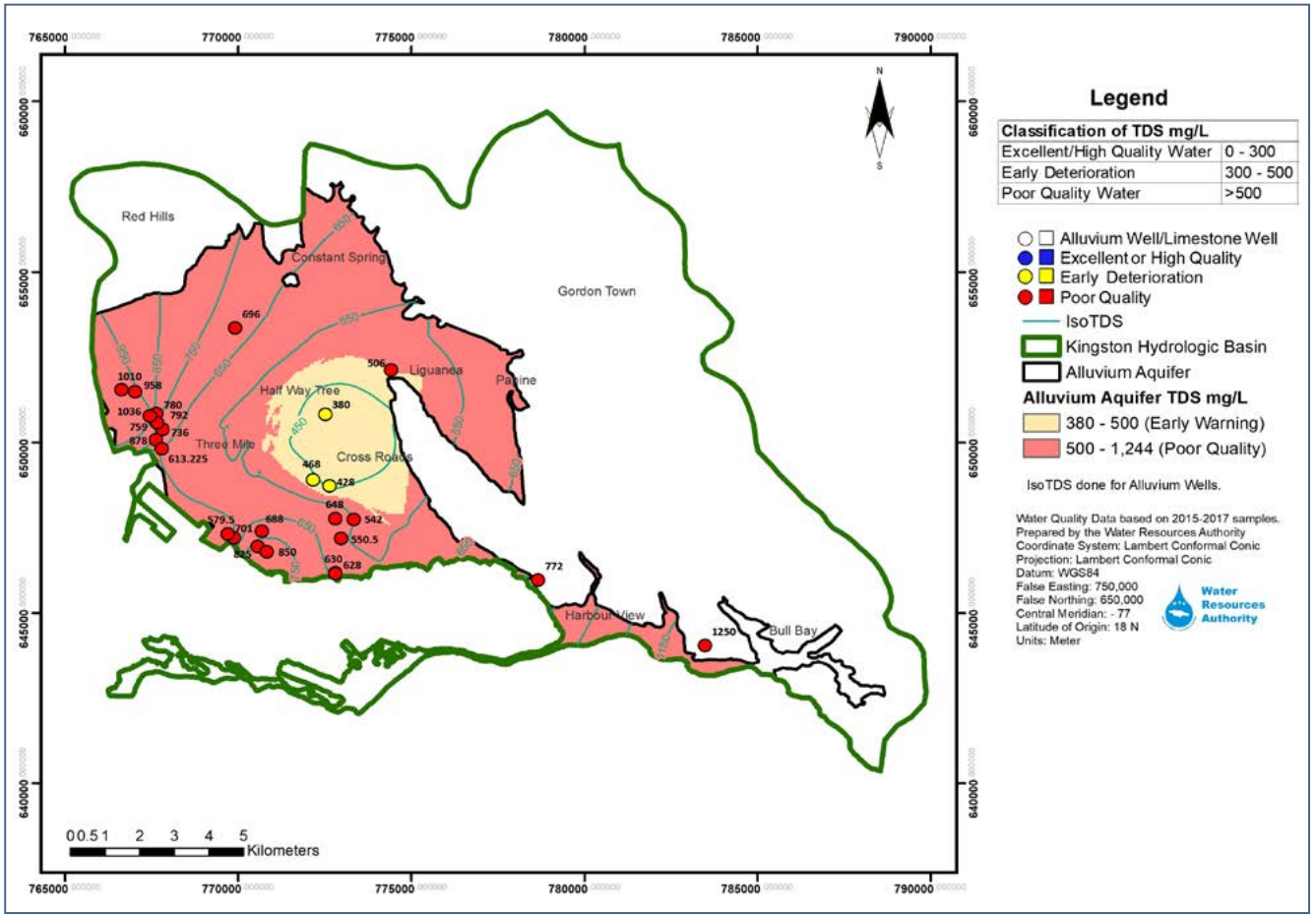


Figure 31: Kingston Hydrologic Basin Spatial Interpolation of the TDS Levels in the Alluvium Aquifer

Figure 31 indicates the spatial interpolation of the water quality results within the Kingston basin for TDS. The interpolated results indicates that the Kingston basin alluvium aquifer predominantly indicated poor water quality for sulphate, with sulphate concentration in excess of the maximum level of the US EPA standard. Eighty six percent of the aquifer indicated TDS level in excess of the US EPA standard. Fourteen percent of the Liguanea aquifer indicated early deterioration, which are TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but within the maximum level of the US EPA standard.

Kingston Hydrologic Basin Surface Water Sample Locations

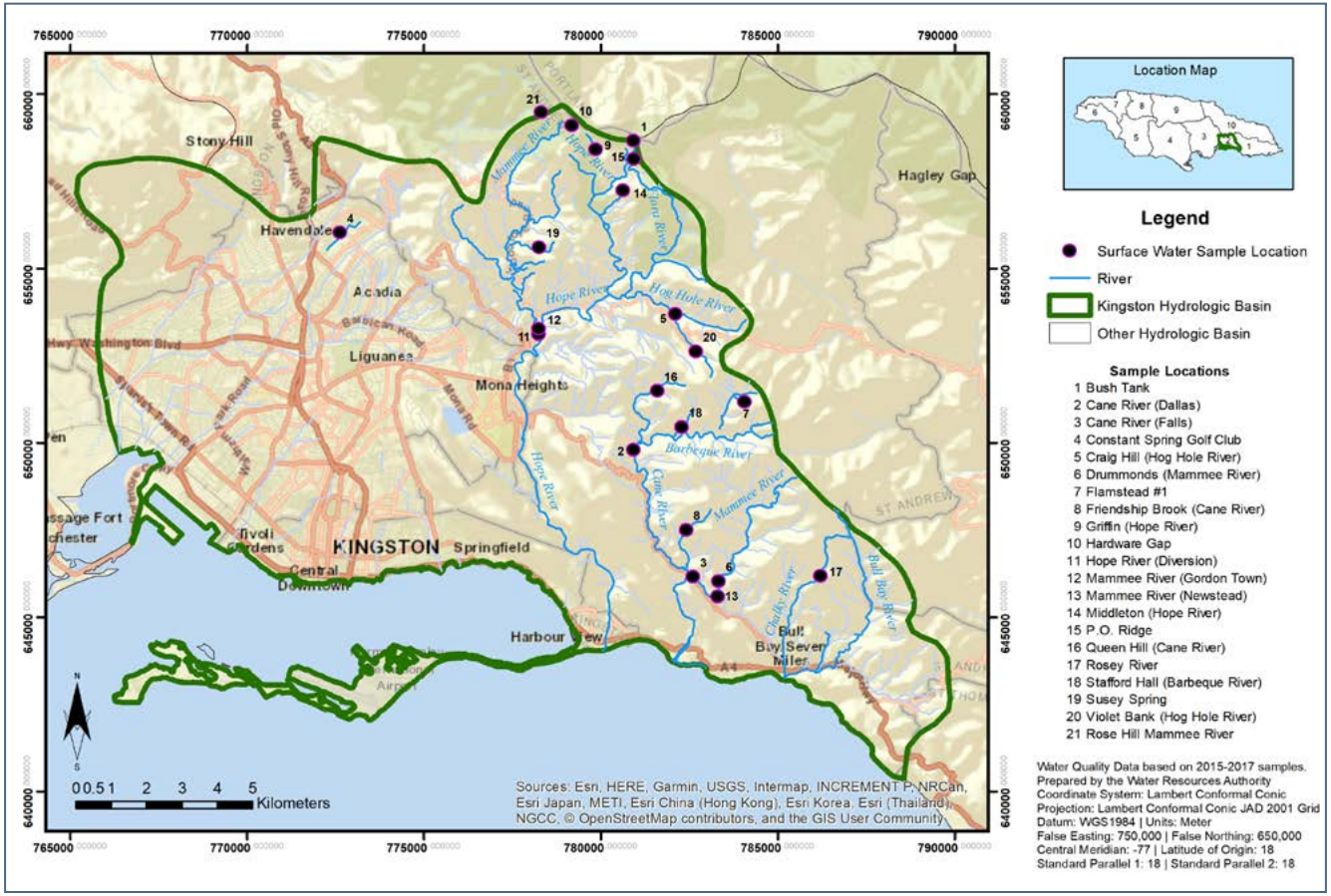


Figure 32: Kingston Hydrologic Basin Surface Water Sample Locations

Figure 32 indicates the location of the twenty-one (21) surface water sampling points utilized in the surface water analyses for the Kingston Basin.

Kingston Hydrologic Basin Nitrate Levels in Surface Water

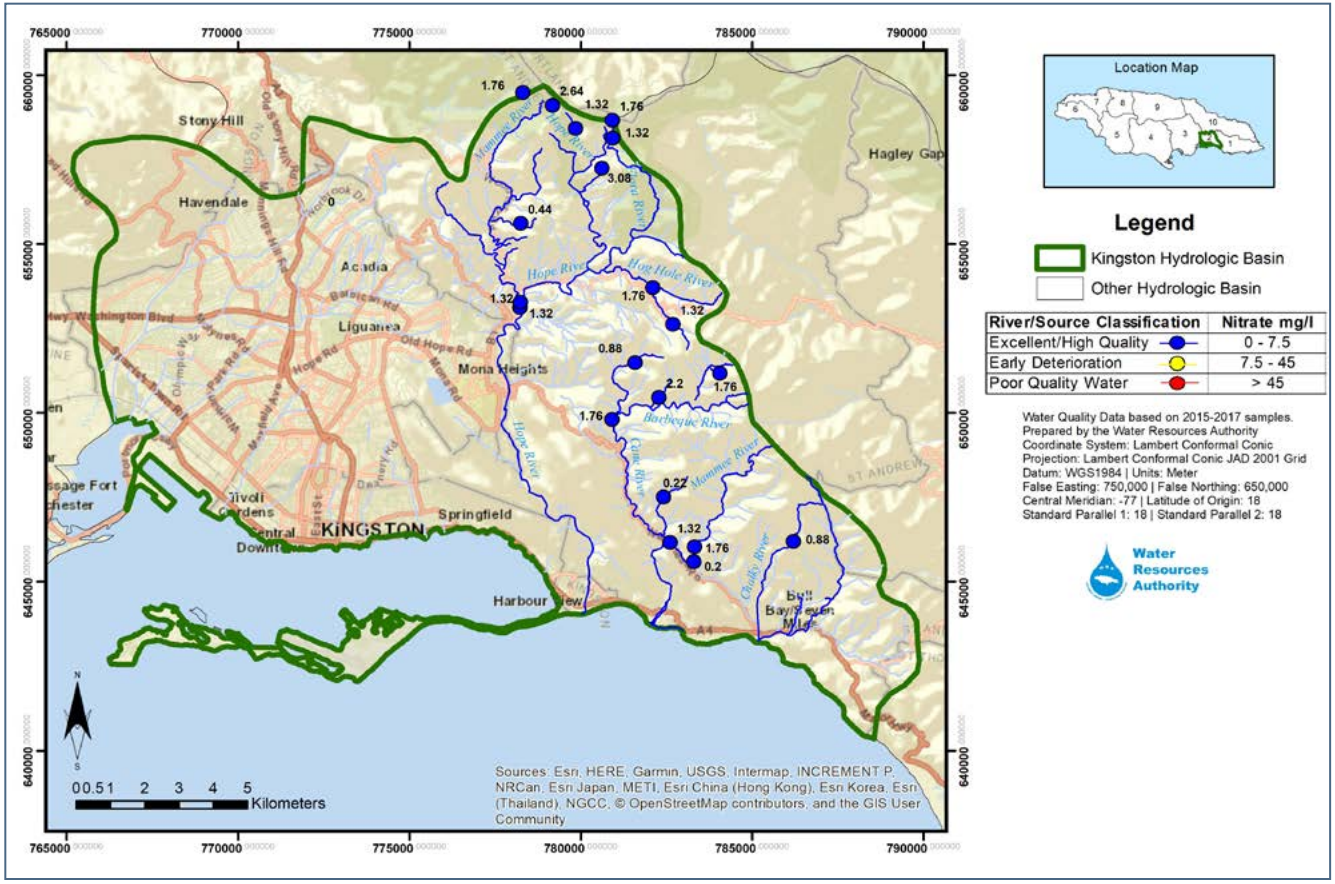
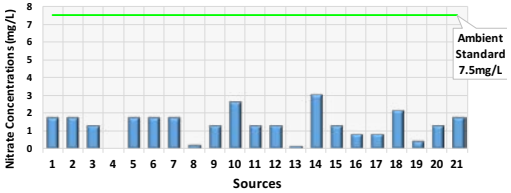


Figure 33: Kingston Hydrologic Basin Nitrate Levels in Surface Water

KINGSTON HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 16: Kingston Basin Nitrate Levels in Surface water

As indicated in Figure 33 and Graph 16, the surface water sources within the Kingston basin have indicated excellent water quality for nitrate.

Kingston Hydrologic Basin Sodium Levels in Surface Water

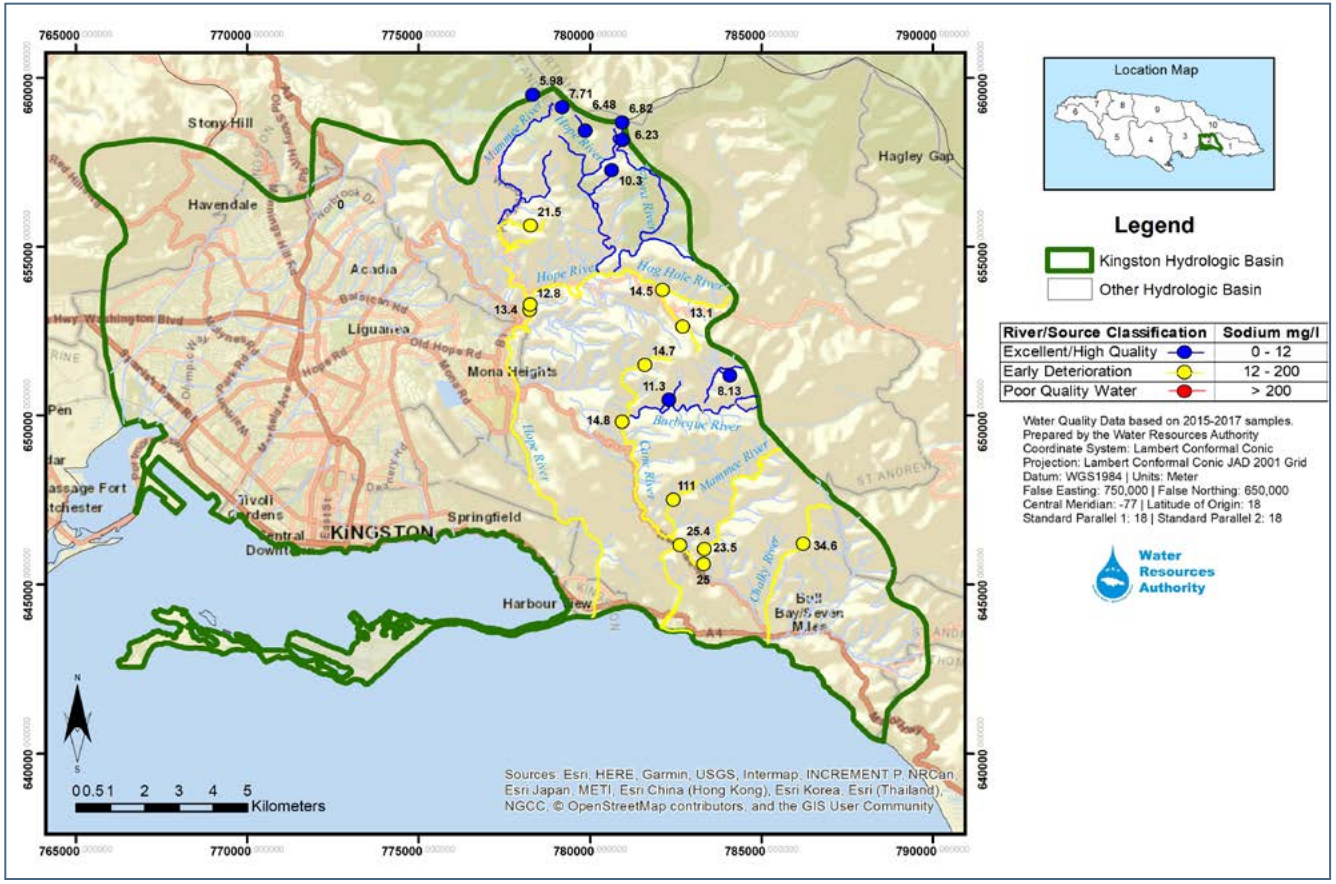
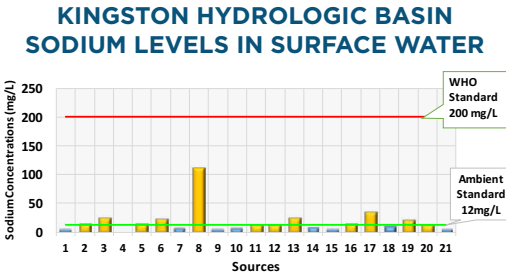


Figure 34: Kingston Hydrologic Basin Sodium Levels in Surface Water



Graph 17: Kingston Basin Sodium Levels in Surface water

As shown in Figure 34 and Graph 17, the surface water sources within the Kingston basin predominantly indicated early deterioration for sodium. Sixty-two percent (62%) of the surface water sources sampled indicated sodium level in excess of the National Ambient Water Quality Standard of 12mg/L. Thirty-eight percent (38%) of the surface water points sampled indicated excellent water quality for sodium. The sources indicating excellent quality are located in the north eastern and eastern sections of the basin.

Kingston Hydrologic Basin Chloride Levels in Surface Water

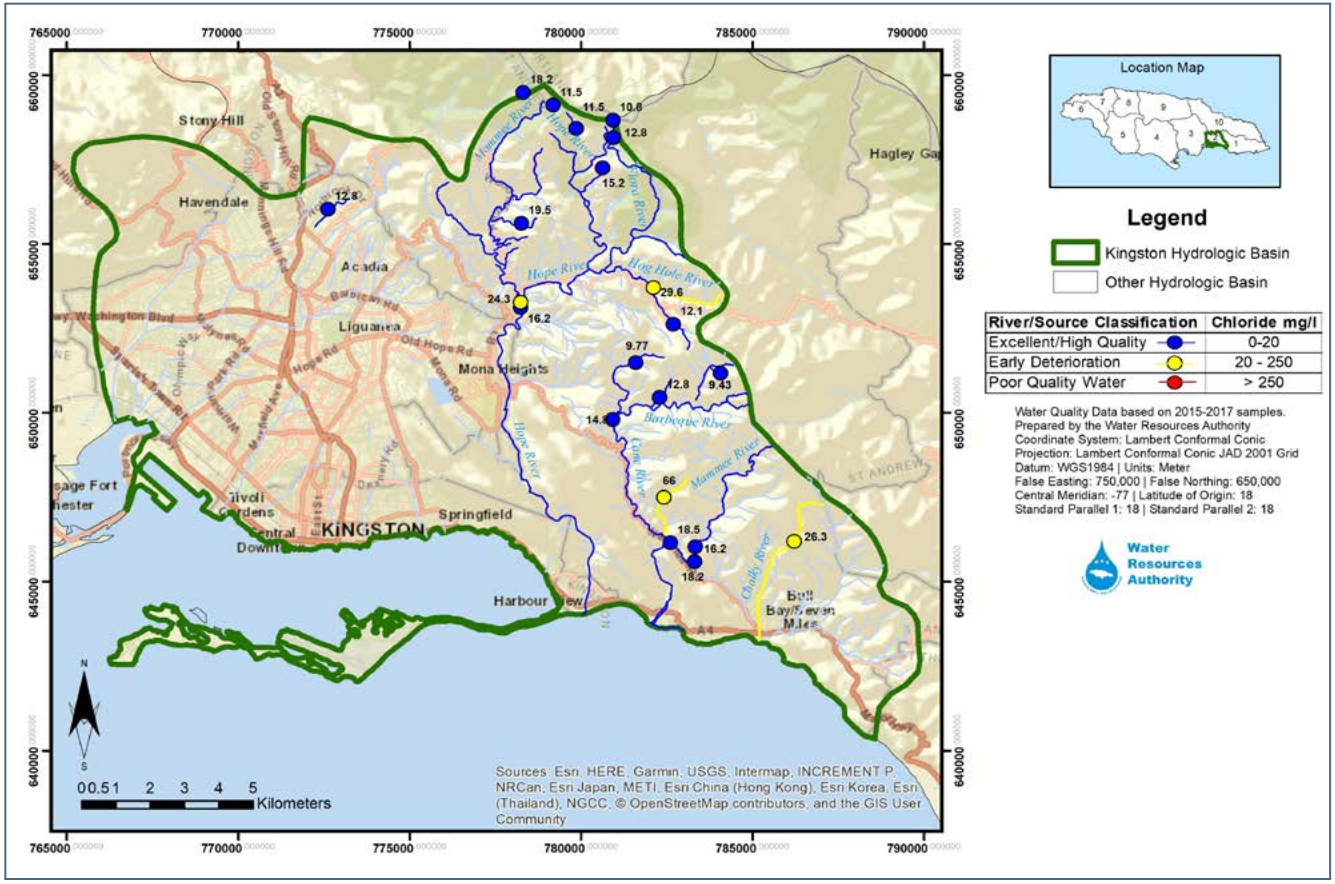
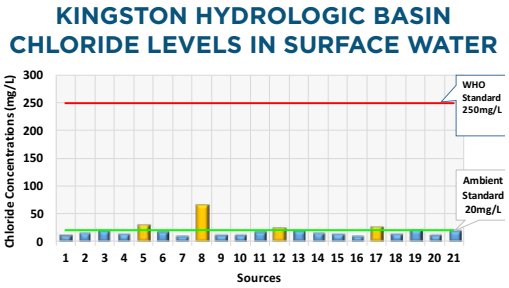


Figure 35: Kingston Hydrologic Basin Chloride Levels in Surface Water



Graph 18: Kingston Basin Chloride Levels in Surface water

As shown in Figure 35 and Graph 18, the surface water sources within the Kingston basin predominantly indicated excellent water quality for chloride with the exception of nineteen percent (19%) of the sources sampled which indicated early deterioration with chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L.

Kingston Hydrologic Basin Sulphate Levels in Surface Water

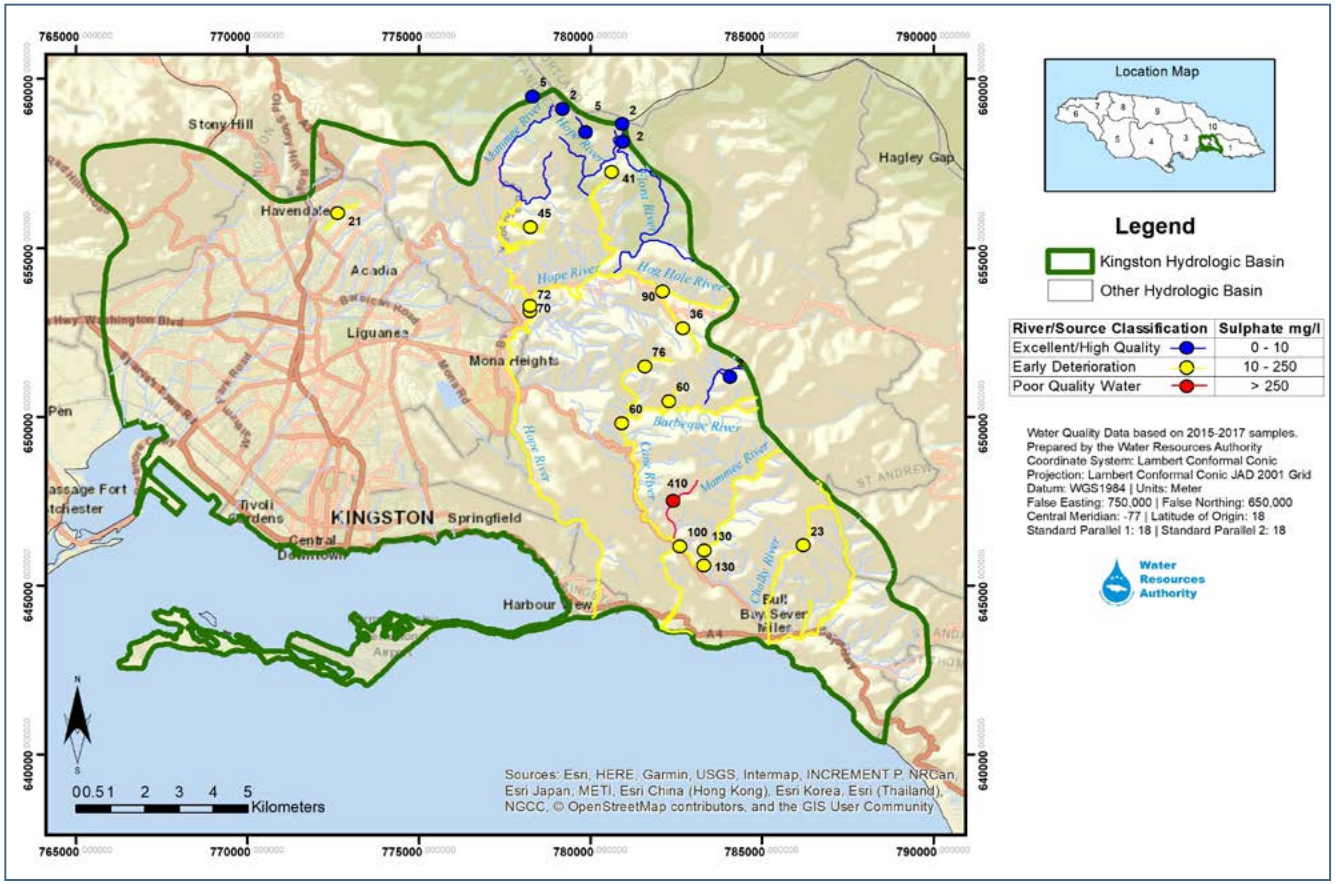
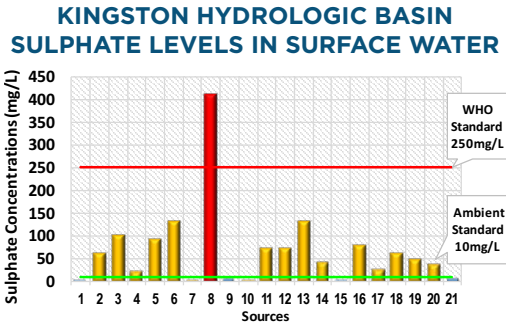


Figure 36: Kingston Hydrologic Basin Sulphate Levels in Surface Water



Graph 19: Kingston Basin Sulphate Levels in Surface water

As indicated in Figure 36 and Graph 19, the surface water sources within the Kingston basin predominantly indicated early deterioration for sulphate with the exception of one source, Friendship Brook- Cane River, which has indicated poor water quality with sulphate levels of 410mg/L, exceeding the WHO Guidelines for Drinking Water of 250mg/L.

Kingston Hydrologic Basin TDS Levels in Surface Water

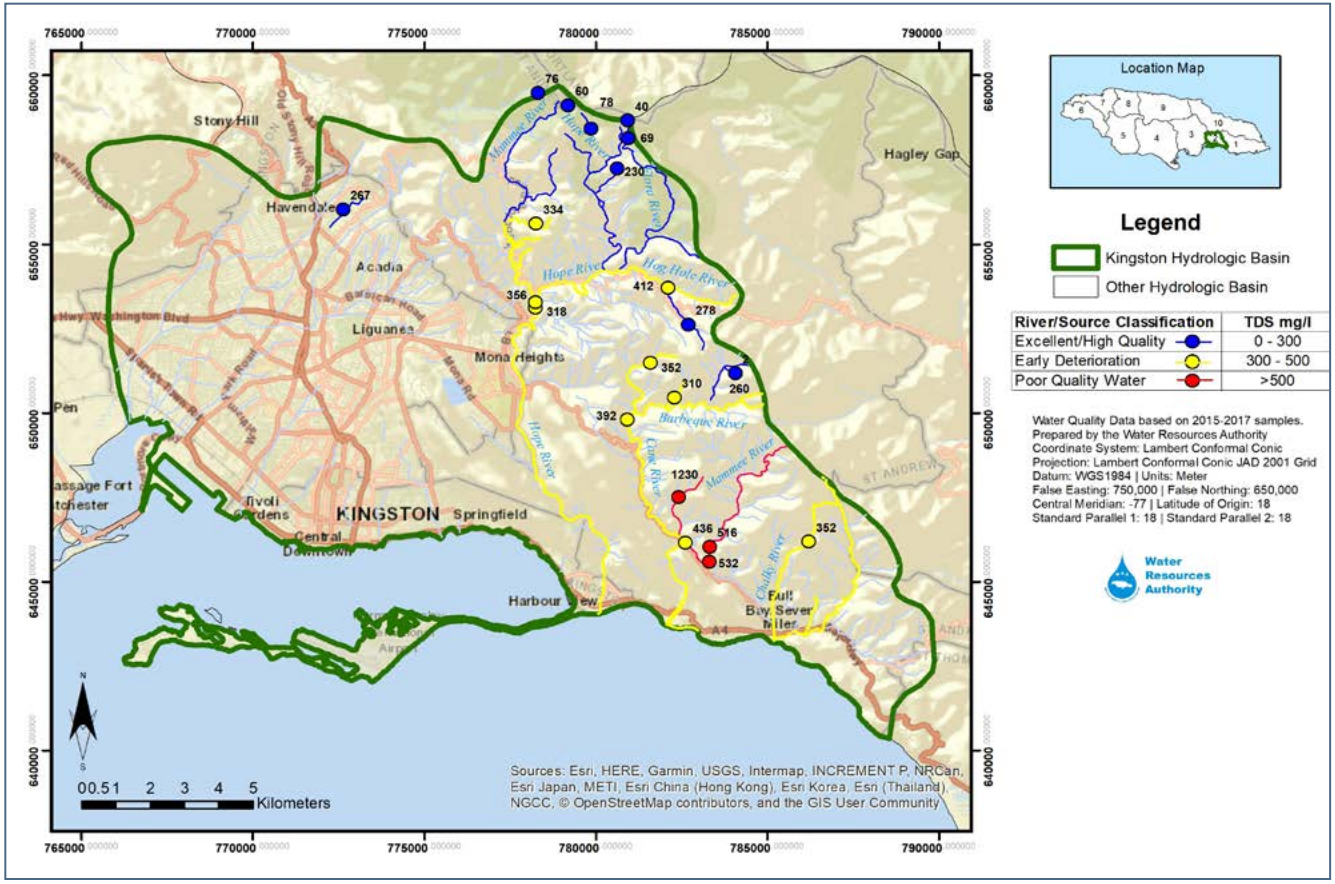
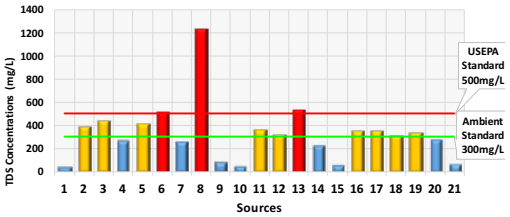


Figure 37: Kingston Hydrologic Basin TDS Levels in Surface Water

KINGSTON HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 20: Kingston Basin TDS Levels in Surface water

As shown in Figure 37 and Graph 20, the surface water sources within the Kingston basin predominantly indicated excellent water quality for TDS. Forty-eight percent (48%) of the sources sampled indicated excellent water quality. Thirty eight percent (38%) of the surface water sources sampled indicated TDS level in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the WHO Guidelines for Drinking Water Quality. Fourteen percent (14%) indicated level in excess of the US EPA standard.

3.0 Basin III- Rio Cobre Hydrologic Basin

The Rio Cobre Hydrologic Basin extends across St Catherine, Northern Clarendon, Southern St Ann and parts of Kingston. The sub basins located within the Rio Cobre are the Upper Rio Cobre, the Lower Rio Cobre, Hellshire, Salt Island Creek, Bowers Gully and Coleburns Gully.

The basin consist predominately of white limestone, interbedded with alluvial and superficial deposits. The western parts of the basin have outcrops of Cretaceous volcanic rock and the eastern boundaries have granodiorite. The basin is drained mainly by the Rio Cobre at Hunts Bay.

The groundwater quality was analysed with the results from forty seven (47) wells (11 alluvium and 34 limestone) and the surface water analyses was done utilizing thirty (30) sources.

Rio Cobre Hydrologic Basin Groundwater Sample Locations

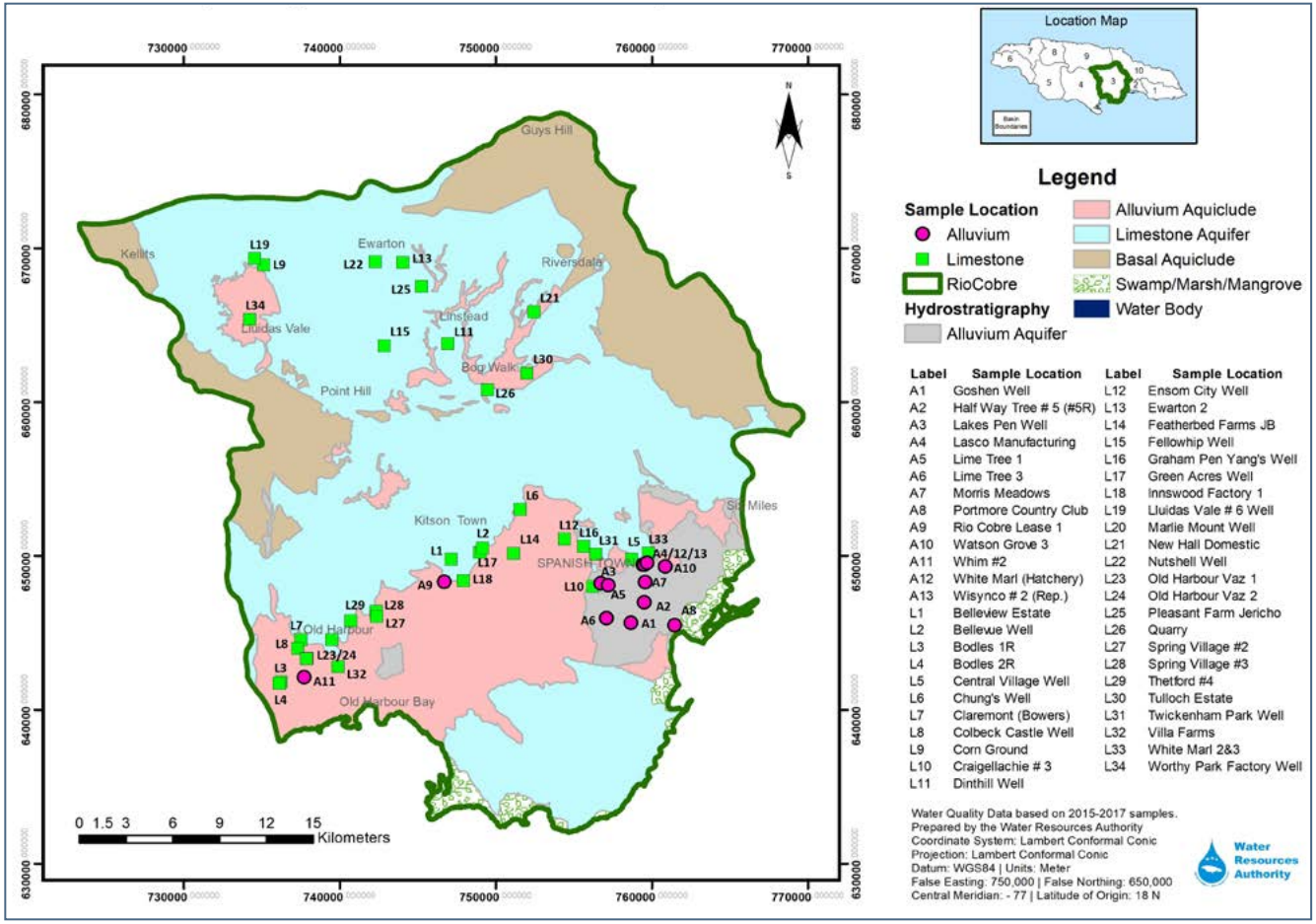


Figure 38: Rio Cobre Hydrologic Basin Groundwater Sample Locations

Figure 38 shows the location of the forty seven (47) ground water sampling points. Thirteen (13) of the sources are classified as alluvium wells and thirty-four (34) limestone wells.

Rio Cobre Hydrologic Basin Nitrate Levels in Groundwater

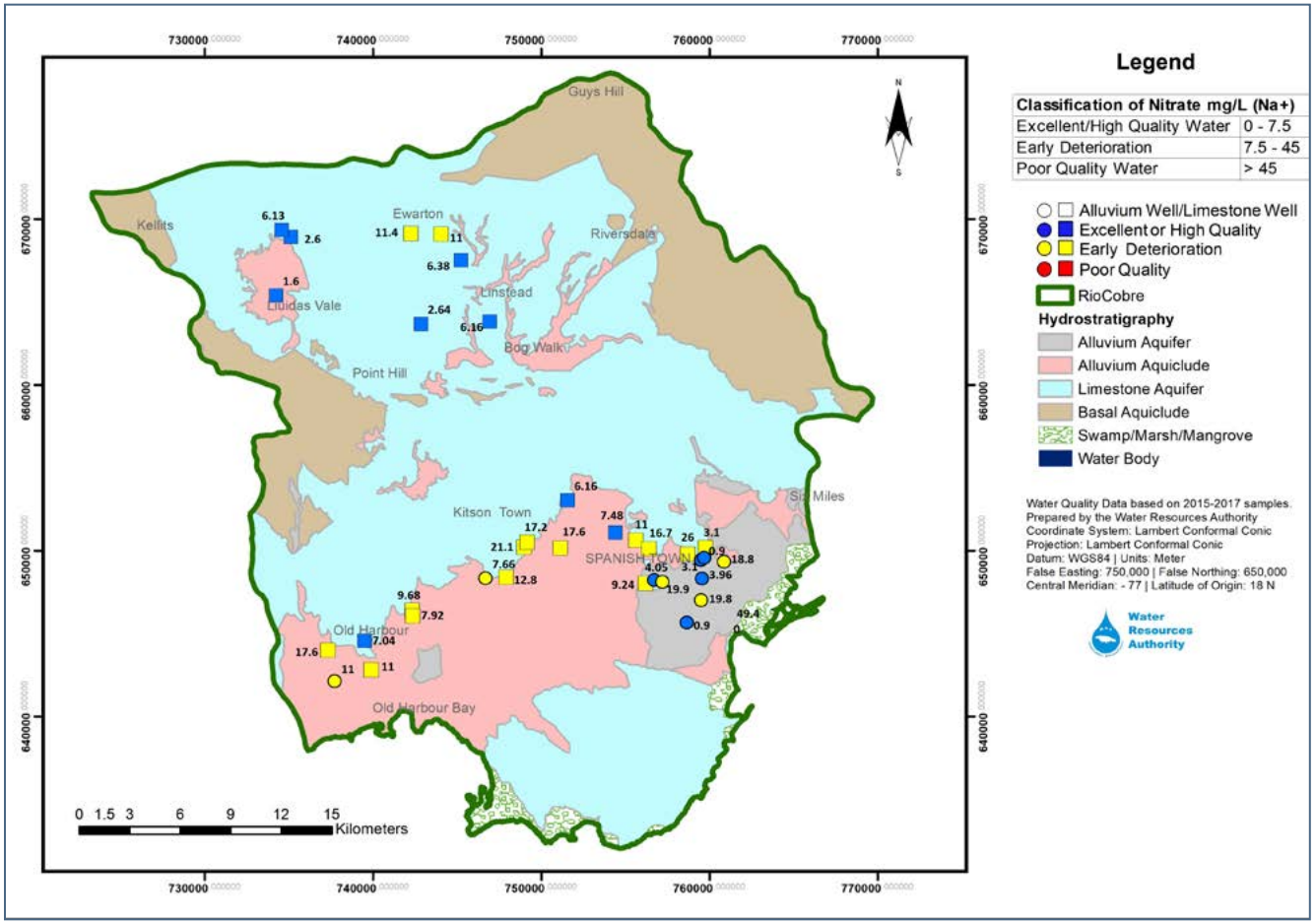
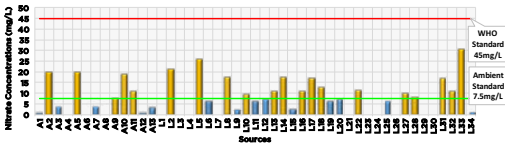


Figure 39: Rio Cobre Hydrologic Basin Nitrate Levels in Groundwater

RIO COBRE HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 21: Rio Cobre Basin Nitrate Levels in Groundwater

The well sources within the Rio Cobre basin predominantly indicated early deterioration for nitrate as indicated in Figure 39 and Graph 21.

Forty-three percent (43%) of the surface water sources sampled indicated nitrate level in excess of the National Ambient Water Quality Standard of 12mg/L but are within the WHO Guidelines for Drinking Water Quality. Fourteen percent (14%) of the sources indicated excellent water quality for nitrate. In the northern section of the basin only Nutshell and Ewarton wells have shown signs of early deterioration.

Rio Cobre Hydrologic Basin Nitrate Levels in the Limestone Aquifer

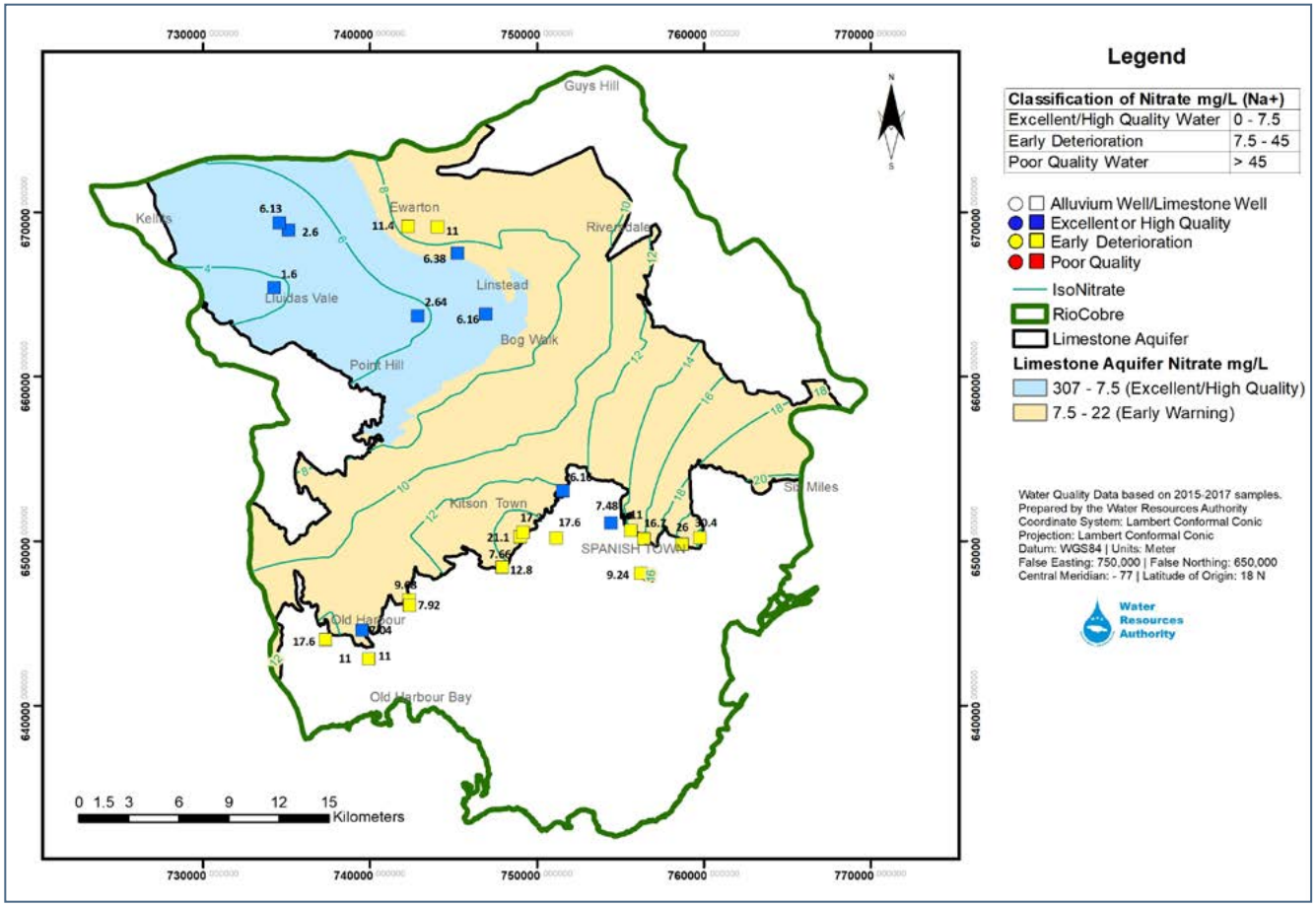


Figure 40: Rio Cobre Hydrologic Basin Spatial Interpolation of the Nitrate Levels in the Limestone Aquifer

Figure 40 indicates the spatial interpolation of the water quality results for nitrates within the limestone aquifer of the Rio Cobre basin. Based on the interpolated results, the basin quality predominantly indicated early deterioration water quality for nitrate, with levels in excess of the National Ambient Water Quality Standard of 20mg/L Approximately twenty five (25%) percent of the aquifer indicated excellent quality for nitrate.

The spatial representation of the data indicated excellent quality at the north western section of the basin.

Rio Cobre Hydrologic Basin Sodium Levels in Groundwater

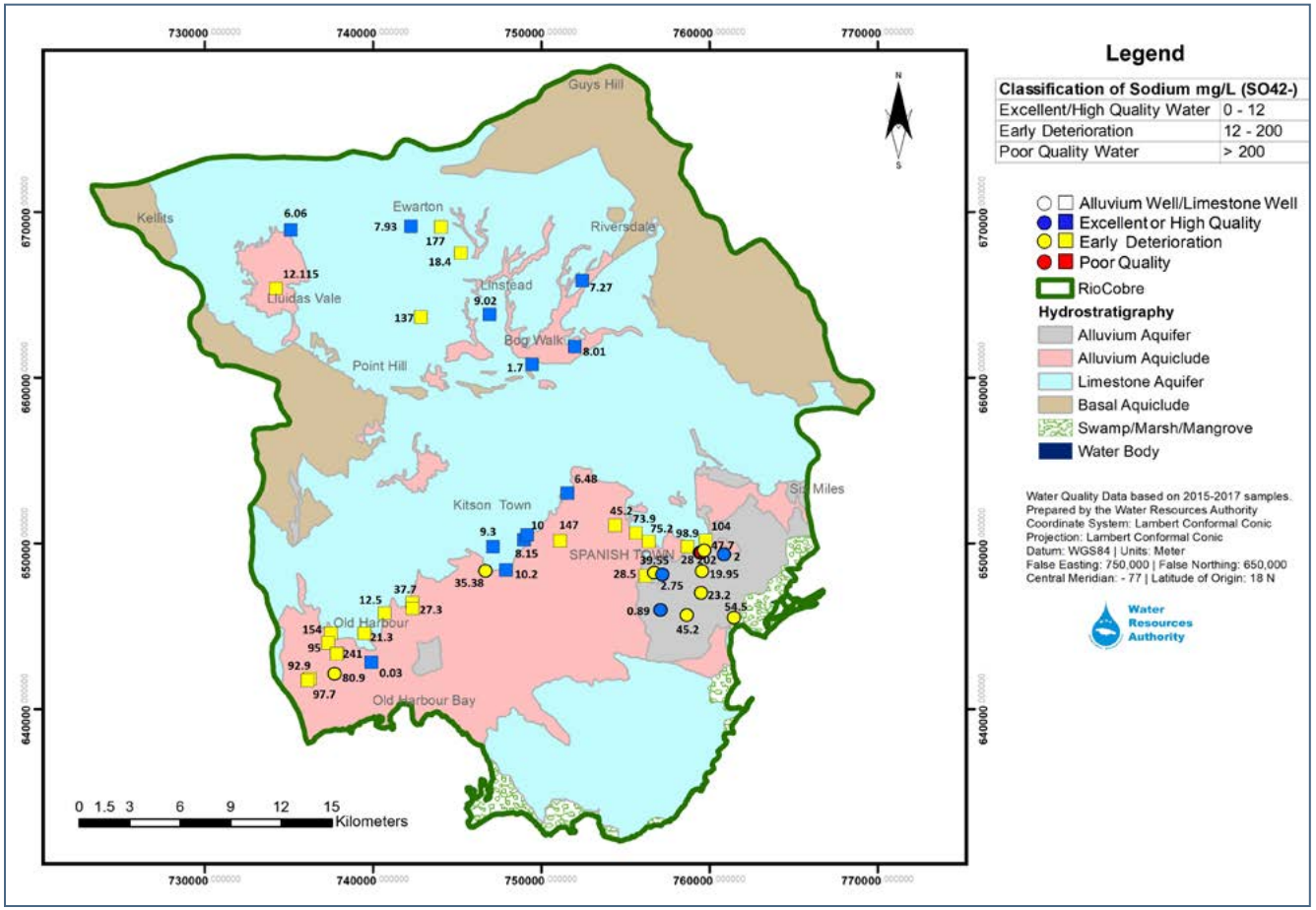
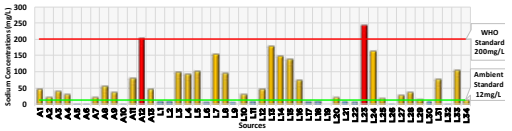


Figure 41: Rio Cobre Hydrologic Basin Sodium Levels in Groundwater

RIO COBRE HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 22: Rio Cobre Basin Sodium Levels in Groundwater

As indicated in Figure 41 and Graph 22, the well sources within the Rio Cobre basin predominantly indicated early deterioration for sodium. Sixty-two percent (62%) of the groundwater sources sampled indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L. Thirty-three percent (33%) of the source sampled indicated excellent water quality and five percent indicated poor water. The sources indicating poor quality are the White Marl (Hatchery) and Old Harbour Vaz 1.

Rio Cobre Hydrologic Basin Sodium Levels in the Limestone Aquifer

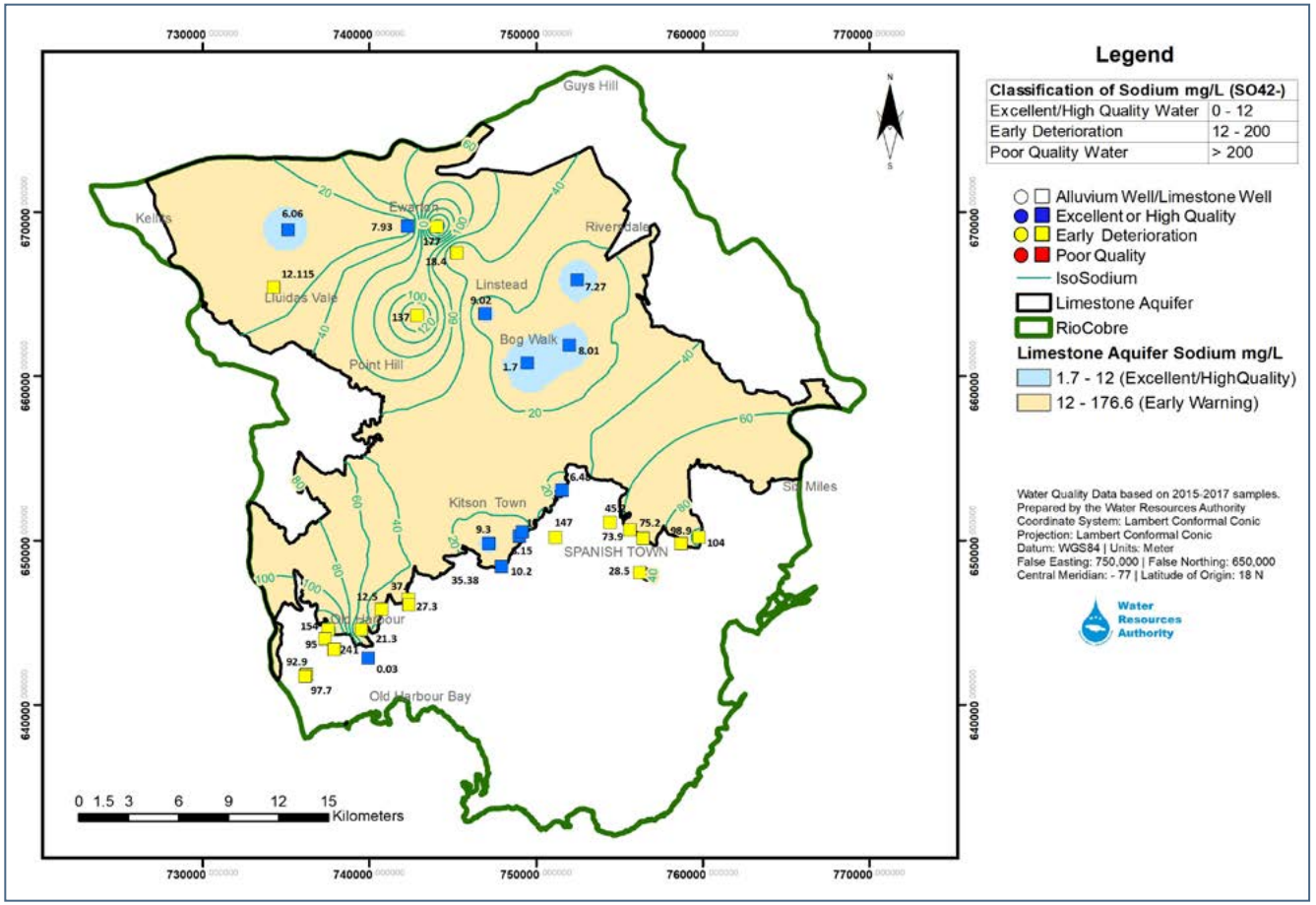


Figure 42: Rio Cobre Hydrologic Basin Spatial Interpolation of the Sodium Levels in the Limestone Aquifer

Figure 42 indicates the spatial interpolation of the water quality results for the sodium within the limestone aquifer of the Rio Cobre basin. Based on the interpolated results the basin quality predominantly indicated early deterioration water quality for sodium, with concentration levels in excess of the National Ambient Water Quality Standard of 20mg/L. The spatial interpolation of the data indicates a few pockets of excellent water quality throughout the basin.

Rio Cobre Hydrologic Basin Chloride Levels in Groundwater

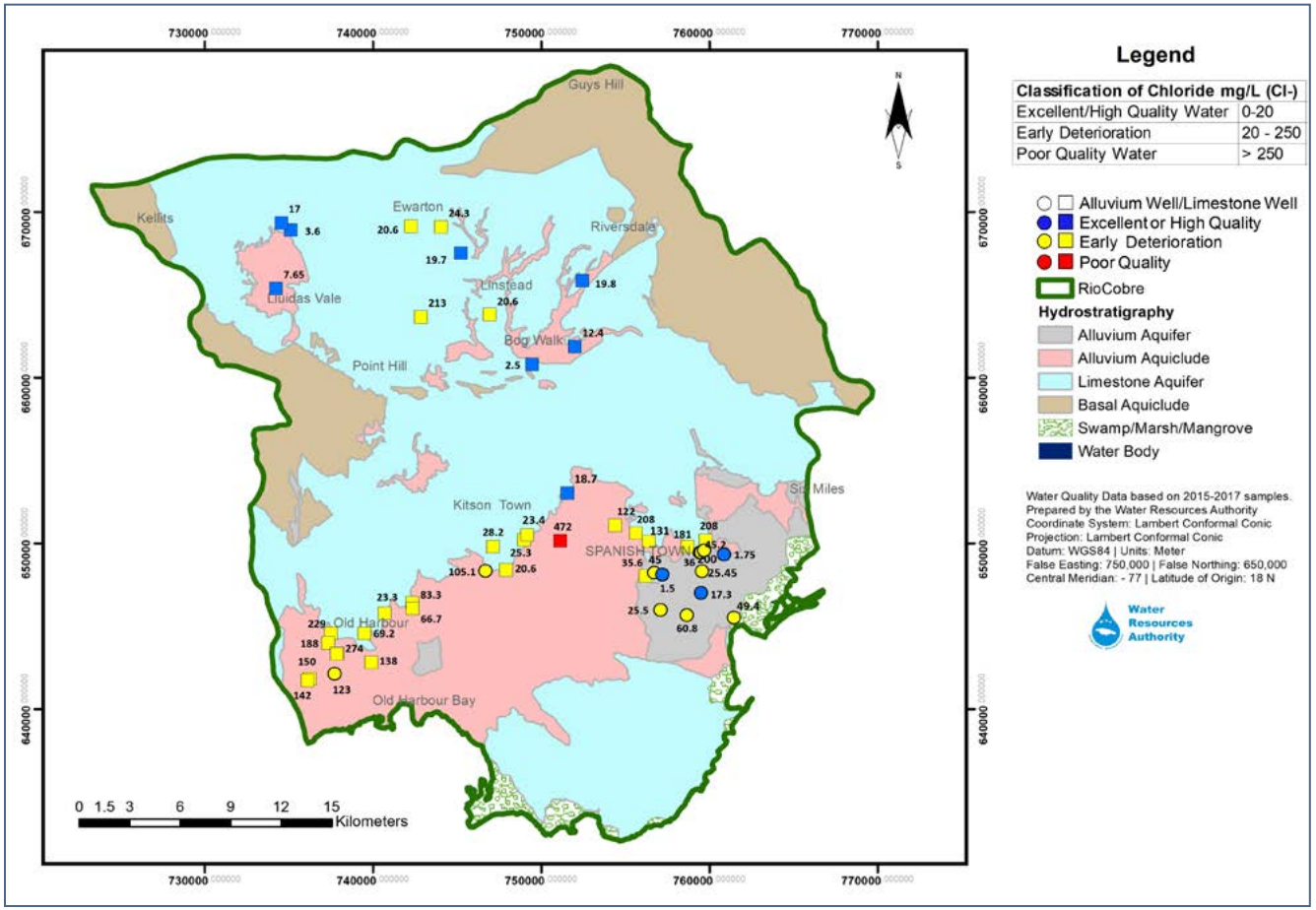
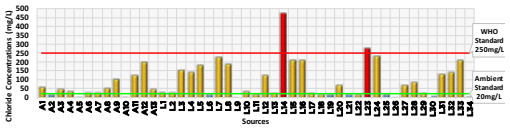


Figure 43: Rio Cobre Hydrologic Basin Chloride Levels in Groundwater

RIO COBRE HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 23: Rio Cobre Basin Chloride Levels in Groundwater

As indicated in Figure 43 and Graph 23, the well sources within the Rio Cobre basin predominantly indicated early deterioration for chloride. Seventy percent (70%) of the well sources sampled indicated sodium level in excess of the National Ambient Water Quality Standard of 2mg/L. Twenty-four percent (24%) of the sources sampled indicated excellent water quality and six percent (6%) indicated poor water quality.

Rio Cobre Hydrologic Basin Chloride Levels in the Limestone Aquifer

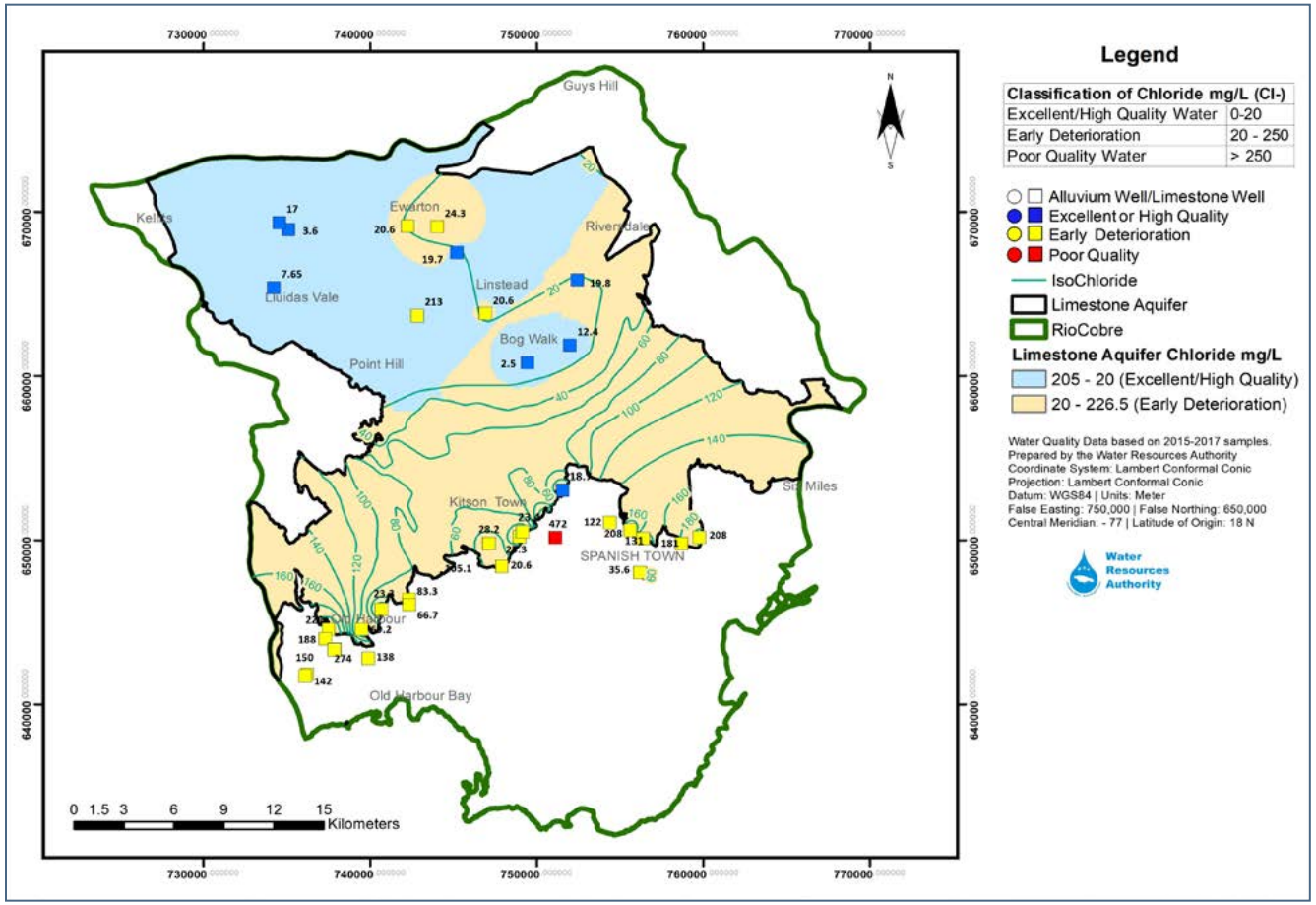


Figure 44: Rio Cobre Hydrologic Basin Spatial Interpolation of the Chloride Levels in the Limestone Aquifer

Figure 44 indicates the spatial interpolation of the water quality results for the chloride within the limestone aquifer of the Rio Cobre basin. Based on the interpolated results the basin quality predominantly indicated early deterioration water quality for chloride, with levels in excess of the National Ambient Water Quality Standard of 20mg/L. The Featherbed Farms and Old Harbour Vaz 1 wells are the only sources indicating poor quality for sodium.

The early deterioration water quality is predominantly concentrated within the southern sections of the basin and excellent water quality at the northern section of the basin.

Rio Cobre Hydrologic Basin Sulphate Levels in Groundwater

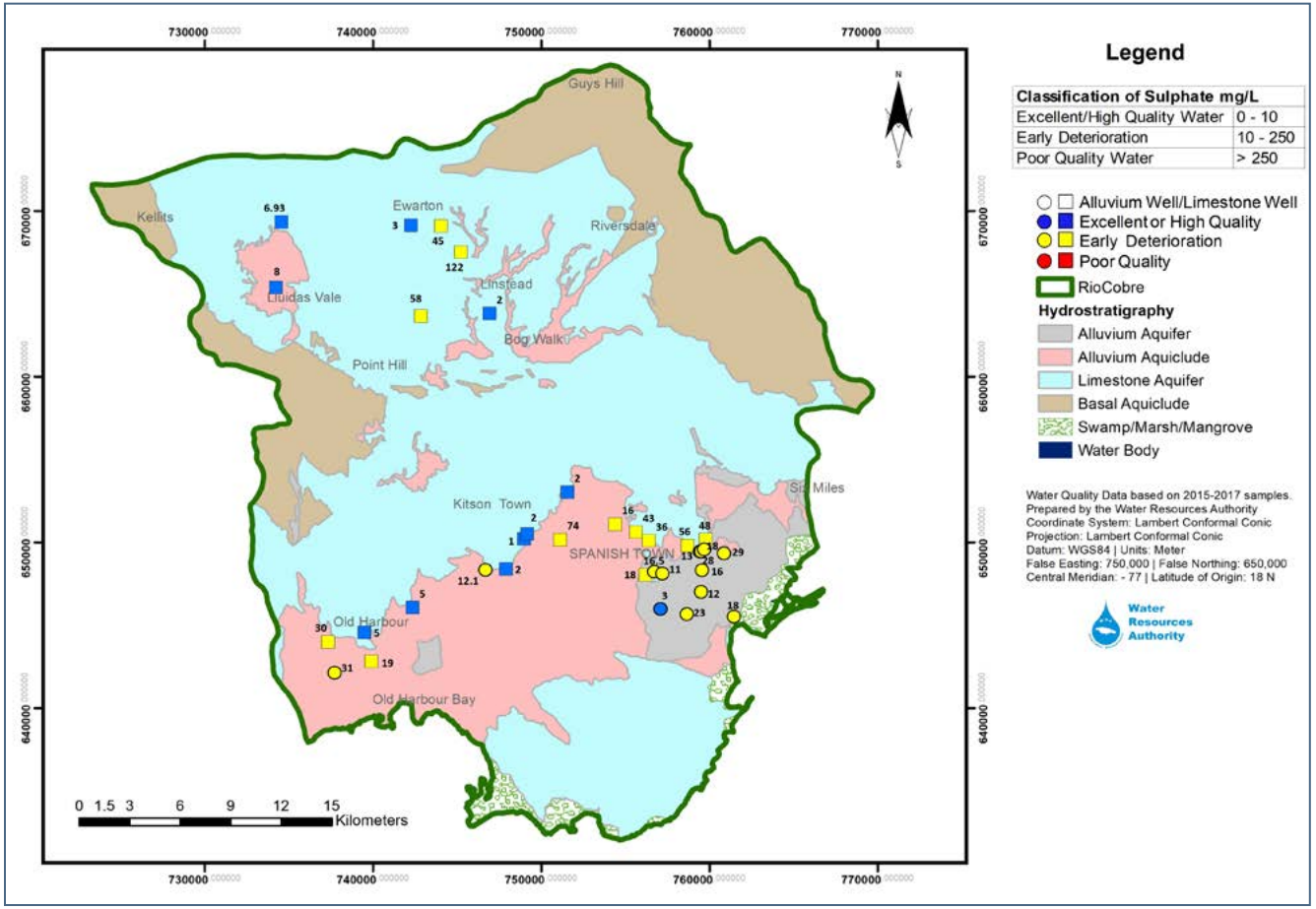
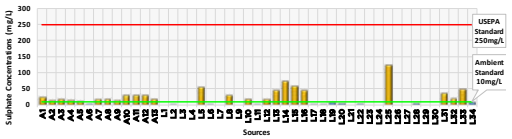


Figure 45: Rio Cobre Hydrologic Basin Sulphate Levels in Groundwater

RIO COBRE HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 24: Rio Cobre Basin Sulphate Levels in Groundwater

As indicated in Figure 45 and Graph 24, the well sources within the Rio Cobre basin predominantly indicated early deterioration for sulphate. Seventy-nine percent (79%) of the wells sampled indicated sodium level in excess of the National Ambient Water Quality Standard of 20mg/L The highest concentration of sulphate is observed at the Pleasant Farm Jericho well, 122mg/L.

Twenty-one percent (21%) of the sources indicated excellent water quality for sulphate.

Rio Cobre Hydrologic Basin Sulphate Levels in the Limestone Aquifer

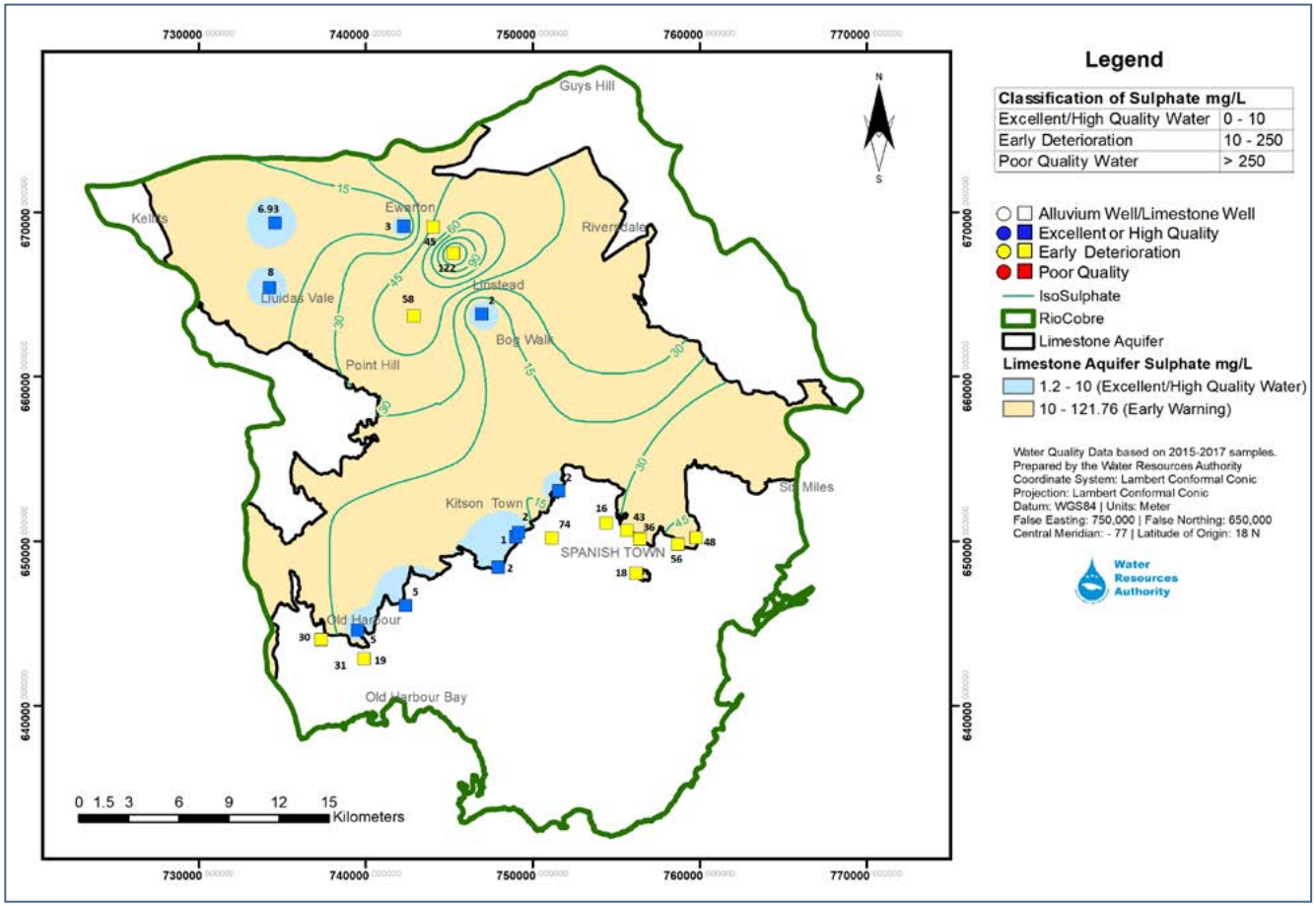


Figure 46: Rio Cobre Hydrologic Basin Spatial Interpolation of the Sulphate Levels in the Limestone Aquifer

Figure 46 indicates the spatial interpolation of the water quality results for the sulphate within the limestone aquifer of the Rio Cobre basin. Based on the interpolated results the basin quality predominantly indicated early deterioration water quality for sulphate, with levels in excess of the National Ambient Water Quality Standard of 10mg/L. The spatial interpolation of the data indicated pockets of excellent water quality throughout the basin primarily at the south western section of the basin. The highest concentration of sulphate is observed at the Pleasant Farm Jericho well.

Rio Cobre Hydrologic Basin TDS Levels in Groundwater

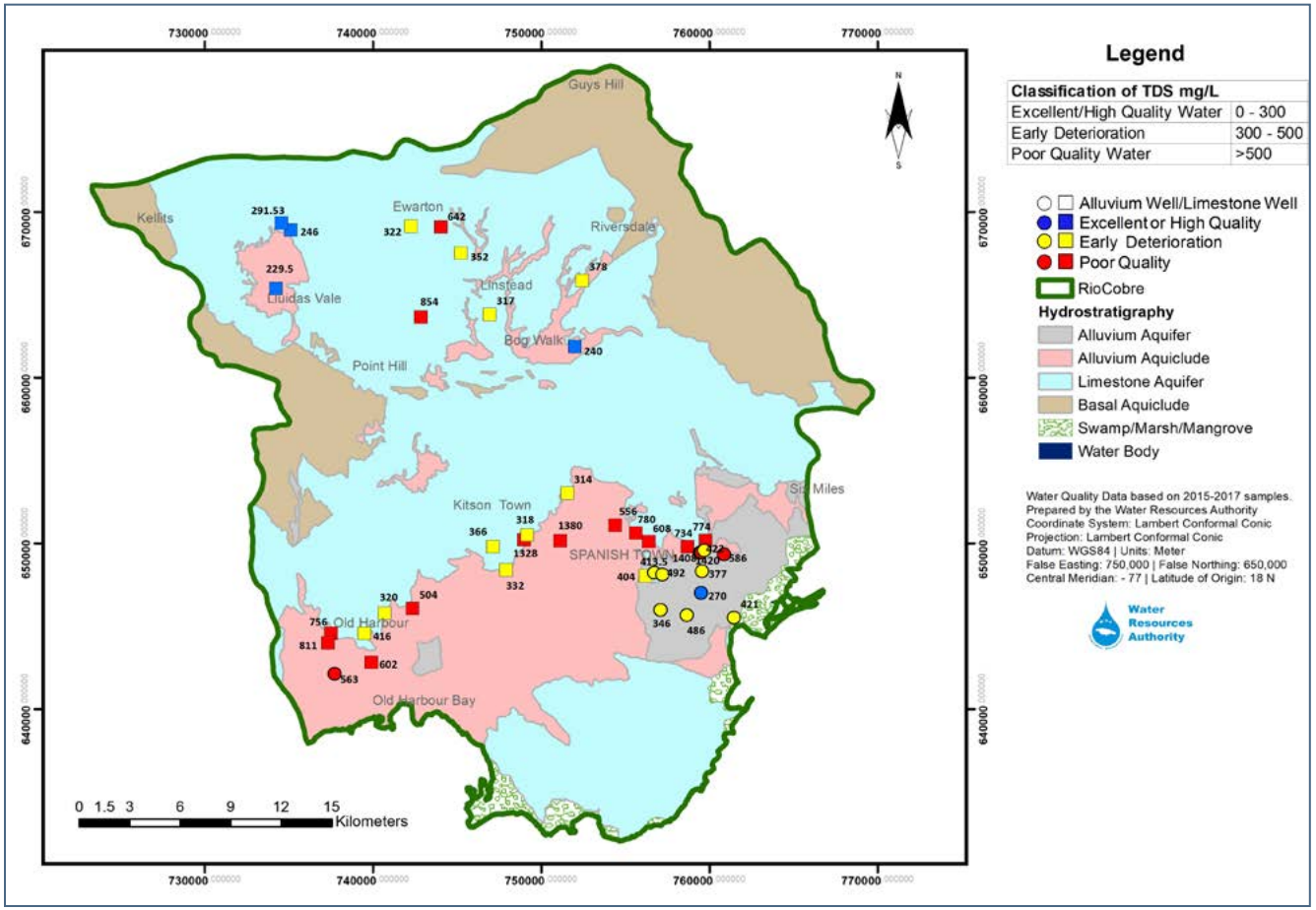
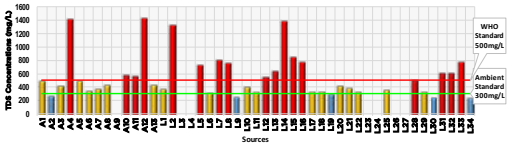


Figure 47: Rio Cobre Hydrologic Basin TDS Levels in Groundwater

RIO COBRE HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 25: Rio Cobre Basin TDS Levels in Groundwater

As shown in Figure 47 and Graph 25, the well sources within the Rio Cobre basin predominantly indicated early deterioration for sodium. Forty three percent (43%) of the well sources sampled indicated TDS level in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Eleven percent (11%) of source sampled indicated excellent water quality and thirty six percent (36%) indicated poor water quality.

Rio Cobre Hydrologic Basin TDS Levels in the Limestone Aquifer

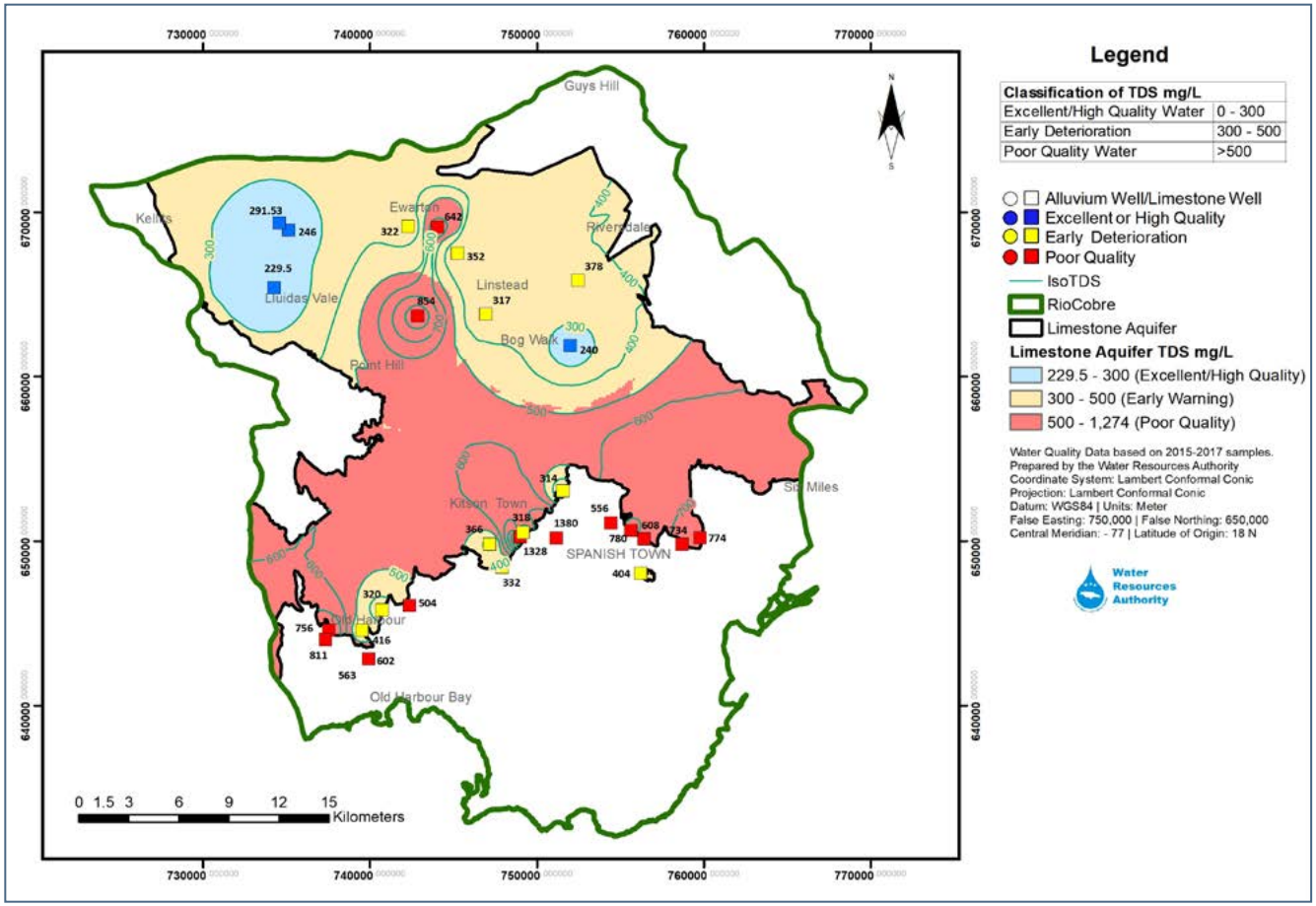


Figure 48: Rio Cobre Hydrologic Basin Spatial Interpolation of the TDS Levels in the Limestone Aquifer

Figure 48 indicates the spatial interpolation of the water quality results for the TDS within the limestone aquifer of the Rio Cobre basin. Based on the interpolated results the basin quality predominantly indicated poor water quality for TDS, with levels in excess of the USEPA standard.

Fifty percent (50%) of the aquifer indicated poor water quality, forty-five percent (45%) indicated early deterioration and five percent (5%) indicated excellent water quality.

The spatial interpolation of the data indicated poor water quality concentrated in the southern half of the basin. The northern sections indicated early deterioration with pockets of excellent water quality observed in the north western and eastern central sections of the basin.

Rio Cobre Hydrologic Basin Alluvium Aquifer Water Quality

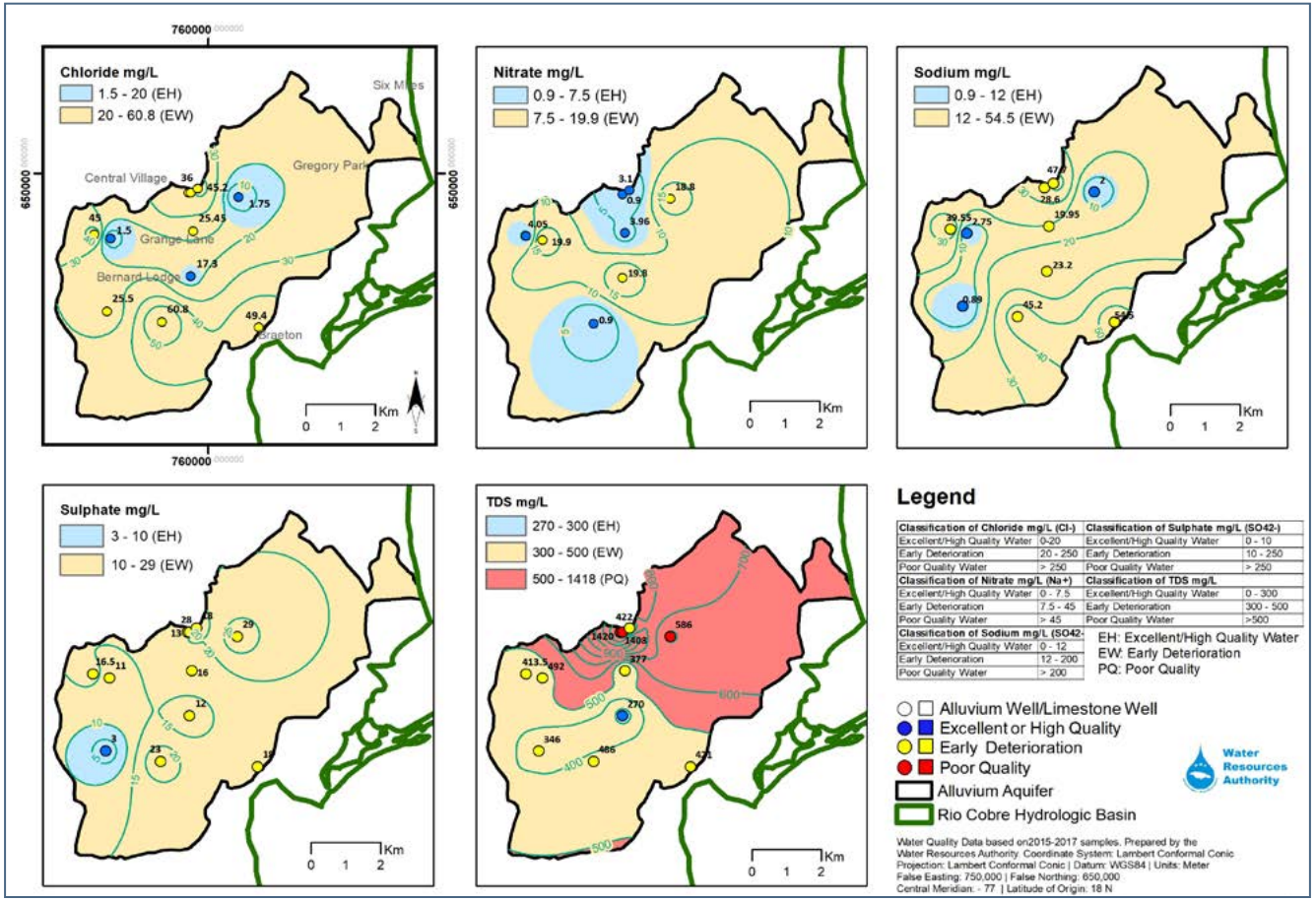


Figure 49: Rio Cobre Hydrologic Basin Spatial Interpolation of the Nitrate, Sodium, Chloride, Sulphate and TDS Levels in the Alluvium Aquifer

Figure 49 indicates the spatial interpolation of data for wells in the Alluvium aquifer of the Rio Cobre Basin. The alluvium well sources within the Rio Cobre Alluvium Aquifer predominantly indicated early deterioration with pockets of excellent water quality for all five parameters: nitrate, sodium, chloride, sulphate and TDS.

The well sources indicated fifty percent poor water poor quality for TDS.

Rio Cobre Hydrologic Basin Surface Water Sample Locations

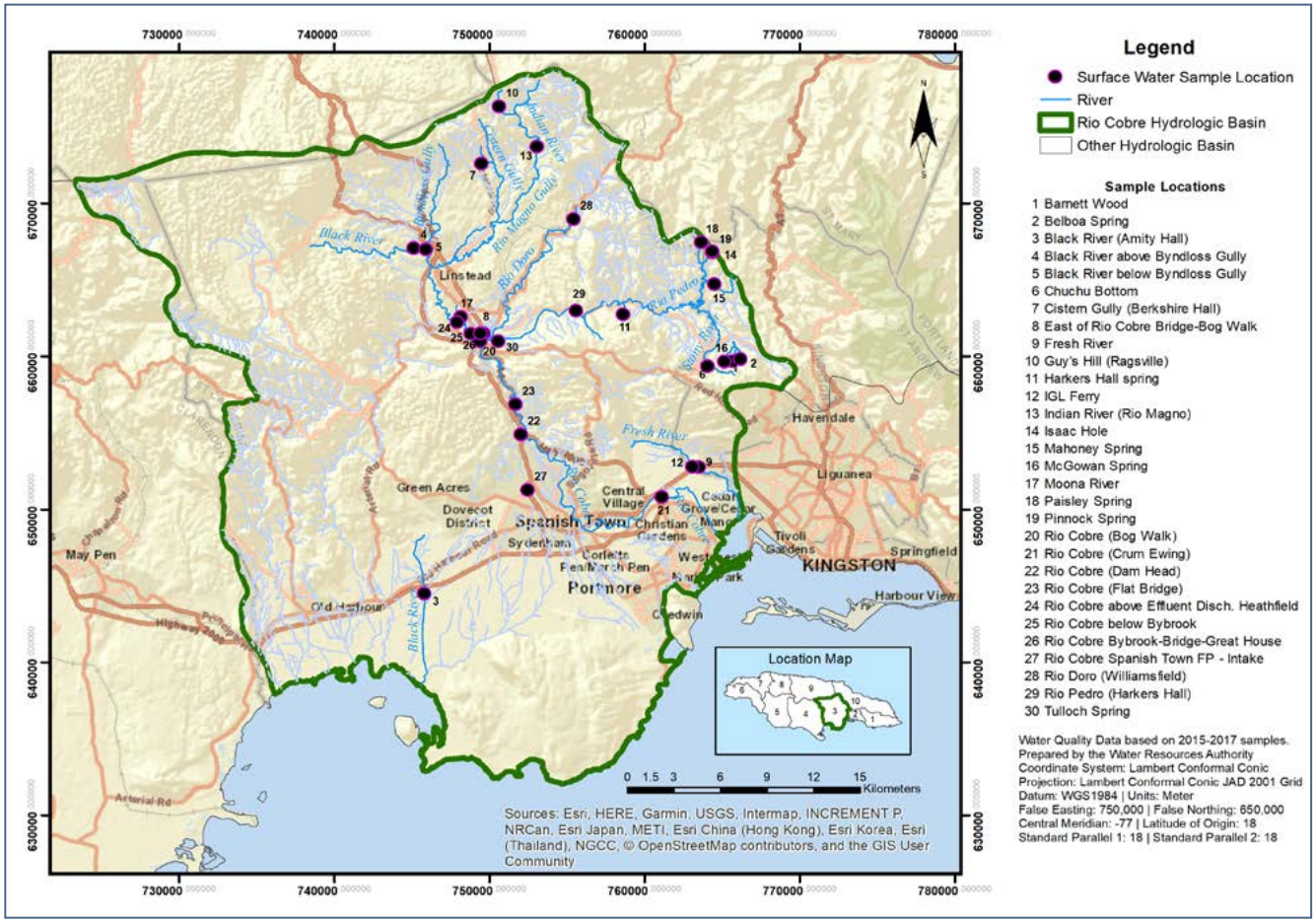


Figure 50: Rio Cobre Hydrologic Basin Surface water Sample Locations

Figure 50 indicates the location of the thirty (30) surface water sampling points utilized in the surface water analyses for the Rio Cobre Basin.

Rio Cobre Hydrologic Basin Nitrate Levels in Surface Water

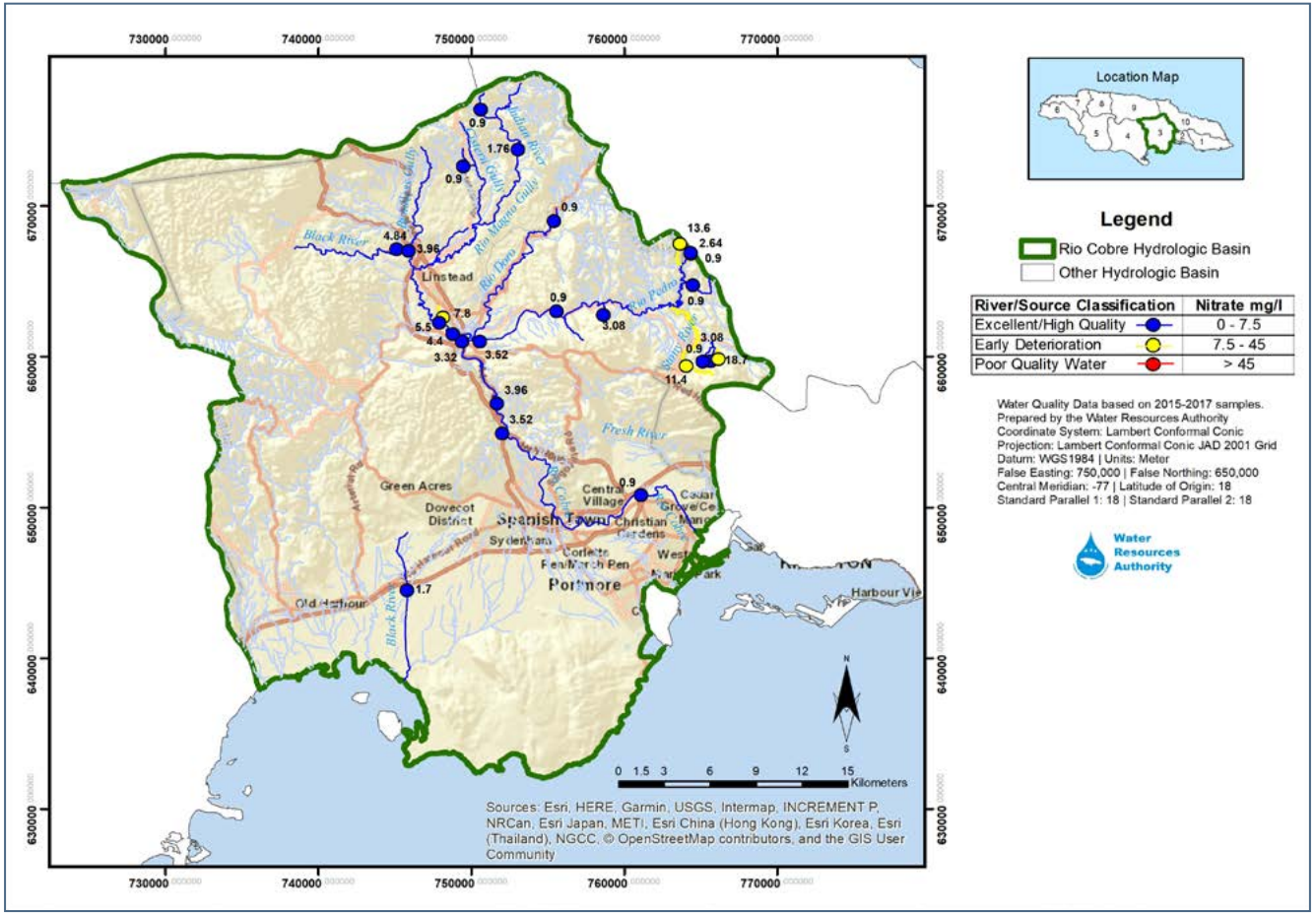
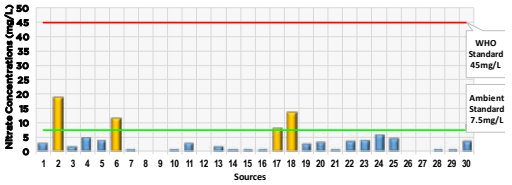


Figure 51: Rio Cobre Hydrologic Basin Nitrate Levels in Surface Water

RIO COBRE HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 26: Rio Cobre Basin Nitrate Levels in Surface water

The surface water sources within the Rio Cobre basin predominantly indicated excellent water quality for nitrate as shown in Figure 51 and Graph 26. Eighty-seven percent (87%) of the sources sampled indicated excellent water quality whilst thirteen percent (13%) of the surface water sources sampled indicated sodium level in excess of the National Ambient Water Quality Standard of 7.5mg/L.

Rio Cobre Hydrologic Basin Sodium Levels in Surface Water

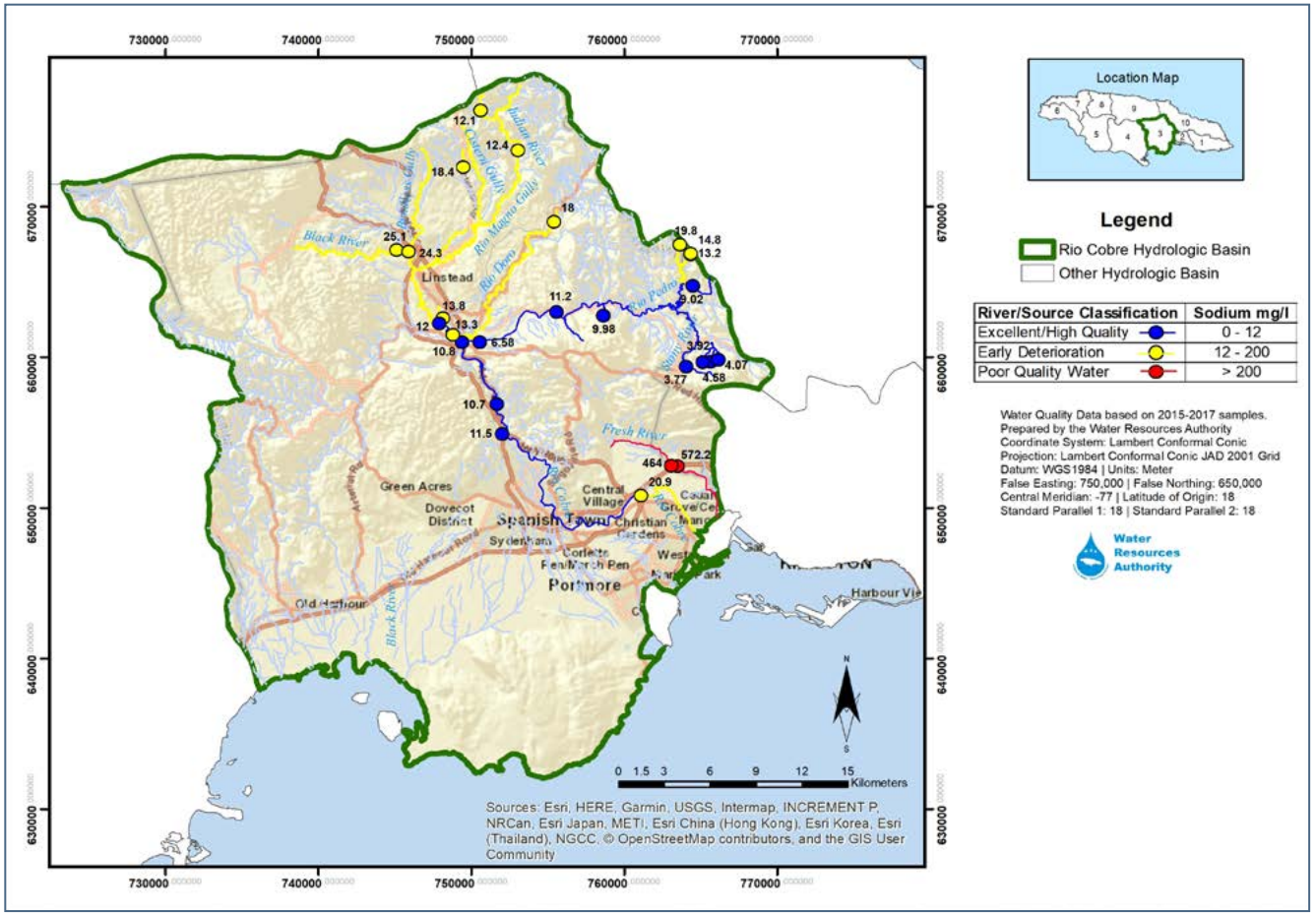
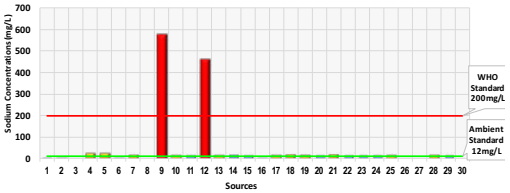


Figure 52: Rio Cobre Hydrologic Basin Sodium Levels in Surface Water

RIO COBRE HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 27: Rio Cobre Basin Sodium Levels in Surface water

As indicated in Figure 52 and Graph 27, the surface water sources within the Rio Cobre basin predominantly indicated early deterioration for sodium. Thirty-seven percent (37%) of the surface water sources sampled indicated sodium level in excess of the National Ambient Water Quality Standard of 12mg/L. Forty-four percent (44%) of the sources sampled indicated excellent water quality and seven percent (7%) indicated poor water quality.

Rio Cobre Hydrologic Basin Chloride Levels in Surface Water

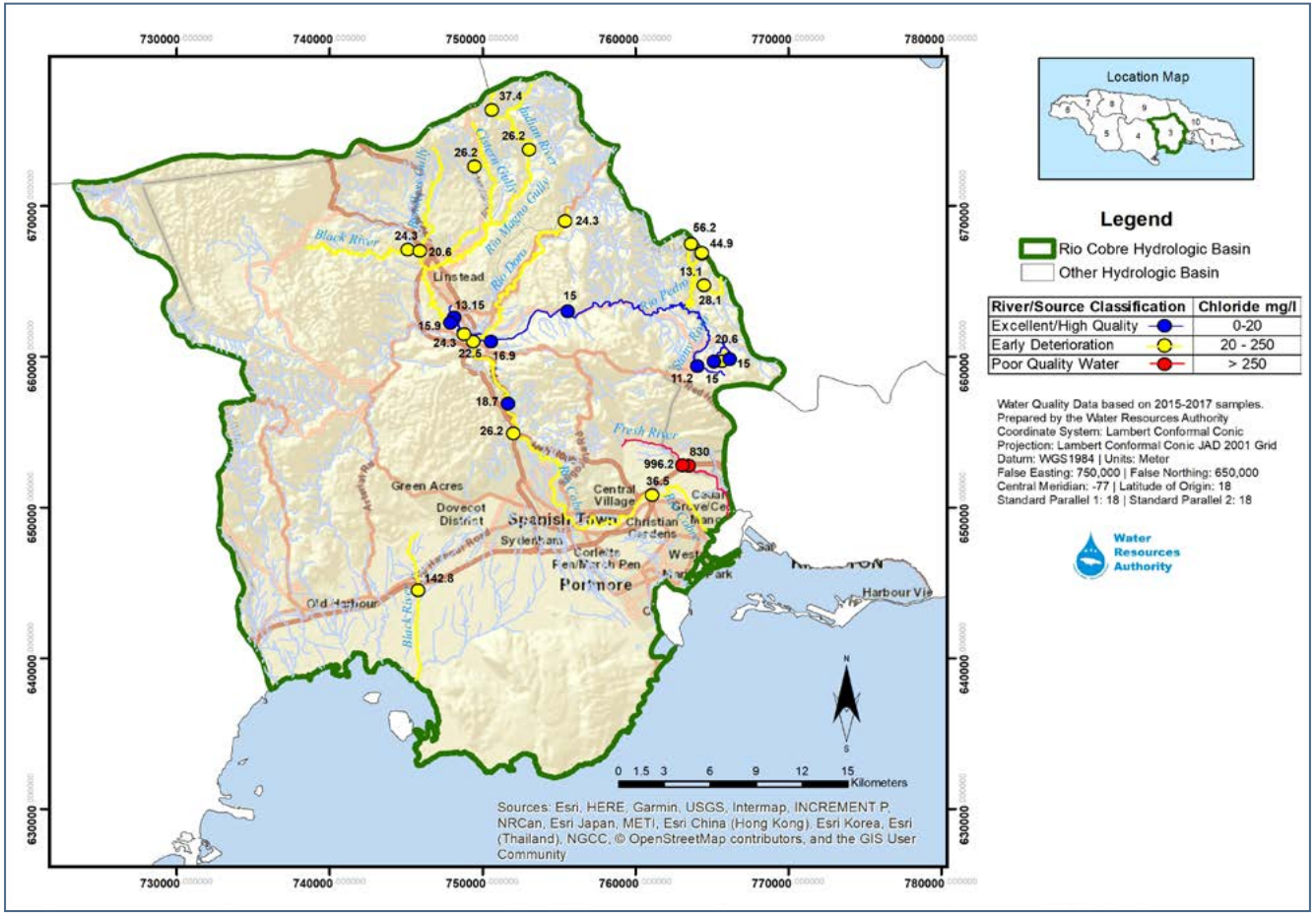
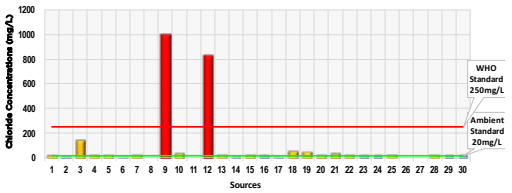


Figure 53: Rio Cobre Hydrologic Basin Chloride Levels in Surface Water

RIO COBRE HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 28: Rio Cobre Basin Chloride Levels in Surface water

As shown in Figure 53 and Graph 28, the surface water sources within the Rio Cobre basin predominantly indicated early deterioration for chloride. Fifty percent (50%) of the surface water sources sampled indicated chloride level in excess of the National Ambient Water Quality Standard of 20mg/L. Forty-three percent (43%) of the source sampled indicated excellent water quality and seven percent (7%) indicated poor water quality. The two sources indicating poor quality are IGL Ferry and Fresh River.

Rio Cobre Hydrologic Basin Sulphate Levels in Surface Water

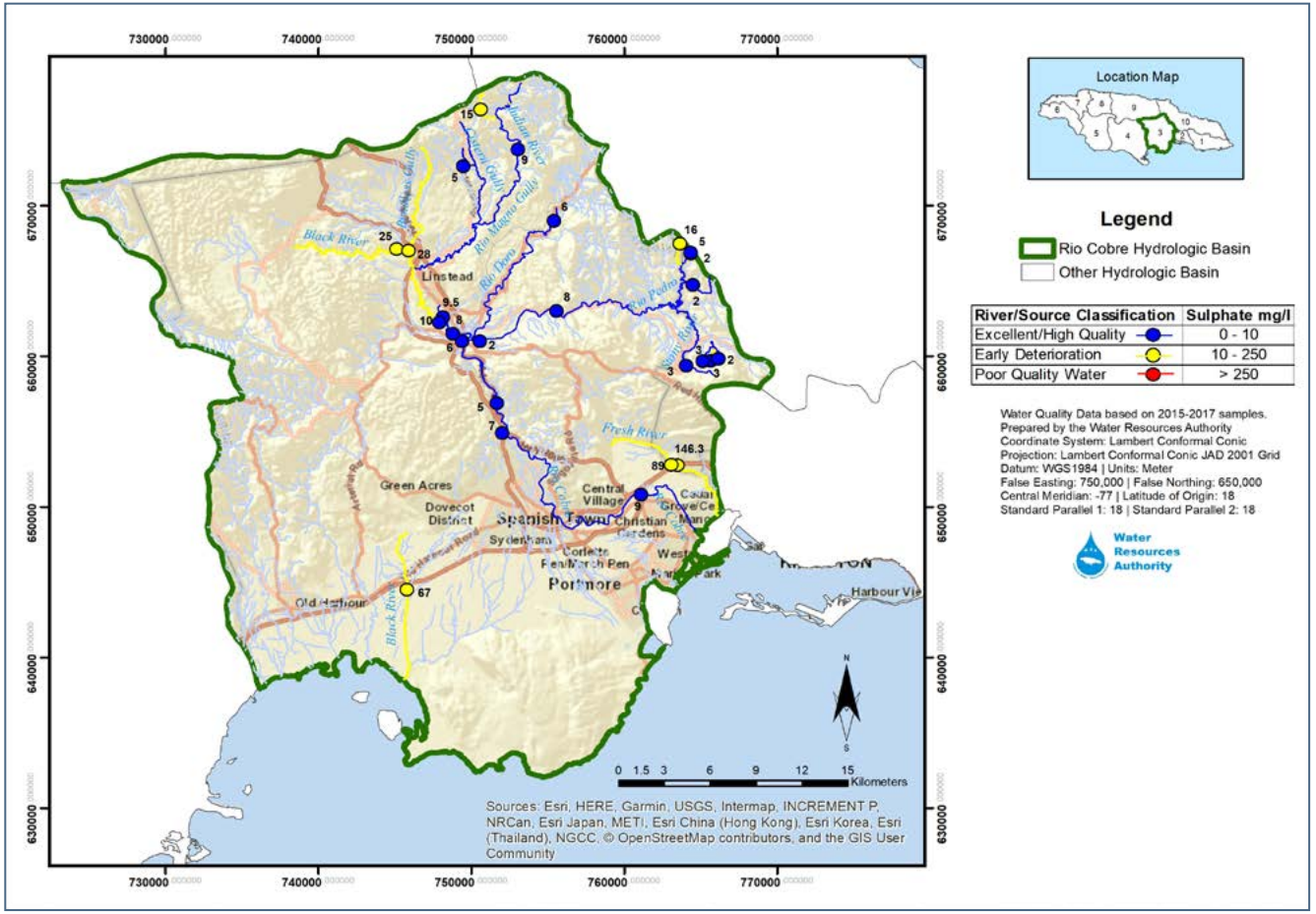
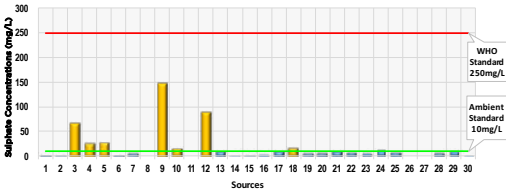


Figure 54: Rio Cobre Hydrologic Basin Sulphate Levels in Surface Water

RIO COBRE HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 29: Rio Cobre Basin Sulphate Levels in Surface water

As indicated in Figure 54 and Graph 29, the surface water sources within the Rio Cobre basin predominantly indicated excellent water quality for sulphate. Seventy-seven percent (77%) of the surface water sources sampled indicated sulphate level within the National Ambient Water Quality Standard of 10mg/L. Thirty-three percent (33%) of the source sampled indicated water quality for sulphate in excess of the National Ambient Water Quality Standard of 10mg/L

Rio Cobre Hydrologic Basin TDS Levels in Surface Water

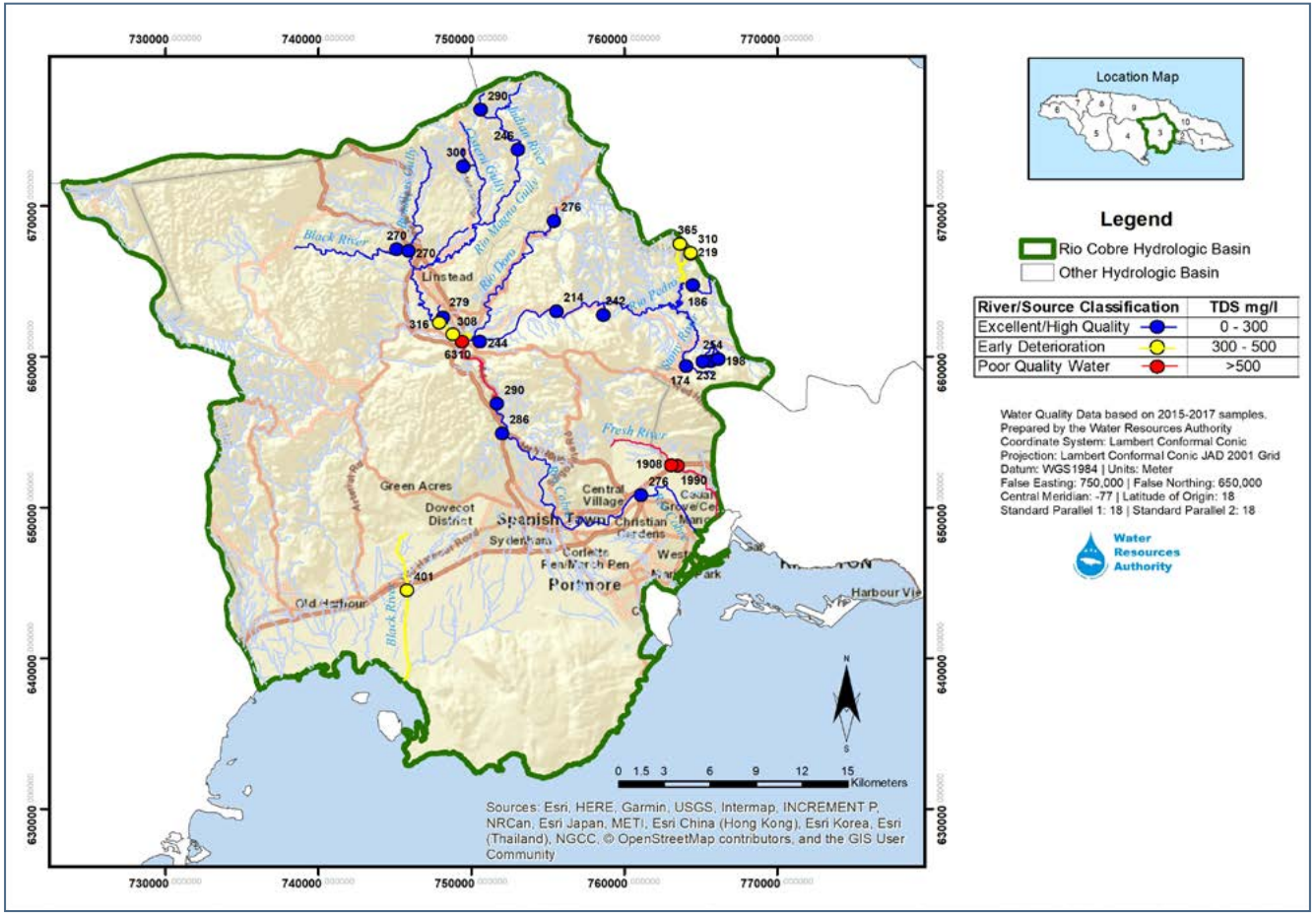
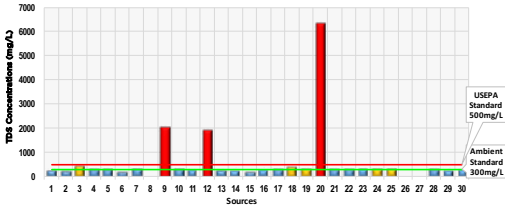


Figure 55: Rio Cobre Hydrologic Basin TDS Levels in Surface Water

RIO COBRE HYDROLOGIC BASIN TOTAL DISSOLVED SOLID LEVELS IN SURFACE WATER



Graph 30: Rio Cobre Basin TDS Levels in Surface water

As shown in Figure 55 and Graph 30, the surface water sources within the Rio Cobre basin predominantly indicated excellent water quality for TDS. Seventy-three percent (73%) of the surface water sources sampled indicated TDS levels within the National Ambient Water Quality Standard of 300mg/L. Seventeen percent (17%) of the sources samples indicated water quality in excess of the National Ambient Water Quality Standard of 300mg/L. The sources indicating poor quality for TDS are Rio Cobre (Bog Walk), IGL Ferry and Ferry River.

4.0 Basin IV Rio Minho Hydrologic Basin

The Rio Minho Hydrologic Basin spans the expanse of Clarendon, Manchester and the western area of St Catherine. The Rio Minho Basin is divided into seven (7) sub-basins for water management purposes and because of its Hydrologic and topographical characteristics. These sub - basins are Upper Rio Minho, Lower Rio Minho, Milk River, Alligator Hole, Portland Ridge, Cockpit Springs and Bowers River.

The most northern regions of the basin are comprised of primarily cretaceous volcanic and are superimposed by younger yellow limestone rocks. Centrally, the basin is comprised of white limestone which takes up the largest portions of the basin. The southern regions are made of alluvial deposits underlain by white limestone with white limestone outcrops. The white limestone underlies the whole of the Clarendon plains and crops out in the Manchester Highlands to the west, the Mocho Mountains to the north and the Harris Savanna and Brazille to Mountains to the east. These areas account for most of the recharge to the aquifer (WRA 1974, Development and Management of Water Resources Jamaica Rio Minho – Milk River Basin).

The southern alluvial deposits form one of the major plains in the island, known as Vere Plains, and the entire basin is drained for the most part by two major rivers, Rio Minho to the east and Milk River to the west.

The groundwater quality was analysed with the results from thirty - two (32) wells (8 alluvium and 28 limestone) and the surface water was done utilizing twenty two (22) sources.

Rio Minho Hydrologic Basin Groundwater Sample Locations

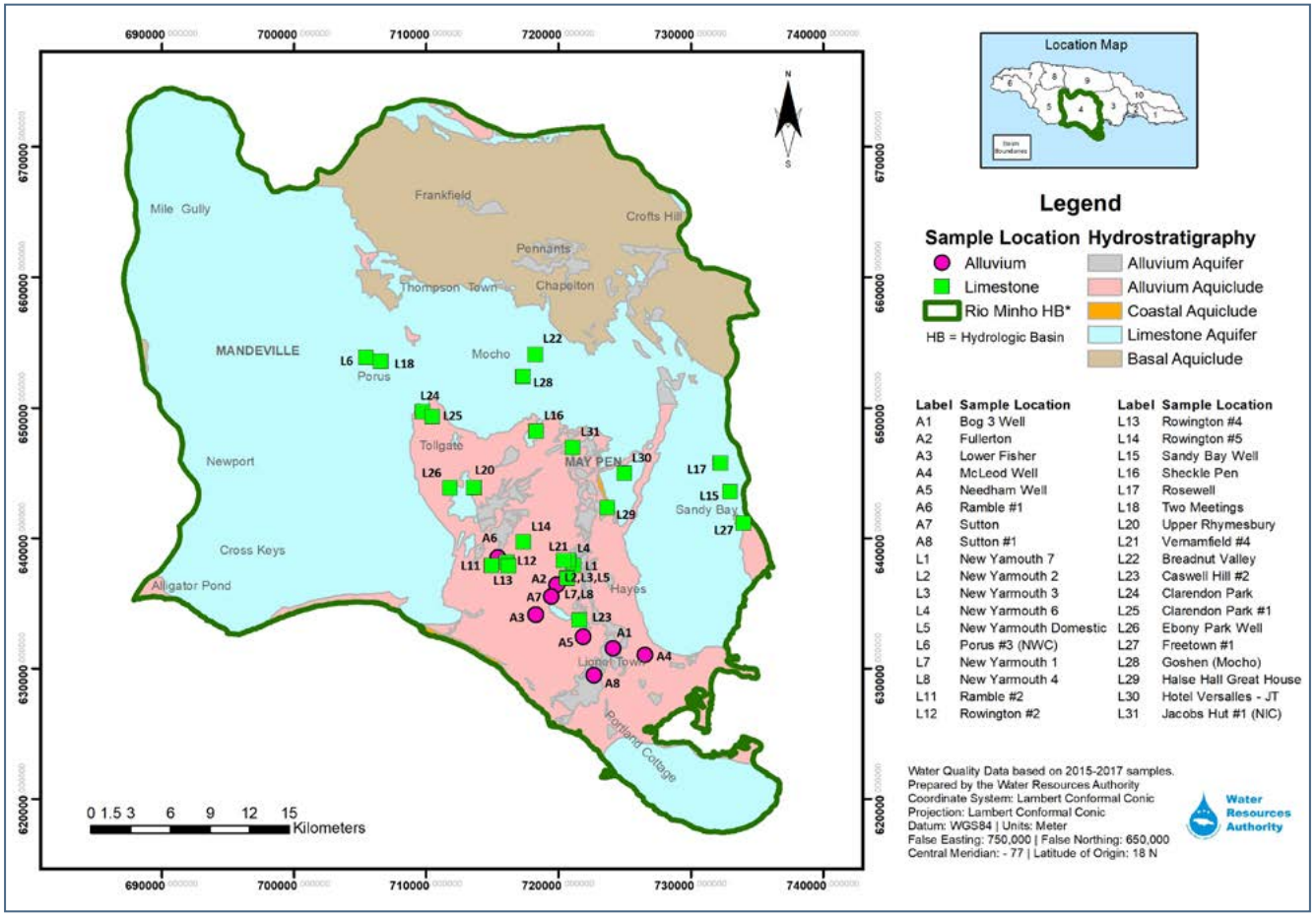


Figure 56: Rio Minho Hydrologic Basin Groundwater Sample Locations

Figure 56 shows the location of the thirty-six (36) ground water sampling points. Eight (8) of the sources are classified as alluvium wells and twenty-eight (28) limestone wells.

Rio Minho Hydrologic Basin Nitrate Levels in Groundwater

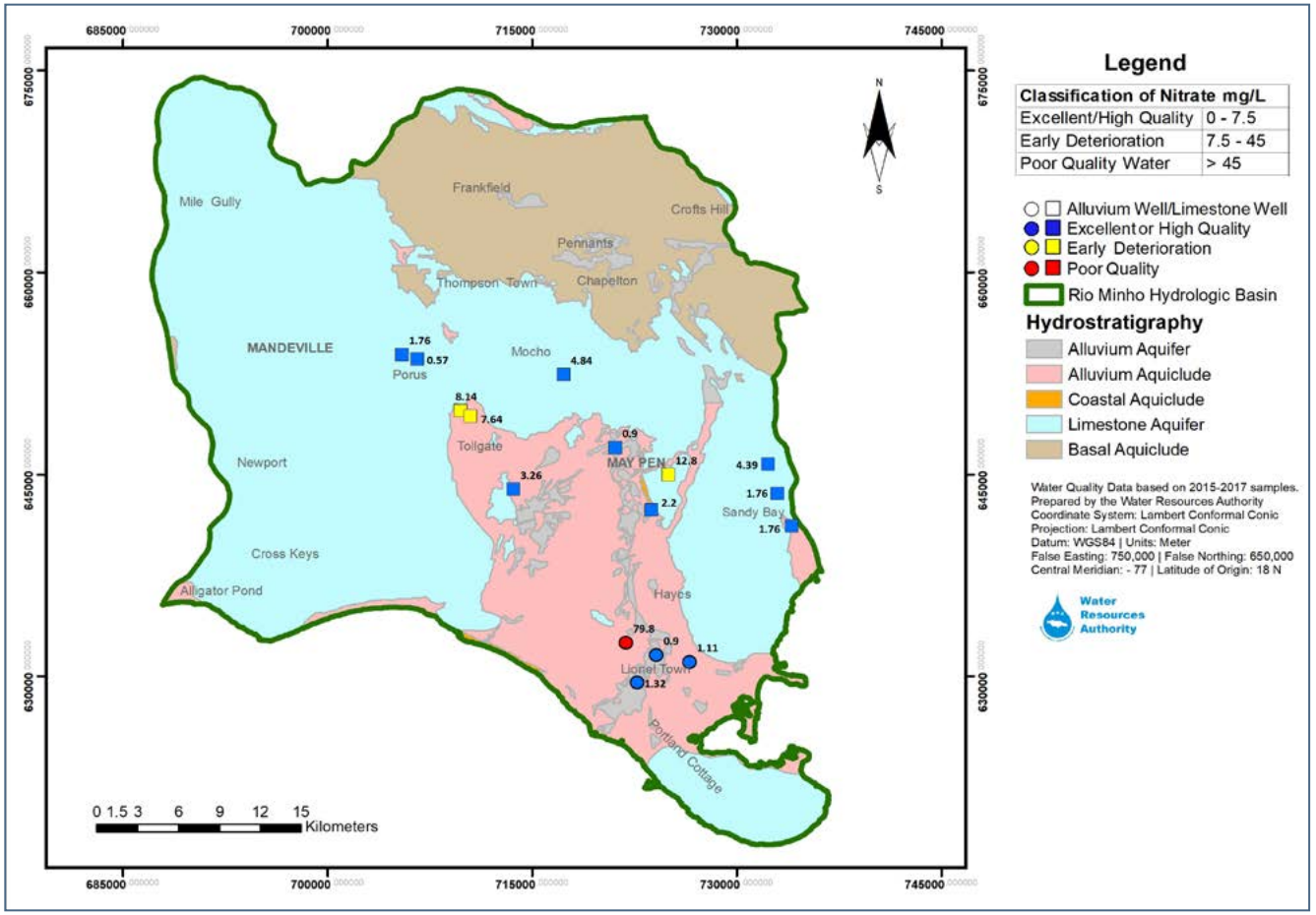
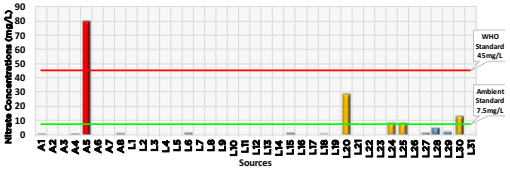


Figure 57: Rio Minho Hydrologic Basin Nitrate Levels in Groundwater

RIO MINHO HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 31: Rio Minho Basin Nitrate Levels in Groundwater

The well sources within the Rio Minho basin predominantly indicated excellent water quality for nitrate as shown in Figure 57 and Graph 31. Thirty-one percent (31%)of the sources sampled indicated nitrate levels within the National Ambient Water Quality Standard of 7.5mg/L. Five percent (5%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 12mg/L, Three percent (3%) of the sources indicated poor water quality for nitrate.

Rio Minho Hydrologic Basin Nitrate Levels in the Limestone Aquifer

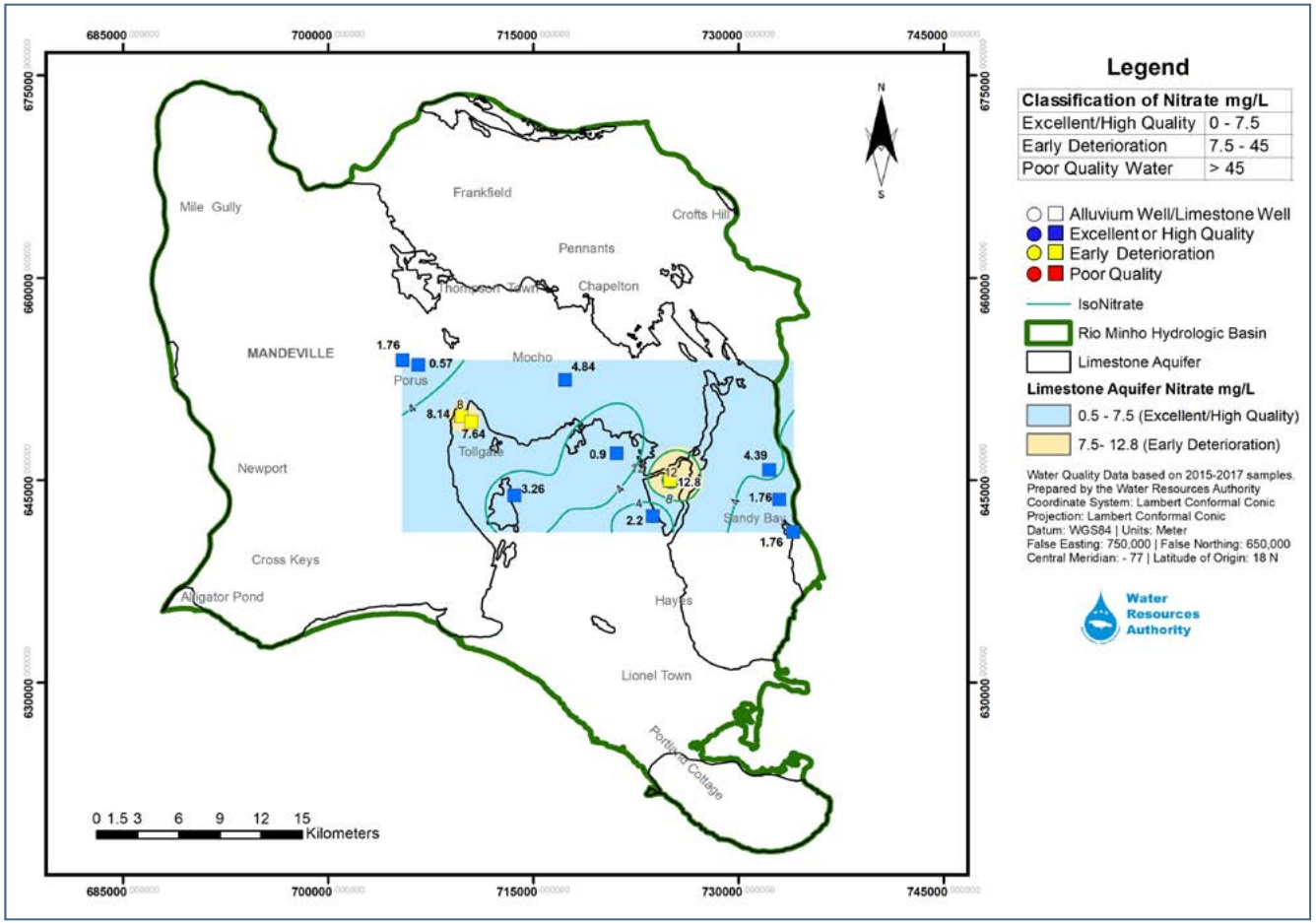


Figure 58: Rio Minho Hydrologic Basin Spatial Interpolation of the Nitrate Levels in the Limestone Aquifer

Figure 58 indicates the spatial interpolation of the water quality results for Nitrate in the Rio Minho Basin limestone aquifer. Based on the interpolated results the basin quality predominantly indicated excellent water quality for nitrate, with levels within the National Ambient Water Quality Standard of 7.5mg/L. The spatial interpolation of the data indicated two pockets of early deterioration water quality primarily within the central sections of the basin.

Rio Minho Hydrologic Basin Sodium Levels in Groundwater

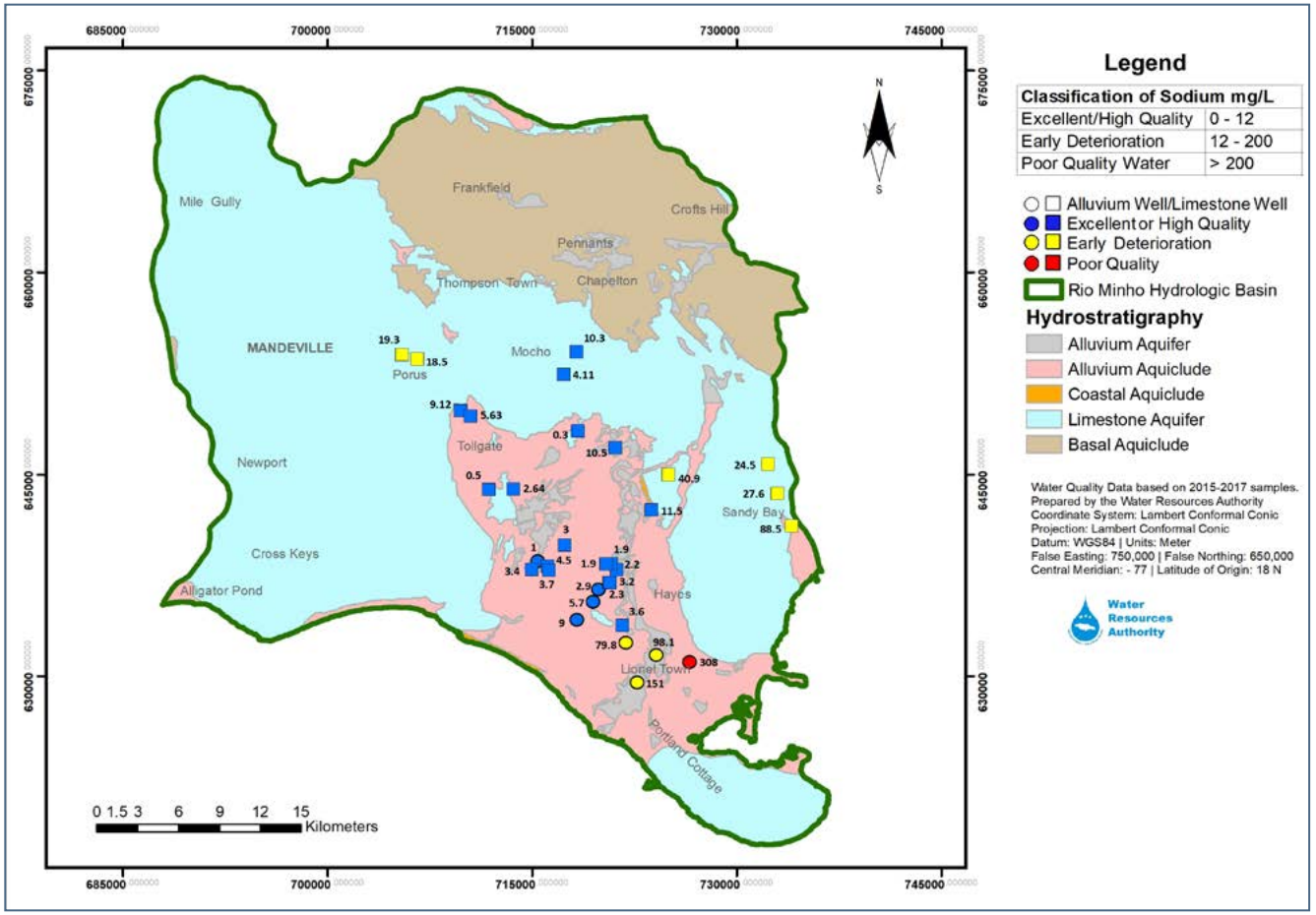
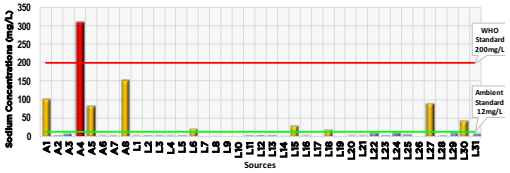


Figure 59: Rio Minho Hydrologic Basin Sodium Levels in Groundwater

RIO MINHO HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 32: Rio Minho Basin Sodium Levels in Groundwater

The well sources within the Rio Minho basin predominantly indicated excellent water quality for sodium as shown in Figure 59 and Graph 32. Fifty-nine percent (59%) of the groundwater sources sampled indicated sodium levels within the National Ambient Water Quality Standard of 12mg/L. Twenty-three percent (23%) of the sources indicated sodium in excess of the National Ambient Water Quality Standard of 12mg/L. Three percent (3%) of the sources sampled indicated poor water.

Rio Minho Hydrologic Basin Sodium Levels in the Limestone Aquifer

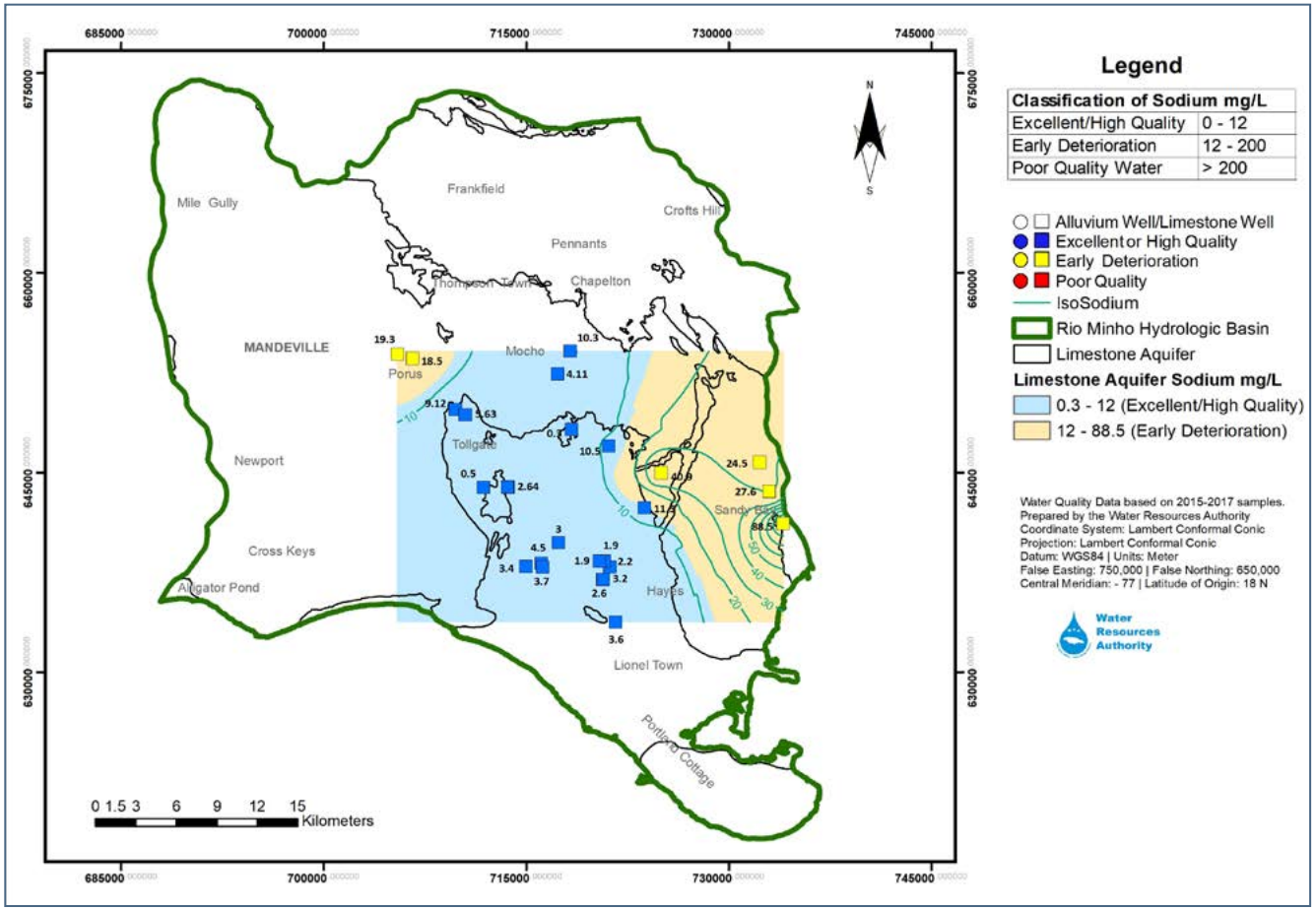


Figure 60: Rio Minho Hydrologic Basin Spatial Interpolation of the Sodium Levels in the Limestone Aquifer

Figure 60 indicates the spatial interpolation of the water quality results for Sodium in the Rio Minho Basin limestone aquifer. Based on the interpolated results the basin quality predominantly indicated excellent water quality for sodium, with levels within the National Ambient Water Quality Standard of 12mg/L. Approximately eighty percent (80%) of the basin indicated excellent water quality for sodium. The spatial interpolation of the data indicated pockets of early deterioration water quality in the north western and eastern sections of the basin.

Rio Minho Hydrologic Basin Chloride Levels in Groundwater

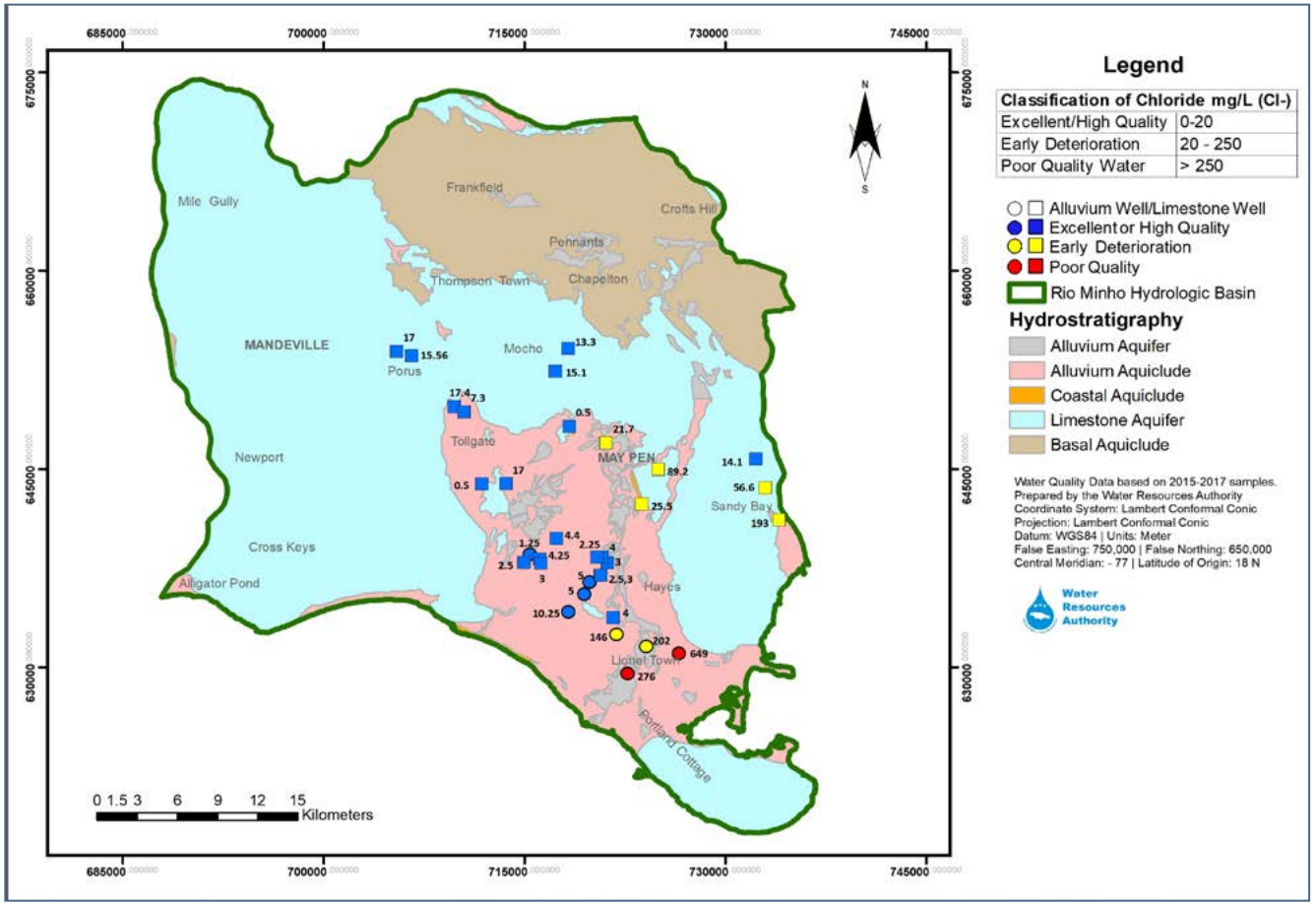
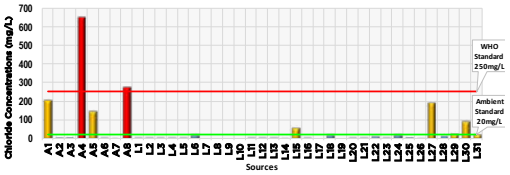


Figure 61: Rio Minho Hydrologic Basin Chloride Levels in Groundwater

RIO MINHO HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 33: Rio Minho Basin Chloride Levels in Groundwater

The well sources within the Rio Cobre basin predominantly indicated excellent water quality for sodium as shown in Figure 61 and Graph 33. Fifty nine percent of the groundwater sources sampled indicated sodium levels within the National Ambient Water Quality Standard of 20mg/L. Eighteen (18%) percent of the sources indicated sodium in excess of the National Ambient Water Quality Standard of 20mg/L. Whilst six percent (6%) of the source sampled indicated poor water quality.

Rio Minho Hydrologic Basin Chloride Levels in the Limestone Aquifer

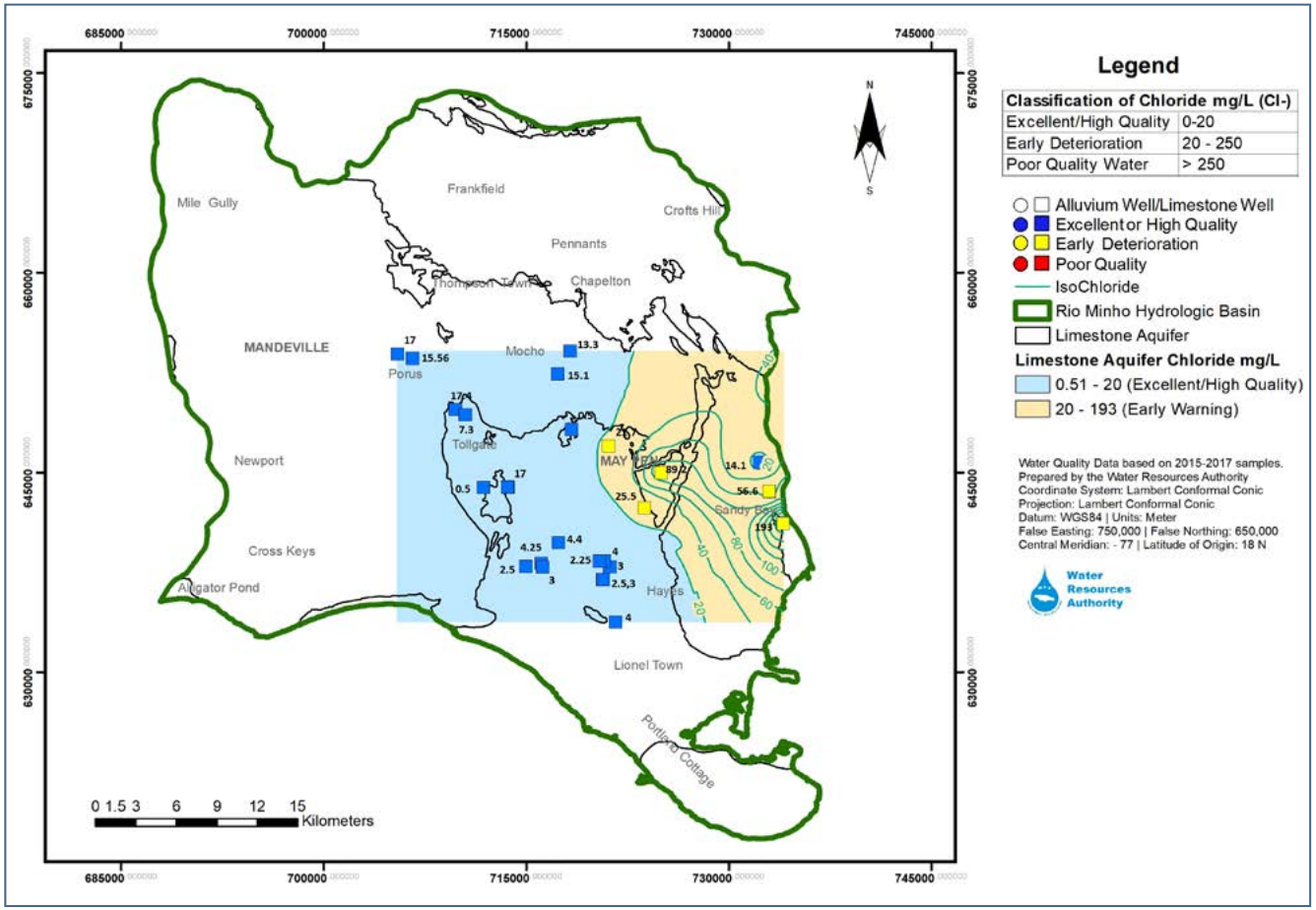


Figure 62: Rio Minho Hydrologic Basin Spatial Interpolation of the Chloride Levels in the Limestone Aquifer

Figure 62 indicates the spatial interpolation of the water quality results for Chloride in the Rio Minho Basin limestone aquifer. Based on the interpolated results the basin quality predominantly indicated excellent water quality for chloride, with levels within the National Ambient Water Quality Standard of 20mg/L. Approximately seventy percent (70%) of the basin indicated excellent water quality for chloride. The spatial interpolation of the data indicated early deterioration water quality in the eastern section of the basin east of May Pen.

Rio Minho Hydrologic Basin Sulphate Levels in Groundwater

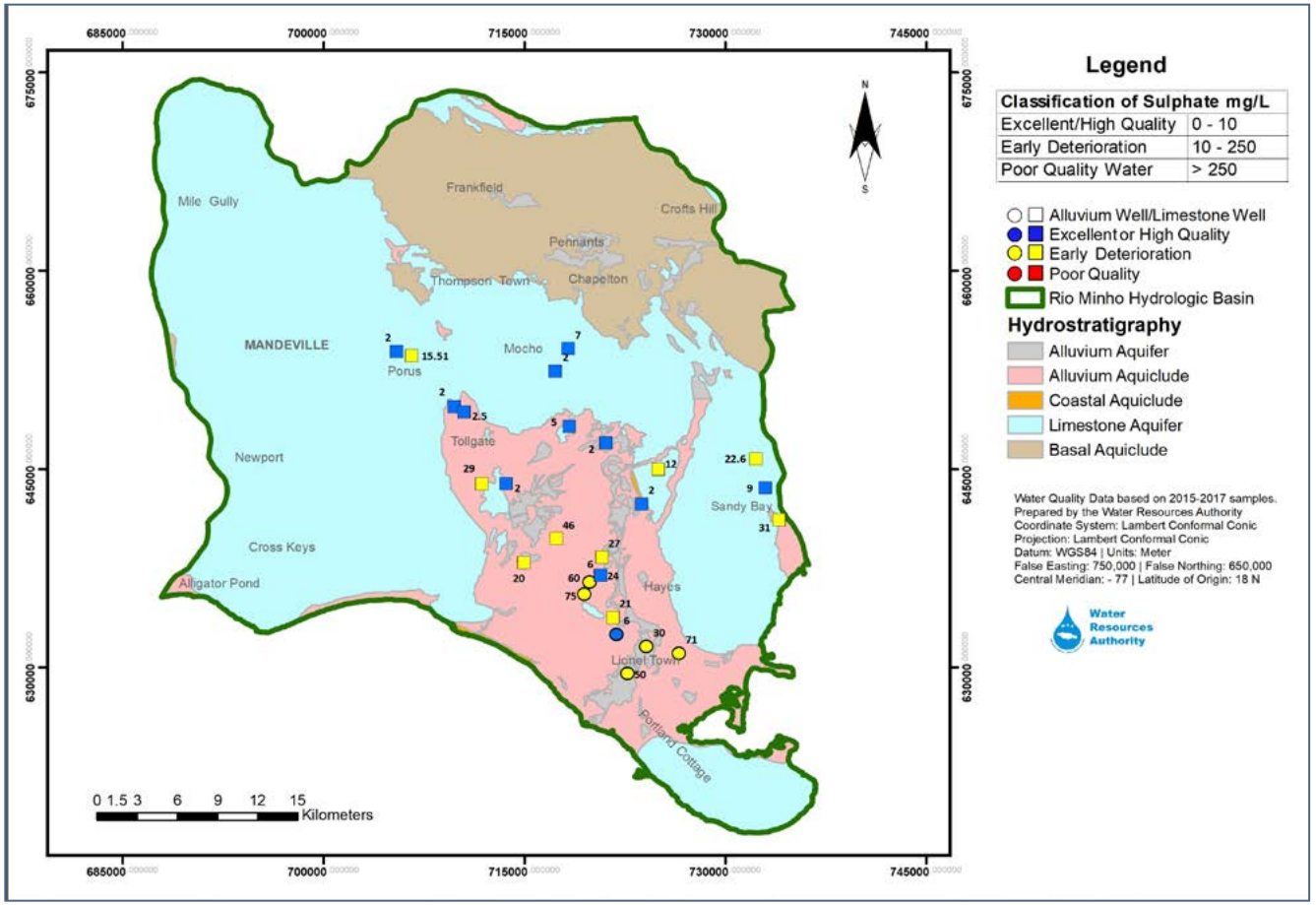
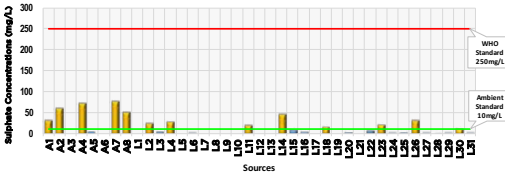


Figure 63: Rio Minho Hydrologic Basin Sulphate Levels in Groundwater

RIO MINHO HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 34: Rio Minho Basin Sulphate Levels in Groundwater

The well sources within the Rio Minho basin predominantly indicated early deterioration for sulphate. Thirty-six percent (36%) the wells sampled indicated sodium level in excess of the National Ambient Water Quality Standard of 10mg/L. Thirty-one percent (31%) of the sources indicated excellent water quality.

Rio Minho Hydrologic Basin Sulphate Levels in the Limestone Aquifer

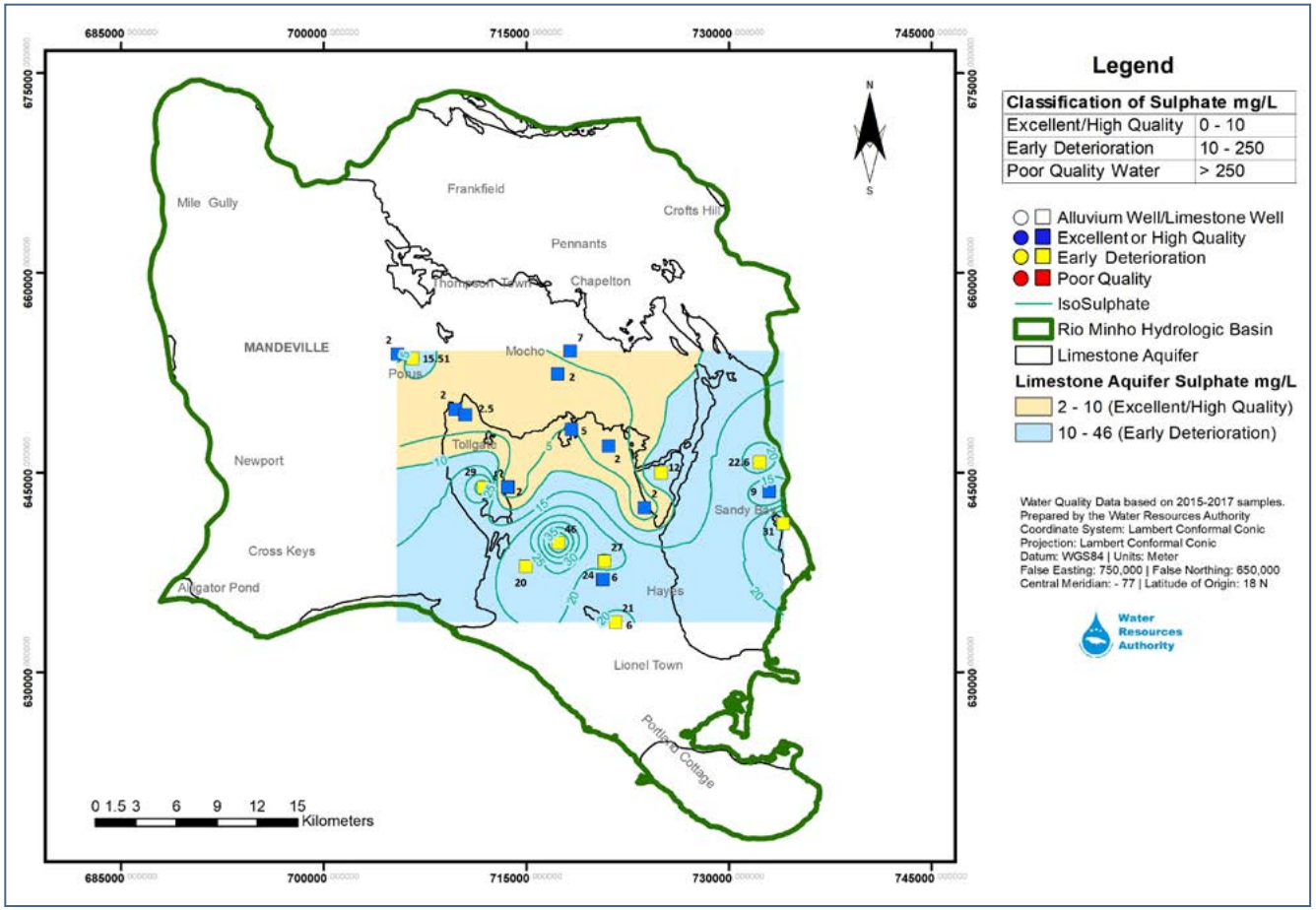


Figure 64: Rio Minho Hydrologic Basin Spatial Interpolation of the Sulphate Levels in the Limestone Aquifer

Figure 64 indicates the spatial interpolation of the water quality results for Sulphate in the Rio Minho Basin limestone aquifer. Based on the interpolated results the basin quality predominantly indicated early deterioration water quality for sulphate, with levels in excess of the National Ambient Water Quality Standard of 10mg/L. The spatial interpolation of the data indicated excellent water quality was within the southern section of the interpolated zone and early deterioration quality within the northern section of the interpolated area.

Rio Minho Hydrologic Basin TDS Levels in Groundwater

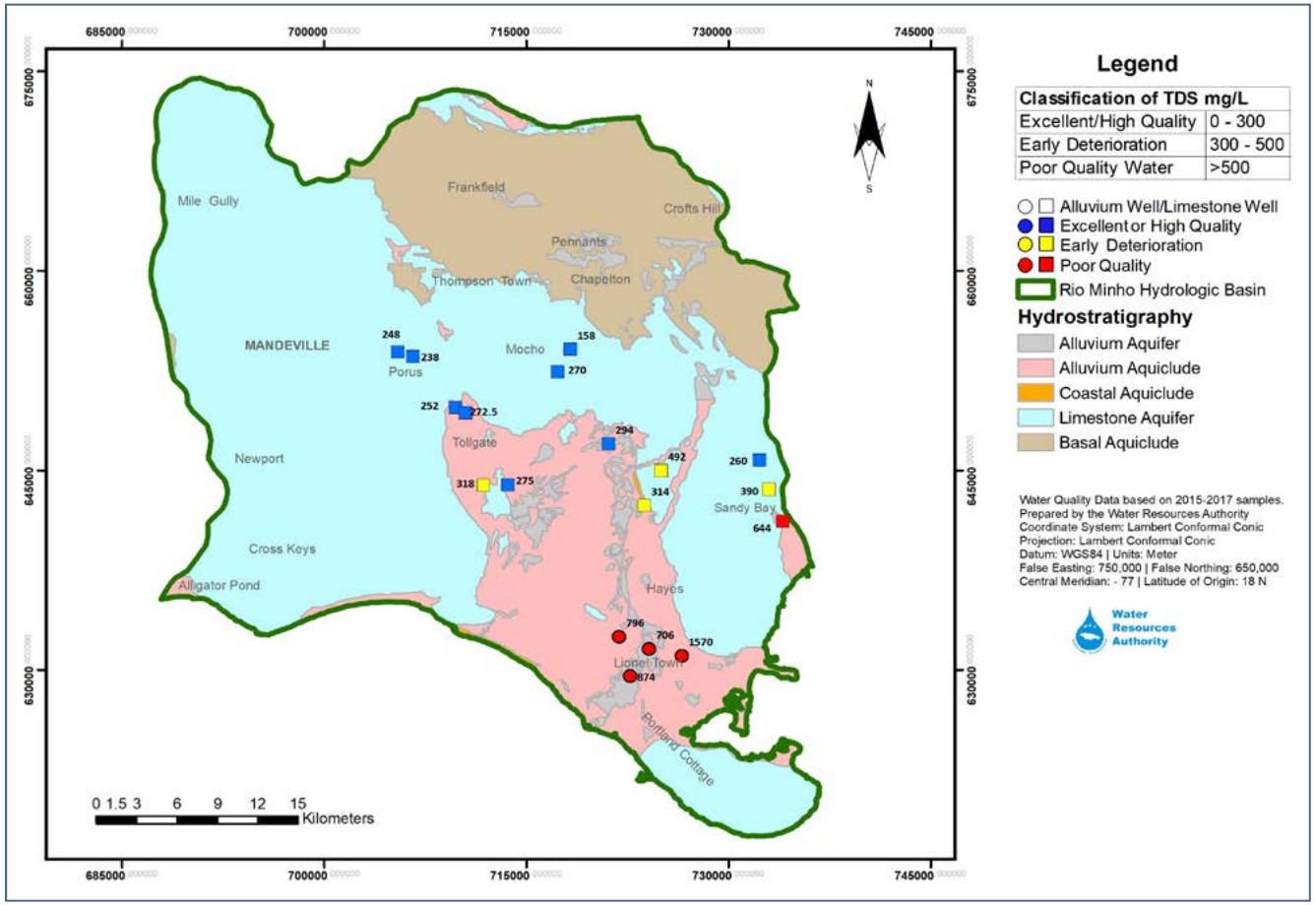
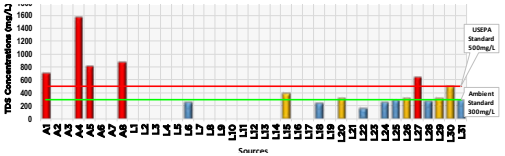


Figure 65: Rio Minho Hydrologic Basin TDS Levels in Groundwater

RIO MINHO HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 35: Rio Minho Basin TDS Levels in Groundwater

As indicated in Figure 65 and Graph 35, the well sources within the Rio Minho basin predominantly indicated excellent water quality for TDS. Twenty-three percent (23%)of the well sources sampled indicated TDS level within the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Ten percent (10%) of the source sampled indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard excellent water quality and thirteen percent (13%) indicated poor water quality.

Rio Minho Hydrologic Basin TDS Levels in the Limestone Aquifer

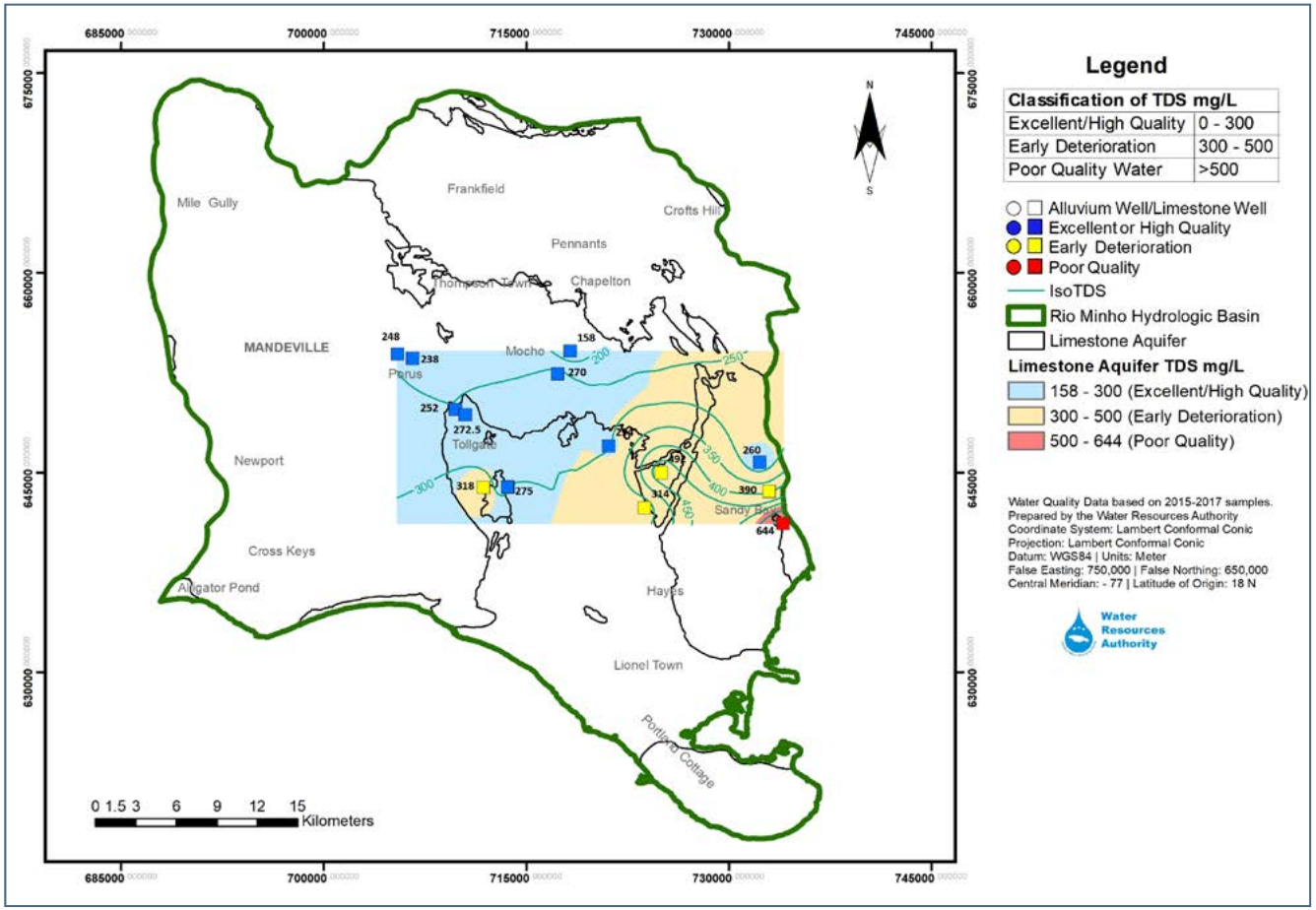


Figure 66: Rio Minho Hydrologic Basin Spatial Interpolation of the TDS Levels in the Limestone Aquifer

The spatial interpolation of the water quality results for TDS in the Rio Minho Basin limestone aquifer is indicated in Figure 66. Based on the interpolated results, the water quality predominantly indicated both excellent and early deterioration water quality for TDS.

Fifty percent (50%) of the interpolated zone (western section) indicated excellent water quality and remaining forty-eight percent (48%) indicated early deterioration (eastern section) of the interpolated area. The remaining two percent (2%) of the wells in the limestone aquifer indicated poor water quality for TDS.

Rio Minho Hydrologic Basin Surface Water Sample Locations

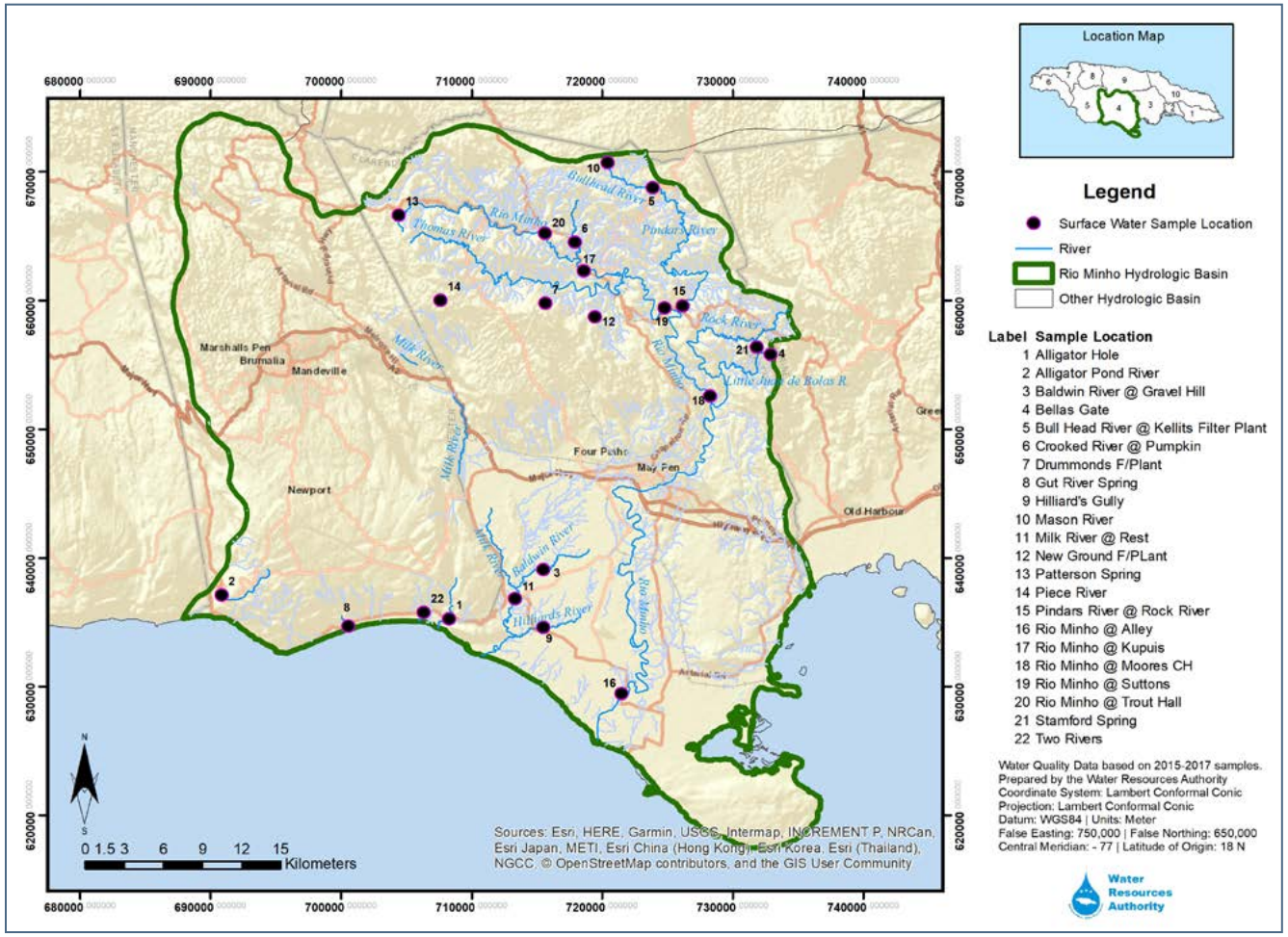


Figure 67: Rio Minho Hydrologic Basin Surface Water Sample Locations

Figure 67 indicates the location of the twenty-two (22) surface water sampling points utilized in the surface water analyses for the Rio Minho Basin.

Rio Minho Hydrologic Basin Nitrate Levels in Surface Water

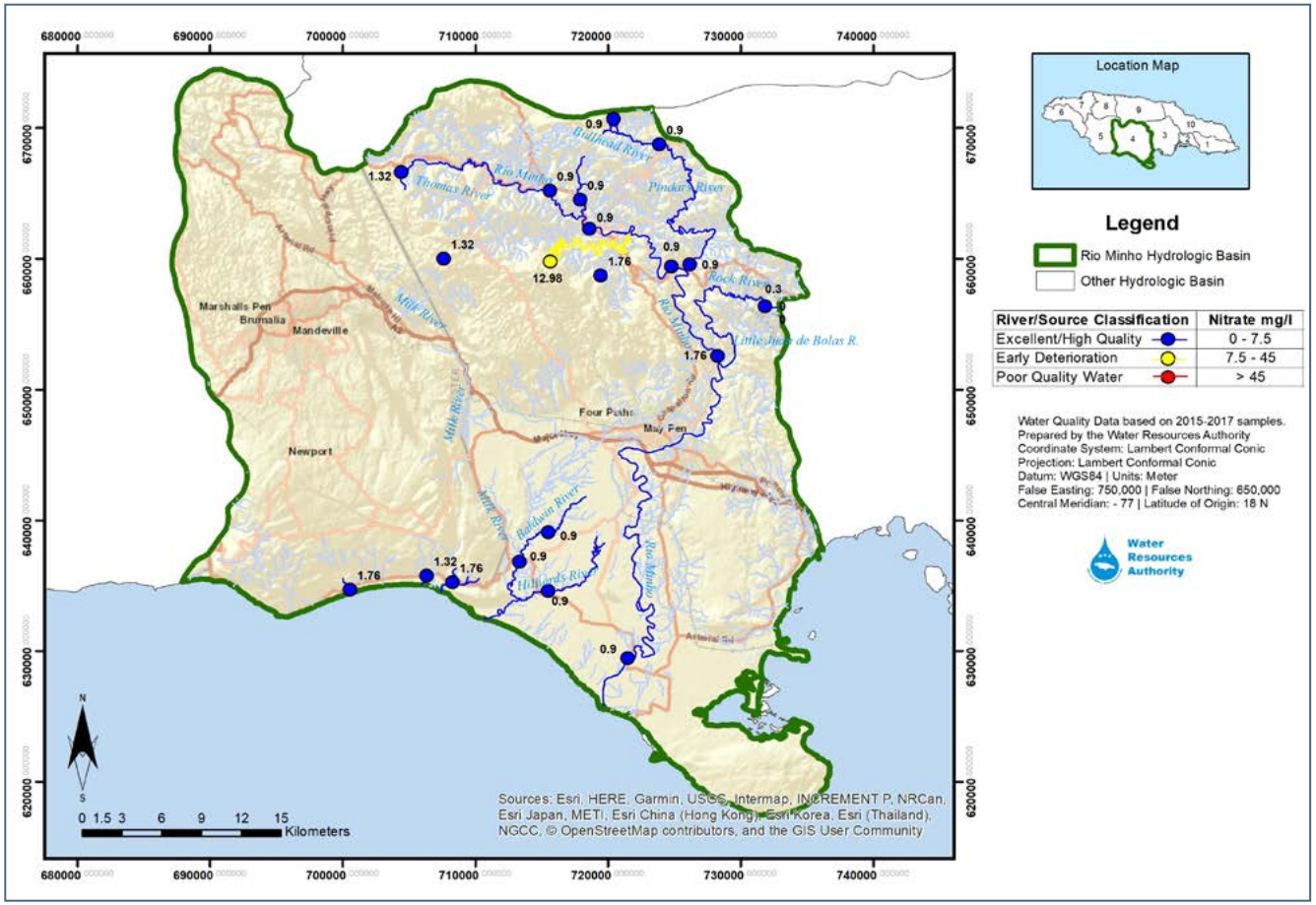
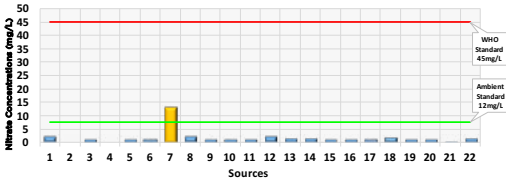


Figure 68: Rio Minho Hydrologic Basin Nitrate Levels in Surface Water

RIO MINHO HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 36: Rio Minho Basin Nitrate Levels in Surface water

The surface water sources within the Rio Minho basin predominantly indicated excellent water quality for Nitrate as shown in Figure 68 and Graph 36. Ninety-five percent (95%) of the surface water sources sampled indicated Nitrate levels within the National Ambient Water Quality Standard of 7.5mg/L. And five percent (5%) of the sources samples indicated water quality in excess of the National Ambient Water Quality Standard of 7.5mg/L.

Rio Minho Hydrologic Basin Sodium Levels in Surface Water

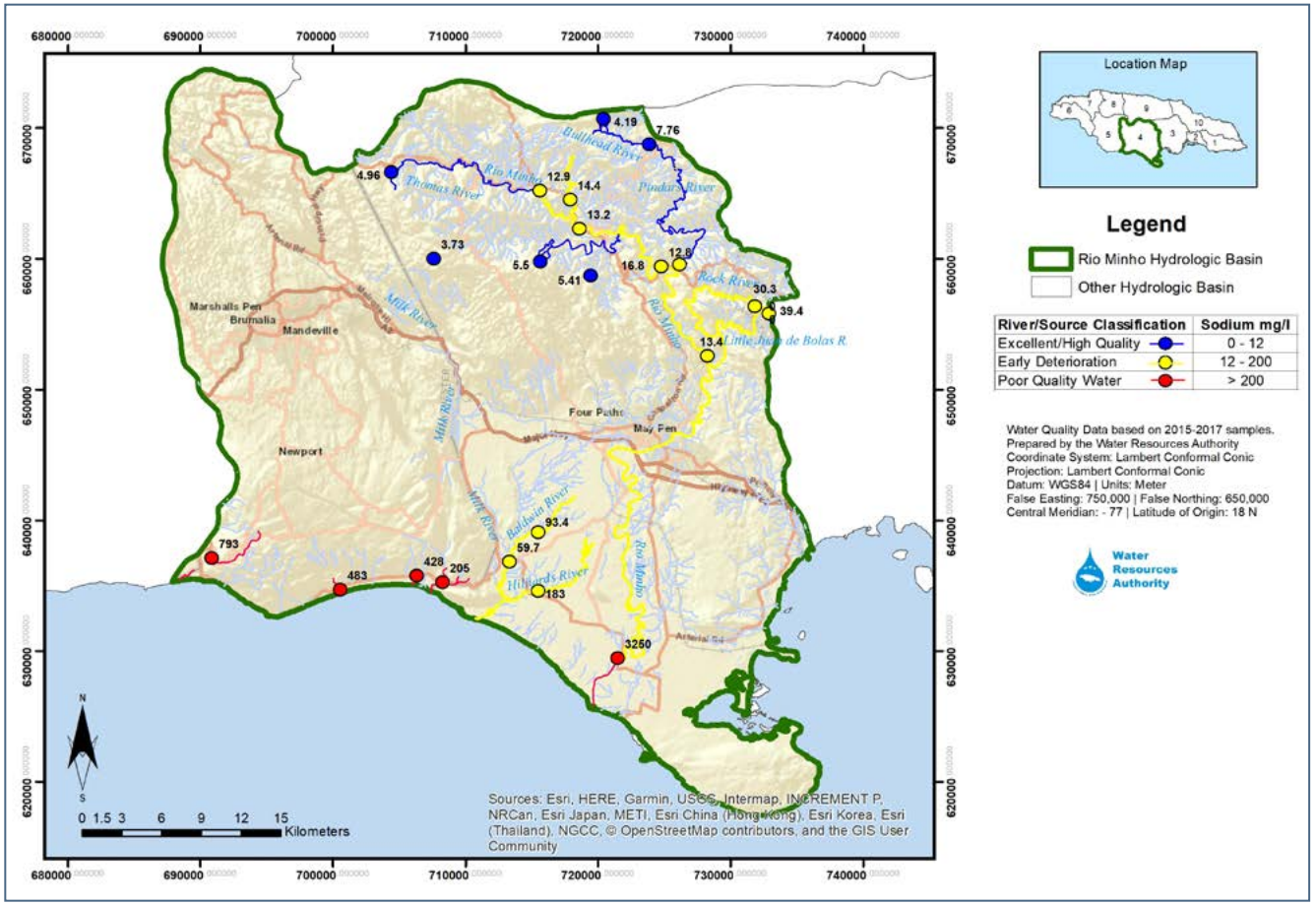
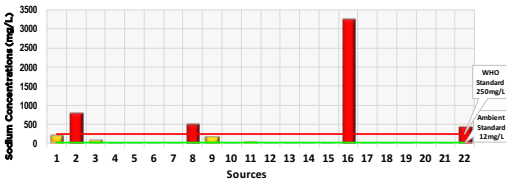


Figure 69: Rio Minho Hydrologic Basin Sodium Levels in Surface Water

RIO MINHO HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 37: Rio Minho Basin Sodium Levels in Surface water

As indicated in Figure 69 and graph 37, the surface water sources within the Rio Minho basin predominantly indicated early warning water quality for Sodium. Fifty percent (50%) of the surface water sources sampled indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L. Twenty-seven percent (27%) of the sources sampled indicated water quality for sodium within the National Ambient Water Quality Standard of 12mg/L. And twenty-three percent (23%) of the sources that indicated poor water are located in the lower reaches of the river system.

Rio Minho Hydrologic Basin Chloride Levels in Surface Water

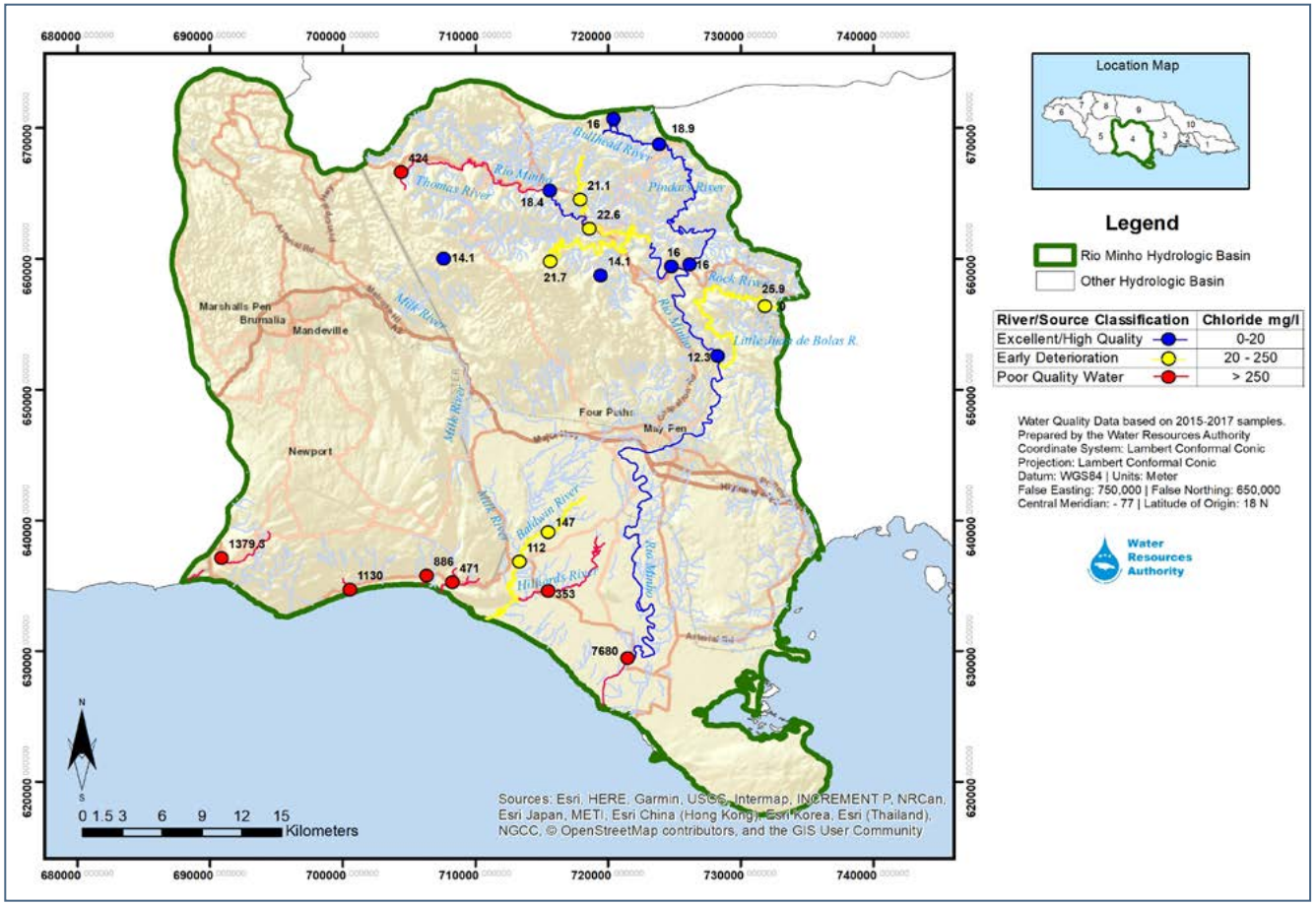
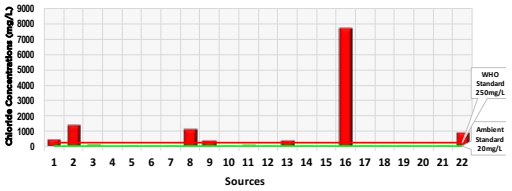


Figure 70: Rio Minho Hydrologic Basin Chloride Levels in Surface Water

RIO MINHO HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 38: Rio Minho Basin Chloride Levels in Surface water

The surface water sources within the Rio Minho basin predominantly indicated excellent water quality for Chloride as shown in Figure 70 and Graph 38. Thirty-eight percent (38%) of the surface water sources sampled indicated chloride levels within the National Ambient Water Quality Standard of 20mg/L. Twenty-seven percent (27%) of the sources indicated chloride concentration in excess of the National Ambient Water Quality Standard of 20mg/L. Twenty-nine percent (29%)of the sources sampled indicated water quality for sodium within the National Ambient Water Quality Standard of 20mg/L. The remaining thirty-three percent (33%) of the sources that indicated poor water quality are located in the lower reach of the river system.

Rio Minho Hydrologic Basin Sulphate Levels in Surface Water

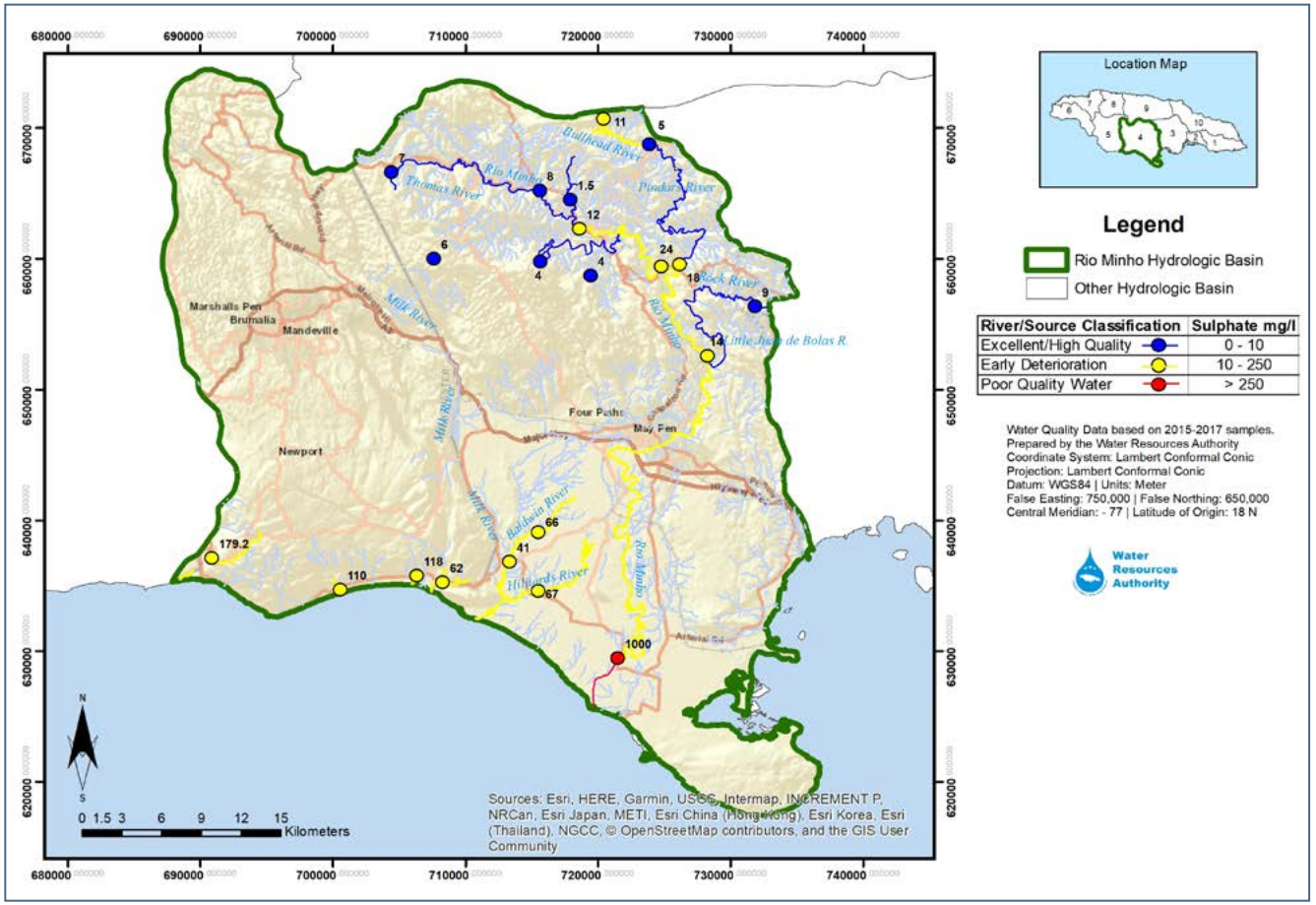
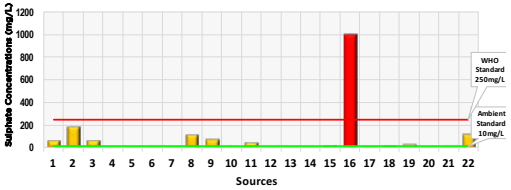


Figure 71: Rio Minho Hydrologic Basin Sulphate Levels in Surface Water

RIO MINHO HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 39: Rio Minho Basin Sulphate Levels in Surface water

As shown in Figure 71 and Graph 39, the well sources within the Rio Minho basin predominantly indicated early deterioration water quality for Sulphate. Fifty-five percent (55%) of the surface water sources sampled indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L. Forty percent (40%) of the sources sampled indicated water quality for sodium within the National Ambient Water Quality Standard of 10mg/L. The remaining five percent (5%) of the sources indicated poor water quality.

Rio Minho Hydrologic Basin TDS Levels in Surface Water

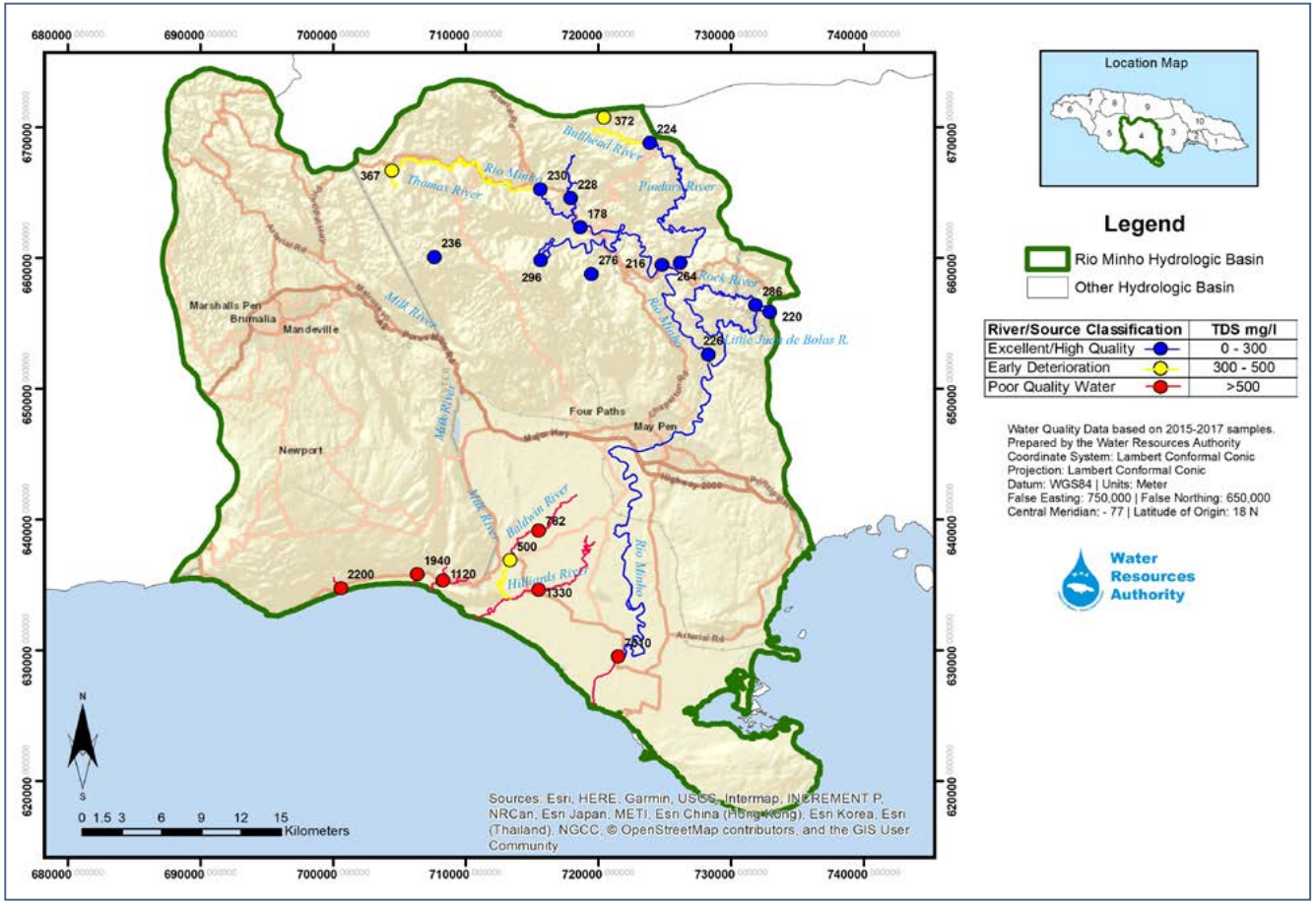
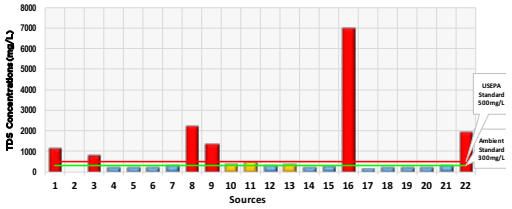


Figure 72: Rio Minho Hydrologic Basin TDS Levels in Surface Water

RIO MINHO HYDROLOGIC BASIN TOTAL DISSOLVED SOLID LEVELS IN SURFACE WATER



Graph 40: Rio Minho Basin TDS Levels in Surface water

The surface water sources within the Rio Minho basin predominantly indicated excellent water quality for TDS as shown in Figure 72 and Graph 40. Fifty nine percent (59%) of the surface water sources sampled indicated TDS within the National Ambient Water Quality Standard of 300mg/L. Fourteen percent (14%) indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Twenty seven percent (27%) of sources that indicated poor water quality.

5.0 Basin V Black River Hydrologic Basin

The Black River Basin primarily covers the parish of St Elizabeth with sections of the parish of Manchester, Trelawny and St James also included. The Black River Hydrologic basin is divided into four sub basins: Bull Savannah, Pedro Plains, Upper Black River and Lower Black River.

The basin is comprised of white limestone (Newport Formation) which takes up the largest portion of the basin, overlain by alluvial deposits formed by the active fluvial system present. The area is primarily drained by the Black River which flows from the north to south west. Ground water has a general southern flow direction towards the coast

The groundwater quality was analysed with the results from forty-three (43) limestone wells and the surface water analyses was done utilizing twenty-one (21) sources.

Black River Hydrologic Basin Groundwater Sample Locations

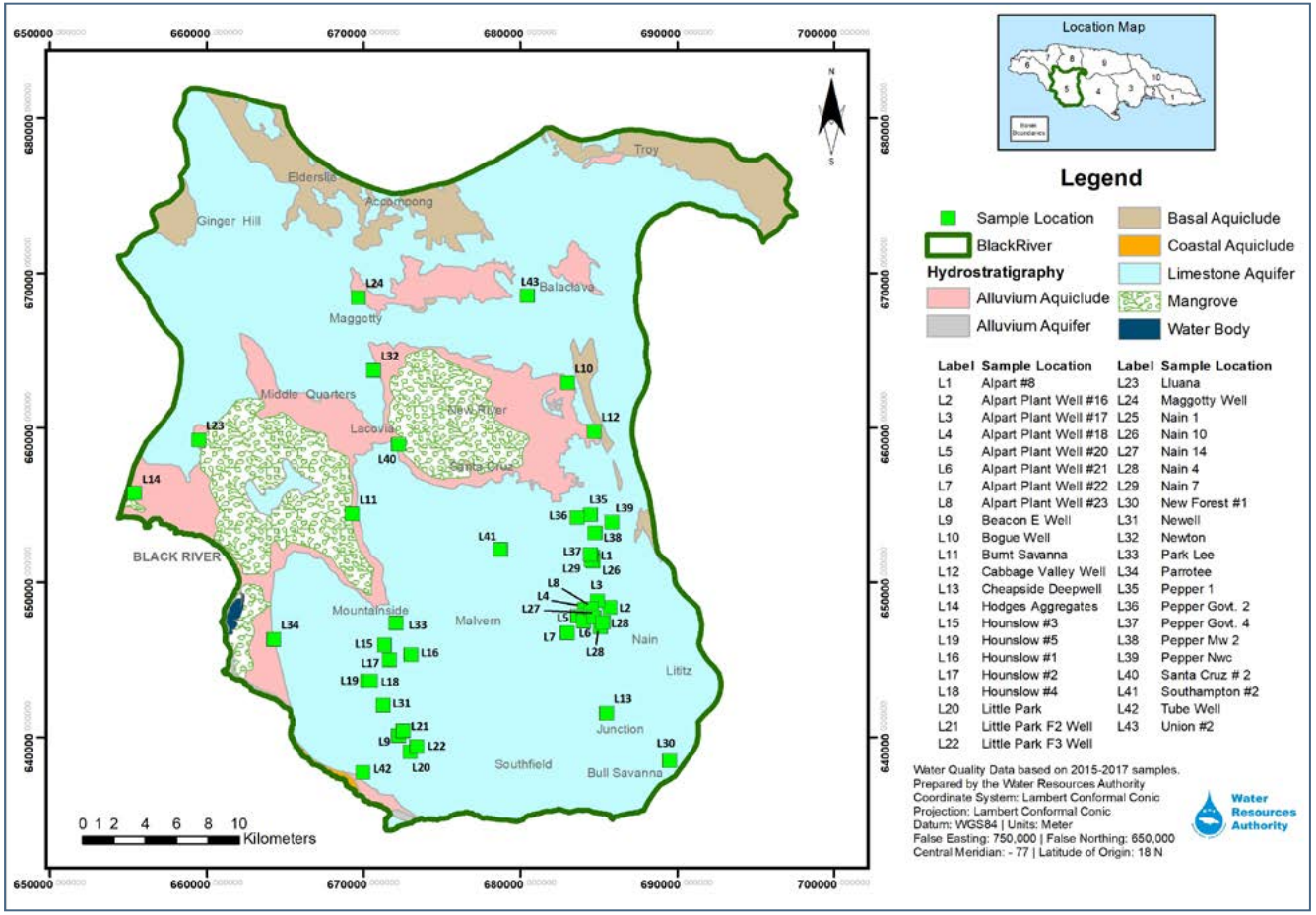


Figure 73: Black River Hydrologic Basin Groundwater Sample Locations

Figure 73 shows the location of the forty-three (43) ground water sampling points. All forty-three (43) sources are classified as limestone wells.

Black River Hydrologic Basin Nitrate Levels in Groundwater

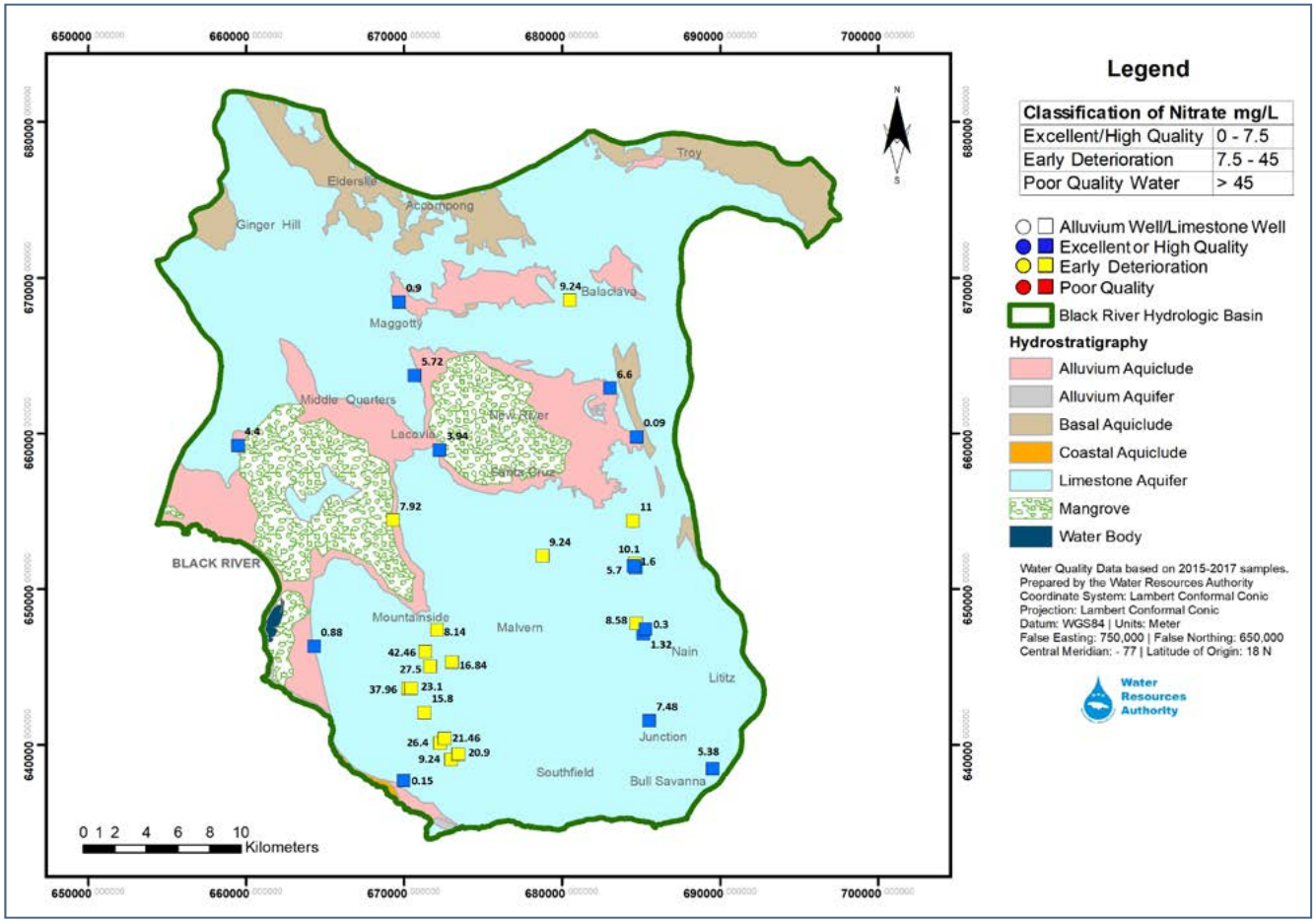
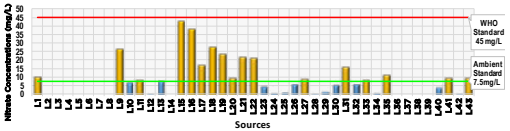


Figure 74: Black River Hydrologic Basin Nitrate Levels in Groundwater

BLACK RIVER HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 41: Black River Basin Nitrate Levels in Groundwater

Figure 74 and Graph 41, shows that the well sources within the Black River basin predominantly indicated early deterioration for nitrate. Forty percent (40%) of the well sources sampled indicated nitrate level in excess of the National Ambient Water Quality Standard of 7.5mg/L. Twenty-eight percent (28%)of the source sampled indicated excellent water quality.

Black River Hydrologic Basin Nitrate Levels in the Limestone Aquifer

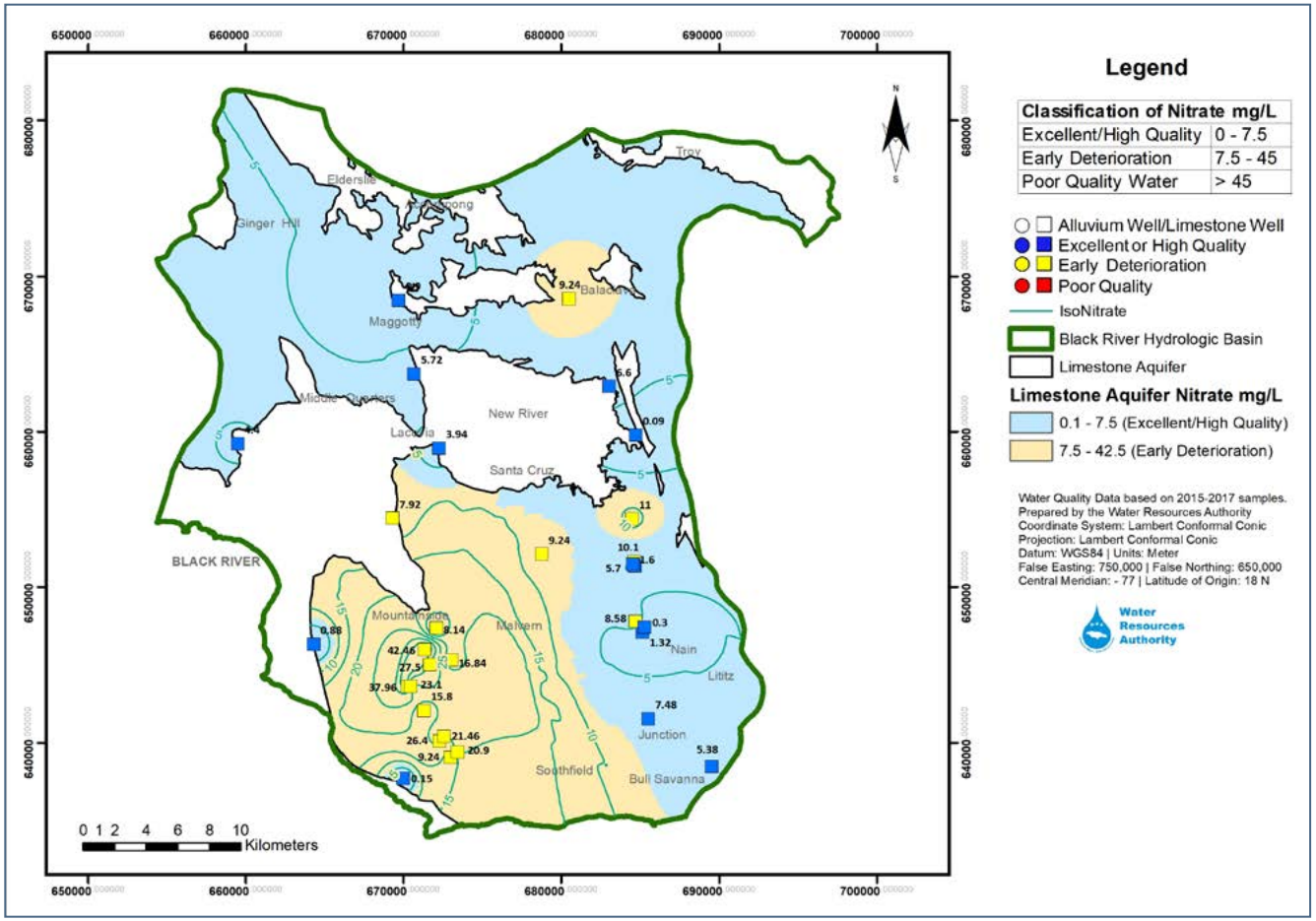


Figure 75: Black River Hydrologic Basin Spatial Interpolation of the Nitrate Levels in the Limestone Aquifer

The spatial interpolation of the water quality results for Nitrate in the Black River Basin limestone aquifer is indicated in Figure 75. Based on the interpolated results the basin quality predominantly indicated both excellent and early deterioration water quality for nitrate.

Seventy percent (70%) of the aquifer indicated excellent water quality and the remaining thirty percent (30%) indicated early deterioration. The early deterioration quality is predominantly observed in the south western section of the basin. Two pockets of early deterioration in water quality were also noted in the north eastern and the eastern central sections of the basin. The northern and south eastern sections of the basin predominantly indicated excellent water quality for nitrate.

Black River Hydrologic Basin Sodium Levels in Groundwater

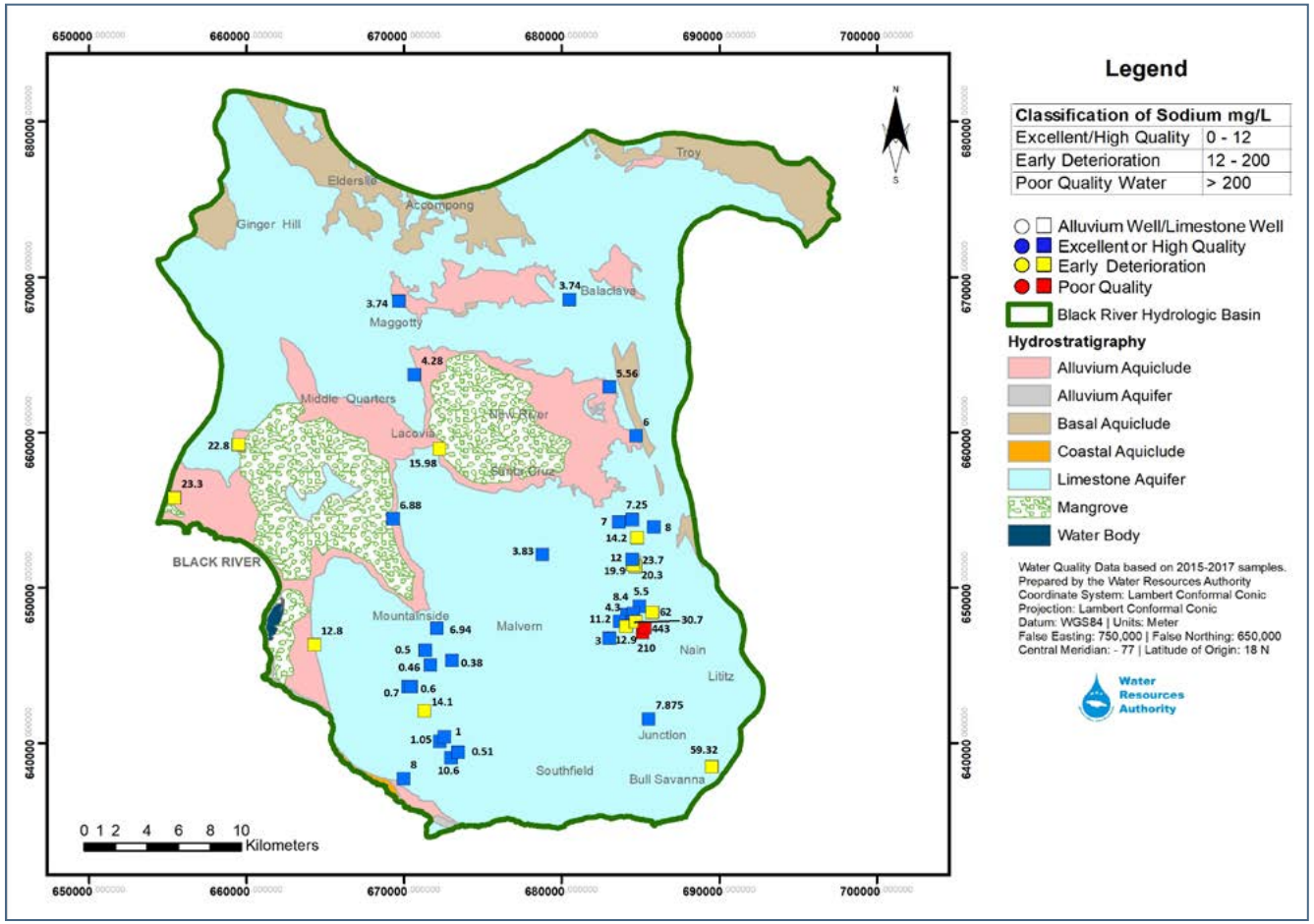
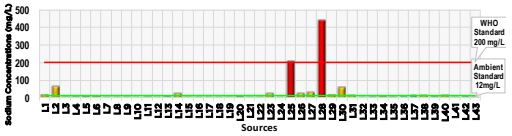


Figure 76: Black River Hydrologic Basin Sodium Levels in Groundwater

BLACK RIVER HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 42: Black River Basin Sodium Levels in Groundwater

As shown in Figure 76 and Graph 42, the well sources within the Black River basin predominantly indicated excellent water quality for sodium. Sixty-five percent (65%) of the source sampled indicated excellent water quality. Thirty percent (30%) of the well sources sampled indicated nitrate level in excess of the National Ambient Water Quality Standard of 12mg/L. Five percent (5%) of sources indicated poor water quality.

Black River Hydrologic Basin Sodium Levels in the Limestone Aquifer

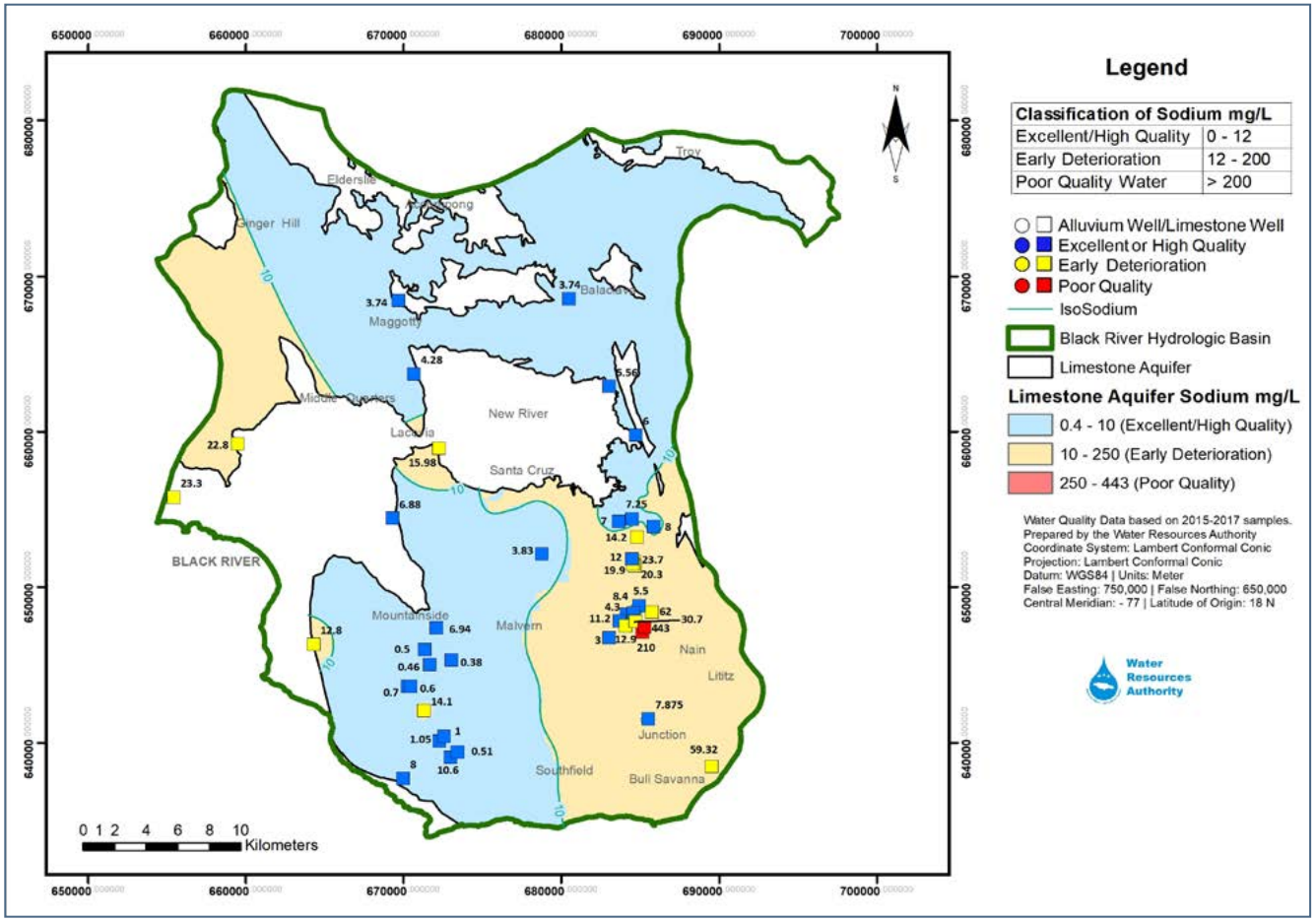


Figure 77: Black River Hydrologic Basin Spatial Interpolation of the Sodium Levels in the Limestone Aquifer

The spatial interpolation of the water quality results for Sodium in the Black River Basin limestone aquifer is indicated in Figure 77. Based on the interpolated results the basin quality indicates both excellent and early deterioration water quality for Sodium.

The spatial interpolation of the data indicated sixty percent (60%) of the aquifer primarily to the north and north western section of the basin and the south western indicated excellent water quality and the remaining forty percent (40%) indicated early deterioration. The areas that indicated early deterioration water quality were the north western and eastern sections of the basin.

Black River Hydrologic Basin Chloride Levels in Groundwater

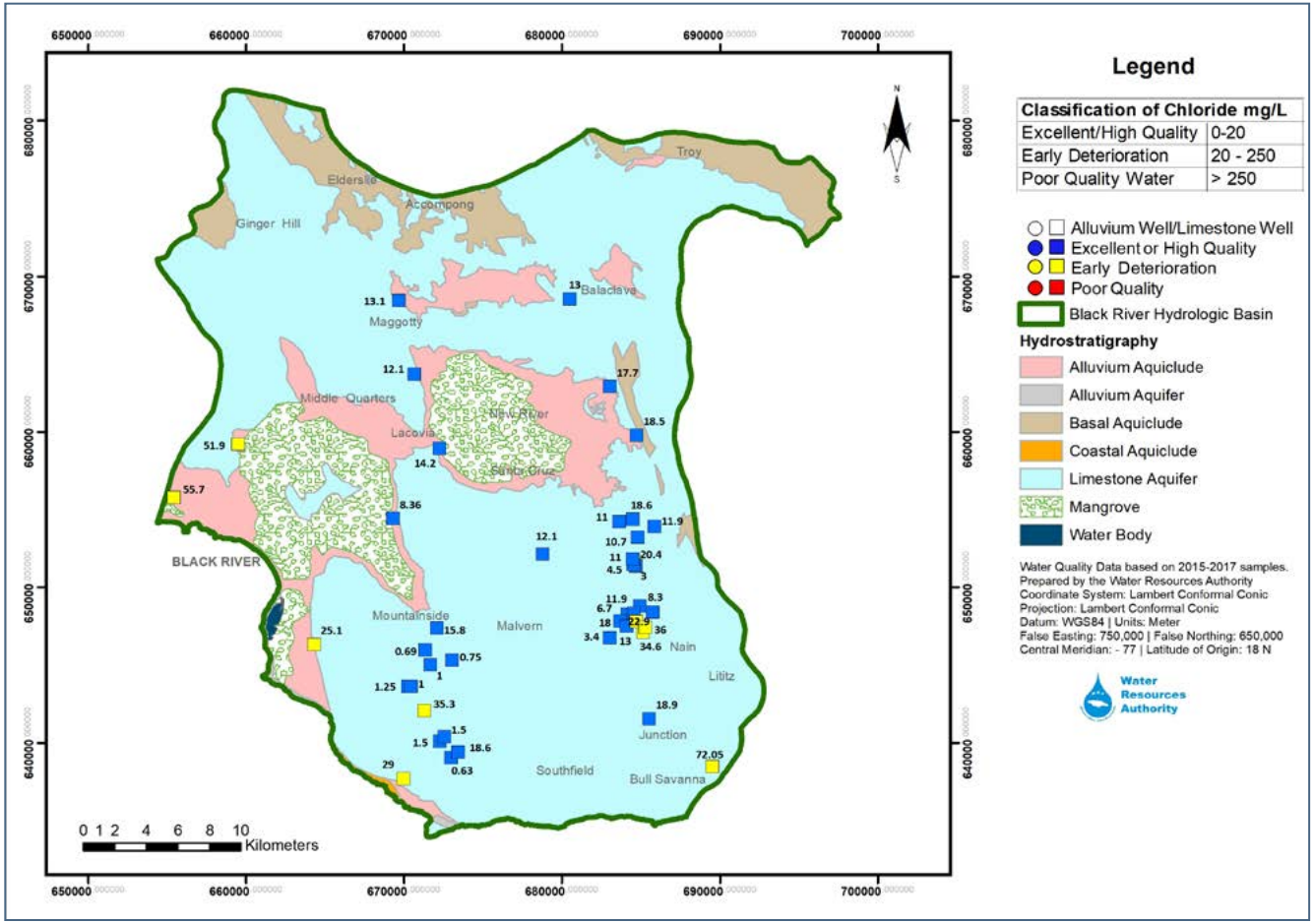
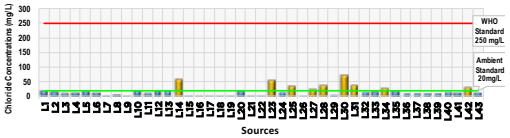


Figure 78: Black River Hydrologic Basin Chloride Levels in Groundwater

BLACK RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 43: Black River Basin Chloride Levels in Groundwater

The well sources within the Black River basin predominantly indicated excellent water quality for chloride as shown in Figure 78 and Graph 43. Seventy-seven percent (77%) of the source sampled indicated excellent water quality. Twenty-three percent (23%) of the well sources sampled indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L

Black River Hydrologic Basin Chloride Levels in the Limestone Aquifer

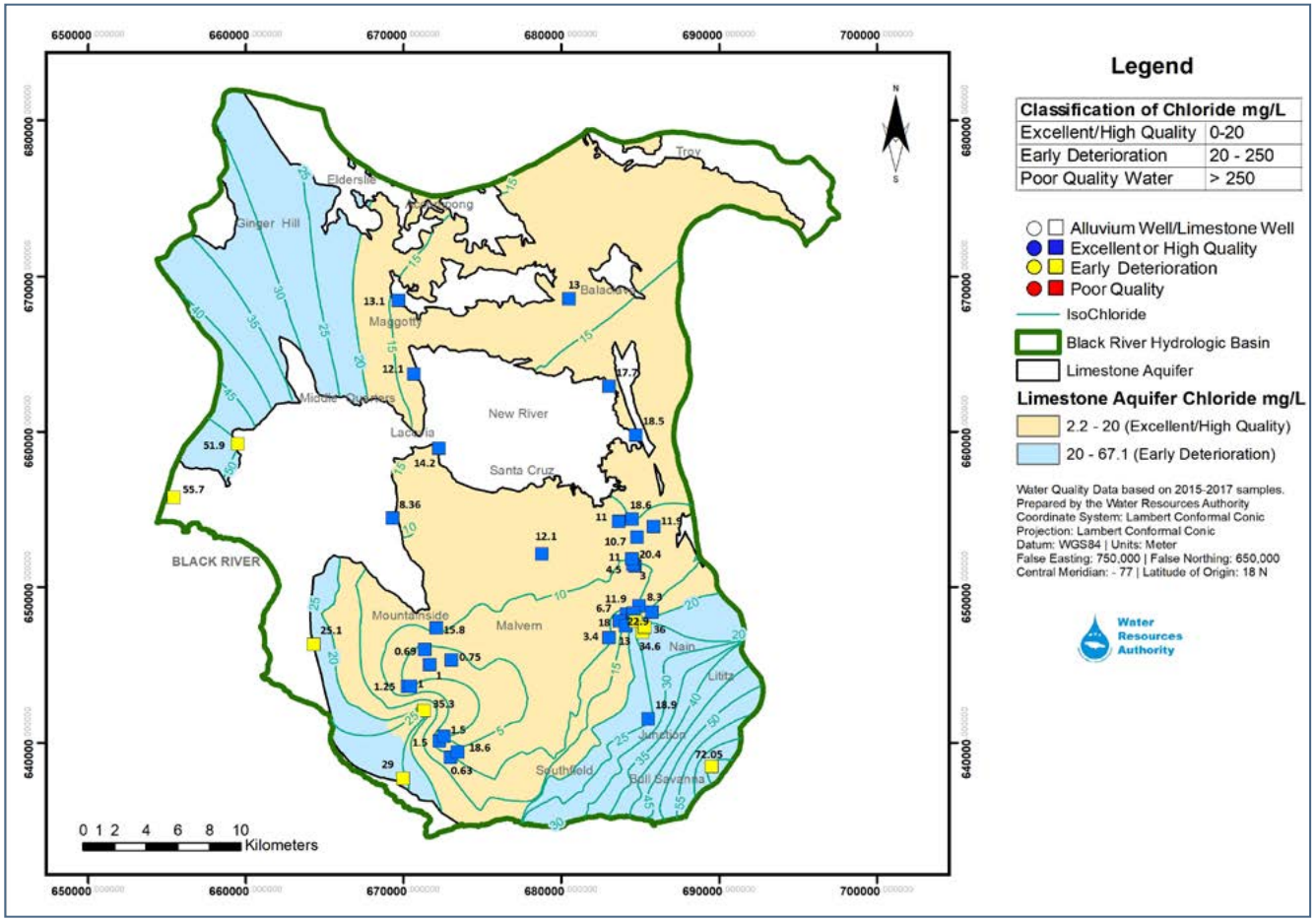


Figure 79: Black River Hydrologic Basin Spatial Interpolation of the Chloride Levels in the Limestone Aquifer

The spatial interpolation of the water quality results for Chloride in the Black River Basin limestone aquifer is indicated in Figure 79. Based on the interpolated results the basin quality predominantly both excellent and early deterioration water quality for chloride.

The spatial interpolation of the data indicated seventy percent (70%) of the aquifer experienced early deterioration in water quality primarily in the north eastern, central and south eastern sections of the aquifer. The remaining thirty percent (30%) indicated excellent water quality within the north western and south eastern sections of the basin.

Black River Hydrologic Basin Sulphate Levels in Groundwater

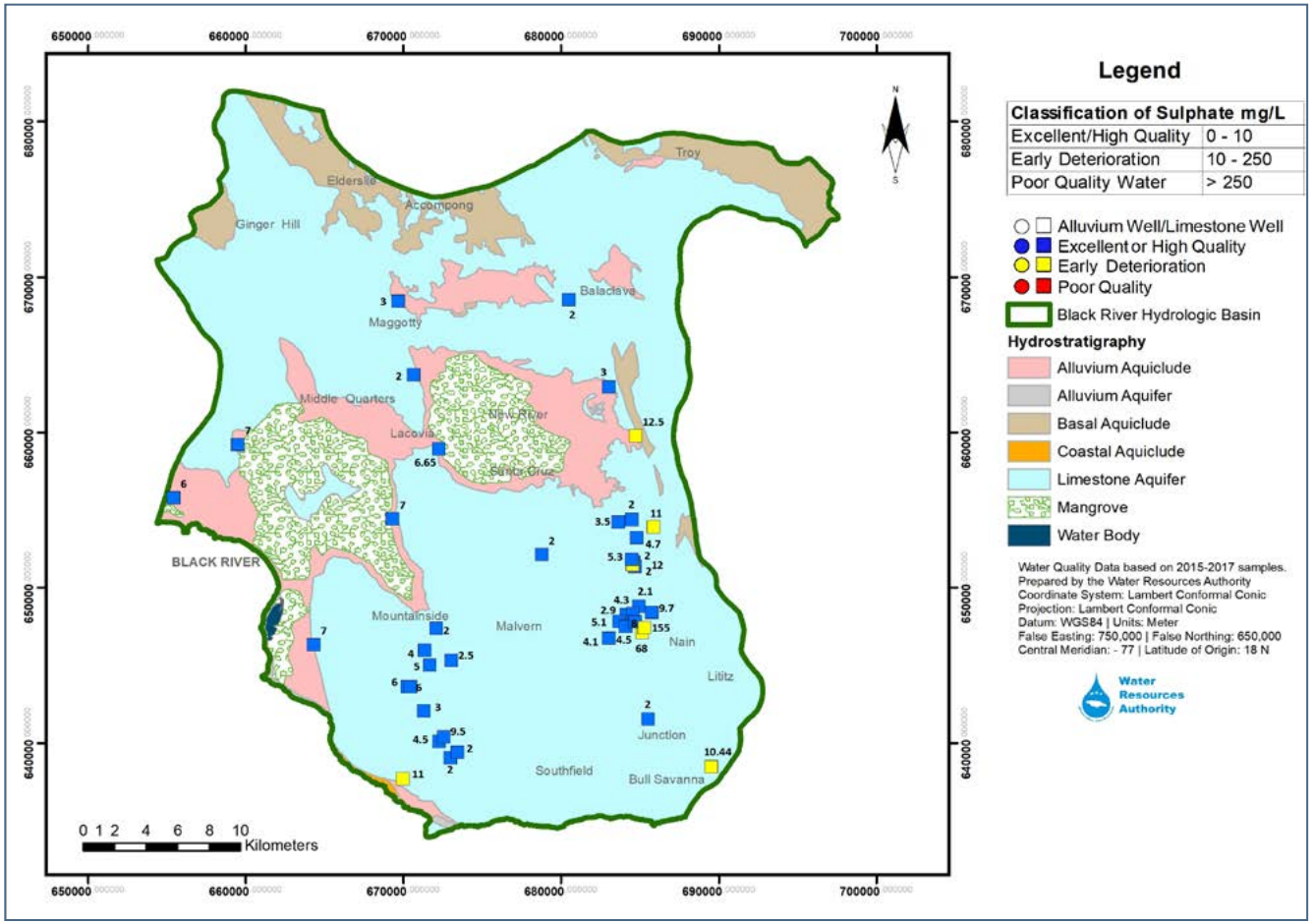
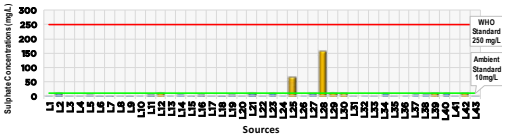


Figure 80: Black River Hydrologic Basin Sulphate Levels in Groundwater

BLACK RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 44: Black River Basin Sulphate Levels in Groundwater

The well sources within the Black River basin predominantly indicated excellent water quality for sulphate as shown in Figure 80 and Graph 44. Eighty-four percent (84%) of the source sampled indicated excellent water with sulphate levels within the National Ambient Water Quality Standard of 10mg/L. And sixteen percent (16%) of the well sources sampled indicated sulphate level in excess of the National Ambient Water Quality Standard of 10mg/L.

Black River Hydrologic Basin Sulphate Levels in the Limestone Aquifer

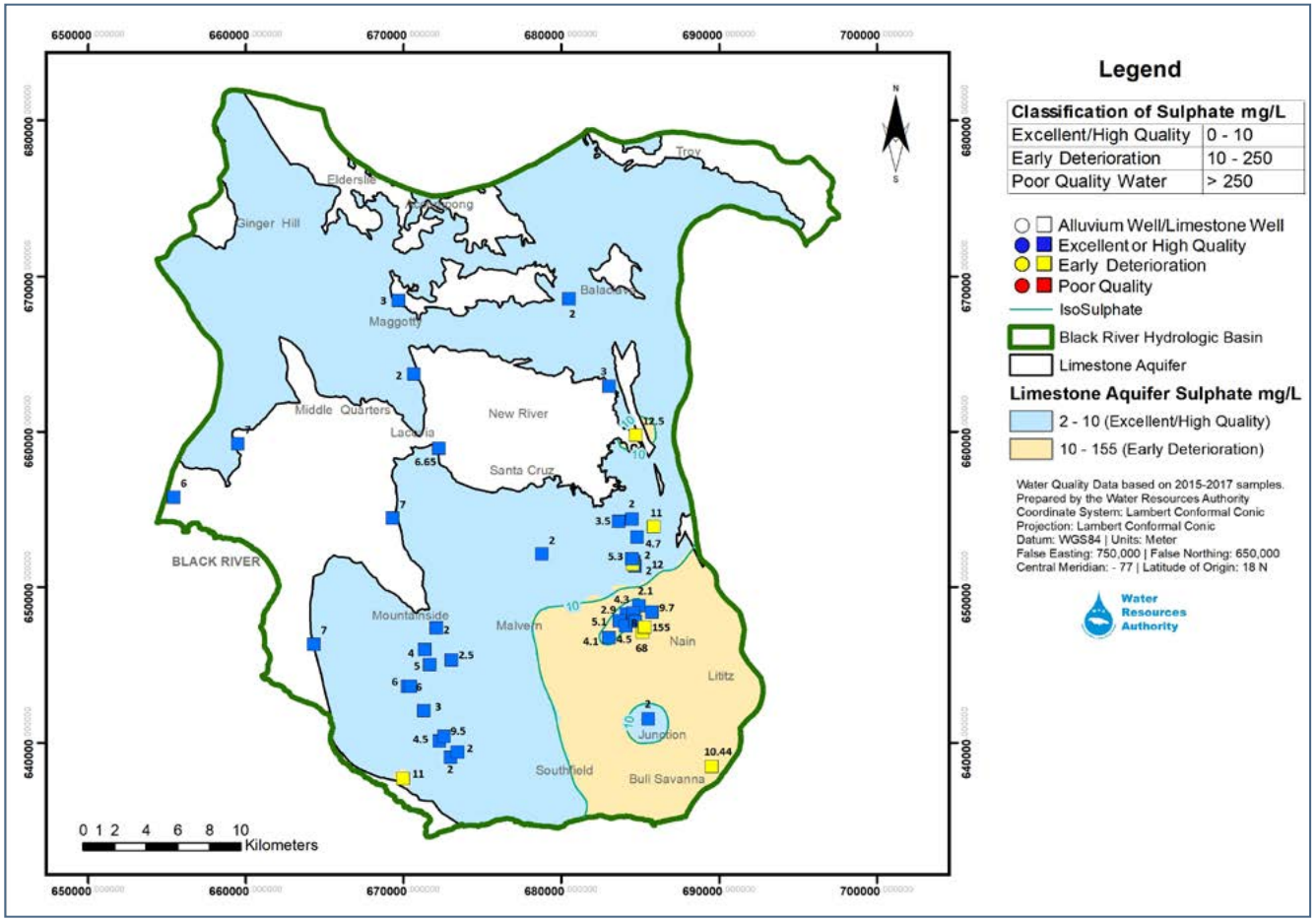


Figure 81: Black River Hydrologic Basin Spatial Interpolation of the Sulphate Levels in the Limestone Aquifer

The spatial interpolation of the water quality results for Sulphate in the Black River Basin limestone aquifer is indicated in Figure 81. Based on the interpolated results the basin quality predominantly both excellent and early deterioration water quality for sulphate.

The spatial interpolation of the data indicated eighty five percent (85%) of the aquifer had excellent water quality and the remaining fifteen percent (15%) indicated early deterioration. A pocket of early deterioration water quality was observed in the south eastern section of the basin south of Nain.

Black River Hydrologic Basin TDS Levels in Groundwater

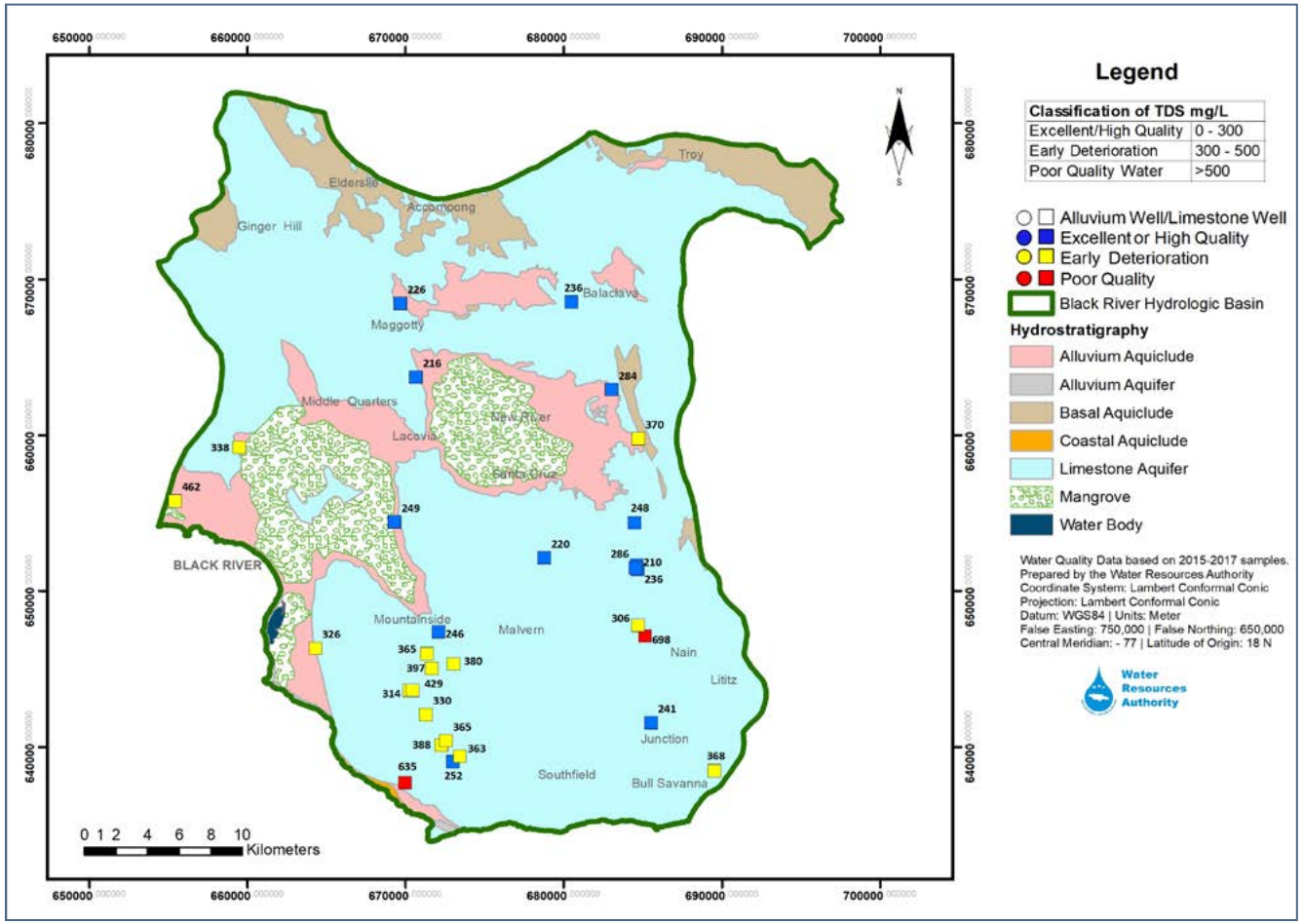
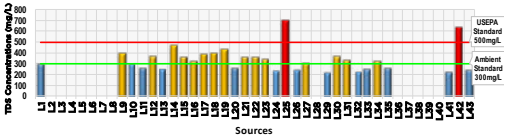


Figure 82: Black River Hydrologic Basin TDS Levels in Groundwater

BLACK RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 45: Black River Basin TDS Levels in Groundwater

The well sources within the Black River basin predominantly indicated early warning water quality for TDS as shown in Figure 82 and Graph 45. Thirty five percent (35%) of the well sources sampled indicated TDS level in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Thirty percent (30%) of the source sampled indicated excellent water with TDS levels within the National Ambient Water Quality Standard of 10mg/L. Five percent (5%) of the sources indicated poor water quality for TDS.

Black River Hydrologic Basin TDS Levels in the Limestone Aquifer

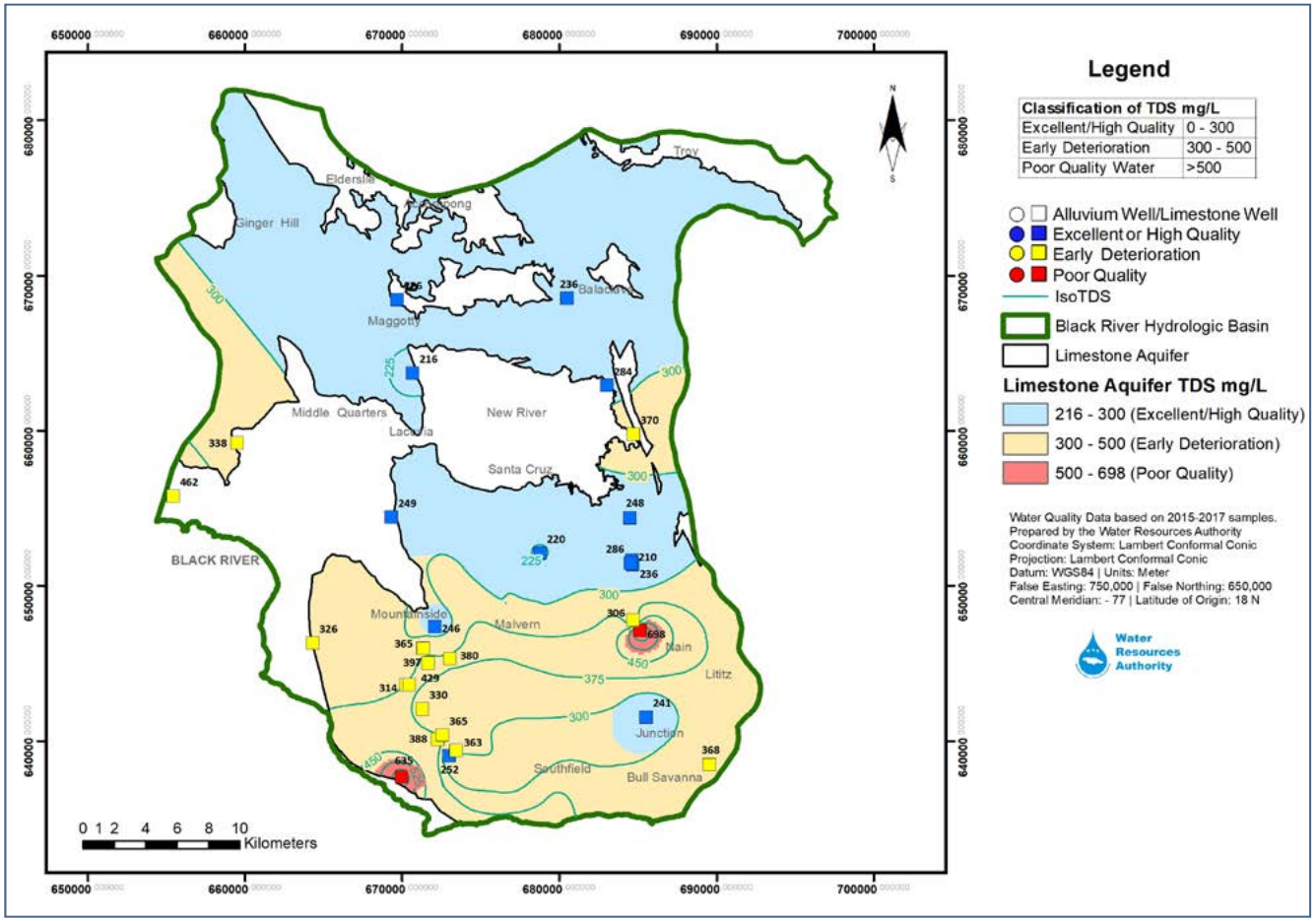


Figure 83: Black River Hydrologic Basin Spatial Interpolation of the TDS Levels in the Limestone Aquifer

The spatial interpolation of the water quality results for TDS in the Black River Basin limestone aquifer is indicated in Figure 83. Based on the interpolated results the basin quality predominantly both excellent and early deterioration water quality for TDS with two small pockets of poor quality noted in the south western and south western sections of the aquifer.

The spatial interpolation of the data indicated sixty percent (60%) of the aquifer with excellent water quality and the remaining forty percent (40%) indicated early deterioration. The early deterioration water quality was noted in the southern section of the aquifer with pockets noted in the north western and eastern central sections of the basin. As noted the pockets of poor water quality was observed in the south eastern and south west section of the aquifer.

Black River Hydrologic Basin Surface Water Sample Locations

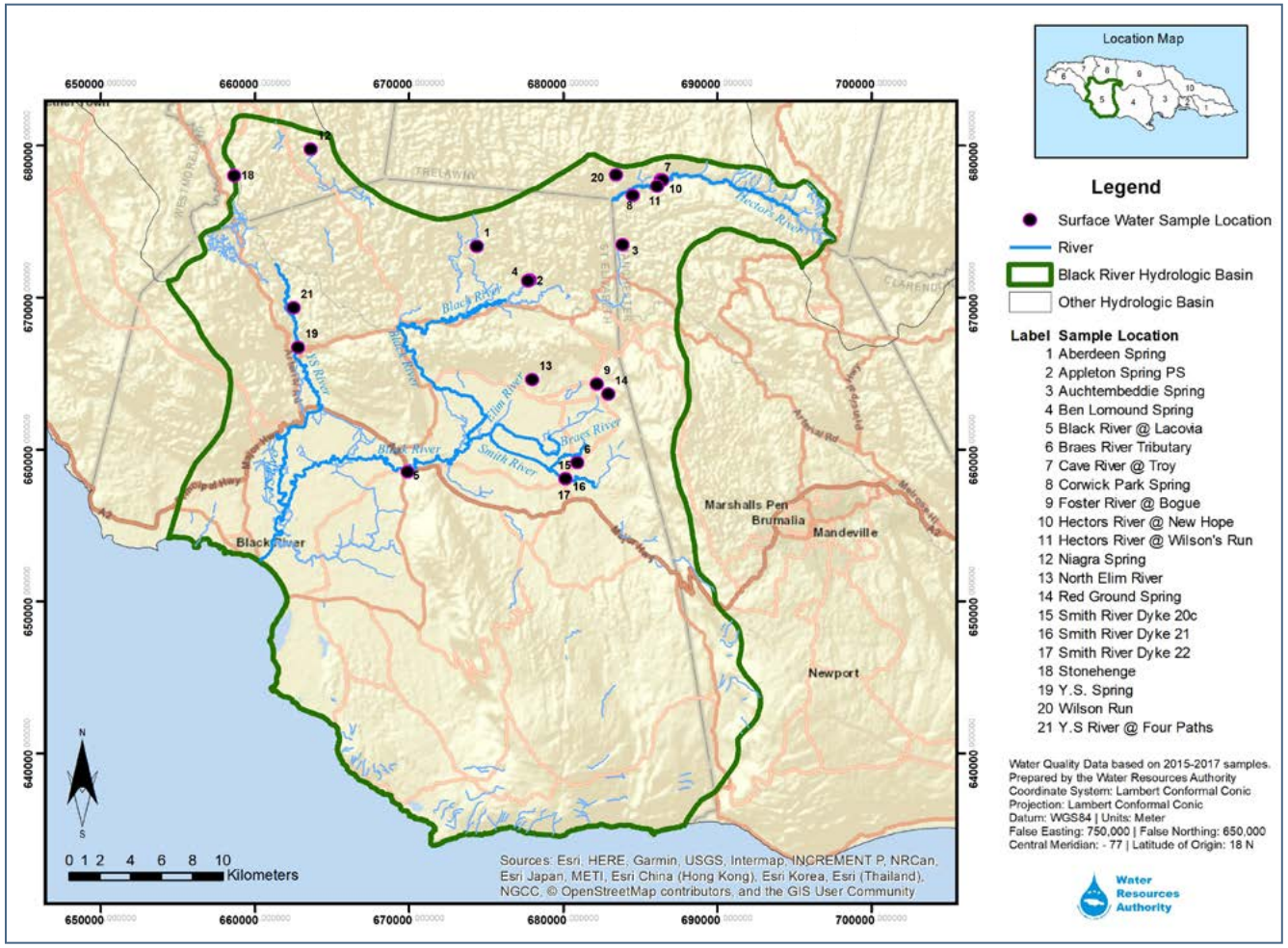


Figure 84: Black River Hydrologic Basin Surface Water Sample Locations

Figure 84 indicates the location of the twenty-one (21) surface water sampling points utilized in the surface water analyses for the Black River.

Black River Hydrologic Basin Nitrate Levels in Surface Water

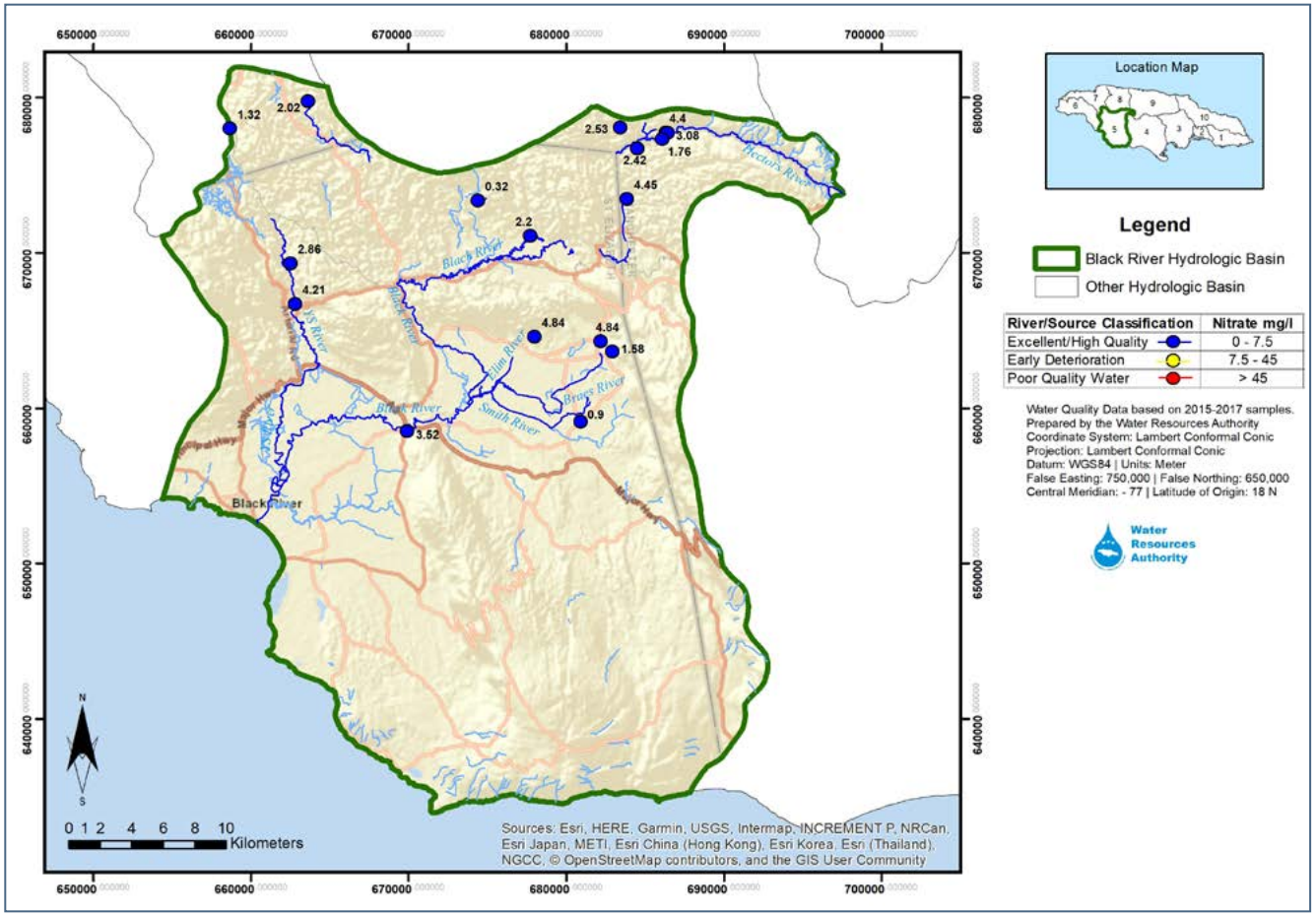
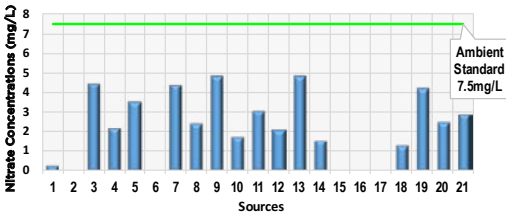


Figure 85: Black River Hydrologic Basin Nitrate Levels in Surface Water

BLACK RIVER HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 46: Black River Basin Nitrate Levels in Surface water

As shown in Figure 85 and Graph 46, the surface water sources within the Black River basin predominantly indicated excellent water quality for nitrate. All the sources (100%) sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L.

Black River Hydrologic Basin Sodium Levels in Surface Water

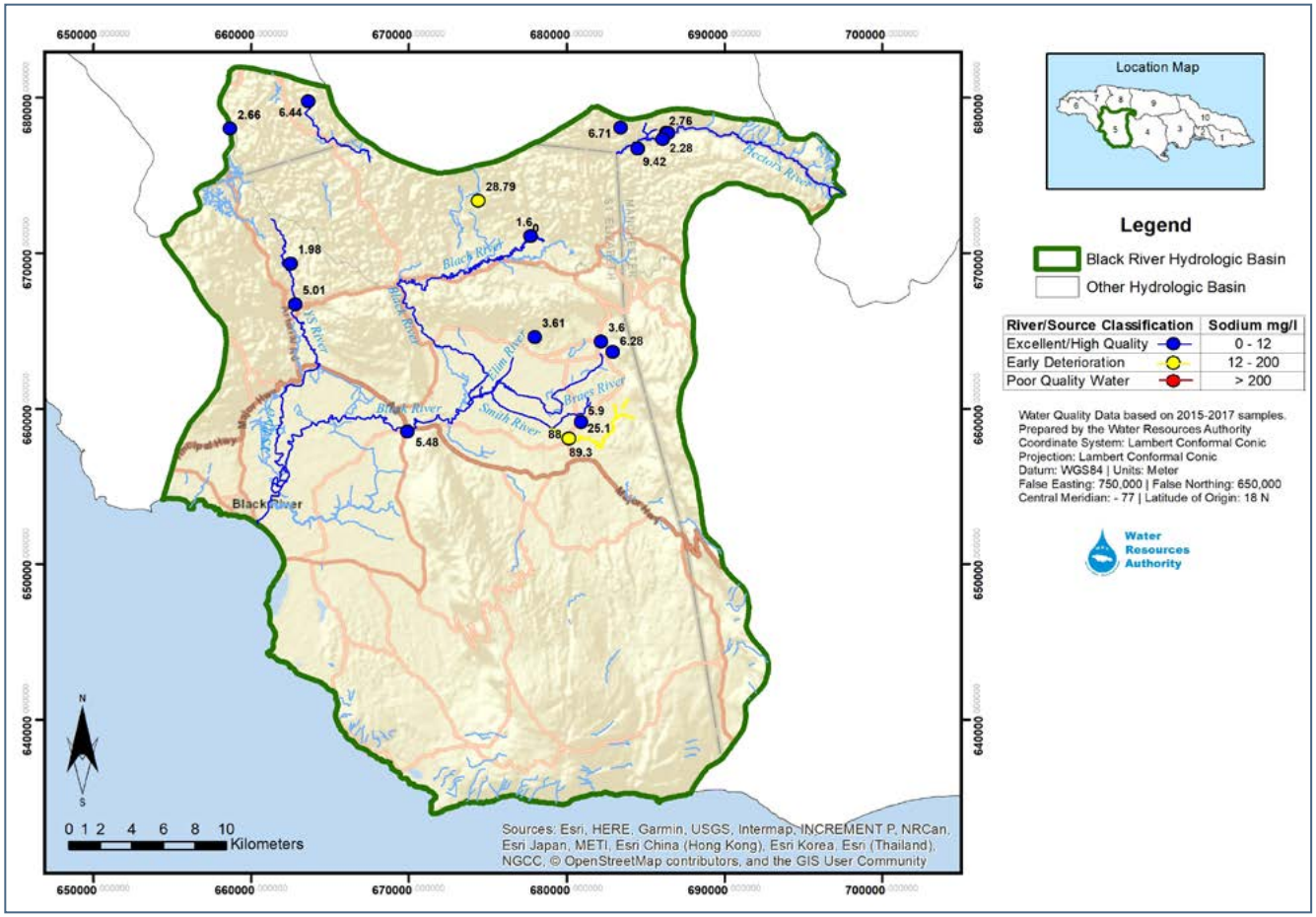
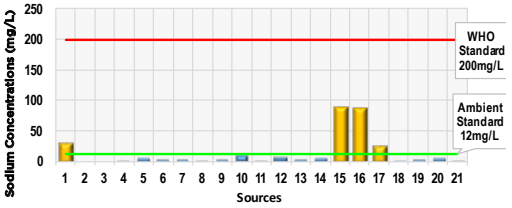


Figure 86: Black River Hydrologic Basin Sodium Levels in Surface Water

BLACK RIVER HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 47: Black River Basin Sodium Levels in Surface water

As shown in Figure 86 and Graph 47, the surface water sources within the Black River basin predominantly indicated excellent water quality for sodium. Eighty-one percent (81%) of the surface water sources sampled indicated sodium within the National Ambient Water Quality Standard of 12mg/L. Nineteen percent (19%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L.

Black River Hydrologic Basin Chloride Levels in Surface Water

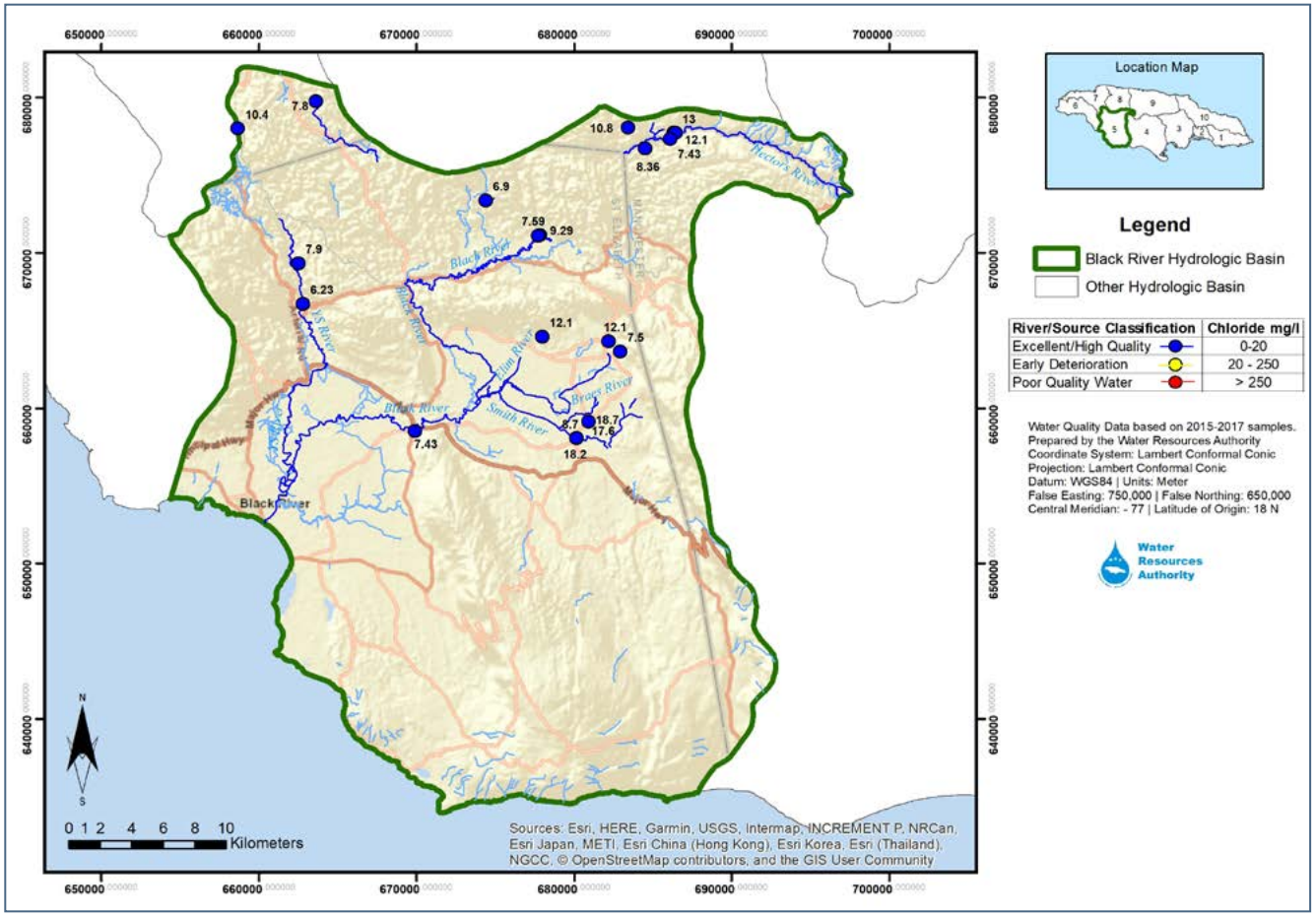
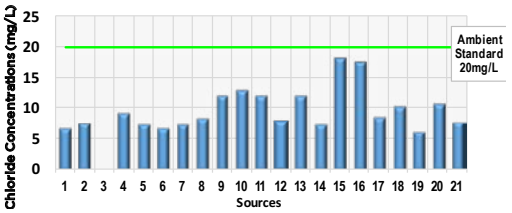


Figure 87: Black River Hydrologic Basin Chloride Levels in Surface Water

BLACK RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 48: Black River Basin Chloride Levels in Surface water

As indicated in Figure 87 and Graph 48, the surface water sources within the Black River basin predominantly indicated excellent water quality for chloride. All the sources (100%) sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L.

Black River Hydrologic Basin Sulphate Levels in Surface Water

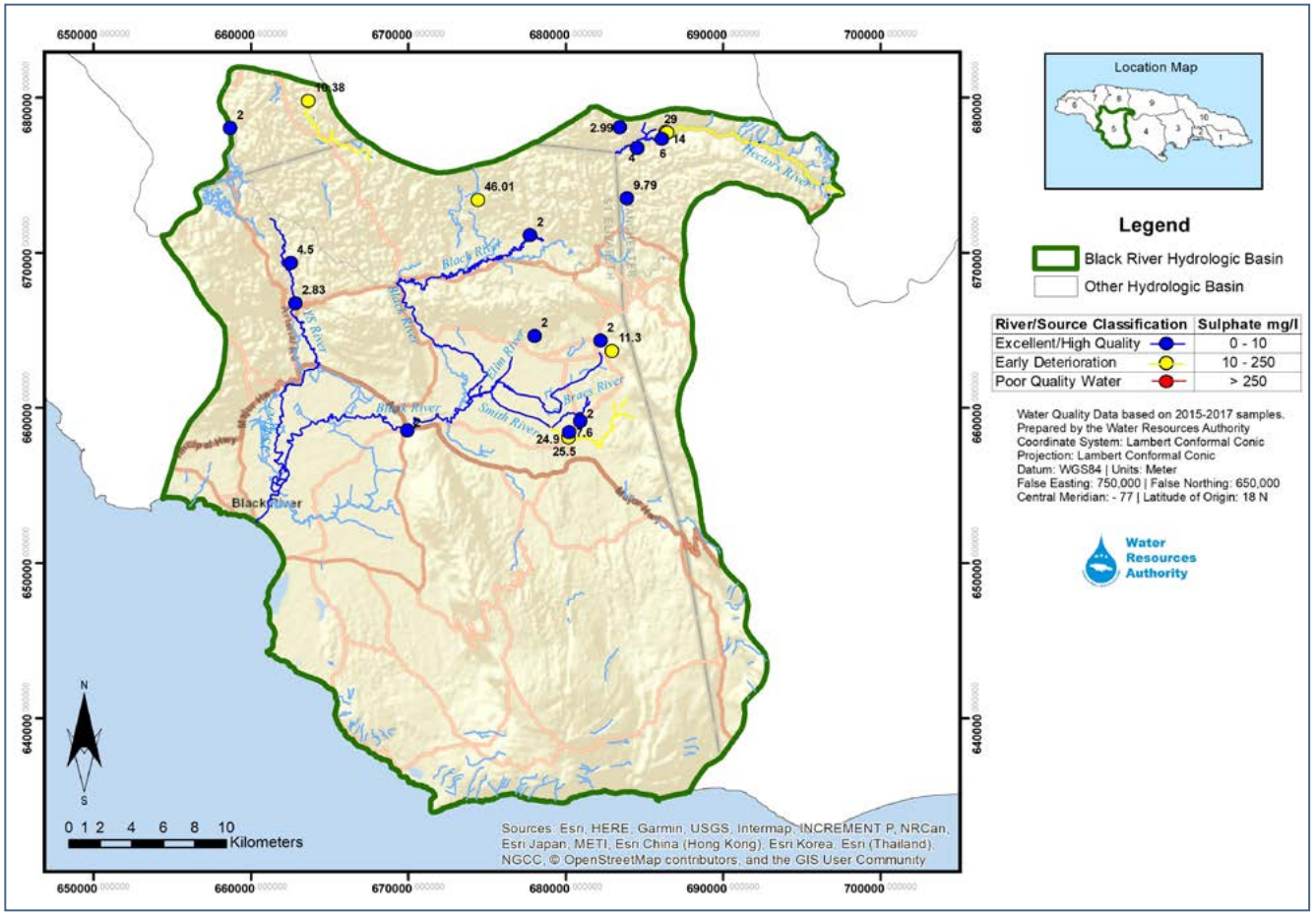
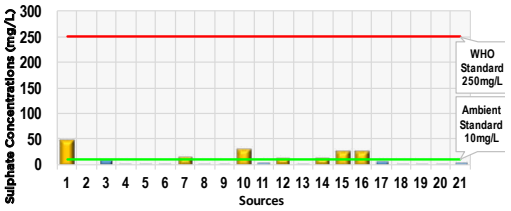


Figure 88: Black River Hydrologic Basin Sulphate Levels in Surface Water

BLACK RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 49: Black River Basin Sulphate Levels in Surface water

The surface water sources within the Black River basin predominantly indicated excellent water quality for chloride as shown in Figure 88 and Graph 49. Sixty-two percent (62%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. Thirty-three percent (33%) indicated chloride levels in excess of the National Ambient Water Quality Standard.

Black River Hydrologic Basin TDS Levels in Surface Water

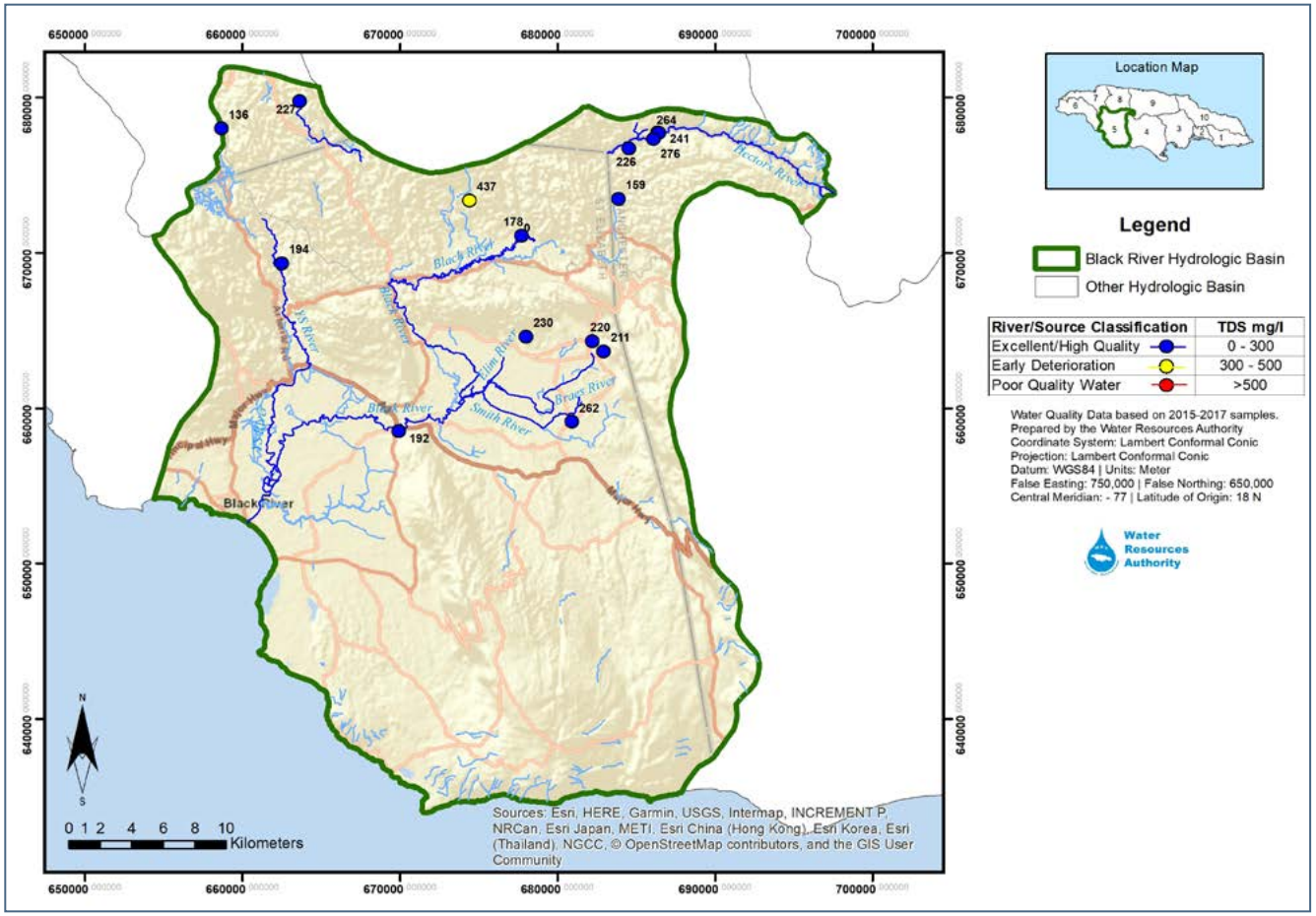
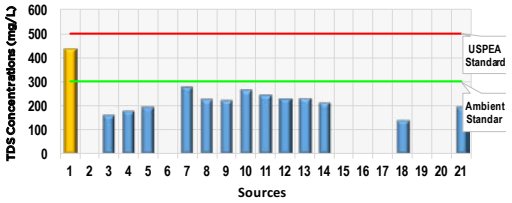


Figure 89: Black River Hydrologic Basin TDS Levels in Surface Water

BLACK RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 50: Black River Basin TDS Levels in Surface water

As shown in Figure 89 and Graph 50, the surface water sources within the Black River basin predominantly indicated excellent water quality for TDS. Sixty-two percent (62%) of the surface water sources sampled indicated TDS within the National Ambient Water Quality Standard of 300mg/L. Five percent (5%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 300mg/L

6.0 Basin VI Cabarita Hydrologic Basin

The Cabarita River is the sixth basin and is located to the south west of the island. The basin is located in the parish of Westmoreland, St Elizabeth and parts of Hanover. For water management purposes, Cabarita River Hydrologic Basin has been divided into four Watershed Management Units (WMU): South Negril-Orange River, New Savannah River, Cabarita River and Deans Valley River. These WMUs are further divided into five sub-WMUs: Great Morass, Orange River, South Negril River, Deans Valley and Goat Gully-White Horse Gully. The basin is split with Alluvial and superficial deposits to the west of the basin, sitting on top of white limestone that is exposed to the east of the basin. This geological bedding is pervasive throughout the basin, with the exception of the small Green Island Inlier at the border of the Cabarita River Basin and the Great River Basin.

The basin is further drained by a network of springs and rivers traversing over alluvium aquiclude in the central section of the basin, and to a lesser extent over limestone aquifer to the eastern section flowing south towards the coast. The primary drainage direction is to the south via the Cabarita River which drains the southern section of the Lucea River and Great River WMUs. The water resources within the Cabarita basin are comprised of groundwater from limestone aquifers and surface water from the rivers and springs that drain the five sub-WMUs.

The groundwater quality was analysed with the results from six limestone wells and the surface water analyses was done utilizing twenty (20) sources.

Cabarita River Hydrologic Basin Groundwater Sample Locations

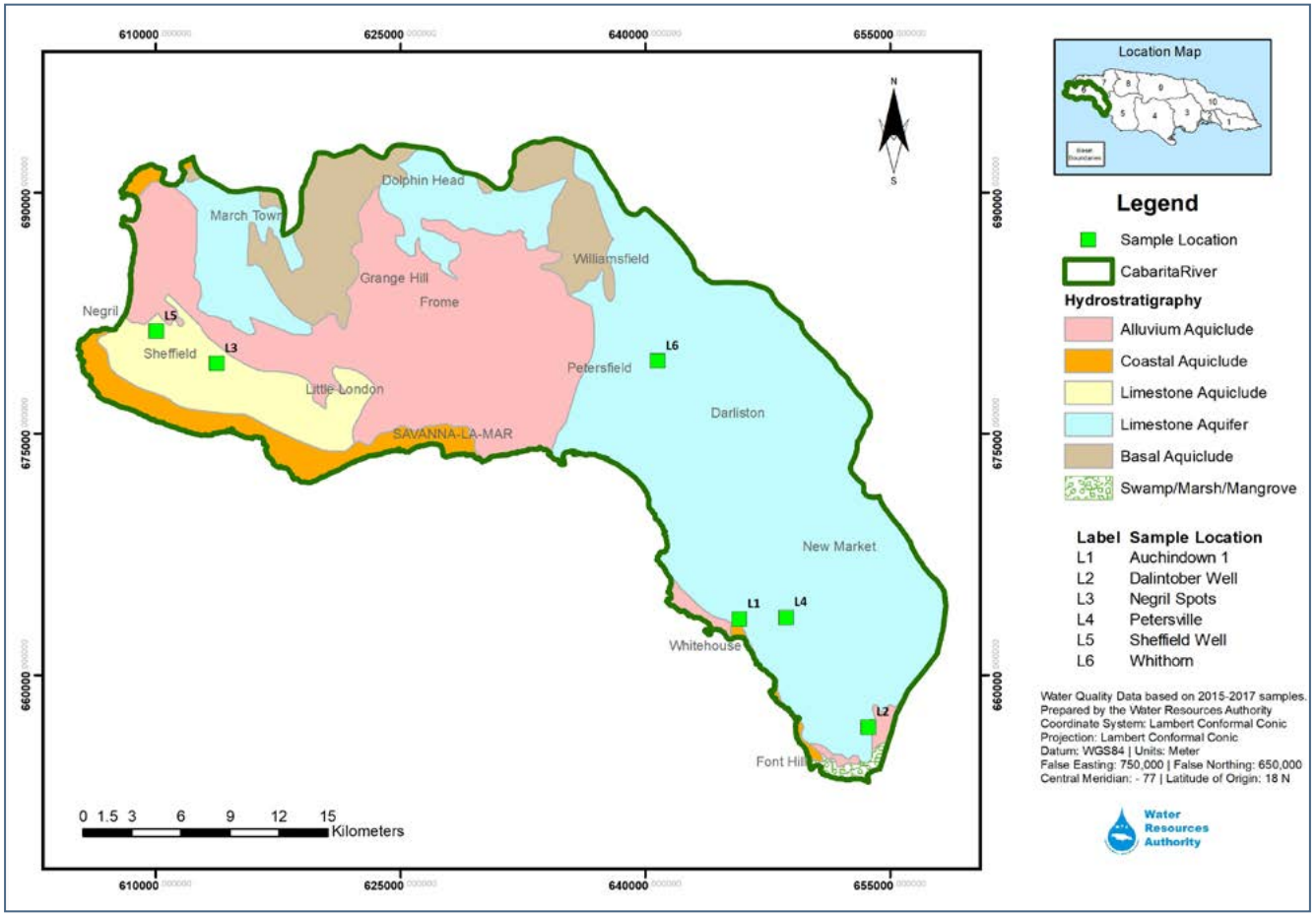


Figure 90: Cabarita River Hydrologic Basin Groundwater Sample Locations

Figure 88 shows the location of the six (6) ground water sampling points. All six (6) sources are classified as limestone wells.

Cabarita River Hydrologic Basin Nitrate Levels in Groundwater

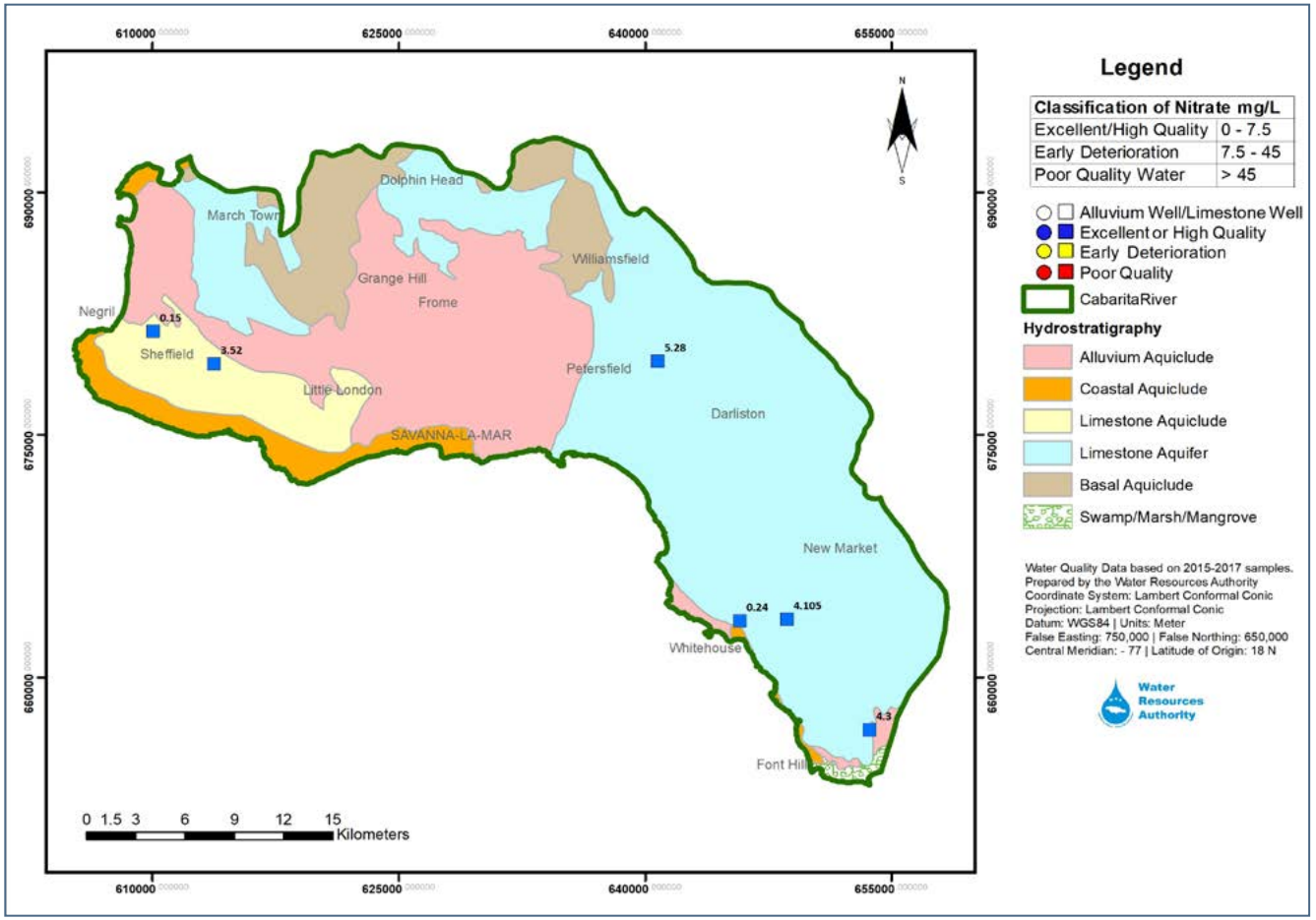
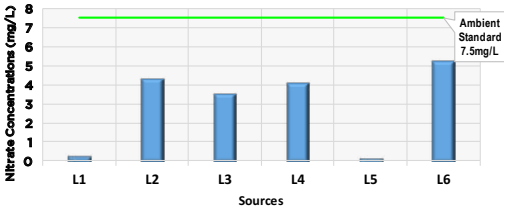


Figure 91: Cabarita River Hydrologic Basin Nitrate Levels in Groundwater

CABARITA RIVER HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 51: Cabarita River Basin Nitrate Levels in Groundwater

Figure 91 and Graph 51, indicated predominantly excellent water quality for nitrate for the well sources within the Cabarita basin. All the sources (100%) sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L.

Cabarita River Hydrologic Basin Sodium Levels in Groundwater

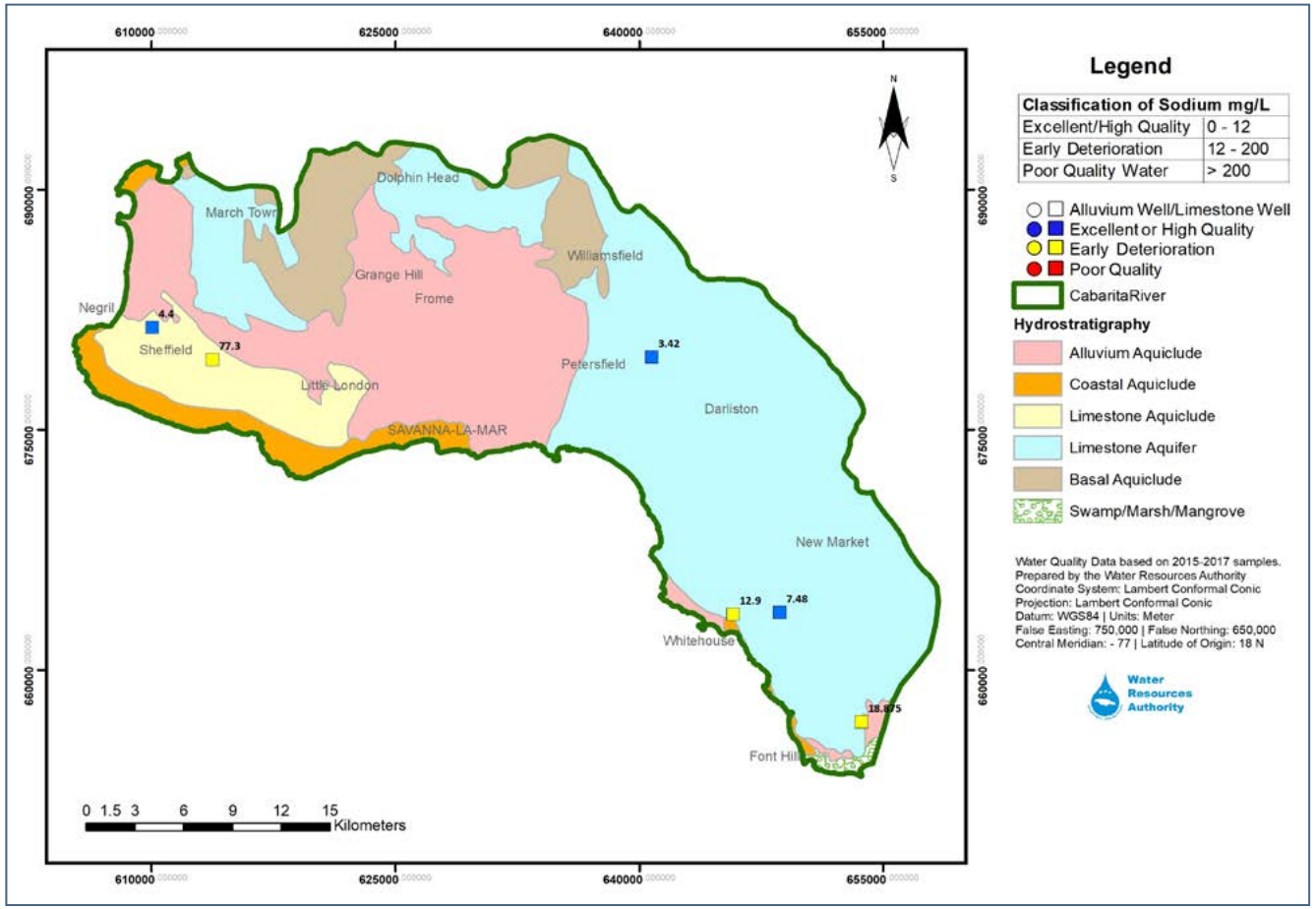
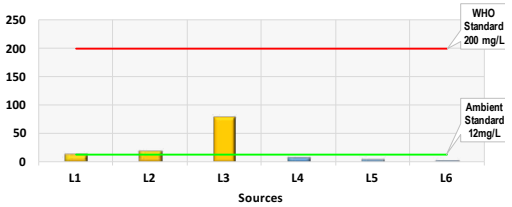


Figure 92: Cabarita River Hydrologic Basin Sodium Levels in Groundwater

CABARITA RIVER HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 52: Cabarita River Basin Sodium Levels in Groundwater

As indicated in Figure 92 and Graph 52, the well sources within the Cabarita basin indicated excellent and early warning water quality for nitrate. Fifty percent (50%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 12mg/L. The remaining fifty percent (50%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L.

Cabarita River Hydrologic Basin Chloride Levels in Groundwater

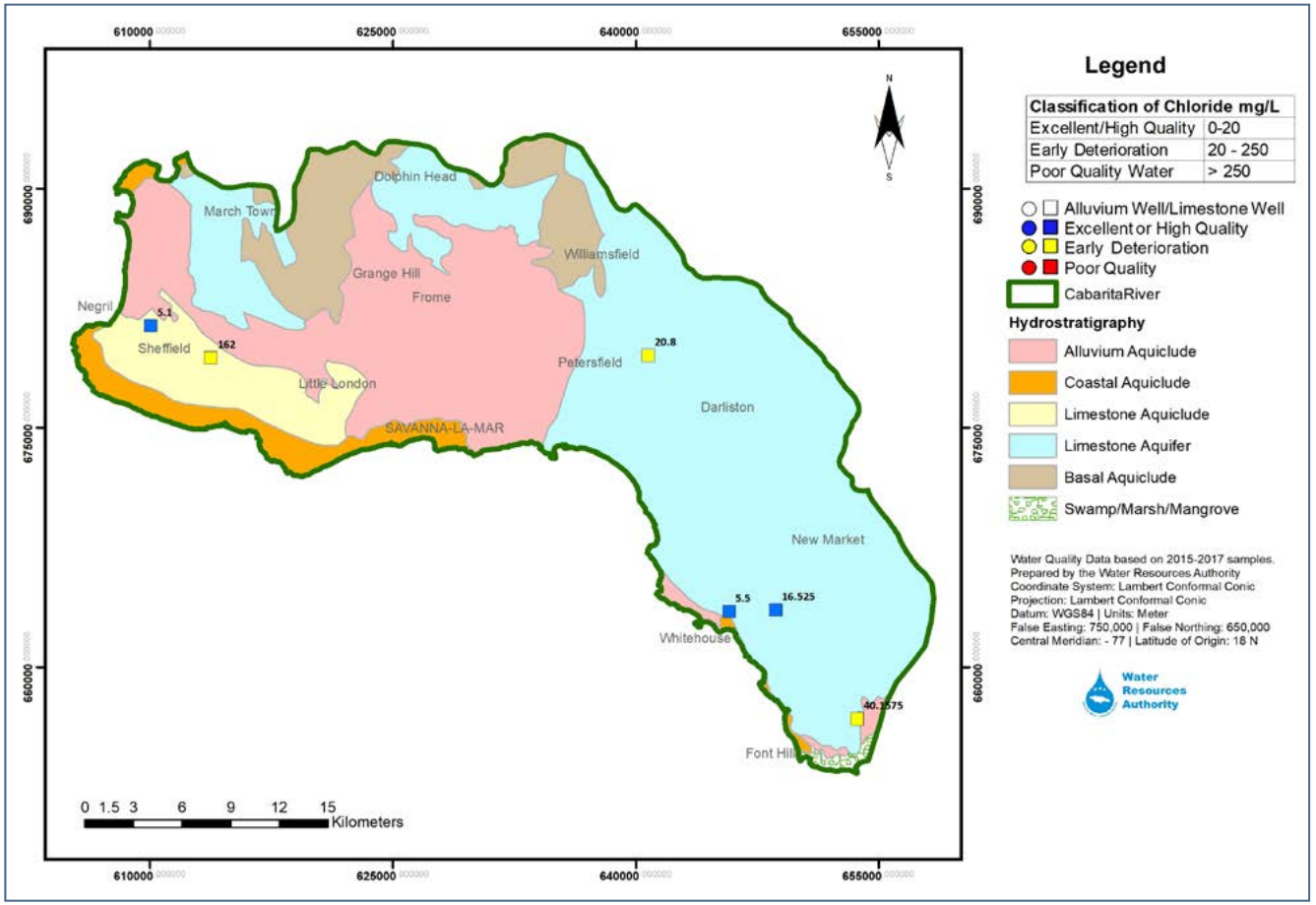
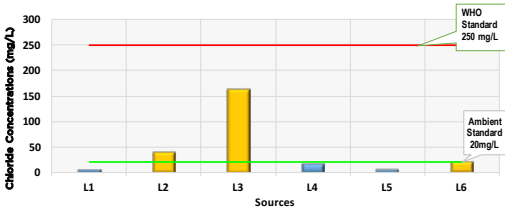


Figure 93: Cabarita River Hydrologic Basin Chloride Levels in Groundwater

CABARITA RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 53: Cabarita River Basin Chloride Levels in Groundwater

As shown in Figure 93 and Graph 53, the well sources within the Cabarita basin indicated excellent and early deterioration water quality for chloride. Fifty percent (50%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 20mg/L (the Sheffield, Auchindown 1 and Petersville wells). The remaining fifty percent (50%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 20mg/L.

Cabarita River Hydrologic Basin Sulphate Levels in Groundwater

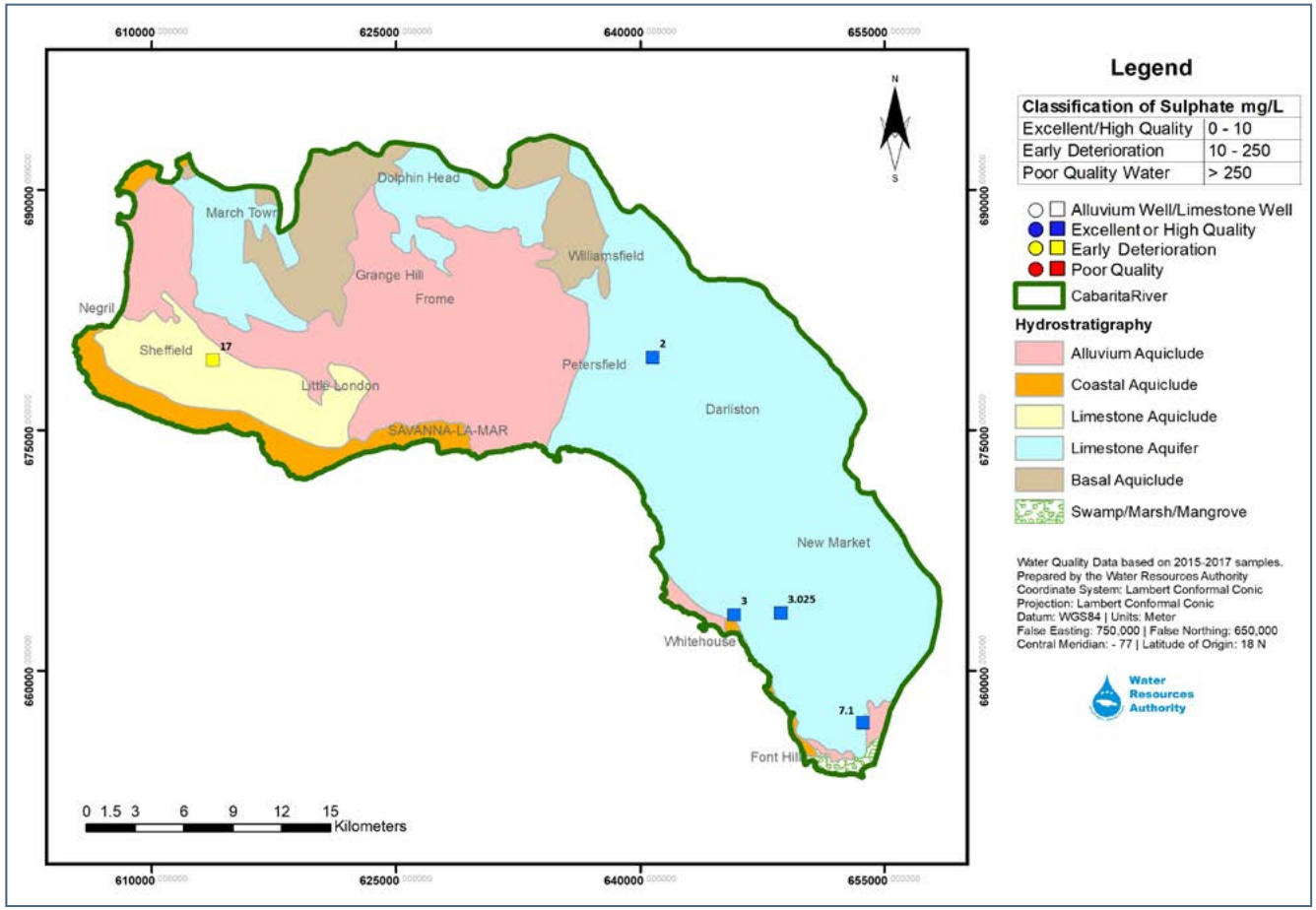
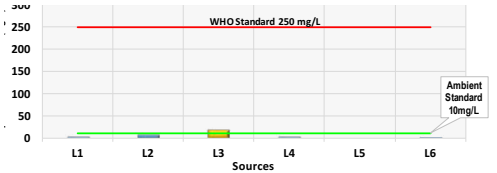


Figure 94: Cabarita River Hydrologic Basin Sulphate Levels in Groundwater

CABARITA RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 54: Cabarita River Basin Sulphate Levels in Groundwater

The well sources within the Cabarita basin predominantly indicated excellent water quality for sulphate as shown in Figure 94 and Graph 54. Sixty-seven percent (67%) of the sources sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L. Whilst seventeen percent (17%) indicated sulphate levels in excess of the National Ambient Water Quality Standard of 12mg/L.

Cabarita River Hydrologic Basin TDS Levels in Groundwater

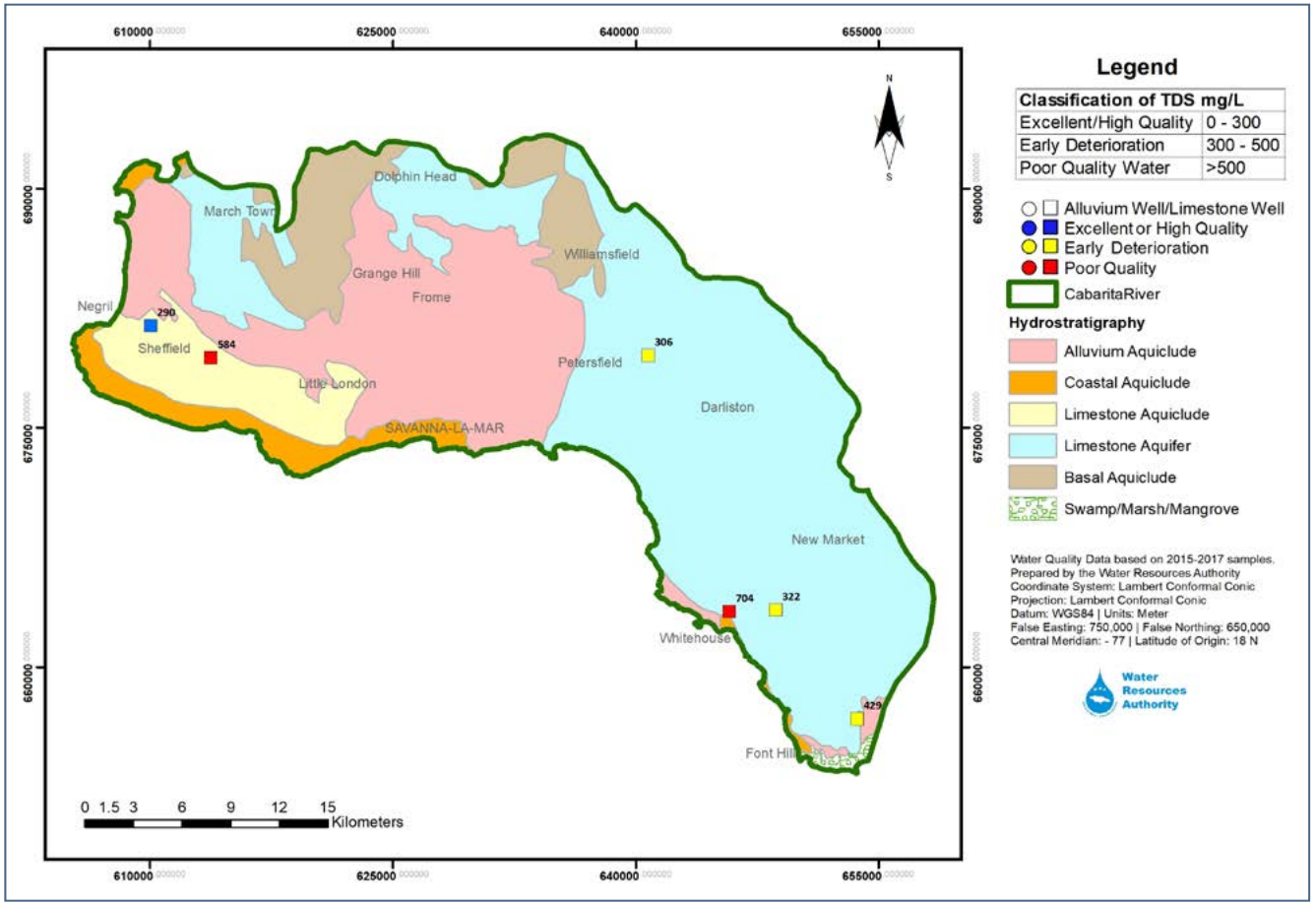
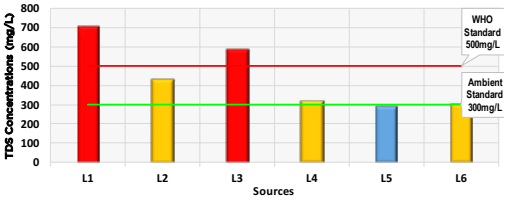


Figure 95: Cabarita River Hydrologic Basin TDS Levels in Groundwater

CABARITA RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 55: Cabarita River Basin TDS Levels in Groundwater

As shown in Figure 95 and Graph 55, the well sources within the Cabarita basin indicated predominantly early warning water quality for TDS. Fifty percent (50%) of the sources sampled indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Thirty-three percent (33%) of the sources indicated poor water quality for TDS (Negril Spots and the Auchindown 1 wells). Seventeen percent (17%) of the sources indicated TDS water quality within the National Ambient Water Quality Standard of 300mg/L (Sheffield well).

Cabarita River Hydrologic Basin Surface Water Sample Locations

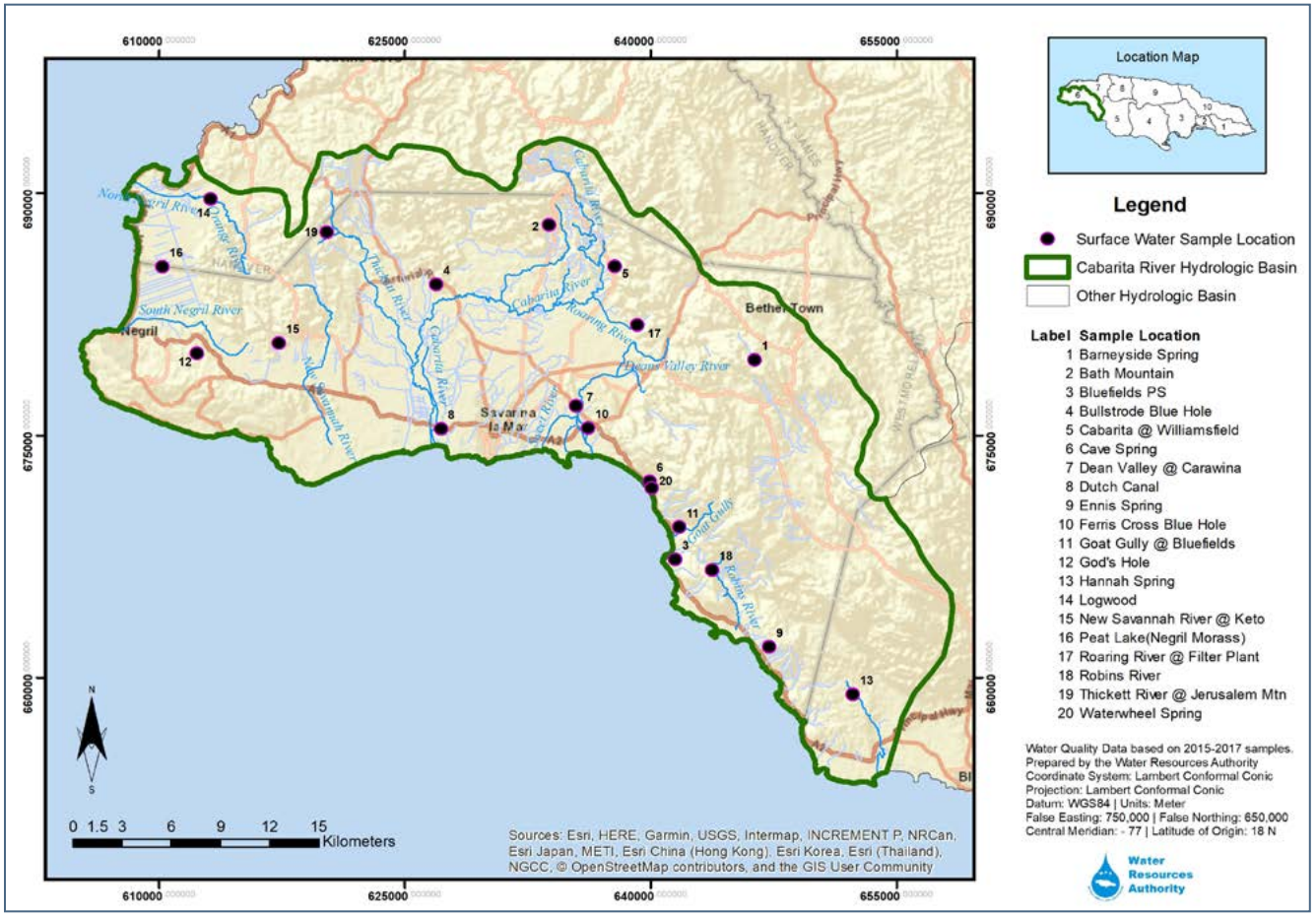


Figure 96: Cabarita River Hydrologic Basin Surface Water Sample Locations

Figure 96 shows the location of the twenty (20) surface water sampling points utilized in the surface water analyses for the Carbarita Basin.

Cabarita River Hydrologic Basin Nitrate Levels in Surface Water

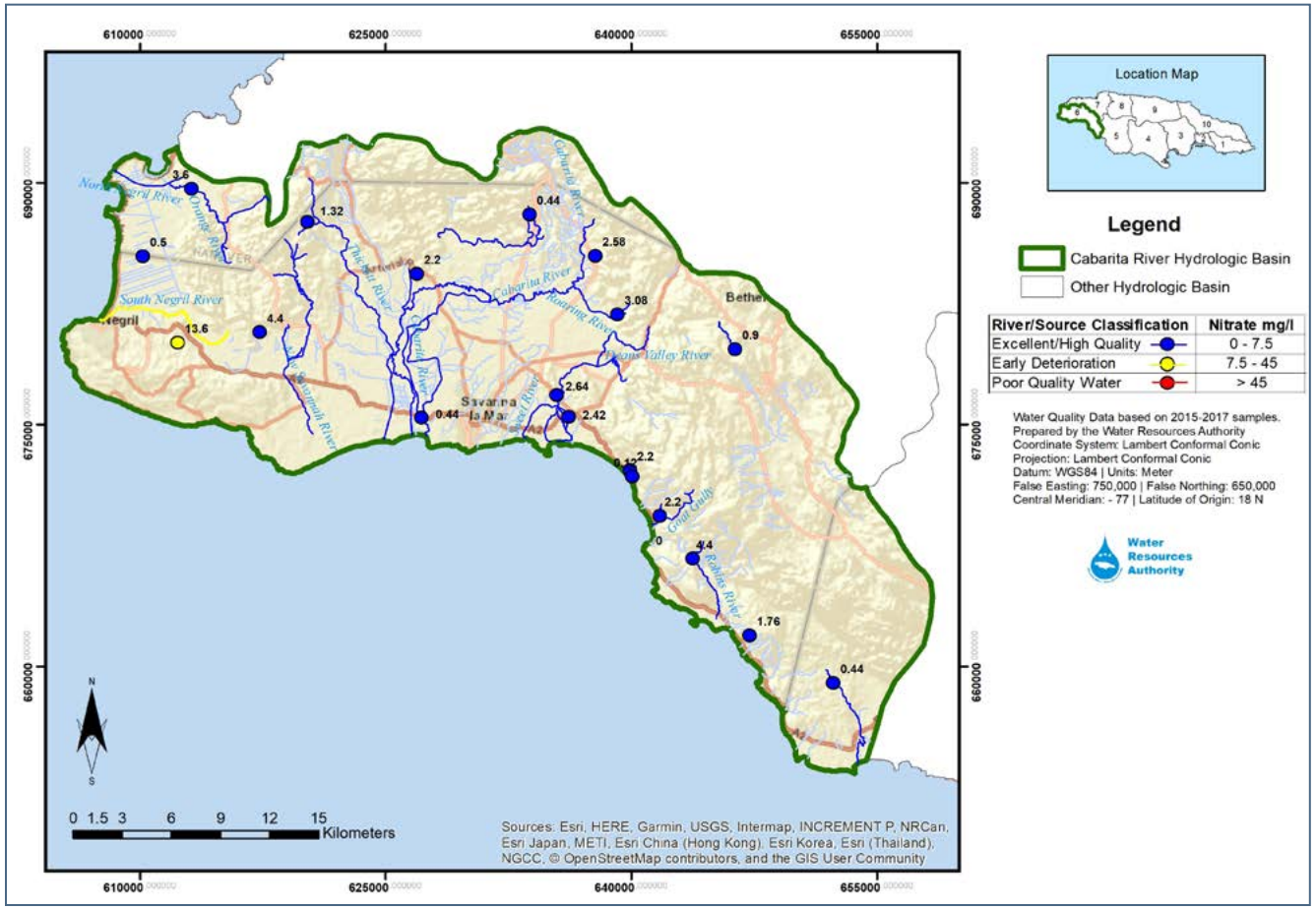
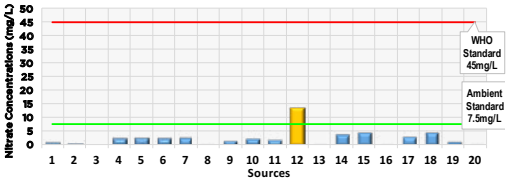


Figure 97: Cabarita River Hydrologic Basin Nitrate Levels in Surface Water

CABARITA RIVER HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 56: Cabarita River Basin Nitrate Levels in Surface water

As shown in Figure 97 and Graph 56, the surface water sources within the Cabarita basin predominantly indicated excellent water quality for nitrate. Ninety-five percent (95%) of the sources sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L. the remaining five percent (5%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L

Cabarita River Hydrologic Basin Sodium Levels in Surface Water

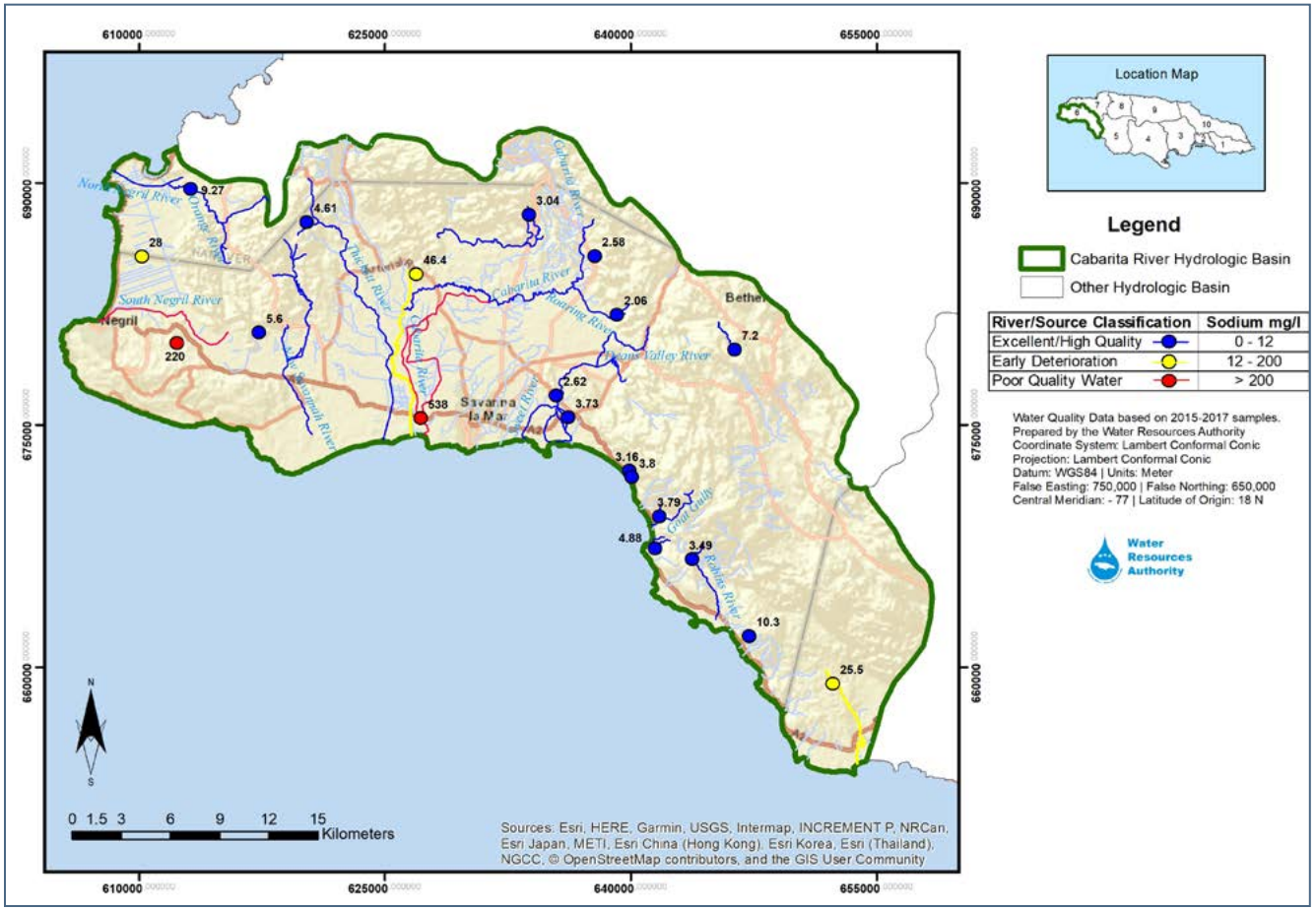
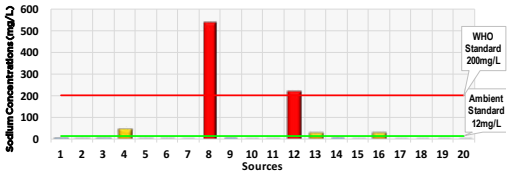


Figure 98: Cabarita River Hydrologic Basin Sodium Levels in Surface Water

CABARITA RIVER HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 57: Cabarita River Basin Sodium Levels in Surface water

As indicted in Figure 98 and Graph 57, the surface water sources within the Cabarita basin predominantly indicated excellent water quality for sodium. Seventy-five percent (75%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 12mg/L. Fifteen percent (15%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L. And ten percent (10%) of the sources indicated poor water quality for sodium

Cabarita River Hydrologic Basin Chloride Levels in Surface Water

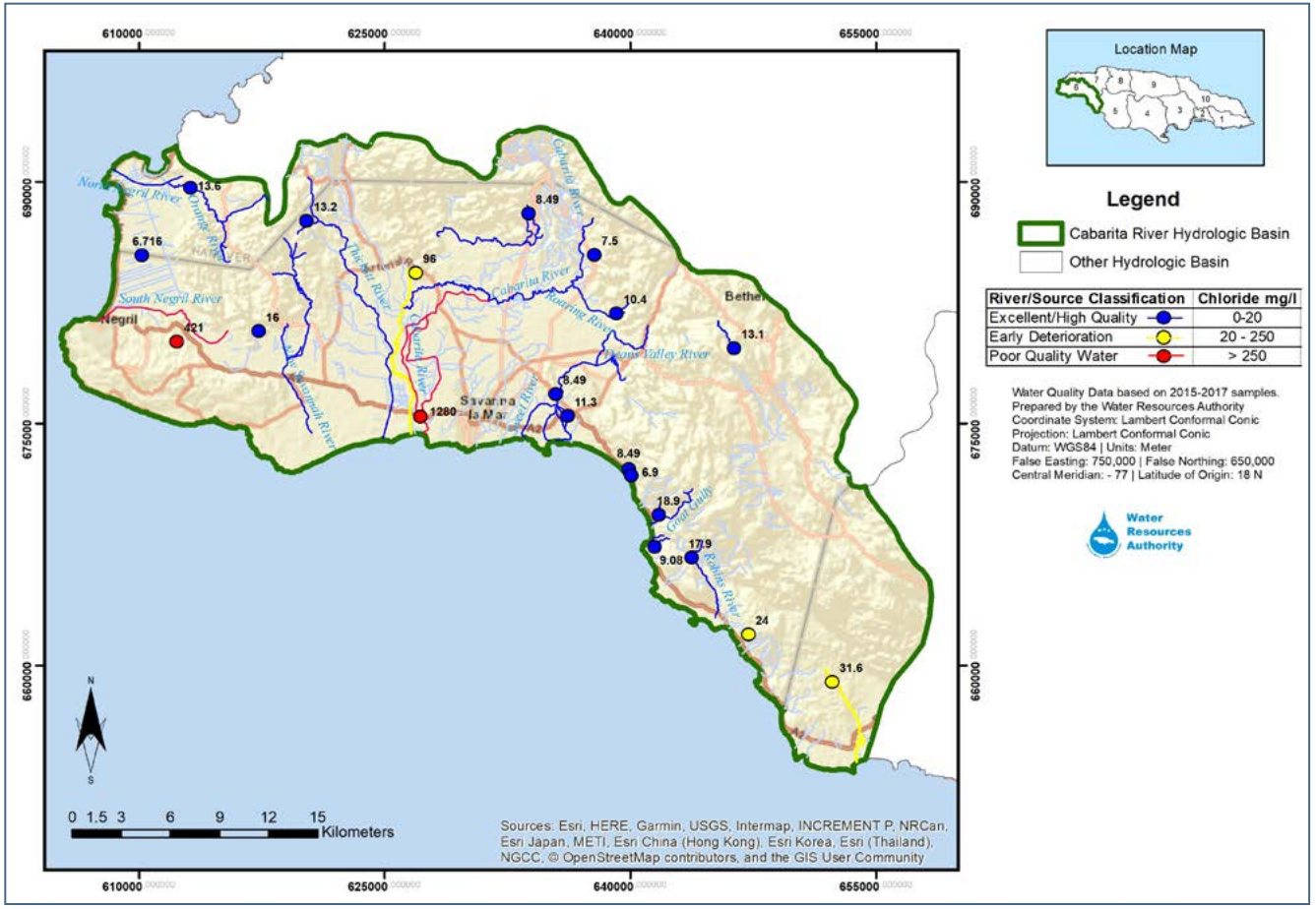
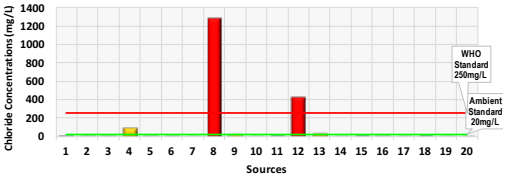


Figure 99: Cabarita River Hydrologic Basin Chloride Levels in Surface Water

CABARITA RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 58: Cabarita River Basin Chloride Levels in Surface water

The surface water sources within the Cabarita basin predominantly indicated excellent water quality for chloride as shown in Figure 99 and Graph 58. Seventy-five percent (75%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 20mg/L. Fifteen percent (15%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L And ten percent (10%) of the sources indicated poor water quality for chloride

Cabarita River Hydrologic Basin Sulphate Levels in Surface Water

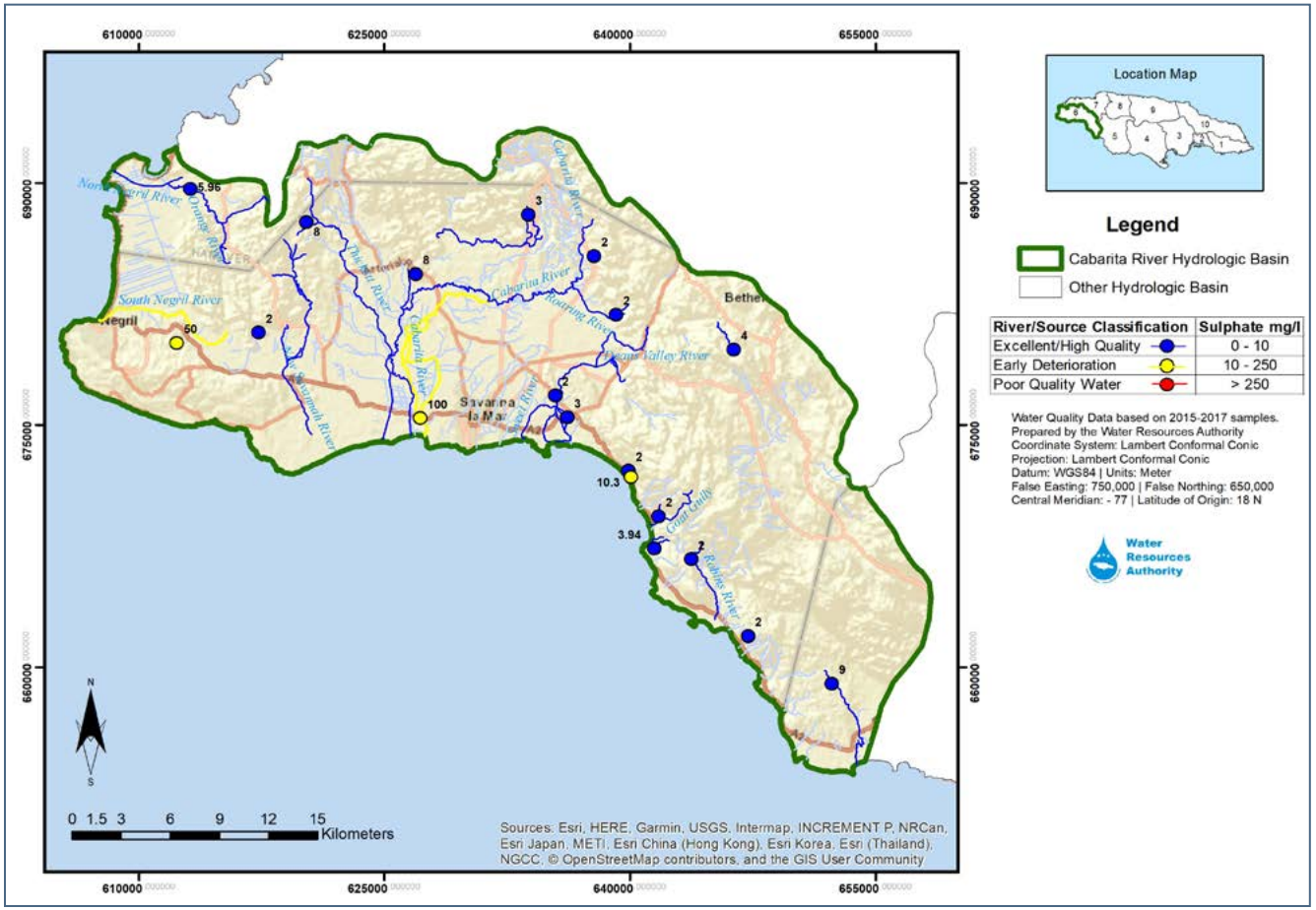
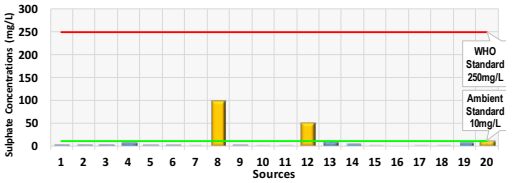


Figure 100: Cabarita River Hydrologic Basin Sulphate Levels in Surface Water

CABARITA RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 59: Cabarita River Basin Sulphate Levels in Surface water

The surface water sources within the Cabarita basin predominantly indicated excellent water quality for sulphate as shown in Figure 100 and Graph 59. Eighty-five percent (85%) of the sources sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L. Whilst fifteen percent (15%) indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L

Cabarita River Hydrologic Basin TDS Levels in Surface Water

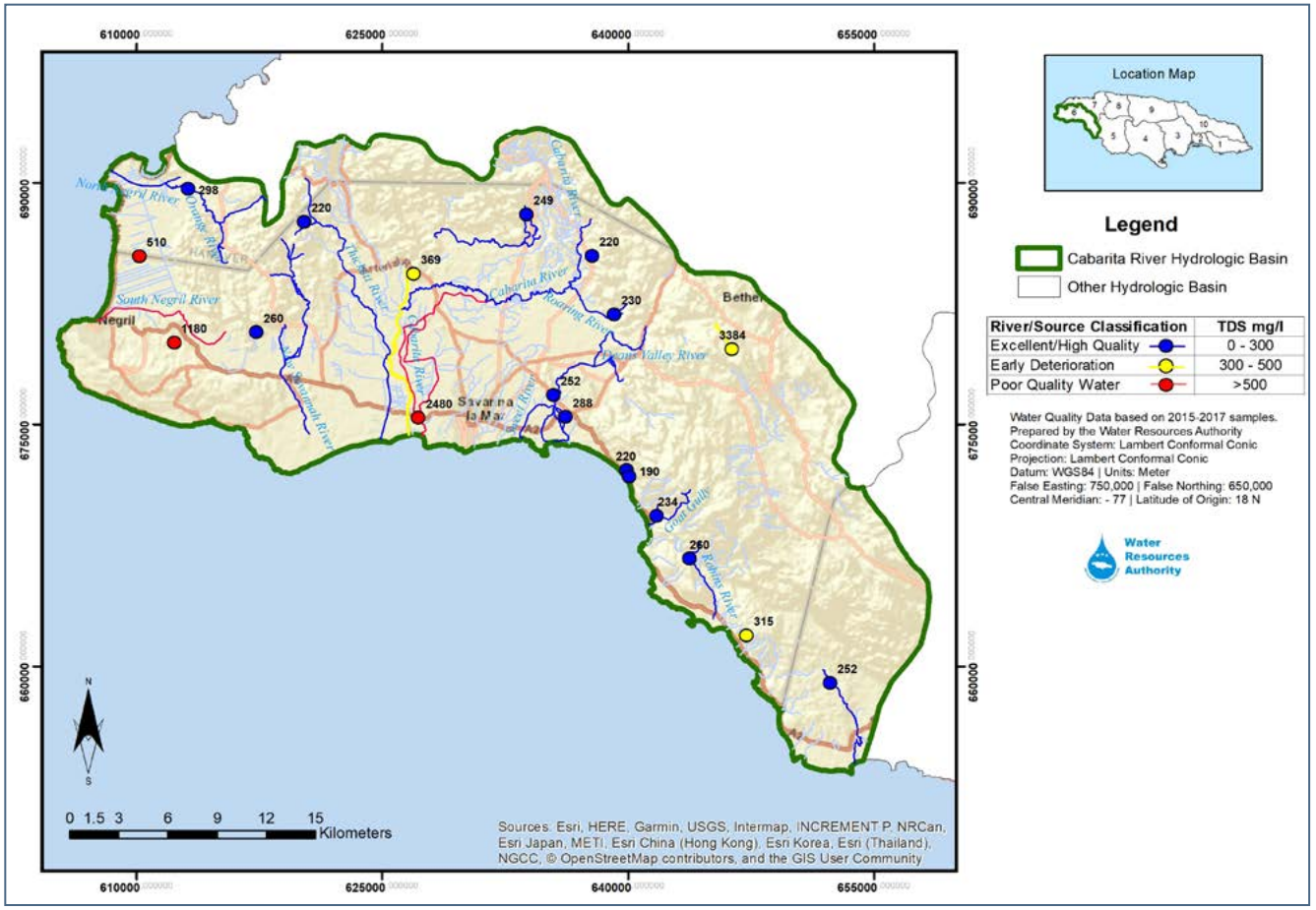
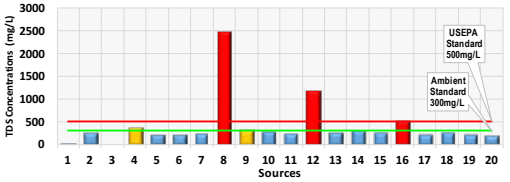


Figure 101: Cabarita River Hydrologic Basin TDS Levels in Surface Water

CABARITA RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 60: Cabarita River Basin TDS Levels in Surface water

As shown in Figure 101 and Graph 60, the surface water sources within the Cabarita basin predominantly indicated excellent water quality for TDS. Seventy percent (70%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 300mg/L. Fifteen percent (15%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Fifteen percent (15%) of the sources indicated poor water quality for sodium

7.0 Basin VII Great River Hydrologic Basin

The Great River Hydrologic Basin includes the parishes of St. James and Hanover. For water management purposes Great River Hydrologic Basin has been divided into three Watershed Management Units (WMU): Lucea River, Great River, and Montego River. These WMUs are further divided into eight sub-WMUs: Green Island River, Lances River, Lucea West River, Mosquito Cove, Great River, Flint River, Montego River and Ironshore.

The water resources within the Great River basin are comprised of groundwater from limestone aquifers, and surface water from the rivers and springs that drain the eight sub-WMUs.

The majority of the basin is underlain by White Limestone with alluvial deposits sitting on top of it. There are also geological structures known as inliers present in the basin. Geological inliers are an area of older rocks surrounded by younger rocks; the Lucea and Green Island inliers are located to the west of the basin where Cretaceous volcanic rocks are surrounded by the younger white limestone. The basin is drained primarily to the north by three major rivers, Montego River, Great River and Lucea River which drain towards the coast, traversing over basement aquiclude in the south and west, limestone aquiclude in the north, limestone aquifer in the central, eastern central and western sections of the basin. The Great River also drains the western section of the Cockpit Country.

The groundwater quality was analysed with the results from nine limestone wells and the surface water analyses was done utilizing twenty (20) sources.

Great River Hydrologic Basin Groundwater Sample Locations

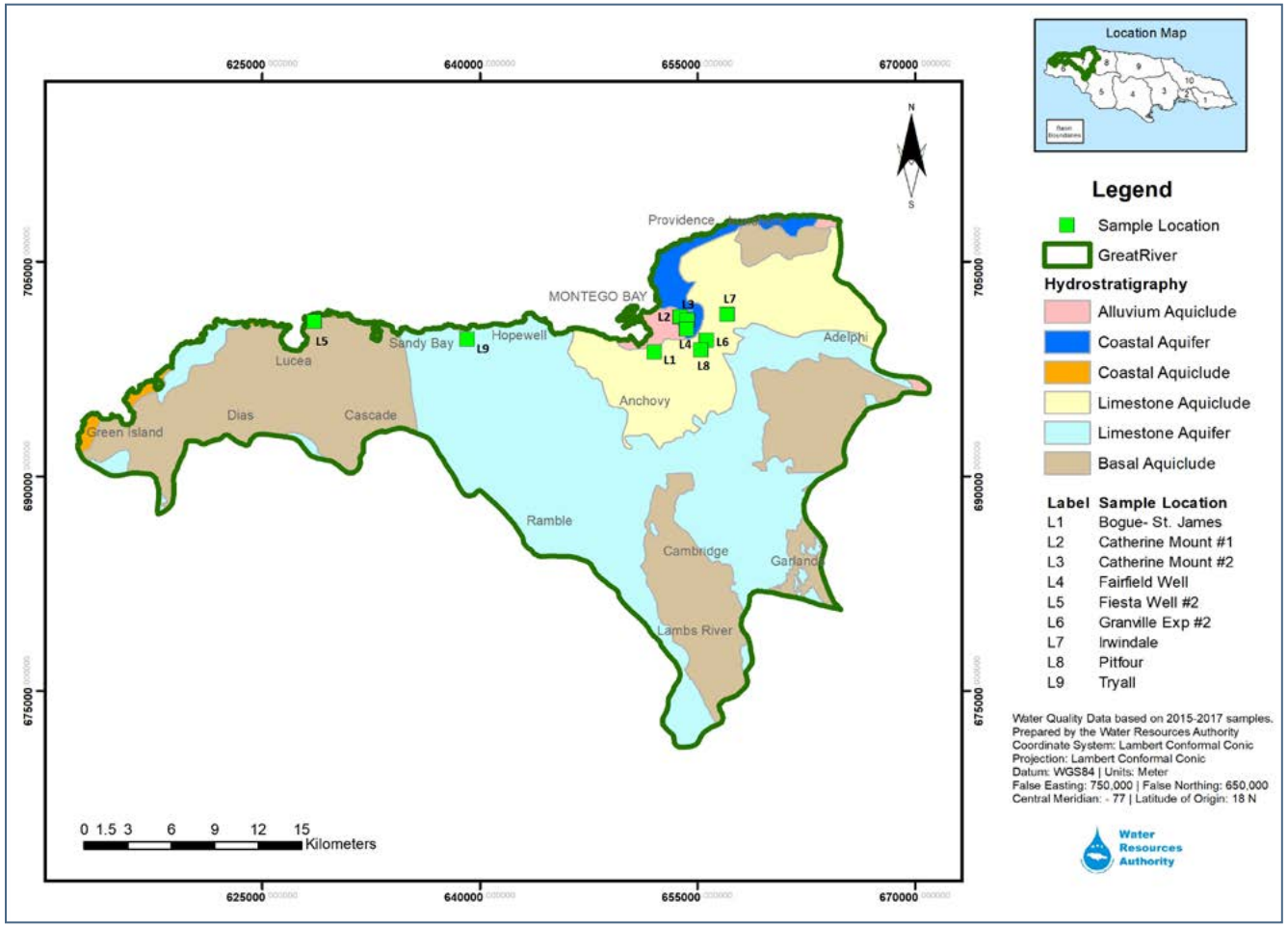


Figure 102: Great River Hydrologic Basin Groundwater Sample Locations

Figure 102 shows the location of the nine (9) ground water sampling points. All nine (9) sources are classified as limestone wells.

Great River Hydrologic Basin Nitrate Levels in Groundwater

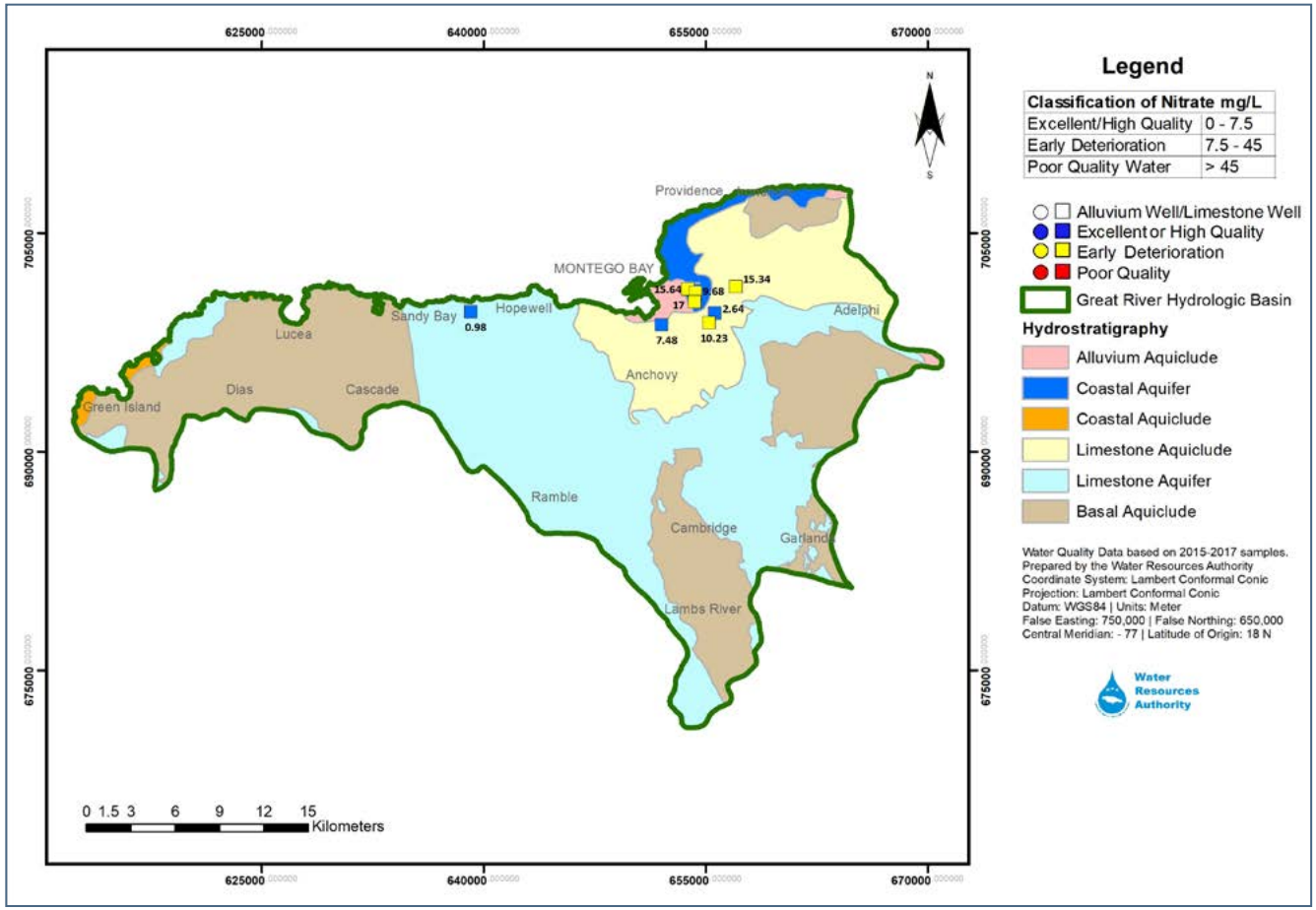
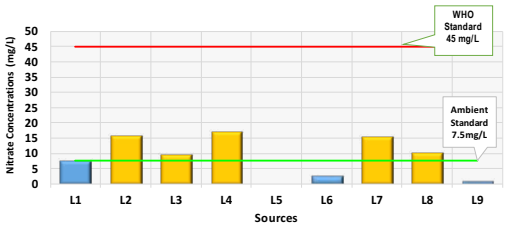


Figure 103: Great River Hydrologic Basin Nitrate Levels in Groundwater

GREAT RIVER HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 61: Great River Basin Nitrate Levels in Groundwater

Figure 103 and Graph 61 show that the well sources within the Great River basin predominantly indicated early deterioration water quality for nitrate. Fifty-six percent (56%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L. Thirty-three percent (33%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 7.5mg/L. The wells that indicated early deterioration water quality are those located east of Montego Bay.

Great River Hydrologic Basin Sodium Levels in Groundwater

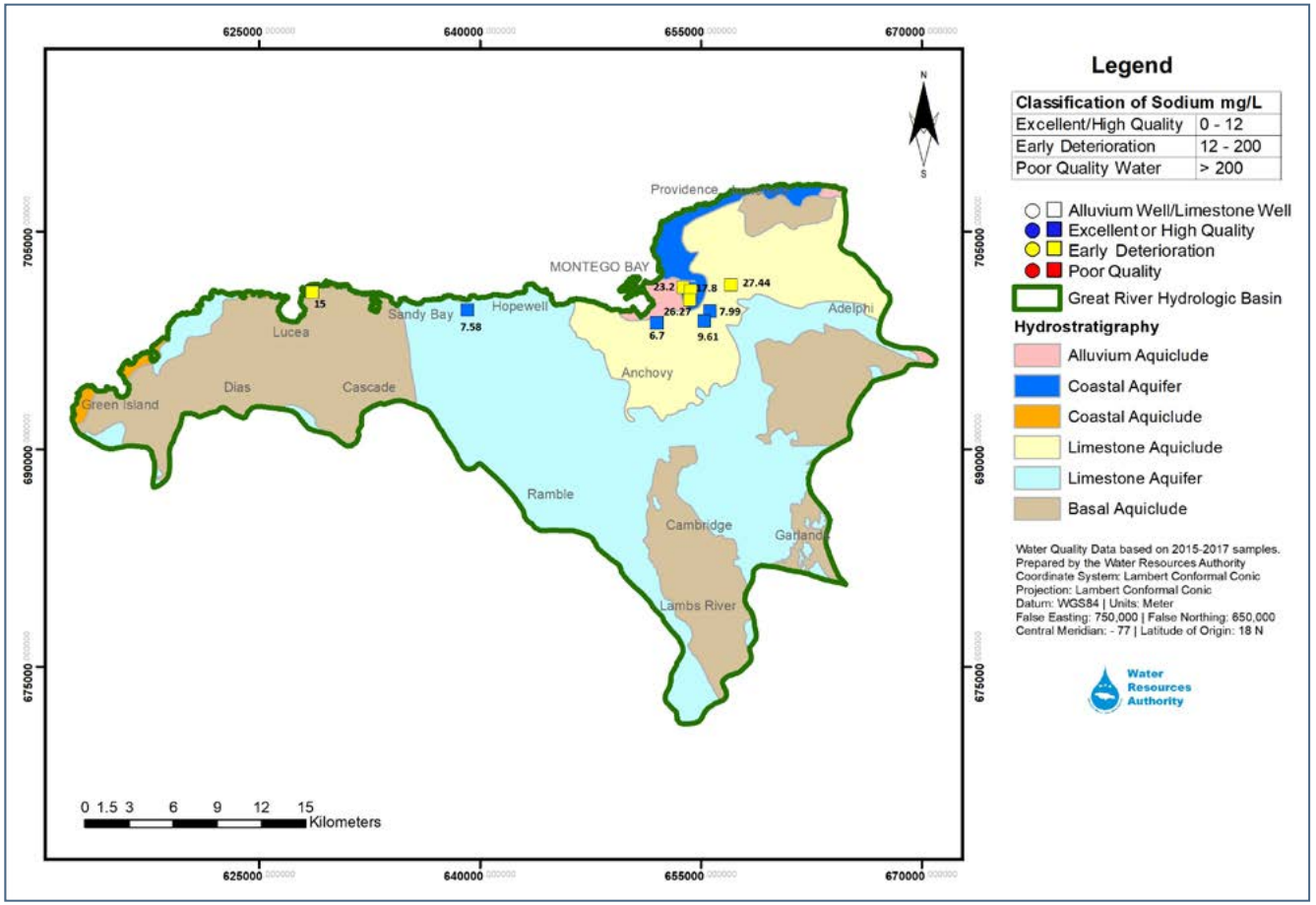
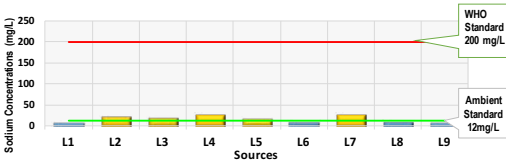


Figure 104: Great River Hydrologic Basin Sodium Levels in Groundwater

GREAT RIVER HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 62: Great River Basin Sodium Levels in Groundwater

Figure 104 and Graph 62 shows that the well sources within the Great River basin predominantly indicated early deterioration water quality for sodium. Fifty-six percent (56%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L. Forty-four percent (44%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 10mg/L. The wells that indicated early deterioration water quality are those located east of Montego Bay along with Fiesta 2 well in Lucea.

Great River Hydrologic Basin Chloride Levels in Groundwater

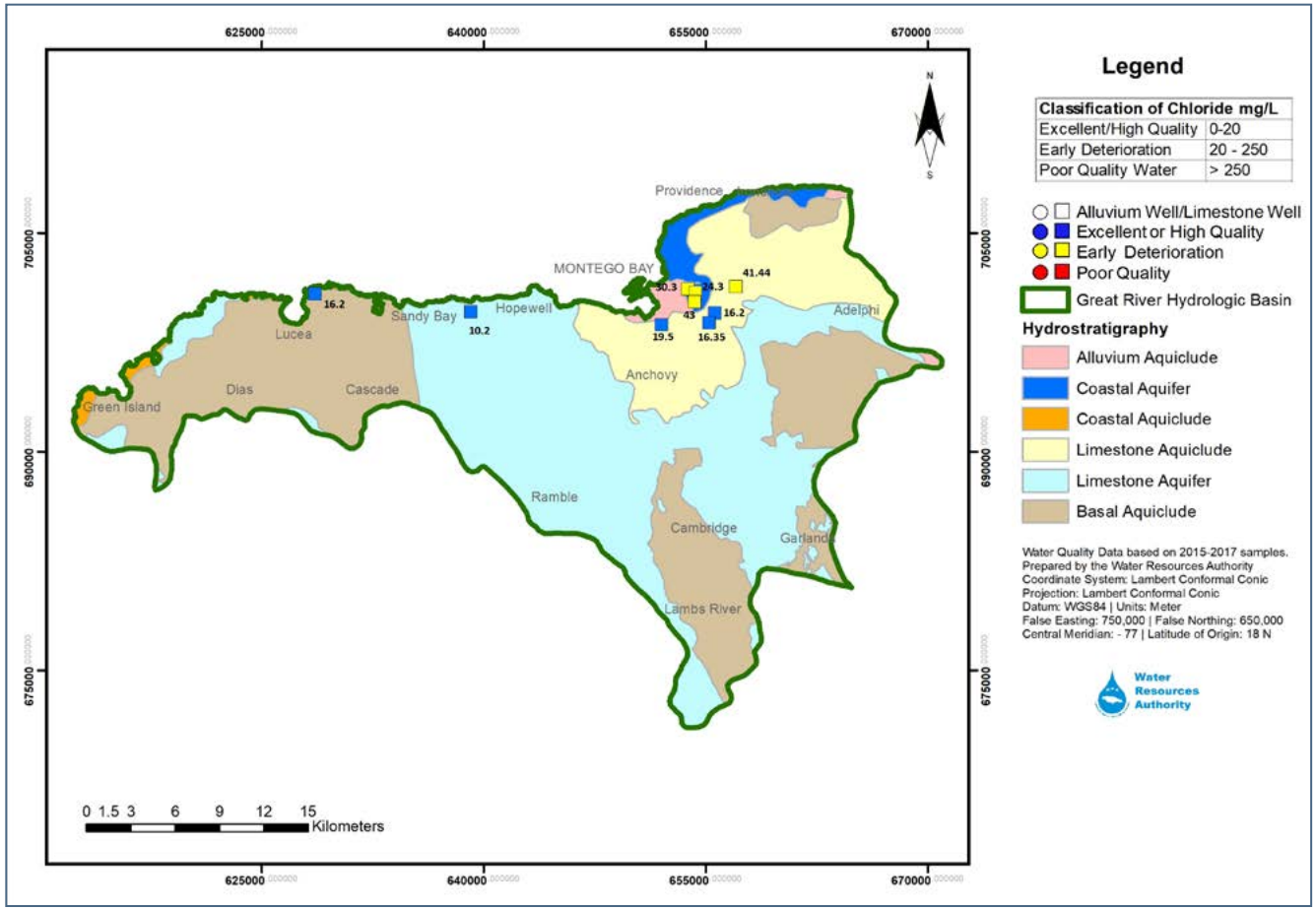
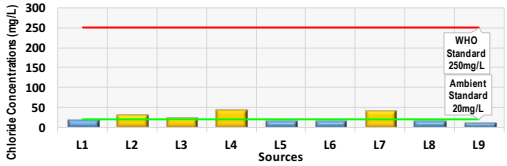


Figure 105: Great River Hydrologic Basin Chloride Levels in Groundwater

GREAT RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 63: Great River Basin Chloride Levels in Groundwater

The well sources within the Great River basin predominantly indicated excellent water quality for chloride as shown in Figure 105 and Graph 63. Fifty-six percent (56%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. Forty-four percent (44%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L. The wells that indicated early deterioration water quality are those located east of Montego Bay.

Great River Hydrologic Basin Sulphate Levels in Groundwater

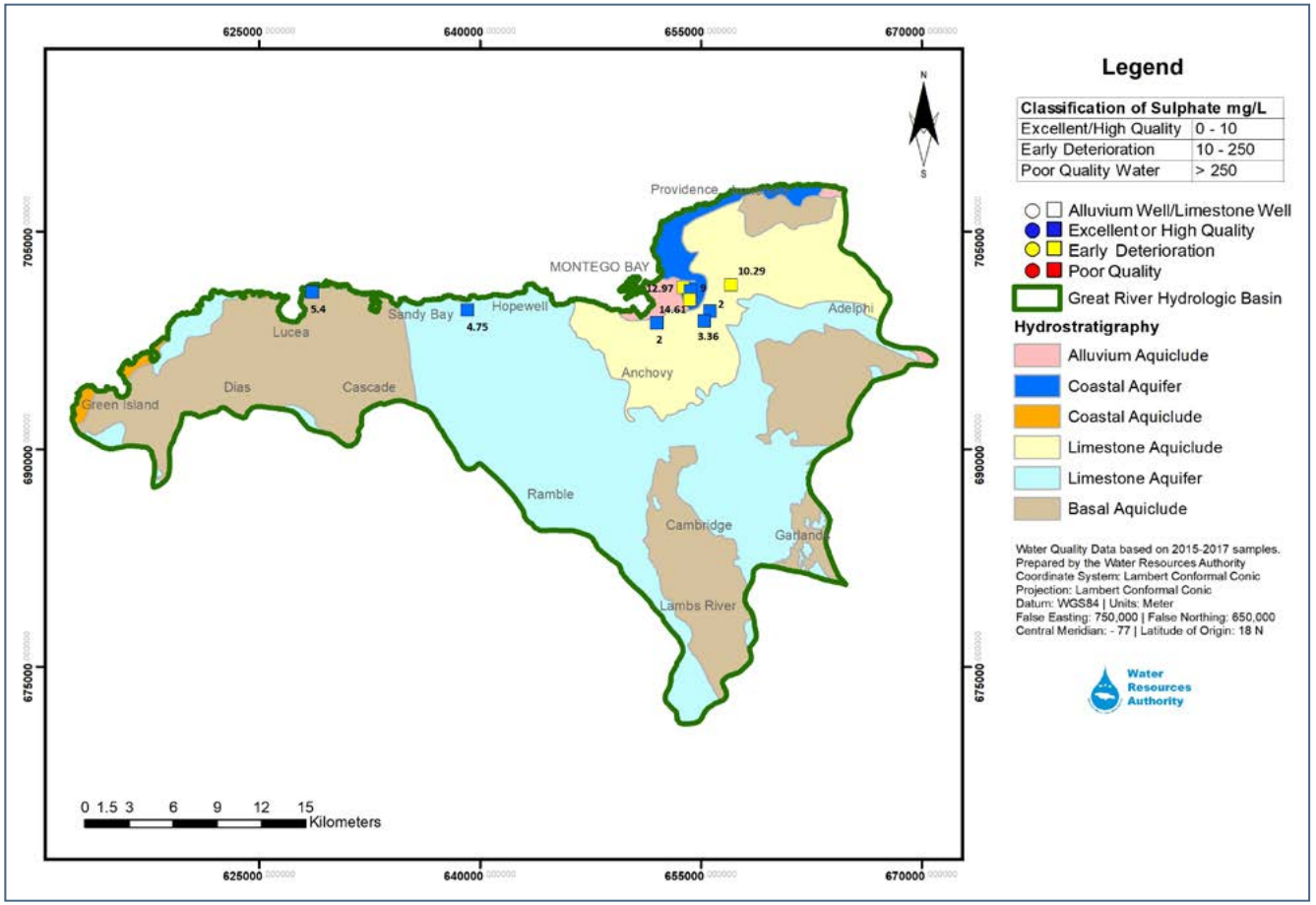
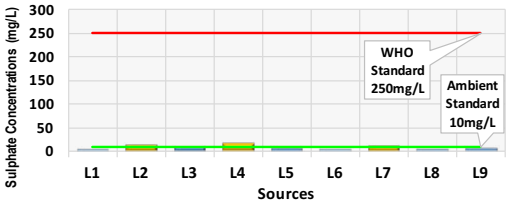


Figure 106: Great River Hydrologic Basin Sulphate Levels in Groundwater

GREAT RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 64: Great River Basin Sulphate Levels in Groundwater

The well sources within the Great River basin predominantly indicated excellent water quality for chloride as shown in Figure 106 and Graph 64. Fifty-six percent (56%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. Forty four percent (44%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L

Great River Hydrologic Basin TDS Levels in Groundwater

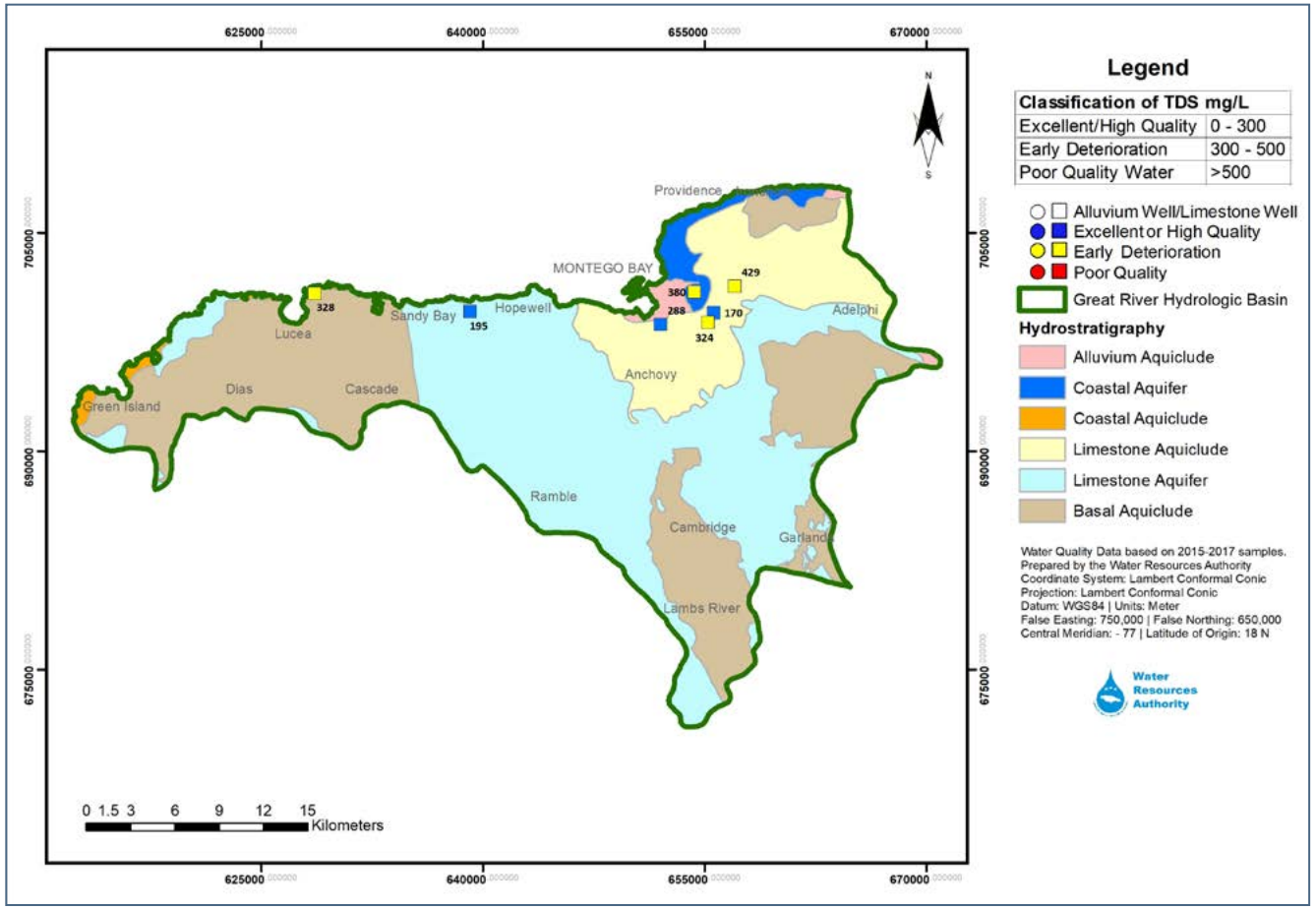
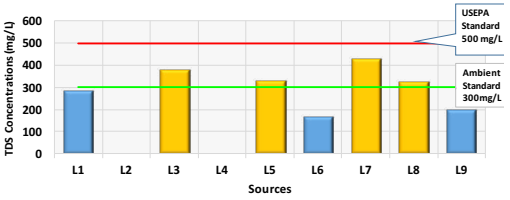


Figure 107: Great River Hydrologic Basin TDS Levels in Groundwater

GREAT RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 65: Great River Basin TDS Levels in Groundwater

As shown in Figure 107 and Graph 65, the well sources within the Great River basin predominantly indicated early deterioration water quality for TDS. Thirty-three percent (33%) of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. Forty-four percent (44%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard.

Great River Hydrologic Basin Groundwater Sample Locations

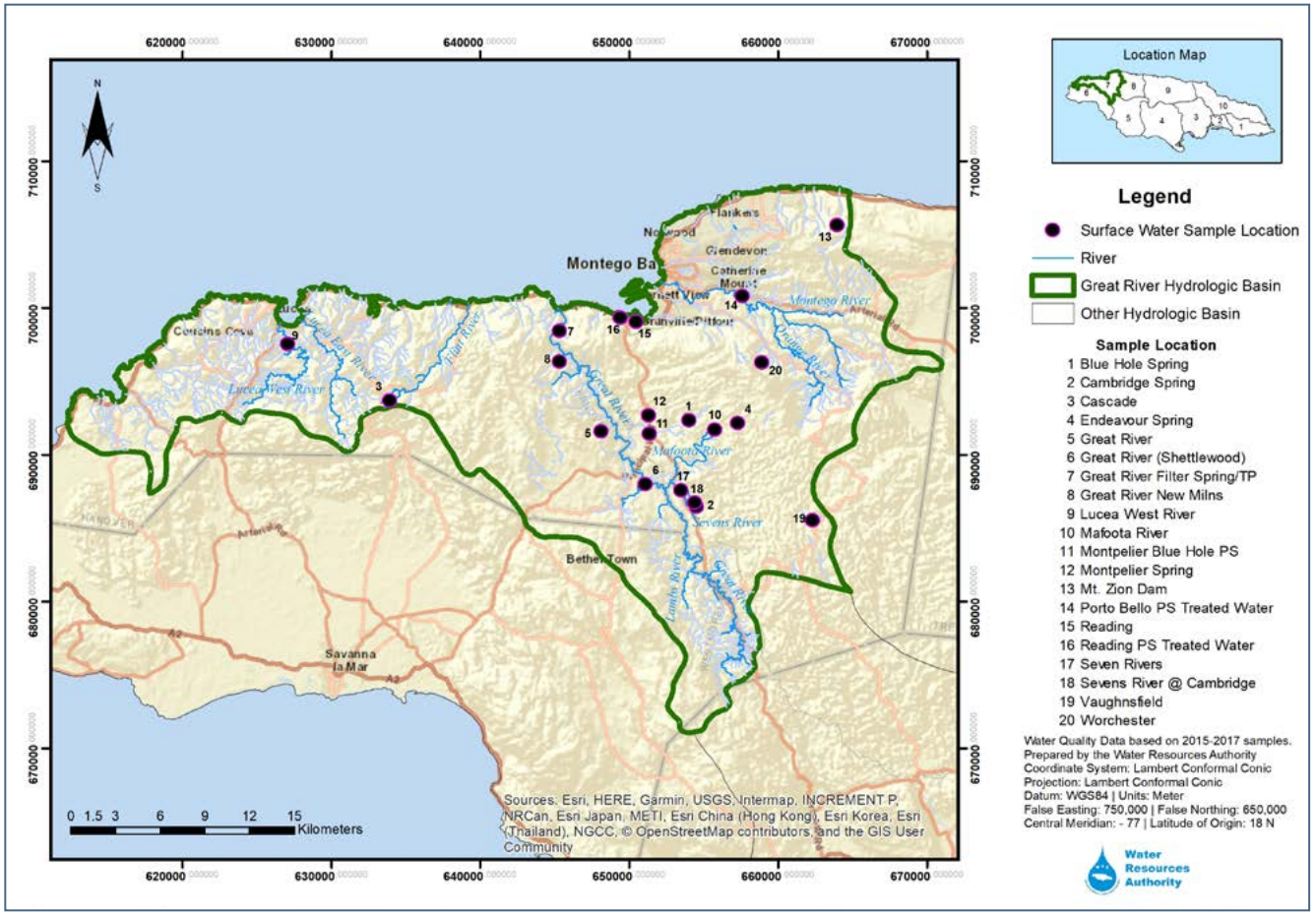


Figure 108: Great River Hydrologic Basin Surface Water Sample Locations

Figure 108 shows the location of the twenty (20) surface water sampling points utilized in the surface water analyses for the Great River Basin.

Great River Hydrologic Basin Nitrate Levels in Surface Water

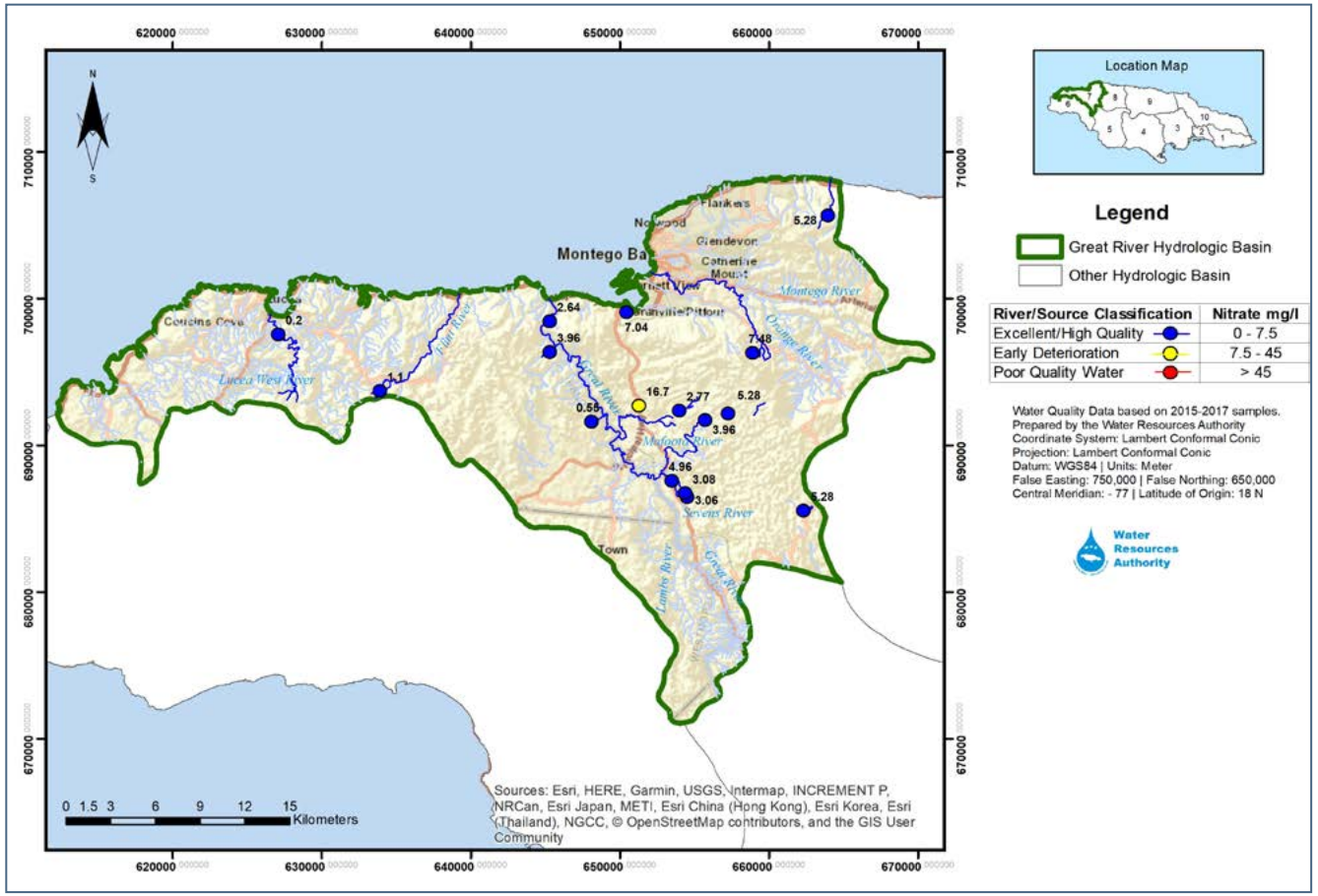
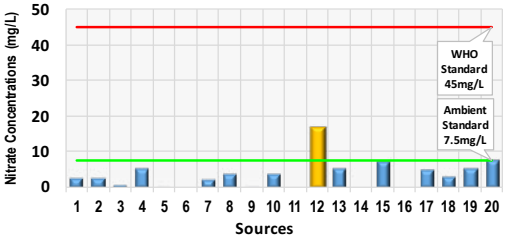


Figure 109: Great River Hydrologic Basin Nitrate Levels in Surface Water

GREAT RIVER HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 66: Great River Basin Nitrate Levels in Surface water

Figure 109 and Graph 66 shows that the surface water sources within the Great River basin predominantly indicated excellent water quality for nitrate. Ninety-five percent (95%) of the sources sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L. Five percent (5%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L

Great River Hydrologic Basin Sodium Levels in Surface Water

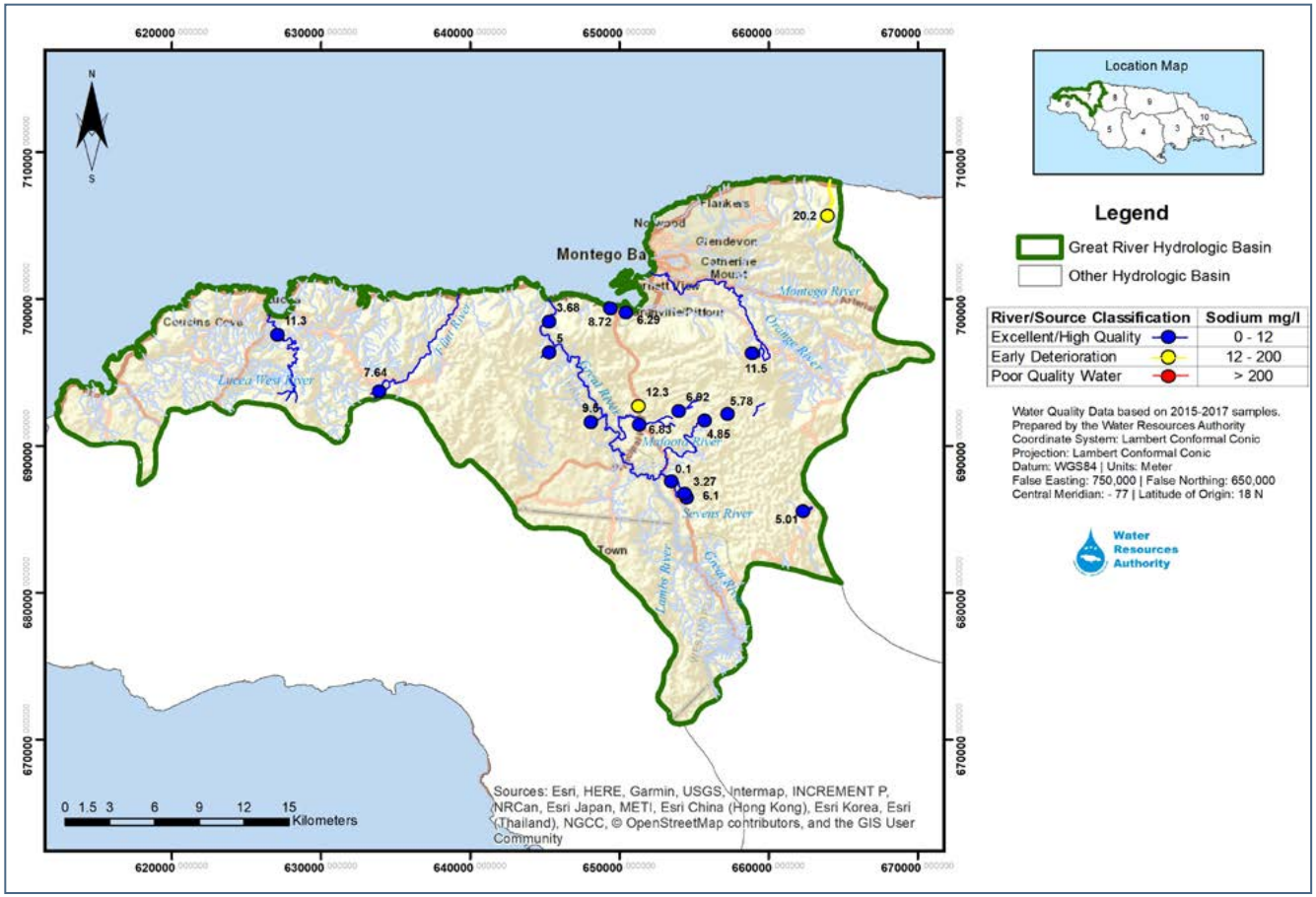
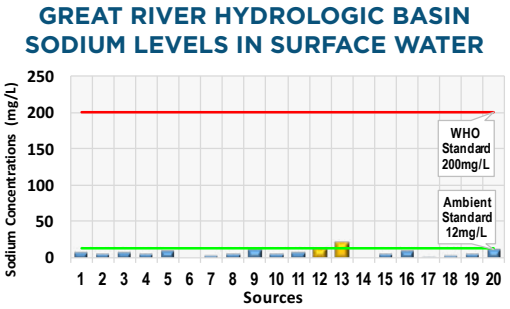


Figure 110: Great River Hydrologic Basin Sodium Levels in Surface Water



Graph 67: Great River Basin Sodium Levels in Surface water

As shown in Figure 110 and Graph 67, the surface water sources within the Great River basin predominantly indicated excellent water quality for chloride. Sixty percent (60%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. Twenty percent (20%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L. Five percent (5%) of the sources indicated poor water quality for sodium

Great River Hydrologic Basin Chloride Levels in Surface Water

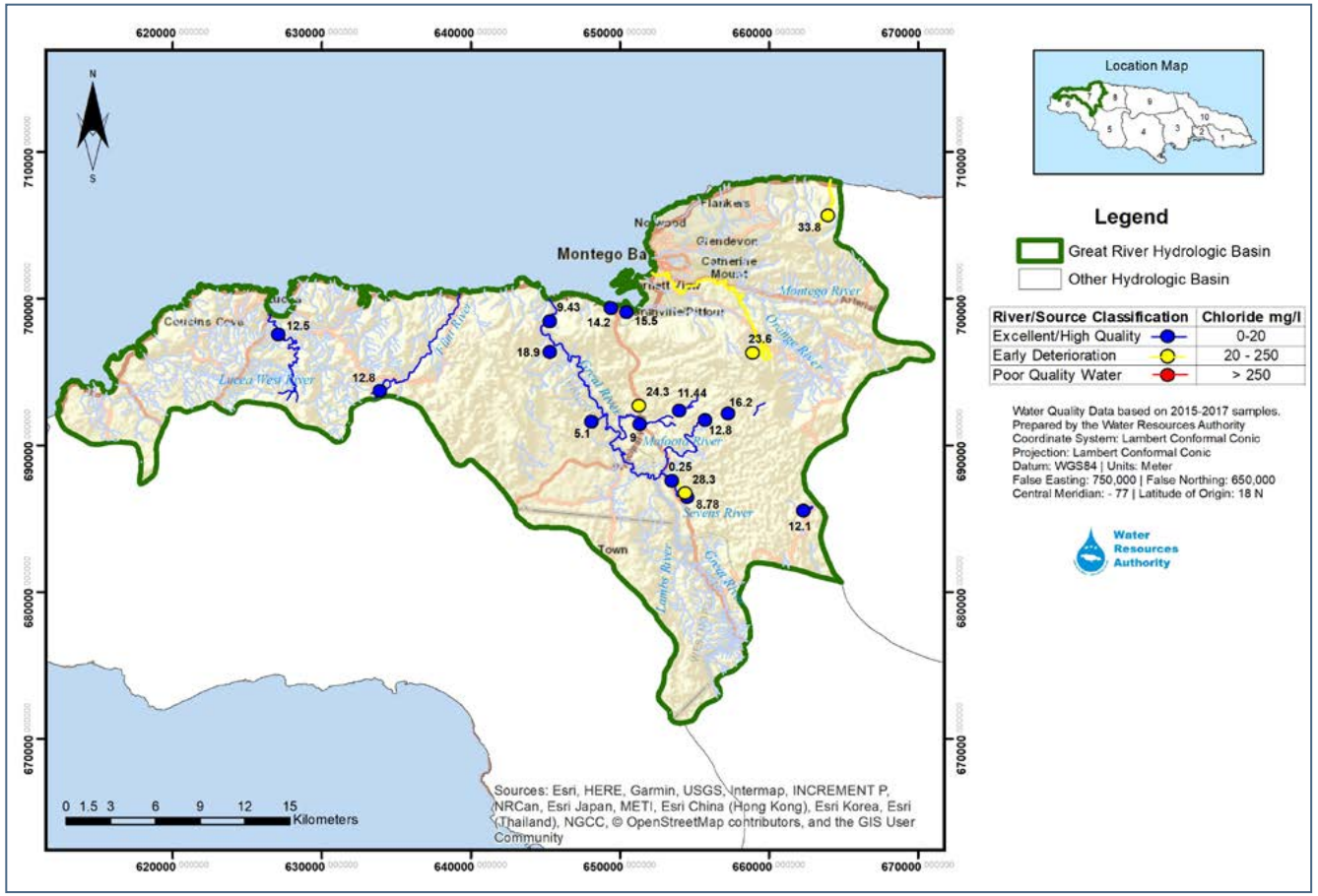
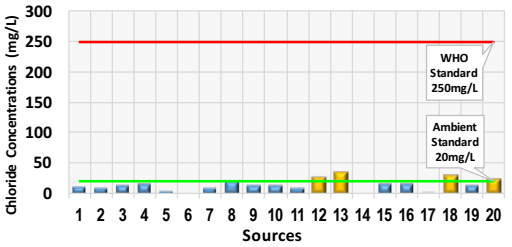


Figure 111: Great River Hydrologic Basin Chloride Levels in Surface Water

GREAT RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 68: Great River Basin Chloride Levels in Surface water

As shown in Figure 111 and Graph 68, the surface water sources within the Great Rivera basin predominantly indicated excellent water quality for chloride. Eighty percent (80%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. And twenty percent (20%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L

Great River Hydrologic Basin Sulphate Levels in Surface Water

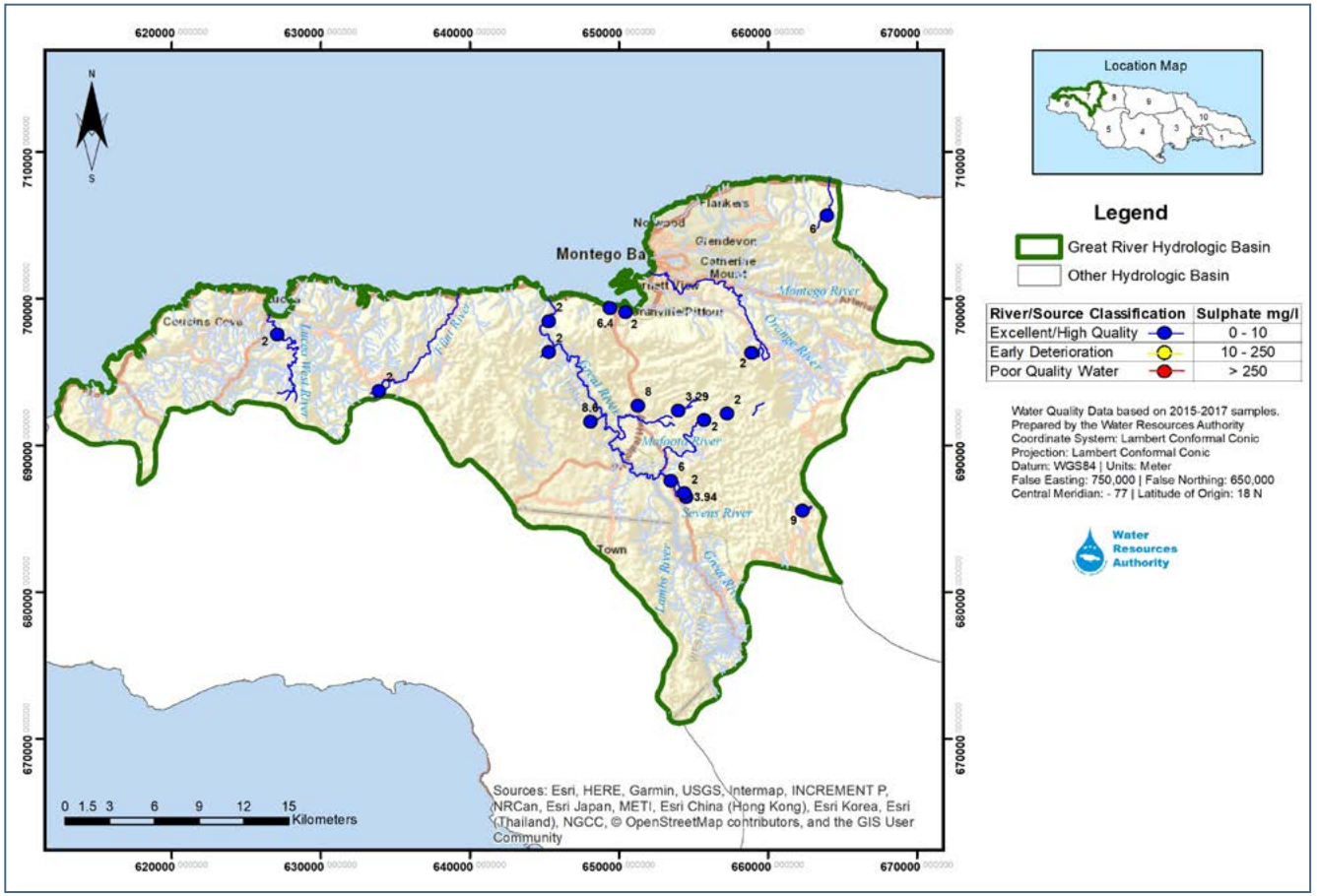
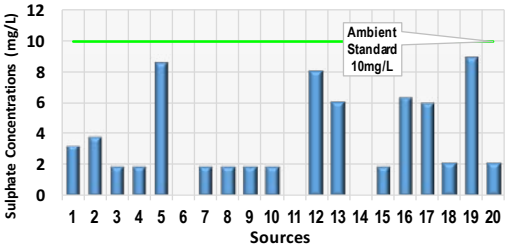


Figure 112: Great River Hydrologic Basin Sulphate Levels in Surface Water

GREAT RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 69: Great River Basin Sulphate Levels in Surface water

The surface water sources within the Great River basin predominantly indicated excellent water quality for sulphate as shown in Figure 112 and Graph 69. All the sources (100%) sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L.

Great River Hydrologic Basin TDS Levels in Surface Water

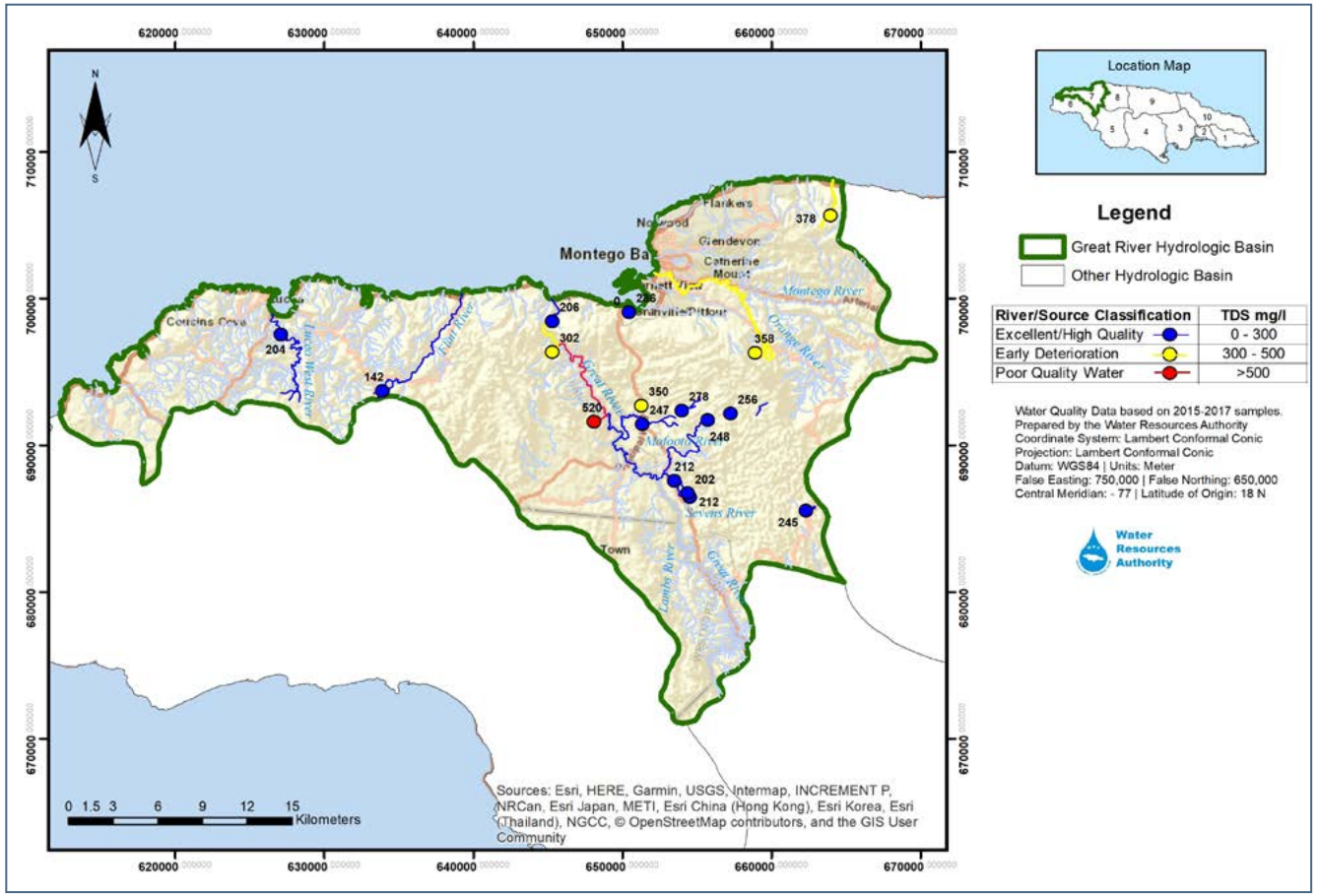
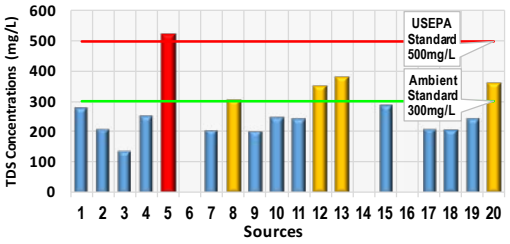


Figure 113: Great River Hydrologic Basin TDS Levels in Surface Water

GREAT RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 70: Great River Basin TDS Levels in Surface water

Figure 113 and Graph 70 shows that the surface water sources within the Great River basin predominantly indicated excellent water quality for chloride. Sixty percent (60%) of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. Twenty percent (20%) indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Five percent (5%) of the sources indicated poor water quality for sodium

8.0 Basin VIII Martha Brae River Hydrologic Basin

The Martha Brae Hydrologic Basin includes the parish of Trelawny. The basin is drained by a network of rivers flowing over mountains (basement aquiclude – low permeability Cretaceous volcanics) in the western, central and eastern sections of the basin across the plain towards the northern coast.

The water resources within the Marta Brae Basin comprise of groundwater from alluvium aquifers and surface water from the rivers that drain the several sub-basins.

The groundwater quality was analysed with the results from six limestone wells and the surface water analyses was done utilizing five (5) sources.

Martha Brae River Hydrologic Basin Groundwater Sample Locations

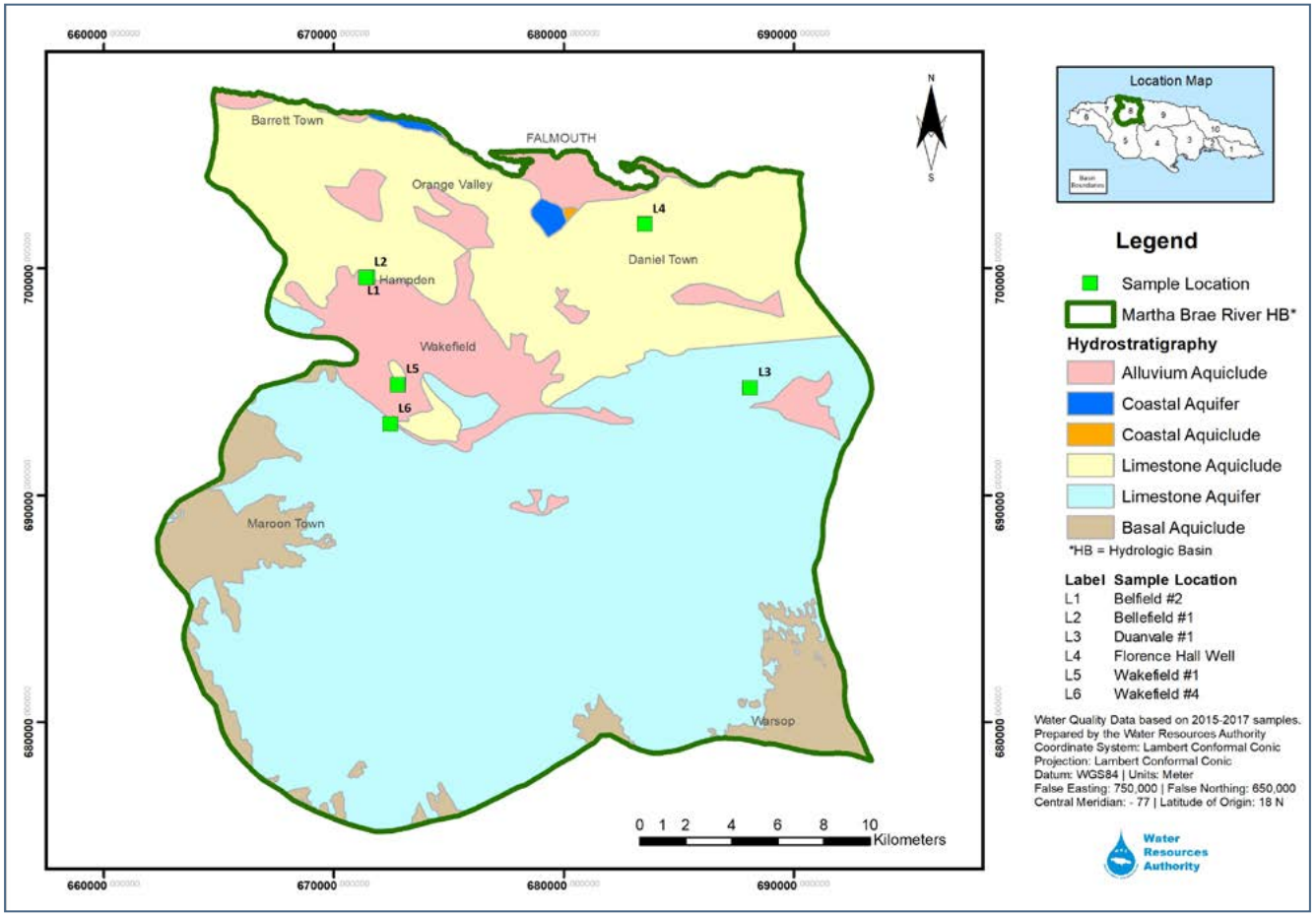


Figure 114: Martha Brae River Hydrologic Basin Groundwater Sample Locations

Figure 114 shows the location of the six (6) ground water sampling points. All six (6) sources are classified as limestone wells.

Martha Brae River Hydrologic Basin Nitrate Levels in Groundwater

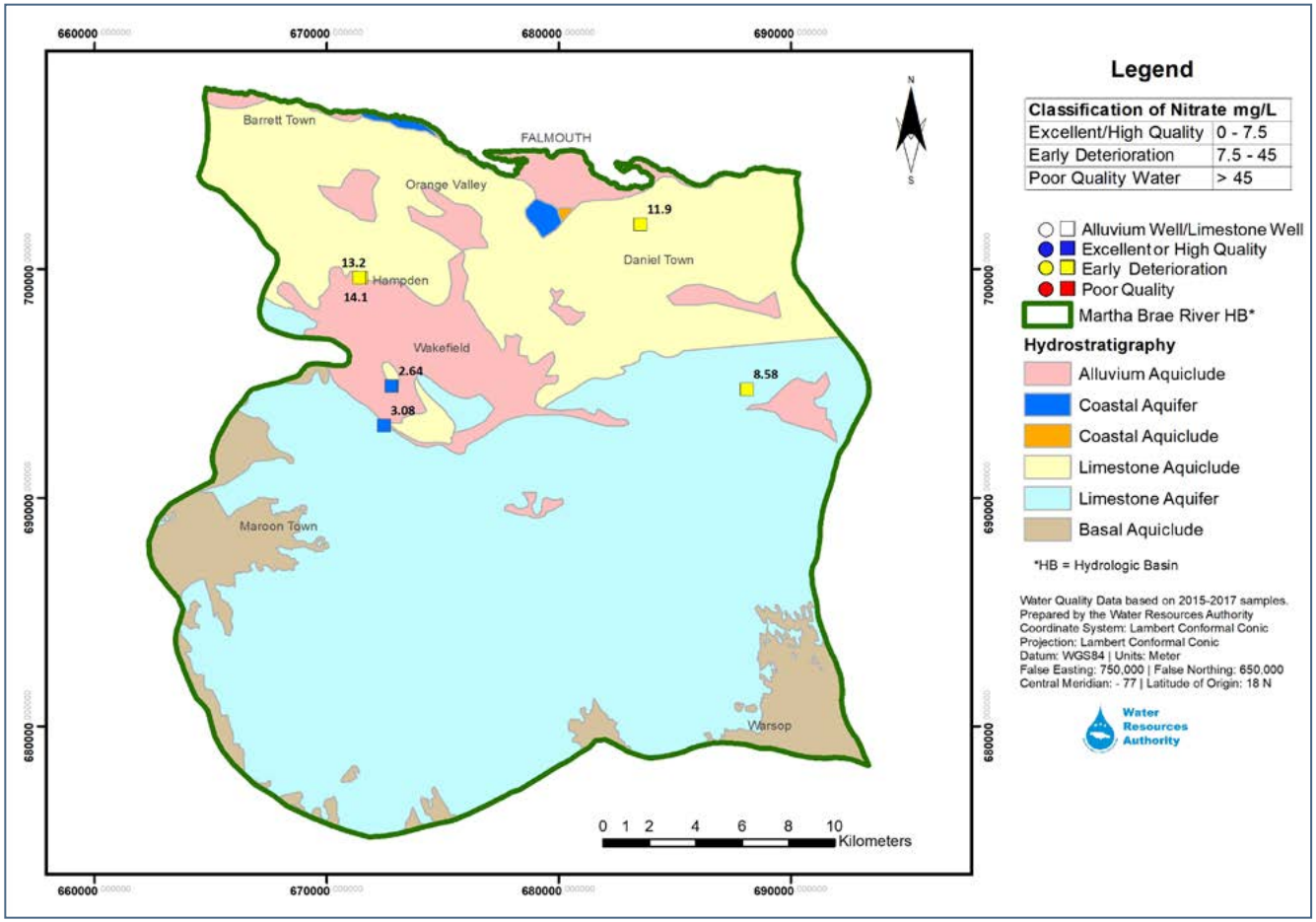
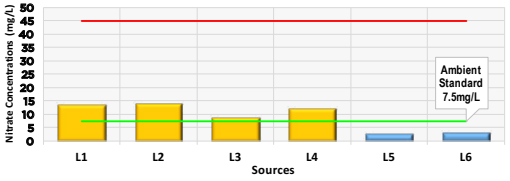


Figure 115: Martha Brae River Hydrologic Basin Nitrate Levels in Groundwater

MARTHA BRAE RIVER HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 71: Martha Brae River Basin Nitrate Levels in Groundwater

As noted in Figure 115 and Graph 71, the well sources within the Martha Brae basin predominantly indicated early deterioration water quality for nitrate. Sixty-seven percent (67%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L but are within the maximum level of the WHO Guidelines for Drinking Water Quality. Thirty-three percent (33%) of the sources sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L.

Martha Brae River Hydrologic Basin Sodium Levels in Groundwater

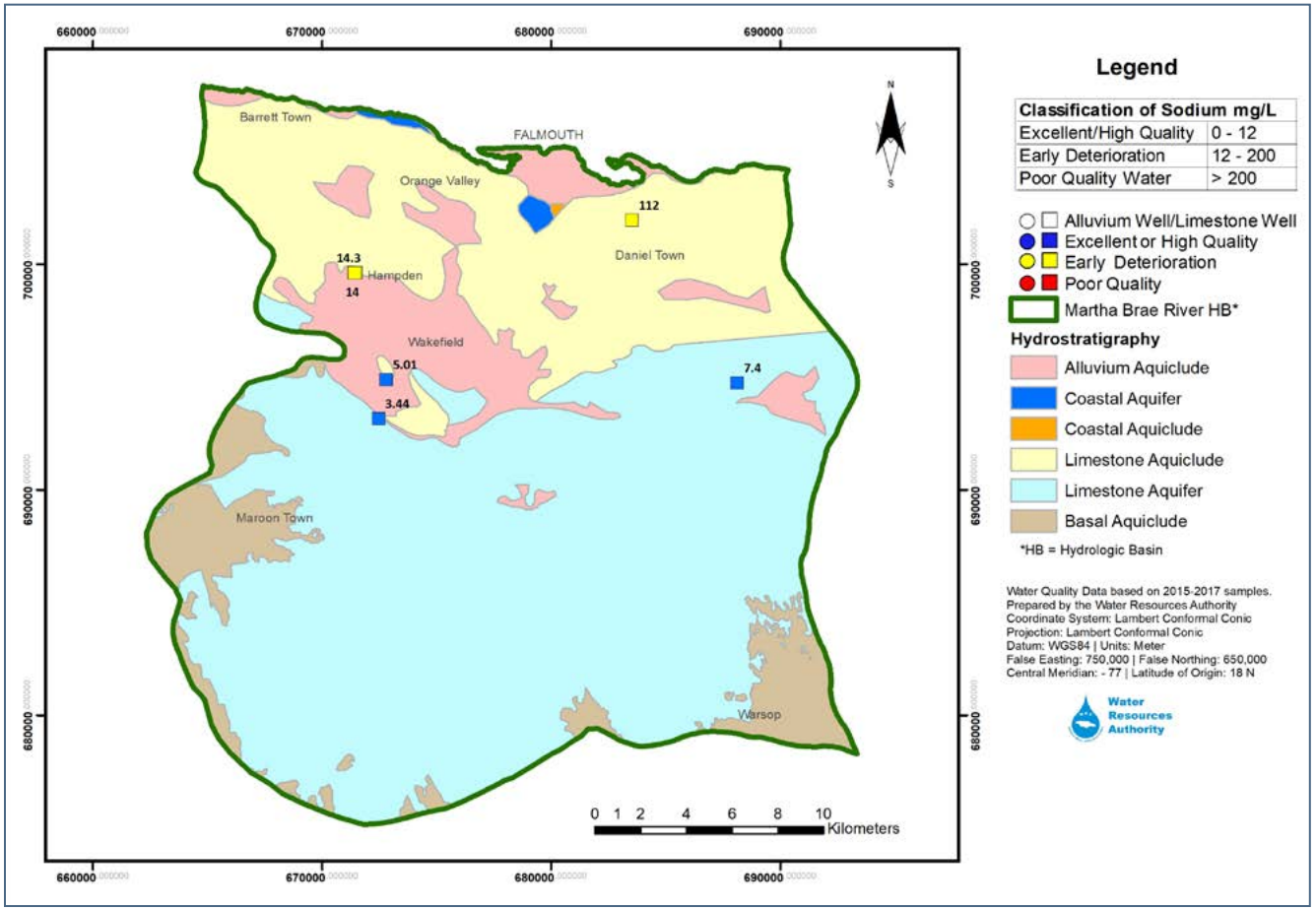
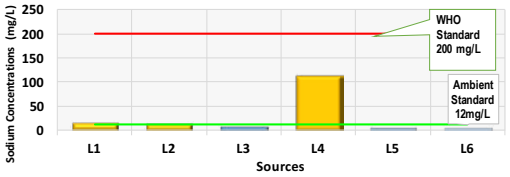


Figure 116: Martha Brae River Hydrologic Basin Sodium Levels in Groundwater

MARTHA BRAE RIVER HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 72: Martha Brae River Basin Sodium Levels in Groundwater

The well sources within the Martha Brae basin predominantly indicated excellent and early deterioration water quality for sodium as shown in Figure 116 and Graph 72. Fifty percent (50%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 12mg/L. the remaining fifty percent (50%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 12mg/L.

Martha Brae River Hydrologic Basin Chloride Levels in Groundwater

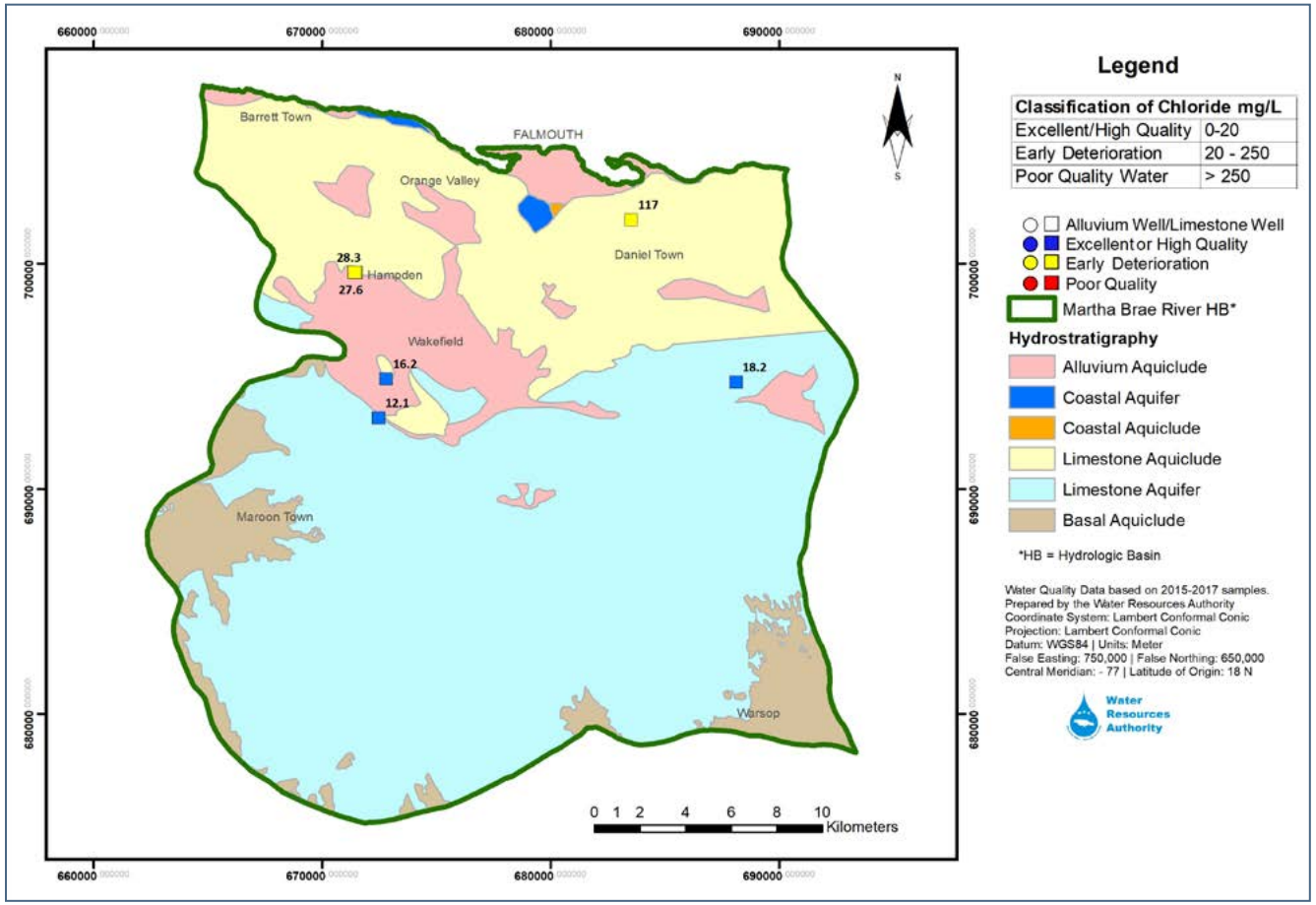
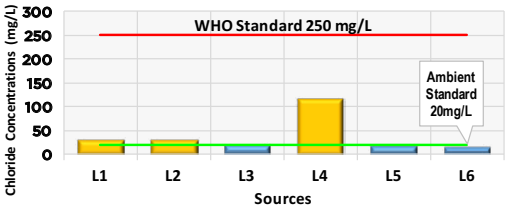


Figure 117: Martha Brae River Hydrologic Basin Chloride Levels in Groundwater

MARTHA BRAE RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 73: Martha Brae River Basin Chloride Levels in Groundwater

The well sources within the Martha Brae basin predominantly indicated early deterioration water quality for chloride as noted in Figure 117 and Graph 73. Sixty- seven percent (67%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/. And thirty-three percent (33%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L.

Martha Brae River Hydrologic Basin Sulphate Levels in Groundwater

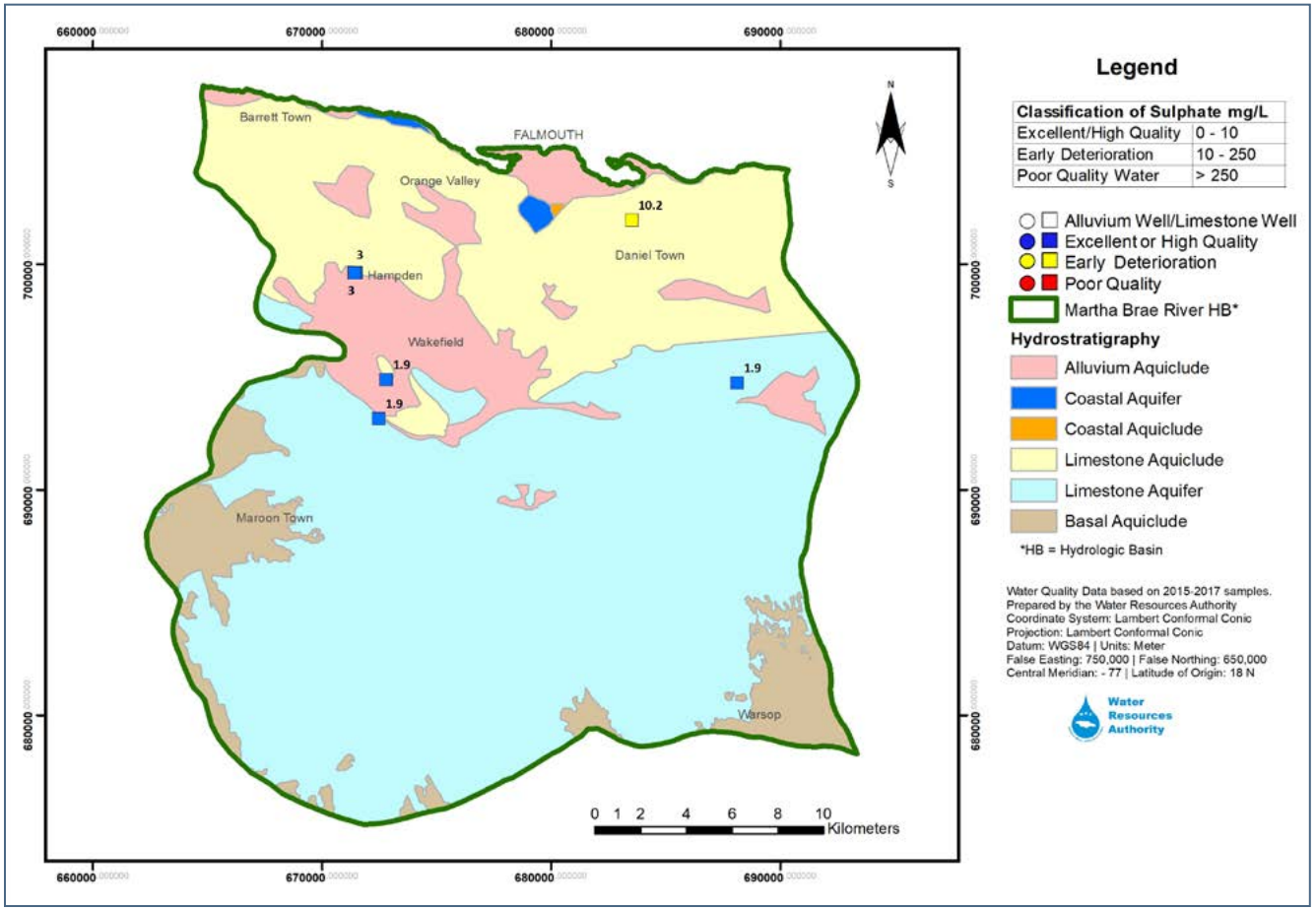
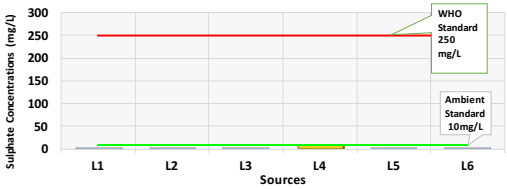


Figure 118: Martha Brae River Hydrologic Basin Sulphate Levels in Groundwater

MARTHA BRAE RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 74: Martha Brae River Basin Sulphate Levels in Groundwater

Figure 118 and Graph 74 has indicated that the well sources within the Martha Brae basin predominantly indicated excellent water quality for sulphate. Eighty-three percent (83%) of the sources sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L. Seventeen percent (17%) indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L

Martha Brae River Hydrologic Basin TDS Levels in Groundwater

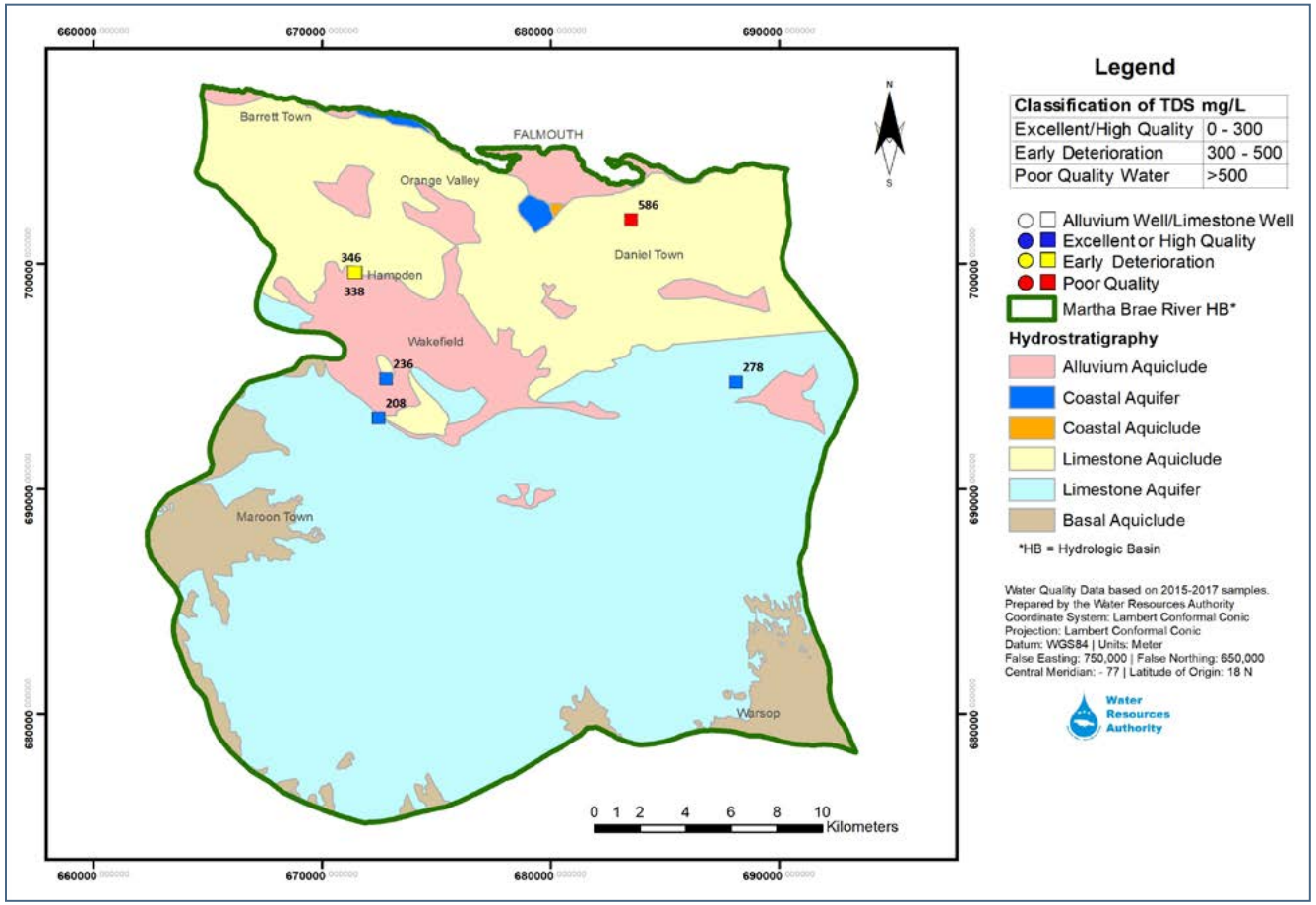
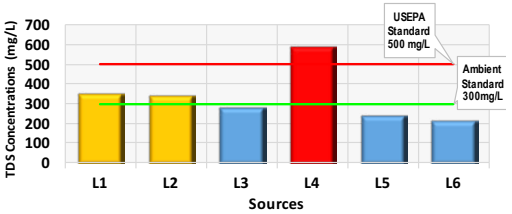


Figure 119: Martha Brae River Hydrologic Basin TDS Levels in Groundwater

MARTHA BRAE RIVER HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 75: Martha Brae River Basin TDS Levels in Groundwater

The well sources within the Martha Brae basin predominantly indicated excellent water quality for TDS as shown in Figure 119 and Graph 75. Fifty percent (50%) of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. Thirty-three percent (33%) indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Seventeen percent (17%) of the sources indicated poor water quality for sodium.

Martha Brae River Hydrologic Basin Surface Water Sample Locations

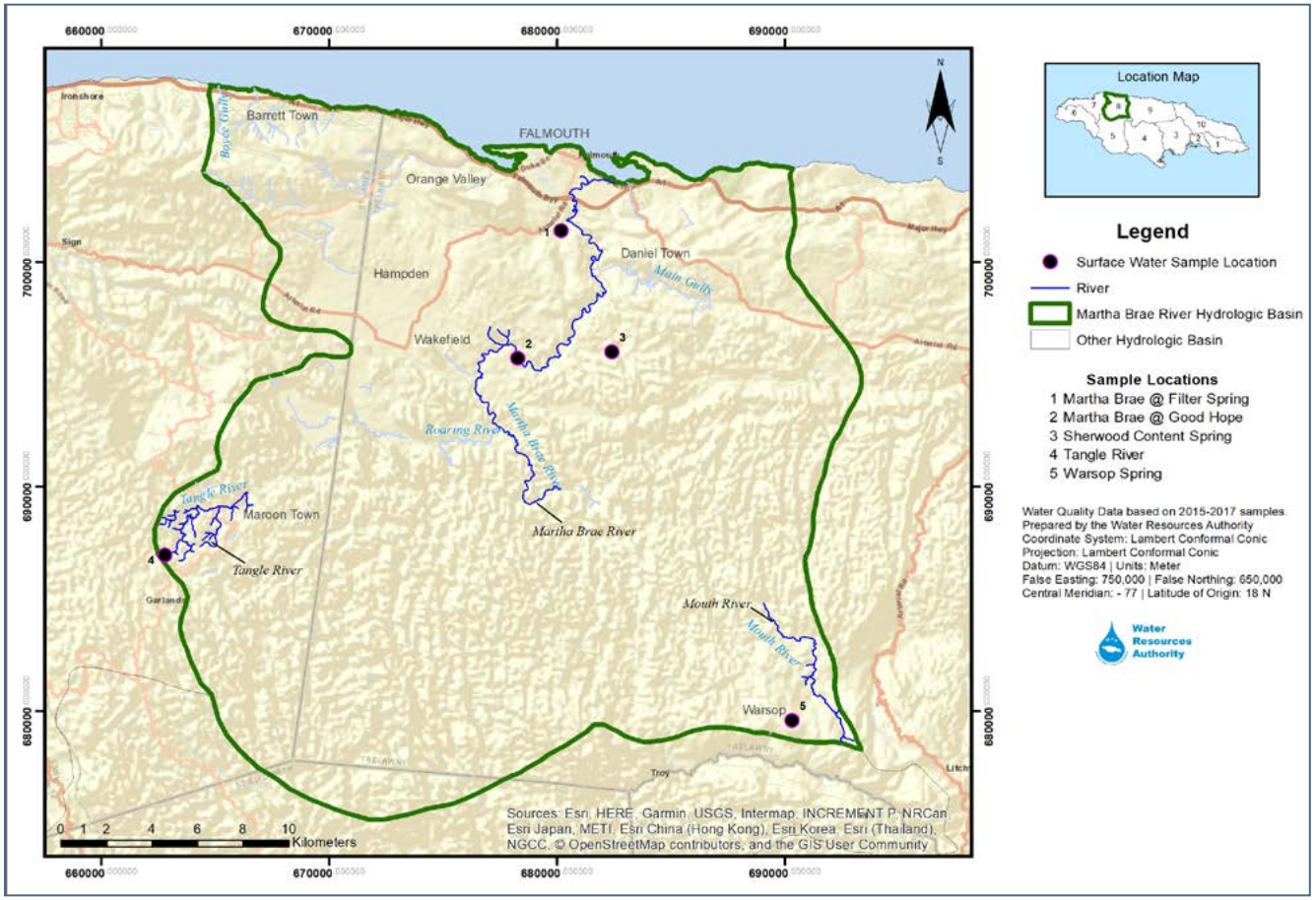


Figure 120: Martha Brae River Hydrologic Basin Surface Water Sample Locations

Figure 120 shows the location of the five (5) surface water sampling points utilized in the surface water analyses for the Martha Brae River Basin.

Martha Brae River Hydrologic Basin Nitrate Levels in Surface Water

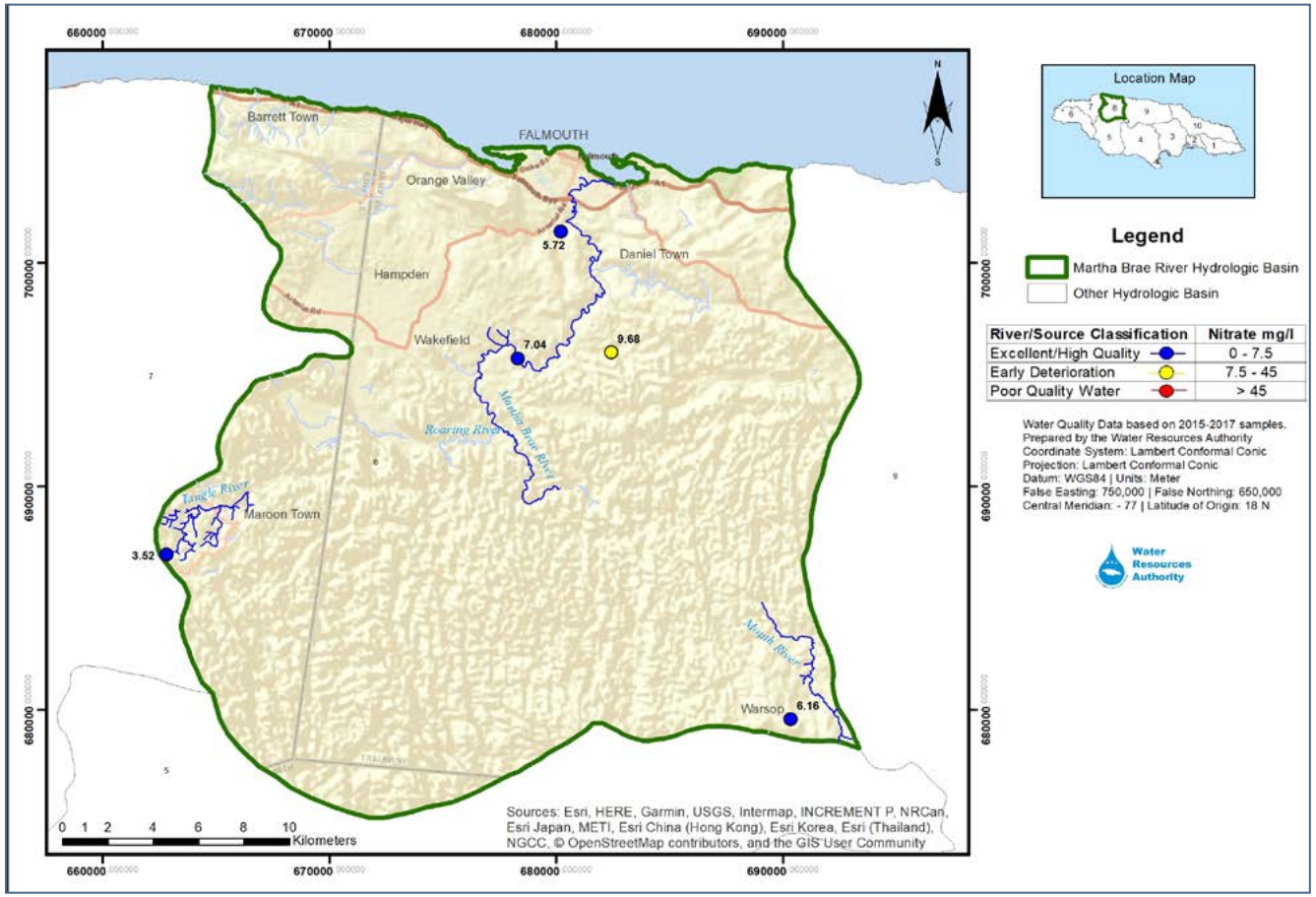
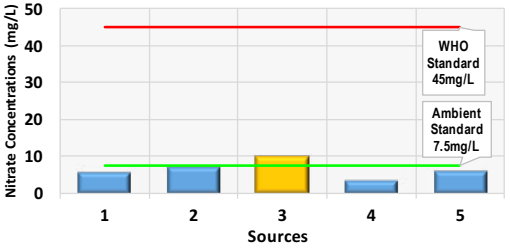


Figure 121: Martha Brae River Hydrologic Basin Nitrate Levels in Surface Water

MARTHA BRAE RIVER HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 76: Martha Brae River Basin Nitrate Levels in Surface water

The surface water sources within the Martha Brae basin predominantly indicated excellent water quality for nitrate as shown in Figure 121 and Graph 76. Eighty percent (80%) of the sources sampled indicated nitrate quality within the National Ambient Water Quality Standard of 20mg/L. And twenty percent (20%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 20mg/L

Martha Brae River Hydrologic Basin Sodium Levels in Surface Water

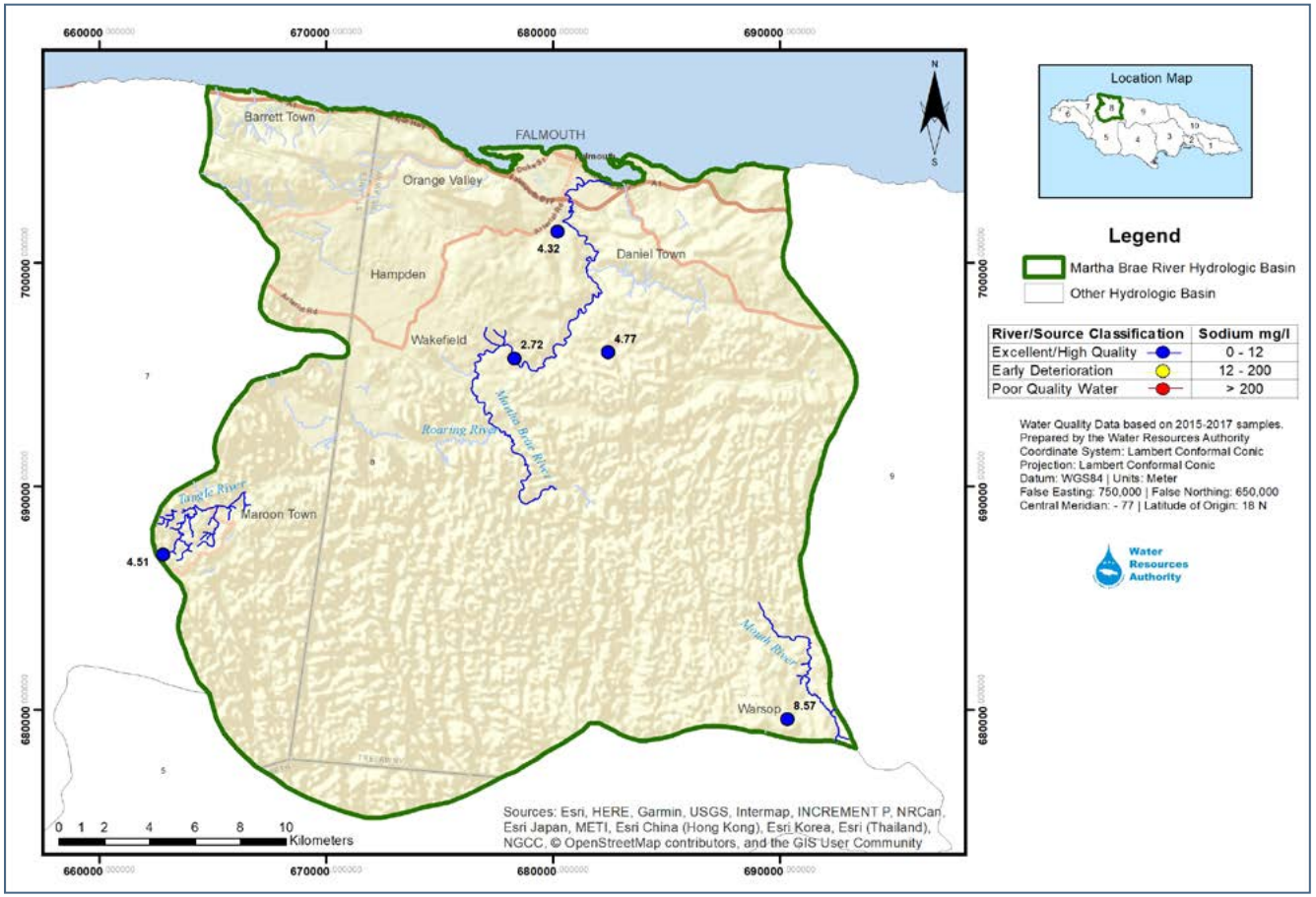
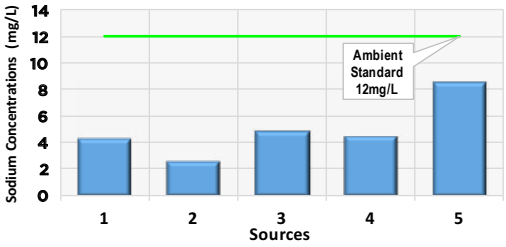


Figure 122: Martha Brae River Hydrologic Basin Sodium Levels in Surface Water

MARTHA BRAE RIVER HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 77: Martha Brae River Basin Sodium Levels in Surface water

As shown in Figure 122 and Graph 77, the surface water sources within the Martha Brae basin predominantly indicated excellent water quality for sodium. All the sources sampled (100%) indicated sulphate quality within the National Ambient Water Quality Standard of 12mg/L.

Martha Brae River Hydrologic Basin Chloride Levels in Surface Water

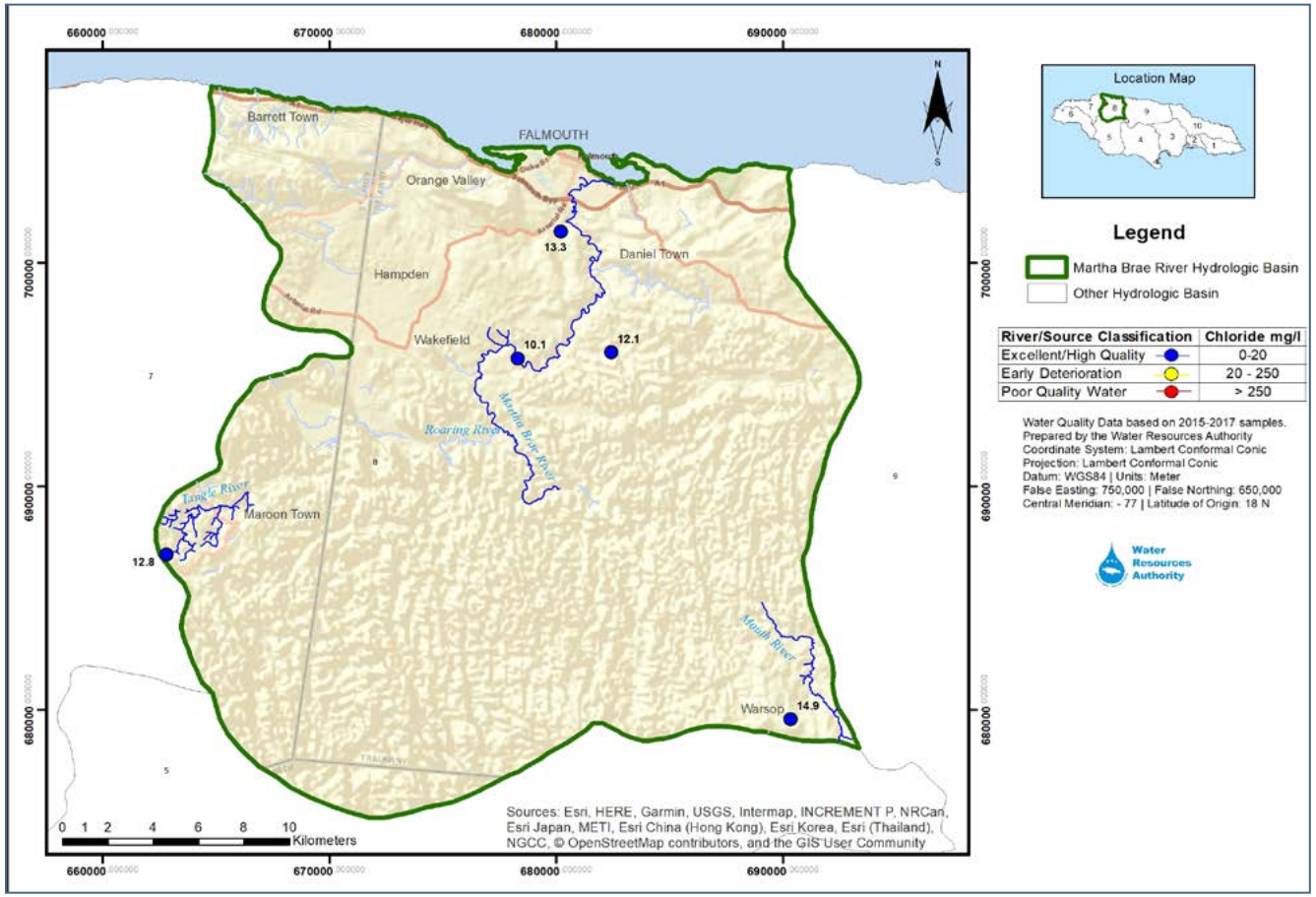
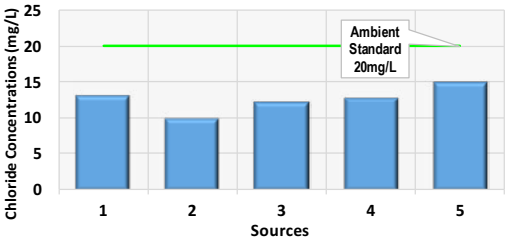


Figure 123: Martha Brae River Hydrologic Basin Chloride Levels in Surface Water

MARTHA BRAE RIVER HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 78: Martha Brae River Basin Chloride Levels in Surface water

As shown in Figure 123 and Graph 78, the surface water sources within the Martha Brae basin predominantly indicated excellent water quality for chloride. All the sources (100%) sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L.

Martha Brae River Hydrologic Basin Sulphate Levels in Surface Water

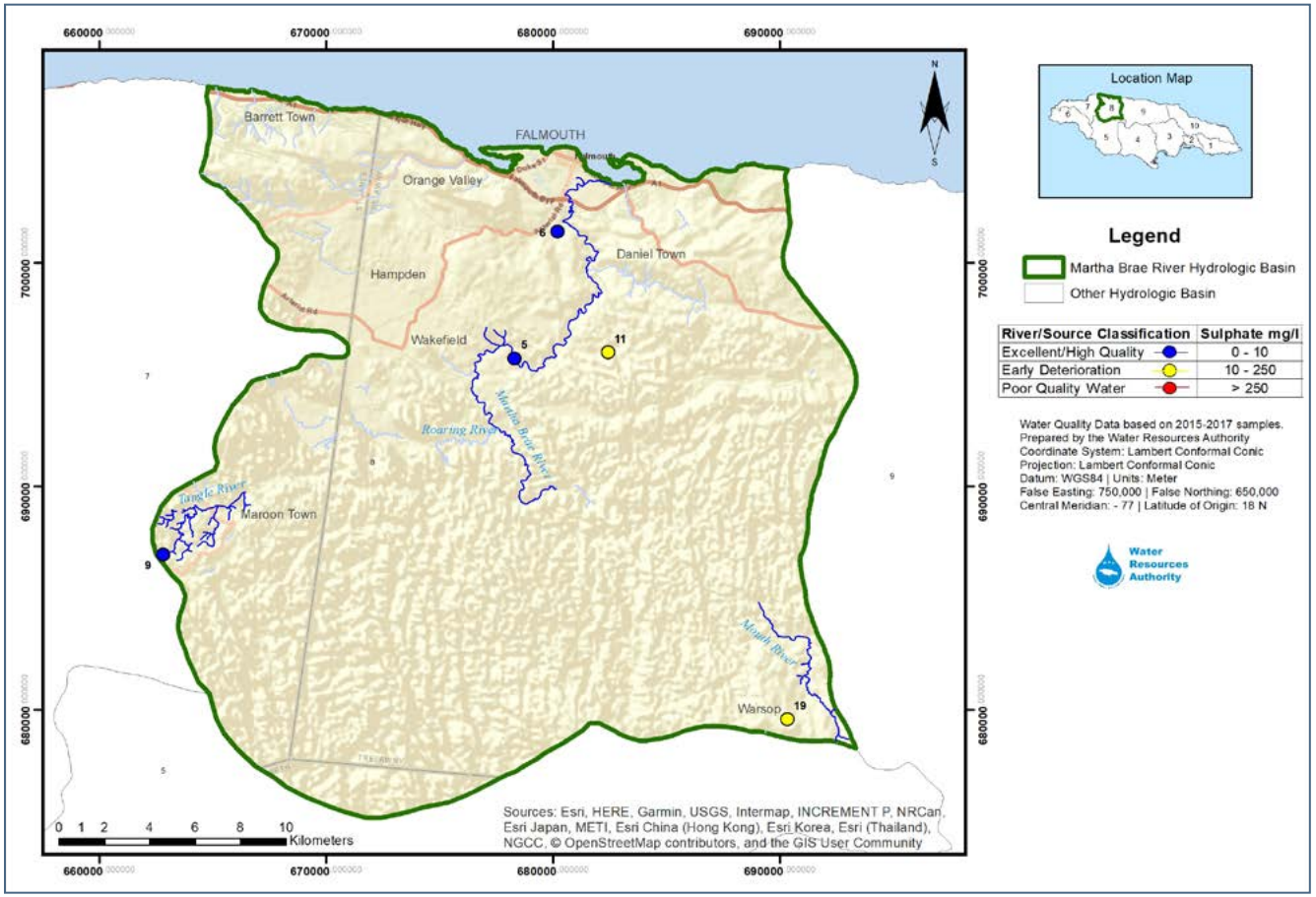
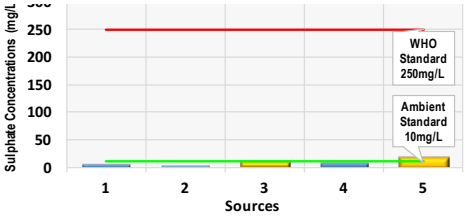


Figure 124: Martha Brae River Hydrologic Basin Sulphate Levels in Surface Water

MARTHA BRAE RIVER HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 79: Martha Brae River Basin Sulphate Levels in Surface water

The surface water sources within the Martha Brae basin predominantly indicated excellent water quality for sulphate as shown in Figure 124 and Graph 79. Sixty percent (60%) of the sources sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L. Whilst forty percent (40%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 10mg/L

Martha Brae River Hydrologic Basin TDS Levels in Surface Water

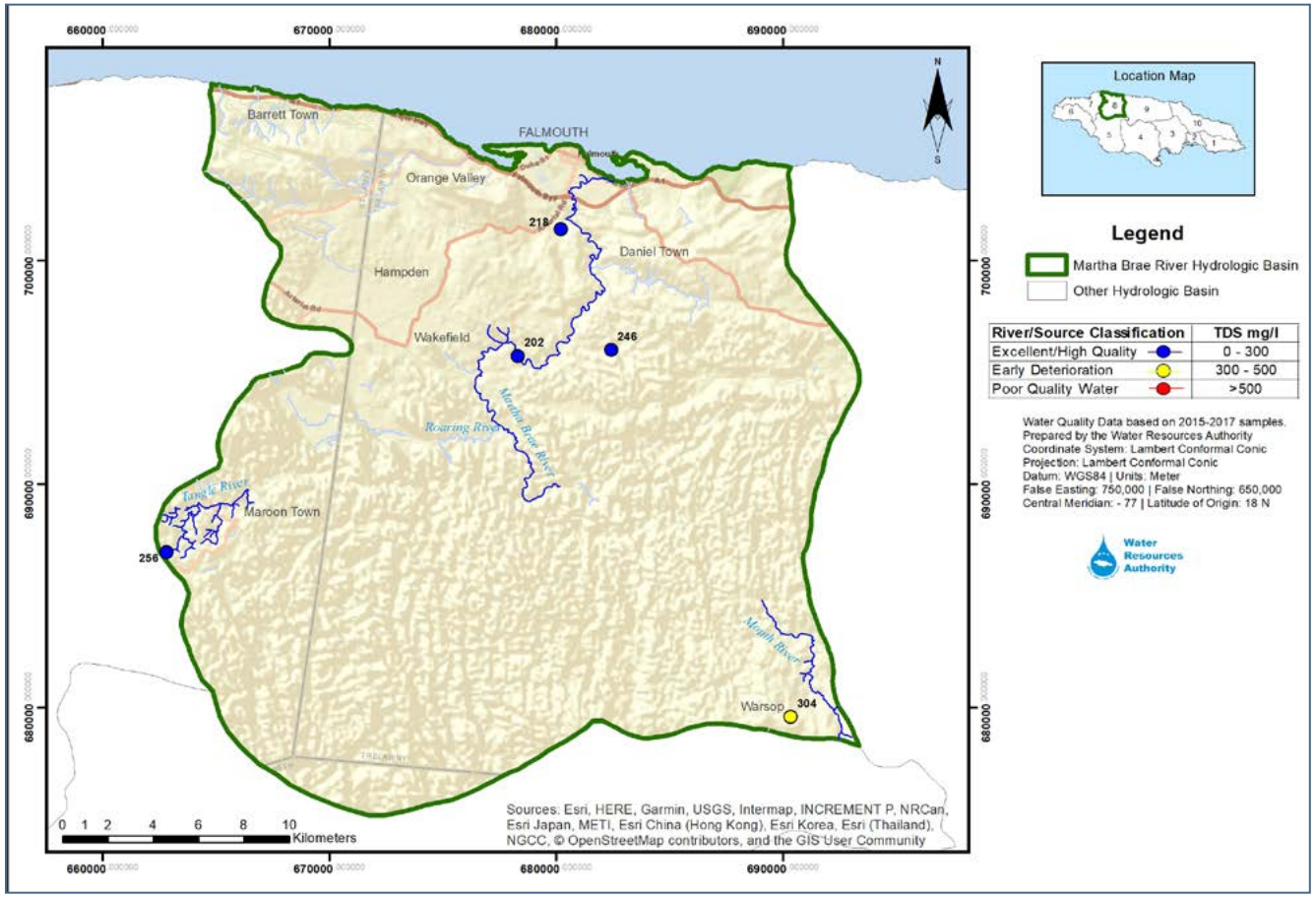
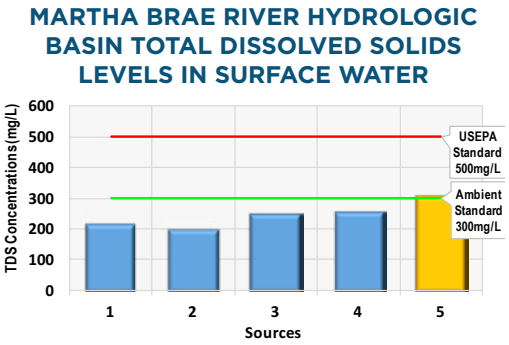


Figure 125: Martha Brae River Hydrologic Basin TDS Levels in Surface Water



Graph 80: Martha Brae River Basin TDS Levels in Surface water

The surface water sources within the Martha Brae basin predominantly indicated excellent water quality for TDS as shown in Figure 125 and Graph 80. Eighty percent (80%) of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. the remaining twenty percent (20%) indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L

9.0 Basin IX Dry Harbour Mountain Hydrologic Basin

The Dry Harbour Mountain Hydrologic Basin includes the parish of St Ann. For water management purposes, this Hydrologic Basin has been divided into two Watershed Management Units: Rio Bueno and White River.

The basin is drained by a network of rivers flowing over mountains (basement aquiclude – low permeability cretaceous volcanics) in the western, central and eastern sections of the basin towards the northern coast.

The groundwater quality was analysed with the results from fifteen limestone wells and the surface water analyses was done utilizing forty (40) sources.

Dry Harbour Mountain Hydrologic Basin Groundwater Sample Locations

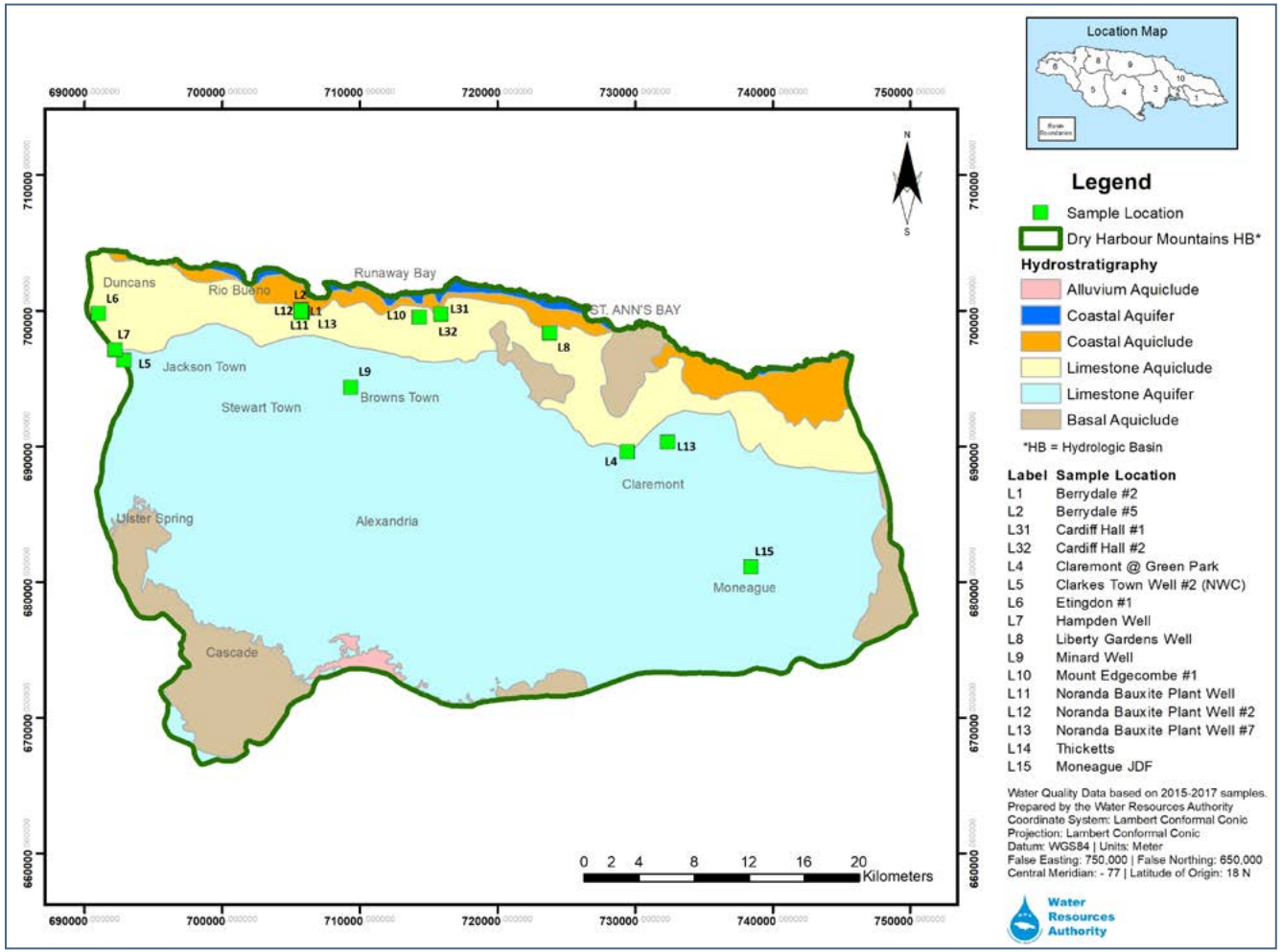


Figure 126: Dry Harbour Mountain Hydrologic Basin Groundwater Sample Locations

Figure 126 shows the location of the fifteen (15) ground water sampling points. All fifteen (15) sources are classified as limestone wells.

Dry Harbour Mountains Hydrologic Basin Nitrate Levels in Groundwater

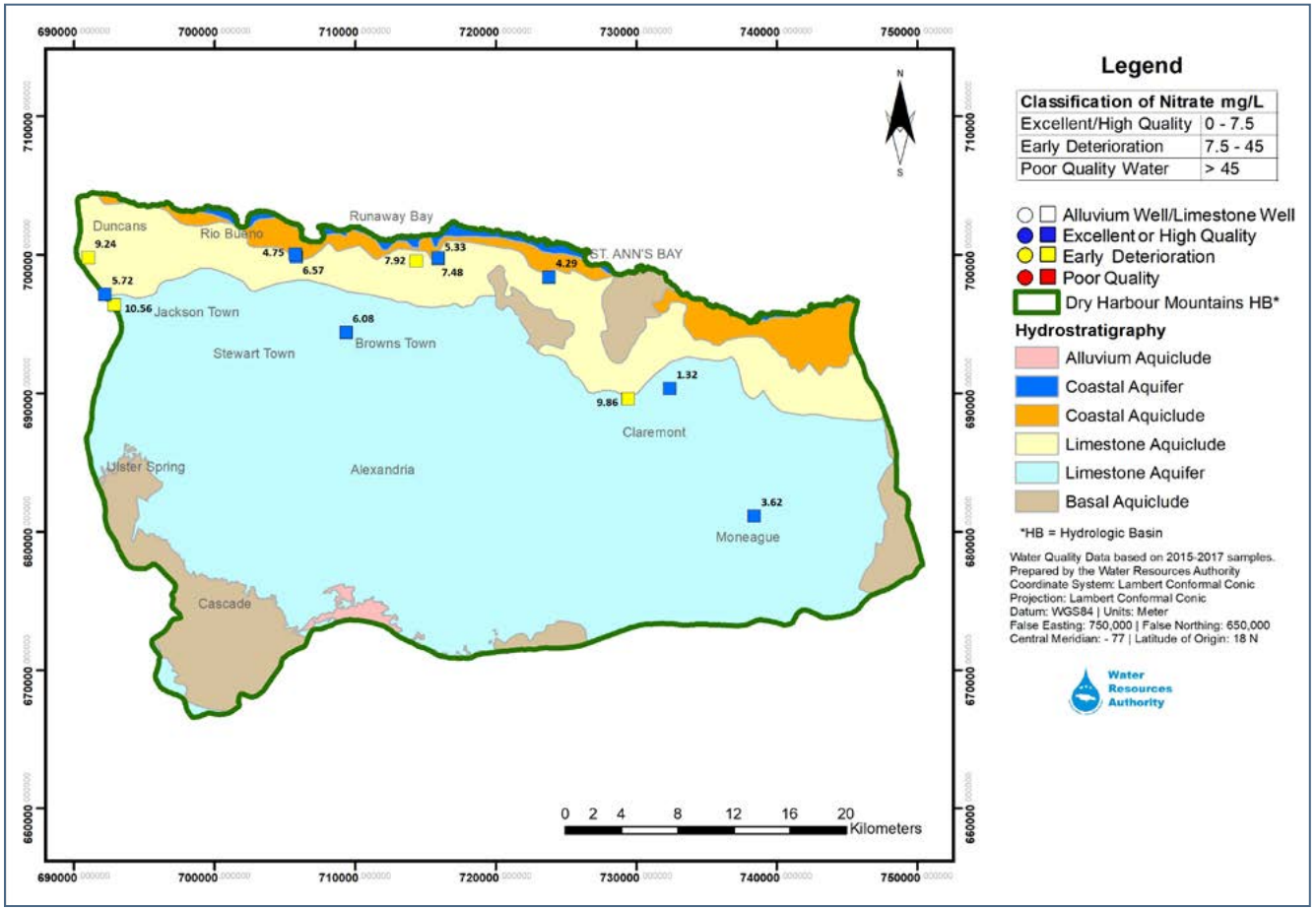
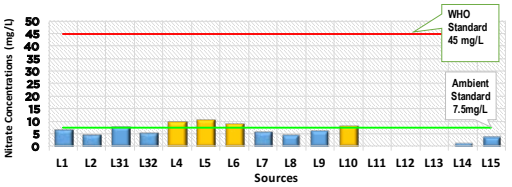


Figure 127: Dry Harbour Mountains Hydrologic Basin Nitrate Levels in Groundwater

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 81: Dry Harbour Mountain Basin Nitrate Levels in Groundwater

Figure 127 and Graph 81 shows that the well sources within the Dry Harbour basin predominantly indicated excellent water quality from nitrate. Forty-seven percent (47%) of the sources sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L. Twenty-four percent (24%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L

Dry Harbour Mountains Hydrologic Basin Sodium Levels in Groundwater

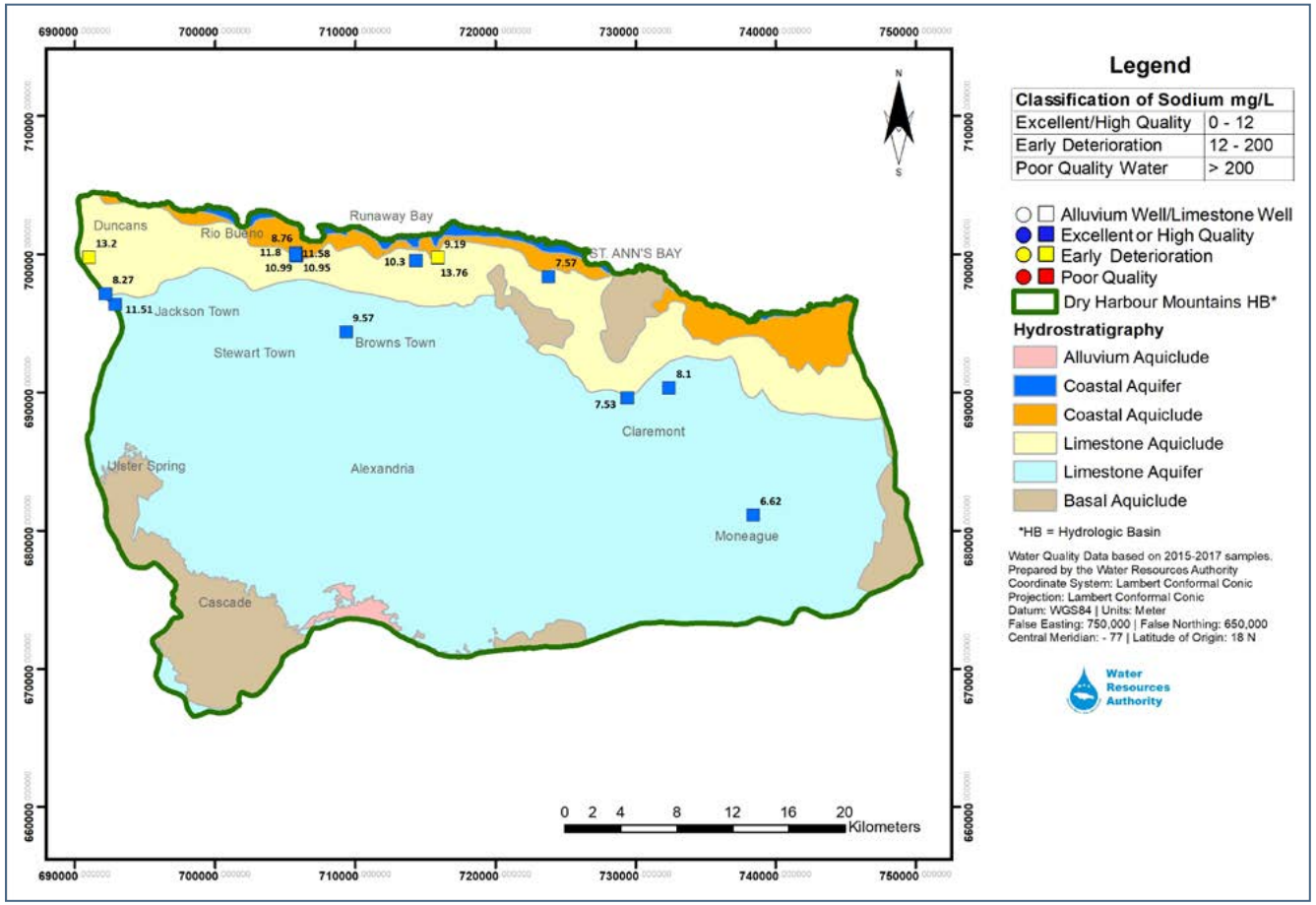
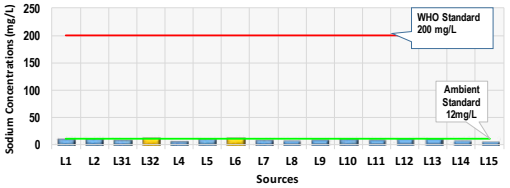


Figure 128: Dry Harbour Mountains Hydrologic Basin Sodium Levels in Groundwater

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 82: Dry Harbour Mountain Basin Sodium Levels in Groundwater

As shown in Figure 128 and Graph 82, the well sources within the Dry Harbour basin predominantly indicated excellent water quality for sodium. Eighty-eight percent (88%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 12mg/L. Twelve percent (12%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L

Dry Harbour Mountains Hydrologic Basin Chloride Levels in Groundwater

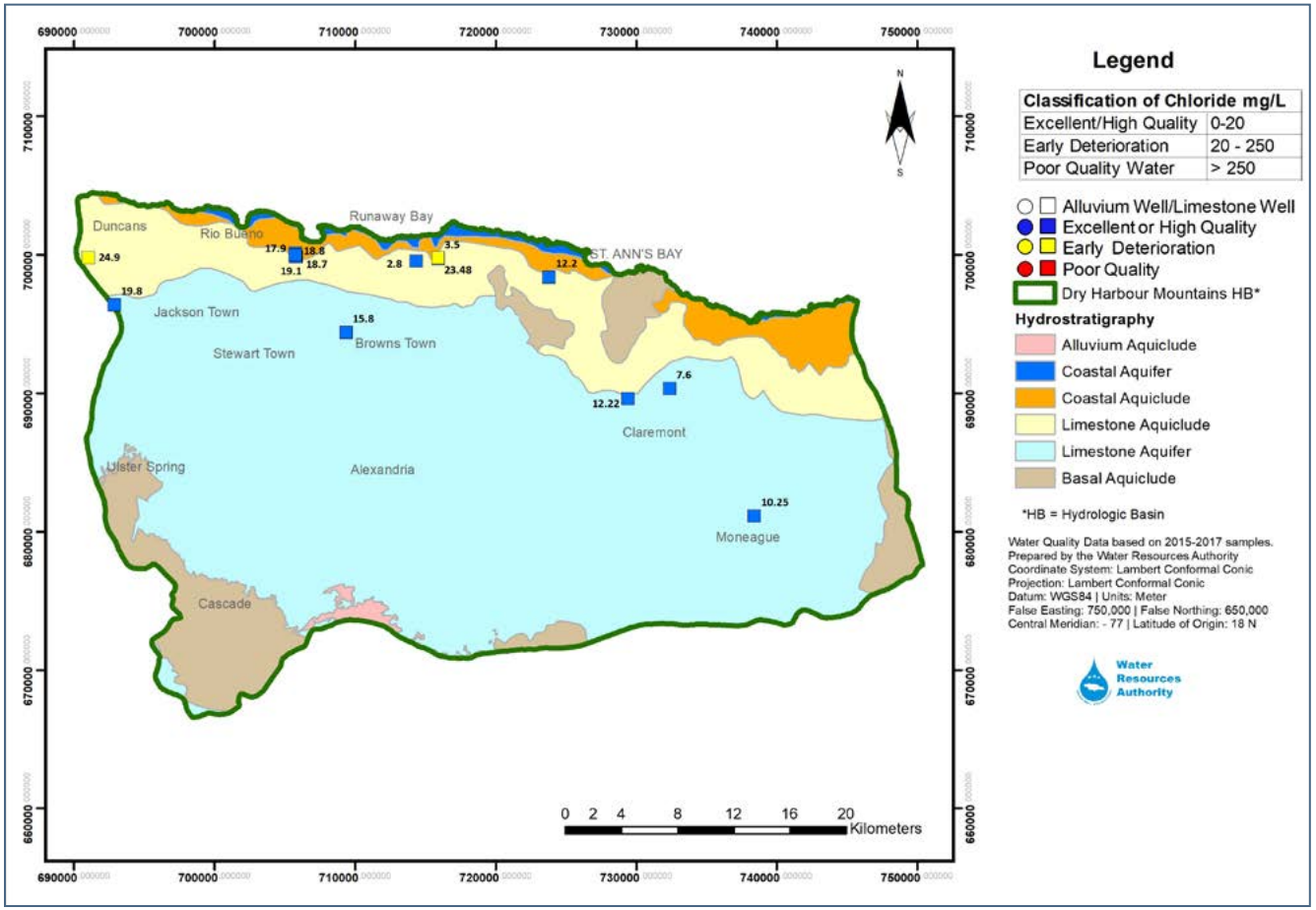
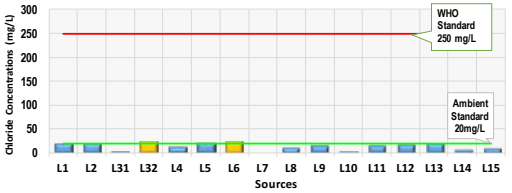


Figure 129: Dry Harbour Mountains Hydrologic Basin Chloride Levels in Groundwater

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 83: Dry Harbour Mountain Basin Chloride Levels in Groundwater

As shown in Figure 129 and Graph 83, the well sources within the Dry Harbour basin predominantly indicated excellent water quality for chloride. Eighty eight percent (88%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. Twelve percent (12%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L

Dry Harbour Mountains Hydrologic Basin Sulphate Levels in Groundwater

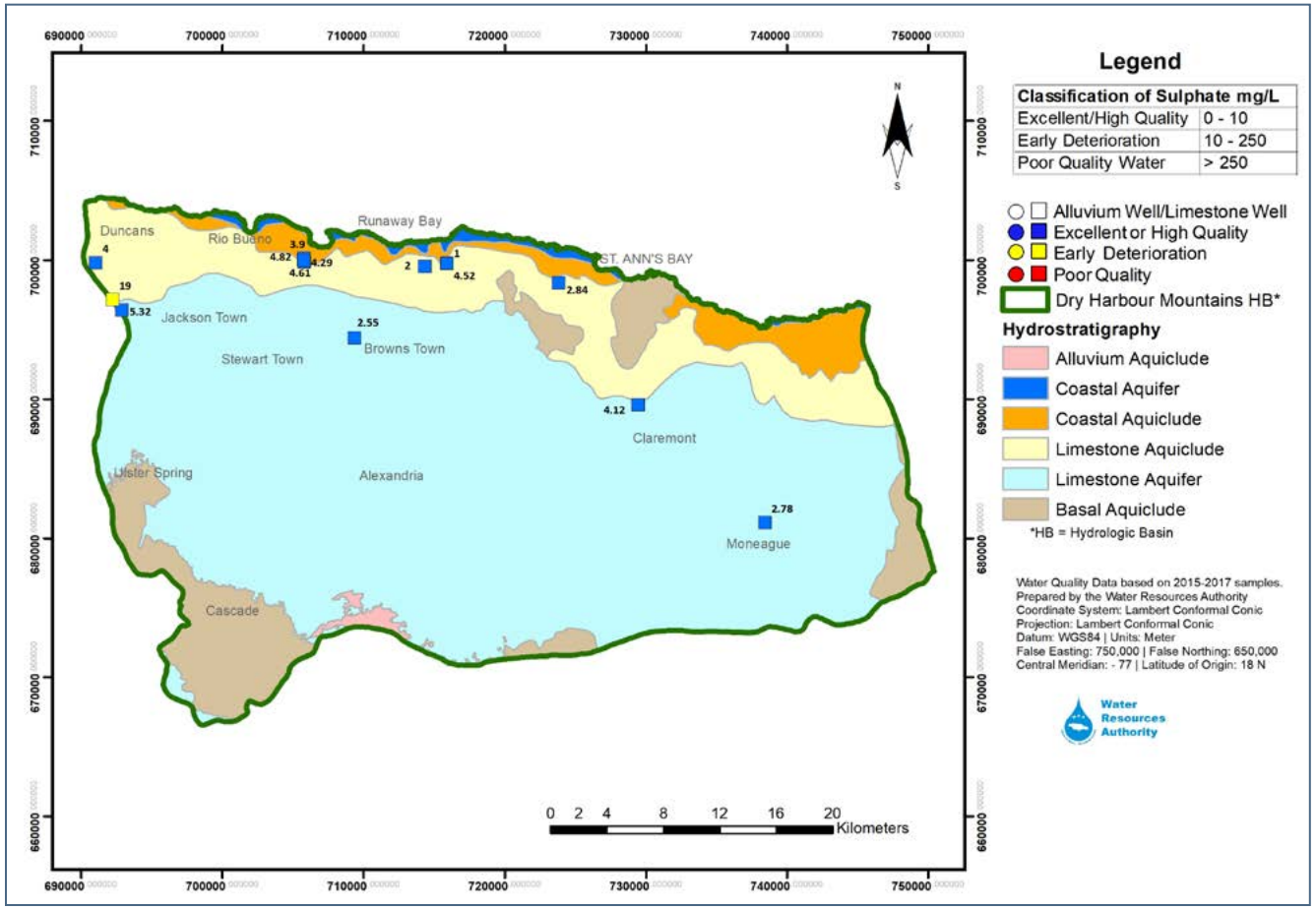
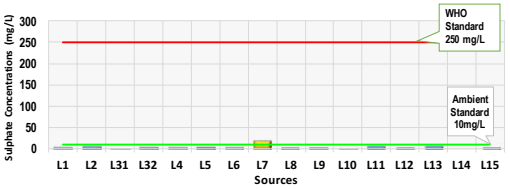


Figure 130: Dry Harbour Mountains Hydrologic Basin Sulphate Levels in Groundwater

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 84: Dry Harbour Mountain Basin Sulphate Levels in Groundwater

As shown in Figure 130 and Graph 84, the well sources within the Dry Harbour basin predominantly indicated excellent water quality for sulphate. Eighty-eight percent (88%) of the sources sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L. Six percent (6%) indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L

Dry Harbour Mountains Hydrologic Basin TDS Levels in Groundwater

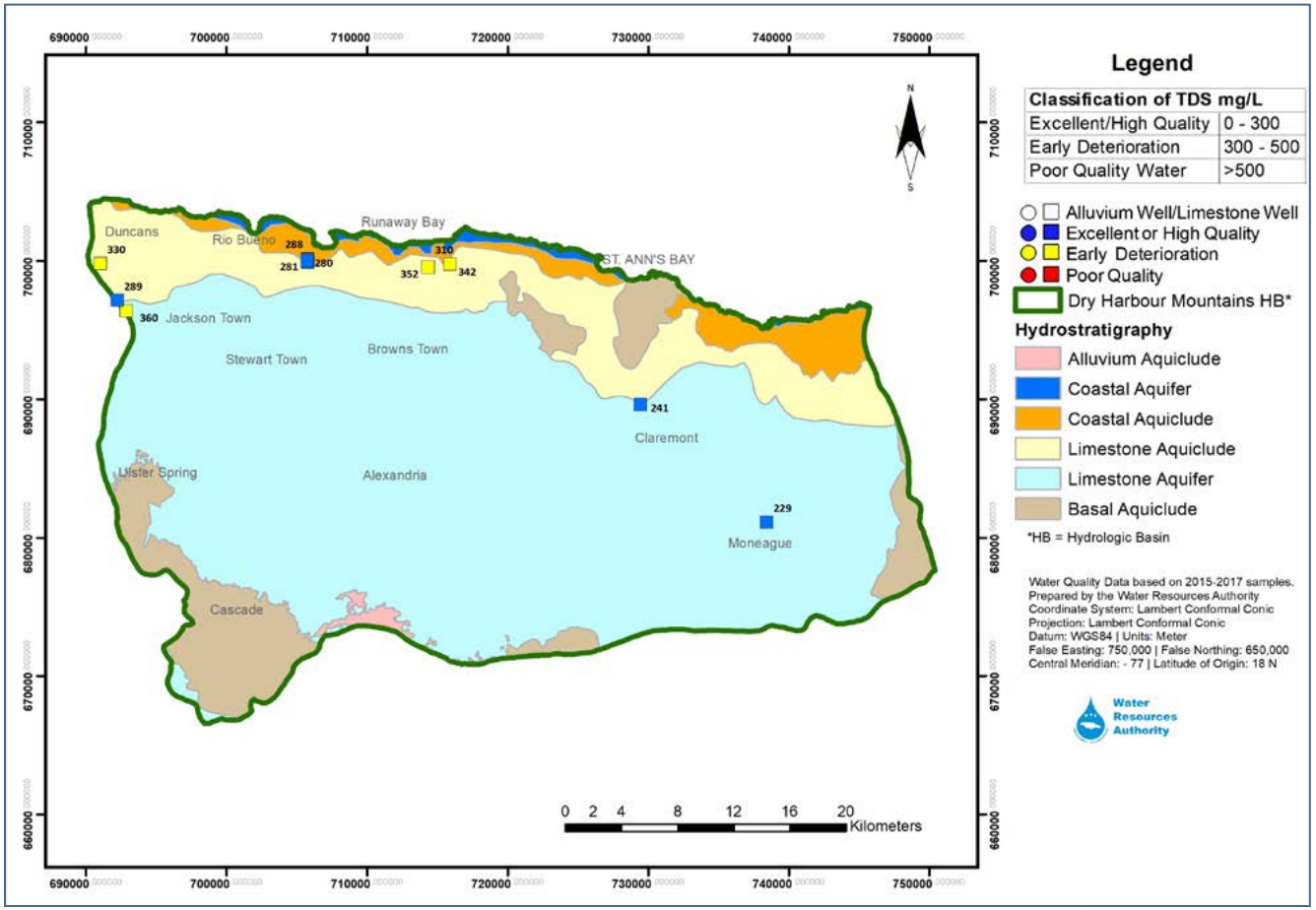
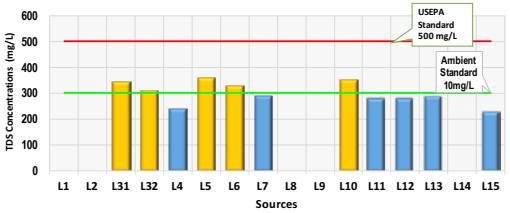


Figure 131: Dry Harbour Mountains Hydrologic Basin TDS Levels in Groundwater

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 85: Dry Harbour Mountain Basin TDS Levels in Groundwater

The well sources within the Dry Harbour basin predominantly indicated excellent water quality for TDS as shown in Figure 131 and Graph 85. Thirty-five percent (35%) of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. Twenty-nine percent (29%) indicated TDS levels in excess of the National Ambient Water Quality Standard of 10mg/L

Dry Harbour Mountains Hydrologic Basin
Surface Water Sample Locations

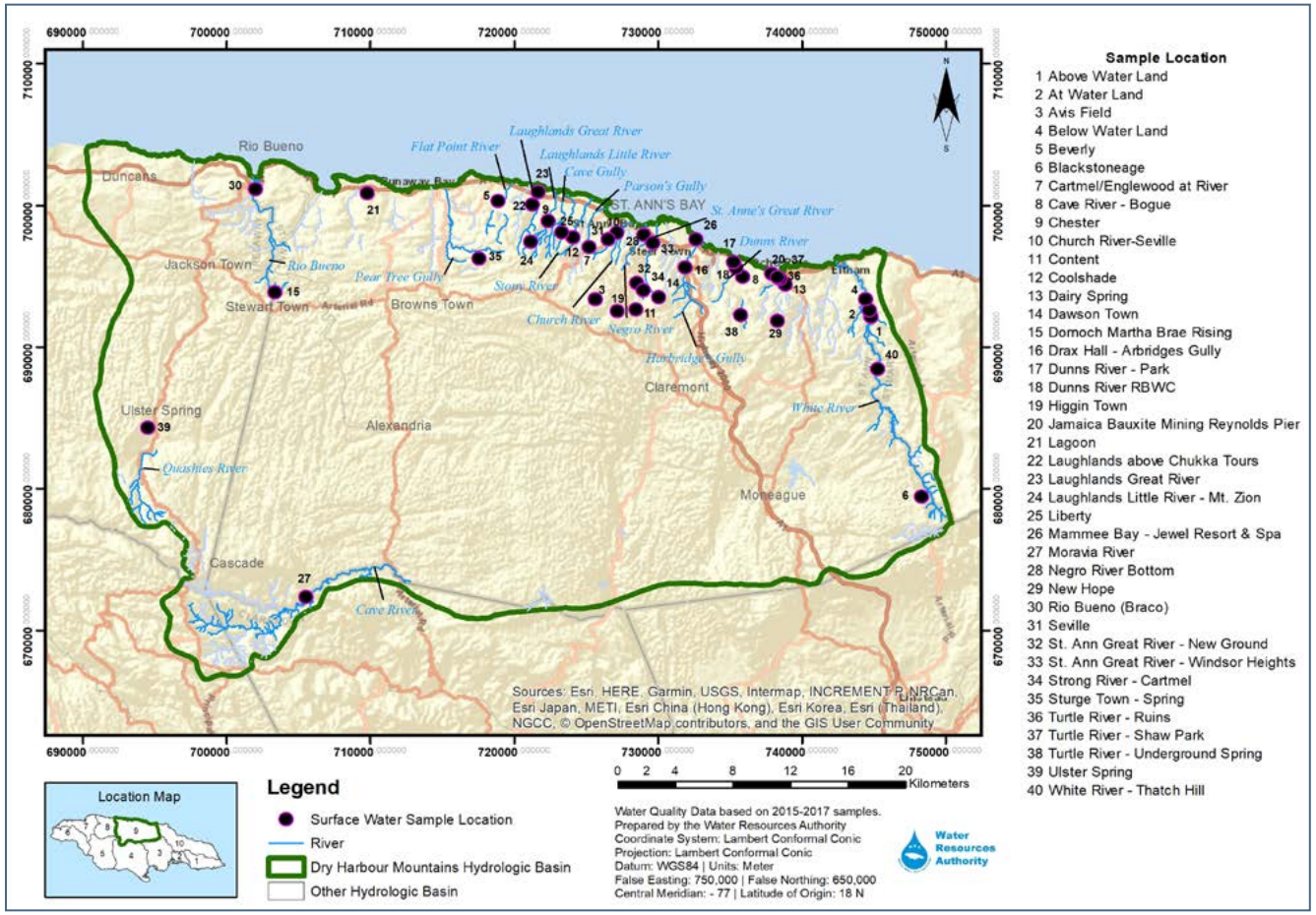


Figure 132: Dry Harbour Mountains Hydrologic Basin Surface Water Sample Locations

Figure 132 shows the location of the forty (40) surface water sampling points utilized in the surface water analyses for the Dry Harbour Mountain Basin.

Dry Harbour Mountain Hydrologic Basin Nitrate Levels in Surface Water

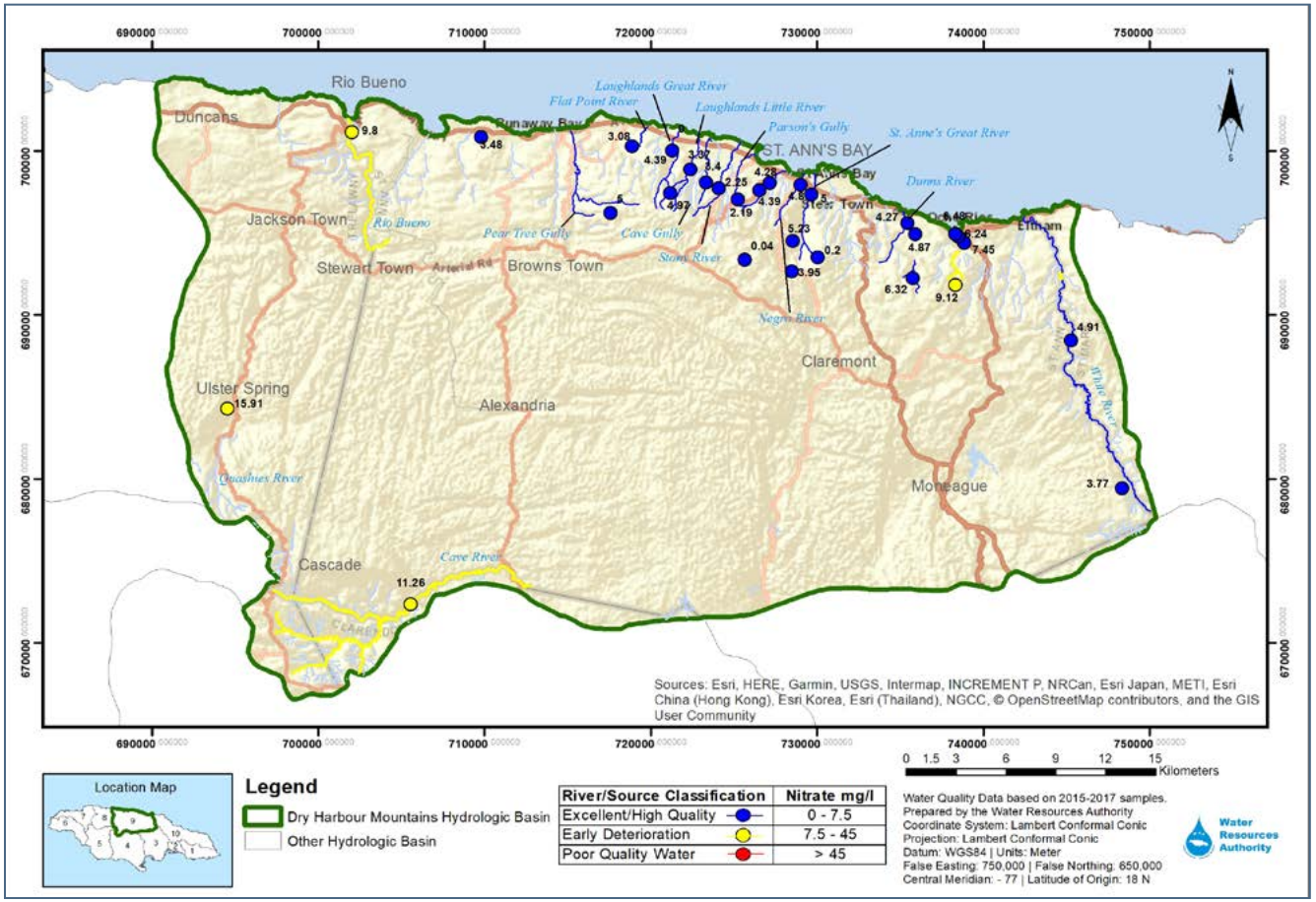
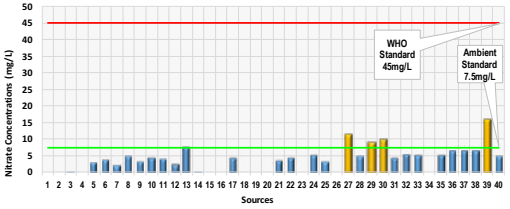


Figure 133: Dry Harbour Mountain Hydrologic Basin Nitrate Levels in Surface Water

DRY HARBOUR MOUNTAIN HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 86: Dry Harbour Mountain Basin Nitrate Levels in Surface water

As shown in Figure 133 and Graph 86, the surface water sources within the Dry Harbour Brae basin predominantly indicated excellent water quality for nitrate. Fifty-eight percent (58%) of the sources sampled indicated nitrate quality within the National Ambient Water Quality Standard of 7.5mg/L. Ten percent (10%) indicated nitrate levels in excess of the National Ambient Water Quality Standard of 7.5mg/L

Dry Harbour Mountains Hydrologic Basin Sodium Levels in Surface Water

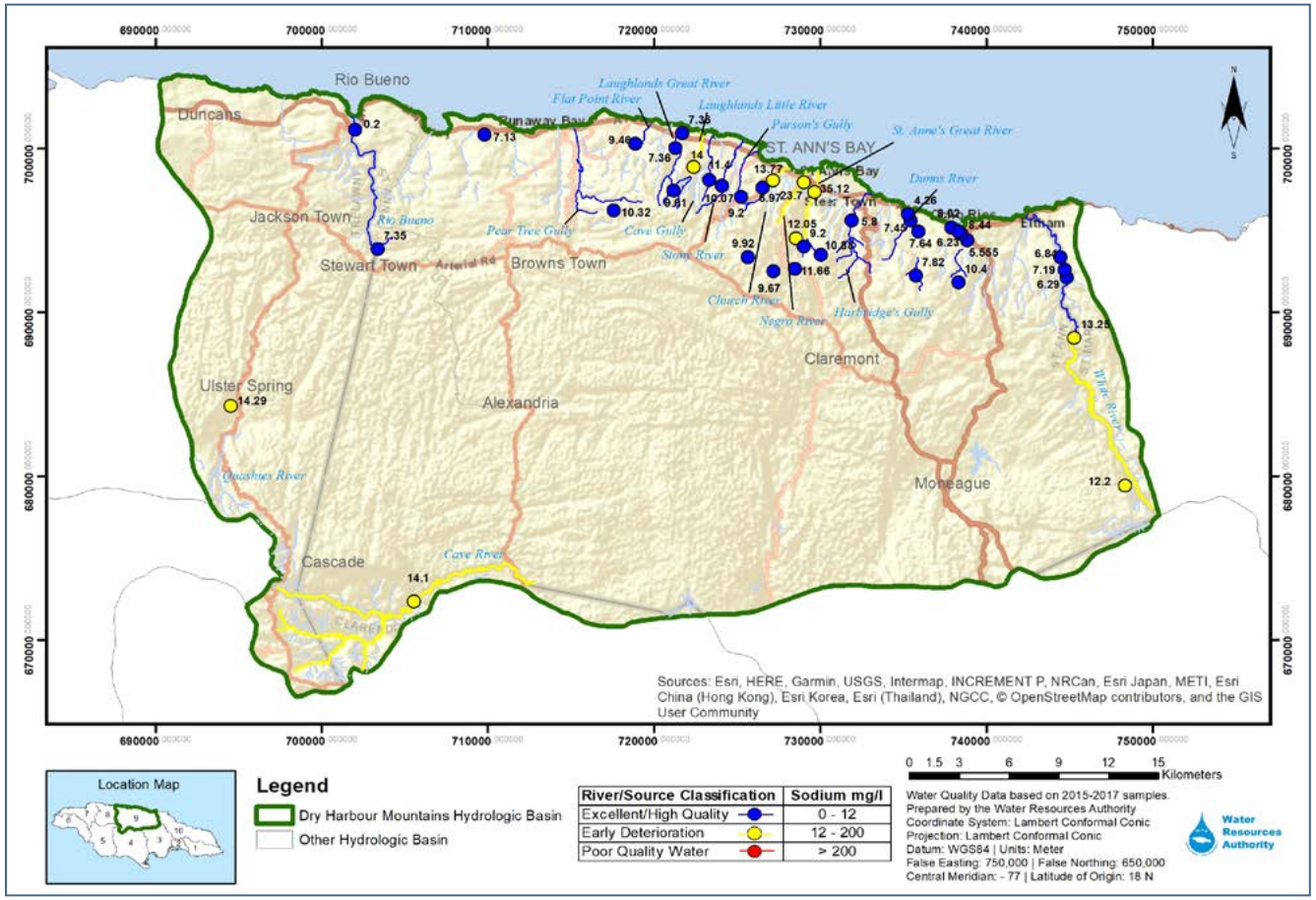
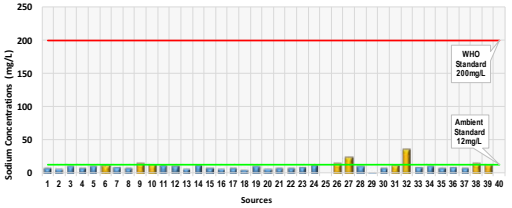


Figure 134: Dry Harbour Mountain Hydrologic Basin Sodium Levels in Surface Water

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 87: Dry Harbour Mountain Basin Sodium Levels in Surface water

As shown in Figure 134 and Graph 87, the surface water sources within the Dry Harbour Brae basin predominantly indicated excellent water quality for sodium. Seventy-eight percent (78%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 12mg/L. And the remaining twenty-two percent (22%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L

Dry Harbour Mountains Hydrologic Basin Chloride Levels in Surface Water

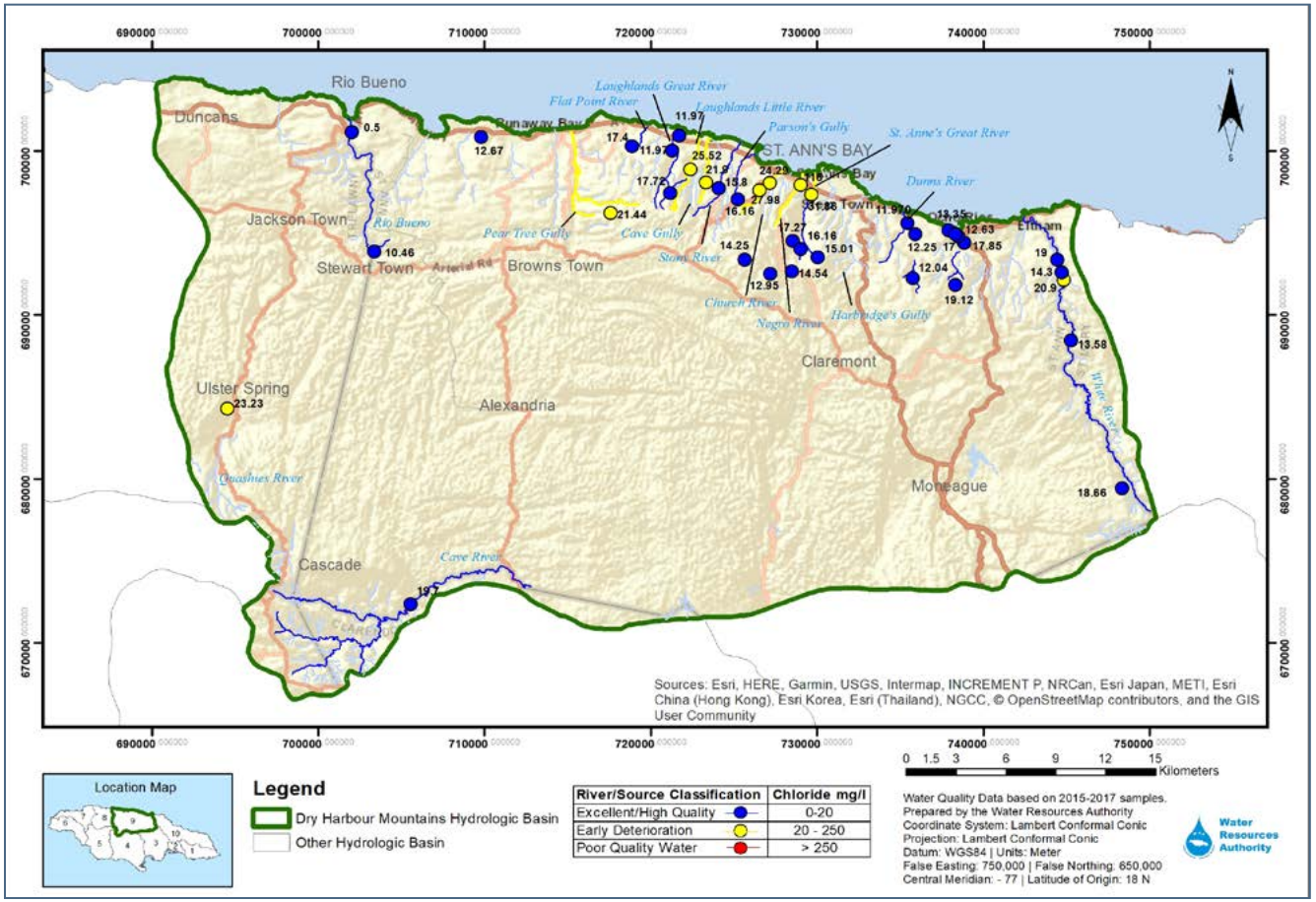
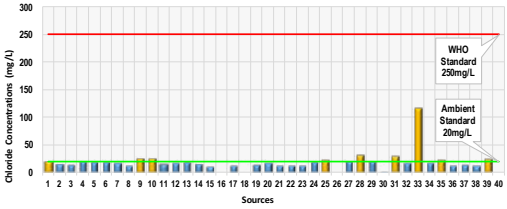


Figure 135: Dry Harbour Mountain Hydrologic Basin Chloride Levels in Surface Water

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 88: Dry Harbour Mountain Basin Chloride Levels in Surface water

The surface water sources within the Dry Harbour Brae basin predominantly indicated excellent water quality for chloride as indicated in Figure 135 and Graph 88. Sixty-eight percent (68%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. And twenty-two percent (22%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L

Dry Harbour Mountains Hydrologic Basin Sulphate Levels in Surface Water

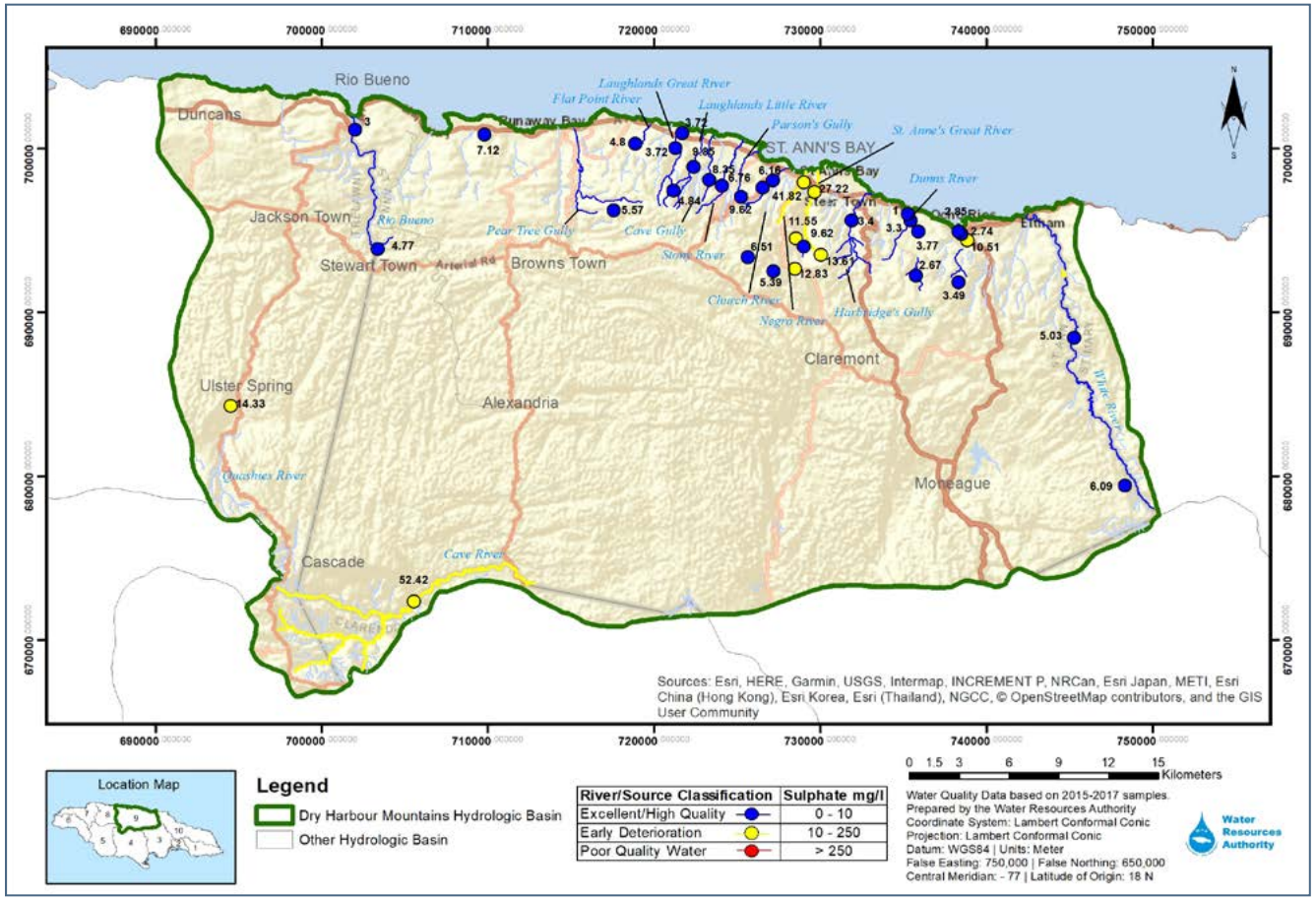
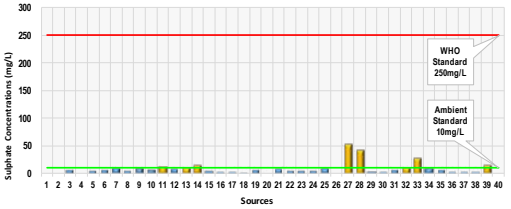


Figure 136: Dry Harbour Mountain Hydrologic Basin Sulphate Levels in Surface Water

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 89: Dry Harbour Mountain Basin Sulphate Levels in Surface water

Figure 136 and Graph 89 shows that the surface water sources within the Dry Harbour Brae basin predominantly indicated excellent water quality for sulphate. Seventy percent (70%) of the sources sampled indicated sulphate quality within the National Ambient Water Quality Standard of 10mg/L. Thirteen percent (13%) indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L

Dry Harbour Mountains Hydrologic Basin TDS Levels in Surface Water

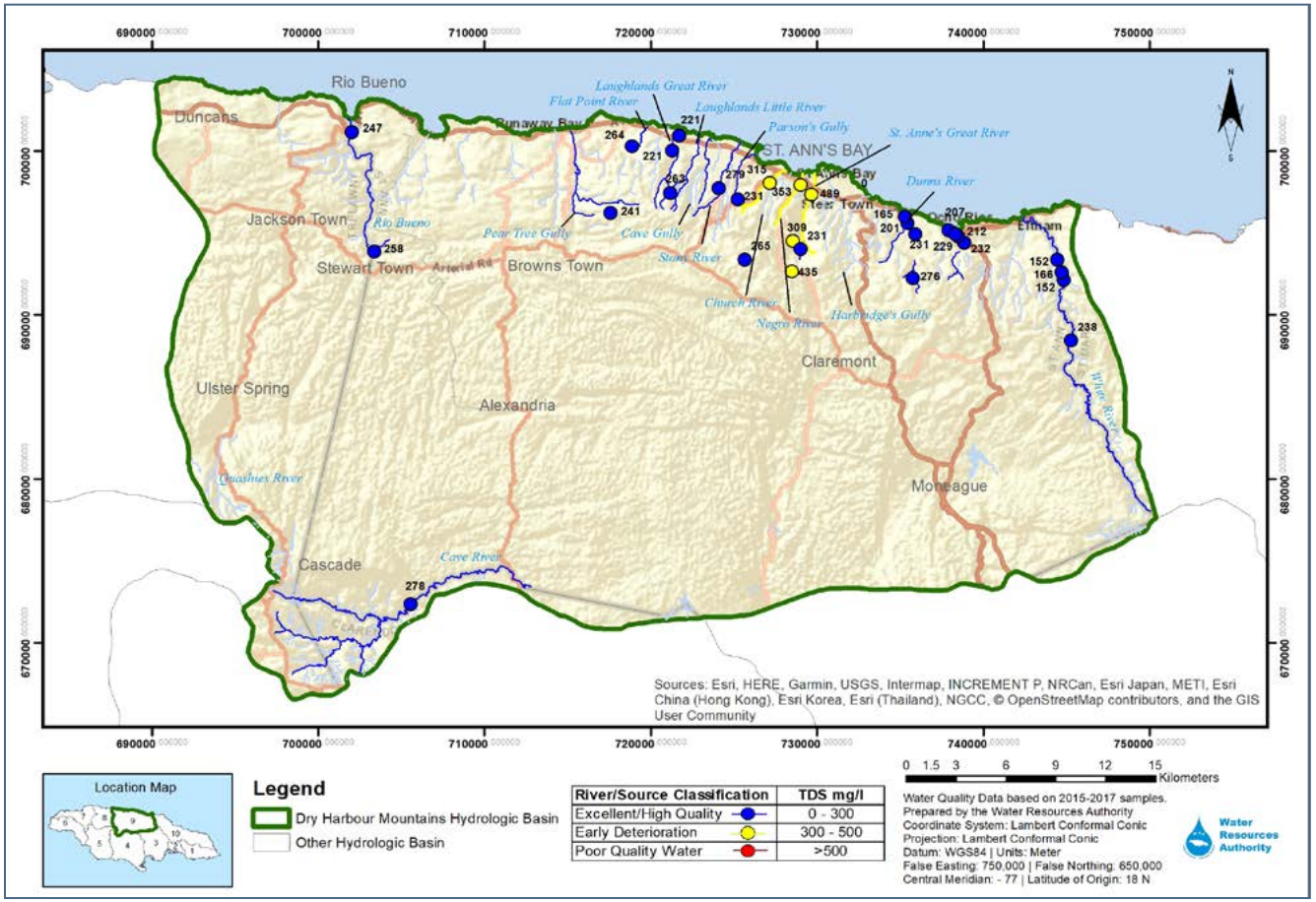
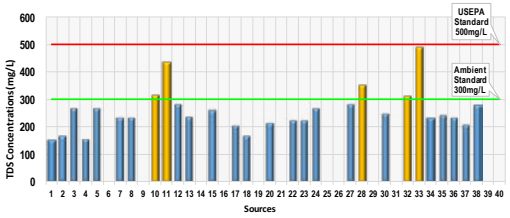


Figure 137: Dry Harbour Mountain Hydrologic Basin TDS Levels in Surface Water

DRY HARBOUR MOUNTAINS HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 90: Dry Harbour Mountain Basin TDS Levels in Surface water

As shown in Figure 137 and Graph 90, the surface water sources within the Dry Harbour Brae basin predominantly indicated excellent water quality for TDS. Fifty-eight (58%) percent of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. Thirteen percent (13%) indicated TDS levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard.

10.0 Basin X Blue Mountain North Hydrologic Basin

The Blue Mountain North Hydrologic Basin includes the parishes of Portland and St. Mary. For water management purposes, the Blue Mountain North Hydrologic Basin has been divided into thirteen sub-basins: Rio Nuevo, Oracabessa River, Pagee River, Wagwater River, Pencar River, Dry River, Buff Bay River, Spanish River, Swift River, Rio Grande, Town Gully, Priestman's River and Driver's River. The basin is drained by a network of rivers flowing over mountains (basement aquiclude – low permeability Cretaceous volcanics) in the western, central and eastern sections of the basin towards the northern coast

The water resources within the Blue Mountain North basin are comprised of groundwater, the limestone aquifer and surface water from the rivers that drain the thirteen sub-basins: Rio Nuevo, Oracabessa River, Pagee River, Wagwater River, Pencar River, Dry River, Buff Bay River, Spanish River, Swift River, Rio Grande, Town Gully, Priestman's River and Driver's River. Alluvial water within the basin is subsurface diversion of the river flows developed within the floodplain of the rivers.

The groundwater quality was analysed with the results from six limestone wells and the surface water analyses was done utilizing five (5) sources.

Blue Mountain North Hydrologic Basin Groundwater Sample Locations

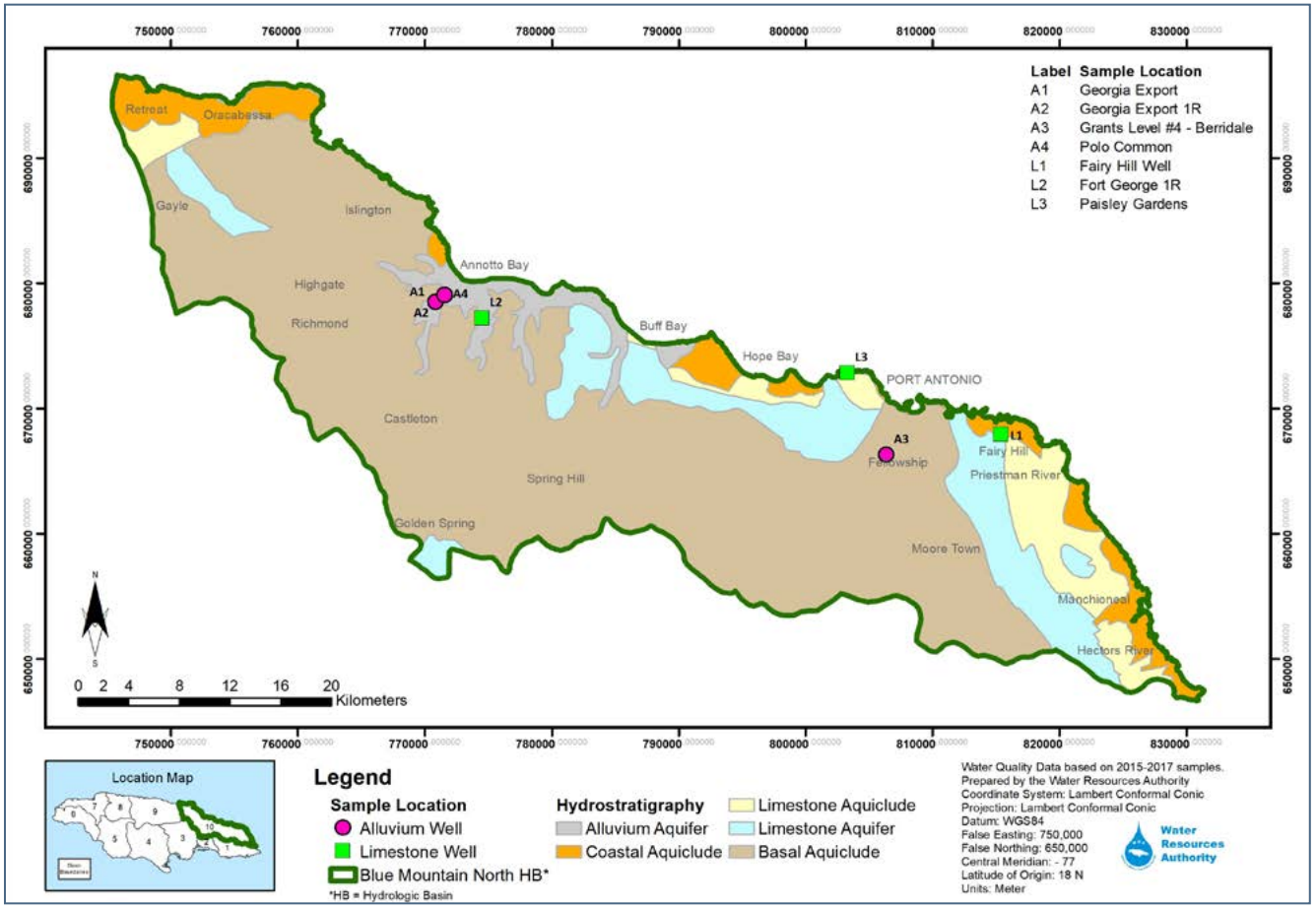


Figure 138: Blue Mountain North Hydrologic Basin Groundwater Sample Locations

Figure 138 shows the location of the seven (7) ground water sampling points. Four (4) of the sources are classified as alluvium wells and three (3) limestone wells.

Blue Mountain North Hydrologic Basin Nitrate Levels in Groundwater

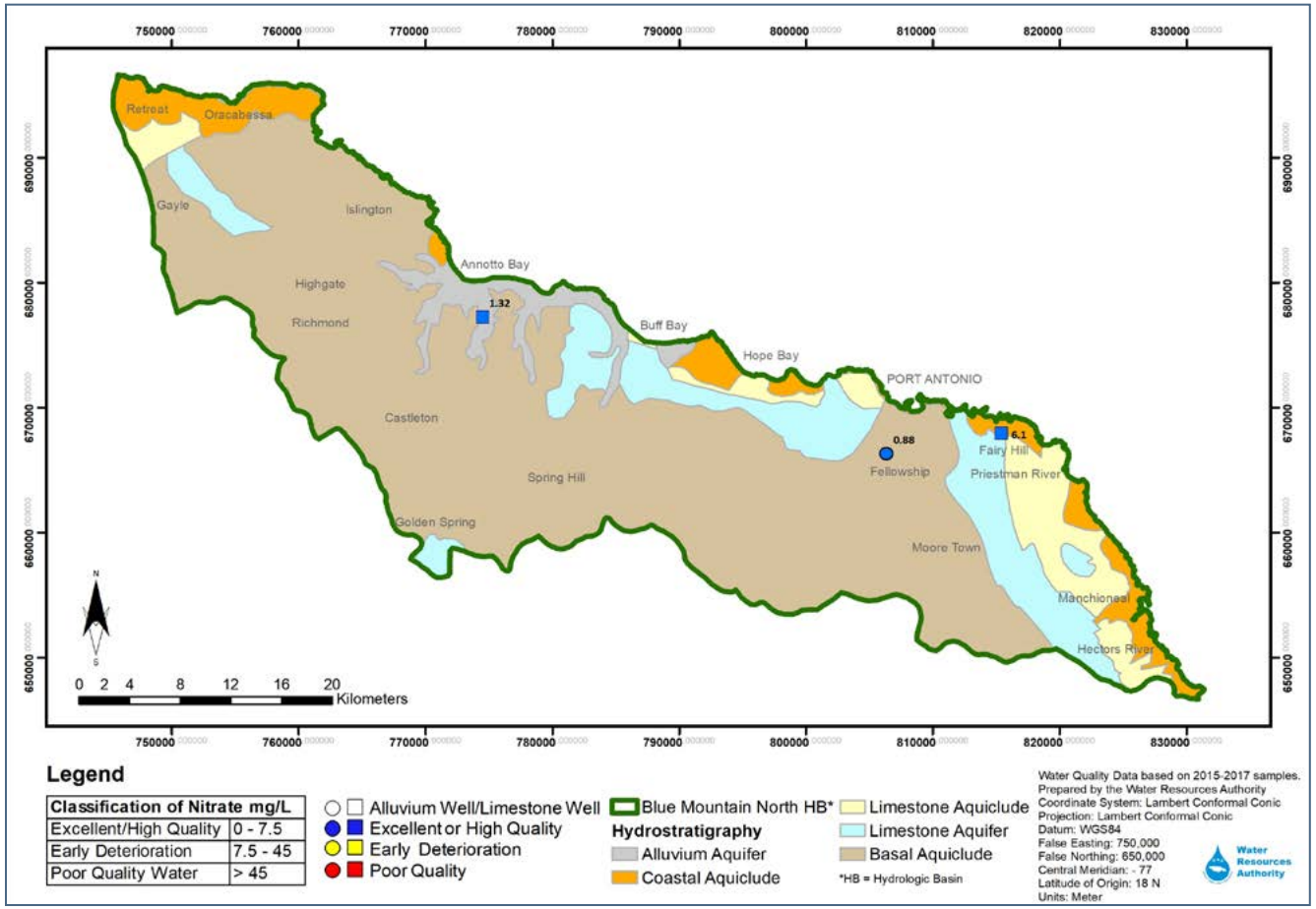
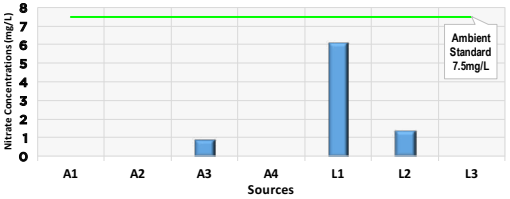


Figure 139: Blue Mountain North Hydrologic Basin Nitrate Levels in Groundwater

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN NITRATE LEVELS IN GROUNDWATER



Graph 91: Blue Mountain North Basin Nitrate Levels in Groundwater

As shown in Figure 139 and Graph 91, the well sources within the Blue Mtn. North basin predominantly indicated excellent water quality for nitrate. Forty-two percent (42%) indicated nitrate levels within the National Ambient Water Quality Standard of 7.5mg/L

Blue Mountain North Hydrologic Basin Sodium Levels in Groundwater

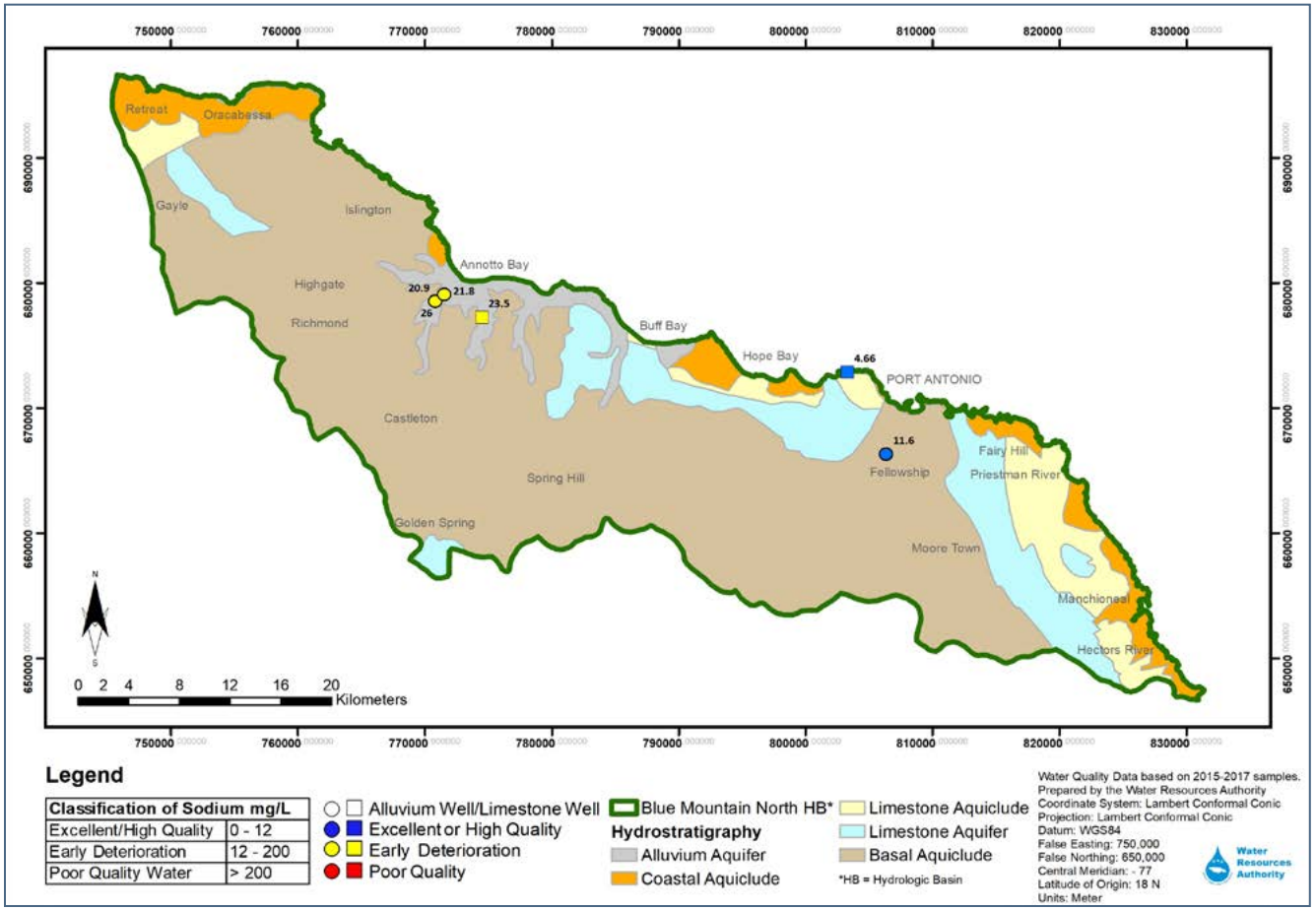
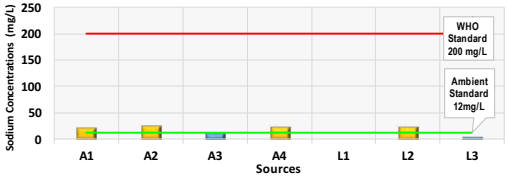


Figure 140: Blue Mountain North Hydrologic Basin Sodium Levels in Groundwater

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN SODIUM LEVELS IN GROUNDWATER



Graph 92: Blue Mountain North Basin Sodium Levels in Groundwater

The well sources within the Blue Mtn. North basin predominantly indicated early deterioration water quality for sodium as shown in Figure 140 and Graph 92. Fifty-seven percent (57%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L. Twenty-nine percent (29%) indicated excellent quality with sodium levels within the National Ambient Water Quality Standard of 12mg/L.

Blue Mountain North Hydrologic Basin Chloride Levels in Groundwater

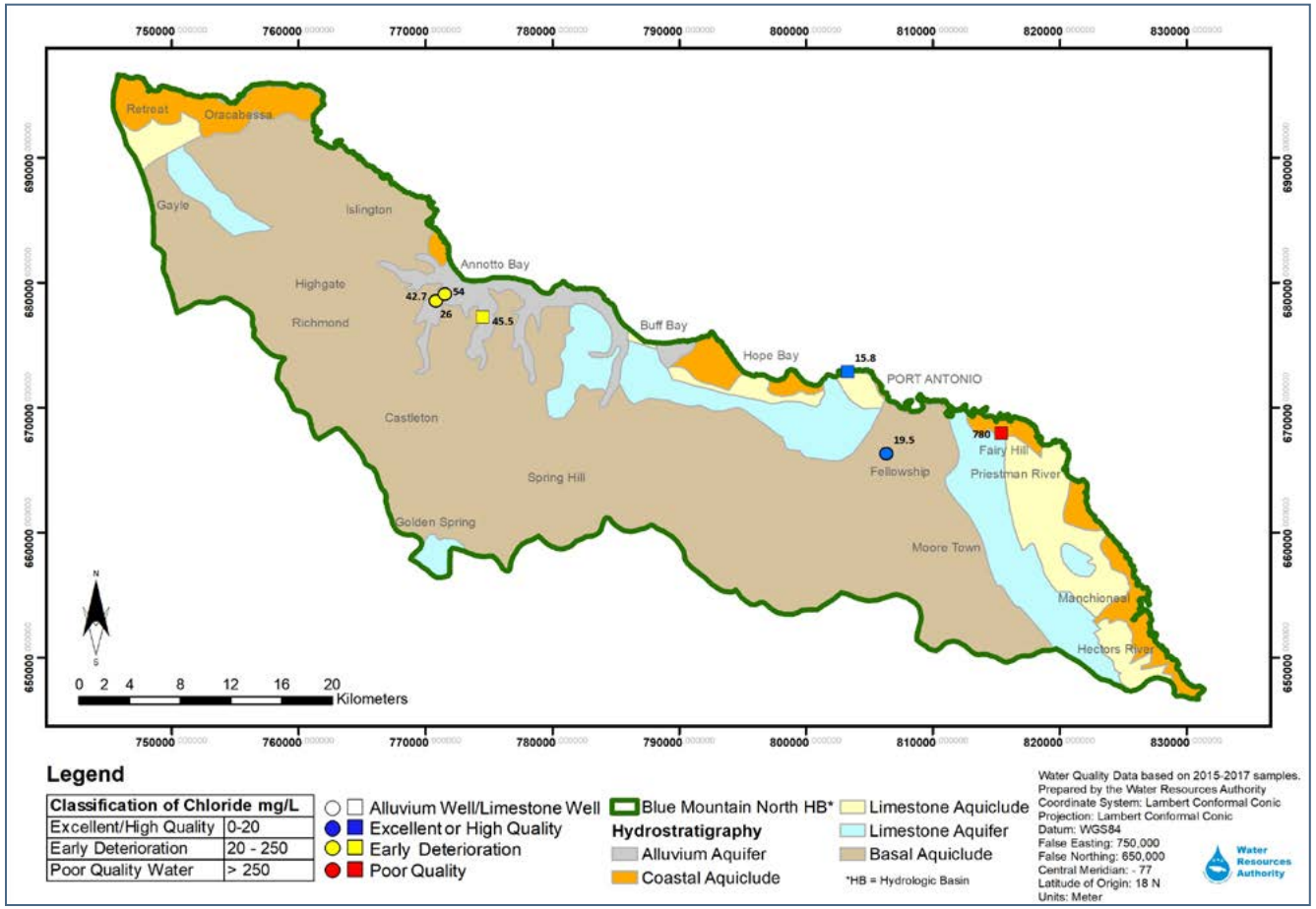
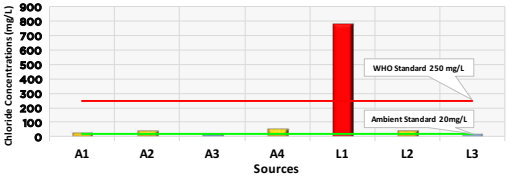


Figure 141: Blue Mountain North Hydrologic Basin Chloride Levels in Groundwater

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN CHLORIDE LEVELS IN GROUNDWATER



Graph 93: Blue Mountain North Basin Chloride Levels in Groundwater

The well sources within the Blue Mtn. North basin predominantly indicated early deterioration water quality for chloride as shown in Figure 141 and Graph 93. Fifty-eight percent (58%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L. Twenty-eight percent (28%) indicated excellent quality with chloride levels within the National Ambient Water Quality Standard of 20mg/L and fourteen percent (14%) of the sources sampled indicated chloride quality exceeding maximum level of the WHO Guidelines for Drinking Water Quality

Blue Mountain North Hydrologic Basin Sulphate Levels in Groundwater

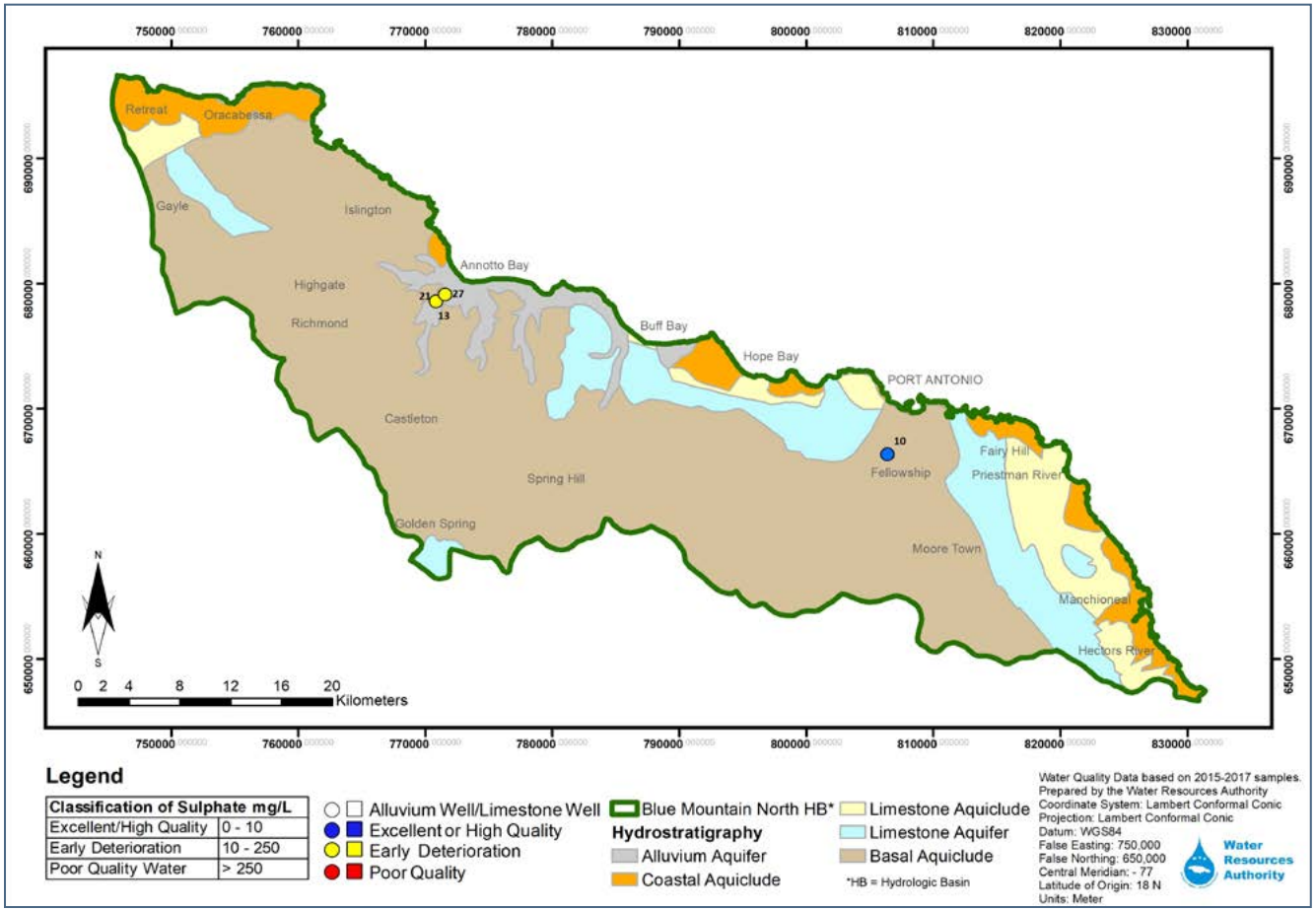
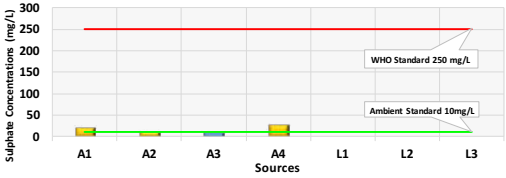


Figure 142: Blue Mountain North Hydrologic Basin Sulphate Levels in Groundwater

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN SULPHATE LEVELS IN GROUNDWATER



Graph 94: Blue Mountain North Basin Sulphate Levels in Groundwater

As shown in Figure 142 and Graph 94, the well sources within the Blue Mtn. North basin predominantly indicated early deterioration water quality for sulphate. Forty-two percent (42%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 10mg/L. Fourteen percent (14%) indicated excellent quality with chloride levels within the National Ambient Water Quality Standard of 10mg/L.

Blue Mountain North Hydrologic Basin TDS Levels in Groundwater

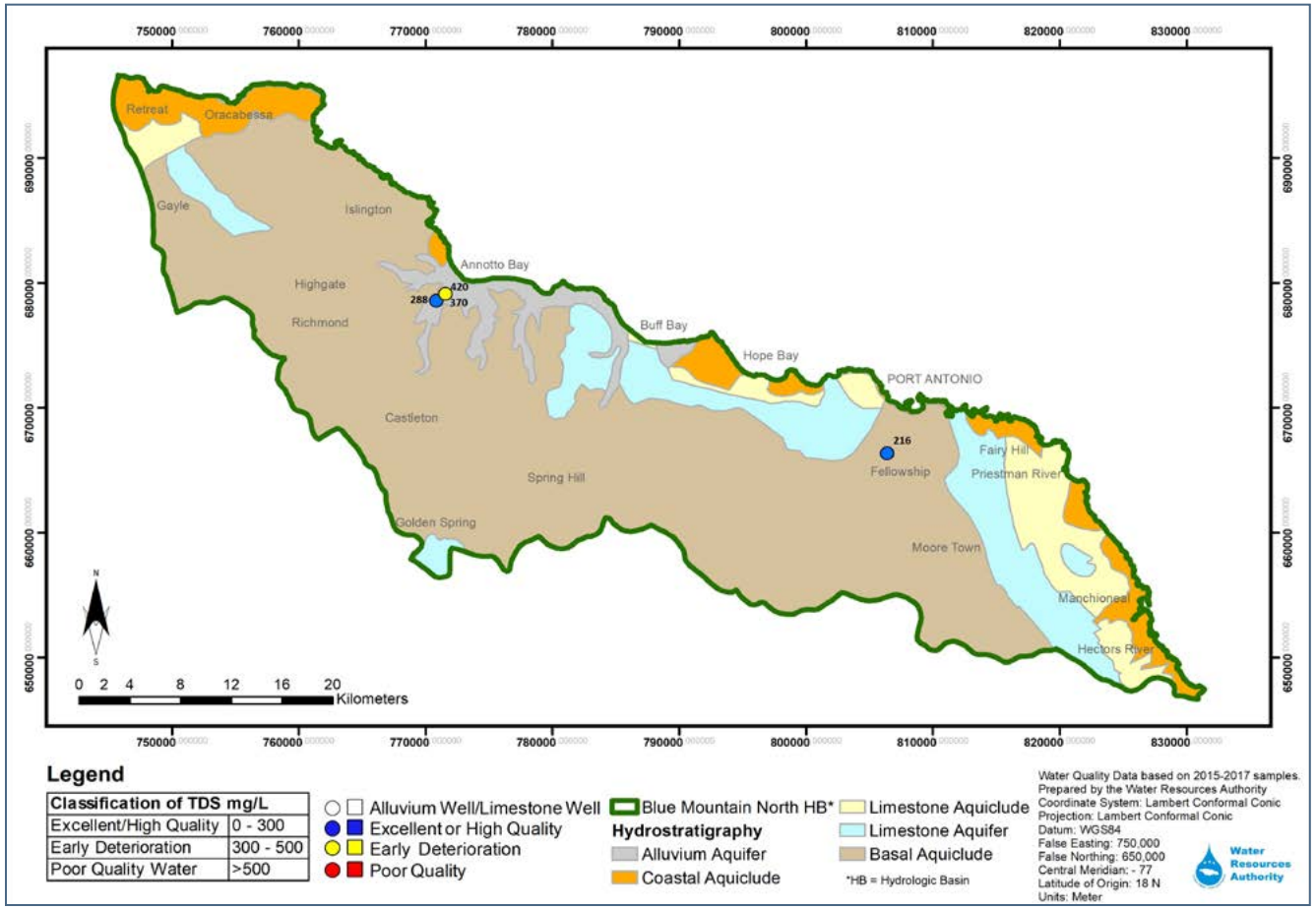
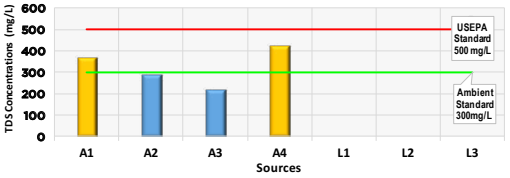


Figure 143: Blue Mountain North Hydrologic Basin TDS Levels in Groundwater

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN GROUNDWATER



Graph 95: Blue Mountain North Basin TDS Levels in Groundwater

As shown in Figure 143 and Graph 95, the well sources within the Blue Mtn. North basin indicated both excellent and early deterioration water quality for chloride. Fifty percent (50%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L. Fifty percent (50%) indicated excellent quality with chloride levels within the National Ambient Water Quality Standard of 20mg/L.

Blue Mountain North Hydrologic Basin Surface Water Sample Locations

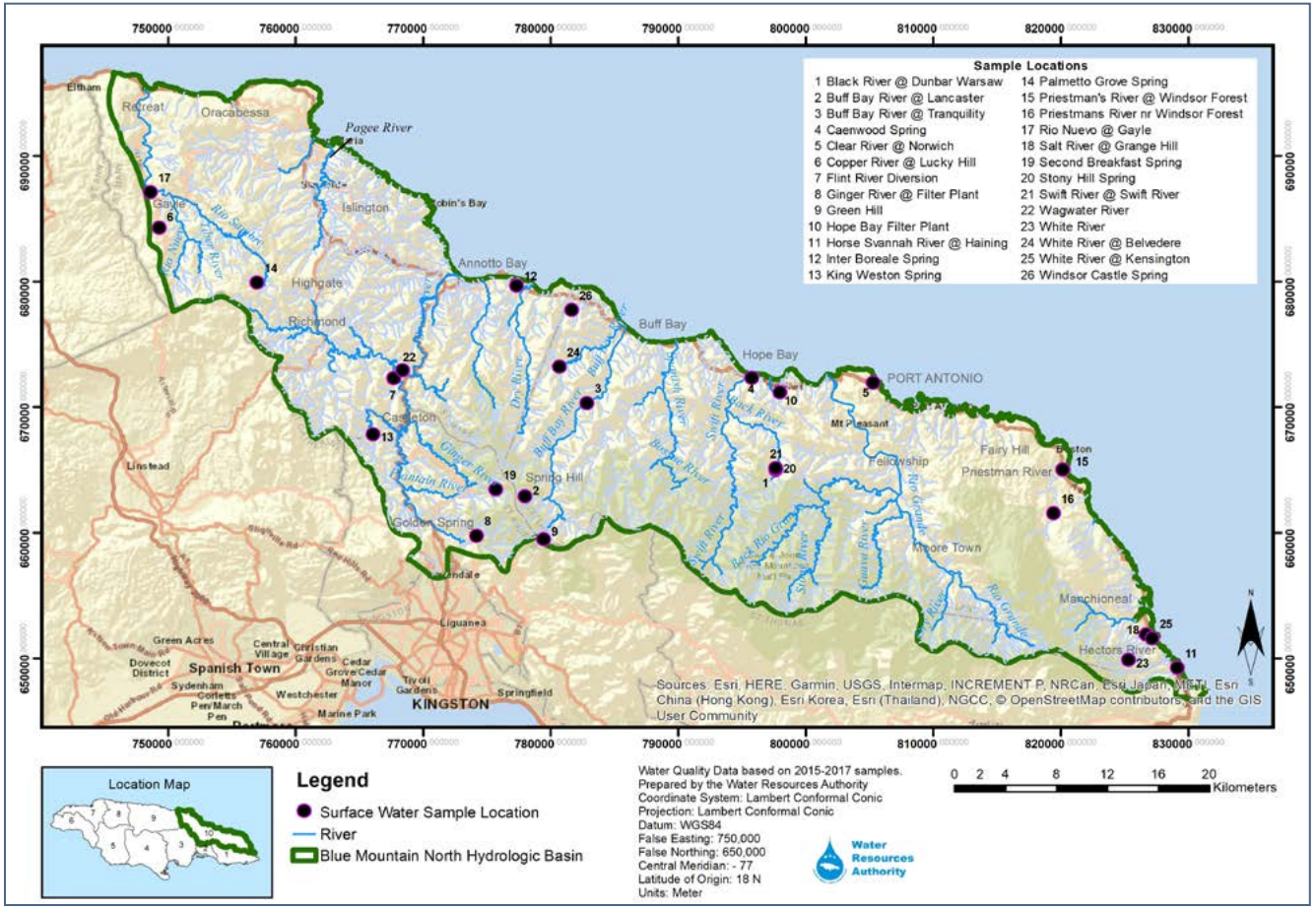


Figure 144: Blue Mountain North Hydrologic Basin Surface Water Sample Locations

Figure 144 shows the location of the twenty-six (26) surface water sampling points utilized in the surface water analyses for the Blue Mountain North Basin.

Blue Mountain North Hydrologic Basin Nitrate Levels in Surface Water

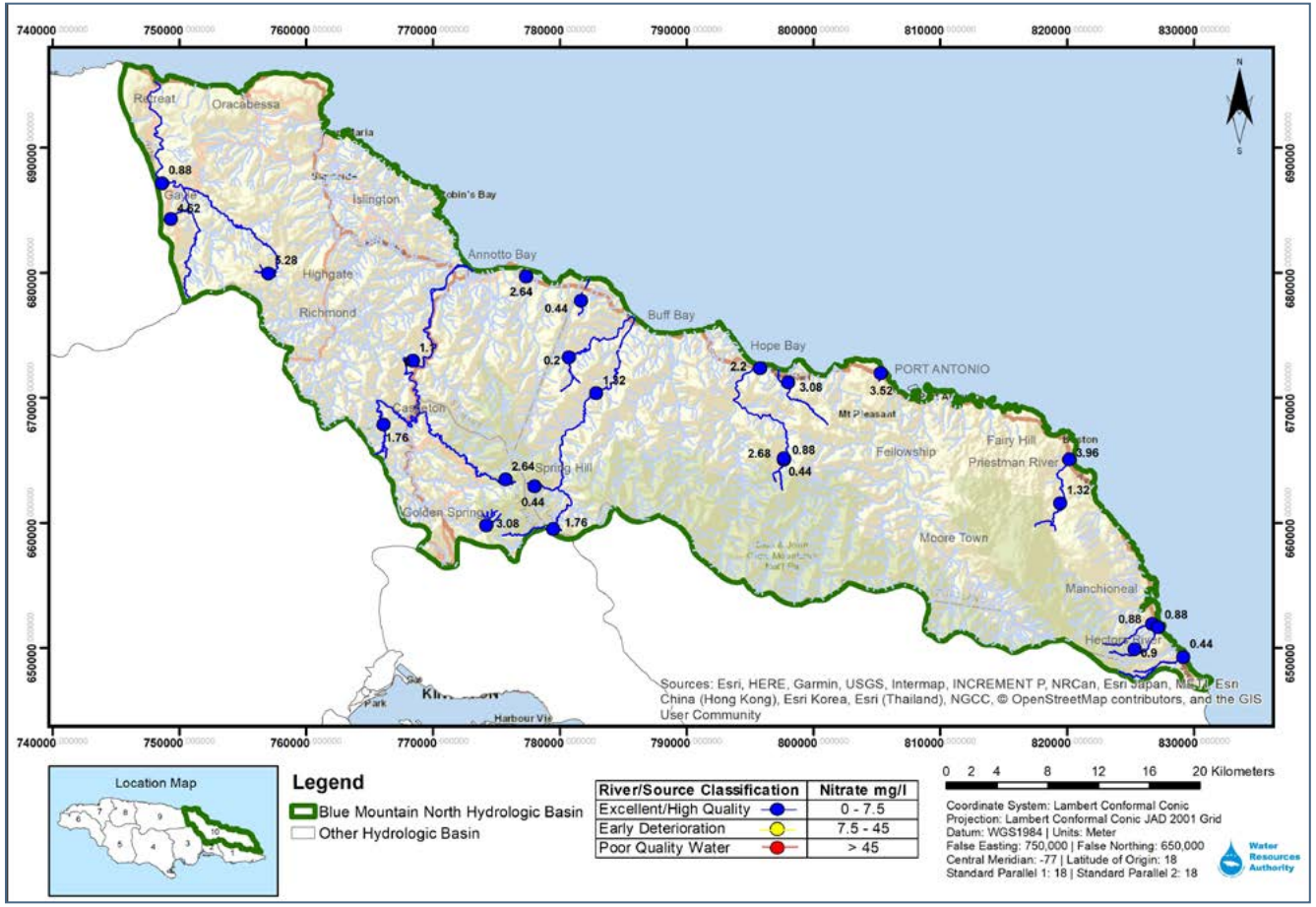
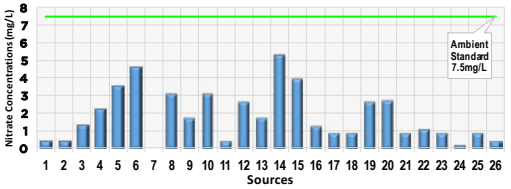


Figure 145: Blue Mountain North Hydrologic Basin Nitrate Levels in Surface Water

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN NITRATE LEVELS IN SURFACE WATER



Graph 96: Blue Mountain North Basin Nitrate Levels in Surface water

The surface water sources within the Blue Mtn. North basin predominantly indicated excellent water quality for nitrate as shown in Figure 145 and Graph 96. All the sources (100%) indicated nitrate levels within the National Ambient Water Quality Standard of 7.5mg/L

Blue Mountain North Hydrologic Basin Sodium Levels in Surface Water

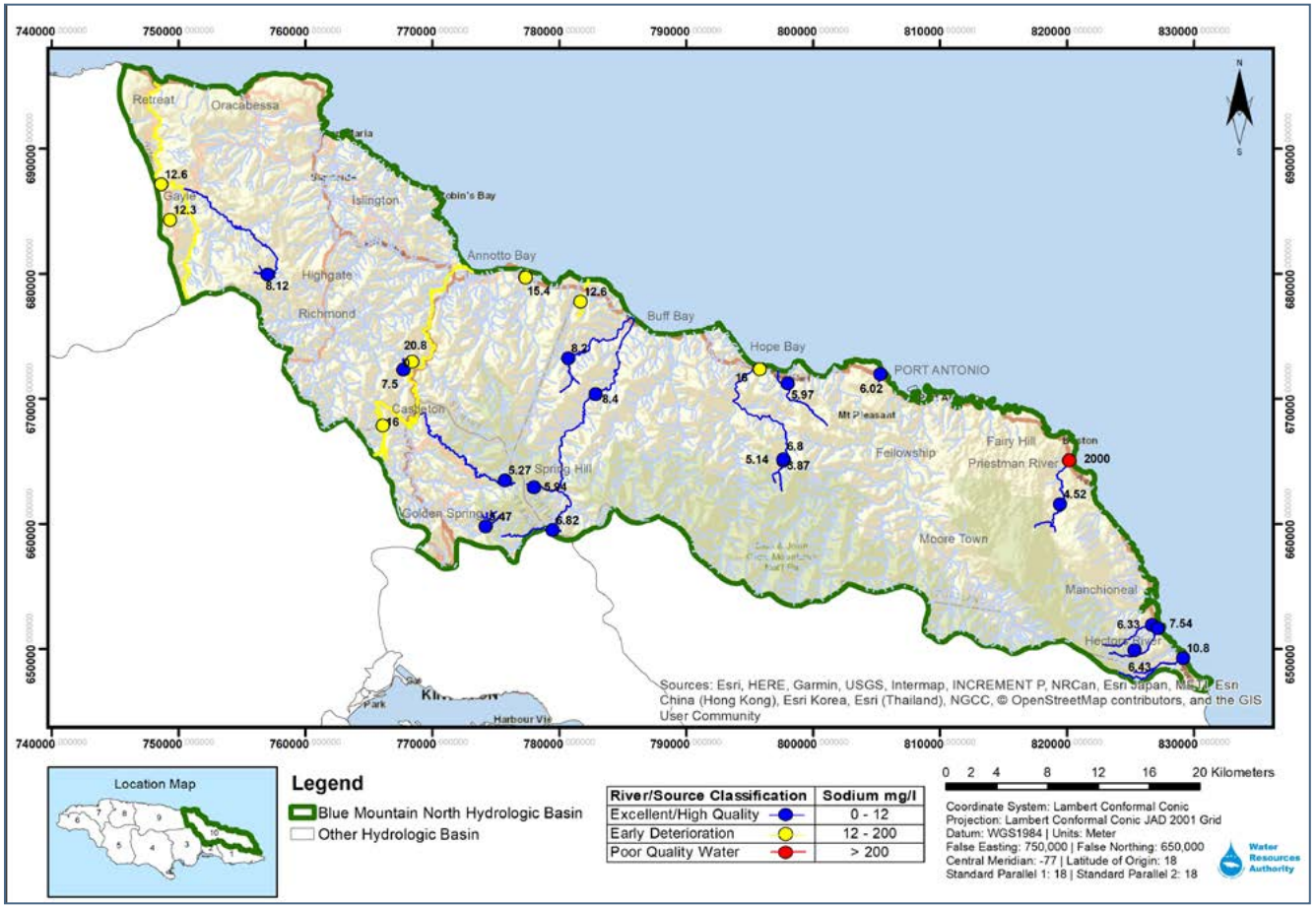
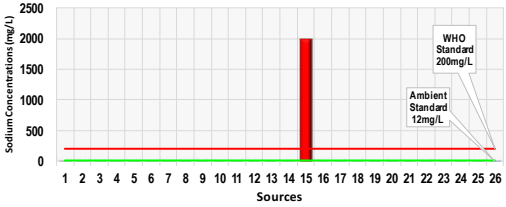


Figure 146: Blue Mountain North Hydrologic Basin Sodium Levels in Surface Water

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN SODIUM LEVELS IN SURFACE WATER



Graph 97: Blue Mountain North Basin Sodium Levels in Surface water

Figure 146 and Graph 97 shows that the surface water sources within the Blue Mtn. North basin predominantly indicated excellent water quality for sodium. Sixty nine percent (69%) of the sources sampled indicated sodium quality within the National Ambient Water Quality Standard of 12mg/L. Twenty seven percent (27%) indicated sodium levels in excess of the National Ambient Water Quality Standard of 12mg/L. Four percent (4%) of the sources indicated poor water quality for chloride

Blue Mountain North Hydrologic Basin Chloride Levels in Surface Water

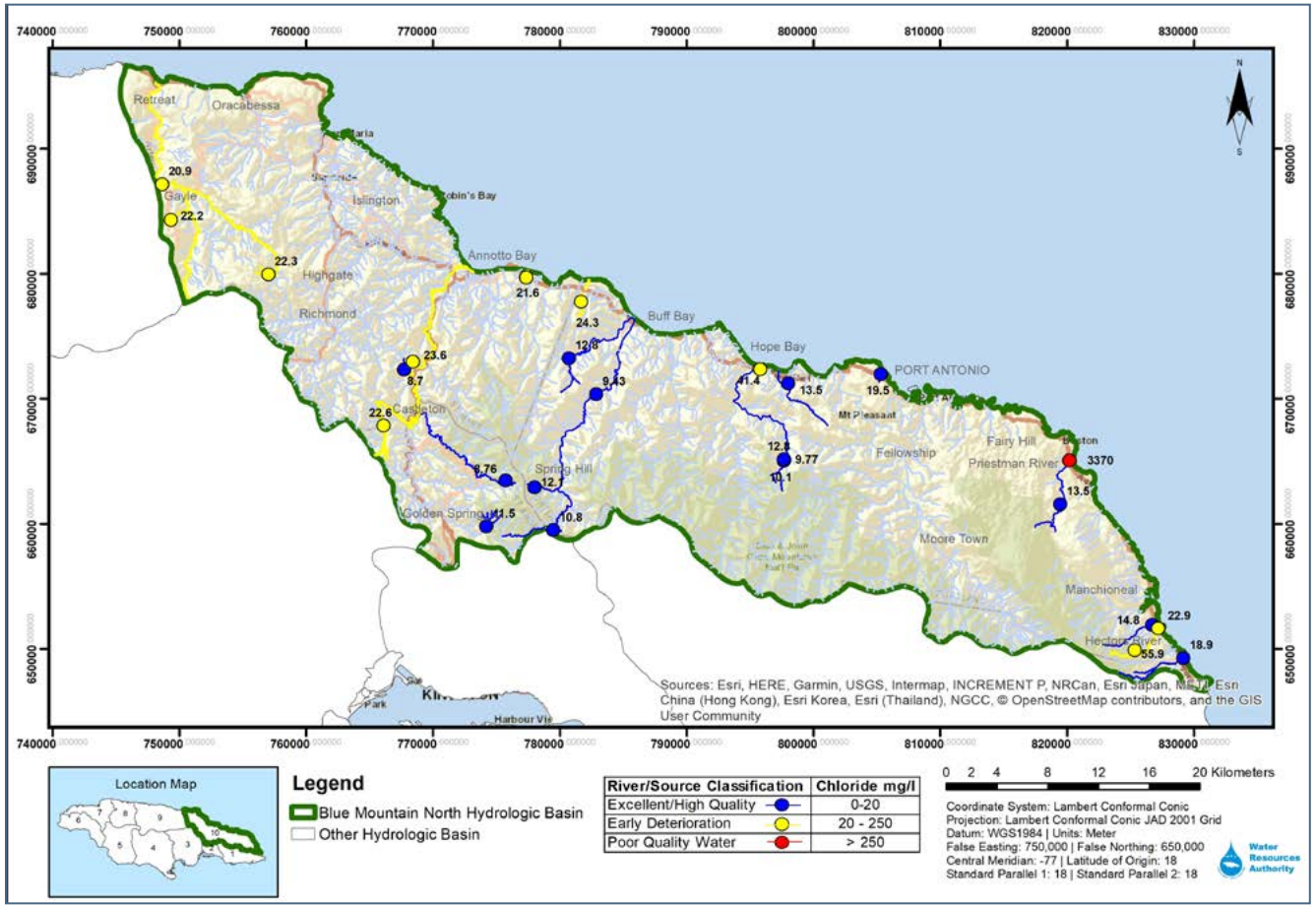
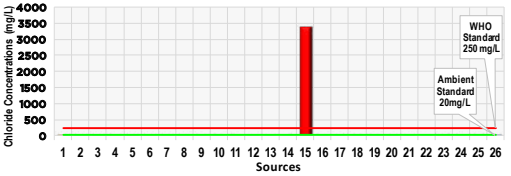


Figure 147: Blue Mountain North Hydrologic Basin Chloride Levels in Surface Water

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN CHLORIDE LEVELS IN SURFACE WATER



Graph 98: Blue Mountain North Basin Chloride Levels in Surface water

As shown in Figure 147 and Graph 98, the surface water sources within the Blue Mtn. North basin predominantly indicated excellent water quality for chloride. Fifty percent (50%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 20mg/L. Thirty-eight percent (38%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 20mg/L. Four percent (4%) of the sources indicated poor water quality for chloride

Blue Mountain North Hydrologic Basin Sulphate Levels in Surface Water

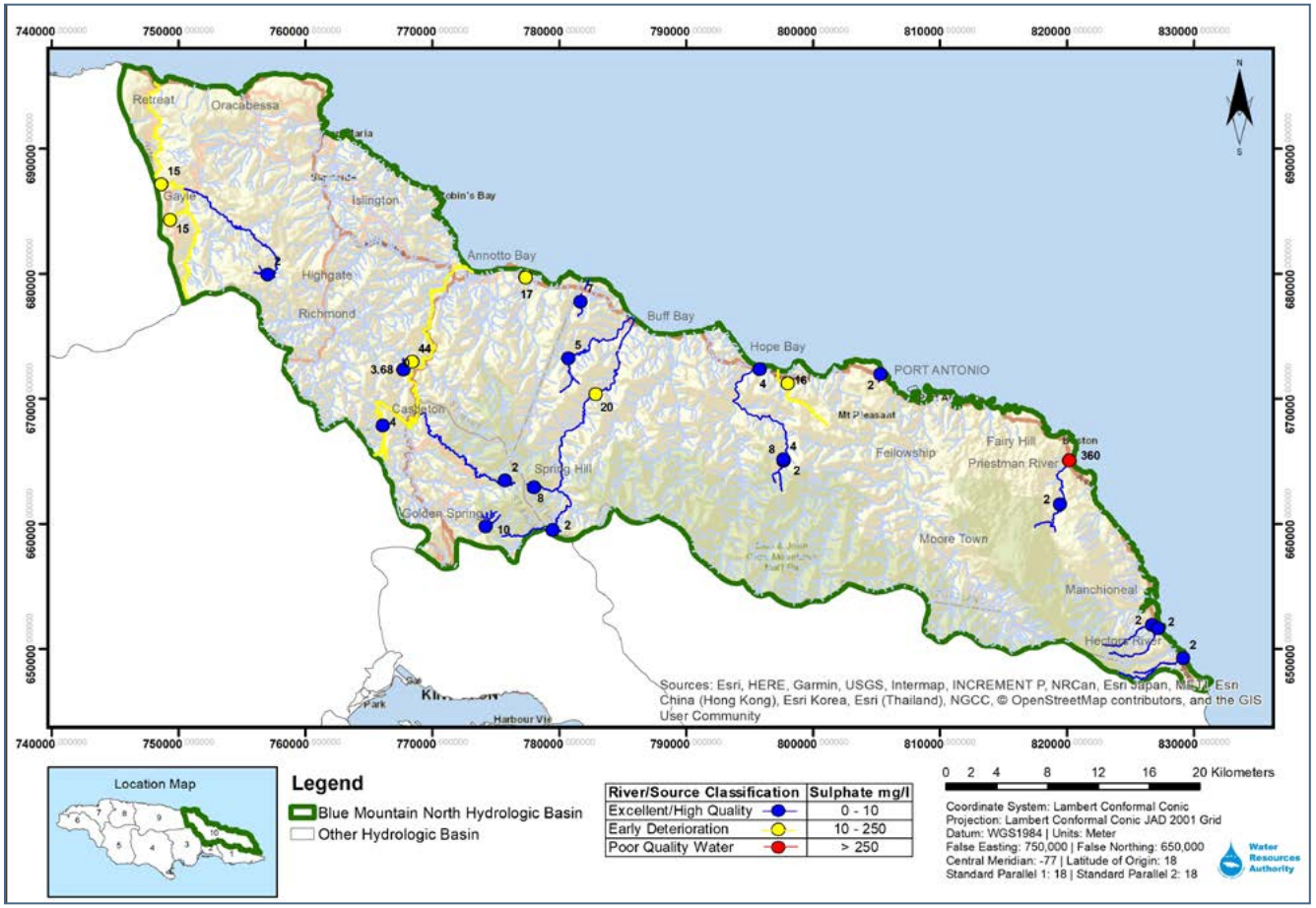
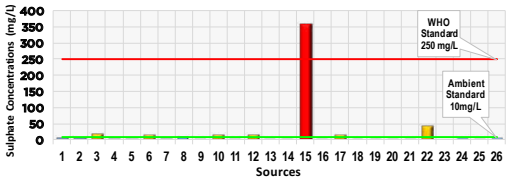


Figure 148: Blue Mountain North Hydrologic Basin Sulphate Levels in Surface Water

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN SULPHATE LEVELS IN SURFACE WATER



Graph 99: Blue Mountain North Basin Sulphate Levels in Surface water

As shown in Figure 148 and Graph 99, the surface water sources within the Blue Mtn. North basin predominantly indicated excellent water quality for sulphate. Sixty nine percent (69%) of the sources sampled indicated chloride quality within the National Ambient Water Quality Standard of 10mg/L. Twenty three percent (23%) indicated sulphate levels in excess of the National Ambient Water Quality Standard of 10mg/L. Four percent (4%) of the sources indicated poor water quality for chloride

Blue Mountain North Hydrologic Basin TDS Levels in Surface Water

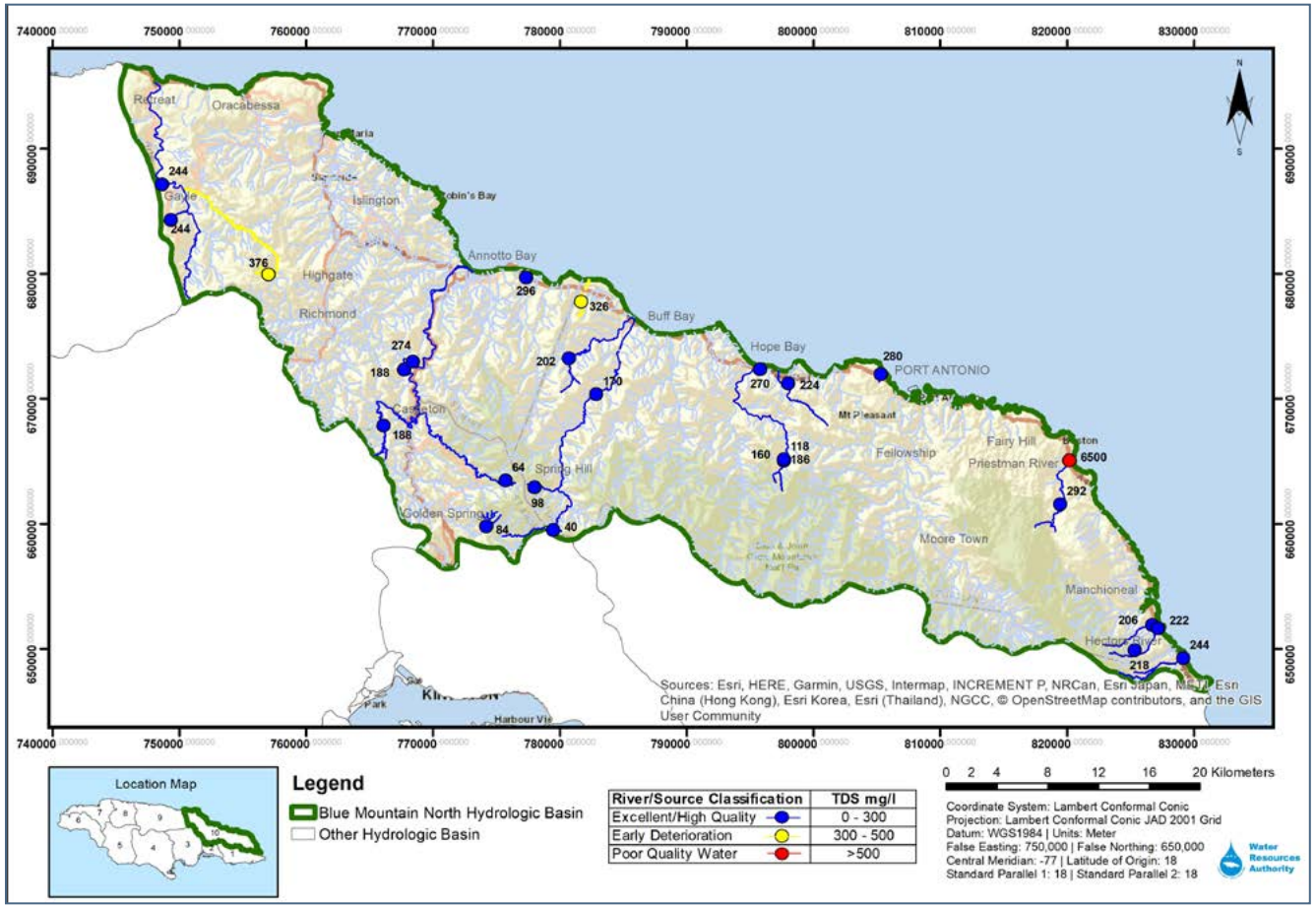
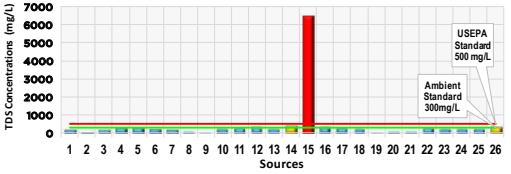


Figure 149: Blue Mountain North Hydrologic Basin TDS Levels in Surface Water

BLUE MOUNTAIN NORTH HYDROLOGIC BASIN TOTAL DISSOLVED SOLIDS LEVELS IN SURFACE WATER



Graph 100: Blue Mountain North Basin TDS Levels in Surface water

As shown in Figure 149 and Graph 100, the surface water sources within the Blue Mtn. North basin predominantly indicated excellent water quality for TDS. Eighty eight percent (88%) of the sources sampled indicated TDS quality within the National Ambient Water Quality Standard of 300mg/L. Eight percent (8%) indicated chloride levels in excess of the National Ambient Water Quality Standard of 300mg/L but are within the maximum level of the USEPA standard. Four percent (4%) of the sources indicated poor water quality for chloride

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Water Resources Authority

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