Dominica Meteorological Service

Hurricane Maria: Hydro-Meteorological Impact on Dominica

Dominica Meteorological Service

Applied Meteorology Section

9/18/2017

METEOROLOGICAL REPORT

On September 12th 2017, a tropical wave emerged off the coast of West Africa into the Eastern Tropical Atlantic and began its westward progression over open water. Being in a region of sea surface temperatures (SSTs) about 1-2 degrees above normal and low vertical wind shear, the tropical wave was able to organize itself into a well-defined mass of convection with an associated low. A dominant high pressure system in the Central Atlantic helped the disturbance to maintain a westerly track.

By September 16th, the disturbance now several hundred miles east of the Lesser Antilles was upgraded to potential cyclone 15 by the National Hurricane Centre (NHC). Tropical storm watches were issued for portions of the Lesser Antilles including Dominica. At this time no clear centre was identified however, being in an environment conducive for development (wind shear 10kts or less, SSTs 29°C), models unanimously showed steady strengthening of the system. The NHC forecast track illustrated the system passing just north of Dominica in 48hours as a hurricane. At 2pm, the disturbance was upgraded to a tropical depression, near 11.9°N 51.6°W with winds near 35mph, estimated minimum central pressure near 1006mb. The depression was moving toward the west near 20mph and a slower west northwest track was expected. By 5pm, tropical storm Maria had developed near 12.3°N 52.6°W, 620 miles (1000km) ESE of the Lesser Antilles. Maximum sustained winds had increased to 50mph, movement westward at 20mph with minimum central pressure near 1002mb. The tropical storm watch remained in effect for Dominica.

With Maria expected to intensify further, the tropical storm watch was upgraded to a hurricane warning at 11am on the 17th. By 5pm, a burst of deep convection had developed over Maria and an Air Force Hurricane Hunter aircraft found maximum flight level winds of 63kts, surface winds of 64kts and an open eye wall. Maria had become a hurricane, near 13.8°N 57.5°W. While modeled intensification indices were not especially high, some rapid intensification of Maria was expected and NHC had predicted the storm to be of a major category near the Lesser Antilles, no greater than category 3. At the time, Maria was projected to be near 15.8°N 61.8°W at 0600Z on the 19th.

Hurricane Maria continued to rapidly strengthen as it approached the Lesser Antilles, becoming a category 3 hurricane about 150km ESE of Dominica at 11am September 18th (14.7°N 60.1°W). Maximum sustained winds had increased to 120mph. Maria had slowed down significantly to 10mph with a minimum central pressure of 959mb. Hurricane force winds extended outward

up to 15 miles from the centre and tropical storm force winds up to 125miles. The forecast track now took Maria directly across the island of Dominica.

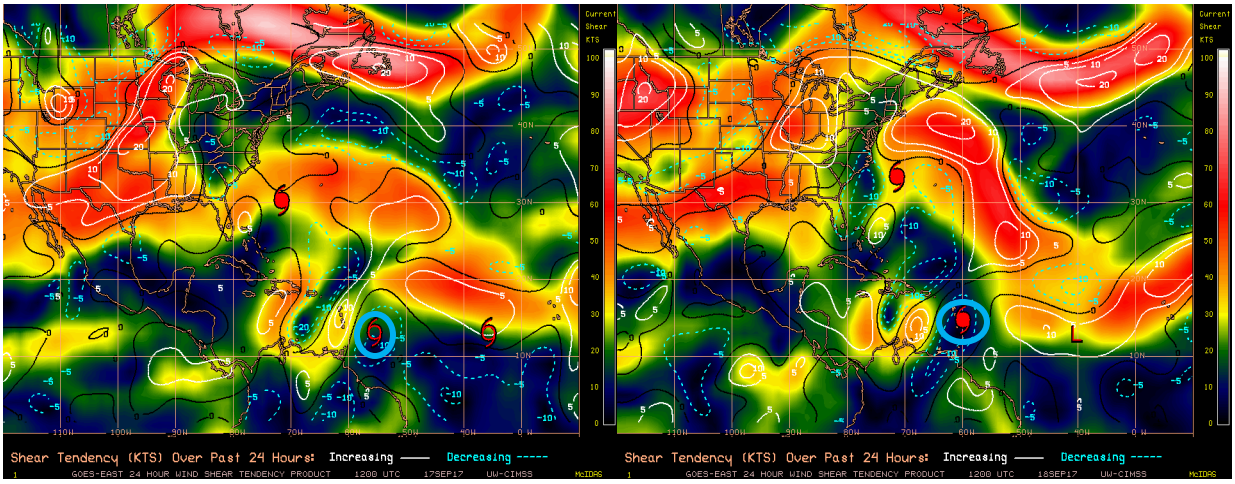

Figure 1 Decreasing wind shear east of Lesser Antilles, Sept 17 (8am) and Sept 18 (8am) (CIMSS)

Extremely warm SSTs between 28°C and 30°C (Fig 2) and decreasing wind shear of 5kts to 10kts (Figs. 1 and 2) continued to provide sufficient fuel for rapid intensification of Maria and by 5pm, the hurricane had deepened to a category 4 system near 15.1°N 60.7°W. At this time, the centre of Maria was visible on Martinique's radar. Maximum sustained winds had increased to near 130mph with higher gusts. Maria continued to move WNW near 9mph. Hurricane force winds extended outward up to 25 miles from the centre and tropical storm force winds up to 125miles. According to NHCs discussion No. 10, Maria was developing the dreaded pinhole eye with a diameter of about 8 to 10 nautical miles. This illustrated a compact and intense system with hurricane force winds confined to a small area near the eye. Intensity forecasts now called for Maria to reach category 5 in 24hrs most likely in the Caribbean Sea.

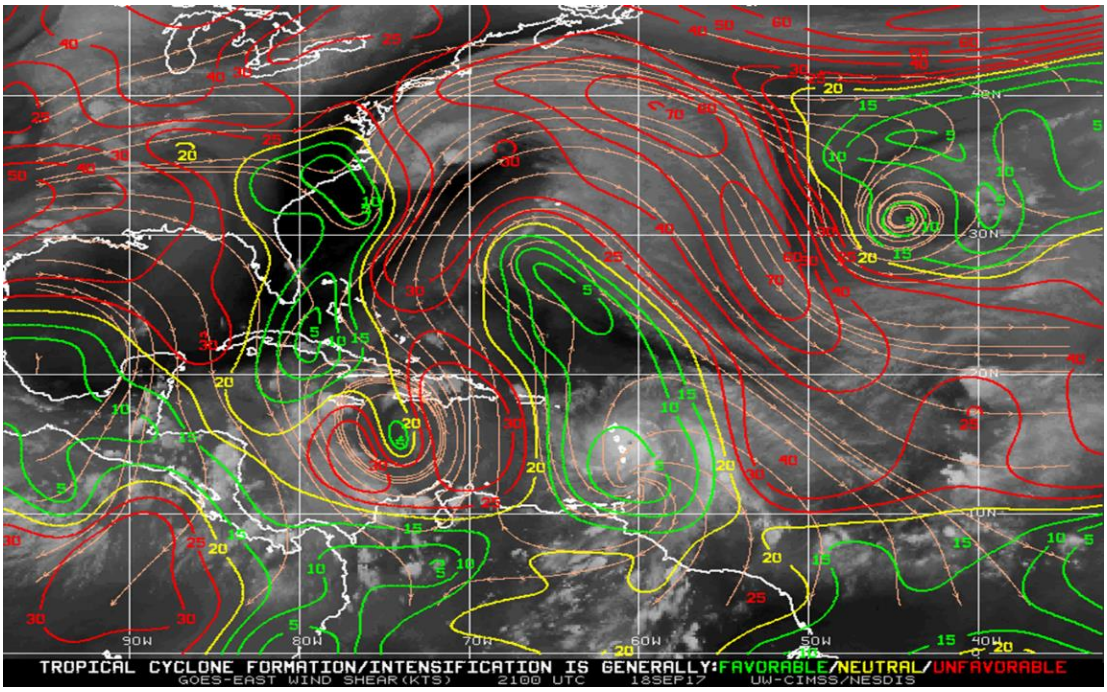

Figure 2 Low wind shear across Lesser Antilles, 18th Sept 2018 (University of Wisconsin-CIMSS)

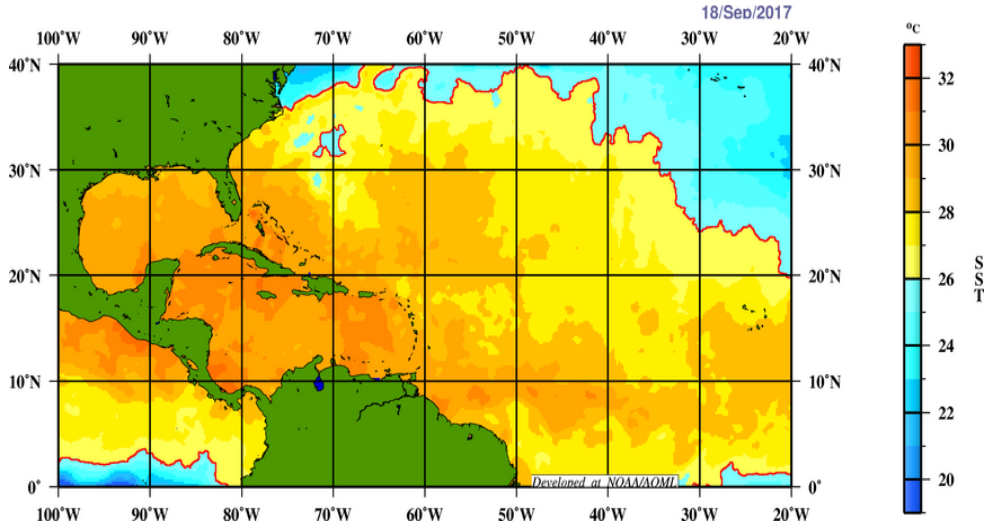

Figure 3 Sea surface temperatures 28°C to 30°C just east of the Lesser Antilles (NOAA/AOMI)

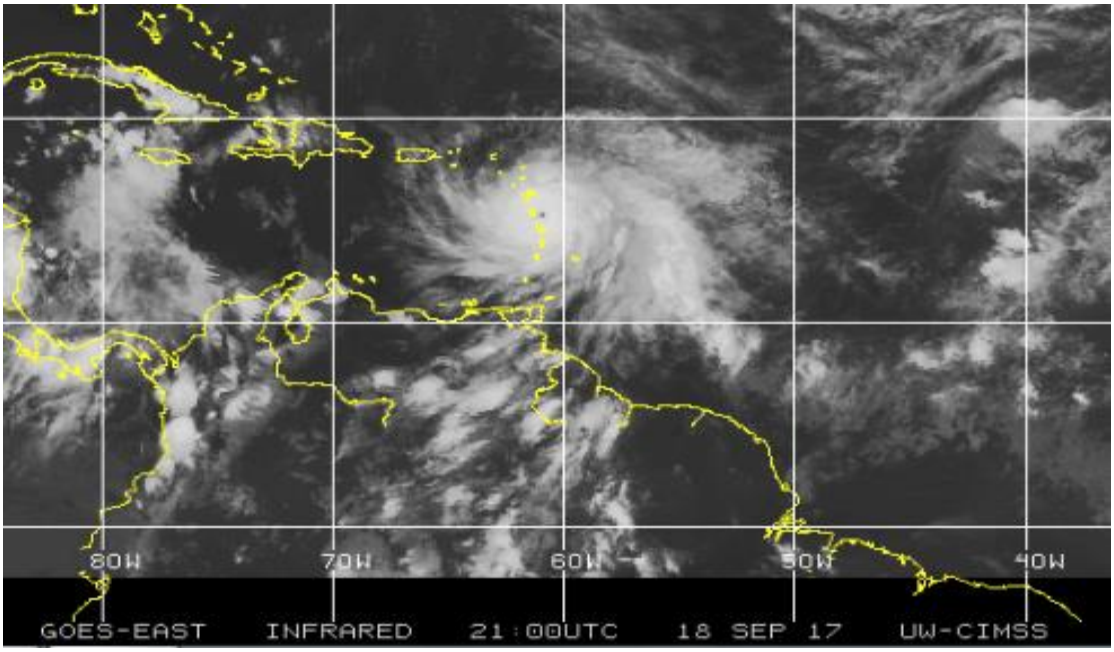

Figure 2 Visible satellite of Maria just south-east, approaching Dominica, 5pm, Sept 18

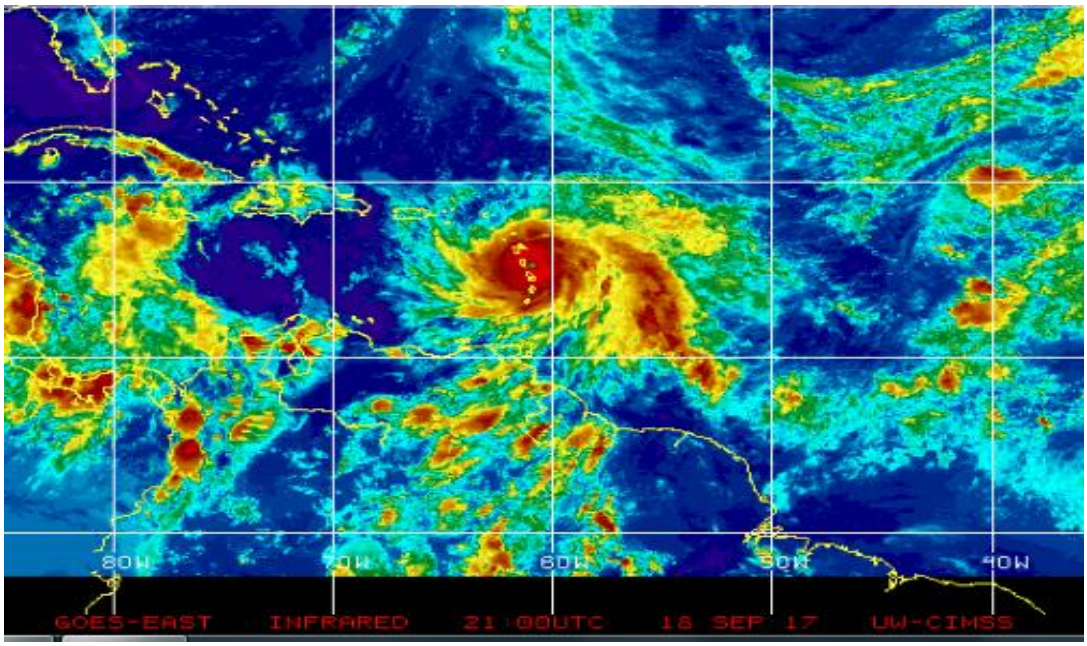

Figure 3 Infrared satellite of Maria approaching Dominica, 5pm, Sept 18th

Chronology of Maria's Movement- 6pm September 18th to 2am September 19th

At 6pm Maria was located near 15.2°N 60.8°W, 35miles ESE of Dominica, maximum winds near 130mph, moving WNW at 9mph and a minimum central pressure of 950mb. At 7pm, the hurricane was near 15.3°N 60.9°W, 30miles ESE of Dominica.

At 7:45pm a Hurricane Hunter aircraft which had been investigating Maria found that the system had intensified to an extremely dangerous category 5 hurricane with winds of 160mph. The centre was near 15.3°N 61.1°W. The core of Maria was expected to pass over Dominica in the next hour or two. Minimum central pressure had decreased to 925mb.

Wind shear products showed Maria just east of the Lesser Antilles in a region of low shear (5-10kts) and moving into an area of gradually decreasing shear across the islands. This ingredient was particularly essential to Maria's rapid intensification.

At approximately 9:15 pm, Maria made landfall with estimated winds of 160mph on the SE coast of the island near the villages of Laplaine and Delices as a category 5 system.

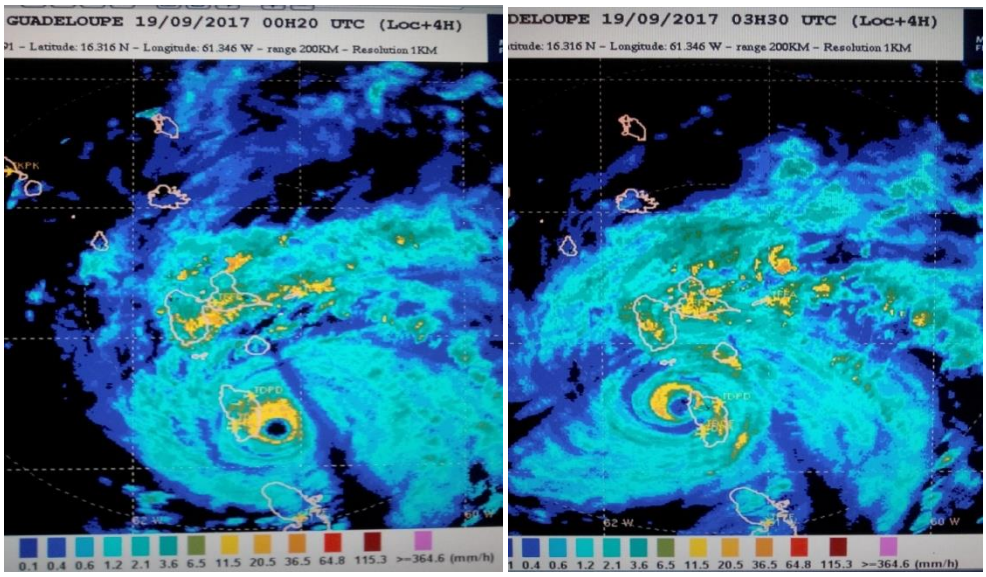

Figure 4 Category 5 Hurricane Maria making landfall and exiting the island of Dominica (Guadeloupe radar, Meteofrance)

At 11pm, the eye was still moving over Dominica towards the north-west, 15.5°N, 61.4°W. Hurricane force winds extended up to 30miles from the centre and tropical storm force winds up to 125 miles.

The eye exited the island around 11:30pm, just south of Portsmouth.

At 2am, the centre was located near 15.7°N 61.9°W. Though some slight weakening had occurred as the system moved over Dominica's mountainous terrain it still remained a dangerous category 4 hurricane. At 11am on the 19th Maria was 16.3°N 63.1°W, 160mph, 115miles W of Guadeloupe. Rainbands continued to affect the island throughout the day.

At 5pm, the Barbados Meteorological Service discontinued the hurricane warning for Dominica.

Hurricane Maria went from a disorganized CAT 1 system to a fully mature CAT 5 in less than 18 hours. Maria's passage resulted in significant loss of life and widespread, catastrophic damage due to flash-floods, mudslides and intense winds.

The NHC report on Mara indicated that the system was already a tropical storm when it was named a potential cyclone. Model consensus did not only fail to predict its development but also to capture the level of intensification that Maria underwent on the 18th making it the 3rd costliest in United States history. Additionally, the report stated that based on various satellite applications, data from flight level winds, the 130kts recorded at Douglas-Charles and other techniques, Maria's maximum winds on landfall in Dominica was about 145kts/ 167mph with a minimum central pressure of approximately 922mb. During her lifetime, Maria's winds topped at 150kts/ 173mph, minimum central pressure of 908mb, 70 miles SE of St. Croix (16.9°N 64.1°W) at 7pm on September 19th 2017.

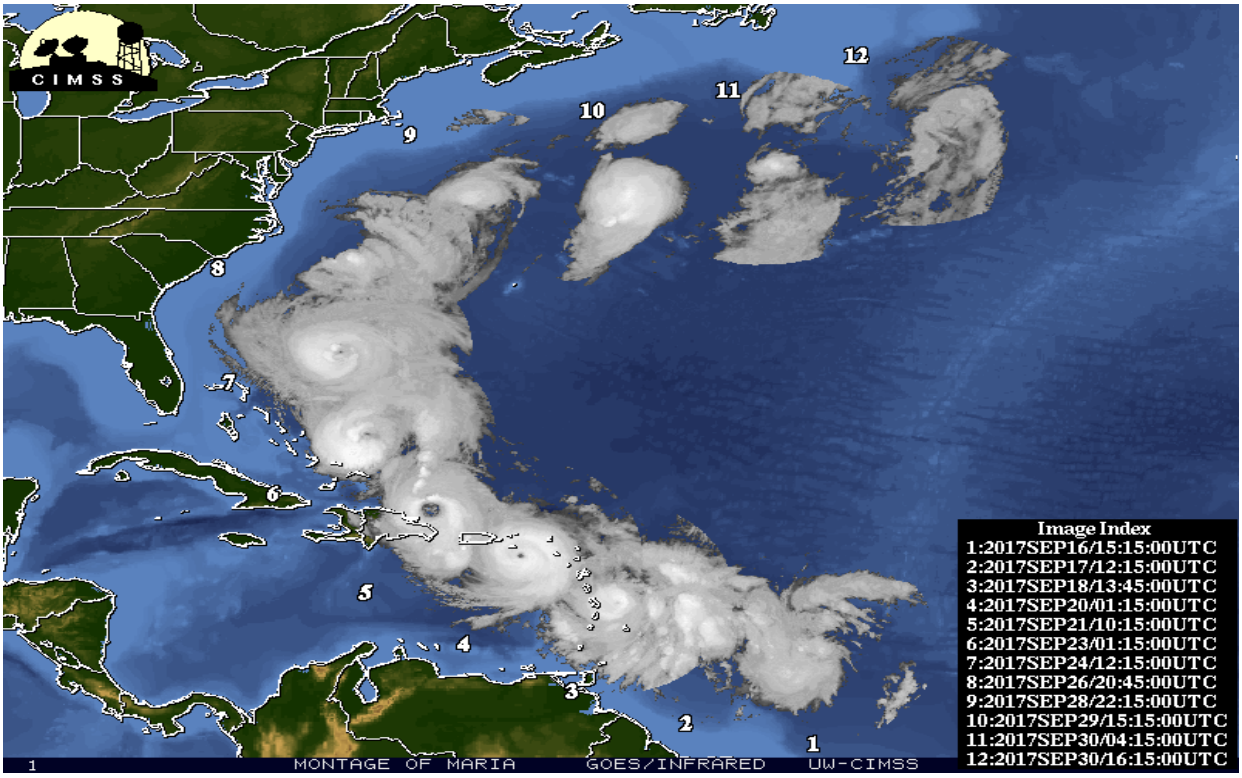

Figure 5 Satellite imagery of Hurricane Maria's track across the Atlantic (CIMSS-University of Wisconsin-Madison)

Rainfall

As one would expect, many of the weather stations on Dominica failed during Maria's passage and only a few provide reliable and consistent data. The rain gauge at Douglas-Charles Airport was compromised and there are no measurements beyond 17:00 (5:00pm) on the 18th.

Local time = UTC - 4hours

Based on data from available stations (Fig. 8), over 500mm/ 20in of rainfall were recorded at Canefield, Copthall and Salisbury. The highest amount recorded was at Copthall of about 579.0mm/ 22.80 inches, followed by Wet Area, Belles with 559.8mm/ 22.04inches then Salisbury with 470.6mm/ 18.53in and lastly Canefield Airport with a total of 451.8mm/ 17.79 inches. The other stations recorded between 100mm to 200mm (4 to 8 in).

Generally, rainfall amounts began increasing from about 5pm on the 18th. Peak amounts and the times in which they were observed varied among the stations. Copthall and Salisbury experienced peak rainfall around 19:00 that night, before landfall while Belles, Canefield and Pond Casse peaked between 21:00 and 22:00, after landfall. Copthall recorded the maximum rainfall intensity among all stations, between 18:00 and 19:00 (6pm and 7pm); 289.2mm within

that hour 11.02in in one hour. This would have resulted in devastating floods downstream of the Copthall River in the Roseau Valley.

All stations except for Copthall continued recording shower activity well into the night and into the morning of September 19th as rain bands continued to affect the island. By late morning into the afternoon, shower activity had begun to taper off.

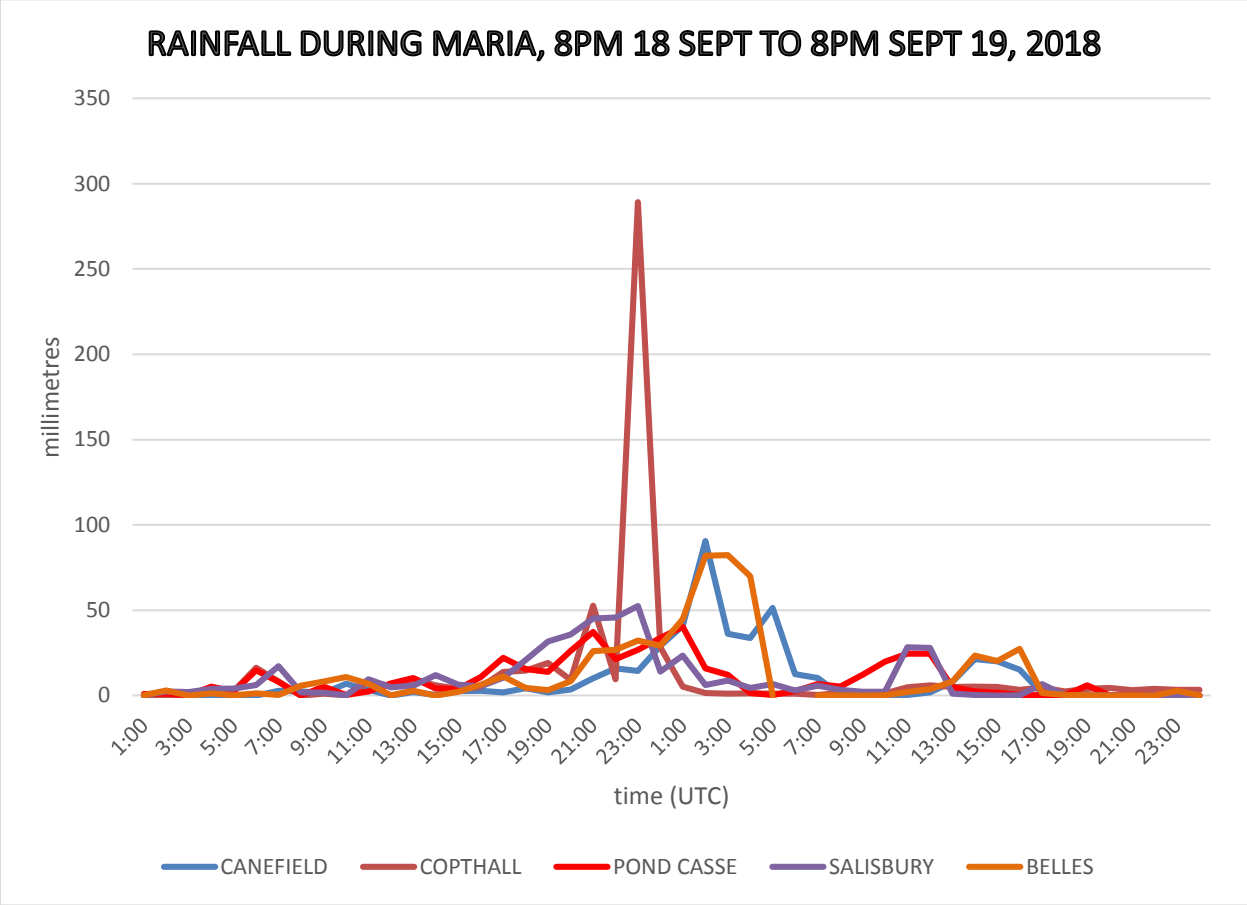

Figure 6 Rainfall amounts from a few stations on Dominica (DMS)

Winds

Douglas-Charles was located in the north-east quadrant of Maria (where the strongest winds are generally observed) and measured an average ten-minute wind speed of 130kts/ 150mph. Winds at Canefield averaged 73kts/ 84mph gusting to 110kts/ 127mph.

At Douglas-Charles, sustained tropical storm force winds (10 minute averages) were recorded from 20:10 (8:10pm) to 04:00 (midnight) and sustained hurricane force winds were from 02:00 to 03:00 (10pm to 11pm) (See fig. 9). Highest instantaneous wind was 98.6kts/ 113mph at 02:50 (10:50pm) (Fig. 9). Maximum gust was 101kts/ 116mph at 02:20 (10:20pm). Possible wind gusts beyond this figure appeared to have occurred for approximately 40 minutes afterward. However, these values were much higher than what the anemometer is capable of measuring. Note blank areas on the graph denotes missing data due to temporary malfunction of the anemometer.

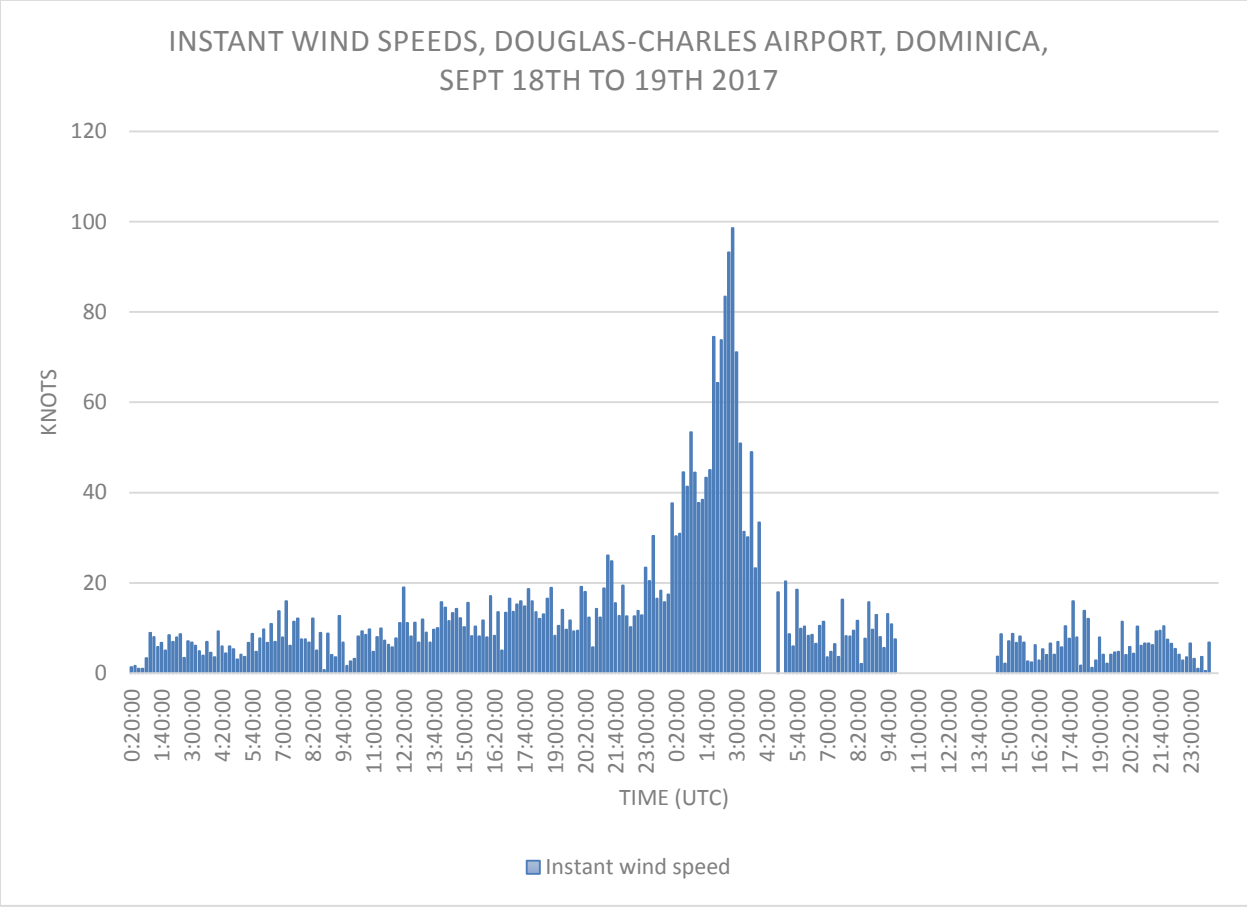

Figure 7 Instant winds at Douglas-Charles Airport (DMS)

Canefield Airport began experiencing tropical storm force winds from about 19:25 (7:25pm) up to 05:00 (1am) where ten-minute winds were averaging 34kts/ 39mph and more (Fig. 10). Sustained hurricane force winds of 64kts/ 74mph and over were observed from 01:00 (9pm) to 02:00 (10pm). Instantaneous winds peaked at 116kts/ 133mph at 01:10 (9:10pm). Afterwards, data indicates several gusts of up to 116kts until 02:50 (10:50pm).

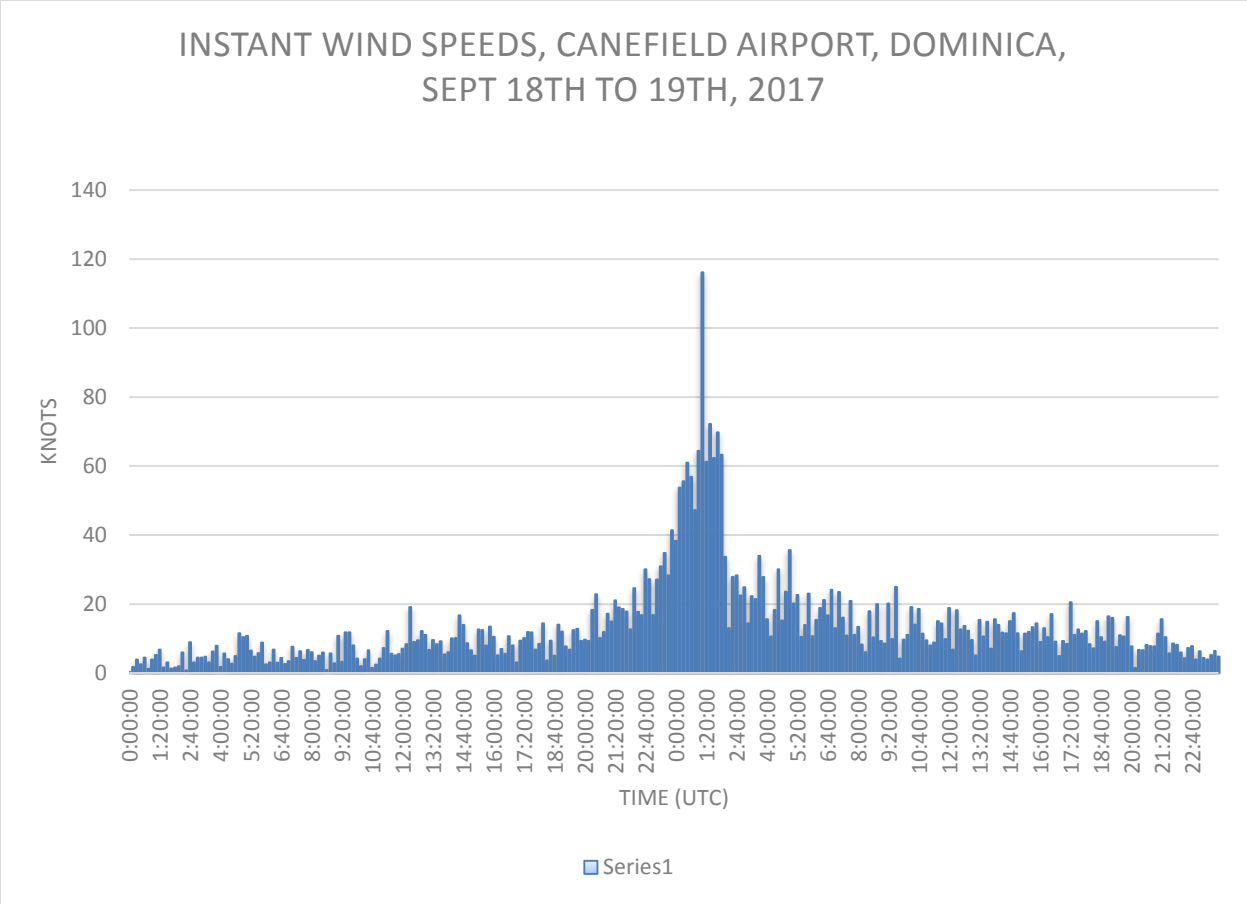

Figure 8 Instant winds at Canefield Airport (DMS)

HYDROLOGICAL ASSESSMENT

During the passage of dangerous category 5 Hurricane Maria, an average of over 500mm (19.7 inches) of rainfall was recorded on the island of Dominica affecting all the river catchments. Given the limited number of river monitoring equipment, it was not possible for the Meteorological Service to capture any significant amount of data in order to make an in-depth analysis. The three rivers with water level sensors (Roseau, Colihaut, Dublanc) provided some data on which analysis was done and inferences drawn.

THE ROSEAU RIVER

The activity and corresponding heights of the Roseau River is highlighted in **Figure.1**. This hydrograph shows the water level from 0000LST to 20:45LST on the 18th of September 2017 up to the time that the instrument stopped recording.

Data recorded from the radar water level sensor indicated that the peak height of the Roseau River was approximately 4.0m (13ft) at 20:45LST.

The water level was slightly above or at 1.40m from 16:45LST (4:45pm) and till 17:20LST (5:20pm) before gradually decreasing as the graph shows. The recession curve at the end of the hydrograph is not seen on the graph because the data recorded after 20:45LST (8:45pm) was erroneous.

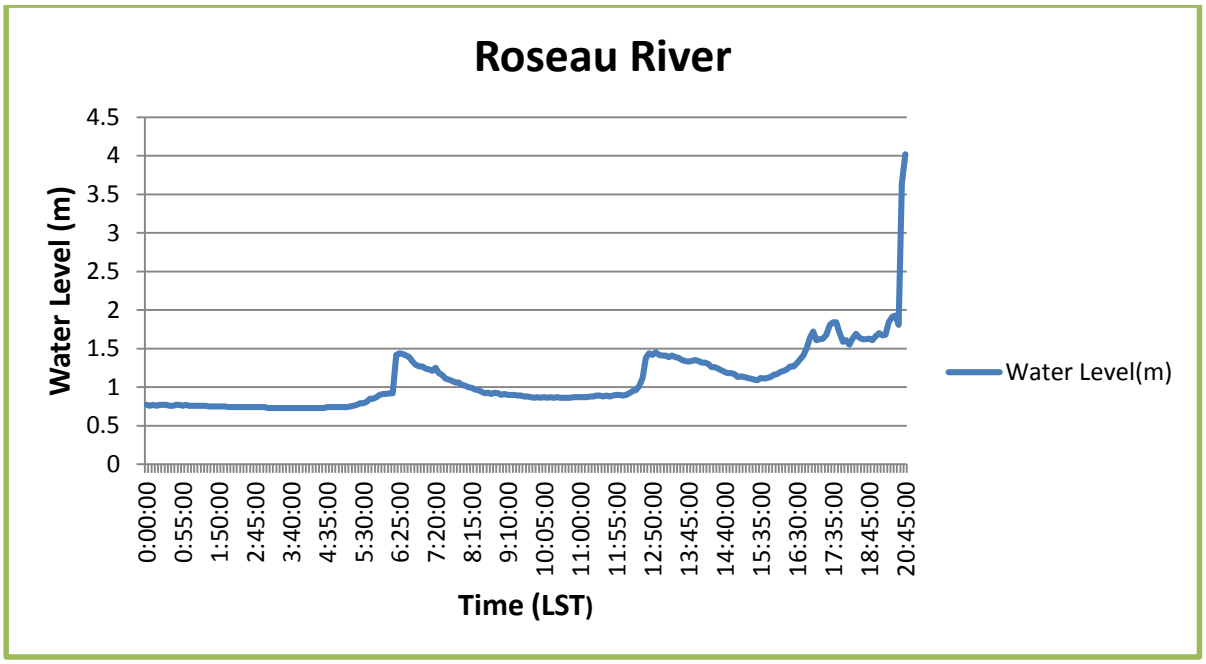

Figure 9 Water level of the Roseau River

The water level sensor is located just above the tributary at Rivière Claire. The second tributary contributing to the Roseau River is the River Douce. Therefore, the water level below the two tributaries would be significantly higher. The discharges of these tributaries totaled the discharge of the Roseau River which caused extensive destruction downstream.

Based on observation conducted, the Roseau River widened thus overflowing its banks and flooding the areas downstream, including the capital city, Roseau. Additionally, it was observed that the Roseau River flowed over the three bridges in the city. Large tree trunks, branches and other forms of debris were seen piled at the top of the bridges. Significant sedimentation occurred in the Roseau River which elevated the river bed.

From field exercises conducted a few weeks after the hurricane, the measured width of the Roseau River was over 30m from the original width of about 10m suggesting an expansion that tripled its original size. The high drainage density and relative small size of the Roseau catchment are contributing factors to the large volume of water which came through the Roseau River.

During the passage of the system, flow from the Roseau River also affected the communities of Copthall, Silver Lake, Elmshall and Bath Estate. These communities are part of the Roseau River drainage basin. As **Figure 5** illustrates, in one hour 289.2mm (11.4 inches) of rainfall was recorded at the Copt Hall Station. In a ten-minute period, a maximum of 116.2mm (4.6 inches) of rainfall was recorded giving rise to a total of 579mm (22.8 inches) for that station. It therefore can be inferred that there was more rainfall at the upper course of the Roseau River.

THE COLIHAUT RIVER

Figure 2 shows a gradual increase in the water level of the Colihaut River from 0000LST (midnight) on the 18th to 1:50LST on the 19th of September 2017. The river peaked to approximately 0.7m at about 10:25LST from a base level of 0.2m with a slight decrease in height to below 0.6m temporarily.

From 21:27LST (9:27pm) the water level remained constantly above 1m. The highest peak of the river recorded was 1.8m at 23:12LST (11:12pm) on the 18th. The true accumulated rainfall at the upper course of the river could not be ascertained due to several gaps in the rainfall data recorded at the Colihaut rainfall station.

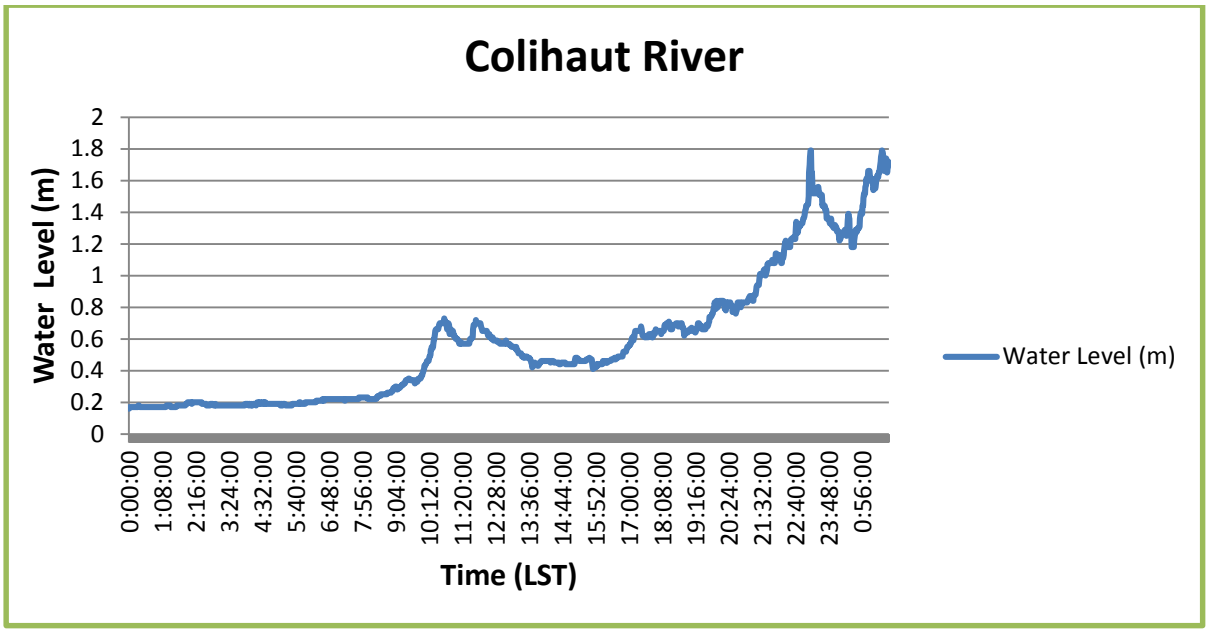

Figure 10 Water level of the Colihaut River

THE DUBLANC RIVER

Figure 3 indicates that Dublanc River peaked to near 1.5m on the 19th of September 2017. The river first peaked above 0.6m on the 18th of September at about 10:24LST. Before the first peak 24.6 mm (0.96 inches) of rainfall was measured by a rain recorder located at the upper course of the river. From 22:40LST (10:40pm) on the 18th to 01:52LST on the 19th of September, the river was near or above 1m in height indicating that the river had a constant high flow for approximately 3 hours.

This height suggests that the volume of water rushing to the sea was extensive and a lot of traction occurred. Looking at the graph, the time of the highest peak of 1.5m was at about 1:35LST on the 19th. An accumulated total of about 100mm (4inches) was measured by the rain recorder at the Colihaut heights before the actual peak.

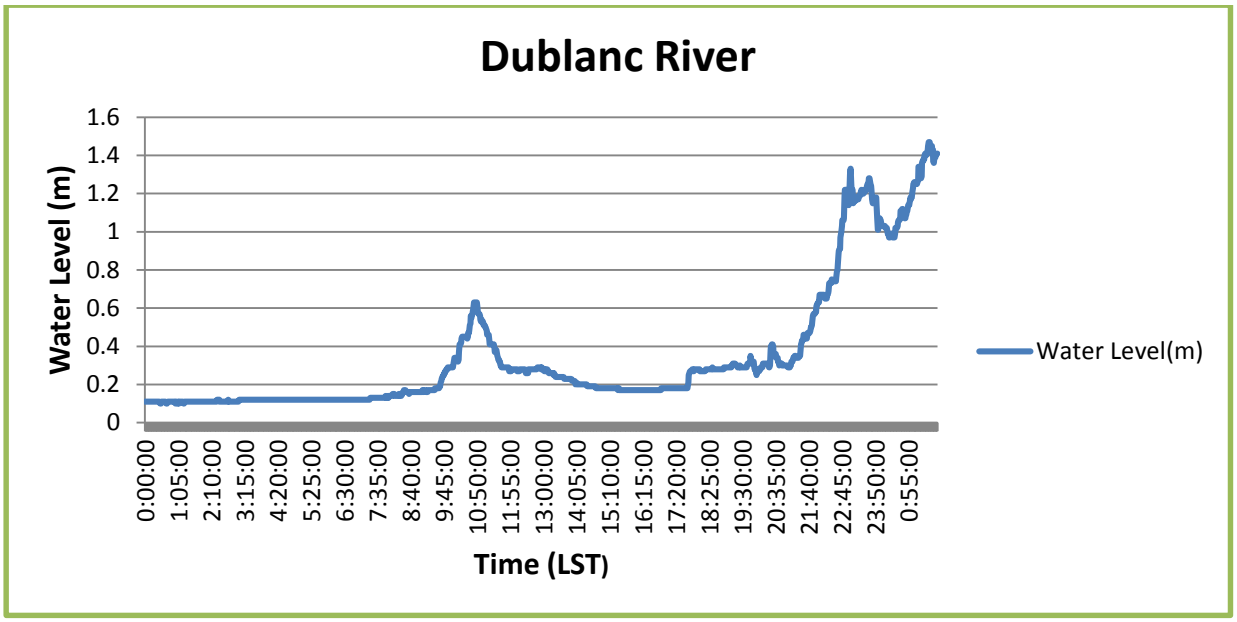

Figure 11 Water level of the Dublanc River

Analysis of the water levels data indicated that the height of the Roseau River was approximately twice that of both the Colihaut and Dublanc Rivers.

Soil Saturation: Pont Casse

Soil moisture observers taken from the Pond Cassé illustrates that not only were the rivers swollen but the soil also became saturated. As a result of intense rainfall during Maria, **Figure 4** indicates that soil moisture in Pont Cassé increased from 58% on the 17th to 65% on the 18th of September. Consequently, there was an increase in overland flow as there was little or no infiltration taking place.

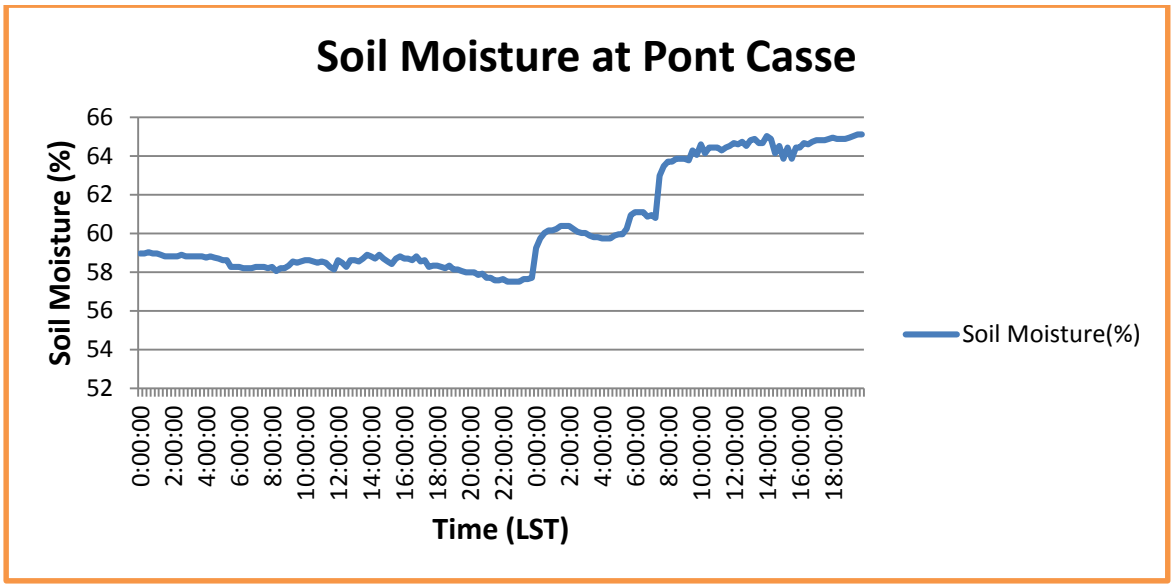

Figure 12 Soil moisture at Pond Casse

Time (mins)	Copt Hall Rainfall (mm)	Salisbury Rainfall (mm)	Pont Casse Rainfall (mm)	Canefield Rainfall (mm)	Wet Area Rainfall (mm)
5	82.6	10.6	8.7	N/A	N/A
10	116.2	18.4	13.1	20.6	61.8
15	140.8	28.6	20.9	N/A	N/A
60	289.2	52.4	40.3	90.6	82.3

Figure 13 Table showing rainfall intensities at various stations

N/A-not available

CONCLUSION

Given the high water levels of the rivers as shown on the graphs in Figures 1, 2 and 3, it is reasonable to conclude that corrosion along the river banks were significant. This also implies that attrition and hydraulic action of the bedload and river banks, respectively, took place. As a consequence of these actions, sedimentation of the rivers would be inevitable and significant.

The increased velocity of the rivers would in turn give rise to an increase in the action of traction, subsequently bringing about the erosion in the rivers and an expansion in the width of the rivers. The increase in rainfall augmented runoff to the rivers. Consequently, the discharges of the rivers were increased carrying along with it anything in its path, such as trees, boulders

and vehicles. All watersheds were vastly affected by the high discharge of the rivers as a result of the torrential rainfall of this catastrophic system.

APPENDIX

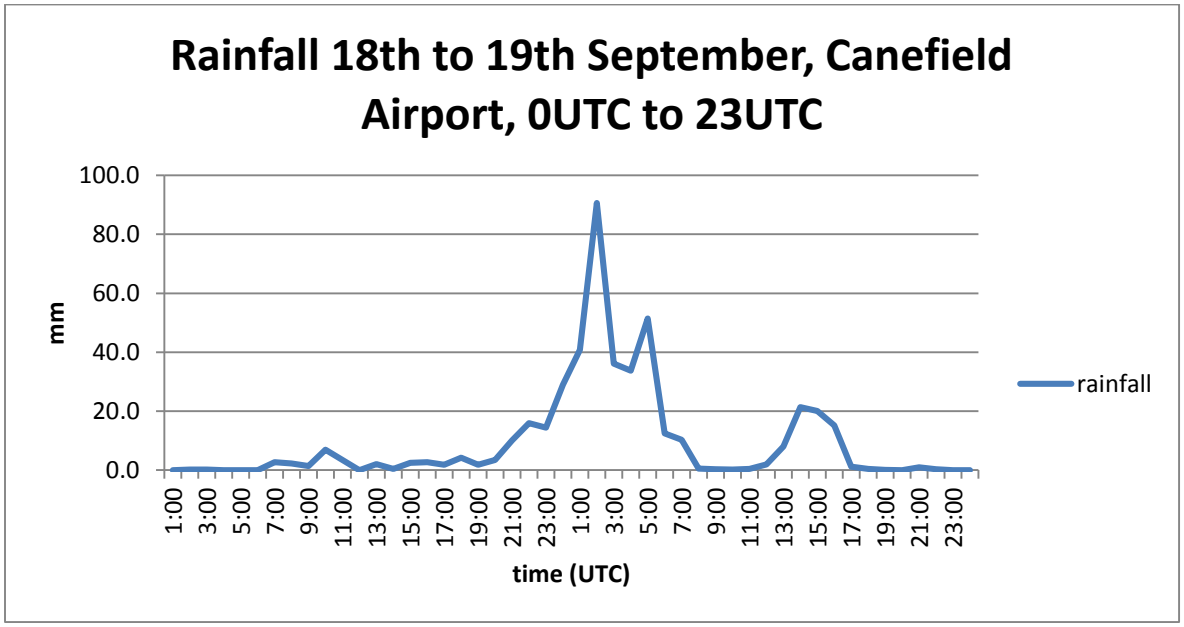

Figure 14 Rainfall at Canefield Airport (DMS)

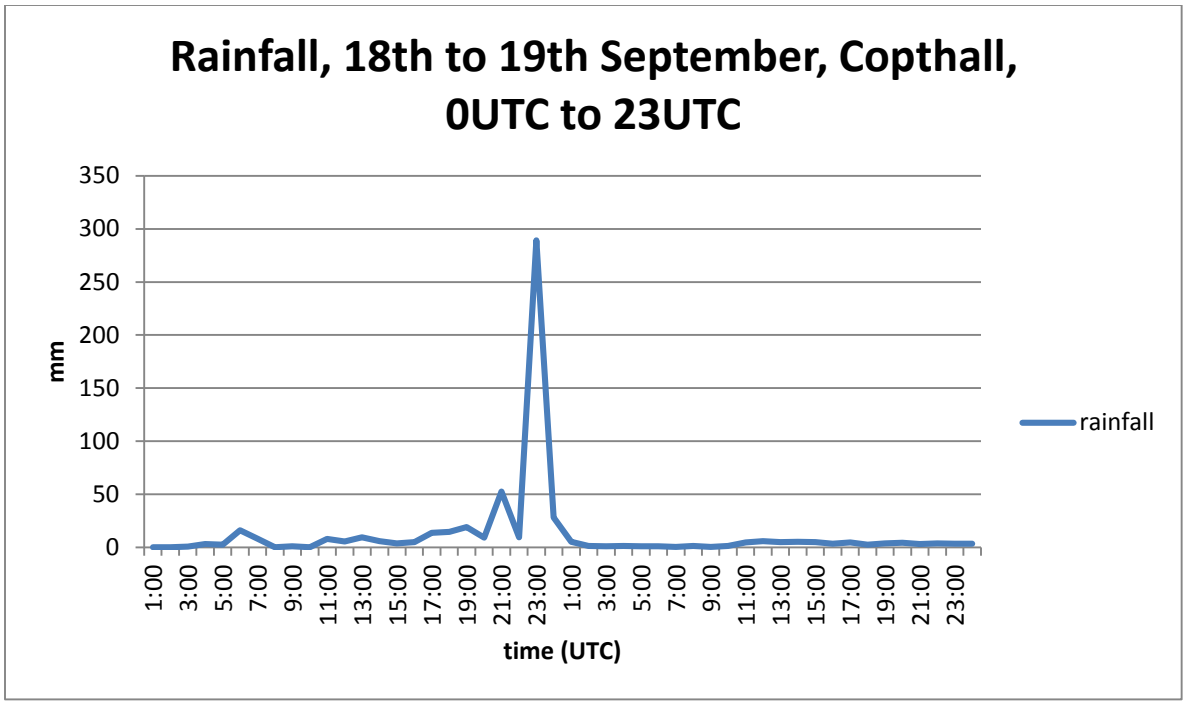

Figure 15 Rainfall at Copthall (DMS)

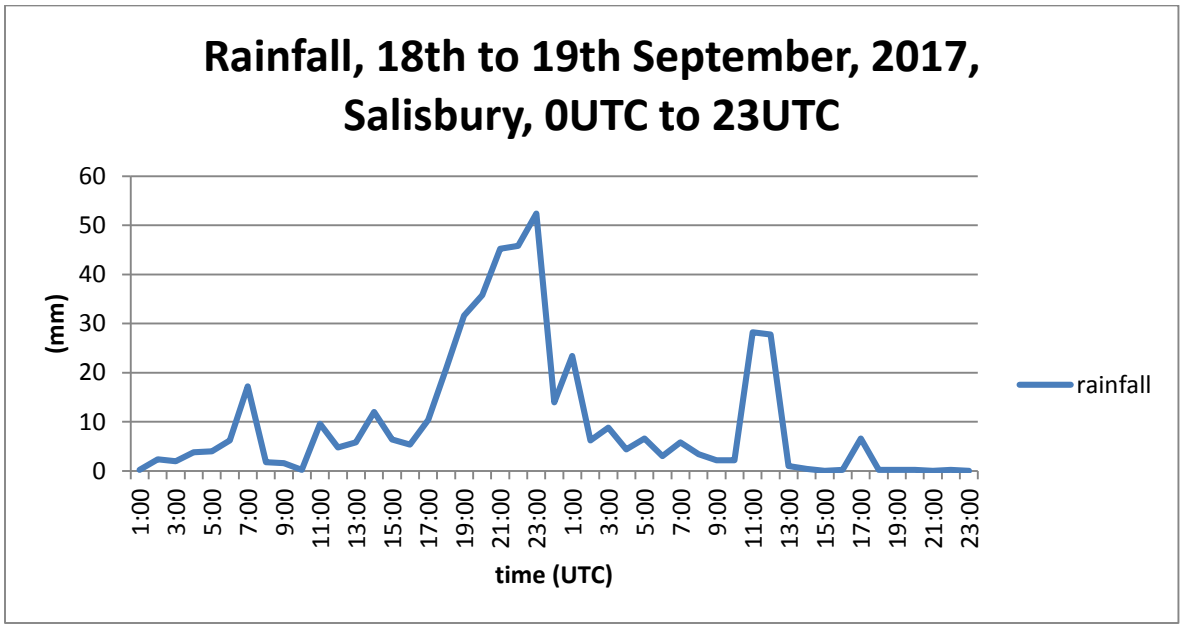

Figure 16 Rainfall at Salisbury (DMS)

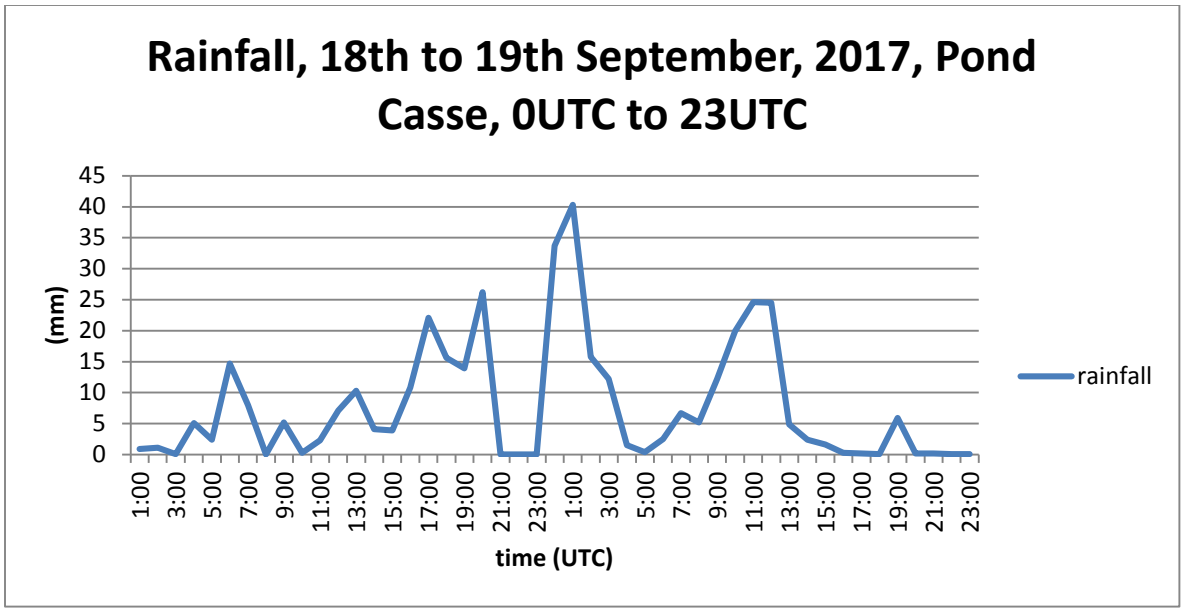

Figure 17 Rainfall at Pond Casse (DMS)

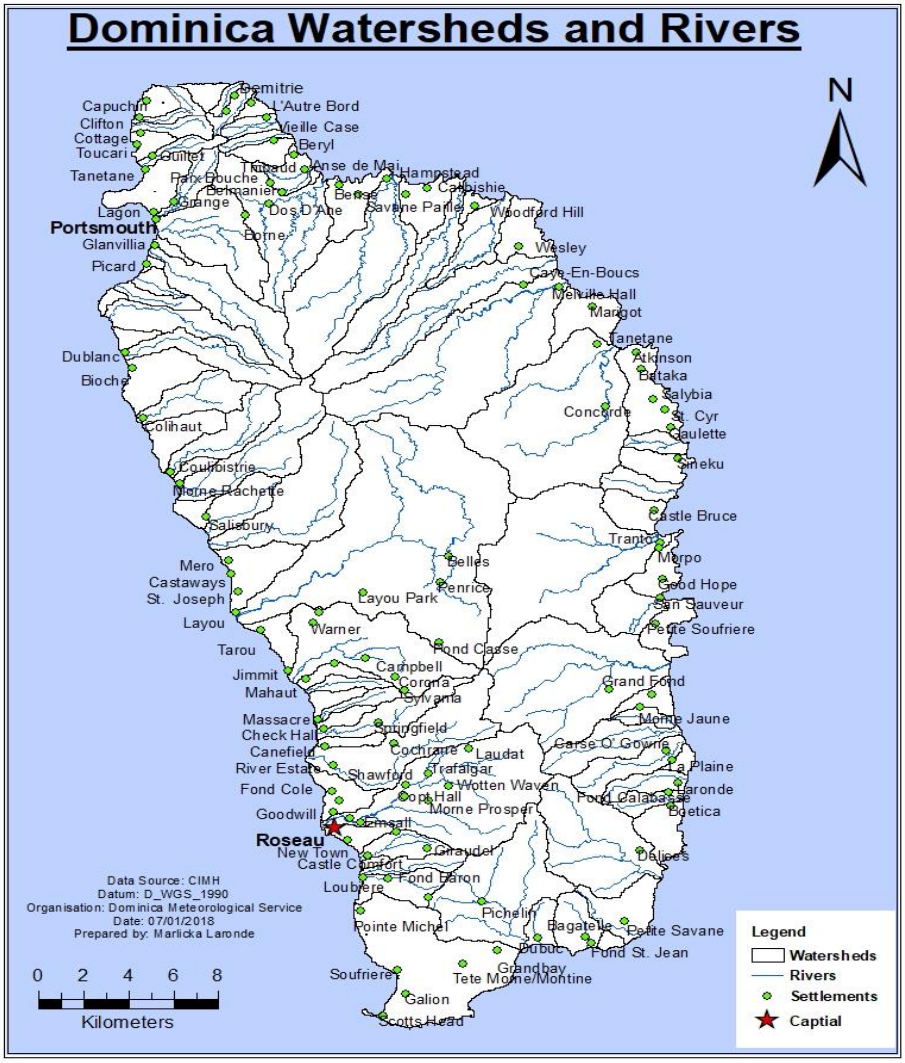

Figure 18 Dominica Watersheds and Rivers

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