

Quick Response Report #124

FIELD EVALUATION OF HURRICANE DAMAGE TO THE WATER RESOURCES, TOURISM INFRASTRUCTURE, AND EMERGENCY RESPONSE OF SAN SALVADOR ISLAND, BAHAMAS

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SALVADOR ISLAND, BAHAMAS**

EXECUTIVE SUMMARY

1. What was the research question?

1. How did Hurricane Floyd damage the water resources and tourism infrastructure of San Salvador, Bahamas?
2. What was the community response to the damage from Hurricane Floyd on San Salvador, Bahamas?

2. What was the methodology of the study?

1. Photo and video documentation of damage to water supply and tourism infrastructure. Specific sights include:
 1. Cockburn Town/Airport public well fields
 2. Bahamian Field Station
 3. Club Med Columbus Isle resort
 4. Riding Rock Inn
 5. Historic markers pertaining to Columbus landing
 6. Beaches, coral reefs, and caves
 7. Cockburn Town tourist attractions
2. Documentation of official and informal response activities by interviewing island government officials and inhabitants.

3. What was the sample size and what were the sample characteristics?

Two water resources facilities: Cockburn Town/Airport Public Well Field, Bahamian Field Station Freshwater Catchment and Filtration Systems. Three tourist facilities: Bahamian Field Station, Club Med Columbus Isle Resort, Riding Rock Inn and Marina.

4. What were the findings?

Given the size and intensity of Hurricane Floyd, the research team was surprised by the lack of significant damage. The only occurrences of building structure failure occurred on the west coast of the island and were created by storm surge. Wind speed estimates based upon damage were 130-145 kph, well below reported wind speeds of 250 kph. Minimal damage occurred to water resource facilities available to resort tourism. Only temporary damage was sustained at the public well fields and the Club Med desalinization system was reported to be undamaged. However, the water supply facilities at the Bahamian Field Station (BFS) was damaged, creating diminished capacity for ecotourism and island residents. Evaluation of hurricane recovery in December indicates close to full recovery of water resource and tourism infrastructure. The greatest threat to continued growth of tourism created by Hurricane Floyd is the potential replacement of water storage tanks at the BFS, and the fewer number of guestrooms available at the Riding Rock Inn. Thus, damage caused by Hurricane Floyd to water resource and tourism infrastructure on San Salvador appears to be moderate to minimal with greatest impact upon recreational tourism and ecotourism.

INTRODUCTION

San Salvador is a Bahamian island 19 km long and 9 km wide and 640 km east-southeast of Miami, Florida (Shaklee, 1994). San Salvador represents one of the small isolated carbonate platforms common to the southeastern Bahamas (Carew and Mylroie, 1997). Due to the historical significance of the location (the landing place of Christopher Columbus in the "New World") and pristine coastal landscapes, San Salvador has been the target of various development plans. Sparked by the 500th anniversary of Christopher Columbus's landing, San Salvador has experienced significant investment in its tourism infrastructure. In particular, a Club Med Resort was built in 1992 north of the island's major settlement, Cockburn Town. In accordance with the development of this resort, the island's airport runway has been extended to accommodate passenger jets from Nassau, Freeport, and Europe.

Club Med is dependent upon a public well field to pump groundwater for freshwater supply. Since the construction of the Club Med resort, the pumping rate of the public well field has increased 382%, and upwelling of saltwater into the fresh water lens has caused a 51% increase in salinity of well water (Erdman et al., 1997). To make the well water potable, Club Med passes the groundwater through a desalinization plant. Without the infrastructure to pump and desalinize the groundwater from the fresh water lens, the Club Med resort would not be able to supply water to guests. The passage of a hurricane over or near the island has the potential to damage or destroy the public well fields and desalinization facilities. To date a hurricane has not passed over the island and damaged the facilities. Thus, the ability of the San Salvador community to respond to hurricane hazards and damage to water resource infrastructure has yet to be measured, and the impact of such damage to tourism infrastructure has yet to be determined. The purpose of this study is to evaluate the damage to water resources and tourism infrastructure on San Salvador from Hurricane Floyd.

The eye of Hurricane Floyd passed 24 km north of San Salvador at approximately 11:30 pm EST on the evening of September 14, 1999, placing the island well within the region of reported 250 kmph winds. A team of researchers surveyed Hurricane Floyd damage September 17-21, 1999 and December 28, 1999-January 7, 2000 to assess the damage to the water resources and tourism infrastructure of San Salvador. Given the size and intensity of Hurricane Floyd, the research team was surprised by the lack of significant damage. The only occurrences of building structure failure occurred on the west coast of the island and were created by storm surge. Wind speed estimates based upon damage were 130-145 kph, well below the reported wind speeds of 250 kph. Minimal damage occurred to water resource facilities available to resort tourism. Only temporary damage was sustained at the public well fields, and the Club Med desalinization system was reported to be undamaged. However, the water supply facilities at the Bahamian Field Station (BFS) were damaged, creating diminished capacity for ecotourism and island residents. Evaluation of hurricane recovery in December indicates close to full recovery of water resource and tourism infrastructure. The greatest threat to continued growth of tourism created by Hurricane Floyd is the potential replacement of water storage tanks at the BFS, and fewer available guestrooms at the Riding Rock Inn. Thus, damage caused by Hurricane Floyd to water resource and tourism infrastructure on San Salvador appears to be moderate to minimal with greatest impact upon recreational tourism and ecotourism.

METHODOLOGY

Activities completed by the research team focused on two primary activities.

1. Photo and video documentation of damage to water supply and tourism infrastructure. Specific sights include:
 1. Cockburn Town/Airport public well fields
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Photo and video documentation was used in a repeat photo analysis. Photos taken by the principal investigator over the past three years were compared to the post-hurricane photos to determine extent of damage. The comparison of the immediate post-impact photos and December 1999 photos will be used to assess progress of rebuilding efforts. For damage assessments, the Saffir-Simpson Scale of Hurricane Intensity was used to estimate maximum hurricane wind speeds.

FIELD EVALUATION SEPTEMBER 1999

Damage to Water Resource Facilities

Two major water supply facilities exist on San Salvador from which tourism facilities can obtain freshwater: the Cockburn Town/Airport (CTA) public well field and the Bahamian Field Station (BFS) freshwater catchment. The CTA well field is a public facility providing water for the island's largest settlement and the island's two largest tourist facilities, the Club Med Columbus Isle Resort and the Riding Rock Inn. According to Bernie Storrs, CTA public well field manager, the only damage to the well field during Hurricane Floyd was loss of power to one well. The power was lost when a person driving an automobile lost control of the vehicle, drove off the road, and disabled the power lines to the well. The well temporarily lost pumping capability and the damage was quickly repaired and power returned to the pump. The damage caused minimal disruption of water supply.

Damage to the BFS freshwater system was more serious. The freshwater system is composed of a concrete catchment from which water is pumped to a raw water tank for storage and settling of solids. From this tank, water is pumped through a filtration system and then stored in one of two filtered water storage tanks. The filtered water is then pumped from the filtered tanks to the BFS or made available to island residents. Tom Goossen (1999), BFS facilities manager, reports that

leaks developed in all three tanks due to flexing of side walls during hurricane winds. The leaks are detectable once the tanks are 1/2 to 2/3 full of water. In addition, a door was blown off of the pump house and struck and fractured the main water line. A full tank of filtered freshwater was lost through the pipe fractures. Caulk and welds were required to repair leaks, and excavation and replacement of the pipe was required to re-establish the water main line. Electricity was unavailable for one week after Hurricane Floyd, and once it was restored not all three phases of power were available. The filtration system pumps require three-phase power and were thus unable to filter water during this time period. Due to the loss of filtered water from one storage tank and the loss of power to the filtration system, the BFS was forced to conserve freshwater remaining in the tanks. The conservation efforts included not making freshwater available to island residents and restricting water available to BFS guests.

Damage to Tourist Facilities and Infrastructure

Three major tourist facilities exist on San Salvador, the Bahamian Field Station (BFS), Club Med Columbus Isle resort, and the Riding Rock Inn. The BFS is a converted U.S. Navy base serving as a research/tourism facility for university faculty and students, and ecotourists (Earth Watch and Elder Hostel). The BFS specializes in ecotourism or tourism that is based upon the observation and research of the island's natural systems such as coral reefs, caves, and iguana colonies. Approximately 1500 visitors stay at the BFS each year (Buchan, oral communication, 1999). The Club Med Columbus Isle Resort is a full-service resort offering entertainment facilities along with island excursions of scuba diving, hiking, shopping, and visiting historic landmarks. Estimates of annual visitors at the Club Med resort were not available, but estimates from island residents range from 10,000-100,000 visitors per year. The resort was founded in 1992, marking the 500th anniversary of the landing of Christopher Columbus on San Salvador and the "New World." The third facility is the Riding Rock Inn, which specializes in recreational tourism, offering scuba diving and sport fishing packages. Each year, 7,000-10,000 guests stay at the Riding Rock Inn.

The BFS experienced no structural damage to its buildings. However, trees were downed and vegetation stripped throughout the grounds, windows were blown out in many buildings, screens were torn, fences damaged, walls were pitted due to sand and gravel blown against buildings, and flashing along roofs was bent and torn ([Figure 1](#)). Standing water was present in several buildings that lost windows. All perishable food items were lost due to the loss of electricity and refrigeration after Hurricane Floyd. As described in the earlier section, a pipe in the freshwater supply system was fractured and two-thirds of the freshwater in one of two storage tanks was lost. Overall, Tom Goossen, BFS facilities manager, believed the damage was moderate and repairs should be completed in several months. Researchers estimate 80-90% of the BFS buildings received damage.

The Club Med Resort had less damage than the BFS. The most extensive form of damage to the Club Med Resort was the loss of shingles from roofs ([Figure 2](#)). Much of the vegetation on the grounds was down or stripped of leaves ([Figure 2](#)). No structural damage was reported for any building at the resort. Some windows were blown out of buildings and water damage was evident in the central club/entertainment house. Chain-link fences surrounding the tennis courts were blown over and severely damaged ([Figure 3](#)). Much sand was washed up over the berm of the

beach and onto interior grounds, burying grass and other vegetation ([Figure 3](#)). Evidence of flooding was present on grass fields near beaches. No damage to the resort's desalinization plant was reported. However, the plant was not made available for inspection by the researchers. Researchers estimate 50-65% of the buildings on the resort grounds experienced damage.

The Riding Rock Inn sustained the most severe damage of the three tourist facilities on San Salvador. The severity of the damage was due to the Inn's location along a westward-facing beach. Storm surge along this beach eroded the foundation of the bar and restaurant building, hotel building, and several cabins ([Figure 4](#)). Beyond foundation damage, the porch attached to the restaurant and bar lost its roof and supports, making it unstable and unusable. Part of the roof of the bar/restaurant was removed during the hurricane, and extensive water damage was evident, including standing water in the building ([Figure 5](#)). Extensive water damage was also evident in guestrooms. A tree fell along the beach, crushing two cabins ([Figure 5](#)). The researchers estimated that 100% of the buildings on the Riding Rock Inn grounds experienced significant damage.

Beyond the three major tourism facilities, researchers also surveyed damage to other tourist attractions on San Salvador, including historical sites, beaches, coral reefs, cave systems, interior hiking trails, and Cockburn Town attractions. Historical sites, particularly Christopher Columbus monuments, received minimal damage. Paint was removed from several monuments by sand carried in the wind. Overall, the most significant damage to the monuments was to monument grounds. The landscaping of monument grounds was significantly altered, with felled vegetation and sand covering grass. During inspection of beaches, the researchers found significant alteration of beach appearance as compared to previous visits in 1997-1999. The most common alteration of beaches and the adjoining coast was the transport of sand above the berm, burying vegetation adjacent to the beach. Due to the removal of debris at or above beach berms and transport of sand inland beyond the berm, it appears the beaches are wider in many locations.

Choppy conditions and poor visibility along coral reefs made inspection difficult, but it appeared that shallow reefs sustained minimal damage. Some locations experienced overwash of sand onto reefs, but widespread physical damage to coral was not observed. Access to the coral reefs and several historical monuments was inhibited due to damage to the Queen's Highway on the western side of the island ([Figure 6](#)). The highway was reduced to one lane, and lost sea walls to storm surge along Fernandez Bay. Inspection of hiking trails and cave systems revealed little damage to the interior of the island. Little vegetation was blown down along trails, and locations farthest inland appeared undisturbed. Formations inside cave systems were in good condition, with no evidence of major flooding events.

Cockburn Town attractions sustained substantial damage. In particular, the town square, which houses a small straw market, was covered by debris, and waves created significant structural damage to square buildings and structures. The local museum and church sustained roof damage ([Figure 6](#)).

Emergency Response

Emergency response by the Bahamian government, public utilities and residents was evident during post-storm evaluation on San Salvador. On the drive from the airport to lodging at the BFS, members of the Bahamian Electricity Company were observed repairing power lines. The workers labored around the clock to restore power to the entire island. Utility workers were made available from the Turks and Caicos to assist the San Salvador workers. On September 21, 1999, one-phase of electricity was restored to the island; just one week after Hurricane Floyd passed just north of the island. On September 18, 1999, the Bahamian Defense Force (BDF) anchored off of the San Salvador harbor and unloaded troops, food, and freshwater. Over the next several days, approximately six soldiers distributed freshwater, completed a census of people on the island, and helped with repairs, including those to schools and the island clinic. Red Cross officials visited the island on September 18, 1999, surveying damage and assessing the needs of the island. Residents indicated that response by the government and other agencies was quick and appropriate. During the hurricane itself, churches most frequently offered shelter. The BFS provided shelter for 70 island residents during the hurricane. Countless stories of island residents, businesses, and churches sharing resources during the hurricane were told to the research team.

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Water Resource Facility Recovery

The principle investigator and a graduate assistant returned to San Salvador December 28, 1999-January 7, 2000, to evaluate Hurricane Floyd damage recovery efforts. The CTA public well field was fully operational with no permanent damage from Hurricane Floyd. The freshwater filtration system at the BFS was fully operational. However, Tom Goossens, BFS facilities manager, indicated that in the future, the storage tanks may need to be replaced or more permanent repairs of leaks need to be completed. The status of the storage tanks will be monitored closely until a permanent solution is found.

Tourism Facility Recovery

The Club Med resort was operating at maximum capacity at the time of evaluation. Nicholas Dupont, Club Med Columbus Isle facilities manager, indicated that a full recovery from Hurricane Floyd damage had been completed. According to Dupont, 100,000 square feet of roofing shingles had been used to repair roofs of 40% of the buildings. Beyond roofing, the damage requiring the greatest recovery effort was removal of sand from the grounds ([Figure 7](#)). Sand had been deposited throughout the grounds and needed to be raked out of gardens and landscaping. Several incidents of sand blowing under roofs of buildings and into electrical systems also required extensive repair efforts. The only remaining repair at Club Med to be completed was the painting of several buildings. The resort was pressed to complete all repairs before the holiday season due to the large number of visitors expected for the millenium celebration. Mr. Dupont indicated that the resort desalinization plant did not need any repairs, but immediately after the hurricane it was not operating efficiently due to escalated salinity levels of the groundwater.

The BFS is operating at maximum capacity and repair of buildings is near completion. Perhaps the greatest damage of Hurricane Floyd to the BFS is the delay of improvements to facilities. Renovation of BFS facilities was scheduled during the fall of 1999. However, since the BFS had to focus on Hurricane Floyd recovery, renovations and improvements were not completed, and at this date it is unknown when the renovations will be completed.

The two "hotel" buildings of the Riding Rock Inn were operating at full capacity during evaluation, but none of the inn's six cabins were available for guests. The dining room/bar, and "hotel" buildings were completely repaired, including new coats of paint, new doors, and new storm windows ([Figure 8](#)). The porch had a new roof and supports. Conflicting reports were given regarding the future of the cabins. One worker stated the cabins would be demolished, while another stated the cabins might be renovated. At the Riding Rock Inn Marina, operations were back to normal, except only one of the six rental slips was operational.

The Queen's Highway had been repaired, allowing full access to coral reefs and historical monuments. The grounds of historical monuments still required removal of storm debris. Debris and structural damage still existed at the Cockburn Town public square. However, some repairs had been made allowing for the continuation of the straw market and operation of souvenir stands. The local museum still required roof repairs.

THE FUTURE

The greatest impact of Hurricane Floyd appears to be upon the smaller tourism facilities on San Salvador, the facilities specializing in ecotourism and recreational tourism. Due to Hurricane Floyd, the BFS potentially faces major repairs to its water storage tanks and a delay of renovations. Whether or not these issues will impact the continued development of the BFS remains to be seen. A worst case scenario would be loss of storage tanks and an inability to provide water to residents without large capital investment. The delay of renovations appears to present minimal hindrance to development. The Riding Rock Inn currently is faced with lower visitor capacity due to loss of cabins, and loss of revenue, in turn due to the inability to rent boat slips. However, given the speed at which the inn repaired Hurricane Floyd damage, the lower capacity and revenue appears to be temporary.

One aspect of the damage survey that surprised the research team was the minimal damage to the island, given the size and intensity of Hurricane Floyd. Many islanders commented that Hurricane Lili, despite being a smaller storm with weaker winds, caused more damage than Hurricane Floyd. Hurricane Lili was a category 3 hurricane (winds 165-185 kph) that approached the island from the southwest on October 19, 1996. If the islanders' assessment of damage caused by Hurricane Lili is correct, it suggests that the size and intensity of the hurricane is not of greatest importance to damage on San Salvador, rather the track of the hurricane may be the key determinant. The northeast quadrant of a hurricane produces the greatest wind speeds and storm surge (Aguado and Burt, 1999). As Hurricane Lili passed over San Salvador, the island was exposed to the northeastern quadrant of the storm. As Hurricane Floyd passed over San Salvador, the island was exposed to the southwestern quadrant of the storm. The quadrant of the storms

may explain the relatively low level of damage from Floyd and the greater amount of damage from Lili. Thus, it is important for officials on San Salvador and the rest of the Bahamas to recognize the path of a hurricane and adjust emergency preparedness and response activities.

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FIGURES

Figure 1. Hurricane Floyd Damage to the Bahamian Field Station September, 1999

- A) Exterior damages to dormitory building. Note downed palm tree, blown out window in center of building, and bent flashing along the roof.**
- B) Interiors of room with window blown out note marks on wall from fallen blinds and fan.**

Figure 2. Hurricane Floyd damage to Club Med Columbus Isle resort September, 1999

- A) Roof damage to buildings note black areas where shingles removed from roof and shingles lying on grass in front of buildings.**
- B) Wind damage to palm trees, tops of trees sheered off.**

Figure 3. Hurricane Floyd damage to Club Med Columbus Isle resort September, 1999

- A) Damage to chain link fence surrounding tennis courts.**
- B) Vegetation buried by sand washed over the berm during the hurricane.**

Figure 4. Hurricane Floyd damage to the Riding Rock Inn September, 1999

- A) Foundation damage underneath bar/restaurant porch.**
- B) Foundation damage adjacent to guest cabins.**

Figure 5. Hurricane Floyd damage to the Riding Rock Inn September, 1999

- A) Roof damage to the bar/restaurant building.
- B) Cabin damage due to fallen tree.

Figure 6. Hurricane Floyd damage to San Salvador Island September, 1999

- A) Damage to Queen's Highway, Fernandez Bay.
- B) Damage to Town Square and straw market Cockburn Town.

Figure 7. Hurricane Floyd damage recovery Club Med Columbus Isle resort December, 1999

- A) Landscaping with sand raked out of grass.
- B) Tennis courts with new chain link fences.

Figure 8. Hurricane Floyd damage recovery Riding Rock Inn December, 1999

- A) New roof above door to bar/restaurant door.
- B) New support for the porch of the bar/restaurant.

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