

## DECISION-MAKING EXERCISE: THE HURRICANE HAZARD

### Introduction

This decision-making exercise examines the impact of Hurricane Floyd, on 7–17 September 1999. Floyd was a large and intense Cape Verde hurricane that pounded the central and northern Bahama islands, seriously threatened Florida, struck the coast of North Carolina and moved up the United States east coast into New England. It neared the threshold of category five intensity on the Saffir/Simpson Hurricane Scale as it approached the Bahamas, and produced a flood disaster of immense proportions in the eastern United States, particularly in North Carolina. The exercise has been designed to give students an insight into hurricane risk and impacts and to develop skills in geographical

analysis. The specific role for students is outlined below.

### Decision-making exercise – student role

Your task is to assume the role of an evaluation consultant working for FEMA (Federal Emergency Management Agency). You will report on the geography of Hurricane Floyd and its impact on parts of the USA. Your specific tasks are to:

1. Outline the pattern of disaster activity in the USA in 1999 and the role of hurricanes in major disasters (draw a map of North America to use as a base map).
2. Plot the best track of Hurricane Floyd using the data and base map

provided, and, annotating the map with a written commentary, describe the hurricane movement and development.

3. Using the data provided, summarise the physical and human impacts on the states that were affected by the track of the hurricane.
4. Using background information and your own knowledge of hurricane formation, explain how and why Hurricane Floyd created so much damage to parts of the USA.
5. Using all the resources in this Geofile, make recommendations to FEMA on planning for a hurricane disaster.

Figure 1: Hurricane tracking base map



Figure 2: News agency report, South Carolina

### Floyd's flooding still affecting S.C. town

CONWAY, S.C., Feb. 1, 2000 (AP) – The natural disaster that was Hurricane Floyd continues to haunt hundreds of area residents and officials. Some families whose homes were all but destroyed by floodwaters in September continue to live in hotel rooms or small mobile trailers. The mortgage payments for their mostly gutted homes still come due every month. As officials search for flood-relief funding and try to get ahead of deadlines, dealing with the emotions and conditions of affected residents can take its toll: "In one way, I'm looking at it first hand, but I go home to my house every day," said Tabby Shelton, Conway grant writer. "If we are not funded, it's going to be extremely difficult for me to have to sit down with these people and say, 'We've done everything we could.' "

Relief may still be some time away for the owners of 224 substantially flood-damaged properties – up to 20 in Conway and 204 in Horry County. In the next two weeks, Conway will request a little more than \$2 million from the disaster relief funding made available after Floyd. That includes roughly \$1.2 million to buy substantially damaged homes (those for which repairs would equal at least half the worth) and about \$1 million to fortify 14 sewer lift stations. Horry County is likely to request between \$5 million and \$10 million to buy or elevate 204 properties. If property is bought, it can no longer be developed. Open space, soccer fields or public parks are possible options. "We are on track, but it's not a real fast process," said Paul Whitten, Horry County emergency preparedness director. With funding limited to \$6.5 million statewide, local officials are not sure how much the area can expect to receive. State officials are taking into account the severity of Floyd's impact. "Conway and Horry County were the hardest-hit areas, so they are still priorities for flood mitigation," said Joe Farmer, public information director of the South Carolina Emergency Preparedness Division. Funding

is not expected to be approved for months, and as of Tuesday, will cover 75% of a property's pre-Floyd worth. March 15 is the deadline to request funding. Then it has to be scrutinized by state and federal officials, which could take a few weeks or a few months. Once funding is approved, the real work begins, Shelton said. Home surveys, appraisals, the demolition of bought-out homes, bidding out work to contractors, inspections and a host of other jobs must be completed within two years. Residents may appeal home appraisals or the cost of elevating homes, while officials have to determine who first receives funding. In Conway, there will be two priority lists. One will be for those living in an identified floodplain and another for those not. Most of the damaged homes are in the Long Avenue area. Identified floodplain residents – those who have insurance and have been flooded before – will top the priority list, followed by first-time flood victims with insurance, then those without insurance. Of 11 homes in this group, two were without flood insurance. Flood insurance holders top the priority list because "they went the extra mile," Shelton said. "They made sure they were protected." A few of the households not in the floodplain were flooded for the first time in decades, surprising many residents. "Some were told you can't buy flood insurance because you are not in a flood zone," Shelton said. "Anybody can buy flood insurance." And that's just what Horry County residents should consider, Whitten said. It's much easier to receive help to rebuild when you have met premiums through a company versus applying for grant money that may not be made available, he said. "I guarantee there are folks out there who wish they had it," Whitten said. Areas that have the highest density of damaged homes will receive the highest priority in the county, Whitten said. Savannah Bluff and Lee's Landing were two areas heavily flooded.

Figure 3: Best track, Hurricane Floyd, 7–17 September, 1999

Date/Time (UTC)	Position Lat. (°N) Lon. (°W)	Pressure (mb)	Wind Speed (kt)	Stage
7/1800	14.6 45.6	1008	25	tropical depression
8/0000	15.0 46.9	1007	30	"
0600	15.3 48.2	1005	35	tropical storm
1200	15.8 49.6	1003	40	"
1800	16.3 51.1	1000	45	"
9/0000	16.7 52.6	1000	45	"
0600	17.1 53.9	1003	45	"
1200	17.3 55.1	1003	50	"
1800	17.9 56.3	996	60	"
10/0000	18.3 57.2	995	60	"
0600	18.6 58.2	990	60	"
1200	19.3 58.8	989	70	hurricane
1800	20.2 59.6	975	70	"
11/0000	20.8 60.4	971	80	"
0600	21.4 61.1	963	95	"
1200	21.9 62.0	962	95	"
1800	22.5 63.0	966	90	"
12/0000	22.7 64.1	967	85	"
0600	22.8 65.2	960	95	"
1200	23.0 66.2	955	105	"
1800	23.2 67.4	940	115	"
13/0000	23.4 68.7	931	125	"
0600	23.6 70.0	922	135	"
1200	23.9 71.4	921	135	"
1800	24.1 72.9	923	125	"
14/0000	24.5 74.0	924	115	"
0600	24.9 75.3	927	105	"
1200	25.4 76.3	930	105	"
1800	26.1 77.0	930	110	"
15/0000	27.1 77.7	933	115	"
0600	28.2 78.5	935	110	"
1200	29.3 78.9	943	100	"
1800	30.6 79.1	947	95	"
16/0000	32.1 78.7	950	90	"
0600	33.7 78.0	956	90	"
1200	35.7 76.8	967	70	"
1800	38.0 75.3	974	60	tropical storm
17/0000	40.6 73.5	980	50	"
17/0600	42.1 72.1	983	50	tropical storm
1200	43.3 70.6	984	45	extratropical
1800	44.2 68.9	985	45	"
18/0000	44.8 67.3	987	40	"
0600	45.4 65.5	990	35	"
1200	46.6 63.0	992	35	"
1800	47.7 59.3	992	35	"
19/0000	48.0 56.3	992	35	"
0600	48.5 52.5	994	35	"
1200	49.5 48.0	992	40	"
1800				merged with low
13/1200	23.9 71.4	921	135	minimum pressure
				Landfalls
14/1200	25.4 76.3	930	105	Near Alice Town, Eleuthera
14/1900	26.3 77.1	932	120	Near Cherokee Sound, Abaco
16/0630	33.8 78.0	956	90	Near Cape Fear, North Carolina

Figure 4: Hurricane Floyd, selected surface observations, September 1999

Location	Peak gust (kts)	Date/time (UTC)	Storm surge (ft)	Storm tide (ft)	Rain (in)	Location	Peak gust (kts)	Date/time (UTC)	Storm surge (ft)	Storm tide (ft)	Rain (in)	Location	Peak gust (kts)	Date/time (UTC)	Storm surge (ft)	Storm tide (ft)	Rain (in)	
<b>Bahamas</b>						Mt. Olive	65	16/0520				<b>Pennsylvania</b>						
Grand Bahama Island	65	14/2000		5.27		Myrtle Grove	89	16/0540				Philadelphia	42	16/2136	2.8	9.34		
Little Harbor					9.32	Newport	58	16/0454				<b>New York</b>						
Abacos						New Bern	58	16/0501			4.29	Central Park	36	16/1450			5.02	
Nassau	68					New River	68	16/0556			8.26	Farmingdale	37	16/2053			3.13	
<b>Florida</b>						Oak Island	69	16/0820		10.0		Airport						
Craig Field		15/1929				Pleasure Island				10.0		HPN Airport	42	16/2350			6.26	
Daytona Beach	60	15/1053			1.23	Rocky Mount/ Wilson Airport					15.15	Islip/ MacArthur	37	16/2356				
Fowey Rocks	44	14/1600				Seymour	60	16/1055				Airport						
Lighthouse						Johnson AFB						JFK Int'l Airport	41	17/0051			3.27	
Ft. Lauderdale	33	15/0653			0.01	South River					3.50*	LaGuardia	41	17/0051			4.94	
Exec						Washington	41	16/0800				Airport						
Ft. Lauderdale Int'l	36	14/2201			0.10	Wilmington	75	16/0855			19.06	MGJ Airport	44	16/2039				
Ft. Pierce	43	15/0736				Airport						MTP Airport	37	17/0454				
Gainesville		15/1407				Wilmington	89	16/0700				Newburgh/ Stewart Airport	54	16/2245				
Jacksonville Int'l		15/0907				Corning Plant						NWS Upton					3.50	
Lake Worth Pier	49	14/1700				Wilmington EOC	104	16/0845				Westhampton	43	17/0153				
Leesburg	20	27 15/1153				Wrightsville Beach	120					Airport						
Melbourne	59	15/0501			1.35	<b>Virginia</b>						White Plains	42	16/2350				
Airport						Fort Eustis	37	16/1640				Airport						
Melbourne WFO	52	15/0655				Gloucester					11.25	<b>Massachusetts</b>						
Miami	29	15/0322			0.04	Hampton					7.50	Beverly	31					
Ocala		15/1535				James City					14.30	Blue Hill	40					
Orlando	42	15/0853			1.26	County						Observatory-Milton						
Patrick AFB (COF)	57	15/0820				Langley AFB	55	16/1355				Boston					10.7	
Sanford	37	14/2024			3.20	Lower James City					12.83	Boston/Logan	38					
Tamiami Airport	31	14/1953				Newport News	44	16/1623			16.57	Airport						
West Palm Beach	38	14/1941			0.38	Norfolk Airport	40	16/1303				Brewster	63	17/0545				
<b>Georgia</b>						Norfolk NAS	48	16/1609				Buzzards Bay	57	17/0300				
Alma		15/1746				Oceana NAS		16/1656				Fox Point			4.2			
Brooklet					0.41	Portsmouth	52	16/1614			10.10	Hurricane Barrier						
Dover					0.40	Richmond	44	16/1405			6.54	Hadley						9.60
Ludowici					0.52	Smithfield					12.50	Hyannis	62					
Newington					0.85	Wakefield WFO					12.73	Lawrence	32					
Rocky Ford					0.20	Weems					10.83	Martha's Vineyard	34					
Savannah Airport	46	15/1810				Yorktown						Nantucket	32				1.3	
St. Simon's Island		15/1804				<b>Maryland</b>						New Bedford Hurr. Barrier	64	17/0600	2.5			
<b>South Carolina</b>						Annapolis					11.60	Norwood	27					
Allendale					0.67	Cambridge					2.5	Orange	29					
Beaufort					1.83	Chestertown					14.00	Plymouth	33					
Charleston City Office	74	16/0150			3.99	Lewisetta					3.5	Southwick						9.16
Charleston Harbor				10.1		Martin State Airport						Taunton	38					
Charleston Int'l Airport	58	16/0046			3.91	Mid-Bay Buoy	60	16/1710			1.71	Westfield	37					
Edisto Beach	47	16/0029				Ocean City	45	16/1653				Worcester	30					
State Park						Patuxent NAS	36	16/1555				<b>Rhode Island</b>						
Florence Airport	54	16/0158			4.04	Salisbury	42	16/2150			5.08	Block Island	39					
Folly Beach	62	15/2300				Solomon's Island					3.0	Newport	35				2.6	
Grand Strand	57	16/0523				St. Inigoes					11.10	Providence	35				5.9	
Ladson					4.30	Tall Timbers	62	16/2040				Westerly	31					
Oakbrook						Thomas Point Light	49	16/1300				<b>Connecticut</b>						
Myrtle Beach	62	16/0455			16.06	<b>Delaware</b>						Bridgeport	39	16/2254				
Airport						Cape Henlopen	56	16/PM				Airport						
Myrtle Beach	68	16/0500				Greenwood					10.58	Bristol						10.80
Springmaid Pier						Lewes			2.6	6.76		Burlington						9.45
Ridgeville					3.58	Vernon					12.36	Danbury Airport	21	17/0153				
St. George					1.90	Wilmington	40	16/2214				Groton/New	43	17/0045				
Walterboro					2.50	<b>New Jersey</b>						London Airport						
Williams					2.42	American Corners						Hartford Airport						
<b>North Carolina</b>						Atlantic City	34	16/2345	2.0	6.22		Meriden						
Beaufort	58	16/0405			5.56	Caldwell/ Essex Co. Airport	38	16/2353			10.21	MMK Airport	34	17/0155				
Castle Hayne 2E	81	16/0715				Cape May			2.6	7.36		New Haven						
Castle Hayne 3SW	104	16/0845				Doylestown					10.07	Airport						9.14
Cherry Point	71	16/0405			3.27	Federalburg					11.20	Southington						
MCAS						Neshanic					10.07	Willimantic	31					
Elizabeth City	56	16/1346			2.65	Newark Int'l Airport	46	16/2351			6.22	Windsor Locks	37					
Federal Point	97	16/0620				Pequannock					11.04	<b>New Hampshire</b>						
Flemington	80	16/0625				Sandy Hook	45	17/0024	1.9	6.57		Manchester	28					
Frisco	61	16/0805			0.34	Somerville					13.34							
Greenville	51	16/0800				Teterboro Airport	38	16/2351			8.53							
Holden Beach	64	16/0820				Wayne/fflows					12.21							
Manteo	53	16/1000				White House					12.98							
Masonboro Island				10.3														

Figure 5: Storm report for Hurricane Floyd from the U.S. National Weather Service (excerpts)

**POST STORM REPORT...HURRICANE FLOYD**  
**NATIONAL WEATHER SERVICE MOUNT HOLLY NJ**  
 1245 PM EDT MON SEP 20 1999

FLOYD POSSESSED CATEGORY ONE HURRICANE CHARACTERISTICS AS HE APPROACHED SOUTHERN DELAWARE AT 15Z ON THURSDAY SEPTEMBER 16, BUT WAS DOWNGRADED TO A TROPICAL STORM AS HE GRAZED THE SOUTHERN NEW JERSEY COAST BETWEEN 20Z SEPTEMBER 16 AND 01Z SEPTEMBER 17 ON A NORTHEASTERLY PATH TOWARD NEW ENGLAND. FLOYD'S FORWARD SPEED INCREASED STEADILY AS HE MOVED INTO HIGHER LATITUDES; OFF THE DELAWARE COAST HIS FORWARD SPEED WAS 29 MPH, WHILE ALONG THE NEW JERSEY COAST HIS FORWARD SPEED HAD INCREASED TO 34 MPH. THIS TRACK PROVIDED A NORTHERLY COMPONENT TO WINDS WELL IN ADVANCE OF THE EYE, AND SO COASTAL FLOODING ALONG THE SHORES OF THE CHESAPEAKE AND DELAWARE BAYS, AND ALONG THE OCEAN FRONT, WAS REDUCED. IN FACT... NORTHERLY WINDS IN THE UPPER END OF THE CHESAPEAKE BAY PRODUCED BLOWOUT TIDES OF ONE-HALF FOOT BELOW NORMAL IN THE CECIL AND KENT COUNTY AREAS ON MARYLAND'S EASTERN SHORE.

FLOYD WILL BE BEST REMEMBERED FOR THE RAIN HE PRODUCED THROUGHOUT THE MID ATLANTIC REGION. A STALLED FRONTAL SYSTEM ORIENTED FROM SOUTHWEST TO NORTHEAST FROM THE NORTHERN DELMARVA INTO CENTRAL NEW JERSEY PROVIDED A FOCUSING MECHANISM FOR HEAVY RAIN AS FLOYD MOVED NORTH. NEW RECORDS WERE SET IN PHILADELPHIA FOR THE MOST AMOUNT OF RAIN IN A CALENDAR DAY (6.63 INCHES), AND 14 INCHES WAS REPORTED IN KENT COUNTY MARYLAND. RECORD FLOODING OCCURRED AT 12 RIVER GAGE LOCATIONS, AND RECORD FLASH FLOODING WAS REPORTED IN NUMEROUS OTHER AREAS OF THE CWFA THURSDAY AFTERNOON AND EVENING. A STATE OF EMERGENCY WAS DECLARED IN DELAWARE, NEW JERSEY, AND EASTERN PENNSYLVANIA.

**A. PEAK WINDS...**

LOCATION	SUSTAINED TIME	PEAK	TIME
ATLANTIC CITY NJ (POMONA)	290/23KT 16/2345Z	110/34KT	16/1914Z
PHILADELPHIA PA (INTERNATIONAL AIRPORT)	350/32KT 16/2136Z	350/42KT	16/2116Z
WILMINGTON DE	030/32KT 16/1238Z	310/40KT	16/2214Z
SANDY HOOK NJ	330/34KT 17/0024Z	330/45KT	17/0024Z
BUOY 44009	120/39KT 16/1800Z		
120/52KT 16/1800Z			
CAPE HENLOPEN DE PILOT TOWER		56KT	16TH PM

**B. LOWEST PRESSURE...**

LOCATION	PRESSURE	TIME
ATLANTIC CITY NJ	980.2 MB (28.95 INCHES)	16/2054Z
PHILADELPHIA PA	985.0 MB (29.09 INCHES)	16/2136Z
WILMINGTON DE	986.0 MB (29.12 INCHES)	16/2106Z
SANDY HOOK NJ	981.0 MB	16/2306Z
BUOY 44009	976.0 MB	
16/1900Z		

**C. RAINFALL...(STORM TOTAL FOR 9/15 TO 9/17)**

LOCATION	COUNTY	TOTAL
CHESTERTOWN	KENT MD	14.00 INCHES
SOMERVILLE	SOMERSET	13.34
WHITE HOUSE	HUNTERDON	12.98
VERNON	KENT DE	12.36
FEDERALSBURG	CAROLINE	11.20
PEQUANNOCK	MORRIS	11.04
GREENWOOD	SUSSEX DE	10.58
AMERICAN CORNERS	CAROLINE	10.20
DOYLESTOWN	BUCKS	10.07
NESHANIC	SOMERSET	10.05

**D. STORM TIDES...**

LOCATION	TIDE	DEPARTURE	TIME
SANDY HOOK NJ	6.57 MLLW +1.91 FT		16/1748Z
ATLANTIC CITY NJ	6.22 MLLW +2.02 FT		16/1612Z
CAPE MAY NJ	7.36 MLLW +2.60 FT		16/1818Z
LEWES DE	6.76 MLLW +2.55 FT		16/1900Z
PHILADELPHIA PA	9.34 MLLW +2.82 FT		16/2236Z

**E. FLOODING...**

ALL RIVER BASINS IN THE PHI CWFA EXPERIENCED RAPID RISES AS A RESULT OF PRECIPITATION FROM FLOYD. FLASH FLOODING AND FLOODING OF POOR DRAINAGE AREAS WAS WIDESPREAD THROUGHOUT THE REGION. RECORD FLOODING OCCURRED ON THE RARITAN RIVER IN CENTRAL NEW JERSEY AND ON TRIBUTARY STREAMS TO THE DELAWARE RIVER IN SOUTHEAST PENNSYLVANIA AND NORTHERN DELAWARE.

**F. STORM EFFECTS**

THERE WERE 14 FATALITIES REPORTED IN THE MT. HOLLY SERVICE AREA... MOST DUE TO FLOODING. EIGHT DEATHS WERE REPORTED IN SOUTHEAST PENNSYLVANIA...FOUR IN NEW JERSEY...AND TWO IN DELAWARE. SEVERAL INDIVIDUALS ARE STILL REPORTED AS MISSING...AND THE DEATH TOLL MAY INCREASE.

DOLLAR DAMAGES WERE CAUSED PRIMARILY BY INLAND STREAM AND RIVER FLOODING. DAMAGE ESTIMATES ARE STILL PRELIMINARY AS WATER IS STILL RECEDING IN SOME LOCATIONS...BUT THEY WILL BE IN THE HUNDREDS OF MILLIONS OF DOLLARS. NUMBER OF PEOPLE EVACUATED IS ROUGHLY 10000...AGAIN MAINLY CAUSED BY RIVER FLOODING. MOST HAVE BEEN ABLE TO RETURN TO THEIR HOMES.

Figure 6: Casualty and damage statistics

<p>There were 57 deaths directly attributable to Floyd – 56 in the United States and 1 in Grand Bahama Island. The death toll by state is as follows: North Carolina 35, Pennsylvania 6, New Jersey 6, Virginia 3, Delaware 2, New York 2, Connecticut 1, and Vermont 1. Most of these deaths were due to drowning in freshwater flooding. Floyd was the deadliest hurricane in the United States since Hurricane Agnes in 1972.</p>	<p>The Property Claims Services Division of the U.S. Insurance Services Office reports that insured losses due to Floyd totalled \$1.325 billion. Ordinarily this figure would be doubled to estimate the total damage. However, in comparison to most hurricane landfalls, in the case of Floyd there was an inordinately large amount of freshwater flood damage, which probably alters the two to one damage ratio. Total damage estimates range from \$3 to over \$6 billion.</p>
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