

The Hurricane of October 21-24, 1878

Delaware Geological Survey
Special Publication No. 22

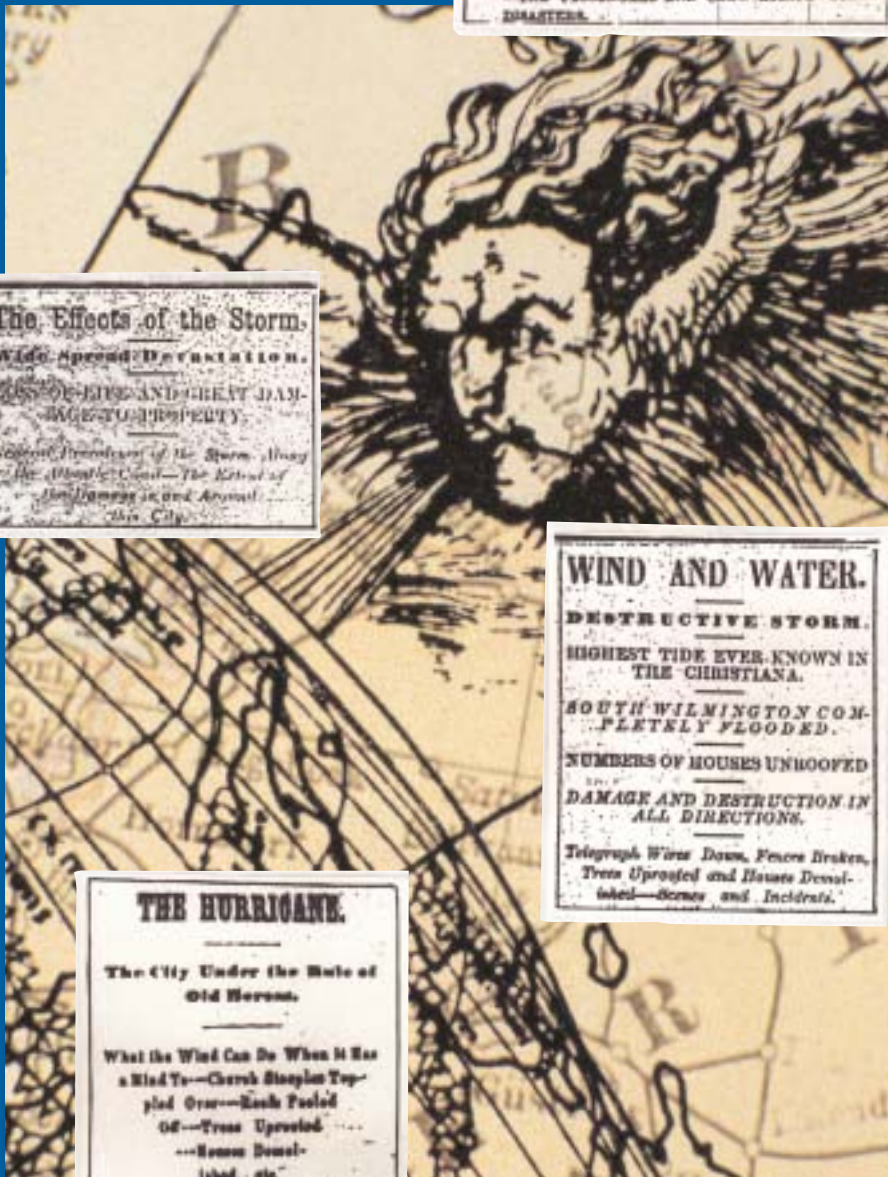
THE WORK OF THE STORM.
TWO STEAMERS LOST AT SEA.
THREE FOUNDEN OFF THE NORTH CAROLINA COAST
—THE PASSENGERS AND CREW ESCAPE—OTHER
DISASTERS.

The Effects of the Storm.
Wide Spread Devastation.
LOSS OF LIVES AND GREAT DAN-
GERS TO PROPERTY.
*General Description of the Storm, History
of the Atlantic Coast—The Method of
the Damage in and Around
the City.*

WIND AND WATER.
DESTRUCTIVE STORM.
HIGHEST TIDE EVER KNOWN IN
THE CHRISTIANA.
SOUTH WILMINGTON COM-
PLETELY FLOODED.
NUMBERS OF HOUSES UNROOFED
DAMAGE AND DESTRUCTION IN
ALL DIRECTIONS.
*Telegraph Wires Down, Fences Broken,
Trees Uprooted and Houses Devol-
uted—Scenes and Incidents.*

THE HURRICANE.
The City Under the Rule of
Old Heron.
What the Wind Can Do When It Has
a Mind To—Church Steeple Top-
pled Over—Roofs Pooled
Off—Trees Uprooted
—Houses Demol-
ished, etc.
Thousands of Dollars Worth of Dam-
age Done.
A NUMBER OF PERSONS KILLED
AND INJURED.

By
Kelvin Ramsey &
Marijke J. Reilly
2002



Special Publication No. 22

**The Hurricane of
October 21-24, 1878**

By

Kelvin W. Ramsey

and

Marijke J. Reilly

2002



CONTENTS

| | |
|--|----------|
| ABSTRACT | 5 |
| INTRODUCTION..... | 6 |
| <i>Acknowledgments</i> | 8 |
| PART I: | |
| THE HISTORICAL RECORD | 9 |
| METEOROLOGICAL CONDITIONS | 9 |
| OCTOBER 21, 1878..... | 9 |
| OCTOBER 22, 1878..... | 11 |
| <i>North Carolina</i> | 12 |
| <i>Norfolk, Virginia</i> | 12 |
| <i>Southern Delaware</i> | 12 |
| OCTOBER 23, 1878..... | 13 |
| <i>North Carolina and Virginia Coasts</i> | |
| <i>to Cape Henry</i> | 13 |
| <i>Norfolk, Virginia</i> | 14 |
| <i>Richmond, Virginia and Central Virginia</i> | 14 |
| <i>Chesapeake Bay, Virginia and Maryland</i> | 14 |
| <i>Eastern Shore of Virginia and Maryland</i> | 16 |
| <i>Washington, D.C.</i> | 18 |
| <i>Baltimore, Maryland</i> | 18 |
| <i>Atlantic Coast of Delaware</i> | 18 |
| <i>Kent County and</i> | |
| <i>Northern Sussex County, Delaware</i> | 20 |
| <i>Collins Beach, Delaware</i> | 23 |
| <i>Southern New Castle County, Delaware</i> | 25 |
| <i>Wilmington, Delaware</i> | 26 |
| <i>New Castle, Delaware</i> | 32 |
| <i>Delaware Bay and River, Delaware and New Jersey</i> | 34 |
| <i>Philadelphia, Pennsylvania</i> | 38 |
| <i>Eastern Pennsylvania</i> | 44 |
| <i>Scranton, Pennsylvania</i> | 45 |
| <i>Trenton and Western New Jersey</i> | 45 |
| <i>Albany, New York</i> | 46 |
| <i>New York City</i> | 46 |
| <i>Hartford and New Haven, Connecticut,</i> | |
| <i>and Providence, Rhode Island</i> | 50 |



| | |
|--------------------------------------|----|
| <i>New England</i> | 50 |
| OCTOBER 24, 1878..... | 51 |
| <i>Wilmington, Delaware</i> | 51 |
| <i>New Castle, Delaware</i> | 52 |
| LATER REPORTS..... | 54 |
| <i>Wilmington, Delaware</i> | 54 |
| <i>Delaware City, Delaware</i> | 56 |

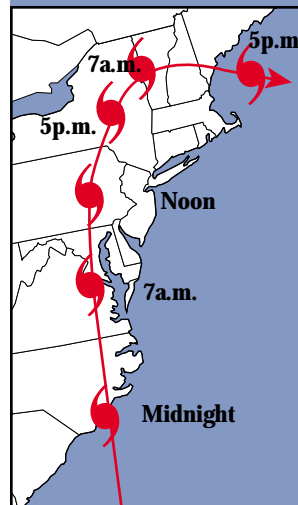
PART II.

| | |
|--|----|
| THE NATURE AND EFFECTS OF THE STORM | 57 |
| METEOROLOGICAL CONDITIONS..... | 57 |
| TIDAL CONDITIONS..... | 57 |
| STORM TRACK..... | 58 |
| FORWARD SPEED OF THE STORM..... | 60 |
| BAROMETRIC PRESSURES, WIND SPEEDS AND DIRECTIONS, RAINFALL AMOUNTS..... | 61 |
| STORM SURGE..... | 64 |
| GEOLOGIC EFFECTS OF THE HURRICANE..... | 68 |
| IF THE STORM WERE TO HAPPEN TODAY..... | 78 |
| REFERENCES CITED..... | 81 |
| ADDITIONAL REFERENCES..... | 84 |
| COMMON HURRICANE TERMS..... | 87 |

*Layout & design by Elizabeth I. Dunkle
Office of Publications
University of Delaware*

FIGURES

| | |
|---|----|
| Figure 1. Path of the Hurricane of 1878 and major cities referred to in the text. | 7 |
| Figure 2. Map showing location of major meteorological systems affecting the track of the Hurricane of 1878 .. | 10 |
| Figure 3. Advertisement of the Buffalo Bill show in Wilmington, Delaware on October 21, 1878 | 11 |
| Figure 4. Engraving of Hygenia House at Collins Beach..... | 24 |
| Figure 5. The Steamship <i>H.B. Plant</i> | 25 |
| Figures 6a and 6b. Engravings of the City of Wilmington in 1851 and 1874. | 27 |
| Figure 7. Engraving of New Castle, Delaware and Tasker's Iron Works in 1872. | 32 |
| Figure 8. Graphs of tidal predictions for selected areas along Delaware Bay and River..... | 59 |
| Figure 9. Map of Delaware Bay and River with locations and times of high tide and other features related to the storm | 67 |
| Figure 10. Pomeroy and Beers Atlas map of Collins Beach area in 1868. | 70 |
| Figure 11. Map showing area of Collins Beach in 1841 | 71 |
| Figure 12. Map showing area of Collins Beach in 1884 | 73 |
| Figure 13. Map showing area of Collins Beach in 1926 | 74 |
| Figure 14. Map showing area of Collins Beach in 1993 | 76 |
| Figure 15. Map showing area of Woodland Beach in 1841 | 77 |
| Figure 16. Map showing area of Woodland Beach in 1927. | 78 |
| Figure 17. Map showing area of Woodland Beach in 1989. | 79 |
| Figure 18. Map of Wilmington showing area affected by flooding in the Hurricane of 1878 that could be flooded by a similar storm today. | 81 |



TABLES

| | |
|--|----|
| Table 1. Predicted times and heights of tide for stations along the Delaware Bay and River..... | 58 |
| Table 2. Documented storm tide heights for October 23, 1878. | 60 |
| Table 3. Forward speed of storm estimated from published storm track map. | 61 |
| Table 4. Barometric pressure, rainfall amounts, wind speed, and wind direction data for the Hurricane of 1878. | 62 |

THE HURRICANE OF OCTOBER 21-24, 1878

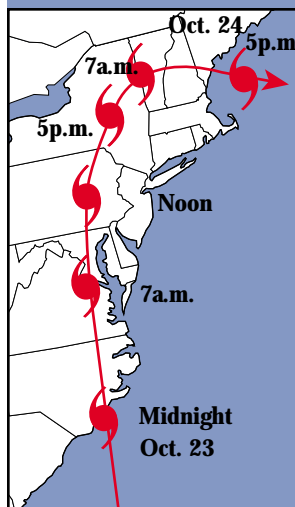
Abstract

On October 21, 1878, a hurricane crossed the island of Cuba and headed east of Key West, Florida. On the evening of October 22, it made landfall north of Cape Lookout, North Carolina, as a low Category 2 hurricane with winds around 100 mph. The storm picked up speed after landfall and moved northward at a rate of greater than 40 mph and maintained tropical storm force wind speeds of greater than 60 mph with gusts much higher. On the morning of October 23, it passed up the west side of the Chesapeake Bay near the cities of Baltimore and Annapolis, Maryland, Wilmington, Delaware, and Philadelphia, Pennsylvania. By the late afternoon it had reached Albany, New York, and turned eastward and passed out to sea north of Boston, Massachusetts, on the morning of October 24.

The storm cut a wide swath of devastation, sinking or driving aground ships in the Atlantic and the Chesapeake and Delaware Bays. The wind's strength was great enough to unroof houses, knock down church steeples, uproot trees, and in some places, destroy buildings. Storm surge was created by east-southeast winds blowing into the entrance of Delaware Bay at the same time as a perigeon high tide causing massive flooding along the Delaware Bay and River, and along the riverfronts in the cities of Wilmington and Philadelphia.

Between Philadelphia and Dover on the Delaware River and Bay coast, the storm surge was in the form of a surge wave perhaps as high as 5 to 8 feet above high tide (12 ft above sea level). It crashed onto shore flooding miles inland and destroying buildings along the coast. The area that this wave hit experienced dramatic coastal change where freshwater swamps and streams became tidal streams over the course of just a few years after the storm and where new inlets formed in the bay-front barriers.

Over 100 fatalities were the result of the hurricane, many of them the result of drowning in shipwrecks. Damage estimates in 1878 dollars likely topped \$10,000,000, which equates to over \$150,000,000 in 1999 dollars. This storm may well be the hurricane of record for the Delaware Bay and River region and provides



a model for a worst-case scenario for a modern hurricane. If such a storm were to occur today, there would be flooding of riverfront development areas in Wilmington and along the industrial riverfront of Philadelphia. In addition, wind damage would cause massive disruption of traffic from downed trees and power lines, and much damage to houses. A hurricane of greater strength would create a storm surge in the Delaware River that would cause catastrophic flooding.

Hurricanes Rarely Make Landfall in the Middle Atlantic States

Since 1900:

No hurricanes have made landfall in Delaware

One Category 2 hurricane made landfall in Maryland

One Category 1 hurricane made landfall in New Jersey

Two Category 1, one category 2, and one category 3 made landfall in Virginia

source: from The Deadliest, Costliest, and Most Intense United States hurricanes of this century (and other frequently requested hurricane facts) [NOAA Technical Memorandum NWS TPC-1] updated in February, 1997.

Introduction

Hurricanes are one of the major natural hazards of the Atlantic Coast of North America. These storms, very intense low pressure systems spawned in the warm tropical waters of the Atlantic, Caribbean Sea, and Gulf of Mexico, rarely make landfall along the Middle Atlantic Coast (New Jersey to Virginia). Over the last 80 years, high tides of record at Breakwater Harbor in Lewes, Delaware, show that coastal flooding is rarely generated by hurricanes in this region. Only six of the top thirty high tides of record were generated by hurricanes; none of these storms caused widespread flooding or damage in the coastal regions of Delaware (unpublished in Delaware Geological Survey data files). Most high tides of record and coastal damage to Delaware results from another type of low-pressure system known as a northeaster. A greater threat to Delaware by hurricanes comes from those that make

landfall to the south, particularly along the North Carolina coast, and move rapidly inland along a track that includes Delaware or its vicinity. These storms bring heavy rains, high winds, and create widespread stream flooding. A recent example was Hurricane Floyd in 1999.

This publication documents one such storm in October of 1878 that created widespread damage to the upper reaches of Delaware Bay, along the Delaware River, and in the area of the City of Wilmington. It affected a vast area from Cuba to coastal North Carolina to Washington, D.C., Baltimore, the Chesapeake Bay, Philadelphia, and as far north as Albany, New York (Figure 1).

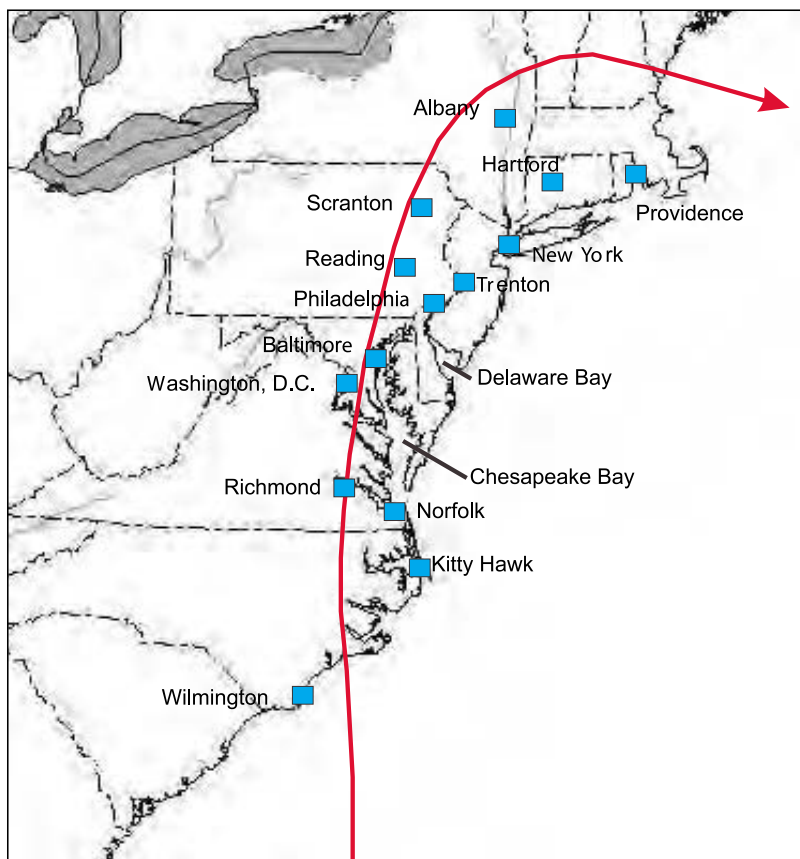


Figure 1: Portion of storm track from October 18-24, 1878 with geographic localities mentioned in the text.

The purpose of this publication is to document the progress of the storm, especially from eyewitness accounts from newspapers of the day, and then to glean from the existing data the nature of the storm, changes along the coast of Delaware that resulted from the storm, and finally its likely effects if a similar storm were to occur today. The majority of the information regarding the storm comes from newspaper accounts, unfortunately no photographic documentation has been found, even though photography was in widespread use in 1878.

Numbers in parenthesis refer to documents in the References Cited section. See the Additional References section for other related information and for those references cited in the figure captions.

Acknowledgments

We would like to thank several individuals for their assistance in gathering and furnishing information vital to this report. Dr. E.D. Bryan provided helpful correspondence plus a copy of his excellent work on the history of Collins Beach. Tom Kendrick of NOAA/NOS provided tide predictions for locations along Delaware Bay and Delaware River. Connie Cooper and Ellen Rendle from the Historical Society of Delaware were very helpful in assistance with researching the diaries and personal accounts of the period of the storm. Barbara Hall from the Hagley Museum was very helpful in locating some of the photographs and figures of ships from the period of the hurricane. The University of Delaware Interlibrary Loan Office staff went out of their way to acquire copies of out of state newspaper articles and storm accounts. Thanks are also given to Daniel Leathers, Delaware State Climatologist and Peter McLaughlin, Delaware Geological Survey (DGS) who reviewed the manuscript and William Schenck (DGS) who provided helpful suggestions about the figures and formatting of the publication.

PART 1: THE HISTORICAL RECORD

Fortunately, numerous newspapers, some official reports, and a few diary accounts exist for October 1878. The following section attempts to recreate the movement and effects of the storm based on these records as well as give a sense of the historical times and places that the storm affected. As with all records of this nature, some caution is needed pertaining to the accuracy of the accounts in describing the storm, reporting data (wind speed, barometric readings, etc.), and describing damage and damage costs. In compiling the records from different sources, we found that there was general agreement of the accounts and that the nature and damage resulting from the storm could be accurately discerned from the historical record. Where dollar amounts of damages or losses were reported in the original accounts and stated in this report, equivalent values adjusted to 1999 dollars are given in parentheses.

Meteorological Conditions

High pressure centered in the Southwest dominated the country west of the Mississippi River. A second high-pressure system was present in the Canadian Maritime Provinces. High pressure extended from this region southward over the Atlantic to Bermuda where it was 30.19 inches (in.) on October 22 and falling. Between these two major high-pressure systems was an extensive area of low pressure with two centers, one over central Canada extending southward to the Great Lakes, and the other the hurricane (Figure 2). Rain from the Canadian system extended southward as far as Illinois. Twenty to thirty mph winds and rain on the Great Lakes brought out cautionary signals for shipping (1).

October 21, 1878

South of Cuba a hurricane formed and moved across the island during the night of the 20th and 21st. At 4:35 p.m. on the 21st, the barometer in Havana read 29.67 in. with light rains and winds up to 24 mph from the NW. At Key West, Fla., northeasterly winds at 46 mph were reported at 7:35 a.m. By 10:41 p.m., the winds had abated to the northwest at 27 m.p.h. The heaviest rainfall and highest winds (54 mph) occurred during the afternoon. Barometric pressure of 29.53 in. was reported at 2:00 p.m. and



Noon
Oct. 21st



Figure 2: Map showing location of major meteorological systems affecting the track of the Hurricane of 1878. The path of the center of the hurricane indicated by the red track line (adapted from Pielke, 1990, and Monthly Weather Review, 1878) The dates (in red) show the approximate position of the center of the storm at 7:00 a.m. E.S.T. that day. High pressure indicated by red H, low pressure by red L.

4:16 p.m. The steamer *Juniata* reported a terrific NE gale and choppy seas offshore Charleston and Tybee, S.C. (1).

That evening Buffalo Bill made an appearance at the Wilmington, Del. Opera House (Figure 3). The following is an account of the show as reported in the *Daily Gazette* (2, 3).

A BIG HOUSE FOR "BUFFALO BILL."

Buffalo Bill appeared at the Grand Opera House last evening and was greeted by the largest audience that ever witnessed his performance in this city – nearly two thousand

people being in the Hall. The play was a good one of the kind, and abounded in striking scenes and stirring incidents, which received the unqualified applause of the large audience. After the close of the drama, the Indians gave a dance, and one of them tried his hand at target-shooting with bow and arrow, but seemed a little excited and did not shoot very well. Buffalo Bill, however, gave some splendid exhibitions of marksmanship with his handsome rifle. He stood about twenty-five feet from the target, and shot in various positions, including one backward shot, with the rifle pointing out between his legs, and one backward shot over his shoulder, viewing the mark by means of a small looking-glass which he held in his hand. He struck his mark nearly every time, and his skill was loudly applauded.



Figure 3: Advertisement for Buffalo Bill's show entitled "The Red Right Hand; or, Buffalo Bill's First Scalp for Custer!" at Wilmington's Grand Opera House on October 21, 1878, 2 days before the hurricane struck the city (from the Early Evening, October 21, 1878).



October 22, 1878

The New York Times reported (4)

THE WEATHER.

SYNOPSIS AND INDICATIONS

Washington, Oct. 22 – 1 A.M. – A storm of great energy not reported from the West India stations, is now east of Florida. Its track is unknown. The pressure is highest in the

Middle Atlantic States; it is generally rising west of the Mississippi River and in the upper lake region. The temperature has fallen, with north-westerly winds and gale west of the Mississippi River and in the upper lake region; elsewhere it has risen, with north-easterly winds in the South Atlantic and East Gulf States, with southerly winds in the lower lake region and Middle States. The rivers have remained nearly stationary.

North Carolina

The hurricane moved northward from east of South Carolina, and by 11:00 p.m. was located between Wilmington and Cape Lookout, N.C. The effects of the storm reached Wilmington by about 3 p.m. with easterly winds. At 10:20 p.m., the winds shifted to the northwest with a maximum velocity of 36 mph. The lowest pressure reported was 29.12 in. at 11:56 p.m. During the storm, 2.92 inches of rain fell at Wilmington. At Cape Lookout at 11:02 p.m., the pressure was 29.05 in. with southeasterly winds of 68 mph. The maximum velocity of wind since 4:35 p.m. was 100 mph. Total rainfall at Cape Lookout was 4.06 inches. At Portsmouth, N.C., winds of 82 mph from the SE and rainfall of 3.48 inches were reported at 11:04 p.m. At 6:30 p.m. the effects of the storm began at Kitty Hawk, N.C. (1).

At 11:45 p.m., the schooner *Altoona* was driven ashore one mile south of Cape Hatteras and was a total loss. The schooner *Magnolia* was wrecked in Albemarle Sound (1).

Norfolk, Virginia

At an early hour in the evening, a gale sprang up from the northeast and by 9:00 p.m. was "knocking things about in a lively style." The rain came in torrents and the streets were at times a driving sheet of water (5).

Southern Delaware

At Dover, it was reported that the area was visited by a terrible storm of wind and rain that began about 9:00 p.m. (6).

October 23, 1878

The New York Times gave the weather report (7).

THE WEATHER.

SYNOPSIS AND INDICATIONS.

Washington, Oct. 23 – 1 A. M. – The storm last night east of Florida has moved with great energy in a northerly path, and is now central near Cape Hatteras. Rain has generally fallen east of the Mississippi, except in New-England. The temperature has generally risen in the Middle States and New-England, and in the North-west; elsewhere it has fallen. Easterly winds prevail in the Middle States and New-England; elsewhere they are mostly south-westerly. The pressure is highest and falling in Texas and Nova Scotia. The rivers have remained nearly stationary.

INDICATIONS.

For New-England, increasing cloudiness, followed by rain, warmer north-easterly winds, falling barometer, followed in the west portions by rising barometer and colder north-west winds.

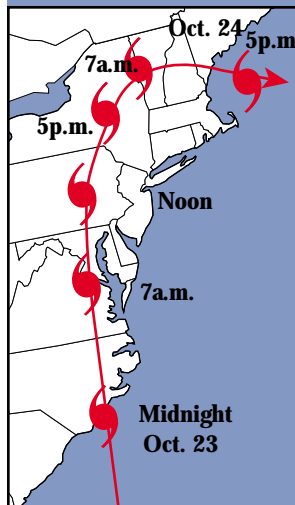
For the Middle Atlantic States, cloudy, rainy weather, warm easterly backing to colder north-west winds, falling followed by rising barometer.

For the South Atlantic States, colder, partly cloudy, and cloudy weather, with frequent rain, north-westerly winds, rising preceded in east portions by falling barometer.

Cautionary signals continue at Lewes, Cape May, Atlantic City, Barnegat, Sandy Hook, Sandusky, Cleveland and Section No. 5 Erie, Buffalo, Savannah, Tybee Island, Charleston, and are ordered for Rochester, Oswego and Section No. 6 New-York, New-Haven, New-London, Newport, Wood's Hole, Boston and Section No. 6 Baltimore. Cautionary and off-shore signals are ordered for Wilmington, Smithville, Macon, Cape Lookout, Cape Hatteras, Kitty Hawk, Cape Henry, and Norfolk.

North Carolina and Virginia Coasts to Cape Henry

At 2:00 a.m., the anemometer at Kitty Hawk, N.C. blew away after recording winds of 88 mph. The barometer read 29.06 in. at its lowest (1). At Cape Henry and Norfolk, Va., the winds shifted from the southeast to the southwest during the night with maxi-



mum winds of 84 and 44 mph, respectively. South of Cape Henry, the ship *A.S. Davis* went ashore at 2:00 a.m. with 19 lives lost. At Cape Lookout at 1:30 a.m., the steamer *Florence Witherbee* went ashore. The steamer *General Barnes* foundered off Cape Hatteras and was a total loss of approximately \$250,000 (\$3,800,000) and the steamer *City of Houston* went ashore on Fry-pan Shoals with a reported loss of \$40,000 (\$608,000) (1,8).

Norfolk, Virginia

The lowest barometer reading at Norfolk was 29.36 in. at 7:00 a.m. (5). The velocity of the wind was reported at 4:00 a.m. at the Signal Office to be 44 mph (9). Considerable damage occurred in the city. Several churches lost their roofs, frame houses under construction were blown down, and cars were blown from the railroad tracks at the Atlantic, Mississippi and Ohio depot. St. Mary's Catholic Church, St. John's Episcopal Church, the Purcell House, and warehouses of the Old Dominion Steamship Company and Clyde's Line were damaged. Trees were blown down, signs and shutters damaged and outhouses thrown down in profusion. A large number of oyster boats and truck boats were swamped and sunk. Armstrong and Son lost from their mill in Portsmouth \$1,500 (\$23,000) worth of saw logs, and Bradshaw's saw-mill on the Seaboard and Roanoke Railroad was destroyed (5, 10, 11). Total rainfall at Norfolk was 2.86 inches (1).

Richmond, Virginia and Central Virginia

Heavy rain and a wind storm occurred in Richmond during a portion of the night, especially after midnight when the winds became almost a hurricane. Signs, fences, and trees were blown down and there was some damage to telegraph lines (5, 12). Much farther inland at Lynchburg, the wind backed from northeast to northwest with heavy rains (1). Total rainfall at Lynchburg was 2.01 inches (13).

Chesapeake Bay, Virginia and Maryland

At Annapolis at 7:30 a.m., the barometer read 28.82 in. Earlier, at 5:45 a.m., the wind had shifted from NE to SE and blew with great violence. On the Chesapeake Bay, the storm was terrific with the greatest effect occurring between Patuxent and Barren Island,

Md. The steamer *Express* foundered off Barren Island in the Chesapeake Bay with the loss of several lives (1). It was later reported that only seven of thirty-one aboard the *Express* survived. The following is an excerpt of their harrowing adventure (13).

The *Express* sailed from Baltimore on Tuesday afternoon for Washington, Alexandria, and Georgetown with a large cargo of freight and the following named passengers... (a list of nine passengers follows)...Down the bay as far as James Point, the weather was very rough and the steamboat was pitching badly, but no alarm was felt. After passing that point, the wind increased in velocity to a frightful extent, and the boat became unmanageable and rolled in the trough of the sea. Captain Barker and the entire crew remained on deck. He directed the movements of the steamboat in the night...

Early on Wednesday morning the gale increased to a frightful extent and the steamboat was tossed helplessly about, unable to make headway. About 4 o'clock a fearful sea broke over her on the port bow staving in her upper works. The entire mass of water rushed through the saloon, carrying away the furniture and life boats. Again and again waves swept over her and the Captain abandoned all hope. Procuring life preservers, he found two of the lady passengers Mrs. Bacon and Mrs. Jones, and adjusted them. He then carried the two ladies on deck and placed them in the stern of the vessel and warned them that the boat was about to go to pieces. He promised to go to their assistance if possible. The Captain then lashed his young son to the saloon and again turned his attention to his vessel. The wind was blowing at a rate that would not allow any one to stand up to it, while the only thing that could be seen in the pitch darkness was the white foam of the raging waters that again swept over the vessel...

After clinging for eight hours to the wreck, the Captain and his companions sighted a small punga near them, by the sailors of which they were rescued. They were nearly unconscious from the effects of their long exposure. The other part of the wreck drifted onto Barren Island, the men clinging to it being rescued by a boat from the steamboat *Shirley* of the York River line which was also ashore on the Island... None of the passengers were rescued, and Capt. Barker is convinced that the ladies perished...Capt. Barker is at his home in Baltimore scarcely able to move and receiving the



attentions of a physician. The house has been besieged all day by friends of the drowned passengers in this city asking for the news of their fate. Capt. Barker is prostrated mentally and physically. His only son is among those drowned.

Later reports increased the number of survivors to 15 (8). *The Express* was a well-known ship in the Chesapeake Bay (14).

The Express was one of the best known boats in the harbor, having been built in 1841, in New York. For thirty-seven years she has been engaged in carrying passengers and freight to various points along the Bay and its tributaries. In 1873 she was rebuilt at a cost of \$20,000 and put in the best order. She was 200 feet long, 25 feet beam, 602 tons burden. She had a horizontal engine with an upright beam and piston. Last winter she was thoroughly overhauled and repaired, and went into the Washington and Potomac Rivers trade. She was owned by the Potomac Transportation Company. The value of the cargo and vessel is estimated at \$30,000. There was no insurance on the vessel.

A loss of \$30,000 would equate to about \$456,000 in 1999. Four or five other steamers and numerous smaller ships went aground in the same area. The schooner *H.I. Patter* was totally wrecked near Five-Mile Beach with two fatalities; the schooner *Sarah Clark* (or *Samuel Clark*) was wrecked at Peck's Beach with two or four fatalities (1, 8).

Eastern Shore of Virginia and Maryland

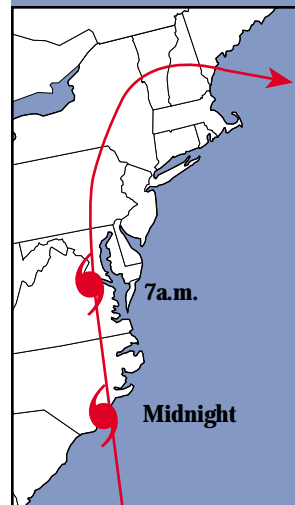
The captain of the steamer *Helen* reported on October 26 that the coast for twenty miles north of Cape Charles has been swept almost entirely of stock, houses, and grain. At Powell's Wharf several vessels were washed ashore. Mr. Powell's losses were estimated at about \$3,000 (\$45,500) and that of the citizens of Powelltown at \$5,000 (\$76,000). The inhabitants of Cobb's and Hogg's Islands were all feared lost. Vessels and small bay boats were sunk and ashore everywhere. Great quantities of merchandise and broken parts of several vessels drifted onto Tangier Island (15).

It was feared that the houses on Chincoteague Island had been swept away (16). The following account is given of the storm at Chincoteague (17).

THE STORM AT CHINCOTEAGUE.

A correspondent at the *Baltimore Sun*, writing from Chincoteague, Va., under date of Oct. 24th says: The flood swept before it sheep and cattle and horses in all directions, and ruining nearly all the crops which the poor islanders had worked hard all the summer to raise for the winter supplies. Granaries and corn cribs were flooded and their contents swept off or ruined where they stood. The greater part of the crops has been scattered. Sweet potatoes and other potatoes are raised, and a good many never will be dug out of the beds. Small boats and large schooner, even, were cast up into corn fields and on the marshes and shoals. Some of these will prove total losses, but others may be saved, but in many cases it will cost half their value to set them afloat again and put on the needed repairs. Very many of the poor islanders have lost everything, and some who were well-to-do before the cyclone are reduced to poverty. Your correspondent traveled by the little steamer *Widgeon* for over 40 miles among the countries, etc. of the Eastern Shore of Virginia and the shores of the rivers, etc. were strewn with the carcasses of horses, cattle and sheep. Many of the hardy "Chincoteague ponies," which are accustomed to stand all kinds of hardships out in all weathers and seasons, were overwhelmed in the rising flood. Upwards of a hundred men and women were seen at work during this tour of observation, stripping the hides of the dead animals and saving them for what they are worth. Everywhere the storm was disastrous in its effects, though, so far as could be learned, only one or two human lives were lost. The life-saving stations along the coast were under two or three feet of water. Captain James Tracy reports that the crew at his station worked all night to keep the windows from being bursted in by the force of the wind. He piled up furniture and everything else that was available against the door to keep his house from being stove up and strewn along the beach. Captain Tracy thinks that but for those precautions they would all have perished, for the water around them was in some places ten feet deep, and no boat could live in the heavy surf that beat the coast. No vessels, however, were driven on the beach.

At Easton, Maryland great damage was also reported including the loss of the spire on the Methodist Episcopal church (18). At Deal's Island, houses were blown down, barns dismantled, trees uprooted, and oyster boats wrecked. Several bodies were later



recovered on the shores of the island including that of one of the passengers of the *Express* (19).

Washington, D.C.

The center of the storm passed "...over, or a little bit to the east" of, Washington, D.C. At 4:40 a.m., the wind shifted from E to S, back again, and then around the compass before settling down to the NE with little or no wind, until 7:00 a.m. when the wind shifted abruptly to the northwest. The lowest barometer reading was 28.80 in. at 7:15 a.m. (1). Total rainfall was 3.54 inches (13).

Baltimore, Maryland

According to the War Department's Monthly Weather Review (a report of the Office of the Chief Signal Officer), the maximum wind velocity at 5:00 a.m. in Baltimore was 45 mph from the SE. The Signal Service recorded wind speed at a mile a minute (60 mph) at 5:00 a.m., but on Chesapeake Bay it blew twice that amount. The barometer dropped to 28.83 in. at 7:37 a.m.; that was the lowest reading ever for the signal station (1, 12). Soon after 9:00 a.m., the sun came out and everything looked serene. At 5:00 p.m., there was a rainbow. Total rainfall was 2.74 inches (12, 13). Because of the storm, the horse races at Pimlico were postponed on account of the flooding of the track (20). Many of the wharves on the waterfront were flooded to a depth of several feet, but few of the ships in the harbor were damaged. Several roofs were reported blown off. Damage in the city was estimated at \$12,000 (\$182,000) (21).

Atlantic Coast of Delaware

As reported in the Wilmington, Del. Every Evening (18), at Lewes, the storm was described as "...being the most terrible gale in 40 years." The wind began at about 2:00 a.m. and increased until 3:00 a.m. when it was "...blowing great guns." The tide broke through Cape Henlopen south of the lighthouse and came rushing in over the flats. The beach in front of Lewes was covered with water 7 feet deep, "...a thing not known before in half a century," nevertheless, the breakwater protected the considerable shipping behind it.

At Rehoboth, the only damage was to the beach in front of the Douglass House that was eroded to within four feet of the hotel. Some of the cottages were slightly damaged and the bathhouses were washed away and broken up. The Rehoboth branch of the J. & B. Railroad suffered no damage except at Maull's Glader where the track bed was washed away somewhat (18).

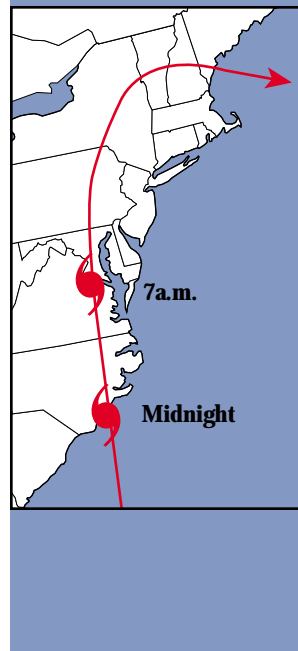
The *D.P. Phillips* went aground six miles south of Cape Henlopen. The following account was given by a survivor (22):

A SHIP-WRECKED SAILOR.

This morning a young man named Frederick Bradford, applied for aid at the Custom House in this city to help him on his way to Boston. He stated that he was a hand on the schooner, *D. P. Phillips* and had been ship-wrecked in the recent gale, six miles below Cape Henlopen. The vessel was loaded with sweet potatoes from Norfolk to Boston where the young man lived with his parents. There were six others on board beside himself, and of the crew five were drowned including the captain, George Lewis. The other saved was a colored man who was washed ashore with his collar-bone broken.

After reaching Lewes, and having no means, Mr. Bradford was informed that by applying at the Custom House in Wilmington he would be sent on to his home at the expense of the Government. Several of our generous-hearted citizens hearing his story, have come to his aid, among whom are Mrs. A. M. Pierson, No. 509 Lombard street, at whose home the unfortunate young man is domiciled. As there are no provisions made for shipwrecked sailors, by the general Government, he will be sent on to his home by the joint efforts of private individuals. He was provided with a whole suit of under-clothing by the generous clothier, Nathan Lieberman.

In other accounts, at Rehoboth, Lewes, and other places along the Atlantic Coast, considerable damage was reported from the high water (13, 21). Ships were reported aground in the vicinity of Lewes and Breakwater Harbor. Winds across the mouth of Delaware Bay at Cape May, New Jersey, were reported to veer from the E to SE to SW and be up to 84 mph at 5:45 a.m. to 6:00 a.m. (1, 21).



Kent County and Northern Sussex County, Delaware

At Wyoming, John Jakes, a railroad agent, merchant, postmaster, and truck gardener, entered into his diary on October 23rd, 1878 (23):

Weather very stormy and windy all day. In the morning it rained and blowed very hard. The storm done great damage and was terrific. Harris did not get down until 7 1/2 p.m. Should have been here at 11.30 am. My dirtys all came off. I lost the corn crop and several other things amounting to 36.19, gave note payable 23c apiece - I was at work got my cellar dug out. Heath had no school.

DIARY ENTRY OCTOBER 24, 1878

Weather beautiful indeed...

The reference to Harris refers to a person who was to arrive by train but was delayed due to damage to the tracks to the north. "Dirtys" presumably refers to clothing hung out on a line to air out for another day's usage.

At Dover, around 12:30 a.m. the wind began to rise and continued to get higher and higher until about 4:00 a.m. when it blew almost a perfect hurricane (6). "The clatter and banging was almost infernal, and the shrill pipings of the wind, high above all, made a perfect pandemonium which continued until daylight when the wind lulled slightly and continued to go down until noon, when it became a perfect calm." A large number of shade trees in Dover were torn to pieces, most notably in the public square and on State Street (6, 24). The only other damage was broken glass and a few shingles and awnings that were torn away. At the fairgrounds near town, damage was considerable, consisting of machinery thrown about by the wind, smashing it completely, and the agricultural products building almost torn to splinters. Total losses for the region were estimated to be not less than \$100,000 (\$1,500,000) (6).

Other damages were reported during the storm.

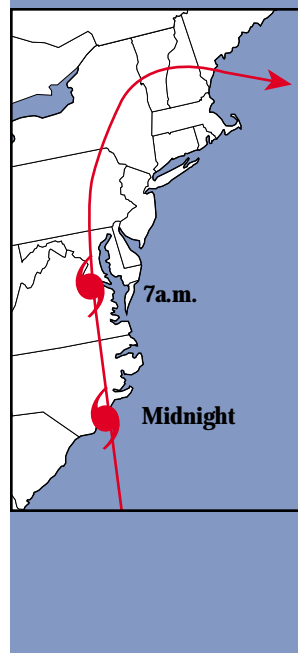
Among the incidents of the storm, some one bored a hole through the door of the Bayard House, and the wind blew

two bottles of whiskey, two boxes of cigars and five dollars in change through the hole, or it got out some other way (6).

The damage was particularly heavy along the bay shore and marshes where the tide rose to depths of eight to ten feet. Several men were believed to have lost their lives on the marshes near Leipsic where they were cutting salt hay. Fortunately they had been able to find a boat and only one of them was drowned. One party was asleep in a shanty on the marsh and awoke to find themselves afloat in Leipsic Creek and had to swim for it. All the cattle on the marshes were believed to be drowned. A large number of vessels were reported ashore on the marshes including a grain schooner and lots of oyster boats (6, 25). One vessel was reported as being carried northwesterly nearly five miles to the mainland. Loss of life was feared to be great as there were a great many persons on the marsh, and the tide rose "...sudden and unexpectedly high." The hotel at Kitts Hammock was twisted around by the wind and other buildings including the bar room, ball room, and bath houses were carried off by the tide. The family occupants had to leave by boat (6).

At Frederica, the steeple of the Methodist Episcopal Church was blown off and landed on the parsonage, but the pastor and family escaped injury (6, 13). At Magnolia, Camden, Wyoming, and other towns there was some minor damage to buildings (6, 24). At Little Creek Landing, the tide was so high that the town was partially under water and the streets could be navigated by boat (6). The tide rose four feet above high water in one hour's time. Oyster boats were swept inland as far as two miles (24). Twenty-four oyster boats were reported grounded at Mahon's Landing (13).

At Milford, the property along the Mispillion River was damaged (13). The schooner *H.P. Laws* went ashore on the marshes near Milford (16). The *Every Evening* reported that high tides and winds were very destructive on Mispillion Creek. The lighthouse keeper and his family were compelled to go to an upper story and were fearful that the water would sweep over the entire house at one time and all their stock, pigs, cow, and fowls were drowned. Many other buildings in the area were unroofed, and, as the water came up so suddenly, many cattle and horses drowned and corn and hay were lost in considerable amounts (18).



At Bombay Hook, the inhabitants and their property also took a beating as was reported in the following excerpt (25).

Bombay Hook was swept from end to end and for the past week has presented the appearance of a vast lake, the beach and banks serving as a rim of a basin to hold the water in. The only communication with the Island has been by boats. Persons on the west of the Island saw the big wave when it mounted the beach and noted its bank, and it was not until they heard the angry roar of splashing waters that they realized the destruction in its wake, and fled for the main land. As it was two children of Hugh Durham ...were drowned aged 3 and 9 years, and he at one time was in water up to his neck.

The destruction of property has been immense, including nearly every corn shock, stack of hay, fodder, most of the poultry and much of the stock. The costly pier of the Bombay Hook Railroad was damaged to the extent of \$3,000, and was rendered nearly useless. At the "Wakeman House," near by, the ball-room, barroom, bath-houses and about 400 bushels of corn were washed away. Mr. Sprunce estimated his loss at \$1,000. The dwelling of Lewis Campbell was moved from its foundation, the waters running through the lower rooms and the waves dashing into the second story windows. The kitchen was moved about 50 feet from the house. The water here was three feet higher than at any preceding storm. Samuel Loatman lives on the highest point of the Island ten or twelve feet above the Bay-level, and the water came up within a few feet of his house. He had about 700 bushels of corn in the shock which was washed away together with the provender and crop of wheat of 60 bushels sowing.

A. Brown lost about 1,000 bushels of corn, 25 head of sheep, all his hay and provender and a field of wheat of 80 bushels sowing which will be ruined. A patch of potatoes not taken up, about 75 bushels, washed out of the ground by the force of the current.

"Fraland" is nearly ruined; all the buildings but the main house washed away, the beach greatly damaged and many of the trees prostrated. A tree fell across one of the houses occupied by a family, and the occupants among which were two women had to wade in water up to their chin to a place of safety. The houses were lodged against a woods two or three hundred yards distant.

Richard Fogg lost about 150 tons of hay and five oxen, one swimming a distance of four miles to the main land and was saved. Six men, two of them from this town, who were helping Fogg get hay, had their shanty stove in and took refuge in a wild cherry tree for several hours, lashing themselves to its branches to keep from being blown away. One of these men was saved from the wreck of the *Metropolis* last January and from his knowledge of such storms took in the situation at once, and but for this fact the whole party would perhaps have been lost.

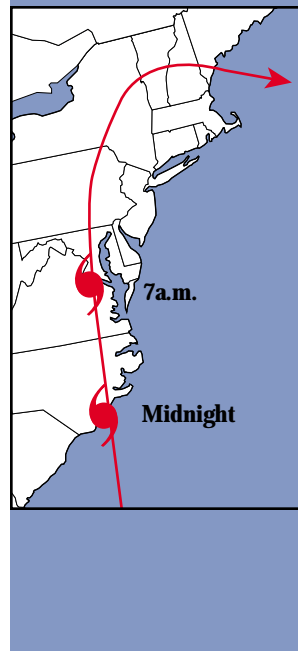
He hastily gathered all the ropes he could find, and a wagon, which would soon have been swept away, was backed up and securely tied to the tree above referred to. He then mounted the tree and cut the top off to better enable it to better resist the force of the wind. He then lashed himself to the upper branches and awaited the result. The other men stood on the ground until the water came up around their waist, then climbed into the wagon and when driven from that, the tree, finding the rope he had collected necessary to secure them against the wind which was driving with a force of about 18 pounds to the square foot [about 60 mph (26)].

Hundreds of other farmers in this vicinity suffered extensively by the loss of stock and crops.

Collins Beach, Delaware

During the latter half of the 19th century, the shoreline of the lower reaches of the Delaware River and upper reaches of the Delaware Bay were dotted with resort facilities and hotels. Day excursions from Wilmington and Philadelphia were common, sometimes involving more than 1,000 people (27). Chief among these resorts was Collins Beach where the Hygenia House (Figure 4) was located (27). Tickets for steamship excursion to Collins Beach from Wilmington cost fifty cents for adults and twenty-five cents for children. The Steamship *H.B. Plant* (Figure 5) was typical of those that traveled along Delaware Bay in the 1870's. Collins Beach boasted a pier for steamship docking, bathing facilities, yachting, shuffle board courts, dining facilities for 150, swings, and even billiards (27). For a much more complete history of Collins Beach, we recommend "Ho! For Collins Beach!" by E.D. Bryan.

Initial news from the resort hotel and facilities was sketchy, reporting that the pier and the out-buildings were washed away



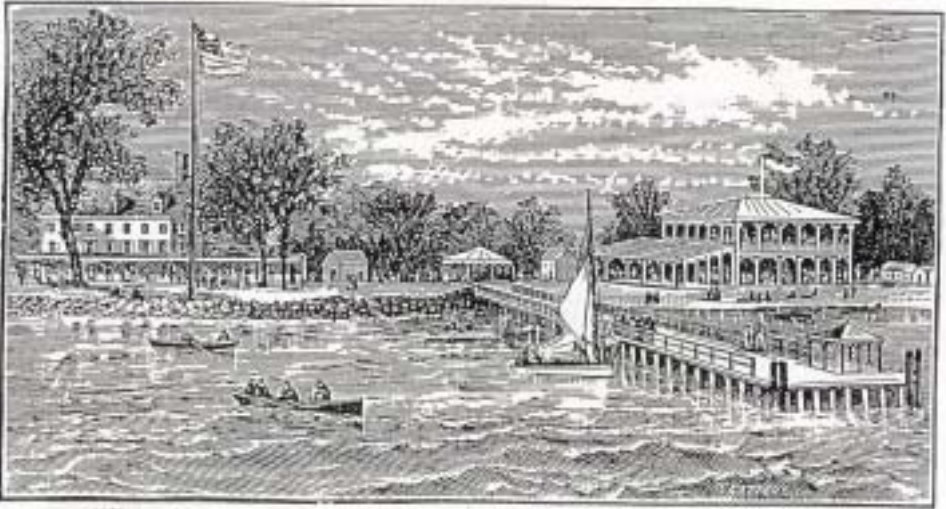


Figure 4: An 1879 view of Collins Beach resort by Philadelphia engraver David Scattergood. Hygenia House hotel is on the left and the restaurant, dance pavilion and bathhouses are on the right (from Bryan, Courtesy of Delaware County (PA) Historical Society).

(13). Later reports give the dramatic scene that unfolded on the shore of Delaware Bay (25).

24

...perhaps received the severest shock from the wind and waves of any other place along the coast. Shortly after daylight, while Mr. Collins was looking out upon the driving tempest, he saw as it were a huge wave lifted up out in the Bay, which came with flying speed breaking over the top of the beach in a mighty billow, bursting open the doors of the hotel, sweeping the ballroom, stables, pavilion, bath-houses – everything but the hotel property, before it and carrying them out of sight. The mighty tide rolled on inland submerging the country for a distance of one or two miles. In addition to the loss of his buildings and the demolition of the new pier, Mr. Collins lost several cattle and a pen of 8 fattening hogs.

In the midst of the storm a large steam collier, the *Rattlesnake*, was driven in upon the fast land about 500 yards above the house, and if gotten off at all must be with great difficulty. The loss of Mr. Collins will be between \$3,000 and \$5,000, and falls heavily upon him, having suffered considerable losses by storms the two preceding years.



Figure 5. The Steamship *H.B. Plant* at Pusey and Jones Shipyard in Wilmington. This shipyard was flooded with at least a foot of water in the buildings (Courtesy Hagley Museum and Library).

A loss of \$3,000 to \$5,000 would equate to about \$46,000 to \$76,000 in 1999 dollars. The effects of this storm would end up being far-reaching and probably signaled the death-knell for the resort industry along Delaware Bay that was within a decade or two supplanted by that of the Atlantic coast resorts.

Southern New Castle County, Delaware

At Middletown, several buildings were damaged (13). At Port Penn, the tide was the highest ever known, and all the farms along the river were flooded including Henry Walter's apple orchard, where a schooner was stranded. Damage was also reported from Odessa. In Delaware City, the water did great damage; the locks of the canal were damaged and the toll house washed away and the town cut off from communication for two days (13, 28). Several roofs were blown off in Delaware City, and the lower end of the town was under water for most of the day. The tow path of the Canal was riddled between St. Georges and Delaware City. The Pennsylvania and Delaware Railroad tracks were washed away for over a mile, and some of the track was carried for over a half-mile.

One farmer's loss of hay and cattle was estimated at \$5000 (\$76,000) and the St. Georges marsh company lost a good deal of their bank which cost \$20,000 (\$300,000) to repair (28).

Wilmington, Delaware

On October 23, William Canby, a Quaker gentleman who farmed in earlier life on Bread and Cheese Island and was a self-styled "simple-hearted aristocrat, not a money-maker," recorded in his diary from his home on West Street in Quaker Hill in Wilmington the following (29):

Violent storm the latter part of the night from the N. East, and continued until about 3 o'clock this morning causing great damage to property throughout the city, unroofing houses, tearing up trees tc. At 9 o'clock A.M. the tide was higher than it has been for twenty years, in some places up to the Rail-Road on Water street. The marshes between the city and the river are under water, extending from near "B. Wine Village" to "Hedgeville" - many houses in "South Wilm'g" have four and five feet of water in them. Horses, cows, sheep, and pigs have been drowned. The latter part of the day has been pleasant. Bishop Lee returned to day from Europe and I. H. Morris and family sail for home - they left this country in June 1876.

DIARY ENTRY OCTOBER 24, 1878

Beautiful morn'g.

This storm was the worst that has hit the city since that of 1840 (30). In both storms, the tides were driven up by heavy winds, but "not to such a great extent as that of 1840." The embankments were broken and the marshes submerged. From the City Hall tower, looking east, there is nothing but a vast expanse of water fully two miles wide (30, 31). At 9:00 a.m., the time for high tide, the water was still being blown in the creeks and was on a level with the Market Street, Third Street, and Eleventh Street bridges (32). Figure 6a, a sketch drawn prior to the Civil War, shows what Wilmington may have looked like. The area to the right (south) of the city was completely inundated by the storm. Figure 6b, another bird's eye view of Wilmington, was inked in 1874, just 4 years prior to the hurricane. The areas below the railroad tracks and on the south side of the river were under water from the storm.



Figure 6a (above): Artist's sketch of Wilmington looking east circa 1851. The Christiania River is shown in the lower right foreground and the Delaware River off in the distance. The green meadows between the two rivers were underwater as a result of the storm, as well as the meadows to the right (south) of the Christiania River. 1-Maryland Avenue, 2-Front Street, 3-City Hall at Market and Sixth Street, 4-Railroad Round House, 5- Location of Pusey and Jones Shipyard, 6- Christiania River, 7-Market Street (E. Whitefield, 1851, from lithograph printed by Hagley Foundation)

Figure 6b (below): Map of Wilmington looking north from 1874 showing the millworks, ship-building industry and houses along the Christiania River and in the City. Note the railroad tracks just north of the river. Much of the area between the tracks and the river, as well as on the other side of the Christiania, were flooded as a result of the hurricane (Bailey & Co. Artists, 1874, Courtesy of Historical Society of Delaware). Numbers same as Figure 6a.

Travel across the Third Street Bridge had to be halted because of the high tide (30). The tide ran up the channel of the Christiana "...like a race horse and beat the waves against the timbers of the bridge with a force that every minute threatened its destruction." The draw of the bridge was raised off the pivot and all travel was suspended from an early hour (31). A rumor developed that the bridge had washed away and a great crowd assembled at the Market Street bridge (30). They were amused at some men endeavoring to get three pigs into a boat. "After much pulling and hauling and an equal (amount) of squealing from the porkers, they were finally landed on the bottom of the boat where they lay as docile as lambs" (33).

The south bank of the Christiana, and the wharves on the north side, were completely overflowed by 9:00 a.m. A great deal of timber and barrels and other articles floated up the river (30). Dozens of men were engaged in frantic efforts to supply themselves with firewood by fishing out the driftwood (31). Many cows were drowned and many small stables flooded which contained considerable quantities of hay, corn, and feed. The corn was gathered up in the afternoon after the flood receded and a considerable quantity carried away by various parties (12).

Along the wharves, the floors of shops and industrial establishments were submerged several feet. At Seidell and Hasting's Rolling Mill, the water extended to the forge pit compelling the men to quit work; likewise, the men at Pusey and Jones Company (Figure 5) quit work with one foot of water in the shops. The Harlan and Hollingsworth Company's lumber yard at the foot of Justison Street was nearly completely flooded along with five houses across the street flooded almost to the second floor (30, 31, 32). Machinery in the machine shop was submerged and covered with black, slimy mud (12). Estimated losses were around \$5,000 (\$76,000). At Jones Guthrie's carriage makers, the show room floor was raised by the floodwaters of the Christiana, and the tops of a number of carriages were crushed against the ceiling and much lumber was ruined by the water. The losses were estimated at \$3,000 (\$46,000). Other carriage maker factories in the vicinity were likewise damaged but not to the extent of Mr. Guthrie's facility (5, 12).

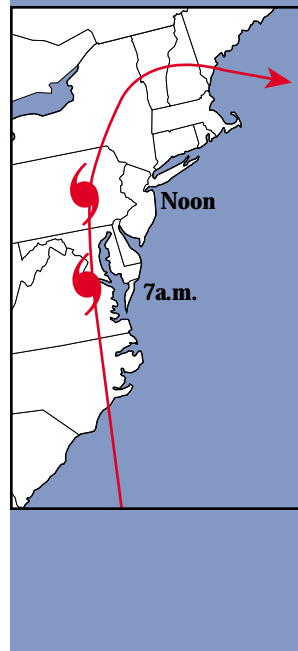
At Jackson & Sharp Company at the corner of Eighth and Railroad Streets, the water was two feet higher than was ever before witnessed (32).

At the Jackson & Sharp Company's yards the storm was really terrific. The water of the creek rose two feet higher than ever known before. Every bank between there and the Delaware river was overflowed and buoys which had been washed from the Government wharf to the Light House were floating about in the creek. The storm put out all the fires in the company's works, and their lumber was thrown about in every direction. Some man who went into an adjoining marsh after his horse, got afloat and came very near being drowned. At 10 o'clock this morning a cow was standing on the Jackson & Sharp Co.'s wharf in the water, and with very little chance of getting off. A broad sheet of unbroken water covers all the marshes between that point and the Delaware River, in which fences, lumber and other material are floating around in all directions. The loss to this company will be considerable.

Brandywine Creek was also high and at 10:00 a.m. the water dashed in over the flooring of the mills below the Brandywine Bridge (Market Street) (30). Nearly the entire tract of land between the Brandywine and the Delaware River was covered with water (33). A large number of cows pastured on the marshes drowned (33), perhaps as many as 50 (12). The *Water Witch* steam yacht broke from its moorings near the foot of Fourth Street, collided with a canal boat, and sunk to the bottom. A sailboat full of potatoes from New Jersey moored near the mouth of the Brandywine went aground and capsized (30).

South Wilmington suffered the most severe flooding. The land between the Delaware Western Railroad Bridge, on the west, and the Delaware River, on the east, was completely covered with water. On the New Castle Causeway, water was two to six feet deep, and before 10:00 a.m. travel was suspended. Many of the houses were submerged to the second floor (31).

Numerous buildings lost their tin roofs (30) including the Masonic Temple and several schools (32). Four of six newly constructed brick houses at Eighth and Van Buren streets were completely demolished as well as another house at Chestnut and Adams streets that was under construction. Four houses at Fourth



Street above Van Buren lost their roofs. The steeple of Olivet Church, also at Chestnut and Adams streets, was blown down. The cross on St. Paul's Catholic Church was blown down, resulting in a hole in the roof. All along Delaware Avenue, roofs were blown off and trees and fences blown down. Other roofs lost were reported at King Street and Harrison Street. At 9:00 a.m., the roof of Wright's factory at Water and Market Streets was blown off with a crash, causing great excitement. Mayor Allmond was narrowly missed by a chimney that fell six feet in front of him on Market Street. At 5:00 a.m., as Peter B. Ayers, letter carrier, entered the Post Office, a sparrow flew in the door as he opened it. "The little bird was almost dead with fright" (30). A milk wagon was caught by the wind and thrown over on Poplar Street below Ninth, and the contents of the cans flowed into the gutters. The workshop of G. B. Guyer was demolished with five men working in it; one was severely injured. The new teahouse on Walton Street, near the Eleventh Street Bridge, was completely demolished (30). Hundreds of panes of glass were broken by wind and flying debris in various parts of the city (33).

Telegraphic communications were stopped, owing to the great number of wires being down. No messages were being sent or received at the Western Union office or along the railroads. The trains were delayed but running (31). Another source, however, reported that the north-bound track of the Philadelphia, Baltimore & Washington Railroad was covered with water, and no trains from Wilmington to Philadelphia had left since 8:10 in the morning (33). The problem area was determined to be 300 yards north of the Shellpot Bridge (12, 32). The water and wind had lifted both the north and southbound tracks and wood ties for a distance of 300 feet, and deposited them in a ditch alongside the southbound track. By 9:00 p.m., one replacement track had been laid and the first train was allowed to pass. About fifty hacks and cabs were procured to facilitate travel for those affected by the train delay. Trains were run to Edgemoor where they were met by the hacks, and the passengers transferred to them and were driven to the Wilmington depot where the train service picked up again. Travel on the Delaware Railroad was also impeded by a wash-out at the old dyke culvert, just below a sand pit, but it was repaired in a few hours and service restored. On the Wilmington and Northern Railroad, the DuPont trestle works (a bridge 330 feet

long) was washed out near DuPont station. It required considerable time to repair the damage (12).

About noon, the tide turned, and the flood soon visibly lowered as the water rushed through the breaks in the banks of the Christiana River and went out with the tide (33). The flood waters had a very strong current (18).

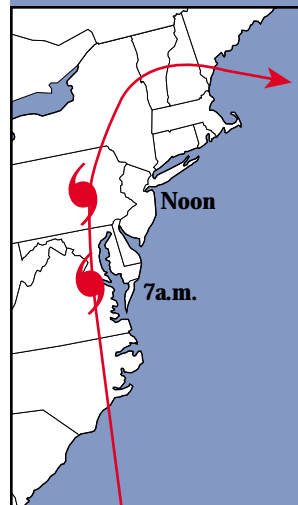
A FIERCE CURRENT.

Some idea of the strength of the current in the Christiana yesterday immediately after the storm, and of the force with which it pressed against whatever offered an obstruction to its free passage, may be gathered from the fact that at Third street bridge the grass, weeds, cornstalks and other debris brought down the stream by the flood, were packed so tightly between the northern abutment and the shore as to form a sort of raft or bridge of sufficient strength to support several small boys who were busy gathering the driftwood and corn that had been swept down from the woods and fields along the creek.

In spite of the storm, life went on (34).

A SURPRISE.

While Mr. Harry Stradley, of 608 West 3d street, was preparing to retire on last Wednesday evening (Oct 23), he was startled by the tramping of many feet on the outside of the house, then followed the ringing of the bell several times in succession. Surely something must be the matter, thought Harry, and he speedily dispatched a messenger to the door. In walks a number of friends, each bearing a package of some description. Looks of surprise came across the faces of the household, but in due time matters were explained by each person presenting Mr. S. with a testimonial of their good feeling in honor of his birth-day. Next in order came an examination of the presents, which were found to be both useful and ornamental. While this was in progress others were engaged in loading down tables, to which all were invited. Time passed merrily away until a seasonable hour for dispersing, when with many wishes for a return of happy birth days, the guests departed, feeling that they had spent an evening pleasantly.



New Castle, Delaware

In New Castle, "...houses were blown down and unroofed, trees hurled to the ground, shutters and windows blown off, and chimneys, awnings, and signs mutilated (35)." Two brick stables were destroyed. Four of the houses on the upper part of Market Street were carried fully a mile and a half inland by the sudden rise of the Delaware River (35). The banks were broken all along the riverfront. A bank refers both to the shore of a stream and to artificial dikes that were placed along the shores of a stream to keep out abnormally high tides. Tasker's Bank (Figure 7) suffered the worst, with the employees at the Iron Works being driven from their avocations (32, 35). The railroad along the shore was completely destroyed even though the bank was stone-faced and over 60 feet wide on top; damages amounted to about \$25,000 (\$380,000) (13,32).

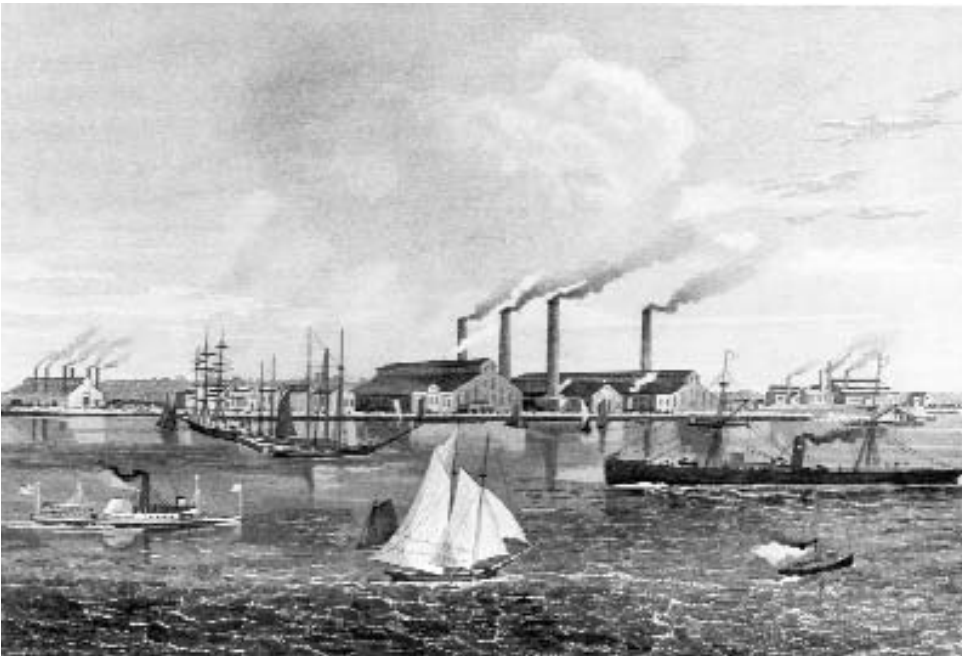


Figure 7: A engraving from 1872 showing the riverfront at New Castle. Tasker's Iron Works is the large building in the foreground in which iron pipes were manufactured (Tyler, 1955). Tasker's Bank is the armored shoreline in front of the factory. Note the various types of ships typical of the time on the Delaware River. (Courtesy of Hagley Museum and Library.)

The worst part of the storm was between 8 and 9 a.m. (35). The water was four feet high in the kitchen of the Jefferson House and on the street as far as the former residence of John M. Clayton (31). The woolen mill caught fire and within one hour was a mass of ruins. The girls employed at the mill jumped from the second story windows and sustained very serious injuries (35). An account of the disaster follows (32).

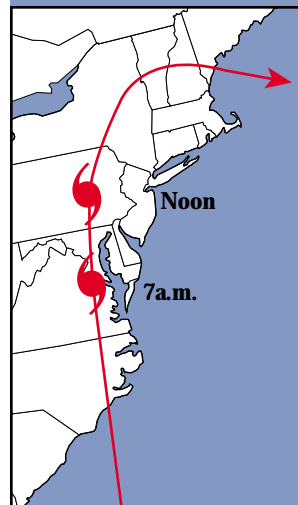
FURTHER PARTICULARS OF THE FIRE THIS MORNING – LOSS OF \$30,000 – LEA & SON’S FLOUR MILL UNINJURED.

By Telephone to Every Evening.

NEW CASTLE, Oct. 23 – 4 p. m. – The fire in Knowles’ woolen mill broke out between 7:30 and 8 o’clock this morning. It was caused by the wind blowing the roof off of the drying house which was immediately over the boilers. This caused a draft which drew the flames up through the fire hole and set fire to some cotton. This communicated the fire to other portions of the mill and in a very few minutes the whole building was in flames. The fire company was late getting out there and a long time elapsed before they got their hose connected with the fire plugs. In the meantime the wind shifted and blew the flames across the railroad toward William Lea & Son’s flour mill and two tenement houses connected with the flour mill property. The houses and flour mill were saved uninjured, although the wind blew directly towards them but it took very hard work to save them. The woolen mill was totally destroyed. Everything was burned and the mill is a complete wreck, the walls having fallen in. The loss is supposed to be about \$30,000. The exact amount and the insurance thereon cannot be ascertained, owing to the absence of the owner, Mr. Knowles, who is at present in Cincinnati. The buildings were known as the New Castle woolen mills.

The loss was later estimated to be about \$30,000 on machinery and stock and \$10,000 on buildings (a total of \$608,000) (13, 32). The mill employed a total of 80 workers with a monthly payroll of \$1,900 (\$29,000) (13).

Water overflowed suddenly onto Water Street and nearly all the residents had their cellars and back yards filled with lumber from wrecks. The tug boat *Jas. McFadden* was sunk early in the morn-



ing at the railroad wharf, a coal barge at Jefferson's Wharf was "...smashed into atoms,... and a number of small boats were mashed up (35)."

Delaware Bay and River, Delaware and New Jersey

From across the Delaware River from New Castle, at the Range R. Light House (New Jersey), came the following report (35):

FROM RANGE R. LIGHT HOUSE.

Six vessels on shore in the fields, one a large sloop lays in the county road at Mrs. Cook's bridge. Schooner *Corry*, *Captain Ray*, was dragged from Salem creek loaded with hay, lays in the bushes just in front of the light house. The schooner *Chambers* sailed across the bank into the road and up in Mr. Nivini's field; they tied it to a tree for two or three hours, hoisting sail they sailed back across Mr. Ayer's wheat field and crossed the road the second time, and took upon the bank where she now lays; the tide in the meantime had fallen 21/2 or 3 feet.

The schooner *Buckeye* was sunk in Delaware Bay with five fatalities. The surviving crew member gave the following account (5).

The *Buckeye* left Wilmington on Tuesday afternoon for Bombay Hook to load with river sand. We anchored in the channel near Fort Delaware. The storm struck us about three o'clock. It was very severe. The sea dashed in the starboard bow. She was about 200 yards from shore. We all got in the little boat thinking that the wind would carry us towards the Fort. In this we were mistaken. The wind caught us and we drifted up the river. The sea was very rough. There was six of us in the boat, Capt. Samuel Applin, his two sons Norris and James, aged respectively 17 and 19 years, John Cavender, his wife and myself. We left the schooner about five o'clock; we beat around until about eleven when the boat swamped and we were all plunged into the water. I got on the bottom of the boat pretty well exhausted. The others went down all around me. The Captain and Norris disappeared first, Cavender and his wife went down in each other's arms and James Applin went down last.

I was floated ashore about two o'clock in the afternoon after being three hours in the water; when the small boat swamped we were about 300 yards from the bank and a mile below Tasker's works. I got up in a willow tree. I had a red handkerchief about me. I cut a long willow, then tied the

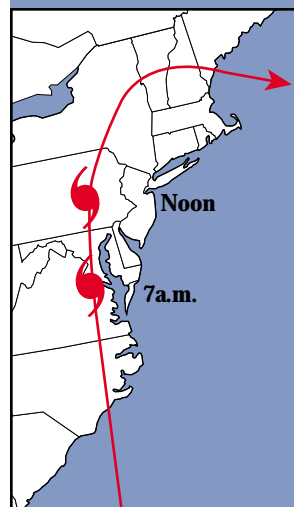
handkerchief upon the stick and hoisted it. It attracted the attention of some fishermen who had been driven ashore for shelter and they came to my assistance. I then walked into New Castle and started from New Castle about 5 o'clock for Wilmington and reached this city about dark.

About the same time, the schooner *Jeremiah Dover* was damaged near Edgemoor with two fatalities. Another ship nearby, the *Estella Bright*, loaded with sand capsized off the Jersey shore opposite New Castle. Of the four crew aboard, one survivor was picked up near New Castle after surviving by clinging to a couple of boards (5, 12). The steam tug *William G. Boulton* left Philadelphia with the brig of the *Orbit* in tow and encountered the storm at the Dan Baker buoy. She went aground and the captain and a boy were drowned. Another tug, the *Hugh McFadden* was sunk at the Cherry Island flats. Over thirty boats were reported ashore in the vicinity of the Maurice River (36). Other vessels found it just as treacherous up the river (13).

An oyster boat is said to have been driven ashore by the gale below Marcus Hook, under full sail. Not a soul was found on board and it is supposed that the crew were washed overboard. Not less than a dozen vessels are ashore between Chester and Wilmington. Many boats broke their moorings on the Jersey shore and blown across the river, some half dozen striking at Eddystone. One of these, the schooner *Stratton*, owned by E. Brewer, of Camden, by some remarkable means got her nose into a large flume, used by the Eddystone Print Works to pump water from the river into the mill.

The suction is great and the schooner being caught in it shot like a rocket up to the pump-house. Both building and pump were completely wrecked, doing many hundred dollars damage. When the captain of the canal boat *Scribner* found his boat sinking off Eddystone, he tied a line around his two little boys and threw them into the river. They were, luckily, caught and pulled ashore. The captain swam to land.

Pea Patch Island and Fort Delaware were strewn with at least sixteen wrecked vessels (16) including the schooner *Eliza Godfrey* and the *Fanny Bliss* (36). The sloop *Snow Flake* capsized off of the fort with one drowned (36). A report sent to the Secretary of War, outlines the damages (37).



**UNITED STATES ENGINEER OFFICE
PHILADELPHIA, PA., NOVEMBER 6, 1878**

...The wind blowing from the S. and E. with a velocity approaching and at times exceeding 70 miles per hour, gave rise in Delaware Bay and River to a tide of unexampled height, which submerged nearly all the reclaimed lands bordering the river.

At Fort Delaware, it rose nearly two feet higher than had ever before been observed, surmounted the dikes, and swept inland with the roll of a heavy sea.

The dikes from the S.W. round to the N.E. angles were badly cut and the full tides now flow over them in several places.

Of the 31 buildings exterior to the fort, 12 were destroyed and the remainder much damaged, the lower stories of those near the S. end of the island being completely gutted. The sheds and outbuilding of all were swept away...

The families living on the island, most of them former (and still occasionally) employees have been subjected to great loss, and in some cases distress. They are at present quartered within the fort.

At Finn's Point Battery, the seawall was disturbed to the depth of two or three courses, the filling of the wharf was washed out, the boat-house moved 300 or 400 feet, and the dike broken in several places with other minor damage.

At Delaware Battery the fencing and bridge were carried away and the wharf and roadway injured. A vessel of 80 tons was beached upon the outer slope of the battery.

At Fort Mifflin, which is still standing near the current site of the Philadelphia Airport, the water rose to a depth of four feet nine inches in the parade ground. All the houses within the fort were flooded, and the bridges over the moats were washed away. There were not less than 2,500 acres of land inundated around the fort (38). A more complete account was given as a report to the Secretary of War (37).

**UNITED STATES ENGINEER OFFICE
PHILADELPHIA, PA., NOVEMBER 13, 1878**

...The severity of the storm along the Delaware River was almost without parallel. At Fort Mifflin, the tide attained

the unprecedented height of 11 feet 3 inches above low-water, accompanied by wind blowing from E.N.E. veering to the E.S.E. and to S. with a velocity of 49 to 72 miles per hour. The water in the Delaware at the above-mentioned height and with its rough surface soon caused large breaks in the dikes submerging the grounds inside and outside the fort to the depth of several feet. The dike along the Delaware front was breached at three different points, and badly washed at twenty points, distributed along the entire dike...

...The old timber revetment at the approach to the wharf was much broken up and washed away, as also was a portion of the earth parapet and stone wall on the river front of the demilune. Water commenced to flow over the dikes at 9:30 o'clock a.m. and at 10 o'clock had attained its maximum height, where it remained until 12:45 o'clock when it began to recede... All of the live stock of value at the fort and four boats (one a small steam-launch of considerable value), were secured and saved from destruction. The greatest depth of water on the parade ground of the fort was 4 feet 9 inches...

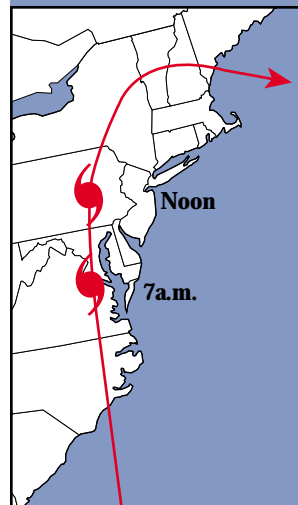
Another letter in support of the damages and proposing recommendations for mitigation gave a more detailed account (37).

**UNITED STATES ENGINEER OFFICE
PHILADELPHIA, PA., JANUARY 2, 1879**

...The storm of October 23 ultimo, though fortunately of brief duration, was very severe, and its greatest strength seems to have been developed in the valley of the Delaware River, where it was accompanied by an unprecedented rise of the water-surface. The tide surmounted all the dikes inclosing the low reclaimed lands bordering on the river, caused immense damage to all owners and occupants of such lands by the destruction of their crops and costly dikes, and exaggerated the disaster to shipping by sweeping inland many of the smaller class to distances from the river ranging from a few yards to one and a half miles....

...At Fort Delaware, many of the people living on the island barely escaped with their lives, the water rising 5 feet in an hour and a half, and reaching a height of 11 feet 8 inches above mean low-water...

Total costs for the damages to Forts Mifflin and Delaware were estimated to be \$47,000 (\$714,000) for repairs and raising of the dikes to prevent such an inundation again (37).



The buildings and ships along the Delaware River in Philadelphia did not fare any better (20).

Along the Delaware River front, no less than twenty warehouses are without roofs, and the water is running into the stores on the east side, doing great damage to private stock, and to goods stored in the wharves. It is estimated that at least fifty of the storehouses along the wharves were blown from their fastenings, and great quantities of good have floated off with the tide. The Reading Railroad ferry-house and slip above South-st. were demolished. On the Delaware River the damage to shipping cannot be obtained at present. The tide was the highest known for twenty-seven years. A ship discharging ballast at Reed Street Wharf was blown on her beam ends, and damaged to the extent of several hundred dollars. At Point Breeze two brigs are reported to have capsized. A ship broke from her moorings at Knight's Point and drifted down the river. A three-masted schooner at Reed Street Wharf was blown on her beam ends, and damaged to the extent of several hundred dollars. At Point Breeze two brigs are reported to have capsized. A ship broke from her moorings at Kaighn's Point and drifted down the river. A three-masted schooner at Reed Street Wharf was dismantled.

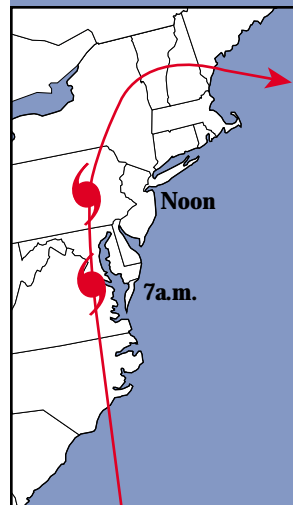
In the southern part of the city known as "The Neck," the Delaware overflowed its banks for a distance of up to one mile from its banks, and inhabitants were taken from the second stories of their houses in boats sent out from the Navy Yard. The loss of livestock was great, and ten or twelve old wooden bridges were swept away. The large ship-house at the League Island Navy Yard was leveled. Shipping was also affected with several loose vessels blocking the Schuylkill, eight sunk, and as many as twenty-two damaged (21).

Philadelphia, Pennsylvania

The wind for three hours had a velocity from 50 to 64 mph with a maximum velocity of 72 mph for a few minutes (5). The wind started at about 2:30 a.m. with speeds of 25 mph, and reached its height between 6:00 and 7:30 a.m. with a maximum velocity of 72 mph (1, 20). Half-hour observations at the Signal Station were as follows (39).

The fall of rain was comparatively light, the fall for the eight hours ending at 7.42 A. M., being .94 inches. The observations to-day were made every half hour, and the following is the result:

| Time (a.m.) | Bar. Press | Temp. | Nom. | Wind Direction | Wind Velocity | Weather |
|-------------|------------|-------|------|----------------|---------------|-----------|
| 5 | 29.42 | 60 | 100 | E. by N.E. | 49 | H'y rain. |
| 5 1/2 | 29.36 | 61 | 100 | E. by N.E. | 48 | H'y rain. |
| 6 | 29.30 | 62 | 100 | E. by S. E. | 56 | H'y rain. |
| 6 1/2 | 29.24 | 62 | 100 | E. by S. E. | 56 | Lt rain. |
| 7 | 29.22 | 64 | 94 | E. | 60 | Lt rain. |
| 7 1/2 | 29.18 | 64 | 94 | S. E. by E. | 64 | Cloudy. |
| 8 | 29.22 | 63 | 100 | E. by S. E. | 64 | L't rain. |
| 8 1/2 | 29.22 | 64 | 100 | S. E. | 50 | L't rain. |
| 9 | 29.22 | 65 | 100 | E. by S. E. | 36 | L't rain. |
| 9 1/2 | 29.25 | 65 | 94 | S. by S. E. | 48 | L't rain. |
| 10 | 29.26 | 65 | 84 | S. by S. E. | 48 | Cloudy. |
| 10 1/2 | 29.97 | 66 | 79 | S. | 40 | Cloudy. |
| 11 | 29.28 | 65 | 73 | S. by S. W. | 36 | Cloudy. |



Nearly 400 buildings were unroofed and 118 partly demolished; 23 churches and 70 factories, warehouses, mills, schools, markets, and depots were damaged. Seventeen vessels were sunk or damaged. Five persons were killed and a large number injured (5, 10). Two other reports claim even more damage: eight lives were lost, 21 persons injured, 650 dwellings unroofed, 35 to more than 40 churches unroofed or spires blown down (12, 20). Another report gave a list of 7 fatalities, all killed by falling debris and an estimate of 75 persons injured (20). Four police stations, 7 market houses, 3 street car depots, and 5 railroad depots were unroofed; 2 bridges blown down, the Neck inundated and 80 families rescued from the second story of their homes by row boats (12). Damage was greatest on the northwestern side of the city (20).

The Philadelphia Evening Bulletin on the afternoon of the storm described the event (39).

That the end is often worse than the beginning was fully illustrated by the hurricane which passed over the city at an early hour this morning. People who retired at midnight had no thought that by dawn of day the streets would be littered with fallen trees, loose bricks, dismantled chimneys and roofs, and debris of all sorts. Last night dark clouds began assembling over the city, coming from the east, and friends meeting each other on the street remarked, "We're going to have some rain." Indeed, the more cautious even carried umbrellas, but midnight came and still no rain. During the night, however, a slight wind began blowing and the policemen buttoned up their coats in anticipation of a cold season. The slight wind soon developed into what the sailors would call a stiff breeze, while at the same time the rain came down as though a long deferred equinoctial was making up for lost time. Towards daylight heavy, low clouds passed over the city from the east and southeast, and at the same time the storm of wind increased in violence from a moderate gale to a regular hurricane.

The first intimation of the coming storm was the rattling of windows and the creaking of signs, and people awakened from their slumbers for a moment by the rushing, whistling wind, turned over for another nap, only to be aroused again by the slamming to of unsecured shutters and the breaking of window glass.

From six to seven o'clock this morning the storm king raged fearfully, and, advancing from the east by southeast, besieged the city with such determination that when at last the hurricane had in a measure subsided, the streets bore witness of the violence of the struggle. Old trees that had battled successfully the storms of a half-century were prostrated like wisps, while walls which masons had reared, one brick at a time, came down in a second. In fact, the whole city presented a field of disaster such as had not been witnessed for many years.

While the storm was at its highest, the streets in some parts of the city were almost deserted, and such pedestrians as were out were in great danger of being struck by falling timbers, patches of tin from roofs, flying bricks and other missiles. How many persons were injured, or how much damage was done, will not be known until all the returns are

in, and as a large number of the telegraph wires are down. It will be several days before the full extent of the injury is known.

The storm appeared to be especially severe in the districts north of Market street, although all sections suffered from the terrific wind. Between eight and nine o'clock the rain came down heavily, but by nine o'clock the storm had abated considerably.

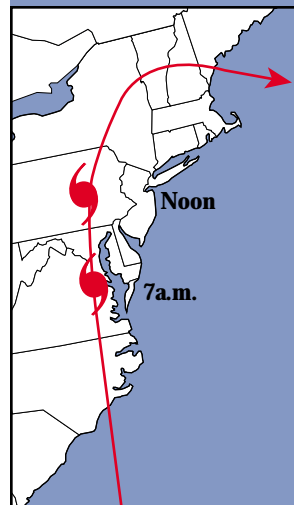
THE PUBLIC SQUARES.

Great havoc was done to the handsome shade trees in the different public squares, and great monarchs that have served for year as shelters from the summer sun were torn up by the roots and thrown ruthlessly down. In Franklin Square four of the finest and largest trees, after facing the hurricane for a while, gave up the conflict and fell. Several of them tore up roots and earth six feet square, while the walks all through the square were obstructed with limbs and branches of trees of all sizes. Many of the little sparrows were driven from home and sought refuge wherever it could be found. Walking through the square was so dangerous that the superintendent locked the gates and kept them closed during the morning.

At Rittenhouse Square, Washington and other squares a similar state of affairs existed, and the damage is such as cannot be well repaired.

TWO PERSONS INJURED AND A HORSE KILLED.

About five minutes before seven o'clock, what might have been a terrible catastrophe happened in the vicinity of Twelfth and Market streets. The Twelfth street market, on the northeast corner of Twelfth and Market streets, and the Farmers' market, adjoining, at the time mentioned were filled with people, while the small street separating the two buildings contained a number of people, and five or six horse and wagons. The force of the wind tore off a large portion of the tin roofs of both market houses, together with a quantity of wood-work, and hurled them with great force into the small street. The people saw the roof coming just in time to run into the market house with the exception of Edward Quigley, a lad 16 years old, and residing at No. 1719 Rittenhouse street. Quigley was struck on the back by the falling timbers and suffered a concussion, of the spine. He was at once rescued, and taken to the Homeopathic



Hospital in the vicinity. A valuable horse was instantly killed, while the others were extricated with slight scratches. Some of the market wagons were pretty well demolished.

As soon as the affair happened a messenger was dispatched to the Ninth District Station house, and a force of policemen were placed on guard about the buildings. The pile of ruins attracted a large number of people during the morning, and while the rain continued, it poured into the market houses to the discomfort of the butchers and farmers.

At the same moment the market houses were partially unroofed, the iron railing in front of John Woertz's shoe store, No. 32 N. Twelfth street, was demolished, and Mr. and Mrs. Woertz were slightly injured.

Many persons made very narrow escapes from being killed. A young man in bed in the upper story of a house, on Fourth street, opposite the Pennsylvania Railroad building, was awakened by being struck by a piece of roof from the railroad building, but fortunately he escaped injury.

A very detailed listing of the damage was given by the *Evening Bulletin*. Among the damages was a large transparency (banner) bearing the names of the Republican candidates, which was displayed in front of the Republican Committee Headquarters of the Twenty-fourth Ward. As the *Evening Bulletin* commented, "The wind made no distinction in regard to Democrats, Republicans, or Greenbackers, and the transparencies at most of the political headquarters were torn in shreds (39)." The damage to the buildings of the International Exhibition was not severe, except for the turbine windmill that was a complete wreck (39).

Walnut Street Presbyterian Church that had just been remodeled was badly damaged. Its 180-foot-high steeple was blown down and damaged the roof of a nearby building and the organ was completely demolished. Total damage to the church was estimated at \$35,000 (\$532,000). Likewise, the 170-foot-high steeple of the First Baptist Church was blown down into the street with the damage to that church estimated to be \$23,000 (\$349,000). Another notable church that lost its steeple was the Emanuel German Lutheran Church whose steeple stood 222 feet above the sidewalk (20).

Railroad facilities were likewise hit hard (20). The shed for departing trains at the Pennsylvania Railroad depot at West Philadelphia was demolished with a loss estimated at \$40,000 to \$50,000 (\$608,000 to \$760,000) (39).

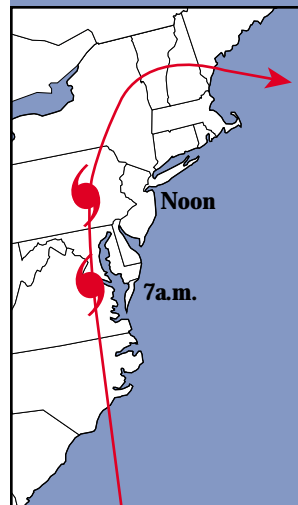
PENNSYLVANIA R. R. DEPOT

THE SHED FOR DEPARTING TRAINS DEMOLISHED – TWENTY CARS CRUSHED.

At the Pennsylvania Railroad depot, Thirty-second and Market streets, the gale had a fine opportunity for working injury. At 7 o'clock this morning, as a train was about to be rung off, the engineer noticed the lower end of the shed for departing trains giving way. He started his engine just in time to save it and himself, though the cab was torn off. The structure seems as though raised from its foundation, and it then fell with a tremendous crash. Fortunately there were but 10 passengers on the train, who all, as well as the employees under the shed, escaped injury. The demolished structure was a long and rather ornamental shed, 600 feet in length, built over the tracks and platform for departing trains. It was built in the year 1876, and to replace it will cost about \$12,000. It was constructed of iron girders supporting a wooden roof covered with tin, the whole resting upon iron pillars. These latter, in most instances, especially at the lower or outer end, were broken off like pipe-stems by the force of the wind. At the time of the fall of the structure there were twenty cars on the tracks underneath, which were all more or less damaged. The loss will average about \$1,000 per car. Immediately after the fall a force of about 300 men were put to work removing the debris and it is expected that the track will be cleared before night and the work of rebuilding the structure begun to-morrow.

Fortunately for the Company, the shed for the incoming trains, west of the one destroyed, withstood the gale, and they are able to send passenger trains out on time.

The eastern end of the Twelfth and Sixteenth Streets stations and the Philadelphia, Wilmington, and Baltimore Railroad depot at Washington Avenue were reduced to ruins. The two western spans of the Falls of Schuylkill Bridge on the Reading Railroad fell into the river (20).



League Island, at the junction of the Delaware and Schuylkill rivers was almost submerged, the highest water reported at about 11:00 a.m. (1). Along the waterfront, the Schuylkill flooded the wharves along the river in the city and numerous vessels were lost from their moorings (20, 39). Vast quantities of goods were destroyed by the water (39). On the Delaware, the high tide according to the nautical chart was marked to be at 11:15 a.m., but the flood brought it at 12:20 p.m., and four inches higher than a flood two or three years prior. It was decidedly the biggest of all the floods within the preceding thirty years. The wind was from the northeast at 4:00 a.m. About daybreak, it shifted to the east, southeast, and then south backing water up the river, and at 9:00 a.m., the entire riverfront was inundated. In some areas, the flood backed up as far as Water Street where merchants rowed to the storehouses and thousands of people were drawn to watch the raging waters. The water was as much as 2.5 feet deep in the storehouses or "hub deep" which was enough to float some of the bales of cotton stored in the buildings (39).

Factories did not escape the damage. The piano factory at Eleventh and Catherine Streets was damaged to the tune of \$10,000 (\$152,000) (20). The Aaron Jones & Sons knitting mills at Wister Street, Germantown, were damaged when a fire started; damages estimated to be at least \$20,000 (\$304,000).

Eastern Pennsylvania

At West Chester serious damage to property was reported including one fatality of an old man hit by debris while trying to prop up a fence. The roof of the Broomall, Miles & Co.'s mill was blown off onto the factory trapping three workmen inside who were quickly freed. At Kennett Square, the three-story high school was demolished costing the community several thousand dollars (18). The storm was violent at Chester, Lancaster, Reading, Scranton, Wilkes Barre, and Pottstown (5, 20, 40, 41). The nail-plate mill of the Pottstown Iron company was destroyed with an estimated loss of \$25,000 (\$380,000), and the loss of the Madison Bridge on the Schuylkill River was another loss of \$10,000 (\$152,000). Other mills and homes in the area were destroyed along with at least one fatality. Other estimates placed the losses within a radius of 8 miles around Pottstown at \$60,000 (\$912,000) and within Pottstown over \$100,000 (\$1,520,000)

(41). Several churches and mills as well as an oil refinery were damaged in Norristown. At Doylestown, the steeple of the Catholic Church was blown down, and the Court House suffered some damage. In Wilkes Barre, a “tornado” inflicted great damage with houses unroofed, trees uprooted, windows broken, and fences and mining equipment demolished. Some of the railroad tracks in the area were badly washed out, causing trains to be delayed (20). Damage was also reported in Harrisburg with churches and buildings losing their roofs (40, 41).

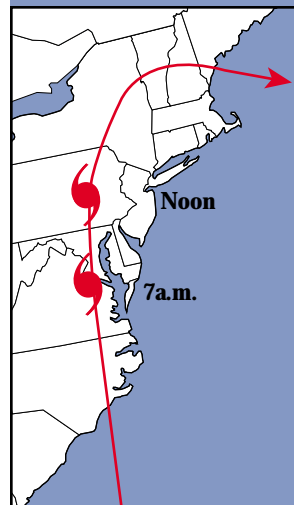
Chester was especially hard hit (20). High wind was reported at 6:00 a.m. “... carrying everything before it.” Seventy dwellings and stores were unroofed, 19 being completely destroyed. Eleven manufacturing establishments were also damaged to the extent that work was suspended. Along the Delaware River, the tide rose to a great height inundating businesses and damaging schooners and sloops and sending five canal boats loaded with coal to the bottom.

Scranton, Pennsylvania

A new paddling mill was destroyed by the wind. It rested on stout iron pillars and had open sides. At 10:30 a.m., it was struck by a whirlwind with the force of a cyclone that lifted the massive roof off of its supports and brought down 300 feet of the building with a crash. In Danmore, the wind blew the roof off of the Methodist Episcopal Church. During “...the early hours of the morning the wind blew a stiff south-easterly breeze, which increased rapidly, bringing down a drenching torrent of rain, and causing the houses to rock violently in the hurricane. The heavy masses of rolling clouds overhead helped to heighten the weird picture as tall stout trees were bent to the earth beneath the blast (40).”

Trenton and Western New Jersey

Tremendous wind and rain hit Trenton around 5:00 a.m. and continued with great severity for about three hours. A tower at Roebling’s wire mill (where the cables for the Brooklyn Bridge were being constructed) fell causing great damage estimated at \$5,000 (\$76,000). Many buildings and churches were unroofed. It was reported that “...the people stood gazing with intense excitement at the oscillations of the several church steeples, expecting them every



moment to fall. None fell, but all were materially damaged." Damage was widespread throughout the countryside with that in Trenton estimated at \$25,000 (\$380,000) (20).

The storm was also severe in Camden with great property damage. Numerous barns were blown down, cattle killed and fences destroyed. Damage was also reported in Bordentown, Beverly, Delanco, Riverside, Riverton, Palmyra, and Morris Station (20). At 2:40 a.m., the schooner *Wm. Collyer* went ashore six miles south of Barnegat, N.J. Along the New Jersey coast, very high tides occurred with Cobb's and Smith's Islands being completely submerged. Winds at Barnegat from the SE at 72 mph and at Atlantic City from the E at 56 mph were reported (1).

Albany, New York

The wind damage was reported to have been the greatest around noon. Numerous buildings were unroofed and trees and chimneys were blown down (20). The roof of All Saint's Cathedral was blown off as well as a portion of the roof of the Albany Hospital (40).

New York City

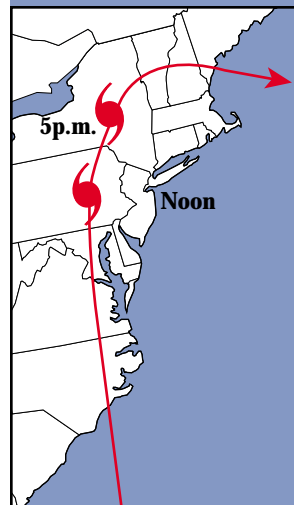
46

The damage in the city consisted mainly of the uprooting of trees, the overturning of chimneys and telegraph poles and the breaking of windows (20). About 5:00 a.m., the wind was blowing at 25 to 28 mph, and by 8:00 a.m. was up to 50 mph where it remained that high until noon when it started to subside. By 8:00 p.m., the wind had fallen to less than 25 mph. Barometric pressures were: 11:00 p.m. on the 22nd, 29.98 in.; 7:00 a.m. on the 23rd, 29.55 in.; 12:00 p.m. on the 23rd, 29.37in.; 8:00 p.m. on the 23rd, 29.53in. (40). The New York Tribune described the events (20).

The storm which broke upon New-York yesterday morning was the severest of the season, but was far less productive of damage than is reported from other points. At 5 a. m. the few people who were in the streets thought it was blowing heavily as they struggled against the blast, vainly trying to protect themselves from the rain which beat under their umbrellas with irresistible force. Persons who had not finished their slumbers had them rudely broken by the howling

of the wind, the rattling of the window-sashes and the slamming of loosened shutters. But the storm had then just begun; the wind was blowing at the rate of twenty-five miles an hour only. Its velocity steadily increased, until 7 o'clock it reached fifty miles an hour. From this time it blew fitfully but with undiminished force until nearly noon. During this time travelling on the streets was attended with a high degree of discomfort and not a little danger. Rain poured down in torrents, and those who strove to shelter themselves beneath umbrellas were compelled to exert all their strength to retain them in their grasp, or saw them ruthlessly turned inside out, the ribs broken and the covers torn to ribbons. Women who ventured out of doors were at times driven forcibly before the wind, or whirled helplessly around while attempting to turn an exposed corner. Signs and loose bricks from chimneys came crashing into the street; trees were uprooted; telegraph poles were broken off and stretched across the street; show windows were crushed in by the mere force of the wind, and some buildings were said by their occupants to tremble to their foundations as the blast struck them.

The storm was not unannounced. On Monday the United States Signal Service Bureau reported a severe storm, having its centre near Havana and pursuing a northeasterly course. Tuesday it swept through Florida, Georgia, South Carolina, and at midnight its centre was at Wilmington, N. C. Storm signals were then ordered to be retained at the Southern stations, and to be hoisted at New-York and the stations north and east. The red light made its appearance on the station on top of the Equitable Building; but when daylight came Dr. Donhauser, the signal officer, found it impossible for a long time to hoist the signal flag on account of the heavy gale. When it had finally been raised, the staff bent before the wind so that it was feared that it would break and fall into the street, and the flag was lowered. Three times it was raised in intervals of the gale, and as many times lowered when the tempest grew more severe, the united strength of three men being required at one time for the service. After noon the wind diminished in strength, and at 3 p. m. the clouds broke away, affording an occasion[sic] glimpse of the blue sky until sunset. Dr. Donhauser said at about 4 o'clock that the storm centre was probably then over New-York, and that there was the lull in the tempest which usually occurs at the storm centre this would probably be followed by more wind and rain, to be followed in turn



sometime to-day by clear and colder weather. These opinions were based entirely upon local observations, he said, as he had received no reports from other parts of the country up to that time, the wires of the Signal Service being disarranged by the storm.

Telegraph wire were broken on nearly all the lines leading out of New-York, so that communication with some parts of the country was almost entirely cut off, and with other parts was greatly interrupted. At the Produce Exchange no reports were received from the North, South, East or West; and in the absence of quotations none except local business was transacted. The Continental Company's line was the only one over which news was received from Philadelphia and the South until late in the afternoon. At 5 p. m. Mr. Brown, Superintendent of the Western Union Telegraph Company, said that all its lines were being rapidly restored to working order, and that business would be wholly resumed in the course of the evening. Some wires, he said, had been broken on the lines of the Hudson River, the New-York Central, and the Erie Railways; but communication had been kept up with the West through New-England lines. The greatest damage had been done to the Philadelphia and Southern lines; but these would soon be in good order again. The streets along the river front in the lower part of the city were inundated, many cellars were filled, and pedestrians found it difficult to pass from the ferries to the opposite side of the street. The Staten Island ferryboats missed one of their trips because of the severity of the storm. The tide last night was from two to three feet higher than usual, and the inclination of the ferry bridges made it difficult for heavily laden trucks to be hauled on board the ferryboats.

The article continues to describe widespread damage of blown down trees, telegraph poles, fallen chimneys, and the breakage of a large plate glass window at Tiffany & Co.'s store at Fifteenth Street and Union Square at a loss of \$1,000 (\$15,000) (20, 40). Damage to the trees in Central Park, however was minimal (40). Damage was also reported among the shipping in the bay, in Brooklyn, and across the bay in New Jersey (including Newark) (20). The rain deluged Hoboken meadows and residents had to make their way from their homes to the streets in rafts. Along the North and East rivers, the piers were flooded along with a few cellars, but damage was not great (40). At least one barge was sunk on the Hudson River with the loss of several lives (42).

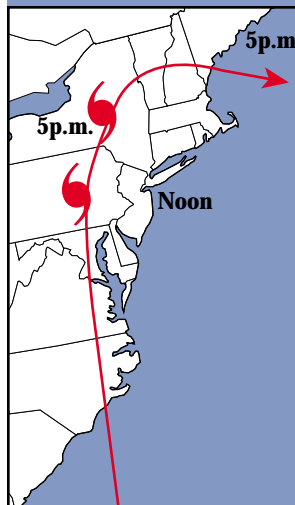
The Brooklyn Bridge, under construction in 1878, was not damaged as the following article attests (21).

Mr. Farrington, the master mechanic having charge of the wire work of the New York and Brooklyn Bridge, said yesterday that the storm of Wednesday morning produced no appreciable effect upon the cables except upon the land span on the New York side, the cables of which were not secured to each other as thoroughly as at the other points and therefore swayed slightly; he took a few of his best men and secured them with ropes in a short time. The span between the towers, he said, were as firm as the towers themselves. At this season of the year he was careful to have everything secured every evening, so as to be in readiness for a gale during the night. The storm of Wednesday did not test the cables severely as the wind struck them diagonally; he had known winds of less force, but coming from different direction, to subject them to a severer strain.

The following damage was described to Coney Island and Staten Island (20).

At Coney Island the damage caused by the storm was great. Engemann's old pier and pavilion, which projected into the ocean between the Atlantic Garden and Feltmann's Pavilion, was entirely destroyed early in the morning. Mr. Engemann valued it at \$10,000, and it's said recently refused an offer of \$8,000 for it. The walls of the Sea Beach Railroad depot were greatly weakened, and it will probably have to be taken down. The pavilion owned by Jacob Endris was wrecked, and a number of small bathing houses were destroyed. The gale forced the water up over the sand nearly to the foot of the culver plaza in front of Cable's Hotel. The bathing houses and restaurants along the beach were partially submerged and their foundations were undermined. At Manhattan Beach and Brighton Beach the hotels and bathing houses were uninjured.

The storm on Staten Island was of unusual severity, old boatmen saying that for a few hours the wind blew harder than for many years previously. Trees, fences and sign boards were blown in every direction. A tree, a land mark for seventy years, on the old Vanderbilt homestead at Stapleton, was uprooted. It was both difficult and dangerous for the Staten Island ferry boats to make their landings owing to the high winds and waves. At the height of the gale the boats did not



land at Stapleton. During the gale a number of carboys of vitrol on Townsend's dock, at Clifton, were washed off the dock. The storm in Westfield was so great that the delegates from there to the Republican County Convention at Clifton, were, with one or two exceptions, unable to attend.

Damages on Coney Island were estimated at about \$6,000 (\$91,000). A building that served as the depot of the New York, Sea Beach, and Coney Island Railroad Company was badly damaged. The building had been brought from Philadelphia where it had served as the U.S. Government Building during the Centennial (40).

Hartford and New Haven, Connecticut, and Providence, Rhode Island

The morning freight train from New Haven was passing Berlin and was swept with a sustained gust of wind that forced a load of lumber and a brakeman off of the moving car (40). The two-hundred ton schooner *Mary L. Tyce* foundered outside New Haven Harbor with two fatalities (5, 20, 40) in spite of the valiant rescue efforts of Capt. Merritt Thompson, a one-armed pilot from the port. At least three other vessels were reported aground in the area. In Providence, Rhode Island, a heavy rainstorm with high winds prevailed on the 23rd, without doing serious damage, but in Newport the gale was more severe (20, 40).

New England

The storm passed into New York State around noon on the 23rd, and into New England during the latter part of the day and into the 24th. Other winds reported on the 23rd include: New York City 50 mph at 7:00 a.m.; New Haven E at 40 mph; New London, E at 60 mph; Newport, SE at 36 mph; Boston, SE at 40 mph; and Portland where the anemometer cups blew away after reading 70 mph winds at 9:00 p.m. Very high tides occurred along the New England coast with much damage to wharves and shipping. At 4:57 p.m., the winds reached 120 mph from the SE on the summit of Mt. Washington (1).

October 24, 1878

The weather synopsis from the *New York Times* read (40):

THE WEATHER.

SYNOPSIS AND INDICATIONS.

WASHINGTON, OCT. 24. – 1 A. M. –

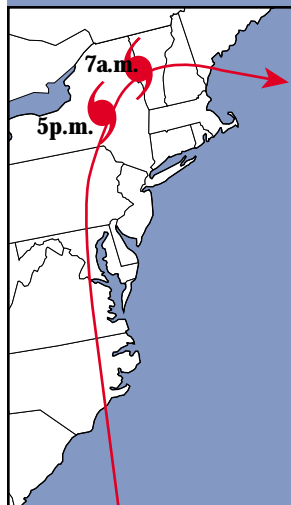
The storm last night central near Cape Hatteras has pursued with great energy a northerly path, and is now central near Montreal. Rain has fallen in the lower lake region and Atlantic Coast States. The temperature has generally risen in the upper lake region, New-England, and west of the Mississippi River; fallen in the South and Middle Atlantic States; elsewhere it has remained nearly stationary. North-westerly winds prevail in the Middle and South Atlantic States, Northwest, and lake region. The barometer is highest in the Gulf States. The rivers have remained nearly stationary.

Wilmington, Delaware

By the 24th, the water had receded except for near the Third Street bridge where "... families are compelled to live upstairs and do their errands on doors, shutters, etc., because of their ground-floors being submerged (5). The damages south of the Market Street bridge were great. The carriage factory of Jones Guthries was inundated, and the floor of the show room was lifted up by the flood waters, causing carriages to be broken as they were pressed against the ceiling. The floors of the shops were filled with water to a depth of several feet, and a coating of mud was on everything which ruined a large amount of valuable lumber. Total damages may have been as high as \$3,000 (\$46,000) (5). The Delaware Iron Works did not resume operations until the following Monday (43).

It is always interesting to see the editorial comments after a storm. Here is an editorial in the *Daily Republican* that reflects upon the damage (43):

Some of the papers are arguing against church steeples because a dozen or more were blown down on Wednesday. But as a hurricane strikes us only once in two or three hundred years, or so, it hardly seems worthwhile to prepare now for the next one by tearing down the steeples.



The late storm reveals the want of a building commission in Wilmington or some power that has the oversight of the erection of new buildings. The unroofing of buildings during the recent storm forms food for thought. This was mostly confined to tin roofed dwellings, which in most cases is said to have been put on in a very indifferent and careless manner under the contract system. The sheets of tin have in some instances been almost a yard in lineal surface, throwing the cleats and joints so far apart that the wind in penetrating beneath them could not help but force off the roof. Other tin roofs equally exposed have withstood the storm. The damage to new dwellings has been immense but this has probably arisen from their unfinished condition, the windows being out and the wind having fair play. There is however a painful apprehension that the mania for building cheap houses is leading to the building of very indifferent ones, which are liable to be blown down by the first severe storm, thereby endangering a loss of life fearful to contemplate. The need of building commissioners has been fully demonstrated not only in Wilmington but in other cities.

New Castle, Delaware

During the aftermath of the storm, searches for and discoveries of victims of the storm were reported in the *Daily Gazette* (13):

52

Yesterday afternoon while a man named Brenhardt was sailing about the river in quest of the body of his brother, who was lost during the late storm, he came upon the body of a woman, which he hauled ashore and gave due notice of the finding. Coroner Rose, together with William Pedrick and Lawrence Connor, went up in search of the body, finding it at Roger's sluice, near Eckle's farm. They brought it to this city where the Coroner empaneled the following jury: Geo. Fox, G. L. Jemison, S. Blackwell, Wm. Crow, Wm. Hunter, F. Landers, W. Rudolph, Wm. Burton, Wm. Talley, L. Vining, C. M. Vandevere, D. Bolden, J. E. George, R. Sutton, Geo. Wilhelm and L. E. Eliason; G. L. Jemison was made foreman and L. E. Eliason, secretary. After viewing the body the jury retired to the parlor of the Jefferson House, when Susan Thompson was sworn. She said she recognized the corpse as that of Mary Jane Marlow; saw her two weeks ago; she is a cousin of mine; Geo. Kelley told me she was drowned yesterday; Kelley was the only one saved, so he said; know by the way her hair is combed that it is her; I am

sure of it; (the woman' hair was not combed but hung down her shoulders.) The witness seemed to have no knowledge other than heresy. It was ordered that the Coroner have the body examined by a doctor, when on motion, the inquest was adjourned until this evening at 7 p.m. Undertaker Fox took charge of the body, and placing it in a coffin took it to the Court House where Dr. J. J. Black made an examination. The woman is apparently from 20 to 22 years of age, black eyes, light brown hair and of small stature. She had on a plaid dress; a chemise was the only article of underclothing and she had on no shoes or stockings. The body was in no way disfigured. Undertaker Fox took it to Wilmington, where it is supposed it may be identified....

In a later edition, it was learned that (13):

The body of the young woman found near New Castle, yesterday afternoon, (as detailed in our New Castle letter) was recognized this morning at Undertaker Fox's office, by Mr. Geo. Mariner, of Philadelphia. He stated that the body was that of his daughter, Mrs. Mary Nolen, wife of one of the hands on the boat that was wrecked near New Castle during the late storm. The body was packed in ice and will be sent to Philadelphia for interment.

Other effects of the storm included animals that were disrupted from their natural habitats (13).

On Wednesday afternoon at least 1000 muskrats were killed by the boys below this city. Tommy Dodd alone captured 85. Nearly every one you would meet coming up had a load, and one ... man was laden with a string of catfish, ten muskrats, two snappers and an opossum. Yesterday the hunt was kept up and many were taken.

People also took advantage of the storm's aftermath as hundreds of men, women, and children were engaged in gathering up wood along the fields (13). Some even tried to make a profit in curious and devious ways (44).

A CURIOUS LARCENY CASE – SAVING A HEIFER FROM DROWNING AND THEN SELLING IT.

A little oldish looking man named Joseph E. Shane was arraigned before Mayor Allmond last night on a queer charge of larceny. From the evidence adduced it appeared that Mr. Edward Wilson was, previous to the storm of



Wednesday morning, the owner of four head of cattle, two of which were drowned. One of the other two, a fine heifer, was rescued from the same fate by Shane, who then drove the animal to the Third street market house, and, representing it as his own, sold it to Mr. William T. Murphy for \$16. The heifer was delivered by Shane at the slaughter house, where it was shortly after seen and recognized by a Mr. Cook, who pronounced it the property of Mr. Wilson. Daniel Bradley also identified the heifer. Mr. Wilson said he valued the animal at something over \$25. Shane had nothing to say at the trial, but had previously claimed the heifer by reason of having found it and saved it from drowning. Mr. Wilson stated that he did not wish to push the case, if the \$16 obtained from Mr. Murray were only refunded. Shane was held in \$300 bail to answer at court.

LATER REPORTS

Wilmington, Delaware

The washout to the north of the Shellpot Creek was repaired by the night of the 24th, and trains were running again in both directions. The trestle work on the Wilmington and Northern Railroad above DuPont Station required several more days to repair; no freight trains were running on the 25th and passengers were transferred around the trestle (28).

Bodies were still being discovered in the rivers as late as the 27th, including this most curious find (45).

ANOTHER VICTIM FOUND – WHO IS IT? VARIOUS THEORIES, BUT NO FACTS – A MYSTERY.

Yesterday forenoon about 10:30 o'clock, the dead body of a man was found by William Taylor and a companion, floating in the Brandywine about 20 yards below the railroad bridge. The two men towed the body up to the railroad bridge, and tied it fast to a boat, after which they sent for the coroner. The latter arrived and towed the body up the river to the first convenient landing place, and then carried it out of the water. Undertaker Fox soon arrived with an ice-box and removed the remains to Sixth and Shipley streets.

The body is about 5 feet 7 inches in height, and rather large in proportion; the face is covered with a thick gray

beard and the hair on the head is also gray, deceased being about 60 years of age. When found the body was clothed in a blue shirt, blue overalls, beneath which were a pair of pantaloons and high boots. In the pockets of the pantaloons were a wooden corn-husking peg, an empty whisky bottle, two clay pipes and a small quantity of tobacco. Strange to say, although the body had evidently been in the water several days, between the thumb and fore finger of the right hand was found the stump of a cigar. This hand was lying on the breast, and the stump was quite loose, as it was lifted out without the least resistance.

Some folks thought that the body was that of one of the men who drowned from the oyster boat Jeremiah Dover on Wednesday last; others were of the opinion that it was that of some unfortunate who was husking corn on Cherry Island marsh at the time that the banks of the creek broke, while others still think that he was intoxicated and lying by some cornshock when he was overtaken by the flood. The husking peg tends to confirm the theory that the deceased was engaged in husking corn, but the cigar between the thumb and finger would rather confirm the opinion that the dead man did not have his wits about him when caught by the water or that he was dead before the water reached him, otherwise the cigar would most likely have been thrown away or dropped in the effort to escape. The Coroner thinks that the body must either have lain in the sun for some time before or after it was first reached by the water, as the odor coming from it is, he thinks, too strong for a corpse just out of water several hours.

Another report makes the finding even more curious (46).

Yesterday morning at 8 o'clock a man named Wm. Taylor, discovered what he supposed to be a man lying in the Brandywine creek, between Eleventh street bridge and the railroad. When he got a boat and rowed out he found a man in an upright position with his feet imbedded in the mud. The body was taken from the water at the railroad bridge and the Coroner notified. The man was short in stature and heavy built, grey and bushy chin whiskers; dressed in blue overalls, dark coat and coarse, heavy boots. He was apparently 50 or 55 years of age. It is supposed the body had been in the water for nearly a week, as it emitted an unpleasant odor. The features were unrecognizable and much discolored. In the pockets were a husking peg, a couple of clay pipes, a



plug of tobacco and some other trivial articles. When found he held a half-smoked cigar in his left hand.

The body was brought to the office of D. Fox, Sixth and Shipley streets, about 9 o'clock, and at 5 o'clock in the evening an inquest was commenced. Mr. Taylor was the only witness, and he gave the facts as stated above. The jury adjourned to meet again at 7.30 o'clock this evening. The body is now at Mr. Fox's awaiting identification.

Delaware City, Delaware.

In the Every Evening of Wilmington, a report of the repairs at Delaware City was given (47).

SPECIAL CORRESPONDENCE OF EVERY EVENING.

DELAWARE CITY, Oct. 28 – Everybody here is busy putting things to rights and trying to efface the marks made by the storm – all have plenty of work now. The Canal Company has over 100 men at work night and day. The bank is badly torn up and it will cost much money to repair it. The tug *Emma* that was just here has been raised and left here yesterday morning for repairs. She had a large hole punched in her side. The residents on the Pea Patch are the greatest sufferers in the vicinity. Some have lost everything except the clothing they had on at the time, barely escaping with their lives, as they were awakened out of their beds. One little girl 12 years of age waded through water up to her neck to a place of safety inside the fort. There had been no movement made as yet towards repairing the railroad, and trains run only to Reybold station, for the present. There is to be a party of inspection from the Pennsylvania railroad to-day to view the damage done. Many think it will not be repaired, at least for the present. Most of the farmers say they do not intend to fix up their banks. There is only one public road from here that is passable. J. O. Eagle is putting up a large and handsome building here, consisting of dwelling, store and granary. It was almost a miracle that it was not blown down, as the doors and windows were all open.

There are three cases of scarlet fever here and there was one death yesterday.

As with most news, the hurricane that so quickly caused wide-spread damage remained within the public eye for a very short

time. Within three days, news related to the storm was relegated to small paragraphs buried in the latter pages of newspapers. Other than those who lost loved ones during the storm, the public allowed the devastation wrought by the storm to fade quickly from memory.

PART II. THE NATURE AND EFFECTS OF THE STORM

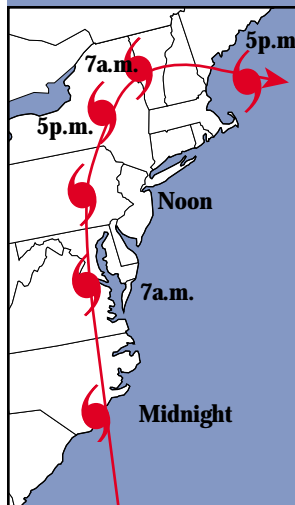
Meteorological Conditions

The following can be discerned from the available data. There was a high-pressure system over the western United States and another one over the Canadian Maritime Provinces. A low-pressure system was to the west of the latter high that was creating stormy conditions in the vicinity of the Great Lakes (1). The high-pressure system in the Maritime Provinces may have connected with a high near Bermuda, or, perhaps, there was another high-pressure system in the Atlantic located near Bermuda.

This configuration of pressure systems (Figure 2) was important in determining the path and speed that the Hurricane of 1878 took, affecting the mid-Atlantic and northeastern United States. A high-pressure system to the west and north and another system to the east created a low-pressure trough, or a path of least resistance, for the hurricane. Historically, hurricanes that have made landfall in the mid-Atlantic region generally have had this configuration. The strong upper level westerly winds created by the pressure gradient between the high- and low-pressure systems tend to accelerate the forward speed of the hurricane. Typically, hurricanes that make landfall along the southern coasts move less than 20 mph (32 km/h). Those that make landfall to the north and are caught up in the low-pressure gradient field move at speeds of 30-40 mph (48-64 km/h) and even up to 60 mph (97 km/h) (48).

Tidal Conditions

The period of October 22-24, 1878, was one of rising high tides with the approach of a new moon (syzygy) on October 25 (49, 50, 51). The 25th also marked the perigee of the moon (the position



of the moon between the earth and sun at which it is nearest to the earth). The combination of perigee and syzygy meant that at the time of the storm, the tidal range (the difference between high and low tides) was at its greatest and the high tides were at their highest. Extraordinary flooding events are often associated with the coincidence of perigee-syzygy, especially with the occurrence of onshore winds as happened during the hurricane (52). Times and heights of predicted high tides at Rehoboth Beach, Delaware, and several locations along the Delaware River and Bay for the morning of October 23 are given in Table 1 (51). Graphs showing predicted high and low tides at selected locations for the period of the storm are shown in Figure 8.

Table 1. Predicted times and heights of tides for stations along the Delaware Bay and River. Taken from Figure 8. Data provided by NOAA.

| Place | Time (Standard time) | Height (ft above MLLW*) |
|-----------------------------|-------------------------|----------------------------|
| Rehoboth Beach | 4:51 a.m. | 4.7 |
| Mahon River Entrance | 6:51 a.m. | 6.4 |
| Reedy Point | 8:26 a.m. | 6.1 |
| Pea Patch Island | 8:32 a.m. | 6.3 |
| New Castle | 8:58 a.m. | 5.8 |
| Christina River, Wilmington | 9:19 a.m. | 5.9 |
| Philadelphia, Pa. | 11:05 a.m. | 6.9 |

*MLLW- mean lower low water- the mean of the lower of the two diurnal tides of the day averaged over a period of 19 years.

No continuous recording of tidal stations was conducted in the 1870s in this region. Tide tables were published in newspapers and almanacs (49) for stations such as Philadelphia. Based on the accounts in Part 1, actual tidal data during the period of the storm in the Delaware River and Bay are shown in Table 2.

Storm Track

By 1878, the Signal Corps (part of the War Department) published monthly weather summaries that included the tracks of major low-pressure systems (1). The hurricane was system number XI for the month of October. A map published with the summary showed the track of the storm giving locations of the center of low

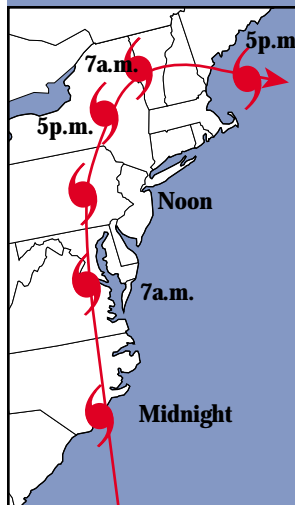
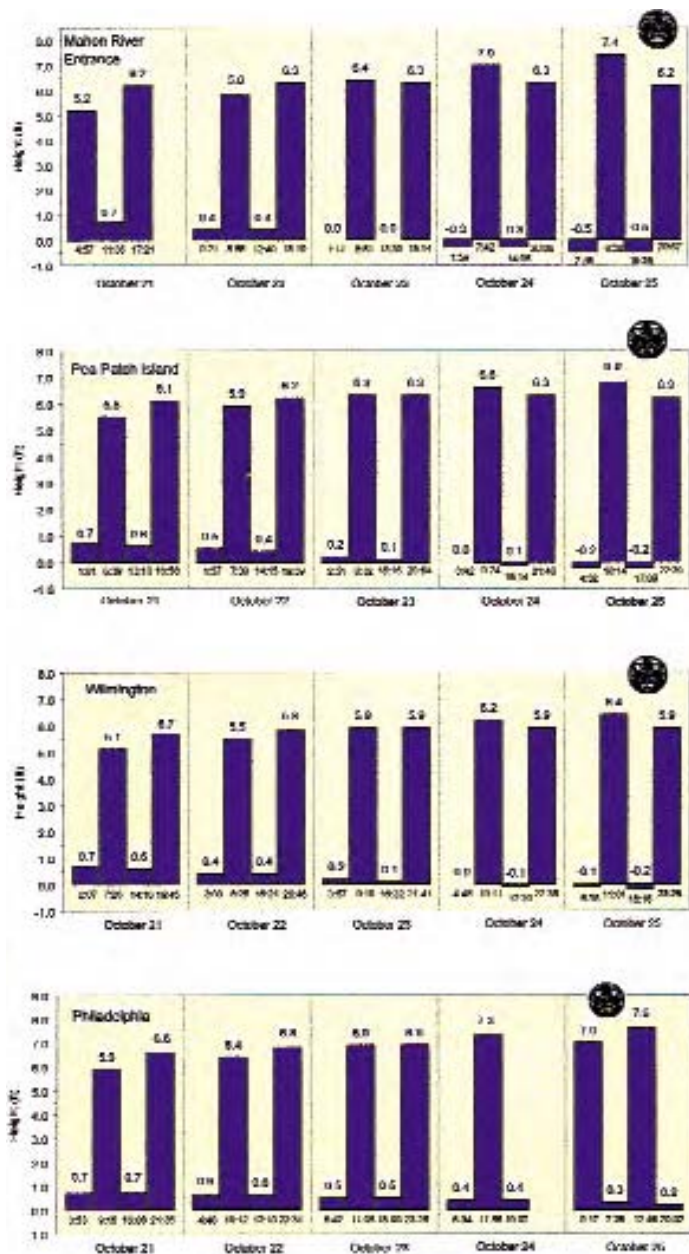


Figure 8: Graphs of predicted heights (above chart bar) and times of tides (below chart bar) at locations along the Delaware River and Bay, and Rehoboth Beach for the period surrounding the storm. The new moon on October 25 indicates the perigee-syzygy event (data supplied by NOAA/NOS).

Table 2. Documented storm tide heights for October 23, 1878. Tide height calculated from the reported heights compared to the closest tidal prediction station in Table 1 (given in parentheses below the place name).

| Place | Time | Tide Height (ft) | Notes (Source) |
|--|------------|------------------|--|
| Little Creek, Del. (Mahon River Entrance) | | 10.4 | 4 ft above predicted high tide (at nearby Mahon River entrance) (24) |
| Pea Patch Island (Pea Patch Island) | | 11.7 | Above mean low water (37) |
| Fort Mifflin (Philadelphia, Pa.) | 10:00 a.m. | 11.3 | Above low water. Stayed at this height until 12:45 p.m. (37) |

pressure at 7:25 a.m., 4:25 p.m., and 11:00 p.m. for each day. The storm track (Figure 2) shows that the storm formed south of Cuba on the 21st, and moved northward to east of southern Florida by the end of the day. It continued its northward track on the 22nd where it made landfall on the coast of North Carolina at about 11:00 p.m. The storm then moved rapidly northward just to the west of the Chesapeake Bay. By 7:25 a.m., it was due east of Washington, D.C., and moved rapidly just to the west of Wilmington, Delaware, and Philadelphia, Pennsylvania, and at 4:35 p.m., was centered near Oneonta, New York. It took an abrupt turn to the east before 7:25 a.m. on the 24th, crossed southern Vermont and New Hampshire and went offshore just south of Portland, Maine, by that evening.

Forward Speed of the Storm

The Signal Corps report gave an average forward speed for the storm as 24 mph (1). It is instructive, however, to break the path into segments to illustrate the increase in forward speed once the hurricane made landfall and moved to the north. From the track map (Figures 1, 2) forward speed was estimated between each of the storm center locations (Table 3). Although rough estimates, these are indicative of the storm's forward speed.

The detailed weather record from the station in Philadelphia indicates that the storm passed there around 7:30 a.m. (the time of

Table 3. Forward speed of storm estimated from published storm track map.

| DAY | TIME | FROM | TO | MILES (approx.) | SPEED (mph) |
|------|------------|-------------------------|-------------------------|--------------------|----------------|
| 21st | 7:35 a.m. | South of Cuba | | | |
| | 4:35 p.m. | South of Cuba | East of S. Florida | 130 | 14 |
| | 11:00 p.m. | East of S. Florida | East of N. Florida | 150 | 23 |
| 22nd | 7:35 a.m. | East of N. Florida | East of Georgia | 150 | 18 |
| | 4:35 p.m. | East of Georgia | East of S. Carolina | 140 | 16 |
| | 11:00 p.m. | East of S. Carolina | Near Wilmington, N.C. | 170 | 26 |
| 23rd | 7:35 a.m. | Near Wilmington, N.C. | E. of Washington, D.C. | 230 | 27 |
| | 4:35 p.m. | E. of Washington, D.C. | Near Oneonta, N.Y. | 200 | 22 |
| | 11:00 p.m. | Near Oneonta, N.Y. | N.Y.-S. Vermont Border | 100 | 15 |
| 24th | 7:35 a.m. | N.Y.-S. Vermont Border | S.E. of Portland, Maine | 200 | 24 |
| | 4:35 p.m. | S.E. of Portland, Maine | 250 mi. E. of Cape Cod | 250 | 28 |

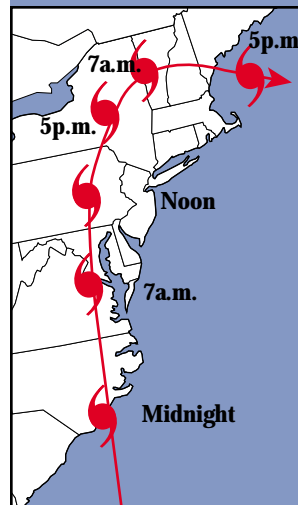
the lowest barometric pressure and the shift in wind direction) (39). If so, then the storm was actually moving faster than the speeds indicated in the above table (350 miles between 11:00 p.m. on the 22nd and 7:30 a.m. on the 23rd), possibly as fast as 46 mph. By the time the storm reached Virginia, it was no longer a hurricane.

Barometric Pressures, Wind Speeds and Directions, Rainfall Amounts

Data from scattered Signal Corps stations provide the bulk of the data. Much of these data were reported in the press and others in official Signal Corps reports. The following tabulation of data (Table 4), chronicled in Part I, is an attempt to relate some sense of the intensity of the storm from the meteorological data.

Using the tabulated data, the hurricane was a Category 1 (wind speeds 74-95 mph) or at most a low Category 2 (wind speeds 96-110 mph) on the Saffir-Simpson scale. Barometric pressure data generally support the classification. Storms of Category 3, or higher, generally have barometric pressures of less than 28.50 inches. The lowest pressures recorded during the storm were 28.80 in. to 28.83 in. at Washington, D.C., Annapolis, Md., and Baltimore, Md.

Wind directions are in agreement with those of a passing hurri-



cane or tropical storm. For those areas on the right side of the hurricane center, the wind began out of the east, eventually changed to the northeast then southeast after passage of the storm center and eventually out of the northwest after passage of the storm. The best example of this can be seen in the half-hour readings from Philadelphia.

The sustained wind speeds during the storm lasted for several hours; Norfolk, Washington, Dover and Wilmington, Delaware, and New York City reported sustained high winds for three or more hours. At Philadelphia, sustained winds greater than 45 mph lasted from 5:00 a.m. to 10:00 a.m. and were greater than 60 mph

Table 4. Barometric pressure, rainfall amounts, wind speed, and wind direction data for the Hurricane of 1878. T=total, M=maximum

| Location | Day (Oct.) | Time | Bar. Press. | Rainfall Amount (in) | Wind Speed (mph) | Wind Direction | Source(s) |
|--------------------|------------|----------------|-------------|----------------------|------------------|----------------|-----------|
| Havana, Cuba | 21 | 4:35 p.m. | 29.67 | light | 24 | NW | 1 |
| Key West, Fla. | 21 | 7:35 a.m. | | | 46 | NE | 1 |
| | 21 | a.m. | | heavy | 54 | NE | 1 |
| | 21 | 2:00 p.m. | 29.53 | | 44 | NE | 1 |
| Wilmington, N.C. | 22 | 3:00 p.m. | | | | E | 1 |
| | 22 | 10:20 p.m. | | | 36 | NW | 1 |
| | 22 | 11:56 p.m. | 29.12 | 2.92 T | | | 1 |
| Cape Lookout, N.C. | 22 | 11:02 p.m. | 29.05 | 4.06 T | 68 | SE | 1 |
| | 22 | post 4:35 p.m. | | | 100 M | | 1 |
| Kitty Hawk, N.C. | 22 | 6:30 p.m. | | | Incr. | | 1 |
| Dover, DE | 22 | 9:00 p.m. | | | heavy gale | | 5 |
| Portsmouth, N.C. | 22 | 11:04 p.m. | | 3.48 | 82 | SE | 1 |
| Kitty Hawk, N.C. | 23 | 2:00 a.m. | 29.06 | | 88 | | 1 |
| Cape Henry, Va. | 23 | early a.m. | | | 84 M | SE | 1 |
| Norfolk, Va. | 23 | 4:00 a.m. | | | 44 | SE | 1, 9 |
| | 23 | 7:00 a.m. | 29.00 | | 36 | | 9 |
| Richmond, Va. | 23 | early a.m. | | heavy | high | | 5 |
| Lynchburg, Va. | 23 | | | | 2.01 T | | 5,12 |
| Washington, D.C. | 23 | 4:40 a.m. | | var. | | | 1 |
| | 23 | 7:15 a.m. | 28.80 | | 3.54 T | NW | 1 |
| Annapolis, Md. | 23 | 5:45 a.m. | | | high | NE to SE | 1 |
| | 23 | 7:30 a.m. | 28.82 | | | | 1 |
| Baltimore, Md. | 23 | 5:00 a.m. | | | 45 M | SE | 1 |
| | 23 | 7:37 a.m. | 28.83 | | 2.74 T | | 1, 12 |

| Location | Day (Oct.) | Time | Bar. Press. | Rainfall Amount (in) | Wind Speed (mph) | Wind Direction | Source(s) |
|----------------------|------------|------------|-------------|----------------------|------------------|----------------|-----------|
| Lewes, Del. | 23 | 2:00 a.m. | | | Incr. | | 18 |
| | 23 | 3:00 a.m. | | | high | | 18 |
| Cape May, N.J. | 23 | 5:45 a.m. | | | 84 | E-SE to W | 1, 21 |
| Dover, Del. | 23 | 12:30 a.m. | | | Incr. | | 6 |
| | 23 | 4:00 a.m. | | | v. high | | 6 |
| Pea Patch Isl., Del. | 23 | a.m. | | | > 70 | | 37 |
| Fort Mifflin, Penn. | 23 | a.m. | | | 49-72 | ENE-ESE-S | 37 |
| Chester, Penn. | 23 | 6:00 | | | high | | 20 |
| Philadelphia, Penn. | 23 | 5:00 a.m. | 29.42 | heavy | 49 | E by NE | 39 |
| | 23 | 5:30 a.m. | 29.36 | heavy | 48 | E by NE | 39 |
| | 23 | 6:00 a.m. | 29.30 | heavy | 56 | E by SE | 39 |
| | 23 | 6:30 a.m. | 29.24 | light | 56 | E by SE | 39 |
| | 23 | 7:00 a.m. | 29.22 | light | 60 | E | 39 |
| | 23 | 7:30 a.m. | 29.18 | | 64 | SE by E | 39 |
| | 23 | 8:00 a.m. | 29.22 | light | 64 | E by SE | 39 |
| | 23 | 8:30 a.m. | 29.22 | light | 50 | SE | 39 |
| | 23 | 9:00 a.m. | 29.22 | light | 36 | E by SE | 39 |
| | 23 | 9:30 a.m. | 29.25 | light | 48 | S by SE | 39 |
| | 23 | 10:00 a.m. | 29.26 | | 48 | S by SE | 39 |
| | 23 | 10:30 a.m. | 29.97 | | 40 | S | 39 |
| | 23 | 11:00 a.m. | 29.28 | | 36 | S by SW | 39 |
| Trenton, N.J. | 23 | 5:00 a.m. | | heavy | v. high | | 20 |
| Scranton, Penn. | 23 | 10:30 a.m. | | v. high | | | 40 |
| Albany, N.Y. | 23 | 12:00 p.m. | | | high | | 20 |
| Barnegat, N.J. | 23 | a.m. | | | 72 | SE | 1 |
| Atlantic City, N.J. | 23 | a.m. | | | 56 | E | 1 |
| New York City, N.Y. | 23 | 5:00 a.m. | | | 25-28 | | 40 |
| | 23 | 7:00 a.m. | 29.55 | | | | 40 |
| | 23 | 8:00 a.m. | | | 50 | | 40 |
| | 23 | 12:00 p.m. | 29.37 | | | | 40 |
| | 23 | 8:00 p.m. | 29.53 | | 25 | | 40 |
| New Haven, Conn. | 23 | 11:00 a.m. | | | 40 M | E | 1 |
| New London, Conn. | 23 | | | | 60 M | E | 1 |
| Newport, R.I. | 23 | | | | 36 M | SE | 1 |
| Boston, Mass. | 23 | | | | 40 M | SE | 1 |
| Mt. Washington, N.H. | 23 | 4:57 p.m. | | | 120 M | SE | 1 |

for over an hour, from before 7:00 a.m. to after 8:00 a.m. Gusts during this time must have been higher. An estimate of a gust factor based on modern hurricanes would be 1.5 to 2.0 times the sustained wind speed (48). This would suggest that winds of 90 to 120 mph were possible

during the peak of the storm. Maximum gusts of 72 mph at Philadelphia and 84 mph at Cape May, New Jersey, would indicate that peak gusts were on the lower side of this estimate.

Storm Surge

Storm surge is the elevated sea surface as the result of a storm caused by the shear of winds across the surface of a body of water (48). It can be thought of as a dome of water driven toward the land by the winds of a hurricane (48). Surge has both a flood component (from the sea to the land as the hurricane approaches land) and an ebb component (from the land to the sea once the hurricane winds shift or decrease releasing the flood surge) (48). This discussion will deal only with the storm surge affecting the Delaware Bay and River for which the greatest amount of documentation exists.

Of the major factors determining the height of the flood surge (wind speed, central pressure, slope and width of the continental shelf, tidal stage, shoreline configuration, and anthropogenic changes along the coast [48]), wind speed and direction, continental shelf geometry, and shoreline configuration were the most important contributors to surge flooding in Delaware Bay. The central pressures of the hurricane were not exceptionally low and were well to the west of Delaware Bay. Anthropogenic modification of the shoreline was not significant in 1878 and did not affect the surge. As will be discussed later, however, dikes along the coast did have some consequences in some areas in terms of shoreline change as the result of the storm.

The wind field from the hurricane affected the southern part of Delaware on the evening of the 22nd. As early as 9:00 p.m., heavy rain and wind were reported in Dover (5). By the early hours of the 23rd, high winds were reported in Dover at 12:30 a.m. and Lewes at 2:00 a.m. (6). Given the southeasterly wind direction reported (1) from stations to the west (Baltimore and Annapolis) and south (Norfolk), it is reasonable to assume that the wind direction was from the southeast in Delaware from late evening on the 22nd to the morning hours of the 23rd.

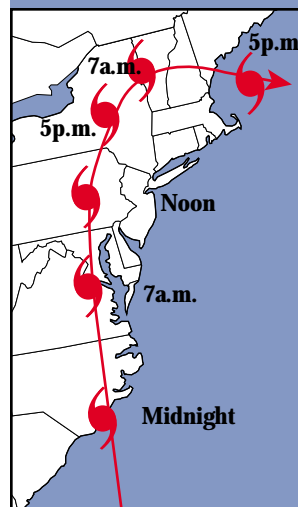
Unfortunately, little is known about the size of the hurricane and the overall area affected by its winds. It is known that at 7 a.m., on October 23rd an area from Washington, D. C., to New York

City was experiencing high winds, a distance of about 200 miles. It is probable, then, that as the hurricane moved northward across North Carolina, Virginia, and even into Maryland, there were high winds from the southeast and east blowing across the Atlantic Ocean toward the mouth of Delaware Bay for a period of at least six, and perhaps as many as nine, hours prior to sunrise (approximately 6:20 a.m. [49]). This long period of time combined with a fetch (distance over which the wind was blowing) of several hundred miles provided the makings for a storm surge in Delaware Bay. The wind was also blowing over a large area of relatively flat, shallow continental shelf which also would contribute to building a storm surge dome (48). Any waves would be developed on top of this surge dome.

The surge would have been unusual in the sense that it was not generated by the hurricane center making landfall, but by high winds blowing for a long period of time building upon the high tide that entered the mouth of Delaware Bay at about 5:00 a.m. At the same time, winds were blowing at Cape May, New Jersey, at 84 mph from E-SE (1, 21). The coincidence with a high tide that was within four tidal cycles of a perigean spring tide (52) is perhaps the most critical factor for the storm surge wave and flooding that occurred along Delaware Bay. Figure 9 is a map of Delaware Bay that shows the locations and times of predicted high tides as well as the localities from which there were reports of a “tidal wave” or fast rise of tide.

Near Leipsic, east of Dover, there was a report that the “tide rose sudden and unexpectedly high.” This was reported to be in the morning hours when men were sleeping on the marsh. At Little Creek Landing, the tide was reported to have risen four feet above high water in one hour’s time. The most dramatic report is from around 6:20 a.m. (daylight or sunrise (49)) at Collins Beach (25).

Shortly after daylight, while Mr. Collins was looking out upon the driving tempest, he saw as it were a huge wave lifted up out in the Bay, which came with flying speed breaking over the top of the beach in a mighty billow, bursting open the doors of the hotel, sweeping the ballroom, stables, pavilion, bath-houses – everything but the hotel property, before it and carrying them out of sight. The mighty tide rolled on inland submerging the country for a distance of one or two miles.



This account gave rise to the anecdotal “Great Tidal Wave” that has been passed on in the area throughout the years (27, 53, 54, 55). At Bombay Hook, a similar account was given (25).

Bombay Hook was swept from end to end and for the past week has presented the appearance of a vast lake, the beach and banks serving as a rim of a basin to hold the water in. The only communication with the Island has been by boats. Persons on the west of the Island saw the big wave when it mounted the beach and noted its bank, and it was not until they heard the angry roar of splashing waters that they realized the destruction in its wake, and fled for the main land.

Farther up the Delaware River at Fort Delaware on Pea Patch Island in the middle of the Delaware River there were reports that “... At Fort Delaware, many of the people living on the island barely escaped with their lives, the water rising 5 feet in an hour and a half, and reaching a height of 11 feet 8 inches above mean low water...” (37).

A funnel-shaped estuary such as Delaware Bay tends to focus surge (48) as the water volume being pushed into the estuary encounters increasingly less shoreline over which to be dispersed, thus magnifying the height of the surge. The areas in which the “tidal wave” was reported are on the western shoreline of the Bay in the area where it narrows. It is hypothesized that the storm surge coincided with the incoming tide. Surges of 5 to 6 feet would be common for a Category 1 hurricane. Added upon the predicted tide height (Figure 8, Table 1), the reported tide heights of greater than 11 feet at Fort Delaware and Fort Mifflin are easily accounted for.

The surge wave entered Delaware Bay at about 5:00 a.m. with the high tide and moved northeastward along the Bay. Between 6:00 and 6:30 a.m., the surge mound encountered the shallow waters (<5 ft deep) offshore the area east of the Murderkill River entrance and built even higher. When the wave reached the shoreline it was perhaps as high as ten feet or more. It crashed onto the shore causing a great deal of damage to any nearby structures and breaking through any of the small beach-barriers along the shoreline. The marshes behind would have been rapidly flooded, and areas along tidal streams, such as Little Creek Landing, would have seen water levels rapidly climb several feet over an hour’s time.

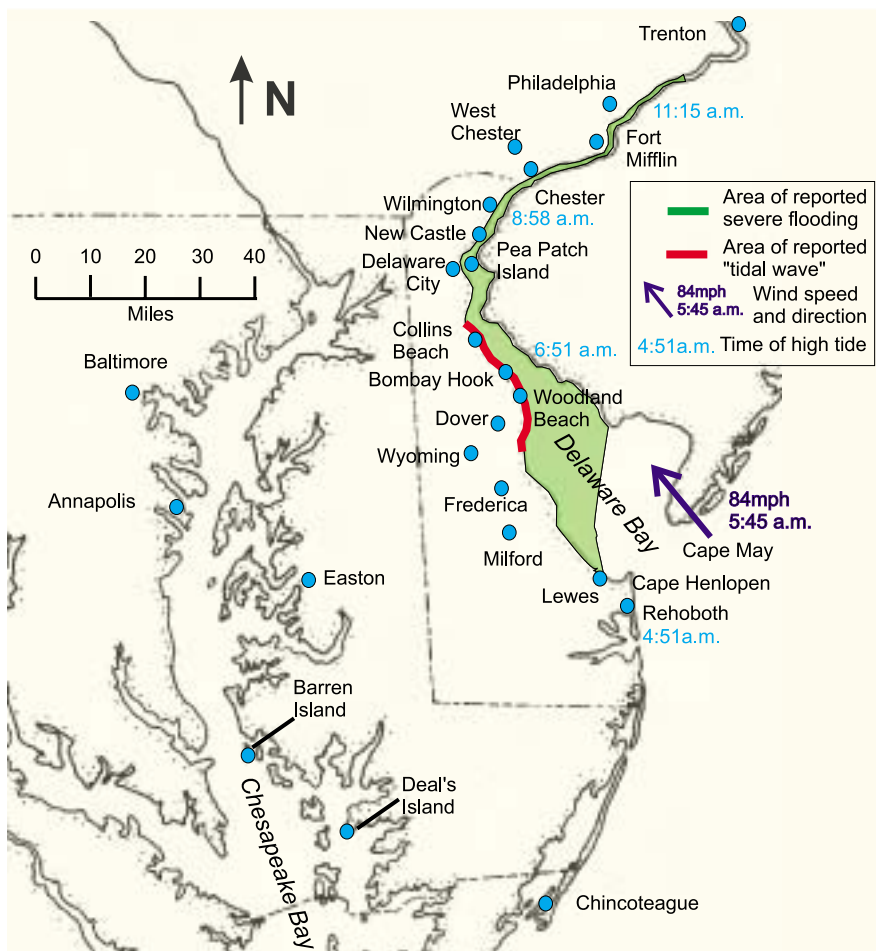


Figure 9: Map of Delaware Bay and River indicating locations and times of predicted morning high tides, areas affected by “tidal wave”, areas of reported river flooding, and the direction and speed of the wind. Geographic locations are mentioned in the text.

The shorelines to the south experienced flooding as well but, because of the greater width of the bay and the sheltering effect of Cape Henlopen and Cape May, did not experience the same level of surge wave.

The surge wave then traveled up the Delaware Bay and River greatly increasing the tide height as its timing also coincided with

high tide. The southeastward winds continued until almost noon and kept the water from ebbing from the bay and river while keeping water levels high for that period. The accounts along the Christiana River do indicate that there was some ebb surge once the winds changed directions allowing the built-up water to recede, as in the following account from the *Every Evening* (18).

A FIERCE CURRENT.

Some idea of the strength of the current in the Christiana yesterday immediately after the storm, and of the force with which it pressed against whatever offered an obstruction to its free passage, may be gathered from the fact that at Third street bridge the grass, weeds, cornstalks and other debris brought down the stream by the flood, were packed so tightly between the northern abutment and the shore as to form a sort of raft or bridge of sufficient strength to support several small boys who were busy gathering the driftwood and corn that had been swept down from the woods and fields along the creek.

Geologic Effects of the Hurricane

As with many coastal storms, the loss of life and damage to property are the most evident results of the impact of a storm. Long-term geologic changes are subtler and not always as well documented as damage to property. The most common geologic changes that occur during hurricanes are beach erosion, dune erosion, inlet formation from flood and ebb surge, landscape changes through tree destruction by wind, and nearshore channeling and sedimentation (48). The most evident effect of the Hurricane of 1878 was shoreline change and the creation of several new tidal stream systems on the Delaware coast of the lower Delaware River and upper Delaware Bay in the area where the “tidal wave” was reported.

Pomeroy and Beer's Atlas, consisting of a series of maps based on the “Hundred” geographical system of Delaware that was published in 1868 (56), showed all roads and locations of buildings as well as names of landowners and homeowners. Rivers and shorelines are also shown on the maps, but the level of accuracy of the survey cannot be stated with any certainty. The roads appear to be located accurately, based on the fact that they can be matched with the modern highways in some areas. This atlas is used as the pre-

hurricane map of the shoreline of Delaware Bay even though the exact nature of the shoreline may not be accurate. Comparing maps in this atlas with later maps shows the important coastal changes.

Figure 10 from Pomeroy & Beers Atlas (56) shows the area of the greatest coastal change along the Delaware portion of Delaware Bay. Two areas are examined in detail, Collins Beach and Woodland Beach, south of Duck Creek. Figures 10 and 11 show a portion of the atlas that covers the area of Collins Beach and an earlier map from a hydrographic survey of the area done in 1841, respectively. In Figure 10, note the location of Hygenia House. This was the resort hotel at Collins Beach constructed after the map of 1841 (Figure 11). Other important features are the configuration of roads going north and south in the area, two streams just to the north of Hygenia Hotel, and Cedar Swamp to the west of the hotel.

A newspaper report from the *Smyrna Times* on October 30 reported the aftermath of the storm (57).

There are four breaches in the bank of 40 or 50 feet in length and constantly widening, through which the tides ebb and flow, forming a little bay of the marsh in the rear of the Hygenia House which must remain unless these breaches are filled; and the losses are so great that Mr. C(ollins) is uncertain as to the future of the property. Cedar Swamp is filled with floating property, from houses furnished (supposed to be from Fort Delaware) down to chicken coops.

The breach (or stopping) was reportedly filled by June of 1879; however, it remained a point of weakness, and in September of 1882, after a heavy rainstorm that lasted for three days, it failed again (27).

Oct. 4, 1882- The washout of the stopping in the bank at Collins Beach is proving a serious matter to the lower portions of Thoroughfare Neck. Hundreds of acres of land, not only of the marsh, but the up-land, are submerged, and have been since Saturday week, with water two or three feet deep from the incursions of the high tides. A number of the farm houses, we are told, are surrounded with water, and the occupants can move about only by the use of boats.

May 9, 1883- It has been a question during the past winter whether the Collins Beach hotel property and pier would

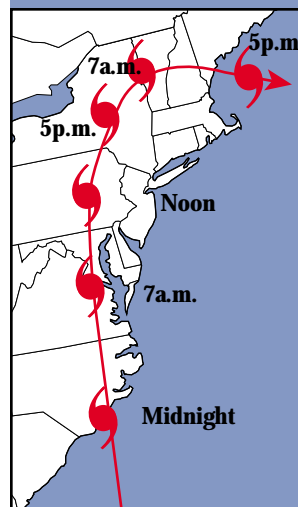




Figure 10: 1868 map showing the locations of roads (highlighted in green) and the Collins Beach resort and Hygenia House (red box) along the Delaware River. Note the location of the roads that run parallel to, but inland from, the river and the location of Cedar Swamp (shaded green) west of the resort hotel (from Pomeroy & Beers, 1868). Refer to Figure 9 for location of Collins Beach.

be available for the coming season or not. During the heavy freshet last fall the stopping between the fast land on which the property stands and the mainland, blew out, leaving an opening which is now between 90 and 100 feet wide and 18 feet deep, through which the tide flows and floods the low lands a considerable distance from the Bay.

E. D. Bryan in his book on Collins Beach (27) goes on to report the efforts of the local business interests and farmers to repair the breach by building a horseshoe-shaped coffer dam and sluice and a bridge across the breach. A bridge was completed by June of 1883



Figure 11: Hydrographic survey of the Collins Beach area from 1841, prior to the construction of the resort (U.S. Coast and Geodetic Survey, 1841). Road shown in Figure 10 highlighted in green and Collins Beach by red box.

so that the hotel could open for business. The bridge was washed away by a storm in January of 1884. The resort did not open again for the summer season. The forecast for the future of the resort was bleak.

Oct. 29, 1884- Collins Beach is assuming more and more the position of a diminishing island. In addition to the deep and broad break in the embankment on the south of the hotel, by which nearly 1,000 acres of ground have been overflown by tidewater, a similar break occurred in the summer a short distance above the house, and the eddying waters of the two are washing away the main land, we are told, very fast. Rapid encroachments are being made on the orchard in the rear of the hotel that once formed a pleasant retreat for visitors, and if the disintegration of the banks by the rapid currents is kept up as at present, it is thought that it will reach the buildings from three to five years. It looks as if Collins Beach is doomed. (57)

A hydrographic survey of 1884 (Figure 12) shows the state of the area. An appeal was filed in Levy Court to repair the breach to protect and restore the flooded farmland. In 1886, the breach was filled by the work of a clamshell dredge financed by a tax levy, and in 1888 the reclaimed marsh supported cattle. In 1889, with some enterprise, a new establishment was opened called Bay-Head but most people still called it Collins Beach. History repeated itself and on October 29, 1890, about 12 years after the Hurricane of 1878, the bank broke again both above and below the hotel and the marshes and swamp behind were flooded one more time. Once again, the breach was repaired. On October 18, 1893, another hurricane passed through and the bank was again blown open. In April of 1894, another storm was reported that was the "worst since the well remembered 'tidal wave' in the fall of 1878," and had heavy wind and rain followed by several inches of snow. The bank held this time but the marshes were flooded by storm washover. The hotel never opened again and in 1904 was torn down. Sometime during this period the bank opened again permanently south of the hotel and the area behind it "...where broad fields of grain and hay once grew the tide now ebbs and flows over a miry muskrat marsh" (27).

A map showing the area in 1884 (Figure 12) notes that the area behind Collins Beach was too flooded to make a proper survey. The U.S. Geological Survey 15-minute map surveyed in 1926-

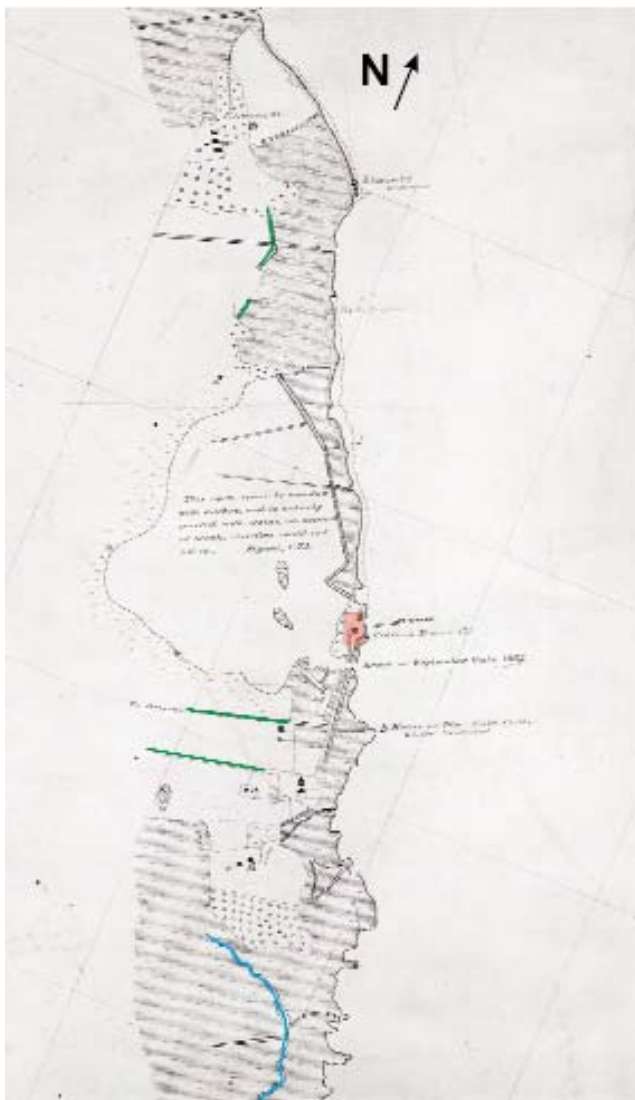


Figure 12: Hydrographic survey of the Collins Beach area from 1884, showing the breach in the bank from the September 1882 gale. The meadow to the west of Collins Beach is shown to be continuously flooded and filled with ditches due to the breaching (US Coast and Geodetic Survey, 1883). Highlighted roads shown in green and Collins Beach by red box. Stream in blue at the bottom of the sketch shown in Figure 13. Faint lines show a 1-minute grid of latitude and longitude.

1927 (Figure 13) shows a fully developed tidal stream system at Collins Beach. This system has been more or less stable to the present (Figure 14). Clearly, in spite of the Herculean efforts to close the breach after the Hurricane of 1878 it was a constant point of weakness, and after every major storm it opened again. Finally, efforts to keep it closed were abandoned, and it developed naturally into a full tidal stream system.

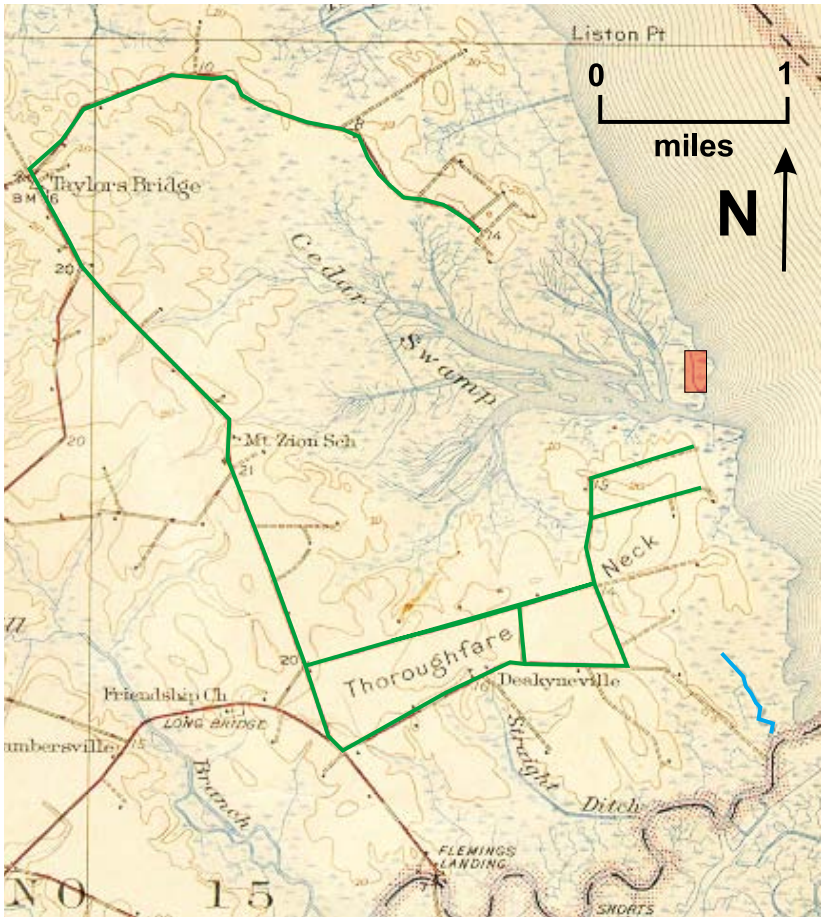
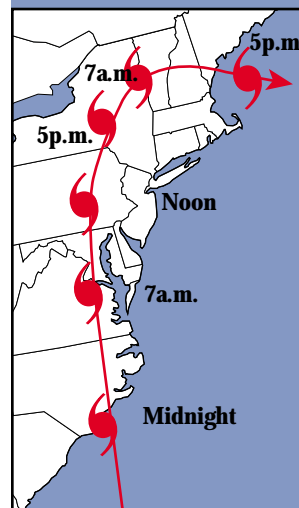


Figure 13: Topographic map from 1926-27 showing the Collins Beach area with a fully-developed tidal stream system that resulted from repeated breaching of the banks along Collins Beach during storm events (USGS, Smyrna, Del.-N.J., 1927). Stream highlighted in blue also shown in Figure 12. Roads and Collins Beach highlighted as in previous figures.

Cedar Swamp, then, went from being a freshwater swamp (53) to a tidal stream in about 20 years. It would have taken only one or two years if the breach were not repeatedly repaired. Evidence indicates that the geologic system was out of balance owing to anthropogenic (man-made) influence. Weslager (53) reported that as early as 1682 a creek called Cedar Creek was navigable by Indian dugout canoes. By 1760, the area along Delaware Bay had been diked and the area behind the dikes drained by ditches (53). The creek itself disappears from later records and maps, and only a stand of cedars was called Cedar Swamp. If the shoreline was diked in the early 1700s, then the land behind the dike that was farmed became relatively lower than the sea level on the Bay side of the dike. Over a period of 180 years or so, the relative difference may have been as much as two feet, corresponding to a relative rise of sea level during the period. Any breach in the dike, then, would obviously have waters from the Bay pouring into the low areas behind. Tidal currents through the breach would downcut and establish a new base-level equilibrium. This is exactly what happened at Cedar Swamp. The morphology of the tidal system is different from that of most marshes along Delaware Bay. The modern Cedar Swamp has a digitate or dendritic pattern and shows none of the typical meandering pattern found in the tidal river tributaries to the Bay. This pattern may be indicative of tidal streams formed in out-of-equilibrium systems as opposed to the meandering streams that appear to be quite stable over periods of hundreds of years that keep in equilibrium with sea-level rise.

The same scenario that occurred at Collins Beach also occurred just to the south of Duck Creek (Figure 15) at Woodland Beach on Bombay Hook Island, where another popular resort, Fraland, was located. As at Collins Beach, eyewitness accounts noted the “tidal wave” (25, 54, 57).

Bombay Hook was swept from end to end and for the past week has presented the appearance of a vast lake, the beach and banks serving as a rim of a basin to hold the water in. The only communication with the Island has been by boats. Persons on the west of the Island saw the big wave when it mounted the beach and noted its bank, and it was not until they heard the angry roar of splashing waters that they realized the destruction in its wake, and fled for the main land.



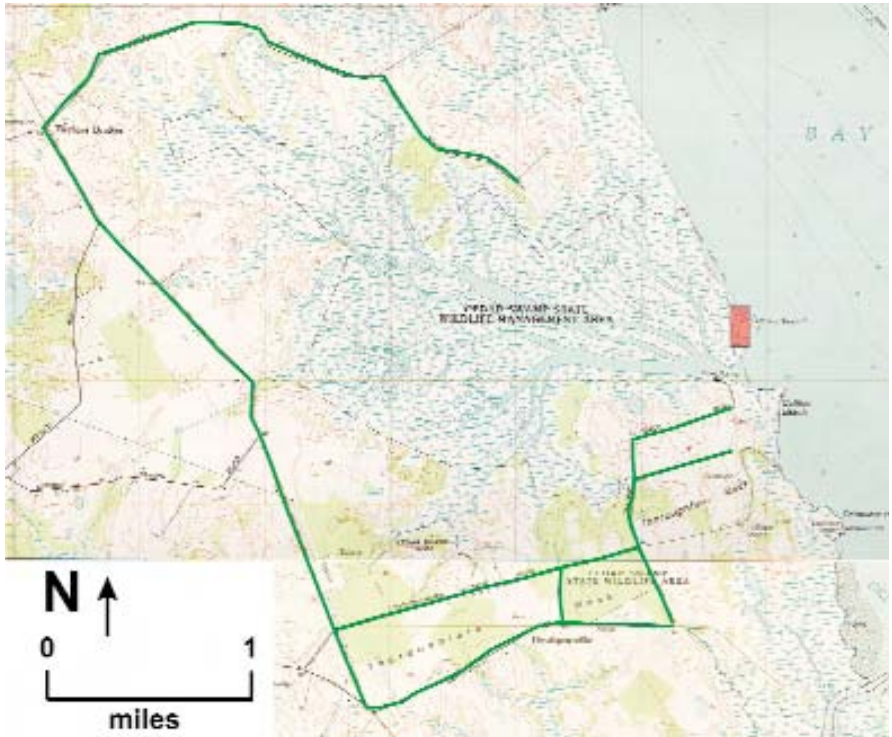


Figure 14: Topographic map of Taylor's Bridge quadrangle from 1993 showing the Collins Beach area. When compared to Figure 12a, very little change has occurred in the tidal stream system in 70 years (USGS, Taylor's Bridge and Smyrna quadrangles, 1993).

...Thomas Maloney says that the big tidal wave came rolling in like a low cloud ten or twelve feet high and broke over the Island just before sun-up...

Much of the lowland inland of Bombay Hook Island was inundated, and a breach in the barrier or dike was formed just north of Woodland (54). Whereas the breaches at Collins Beach were repaired, no documentation of such an effort has been found for Woodland Beach. The drowned area became a tidal basin that maintained an open water character and was fed by the breach. Old Duck Creek ran across the area and into the Smyrna River, then fed this tidal lake. According to Florio (54), at first the breach was shallow and only allowed water in at low tide. Ebb waters flowed out the old path of Duck Creek into the Smyrna River. A sluice was constructed where a road crossed Old Duck Creek to stop this ebb flow. The area of the tidal lake became

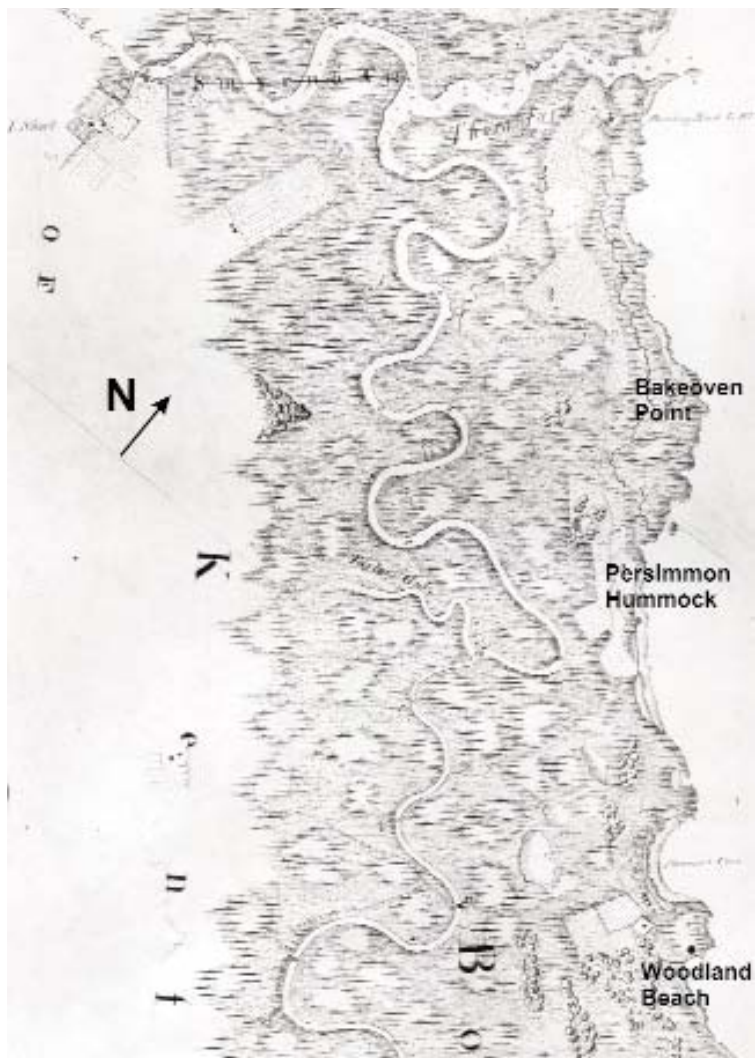


Figure 15: Map of Woodland Beach from 1841, prior to any breaching of banks from the Hurricane of 1878. The Smyrna River runs west-east, and Duck Creek meanders north-south and empties into the Smyrna River (U.S. Coast and Geodetic Survey, 1841). Geographic names added that are shown on following maps. Woodland Beach shown on Figure 9.

known as Broadway Meadows. As the breach deepened, and a few more were formed by subsequent storms, the area became a tidal flat flooded by high tides twice a day and exposed during low tides.

Today Broadway Meadows is a large marsh with the digitate tidal creek (Figure 16, 17) pattern similar to that of Collins Beach (Figure 14). The Hurricane of 1878 was the chief contributing factor to the development of these tidal creeks. This area was originally marsh and dominated by a meandering Old Duck Creek, like that found to the south of the present road to Woodland Beach (Figure 15).

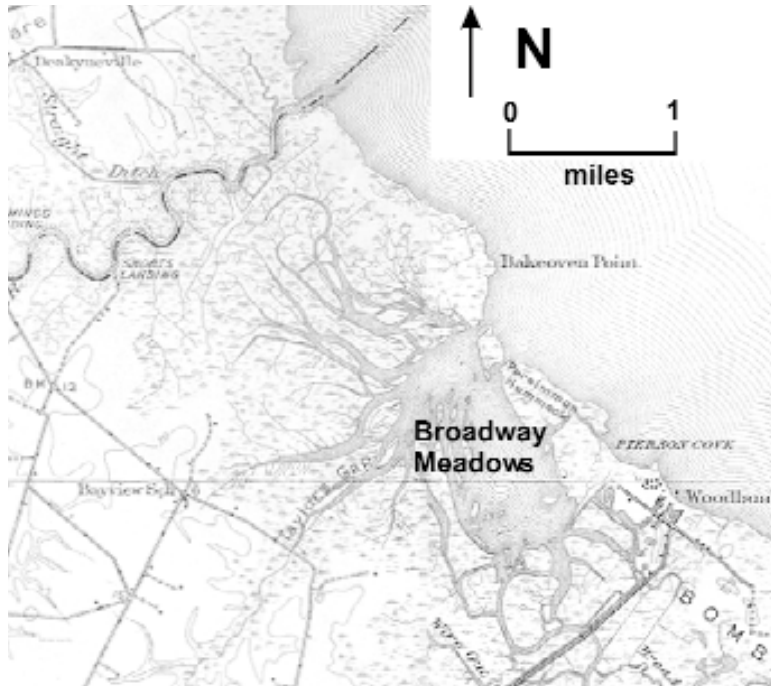


Figure 16: Map of Woodland Beach from 1926-27 showing Broadway Meadows as a large marsh with a digitate tidal creek. The marsh and tidal creek were allowed to evolve after a breach in the banks was not repaired after the Hurricane of 1878 (USGS, Shiloh, N.J.-Del, 1927 and USGS, Smyrna, Del.-N.J., 1927).

If the Storm Were to Happen Today

One obvious difference between the world of 1878 and today is the ability to forecast and track hurricanes. If a hurricane similar in intensity and track were to happen today, adequate warnings would be given to the areas affected by its path. Loss of property and life, especially on the water in Chesapeake and Delaware bays

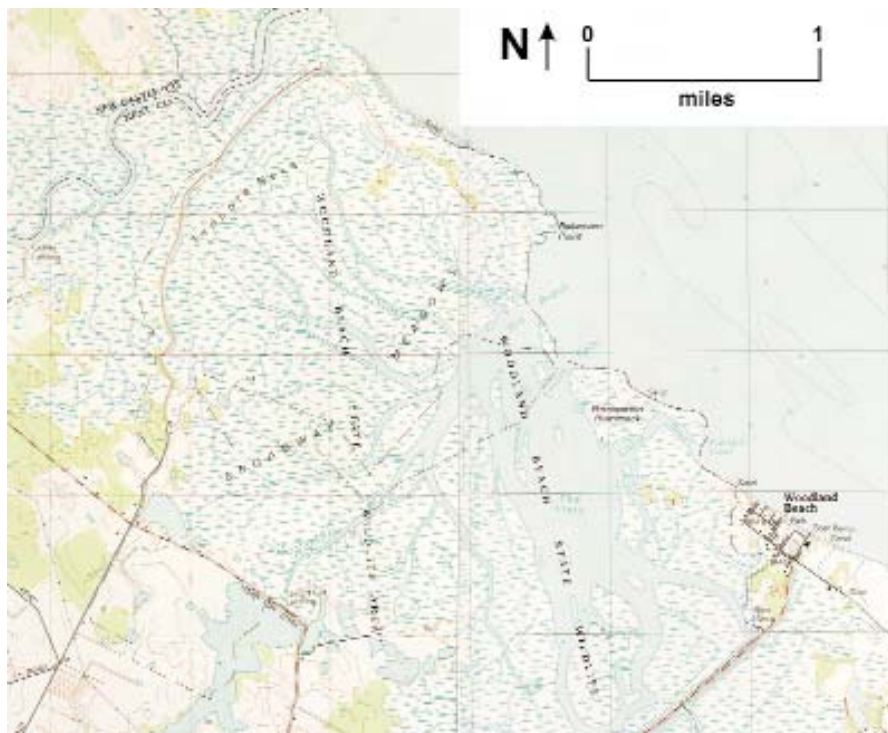


Figure 17: Map of Woodland Beach in 1989 showing the present tidal system of Broadway Meadows. The tidal system has not changed much from 1926 (USGS Smyrna and Bombay Hook Island quadrangles, 1992).

would certainly be less. The regions along the Delaware Bay and River shoreline affected by the “tidal wave” are not greatly more developed than they were in 1878; much of the land being in state or federal wildlife refuges. If this is the case, then is there any concern about such a storm striking today?

The answer is yes. First, the wind damage as a result of the Hurricane of 1878 was great and widespread. This would not change today. The most obvious damage would be widespread disruption of electrical services caused by downed power lines, mainly from tree blow-downs. This has been the case with most recent hurricanes. Hurricane Fran in 1996 affected central North Carolina and Virginia and caused over three billion dollars worth of damage much of it inland away from the coast. High winds

knocked down trees, disrupted electrical service, that in some areas took over a week to restore, and damaged houses with removal of siding and shingles and crush by tree fall.

Damage to buildings may be less now than in 1878. The sheet metal (tin) roofs that were popular at the time were especially susceptible to damage; however, modern construction is not immune to wind damage. Shingles, vinyl or aluminum siding, and other features that are susceptible to lifting once the wind gets under them are likely to be damaged during an episode of several hours of greater than 60 mph wind speeds. Flying debris can and will break windows, a circumstance cataloged in Wilmington, Delaware, during the Hurricane of 1878. Modern construction will not be immune to such damage.

Perhaps the most vulnerable areas in such a storm, especially if the tidal conditions of a perigean high tide occur near the time of the storm, are those same areas along the Delaware River affected by the Hurricane of 1878. As development increases along the Christina and Brandywine rivers in Wilmington, and along the Delaware and Schuylkill rivers, these areas are subject to higher risk for flooding. Any areas along these rivers that are less than 12 feet above present sea level could be flooded during such an event.

Transposing areas known to have been flooded during the Hurricane of 1878 on a modern topographic map (Figure 18) of Wilmington, Delaware, shows the vulnerability of such an area to tidal flooding. This is not flooding in the normal sense of heavy rainfall in the drainage basins to the north and west of the City. This is flooding from the Delaware River as a result of the storm surge. From an inspection of Figure 18, it is clear that widespread flood damage is possible if such an event were to occur.

Events such as the Hurricane of 1878 may be rare. As a Wilmington newspaper stated in 1878 when considering the number of church steeples blown down "...but as a hurricane strikes us only once in every two or three hundred years, or so, it hardly seems worthwhile to prepare now for the next one by tearing down the steeples..."(43). This philosophy is common, but shortsighted. The cost of replacing infrastructure and repairing flood damage to buildings today is probably well beyond the cost of that in 1878 even when considering inflation. A storm that caused \$150,000,000 dollars in damage in 1878 would likely be ten or a hundred times that today. Planning and development, whether



Figure 18: Portion of Wilmington-South quadrangle map (USGS, 1993) showing areas of Wilmington along the Delaware and Christiana flooded during the storm surge of the Hurricane of 1878 and that could be flooded by a similar storm today.

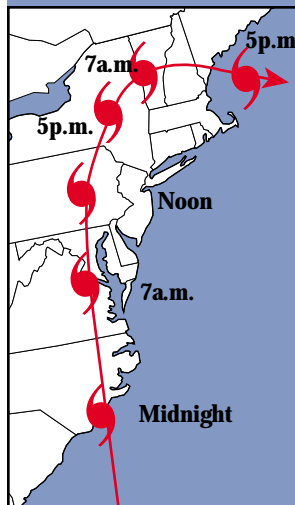
located on high and dry ground or along the waterfronts of our region, should take into account that storms such as that of October 1878 can and do occur.

REFERENCES CITED

1. Monthly Weather Review. War Department, Office of the Chief Signal Officer, October 1878.
2. "A Big House for Buffalo Bill," *The Daily Gazette*, October 22, 1878, Vol. VII, No. 64, p. 1.
3. *The Daily Gazette*, October 22, 1878, Vol. VII, No. 64, p. 3.
4. "The Weather," *The New York Times*, Vol. XXVIII, No. 8459, October 22, 1878, p. 2.
5. "The Storm Elsewhere," *Daily Republican*, October 24, 1878, Vol. V, No. 73, p. 1.

6. "Terrible Storm Down the State," *The Daily Gazette*, October 25, 1878, Vol. VII, No. 67, p. 1.
7. "The Weather," *The New York Times*, Vol. XXVIII, No. 8460, October 23, 1878, p. 5.
8. "The Work of the Storm," *New York Tribune*, Vol. XXXVIII, No. 11, 726, October 26, 1878, p. 1.
9. "The Late Storm: Force of the Wind," *Norfolk Virginian*, October 27, 1878, p. 1.
10. "The Storm Elsewhere," *Every Evening*, Vol. XIV, No. 254, October 24, 1878, p. 1.
11. "The Storm," *Norfolk Virginian*, October 24, 1878, p. 1.
12. "The Effects of the Storm," *The Daily Gazette*, October 24, 1878, Vol. VII, No. 66, p. 1.
13. "New Castle Letter," *The Daily Gazette*, October 25, 1878, Vol. VII, No. 67, p. 4.
14. "The Disaster on the Chesapeake," *New York Tribune*, Vol. XXXVIII, No. 11, 725, October 25, 1878, p. 10.
15. "Havoc on the Eastern Shores of Maryland and Virginia," *Daily Republican*, October 26, 1878, Vol. V, No. 75, p. 4.
16. "The Gale's Violent Work," *The New York Times*, Vol. XXVIII, No. 8462, October 25, 1878, p. 5.
17. "The Storm at Chincoteague," *Every Evening*, Vol. XIV, No. 258, October 29, 1878, p. 3.
18. "Still the Storm," *Every Evening*, Vol. XIV, No. 254, October 24, 1878, p. 3.
19. "Affairs at Seaford," *Every Evening*, Vol. XIV, No. 260, October 31, 1878, p. 1.
20. "Work of a Violent Gale," *New York Tribune*, Vol. XXXVIII, No. 11, 724, October 24, 1878, p. 1.
21. "The Gale Along the Coast," *New York Tribune*, Vol. XXXVIII, No. 11, 725, October 25, 1878, p. 1.
22. "A Ship-Wrecked Sailor," *Daily Republican*, October 29, 1878, Vol. V, No. 78, p. 1.
23. Jakes, John T., diary entry, October 23, 1878, Wyoming, Delaware.
24. *The Delawarean*, October 26, 1878, p. 2.

25. "Storm in Kent County," *The Daily Gazette*, November 1, 1878, Vol. VII, No. 74, p. 1.
26. "Wind Velocity," *The Daily Gazette*, October 25, 1878, Vol. VII, No. 67, p. 3.
27. Bryan, E. D., Ho! For Collins Beach, pp. 49-51.
28. "The Storm in Kent," *Every Evening*, Vol. XIV, No. 255, October 25, 1878, p. 4.
29. Canby, William, diary entry, October 23, 1878, Wilmington, Delaware.
30. "Boreas on a Bender," *Daily Republican*, October 23, 1878, Vol. V, No. 72, p. 1.
31. "Wind and Water," *The Daily Gazette*, October 23, 1878, Vol. VII, No. 65, p. 1.
32. "Last Night's Storm," *Every Evening*, Vol. XIV, No. 253, October 23, 1878, p. 3.
33. "The Storm," *The Daily Gazette*, October 23, 1878, Vol. VII, No. 65, p. 4.
34. "A Surprise," *Daily Republican*, October 25, 1878, Vol. V, No. 74, p. 1.
35. "Letter From New Castle," *Daily Republican*, October 25, 1878, Vol. V, No. 74, p. 1.
36. "Storm Facts," *Philadelphia Evening Bulletin*, Vol. XXXII, No. 171, October 25, 1878, p. 7.
37. "Appendix No. 2," *Annual Report of the Secretary of War for the Year 1878*, Washington Government Printing Office, Vol. II, Part I, pp. 237-43.
38. "Fort Mifflin Storm Damage," *Daily Republican*, October 29, 1878, Vol. V, No. 78, p. 3.
39. "The Hurricane," *Philadelphia Evening Bulletin*, Vol. XXXII, No. 169, October 23, 1878, pp. 1-3.
40. "A Terrific Autumn Gale," *The New York Times*, Vol. XXVIII, No. 8461, October 24, 1878, pp. 1-2.
41. "The Atlantic Coast Gale," *New York Tribune*, Vol. XXXVIII, No. 11, 724, October 24, 1878, p. 8.
41. "Wrecked in the Tempest," *The New York Times*, Vol. XXVIII, No. 8463, October 26, 1878, p. 5.



42. Editorial, *Daily Republican*, October 26, 1878, Vol. V, No. 75, p. 2.
43. "The City and Vicinity," *Every Evening*, Vol. XIV, No. 255, October 25, 1878, p. 1.
44. "Another Victim of the Storm," *Every Evening*, Vol. XIV, No. 257, October 28, 1878, p. 3.
45. "A Floating Corpse," *The Morning Herald*, Vol. XII, No. 7, October 28, 1878, p. 1.
46. "Delaware City," *Every Evening*, Vol. XIV, No. 258, October 29, 1878, p. 3.
47. Coch, Nicholas K., Geologic effects of hurricanes, *Geomorphology*, v. 10, p. 37-63, 1994.
48. Public Ledger Almanac, Philadelphia, 1878.
49. Jayne's Medical Almanac, Philadelphia, 1878.
50. 1878 tide predictions supplied by Tom Kendrick of NOAA/NOS.
51. Wood, Fergus J., *The Strategic Role of Perigean Spring Tides In Nautical History and North American Coastal Flooding, 1635-1976*, US Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, 1976.
52. Weslager, C. A., "Cedar Swamp and the Lost Cedar Creek," *Delaware History*, Vol. VII, The Historical Society of Delaware, 1956-57, p. 14.
53. Florio, Tony, "Tales of Bay View Neck: The Great Tidal Wave," *Delaware Conservationist*, Summer 1973, Vol. XVII, No. 2, pp. 15-18.
54. Caulk, Elizabeth, T., and Anthony J. Florio, "Take a Ramble Along Route 9," *Delaware Conservationist*, Fall 1977, Vol. XXI, No. 3, pp. 4-22.
55. Atlas of the State of Delaware, Pomeroy & Beers Publishers; Philadelphia, 1868.
56. *The Smyrna Times*, October 30, 1878, pp 1-2.

Additional References

British Almanac and Companion, The British Almanac of the Society for the Diffusion of Useful Knowledge, For the Year of Our Lord 1878, London, 1878, p. 33.

Bailey, H.H. & Company Artists, "Wilmington, Del.", lithograph, G. W. Lewis Inc., Albany, N. Y., 1874.

Delaware River from Stony Pt. To Ben Davis Pt., map, U.S. Coast and Geodetic Survey, 1841.

Pielke, Roger A., *The Hurricane*, 1990, p. 228.

Seibold, David J., and Charles J. Adams III, *Shipwrecks, Sea Stories & Legends of the Delaware Coast*, 1989, p. 37.

Scattergood, David, "Collin's Beach", lithograph, Delaware River Illustrated: from Trenton to the Sea, 1861.

Shore of Delaware River: St. George's Cr. To Bombay Hook Lt., U.S. Coast and Geodetic Survey, 1882.

Snyder, Frank E., and Brian H. Guss, *The District: A History of the Philadelphia District, U. S. Army Corps of Engineers, 1866-1971*, January 1974, pp. 127-131.

Tyler, D.B., 1955, *The Bay and River Delaware, A Pictorial History*: Cornell Maritime Press, Cambridge, Maryland, 244 p.

The Hurricane History of Coastal Virginia; Virginia Tidewater Genealogy, Hampton, Virginia. Vol. 21, no. 2, June 1990, p. 54.

Whitefield, E., "View of Wilmington, Del.", Lithograph of Endicott & Co., New York, 1851.

U.S. Geological Survey, Smyrna, Del.-N.J., 15-minute series map, 1/62500 scale, 1927.

U.S. Geological Survey, Shiloh, N.J.-Del., 15-minute series map, 1/62500 scale, 1927.

U.S. Geological Survey, Wilmington-South quadrangle, Digital Line Graphs, 7.5-minute series, 1/24000 scale, 1993.

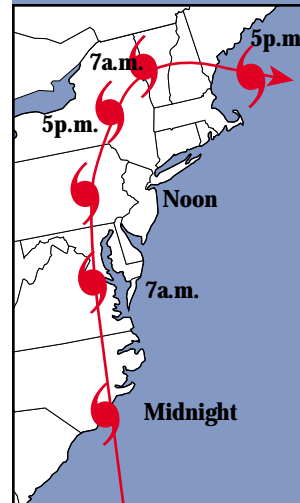
U.S. Geological Survey, Taylor's Bridge quadrangle, Digital Line Graphs, 7.5-minute series, 1/24000 scale, 1993.

Advertisement, *Every Evening*, Vol. XIV, No. 251, October 21, 1878, p. 2.

"Weather Bulletin," *Philadelphia Evening Bulletin*, Vol. XXXII, No. 168, October 22, 1878, p. 8.

"Midnight Weather Report," *New York Tribune*, Vol. XXXVIII, No. 11, 723, October 23, 1878, p. 5.

"The Tempest," *Philadelphia Evening Bulletin*, Vol. XXXII, No. 170, October 24, 1878, p. 4.



“The Great Storm,” *Every Evening*, Vol. XIV, No. 254, October 24, 1878, p. 2.

“Delmar: The Effect of the Gale at the Delaware Railroad Terminus,” and “New Castle: Additional Storm Disasters,” *Every Evening*, Vol. XIV, No. 255, October 25, 1878, p.2.

“The Storm,” *Every Evening*, Vol. XIV, No. 256, October 26, 1878, p.3.

“A Gale’s Disastrous Work,” *The New York Times*, Vol. XXVIII, No. 8464, October 27, 1878, p. 7.

“Repairs on the W. & N.,” *Every Evening*, Vol. XIV, No. 258, October 29, 1878, p. 1.

“The Bodies of Captain Applin and One of His Sons Found,” *Every Evening*, Vol. XIV, No. 262, November 2, 1878, p. 3.

COMMON HURRICANE TERMS*

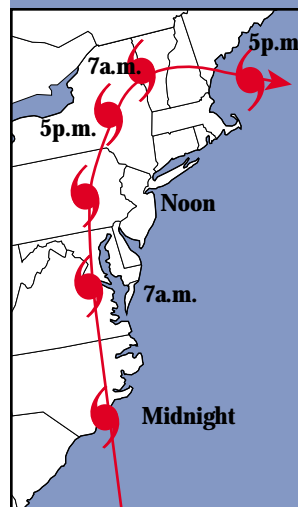
Cyclone: An atmospheric closed circulation rotating counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

Hurricane/Typhoon: A warm-core tropical cyclone in which the maximum sustained surface wind (using the U.S. 1-minute average) is 64 kt (74 mph or 119 km/hr) or more. The term hurricane is used for Northern Hemisphere cyclones east of the International Dateline to the Greenwich Meridian. The term typhoon is used for Pacific cyclones north of the Equator west of the International Dateline.

Hurricane Season: The portion of the year having a relatively high incidence of hurricanes. The hurricane season in the Atlantic, Caribbean, and Gulf of Mexico runs from June 1 to November 30. The hurricane season in the Eastern Pacific basin runs from May 15 to November 30. The hurricane season in the Central Pacific basin runs from June 1 to November 30.

Hurricane Warning: A warning that sustained winds 64 kt (74 mph or 119 km/hr) or higher associated with a hurricane are expected in a specified coastal area in 24 hours or less. A hurricane warning can remain in effect when dangerously high water or a combination of dangerously high water and exceptionally high waves continue, even though winds may be less than hurricane force.

Hurricane Watch: An announcement of specific coastal areas that a hurricane or an incipient hurricane condition poses a possible threat, generally within 36 hours.



Tropical Depression: A tropical cyclone in which the maximum sustained surface wind speed (using the U.S. 1-minute average) is 33 kt (38 mph or 62 km/hr) or less.

Tropical Disturbance: A discrete tropical weather system of apparently organized convection—generally 100 to 300 nmi in diameter—originating in the tropics or subtropics, having a non-frontal migratory character, and maintaining its identity for 24 hours or more. It may or may not be associated with a detectable perturbation of the wind field.

Tropical Storm: A tropical cyclone in which the maximum sustained surface wind speed (using the U.S. 1-minute average) ranges from 34 kt (39 mph or 63 km/hr) to 63 kt (73 mph or 118 km/hr).

Tropical Storm Warning: A warning for tropical storm conditions including sustained winds within the range of 34 to 63 kt (39 to 73 mph or 63 to 118 km/hr) that are expected in a specified coastal area within 24 hours or less.

88

Tropical Storm Watch: An announcement that a tropical storm poses or tropical storm conditions pose a threat to coastal areas generally within 36 hours. A tropical storm watch should normally not be issued if the system is forecast to attain hurricane strength.

Tropical Wave: A trough or cyclonic curvature maximum in the trade-wind easterlies. The wave may reach maximum amplitude in the lower middle troposphere.

*from National Hurricane Center Tropical Prediction Center web site

Special Publication No. 22



State of Delaware
Delaware Geological Survey
Robert R. Jordan, State Geologist