**PBS NOVA: Inside the Megastorm (November 2012)**

NARRATOR: Anatomy of a catastrophe.

FIREFIGHTER: The mayor of the City of New York has ordered a mandatory evacuation.

NARRATOR: Superstorm Sandy slams the Northeast.

[WAVES CRASHING]

MARTY INGRAM: : And the water never stopped coming.

ARIEL FAHY: It came down, and it just washed everything away.

NARRATOR: Dozens dead, tens of thousands homeless, entire communities obliterated.

ARIEL FAHY: The entire sky was just lit up.

GUY FERRARO: Like a bomb went off.

NARRATOR: Are lethal storms becoming more frequent, more destructive, even more deadly?

SANDY MACDONALD: It really was a combination of the worst that nature delivers in storms.

NARRATOR: Storm chasers take you inside the eye of Hurricane Sandy for a blow-by-blow account of an epic natural disaster.

JEFF WEBER: So it came in right at high tide during a full moon, record storm surge with incredible winds.

NARRATOR: How vulnerable are the most populated cities?

JEFF WEBER: So there were parts of Manhattan that were being impacted 25 feet above sea level.

NARRATOR: Can we engineer our way to safety if Sandy is a sign of things to come? "Inside the Megastorm," a special presentation, right now on NOVA.

[THEME MUSIC PLAYING]

MALE ANNOUNCER 1: Major funding for NOVA is provided by the following. The David H. Koch Fund for Science, supporting NOVA, and promoting public understanding of science.

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MALE ANNOUNCER 1: And the Corporation for Public Broadcasting, and by PBS viewers like you. Thank you. Additional funding from Lockheed Martin, inspiring tomorrow's engineers and technologists. And Millicent Bell, through the Millicent and Eugene Bell Foundation.

[MUSIC PLAYING]

NARRATOR: In the warm waters of the Caribbean, a tropical storm is forming, one that is about to write its way into the history books. It's the 18th storm of the Atlantic season. The National Weather Service assigns a name from near the bottom of this year's predetermined list, an innocent-sounding label for what will soon become, against all odds, a devastating megastorm, Sandy.

It's October 22nd 2012.

MATT LAUER: --storm Sandy. Al, good morning.

AL ROKER: That's right. All eyes right now on the Caribbean, Matt. Sandy is 120 miles-- it's 120 miles south of Kingston, Jamaica. 70 mile per hour winds, just not quite a hurricane yet.

[WAVES CRASHING, MUSIC PLAYING]

NARRATOR: Tropical storms are a fact of life in the Caribbean but only about half strengthen into hurricanes.

JEFF WEBER: Hurricanes are systems that are born in the tropics. And they need to have 26 degrees Celsius, approximately 80 degrees Fahrenheit water, to get the systems going. They actually act as a heat engine. They take the warm water, and rise it up as water vapor. And as that water vapor condenses, it releases latent heat into the atmosphere. And that's where the wind energy is coming from.

NARRATOR: Only one in 20 Atlantic hurricanes ever strikes the east coast. Odds are that Sandy will do what virtually all of these hurricanes do, head into the Gulf of Mexico, like Katrina, or blow into the cold Atlantic and fade harmlessly away.

But then, a startling prediction from 4,000 miles away upends all expectations. A day even before Sandy has been named, the supercomputers at a European Weather Center predict that she will not follow the normal course.

TIM HEWSON: Conventional wisdom said that Sandy would move towards the north because it was in the Caribbean, and then towards the Northeast, and then it would die, and not effect land. But there were suggestions that the hurricane might not behave in the normal way, and might actually end up over the Northeast of the US.

NARRATOR: Worse than that, the model goes on to predict that once Sandy reaches the Northeast, it will make a sudden, improbable left turn, sending it straight into the heart of the Jersey Shore and New York City.

SANDY MACDONALD: When the European Center model came out, eight days before, I think the reaction was, this is a really dangerous possibility, but it's so far in advance, we're going to just have to watch this.

NARRATOR: Now late in October, with the hurricane season drawing to a close, New Yorkers are preparing Halloween parties, not thinking about a storm.

[MUSIC PLAYING]

But that's about to change, because the storm with the innocent name is about to ring their doorbell, dressed as a monster.

[THUNDER]

1,000 miles to the south, Sandy is becoming a storm to be reckoned with. Since her birth as a tropical depression, she has steadily gathered energy, fed by the warm tropical waters. On October 25, she is officially upgraded to a category 2 hurricane. With sustained wind speeds of more than 110 miles per hour, she has already brought devastating winds and fierce rains to Haiti and Jamaica, and now heads north to Cuba and beyond. At this point, computer models at NOAA, the National Oceanic and Atmospheric Administration, are still showing several possible paths.

ADAM SOBEL: The American model, like all these models, was run in an ensemble mode, where the model is run many times each day. And as late as Wednesday or Thursday, the 24th or 25th, the American model had some tracks coming in and making landfall, but other tracks going out to sea. And by about Thursday or Friday, the American model started to agree more with the European models, and we became quite confident that Sandy would make the left turn, and come into the mid-Atlantic region.

NARRATOR: Now all the models are converging, forecasting that Sandy will swing sharply around from its Northeast track, and crash into New York and New Jersey and much of the East coast. Parts of the coastlines of New York and New Jersey are only a few feet above sea level. Strong winds could push the ocean right onto the land, causing extensive flooding.

ADAM SOBEL: It was quite clear that there was a possibility of a very high storm surge, and that it could be a catastrophic event.

MAN ON RADIO: The time now is 13:07.

NARRATOR: The city's emergency services-- police, fire, and hospitals, begin to prepare for the worst.

POLICE OFFICER: We started on the Thursday before the storm hit, people checking their equipment, checking their pumps, making sure our boats were in order-- all the prep that you would do for a storm.

NARRATOR: But despite all the warnings, there remained plenty of doubters.

MICHAEL CLARKE: We thought they were just amping it up more than what it was to cover themselves, basically.

LINDA CLARKE: We said, oh, yeah, here comes another storm.

[DRAMATIC MUSIC PLAYING]

NARRATOR: Sandy heads north out of the Caribbean, leaving more than 70 dead and dozens missing. It is a massive system, sending tropical-storm-force winds across an area nearly 600 miles wide. Now the first of many unusual meteorological conditions begin to affect the storm's path.

JEFF WEBER: There is a high pressure system that kind of lives over Bermuda. It's called the Bermuda High. And generally speaking, Atlantic systems will kind of come along on the bottom side of that high, and then kind of curve around it, and move its way back out into the eastern Atlantic.

NARRATOR: But this time, there's no Bermudan High to steer Sandy away from land, so the storm heads to the Northeast, parallel to the eastern seaboard. Though most of the ocean gets colder, Sandy feeds off a ribbon of warm water that keeps it alive, The Gulf Stream, a circulating current that pumps warm water from the Gulf of Mexico up and across the Atlantic. And right now, the surface waters are even warmer than usual.

RADLEY HORTON: Parts of the North Atlantic were five degrees warmer than normal. And you could see, as you watched those satellite images, as Sandy passed over that unusually warm water, it increased in strength. You could see new convection, new thunderstorms forming.

NARRATOR: Though Sandy is still more than 200 miles off the US coast, storm-force waves and winds have been pounding Florida and North Carolina, knocking out highways. At 5:00 AM on Sunday, NOAA meteorologist Dr. Alexander "Sandy" MacDonald flies NOAA's P3 Orion right into the heart of the hurricane in order to get a firsthand look at the anatomy of the growing storm.

SANDY MACDONALD: We take a lot of measurements that allow us to determine what the hurricane is going to do. Is it going to intensify? Where is it going to go? When the answers start to emerge, the news is not good. Sandy is undergoing a dangerous transformation. Sandy is rolling up the eastern seaboard, feeding off of the Gulf Stream waters. As we roll into the 28th of October, Sandy is starting to expand and lose its tropical characteristics.

NARRATOR: As they move north into cooler waters, most hurricanes begin to fade. But since these waters are warmer than normal, Sandy doesn't flag. Even worse, flying through the heart of the hurricane, Dr. McDonald sees something shocking. Sandy is actually growing in size, with the help of a second storm.

SANDY MACDONALD: It had been a fairly normal category 1 hurricane. But as it came north, there was what we call a Nor'easter. The Nor'easter is a winter storm that has been developing inland, parallel to Sandy's track north. A Nor'easter can be 500 or 700 miles across.

NARRATOR: From his vantage point inside the hurricane, Dr. MacDonald can see the two storms morphing into a hybrid, a superstorm.

SANDY MACDONALD: It had the big size, the huge rains. And right in the center of it, it had those super-strong winds and super-low pressure. It really was a combination of the worst that nature delivers in storms-- two put together.

[MUSIC CRESCENDOS, THEN FADES]

NARRATOR: Sandy is no longer a hurricane that can fade and die as the water temperature falls. It's become too big and powerful.

[CAMERA SHUTTER CLICKING]

Now, with Halloween just days away, news services have given Sandy a new name, Frankenstorm.

CHARLIE ROSE: --a new word to describe the potential impact of Hurricane Sandy on the east coast. They're calling it Frankenstorm.

[MUSIC PLAYING]

NARRATOR: In New York, full-scale preparations are underway for a major hurricane hit.

SALVATORE CASSANO: Sunday morning, we were on a conference call with the National Weather Service and the National Hurricane Center. The tone of the report they gave us on Sunday morning, sort of started to realize this was going to be as bad a storm as they had predicted all along.

FIREFIGHTER: Residents of Broad Channel, the mayor of the City of New York has ordered a mandatory evacuation of the island of Broad Channel.

NARRATOR: Officials in both New York and New Jersey order a mandatory evacuation of flood-prone areas. But not everyone is prepared to heed the warning. And many know just what to blame for that-- Hurricane Irene. In August 2011, Hurricane Irene hit New York. It was a powerful and destructive storm. But because it didn't inflict as much damage as predicted, it left New Yorkers skeptical.

JEFF WEBER: I have family and friends in the New York and New Jersey area. And they were asking me, they said, well, is this going to be like Irene? Because we were fine with Irene. We didn't have any problems with Irene. And I had to respond to them saying, no, this is much bigger. This is going to have a far greater impact than Irene.

NARRATOR: For the skeptics, Irene holds out a false promise that city services, like electric power, could escape without disruption.

JOHN MIKSAD: Irene was sort of a dry run. Nothing-- not the generation system, not the transmission system, not the substations nor the distribution system were impacted by floodwaters in Irene.

NARRATOR: But any hopes that the city would escape unscathed this time around are dashed, when at 7 PM, the New York Transit Authority system begins to shut down. The city's lifeline, the subway, closes.

JOSEPH LHOTA: It takes about 12 hours to completely shut down the New York City subway system. And we did not want to bring everybody into New York City on Monday and strand them here. So that's why we proposed the beginning of a shutdown of the subway system on Sunday night at 7 o'clock, and all of our assets were tied up and locked up by 3 AM Monday morning.

NARRATOR: 5,900 buses, and 8,663 subway and rail cars are now parked. 2,047 miles of track, above and below ground, are empty. Also within its complex network are 14 underwater subway tunnels, 14 tunnels into which, if the water pours, it doesn't come out. The city that never sleeps is closing up shop.

[FAST CELLO MUSIC PLAYING]

Sandy is now 425 miles from New York. The hybrid, two storms in one, spreads tropical storm force winds over more than 1,000 miles, carrying the energy of five Hiroshima bombs. Still traveling parallel to the coast, it runs headlong into the most significant event in its seven-day life, a massive system of high pressure looming over the Atlantic.

ADAM SOBEL: A so-called blocking high, or high pressure system, was forming out in the Atlantic around the southern end of Greenland. And those blocking highs prevent storms from making their way out to sea.

NARRATOR: But Sandy does not simply grind to a halt. High in the atmosphere are fast-moving winds, collectively called the jet stream, normally traveling west to east. But in this case, the jet stream isn't following its normal west-to-east course. Disrupted by the high pressure system to the north and the winter storm, part of the jet stream turns back toward the west.

RADLEY HORTON: Most storms, as they get about as far north as New Jersey, especially this late in the hurricane season, are picked up by the jet stream, and moved to the east. This storm, it became more and more clear, was going to take that turn to the west that would bring millions of people into harm's way.

[EERIE MUSIC PLAYING]

NARRATOR: Early on October 29, the forecasters' predictions come true. Sandy takes a sharp left. If there had been any doubt, it's gone by now. Sandy will slam into the east coast in a little more than 12 hours, right at high tide, the worst possible timing.

ADAM SOBEL: At that point, my scientific fascination started to mix with actual fear for the fate of the city and the surrounding areas.

[WAVES CRASHING]

JOHN MIKSAD: We were certainly in a heightened state of awareness. We had our emergency response center running, made sure that all the floodgates in our generating stations and substations were prepared. I would say "anxious" would probably be a good description of the mood in here.

NARRATOR: Air traffic in and out of New York and New Jersey is grounded. Both states are now being battered by winds of 75 miles per hour.

[WATER RUSHING]

The New York Stock Exchange closes for the first time since 9/11. Even though the eye of the storm is still 260 miles from Atlantic City, 310 miles from New York, the battery promenade in lower Manhattan is already underwater. The sea level is already three or four feet above normal.

RADLEY HORTON: Monday morning, a full 10 or 12 hours before the storm was forecast to make landfall, you were already seeing record-high flooding levels throughout the New York City region.

[STRING QUARTET PLAYING MELANCHOLY MUSIC]

NARRATOR: It's the beginning of the powerful storm surge, driven by the unrelenting winds.

ADAM SOBEL: As the wind pushes on the water, if it pushes it towards the shore, then when the water gets close to the coast, where the bottom is shallow, the water level gets raised. And that's the storm surge. And that comes on top of whatever the tide is.

NARRATOR: The worry is that if Sandy strikes at high tide, the resulting storm surge will overwhelm the city, particularly lower Manhattan, parts of which are less than 10 feet above sea level, and do the same to a vast expanse of the New Jersey Shore.

At around 11 AM, veteran storm chaser Scott McPartland heads towards the Bronx.

VIDEOGRAPHER: Back up a bit?

SCOTT MCPARTLAND: Yeah, well, I want to go to one of these side streets. We should go to another vantage point. Like, try to get down--

VIDEOGRAPHER: And shoot this way.

SCOTT MCPARTLAND: Yeah, yeah, yeah.

Well, we first left the house about 11 o'clock in the morning on Monday, the day of the storm, and we traveled right up to Whitestone, Queens, right at the foot of the Bronx Whitestone Bridge. When we got there, the water was already pouring over the seawall. It was inundating neighborhoods. It was already in people's backyards, already in people's homes at this point. When I saw this taking place, and it was still so early in the day, and we knew that the worst of this storm is still many hours away, that's when it really started to set in that this storm was really going to be as bad as everybody said it was going to be.

[OMINOUS MUSIC PLAYING]

NARRATOR: Exactly as predicted, as Sandy gets closer to land, it absorbs energy from the high altitude wind of the jet stream.

JEFF WEBER: So it went from 18 miles an hour to about 28 to 30 miles an hour. That speed increase will increase the surge, increase the waves, increase the wind, and allow it to make faster progress inland.

NARRATOR: Within the storm, wind speeds rise to over 90 miles per hour as Sandy accelerates.

[AMBIENT MUSIC PLAYING]

The monster drives a surge of water toward the New Jersey Shore and the five Boroughs of New York City. Scott is stationed in low-lying Queens at 4 PM, with 5 hours to go before the peak of the storm. And even for him, the sudden influx of water is alarming.

SCOTT MCPARTLAND: Water at this point, at Rockaway Beach, was already hitting the boardwalk. The storm surge is winning already. It was the first time that I could remember that the ocean really scared me. Seeing the water in that state, it was whitewater. You could feel the entire boardwalk shaking as you're standing on it. At this point, there were still people-- residents, wandering on the-- walking their dogs. I think, at this point, most people did understand how serious this was, but there still seemed to be a few that didn't get it.

[FAST CELLO MUSIC PLAYING]

NARRATOR: Rockaway, a low-lying area at the south end of Queens, is within the evacuation zone. In late afternoon, things begin to go wrong for residents like Shatisha Hayward.

SHATISHA HAYWARD: The lights start to flicker on and off. Then they went off. They came back on, then they went off again. They came back on, and then around 5:30 they were completely out, and it was dark.

NARRATOR: Her six children are frightened.

SHATISHA HAYWARD: Because it was just like, mom, the lights went off. Turn the lights back on. And I'm like, I can't turn the lights back on.

NARRATOR: Near Rockaway Beach is the Breezy Point neighborhood, perched on a narrow spit of land. The local volunteer fire crew has spent several days preparing to protect those who would not or could not leave

MARTY INGRAM: We had purchased food, we had sleeping gear. Our plan was to hunker down here, and shelter in place, and make sure the trucks' batteries, the water, gas, everything was at prime.

NARRATOR: But despite their best efforts, Breezy Point is about to become one of the worst-hit casualties of Sandy's fury when the storm surge submerges the entire town.

MAN 1: There it is, huge storm surge [? live. ?] Hey buddy, here we go. Oh my gosh. [INAUDIBLE] six inches, a foot of water.

MARTY INGRAM: At 5:30, the tidal surge came. And that was 2 and 1/2, 3 hours before moon high tide. And the water never stopped coming.

ARIEL FAHY: When I tell you the storm hit like a bolt of lightning, it came down, and it just washed everything away.

NARRATOR: As water floods the town, members of the fire department urge residents to retreat to the relative safety of the local community center. But soon, that building also begins to flood.

ARIEL FAHY: We had a marble floor in there. It was bubbling up through the seams by the marble. And we were three hours away from high tide, and we knew we were in for an interesting evening.

NARRATOR: All across New York City, the storm surge builds, amplified by an accident of geography.

MALCOLM BOWMAN: Long Island Sound is shaped like a funnel. And winds pushed this water into western Long Island Sound, and that squirts through the East River, into New York Harbor.

NARRATOR: The narrow waterway concentrates the waves that pound not only Queens, but the harbor, and especially Staten Island.

[DRAMATIC ORCHESTRAL SCORE PLAYING]

[WAVES CRASHING]

On Fox Beach Avenue, ex-Marine John Filipowicz and his son, John Jr., have been feverishly working to protect their home.

John Sr.'s brother, Neil, was staying in touch by phone.

[AMBIENT MUSIC PLAYING]

NEIL FILIPOWICZ: I spoke to him in the afternoon. I had asked him, do you want me to come down? He said, no, that's all right. I got Johnny. I'll be OK. He prepared his home for it. He not only sandbagged the door downstairs, he put a expandable foam and tape around the creases in the door. There was no way the water was getting in.

NARRATOR: But the nightmare was just beginning.

JEFF WEBER: People in New York City were experiencing hurricane-force winds for eight hours or more. Hurricane Sandy had an expanse of about 1,000 miles. It was huge. It takes a long time to move 1,000 miles of weather across a city.

NARRATOR: On the Rockaways, the surge inundates the streets.

SHATISHA HAYWARD: It got darker. The water started to rise. And my 14-year-old son, he came and he said, mom, the water is over dad's car. So I'm like, no, the water can't be over dad's car.

CHILD: Whoa.

[WIND GUSTING]

SHATISHA HAYWARD: I looked out the window. The water was over my husband's car.

[PEOPLE SCREAMING]

I mean, you can hear people screaming, help. It was like a nightmare, like a pitch black movie. And they were just yelling, help. You heard a young lady, and you heard a couple of male voices. And there were screaming, help.

[WIND GUSTING]

[MUSIC PLAYING]

NARRATOR: With people struggling in the dark, power company technicians who have been anxiously monitoring their systems suddenly find the entire grid in peril.

JOHN MIKSAD: Around 7 or 8 o'clock, we got the word that they're being overcome, and that the water is getting into the underground system.

NARRATOR: Most of Manhattan's transmission lines and many circuit breakers are located below ground. Salt water and electricity are a dangerous mix. In order to prevent electrical fires, Con Ed makes a brutally tough call. The power company pulls the plug, plunging much of lower Manhattan, including Wall Street, into darkness.

Across the harbor, in the close-knit Staten Island community, conditions continue to deteriorate.

MICHAEL CLARKE: I stayed till about 7:30, 8 o'clock, try moving cars up a few blocks that way. By the time I came back here to get dry clothes out of the house, the water was probably up to here on me.

[STRING MUSIC PLAYING]

It was like a tidal wave. Boom, in.

NARRATOR: Michael Clarke's parents, Linda and Bob, live just around the corner. They don't want to abandon their home.

LINDA CLARKE: We have two dogs and a cat. Then he said-- oh, and chickens. He had two chickens--

[CHUCKLING]

--which I think he's worried about more than anything. But--

ROBERT CLARKE: Doing the backstroke.

LINDA CLARKE: He said, oh, I think we'll stay. I think we'll stay.

NARRATOR: By the time Linda finally decides to drive out on her own, it's too late.

LINDA CLARKE: I put the key in the ignition, and I looked up, and I saw a wave of water coming around Cedar Grove Avenue. And I said, oh my God. And I went to get up of the car, because I realized it wasn't going to start. And the wave hit the car. And I had to push my way Out of the car because the water was coming against the door. And I tried to make it to the back of the house, and the water was pushing me away. I was screaming. Bob came running out, and he pulled me up. He helped me get up the stairs. He pulled me out of the water. And we ran for the bedroom, because he said, we have to get in the attic. We have to get in the attic.

NARRATOR: Linda and Bob are not the only residents fearing for their lives. 911 calls from Staten Island are flooding the fire department switchboard.

SALVATORE CASSANO: Just dealing alone with Staten Island would have been enough for the department, without anything else going on. So that was another point of concern for me, in that Staten Island was really, really being wiped out. I live on Staten Island. So my family was there.

NARRATOR: But on higher ground, in parts of Brooklyn, Sandy feels like a bad storm, not a catastrophic killer.

MARCIA SIKOWITZ: I was listening to the news, and hearing about what was coming to the areas on the shore, and realizing this seemed like it was going to be a substantial storm. But I didn't have any real concerns for our safety or comfort where we were in Brooklyn.

NARRATOR: When [? Jacob ?] [? Vogelman ?] receives a call for help from a friend, he tells his mother he's going to brave the strong winds and rain.

MARCIA SIKOWITZ: When Jake said he was going out, and I knew they kept saying, the peak of the storm will be in 40 minutes, I said, Jake, I don't think this is a really good time to be going out. And he said, well, Jesse needs me to come over. And that was it. I mean, Jesse needed him, and he went.

NARRATOR: The storm is reaching its peak. Close to 8 PM on October 29th, the eye of the storm hits Atlantic City, New Jersey, bringing wind speeds of more than 80 miles an hour and waves higher than 40 feet.

JEFF WEBER: Once the eye makes its way onto land, that's the most intense part of the system. The eye wall is where all that energy and wind energy is at.

[DRAMATIC CELLO MUSIC PLAYING]

Atlantic City suffered extreme damage-- severe storm surge and monstrous flooding. And they also record the lowest pressure ever recorded in Atlantic City, at 940 millibars.

WOMAN: This is worse than Katrina in size. We never went through anything like this.

MAN 2: 30 minutes, the water was up four feet. And just watching it come up each step.

PUBLIC SAFETY OFFICIAL: Unprecedented in my 20-year career in leadership in emergency management in this county.

[RAIN FALLING]

GUY FERRARO: A wind came through here like I've never seen. Sounded like a train coming.

[WIND ROARING]

And I had like 10 sliding doors all in a line in the back. They all just exploded from the wind, like a bomb went off.

[CRASHING NOISES]

And then, minutes later, the whole roof went up in the air. It was like Wizard of Oz.

[WIND SHRIEKING]

There was 10 feet of water all the way around me. There was just no way for me to go. So after the roof blew off, and then all the walls caved, the floor went down into the basement, I swam to that car there that you see, and got inside of it.

NARRATOR: Throughout the region, people are finding themselves in life-or-death situations. In the Rockaways, Shatisha and her six children are trapped by floodwaters. She calls 911.

SHATISHA HAYWARD: We got a voicemail. And it was saying, everybody's call is important, leave a message. But I wasn't leaving no message. This is 911. And I know 911 will pick up their phone. So I was able to get on Twitter. I was able to get on Twitter. And I tweeted. And I was like, a huge shout out to the FDNY.

NARRATOR: At the fire department control center, Emily Rahimi runs social media.

EMILY RAHIMI: I was prepared to be tweeting out safety information. And I started getting a lot of tweets from people who said they did not have phone service, that they would try calling 911, and they'd have them on there for a second, and then it would drop. A lot of them still had some connectivity with their phones to something like Twitter. And so that was just their way of reaching out somehow to get to somebody to help them.

NARRATOR: Shatisha's desperate tweet appears on Emily's screen.

EMILY RAHIMI: I remember she and her six boys were trapped in their house. Floodwaters were rushing in, and she was really panicked. She didn't want to see her children in danger. And I knew I had to do something to help. So I started calling fire department dispatchers to make sure that they had that information.

NARRATOR: At 8:30 PM, the Hudson River breaches its banks, and inundates the West Side Highway in Manhattan. From there, it floods a critical electrical substation. Salt water hits the cables carrying power to 1/4 million New Yorkers.

[EXPLOSION]

The result is cataclysmic.

[DISTANT SHOUTING]

[EXPLOSION]

[SHOUTING CONTINUES]

JOHN MIKSAD: With that explosion, 10 networks went simultaneously, which basically took out everything from 34th Street down to the Battery, almost half of this island.

NARRATOR: Lower Manhattan goes dark.

MAN 3: You would never think this was happening in New York. So the best way to deal with it now is just not panic. People just gotta stay civil.

NARRATOR: By now, three million people in New York and New Jersey are without power. As bad as conditions are in lower Manhattan, the situation at Breezy Point is far worse. For a still unknown reason, a house bursts into flame, and fire quickly spreads.

ARIEL FAHY: The entire sky was just lit up in the reddest, orangest color you could ever imagine. I called my mom, and she was hysterical on the phone. She was like, just say a prayer. It was a very emotional time.

[CHUCKLING]

I didn't know how I was going to get out.

[AMBIENT STRING MUSIC PLAYING]

NARRATOR: Meanwhile, the volunteer fireman are trapped by ever-rising floodwaters in their community center. They can do nothing while their town burns.

[CAR ALARM SOUNDING]

Parts of New York and New Jersey are now under 14 feet of water or worse.

JEFF WEBER: Now keep in mind that, on top of that storm surge, you also have the wave action. And there are ways 10, 15 feet high in this storm. So there are parts of Manhattan that were being impacted 25 feet above sea level.

NARRATOR: By now, the water coursing across lower Manhattan is pouring into the subway system. MTA Chief Joe Lhota is powerless to stop his beloved network from being overwhelmed.

JOSEPH LHOTA: This is worse than my worst fear. The water from the Hudson River was flowing down into the Battery Tunnel. There were white rapids flowing into the tunnel. And it sounded like a waterfall. It ended up, the Brooklyn Battery Tunnel, each tunnel had 43 million gallons of water. Over 6,000 feet-- more than a mile-- filled with water, floor to ceiling, side to side, completely filled up all the way. At the fire department command post, calls for help continue to come in from every direction.

SALVATORE CASSANO: But I got a six alarm fire in Breezy Point--

[SIRENS BLARING]

--I got tons of people trapped in the water, I got a fire on City Island--

[INDISTINCT SHOUTING]

--I got people in Garretson Beach calling that they're trapped. I got people in lower Manhattan that have no power.

NARRATOR: At 9 PM, as the peak of the surge finally passes and the waters begin to recede, the Breezy Point firefighters manage to make their way back to their flooded station, where at last they catch a break.

MARTY INGRAM: Miraculously, even though these trucks were under water, they did start up. Once we started driving, the firemen stayed with the trucks, and we started rescuing other people.

ARIEL FAHY: I saw the flashlight going back and forth. They were like, the fire's coming this way. You need to get out of here. It's not safe anymore. When I finally got up to the firehouse, my dad was up there. And he just saw me, and grabbed me, and didn't let go.

NARRATOR: In Rockaway, firefighters alerted by her tweets rescue Shatisha Hayward and her children. Her desperate husband finally manages to get through to her.

SHATISHA HAYWARD: I said, we're safe, we're fine, we're on a boat. And he was like, a boat? What do you mean, you're on a boat? And we joke a lot. So he basically was like, Shatisha, I'm really not playing with you at this time. So I kept saying to myself, I'm like, babe, I'm really not joking. I'm so serious. We're on a boat.

NARRATOR: In Ocean City, Guy Ferraro has been trapped in his flooded car for nearly five hours.

GUY FERRARO: You knew the tide was going out. And by then, my legs were completely numb. I couldn't feel them at all. I was only in pajamas at that point at that point. I waited until I saw the police lights. And I knew that I couldn't stand the cold too much longer. And I knew I could get across that road. I was certain I could get across that road by that time. Because it was just bedlam-- people screaming for hours, and hours, and hours for help.

NARRATOR: The emergency services are now receiving 20,000 911 calls every hour. In Staten Island, Michael Clarke has heard nothing from his parents for hours. The water has made reaching them by foot or by car impossible.

MICHAEL CLARKE: I call my friend Brian. I said, Brian, you've got a boat. Get something, do something, get down here.

LINDA CLARKE: It was dark. We couldn't see anything. We had one little flashlight. And I kept saying to Bob, Bob, is the water coming up more? Because I was afraid that it was going to come up so high, and there was no way out of the attic. But he kept saying, no, no, Linda. It's not coming up. It's not. I go, Bob, I think it's going to come up, and we're going to drown.

MICHAEL CLARKE: Banging on my mother's door, and hearing their voice, it was like hitting the lottery. My mother looked at me, and said, what the hell are you doing here?

LINDA CLARKE: I just started crying hysterical. I just--

ROBERT CLARKE: I said, you're nuts, Michael. What are you doing here? He said, I come to get you and mom. You didn't call. I said, how am I going to call? The phone's broke. I drowned it. That was that.

MICHAEL CLARKE: What else could you do? I assume anybody would do it for their parents, right?

NARRATOR: Just before dawn, nearly 300 firefighters are finally able to converge on Breezy Point. But in the cruelest of ironies, they discover that low pressure in the fire hydrants has left them desperately short of the one thing they need most, water. They stand by and watch as more than 100 houses burn to the ground.

[PENSIVE STRING MUSIC PLAYING]

When the sun rises on Tuesday, October 31, large parts of New Jersey, New York, and Long Island are like war zones, with damage extending up and down the eastern seaboard.

[SIRENS BLARING]

The death toll will reach 200 people, which includes more than 70 who lost their lives in the Caribbean.

[SIRENS BLARING]

NEWS ANCHOR: When daylight came, the severe and widespread damage from Hurricane Sandy was painfully clear.

WOMAN 2: Nothing's going on, no traffic lights, no street lights, just there's cops everywhere. There's just debris and wetness everywhere.

[MELANCHOLY STRING MUSIC PLAYING]

NARRATOR: Ships have been tossed onto land, houses driven from their foundations.

MAN 4: You can see the foundation right here. [INAUDIBLE] You can see everything underneath here, all the water. The pipes broke up there.

NARRATOR: More than 8 million people are without power. The Jersey Shore, where for decades millions have enjoyed spending the summer, has been virtually wiped out. Eight counties have already been declared disaster areas. 5,500 residents seek refuge in emergency shelters.

On Staten Island, Neil Filipowicz finally makes his way to Fox Beach Avenue. He's been trying unsuccessfully to reach his big brother, Flip, and nephew John. They had chosen not to evacuate in order to protect their home.

NEIL FILIPOWICZ: I'm going to yell at them for not calling anybody to let us know that he was OK. I was-- I'm like, here we are, everyone's trying to get in touch with him, his phones aren't working, no one's answering, it's going right to voicemail.

NARRATOR: Across New York and New Jersey, landlines and mobile phone towers are down. So when he finally arrives, he's unprepared for the chilling scene before him.

NEIL FILIPOWICZ: The wall on one side was pushed in. All the cinder blocks were missing of the foundation. And I saw the water, and I said, wow, this house got really destroyed. I made my way down in the basement, and it was completely pitch black down there. I was calling them, but I didn't have a flashlight. And like I said, it was completely dark.

NARRATOR: But there was no sign of his brother or nephew.

In Brooklyn, Marcia Sikowitz had also been searching for hours, trying to reach her son, Jake. Jake had never returned from going out to help his friend, Jesse.

MARCIA SIKOWITZ: I just started calling his cell phone every 15 minutes, which I knew didn't make a whole lot of sense. But I didn't know what else to do. And finally a man answered his phone. And I said, where's my son? I thought maybe he had been mugged, or you know, why was this man answering his phone? I said, where's my son? And he said, what's your address? And I said, where's my son? And he said, this is Detective Simon. Tell me your address. I'm coming over to your apartment.

NARRATOR: A short time later, five officers arrived bearing the worst possible news. Jake and his best friend Jesse were killed by a falling tree at 7:45 the previous evening. The emergency services were so overwhelmed they hadn't reached their bodies for nearly 12 hours.

MARCIA SIKOWITZ: One of my neighbors said there was a disturbance in the force, you know, the force of goodness of Jake and Jesse. Somehow there was a disturbance, like God looked away for a second, and something terrible happened.

[STRING MUSIC PLAYING]

NARRATOR: Neil Filipowicz has still had no luck tracking down his brother and nephew. Neil returns to his brother's damaged home for another look.

NEIL FILIPOWICZ: Like I said, when I came in, I didn't get very far. And I panned-- from this way here-- around, with the good flashlight that I had. I went to the left and I saw, in this area right here, a hand. And I was praying, please let that be a doll's hand. I reached in with my right hand, and I pulled up, and I could see my brother's face, and right behind it was my nephew's. And they came up together out of the water. And I seen my brother had his other hand-- his right hand-- around his back. And my nephew was holding him around the waist, with his head buried in his chest. And I can only think that they knew they were going to die. And they just grabbed a hold of each other, to say, well, I got you.

NARRATOR: John left behind his wife, Christine, and their two surviving children.

[HELICOPTER ENGINE RUNNING]

At Breezy Point, residents estimate more than 100 homes have been consumed by fire. Debris and sand are everywhere. Yet incredibly, not a single person has died, thanks in part to the heroic efforts of the local fire volunteers.

MARTY INGRAM: Pulling up to the scene on the south edge, and seeing the flames just in the sky, and then walking into the fire, that memory will never leave. And seeing my men, you know, just unrestrained and motivated, without any fear, and so dedicated to others and not themselves. It's so outstanding. I'm so proud of them.

NARRATOR: Transportation infrastructure has been crippled. Seven subway tunnels are flooded to the roof. 6 bus garages are underwater.

JOSEPH LHOTA: We didn't know-- at that point, we had no idea of the severity of the situation. We knew it was bad. We just didn't know how bad it was.

NARRATOR: The Army Corps of Engineers is called in to help the city pump hundreds of millions of gallons of water. Engineers set out to assess the severity of damage caused by the corrosive saltwater.

MATTHEW ALBANESE: You have to understand, saltwater is brine. It eats up everything. All the signal equipment is going to have to be taken out, dried, and tested. The wires that were on the side of the tunnel walls and whatnot just cooked. I mean, all that you saw was bare copper when you came down here. You had that smell of diesel fuel, human waste, everything. It was like a cornucopia of rotten smells.

NARRATOR: Saltwater has destroyed parts of the electric grid, making repair work unusually hazardous.

JOHN MIKSAD: It's dangerous work on a blue sky day. I mean, these folks are working with high voltage, high pressure, high temperature heavy machinery. It is dangerous work on any day. When you have these hazards that are superimposed on the routine hazards, it can be a very dangerous combination.

NARRATOR: It will take days for Con Ed crews to bring power back to the city. Some places will be without electric power for weeks.

[NYSE OPENING BELL RINGING]

However, the stock exchanges manage to open two days after Sandy, thanks to emergency generators. Not just the city, but the entire region is reeling. It's getting cold, and many homes have no heat. Food deliveries are a problem, and gasoline will have to be rationed. Subway engineers work around the clock to restore service.

JOSEPH LHOTA: The subway system is relatively simple-- staircase, hole in the ground, another staircase. And it just keeps going and going, so we can make the city as mobile, and move everyone around as quickly as we possibly can.

NARRATOR: Finally, on Friday, fully four days after the storm, Con Ed turns on the lights in lower Manhattan. Life begins to return to normal. But harder-hit areas, like the New Jersey Shore and Staten Island, will take far longer to recover. Still, the city and the world begin to ask, what's next? Was this truly a once-in-a-100-year storm, or is it the beginning of things to come? Did global warming influence the path or severity of this nearly unprecedented storm?

Experts agree that Sandy followed a highly unusual track. Typically, the powerful jet stream pushes hurricanes eastward and out to sea, but Sandy turned hard left and headed west into the most densely populated region of the continent. One obvious culprit was a strong high pressure system over the Atlantic associated with a disturbed and wavy jet stream.

RADLEY HORTON: With a wavier jet stream, it's easier for a storm to stagnate, or even turn towards the west, towards the coast, which is what happened with Sandy.

NARRATOR: The shape of the jet stream is influenced by the temperature difference between the warm atmosphere at the Earth's equator and the cold air at the North Pole. But arctic temperatures have been rising twice as fast as temperatures over the rest of the globe. And some recent studies have found an association between a wavier jet stream and those rising temperatures.

So did a warmer arctic set the stage for Sandy to turn? Most scientists say it's too soon to know for sure.

RADLEY HORTON: What we can say, though, is that there's a lot of evidence suggesting that if you remove ice from the Arctic, you see a wavier jet stream of the type that makes it easier for weather systems like Sandy to turn towards the west instead of getting deflected towards the east.

NARRATOR: Right now, we can't blame Sandy's fateful turn directly on global warming. And neither is it clear whether global warming is affecting the frequency of these destructive storms. As some models show, any relationship between global warming and hurricanes is complicated.

ADAM SOBEL: And in those models, what happens as the climate warms is that the number of hurricanes actually is more likely to decrease than increase. But at the same time, the hurricanes that there become more intense.

[WIND ROARING]

So right now, our models are predicting that hurricanes in a warmer climate will become fewer but more intense.

NARRATOR: But there is one undeniable factor that does relate directly to global warming and contributed to Sandy's destructiveness, sea level. The water in the ocean is warmer than it used to be, and warm water takes up more volume. Warmer seas are higher seas. Add to this melting ice at the poles.

ADAM SOBEL: What we do know is that as the climate warms, the sea level will rise. It's already risen around a foot in the last 100 years in the New York area. We don't know exactly how fast the sea level will rise, but we know for certain that it will rise. It could be as much as several feet in the next century.

NARRATOR: And that means, decades from now, a storm like Sandy would be even more devastating.

RADLEY HORTON: As you raise those average sea levels, it's like raising the floor of a basketball court. If you don't change the height of the rims, you're going to get more slam dunks, just because that average sea level has gotten higher.

NARRATOR: This will force coastal cities all over the world to consider hardening their infrastructure, transportation, electrical, and emergency services, and possibly to spend billions of dollars on protective barriers like storm gates.

RADLEY HORTON: I think that Sandy was a huge wake-up call, not just for New York City, but for the US. Sea levels are rising. We're going to see more coastal flood events in the future.

[STRING MUSIC PLAYING]

NARRATOR: For those who survived this storm, that cannot be welcome news.

MICHAEL CLARKE: I tell you right now, even before this, my outlook on it, Mother Nature rules. It's one thing I don't screw with, the water. Water, wind, it all rules over us.

LINDA CLARKE: I don't know if we could go through what we just went through again. It is enough for a lifetime. I see that wave coming around the corner every night when I go to sleep, and it's just not a good feeling.

NARRATOR: As time passes, hurricane names get reused, except for those whose deadly legacy is carved into the history books. There will never be another hurricane named Sandy.

MALE ANNOUNCER 2: The exploration continues online, where you can watch any part of this program again. What's the connection between climate change and hurricanes? And how should cities prepare for future storm surges? On NOVA' website, watch short-form videos, hear from experts, and explore interactives. Find us at PBS.org/Nova. Follow us on Facebook and Twitter.

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[THEME MUSIC PLAYING]

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