



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

July 5, 2019

Weather Study

METEOROLOGY

ERA19LA150

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A. ACCIDENT

Location: New York, New York
Date: April 14, 2019
Time: 2215 eastern daylight time
0215 Coordinated Universal Time (UTC) on April 15
Aircraft: Cessna 172, Registration: N5296H

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are eastern daylight time (EDT) on April 14, 2019, and are based upon the 24-hour clock, where local time is -4 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of miles. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports and "P" for OCONUS airports.

The accident site was located at latitude 40.6769° N, longitude 73.7142° W at an approximate elevation of 30 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large-scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the Weather Prediction Center, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H.¹

¹

1.1 Surface Analysis Chart

The northeastern United States section of the NWS Surface Analysis Chart for 2300 EDT is provided as figure 1 with the location of the accident site marked within the red circle. The chart indicated a low pressure center with a pressure of 990-hectopascals (hPa) over eastern Lake Ontario and a second low pressure center with a pressure of 991-hPa over northern Lake Erie. A warm front stretched from western New York eastward into Massachusetts and became a stationary front that continued to stretch eastward into the Atlantic Ocean. A cold front stretched from western New York southward across western Pennsylvania, West Virginia, and into the southeastern United States. A surface trough² stretched from central New York southward into Pennsylvania, West Virginia, and Virginia. The accident site was located south of the warm frontal boundary in the warmer airmass.

The station models around the accident site depicted air temperatures in the upper 50's to low 60's degrees Fahrenheit (°F), dew point temperatures in the mid to upper 50's °F with a temperature-dew point spread of 1° or less, a south to southeast wind between 10 and 15 knots, overcast cloud cover, mist, and light rain.

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

² Trough – An elongated area of relatively low atmospheric pressure or heights.

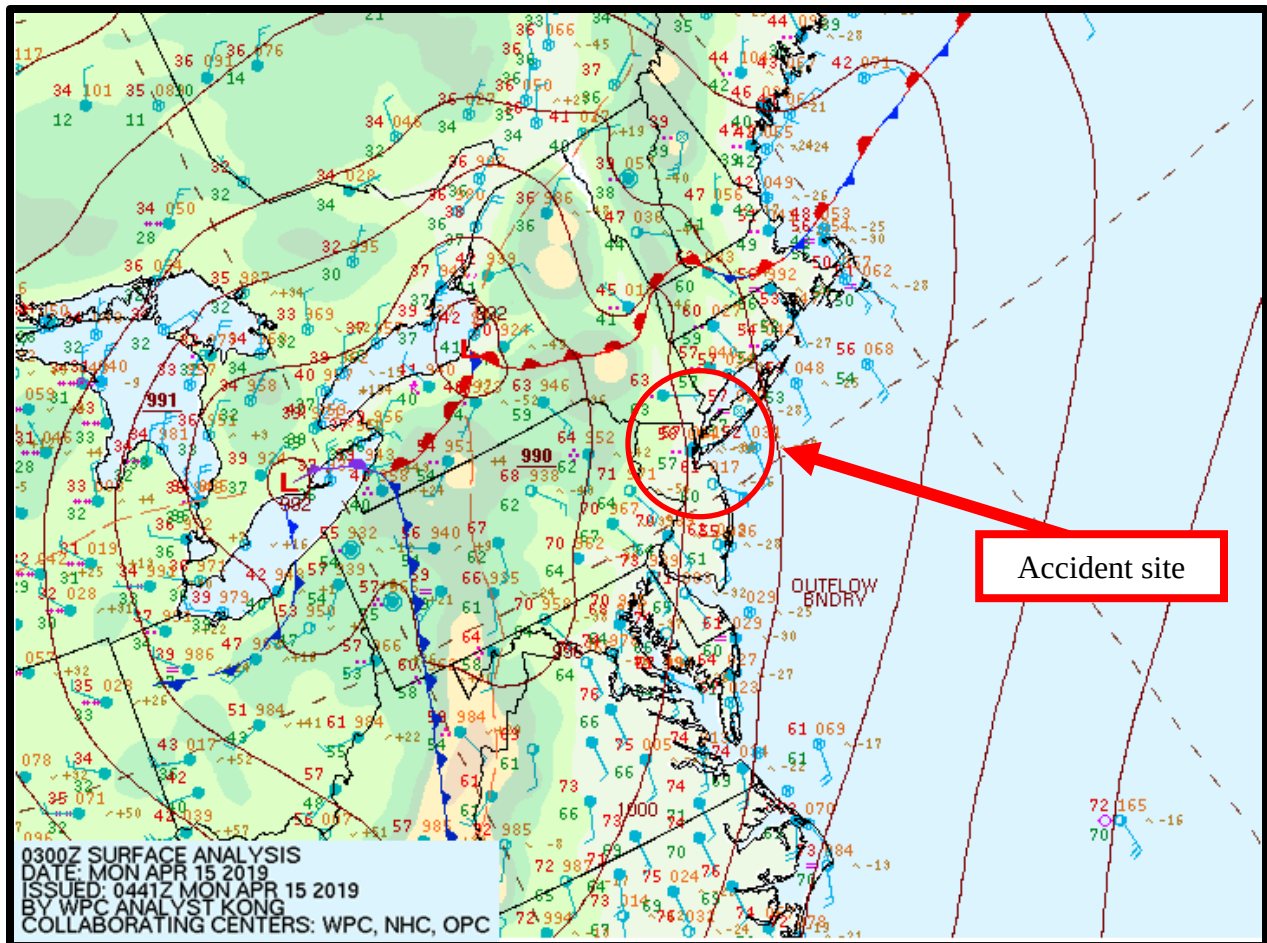


Figure 1 – NWS Surface Analysis Chart for 2300 EDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 2000 EDT at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. There were low- and mid-level troughs located south and southwest of the accident site. Troughs can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. The wind was from the south at 35 knots at 925-hPa with the wind becoming south-southwesterly at 40 knots by 700-hPa (figure 4). At 300-hPa, the wind was from the southwest at 50 knots (figure 6).

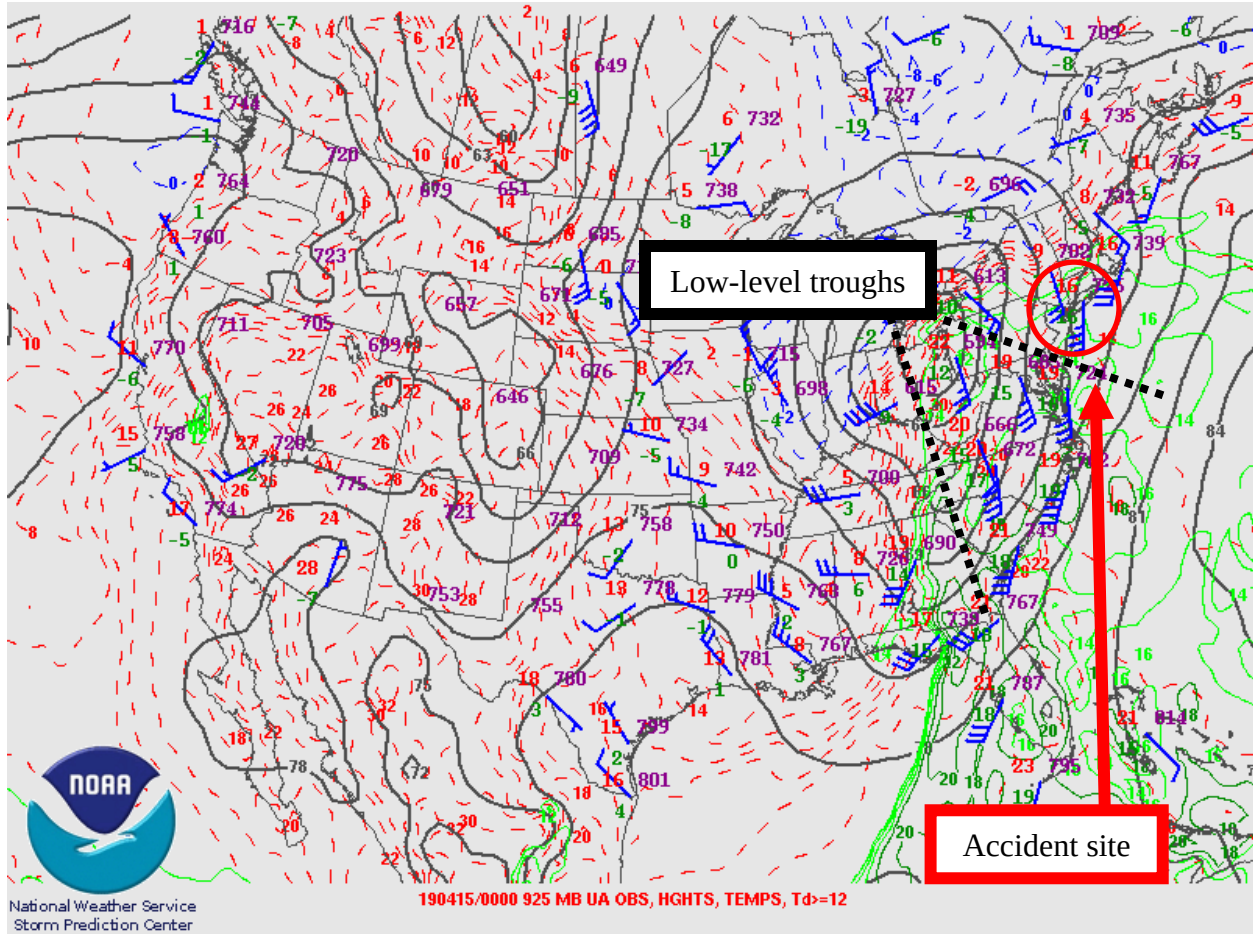


Figure 2 – 925-hPa Constant Pressure Chart for 2000 EDT

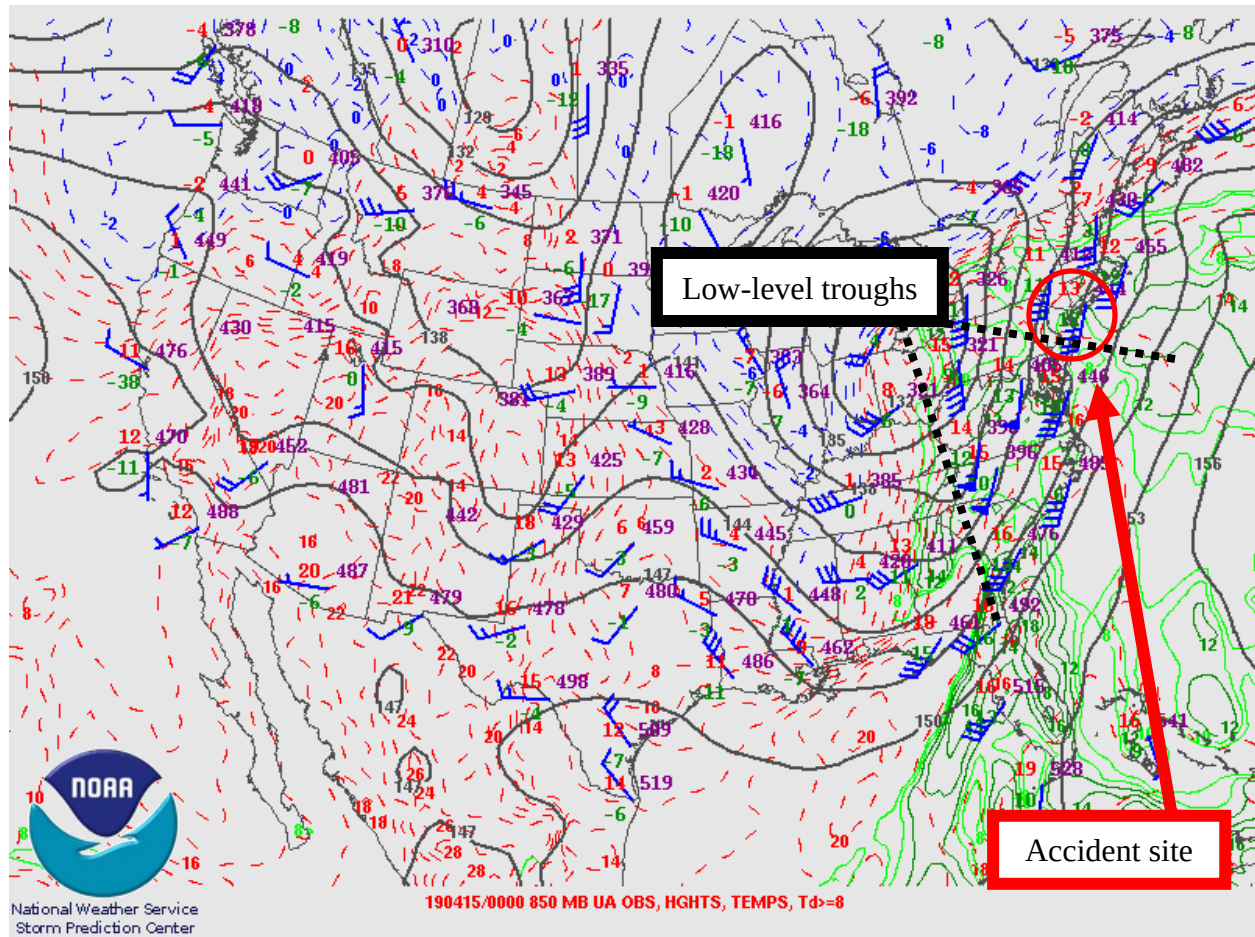


Figure 3 – 850-hPa Constant Pressure Chart for 2000 EDT

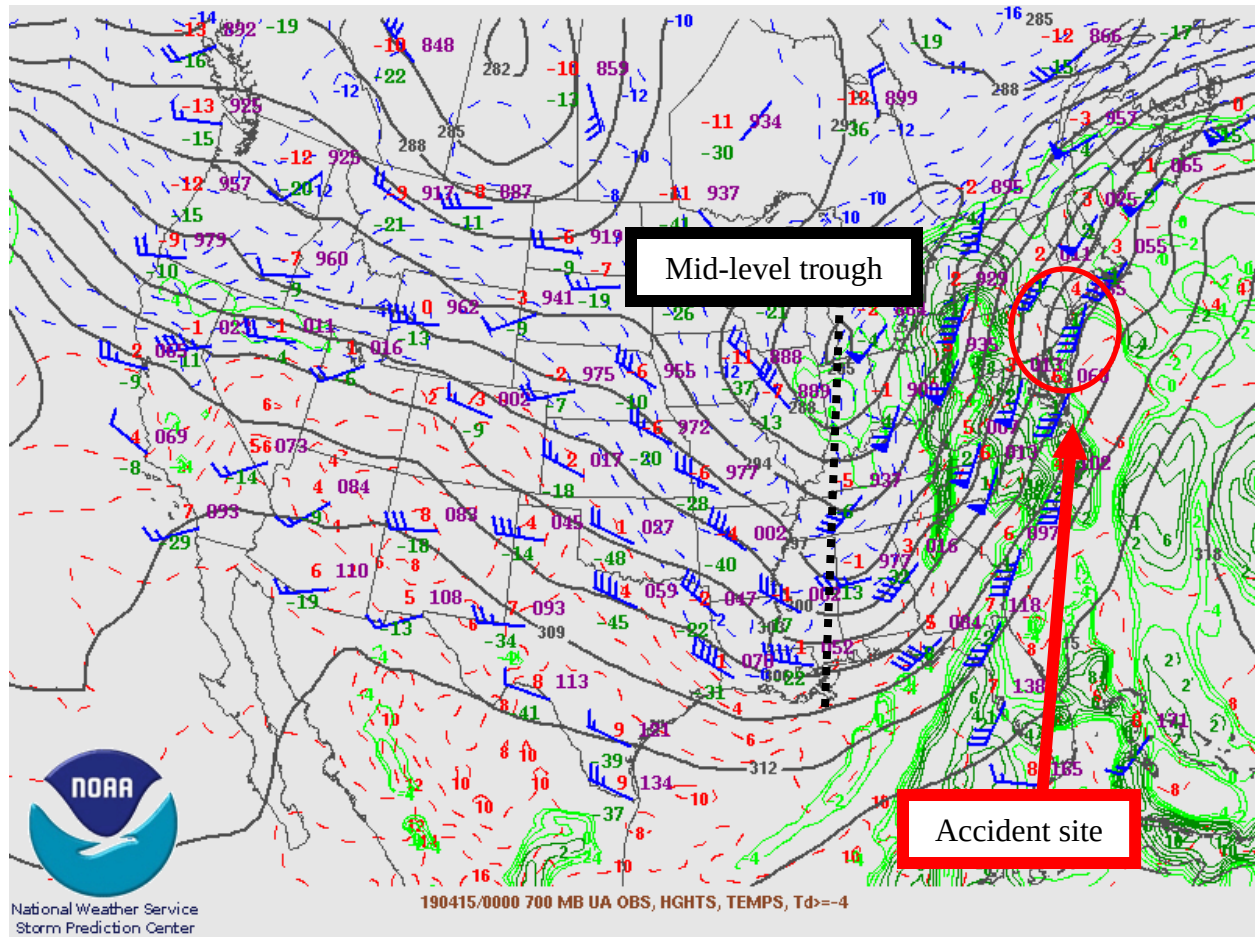


Figure 4 – 700-hPa Constant Pressure Chart for 2000 EDT

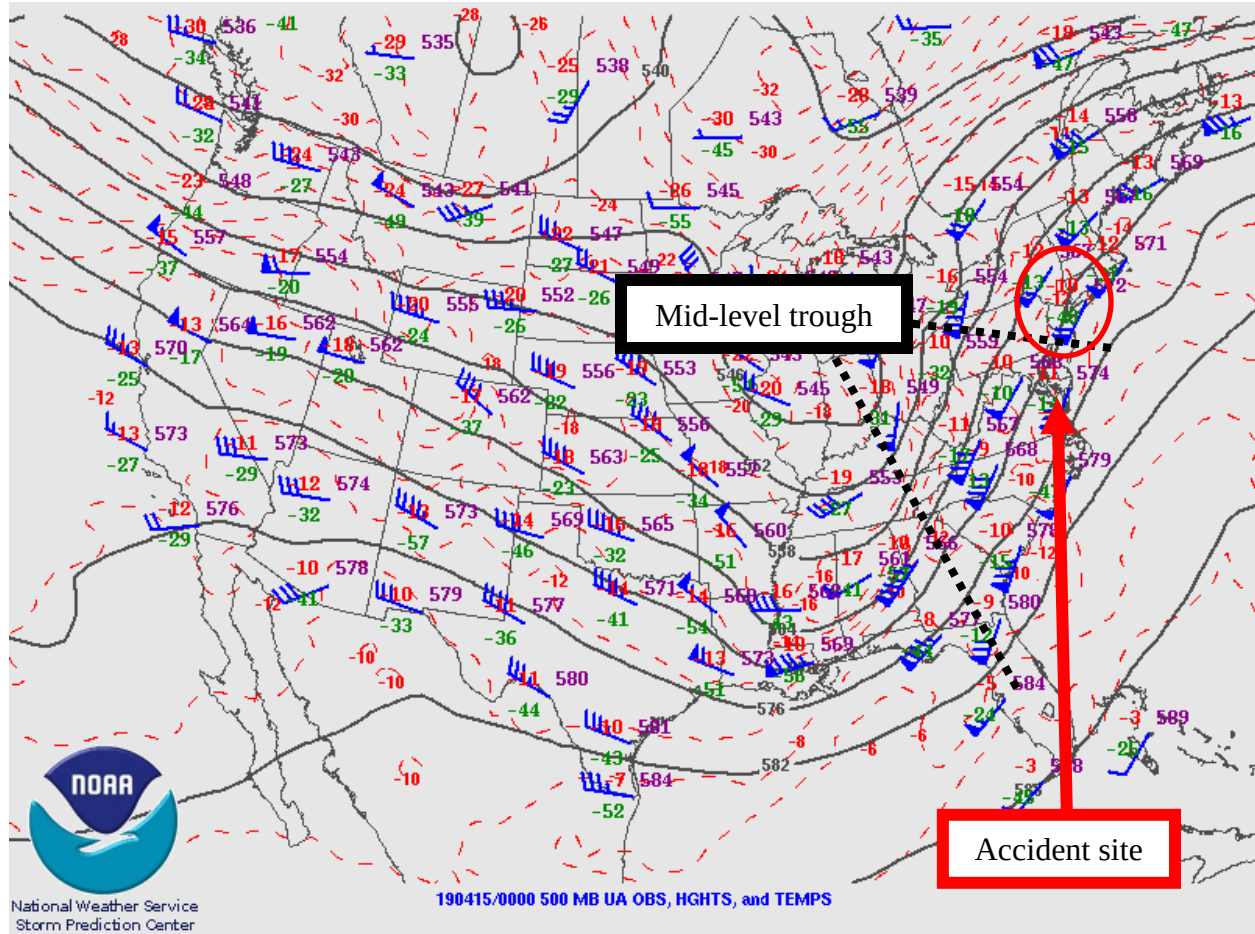


Figure 5 – 500-hPa Constant Pressure Chart for 2000 EDT

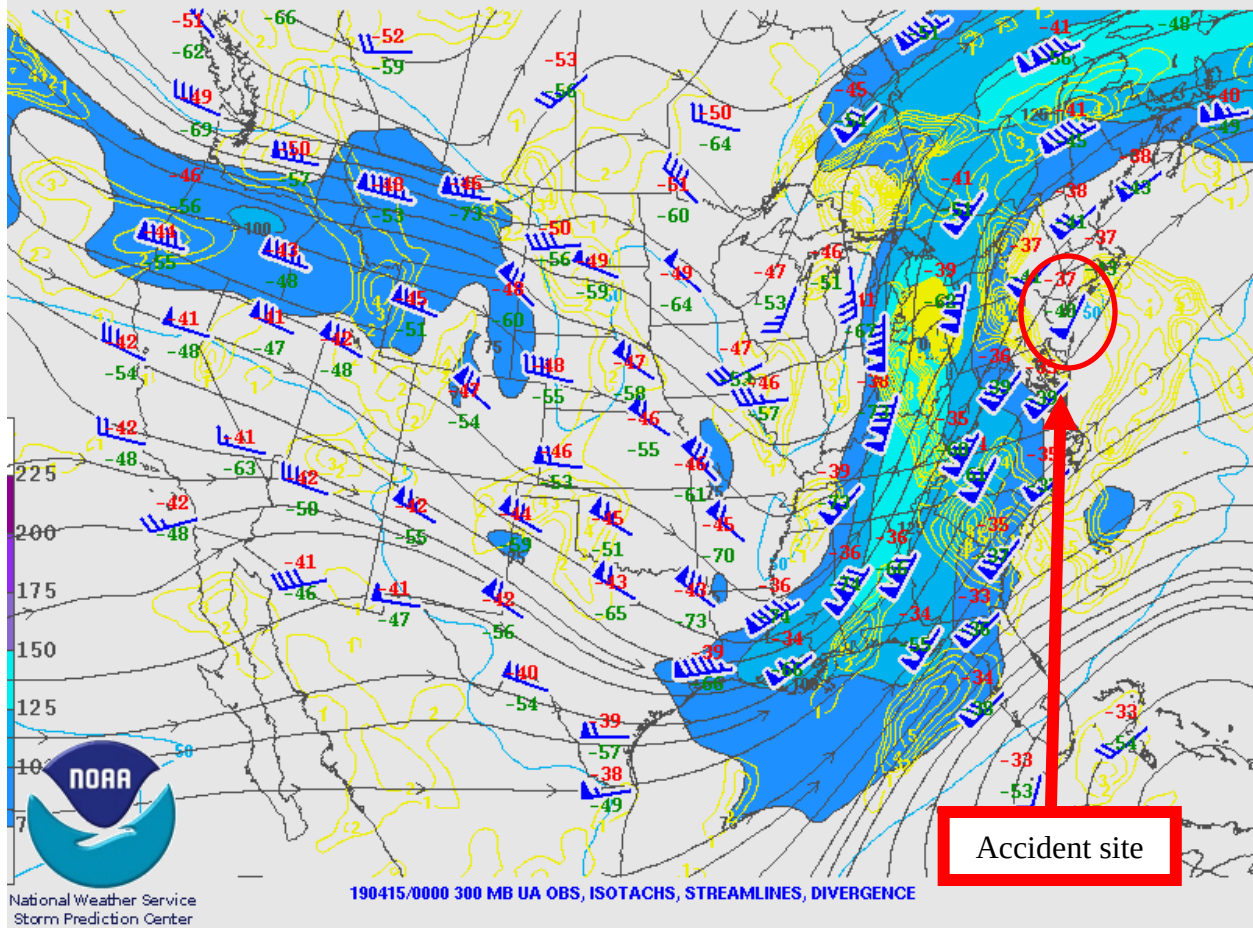


Figure 6 – 300-hPa Constant Pressure Chart for 2000 EDT

2.0 SPC Products

The SPC issued the following Day 1 Convective Outlook at 2355 EDT (figure 7) with areas of thunderstorms and a marginal risk for severe thunderstorms forecast for the accident site (forecast valid from 2100 EDT April 14 to 0800 EDT April 15). The accident site was located in an area where the SPC forecasted a 2 percent chance of a tornado within 25 miles of a point (figure 8), 15 percent chance of damaging thunderstorm winds or wind gusts 50 knots or greater within 25 miles of a point (figure 9), and a 5 percent chance of one-inch diameter hail or larger within 25 miles of a point (figure 10). Similar forecast and graphics were issued with the Day 1 Convective Outlook valid at the time of departure (around 1710 EDT):

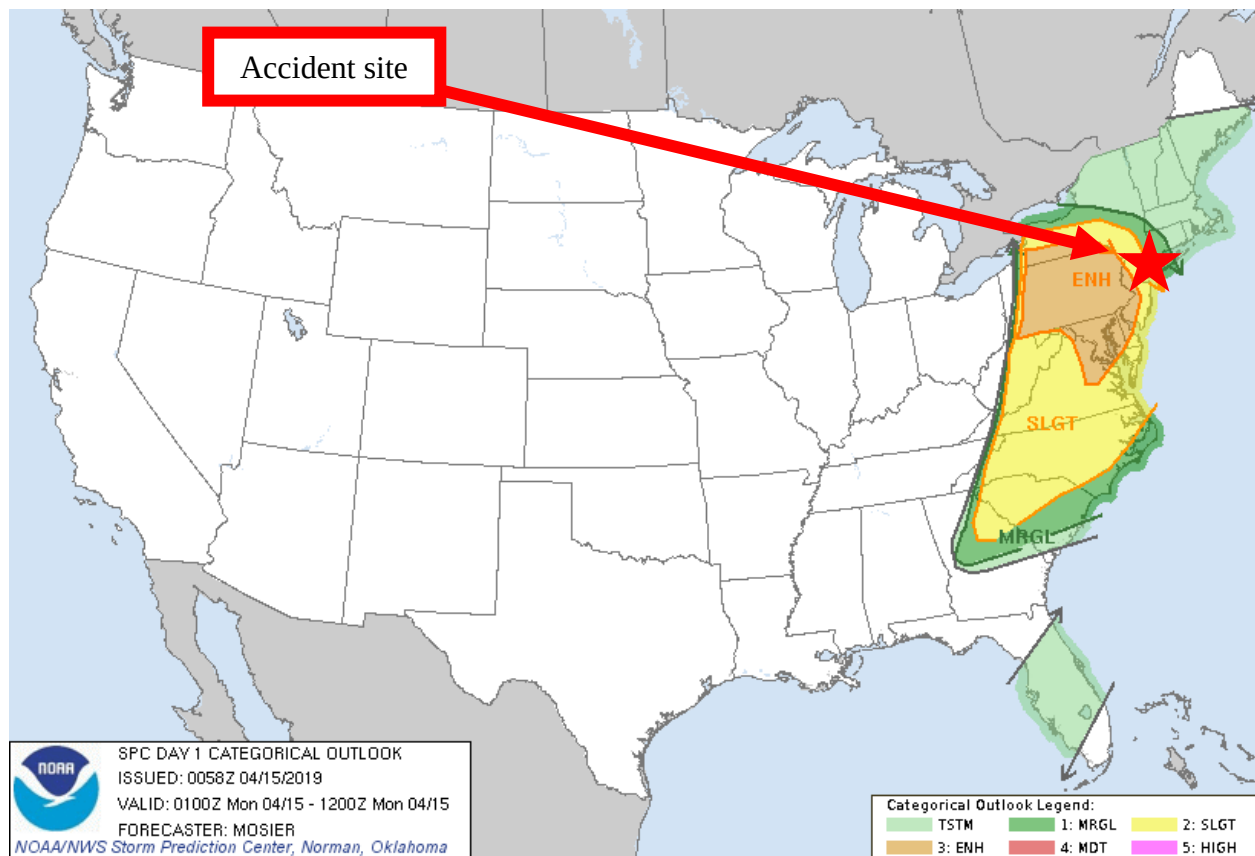


Figure 7 – SPC day 1 Convective Outlook valid at the time of the accident

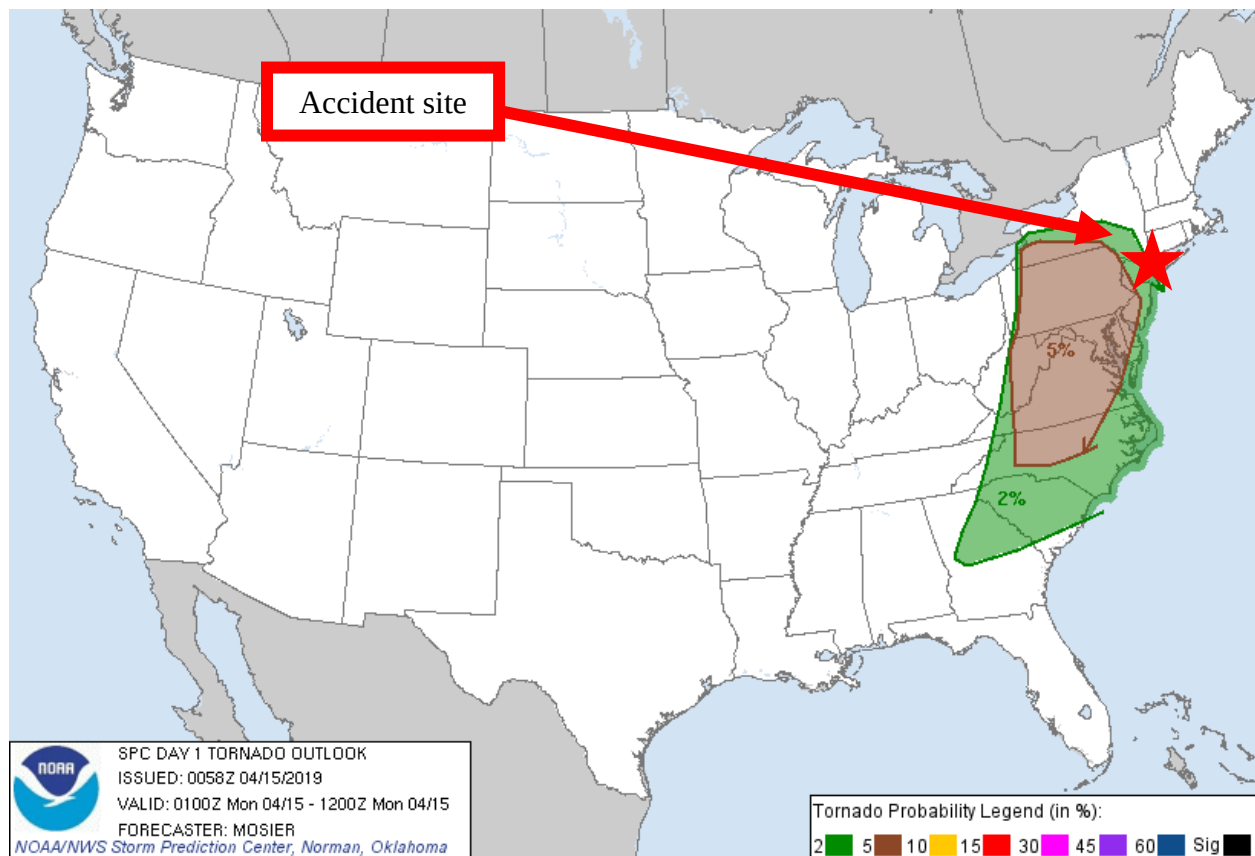


Figure 8 – SPC day 1 Tornado Outlook valid at the time of the accident

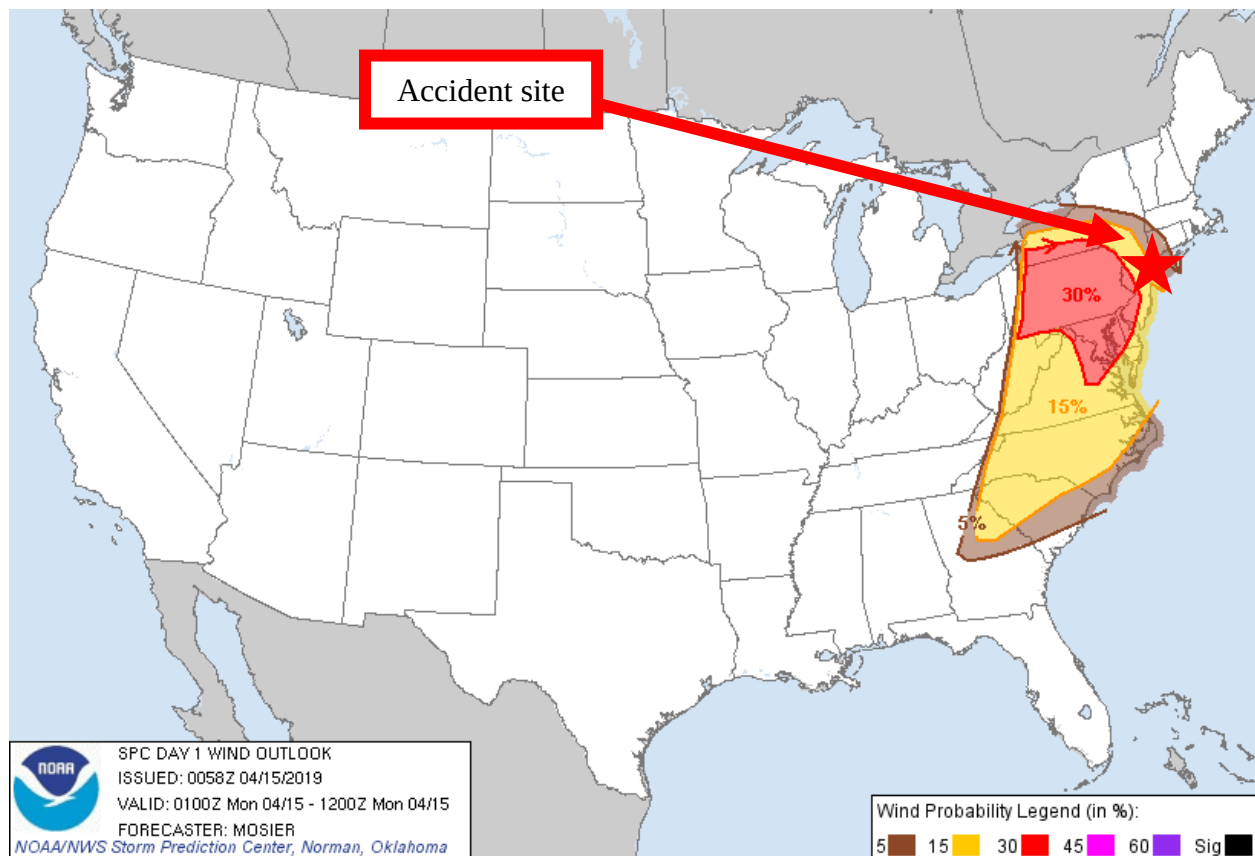


Figure 9 – SPC day 1 Wind Outlook valid at the time of the accident

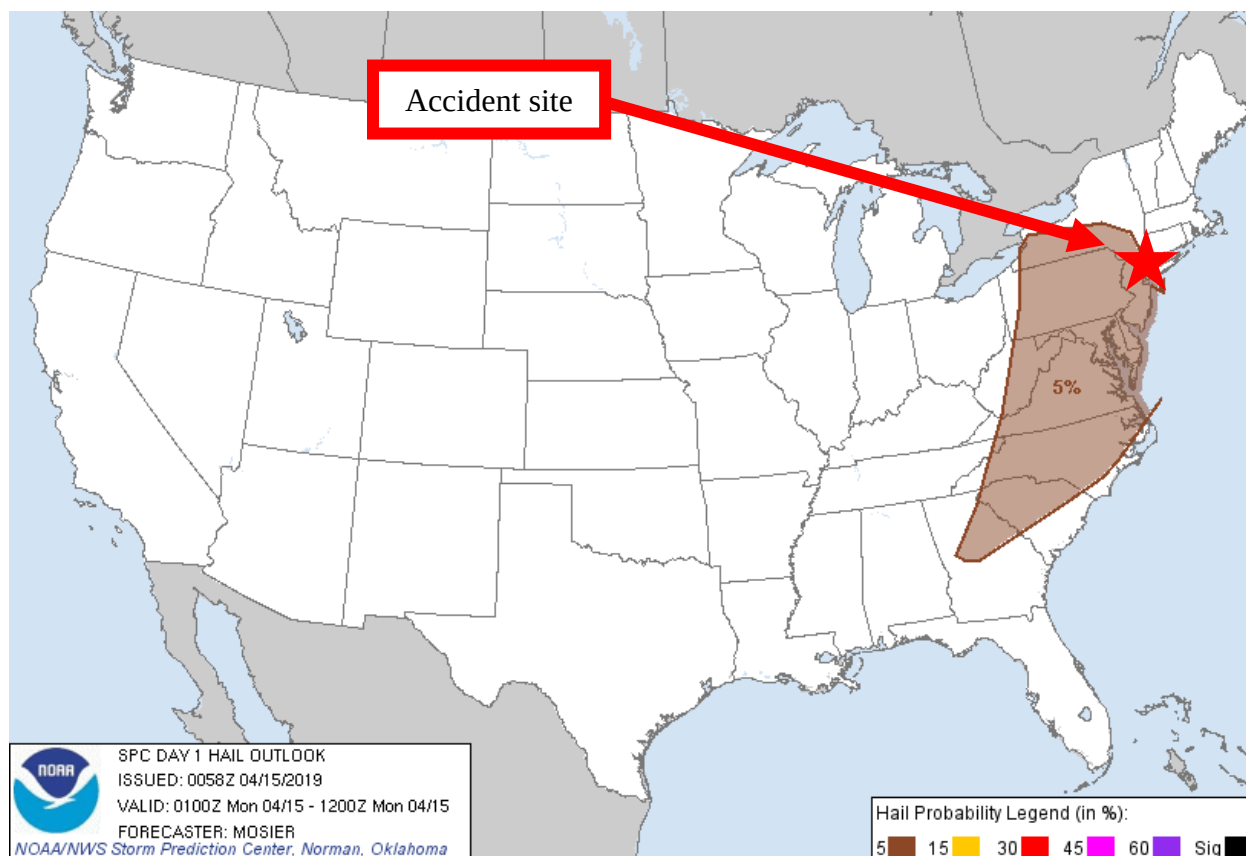


Figure 10 – SPC day 1 Hail Outlook valid at the time of the accident

SPC AC 150355

Day 1 Convective Outlook CORR 1
NWS Storm Prediction Center Norman OK
1055 PM CDT Sun Apr 14 2019

Valid 150100Z - 151200Z

...THERE IS AN ENHANCED RISK OF SEVERE THUNDERSTORMS ACROSS FAR
WESTERN NEW YORK...MOST OF PENNSYLVANIA...WESTERN NEW
JERSEY...EASTERN MARYLAND...DELAWARE...NORTHEAST VIRGINIA...

CORRECTED FOR INCORRECT GEOGRAPHIC REFERENCE

...SUMMARY...

Damaging wind gusts and a few tornadoes remain possible tonight
across the Mid-Atlantic States.

...Discussion...

Expansive upper trough continues to move across the eastern CONUS,
interacting with a modestly moist and unstable air mass ahead of it
to provoke scattered thunderstorm development from Lake Erie
southward into GA. Numerous watches, both Severe Thunderstorm and
Tornado, are in effect to cover this threat. Most significant
changes to the outlook have been made on the western edge, where the
outlook was trimmed based on the position the surface trough.

Southern portion of the organized line extending from far western NY through WV is beginning to show signs of better organization and stronger updrafts. The northern portion near the NY/PA border remains fairly strong while storms along the line just south (across western PA) have struggled to maintain intensity. Expectation is for this entire line to gradually strengthen as the upper trough continues eastward and the associated height falls spread across the region.

Additionally, an increase in storms is anticipated from central South Carolina through central North Carolina and into south-central Virginia as the low-level jet increases. This initially cellular activity could pose a threat for damaging wind gusts and a tornado or two.

..Mosier.. 04/15/2019

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 0600Z

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). Figure 11 is a sectional chart with the accident site and the closest weather reporting locations to the accident site marked. The pink line is the direct line between the departure (Niagara Falls International Airport, KIAG) and destination airports (Republic Airport, KFRG).



Figure 11 – Sectional chart of accident area with the location of the accident site and the closest surface observation sites

The closest official weather reporting facility to the accident site was John F. Kennedy International Airport (KJFK), New York, New York, at an elevation of 13 ft, and was 4 miles southwest of the accident site. KJFK had an Automated Surface Observing System (ASOS³) whose reports were supplemented by official human observers and KJFK had a 13° westerly magnetic variation⁴ (figure 11). The following observations were taken and disseminated during the times surrounding the accident:⁵

- [1951 EDT] METAR KJFK 142351Z 17013KT 1/8SM R04R/2200V3000FT FG VV003
13/13 A2969 RMK AO2 SFC VIS 1/2 SLP053 T01330133 10156 20133 58024 \$=
- [2028 EDT] SPECI KJFK 150028Z 16010KT 1/8SM R04R/1600V2200FT FG VV002
13/13 A2967 RMK AO2 SFC VIS 1/2 T01330133 \$=
- [2039 EDT] SPECI KJFK 150039Z 15011KT 1/8SM R04R/2200V2800FT FG VV002
13/13 A2966 RMK AO2 SFC VIS 1/2 T01330133 \$=
- [2051 EDT] METAR KJFK 150051Z 17012KT 1/8SM R04R/1800V3000FT FG VV003
13/13 A2968 RMK AO2 SFC VIS 1/2 SLP049 T01330133 \$=

³ ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

⁴ Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

⁵ Bolded sections in this report highlight information that directly reference the weather conditions that affected the accident location around the accident time.

[2151 EDT] METAR KJFK 150151Z 17013KT 1/8SM R04R/3500V4000FT BR VV003
13/13 A2965 RMK AO2 SFC VIS 3/4 SLP038 T01280128 \$=

**[2212 EDT] SPECI KJFK 150212Z 18015KT 1/8SM R04R/1400V1800FT FG VV002
13/13 A2964 RMK AO2 SFC VIS 1/4 T01280128 \$=**

ACCIDENT TIME 2215 EDT

**[2217 EDT] SPECI KJFK 150217Z 18014KT 1/8SM R04R/1400V1800FT FG VV002
13/13 A2963 RMK AO2 SFC VIS 1/4 T01280128 \$=**

[2251 EDT] METAR KJFK 150251Z 16007KT 1/8SM R04R/1800V3000FT FG VV002
13/13 A2959 RMK AO2 SFC VIS 1/4 SLP019 T01280128 58035 \$=

[2335 EDT] SPECI KJFK 150335Z 18015G18KT 3/4SM R04R/P6000FT BR OVC003
13/13 A2957 RMK AO2 SFC VIS 4 T01280128 \$=

KJFK weather at 2212 EDT, wind from 180° at 15 knots, 1/8 miles visibility, runway visual range varying between 1,400 and 1,800 ft on runway 04R, fog, vertical visibility 200 ft above ground level (agl), temperature of 13 °Celsius (C), dew point temperature of 13 °C, and an altimeter setting of 29.64 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, surface visibility 1/4 miles, temperature 12.8 °C, dew point temperature 12.8 °C, maintenance is needed on the system.

KJFK weather at 2217 EDT, wind from 180° at 14 knots, 1/8 miles visibility, runway visual range varying between 1,400 and 1,800 ft on runway 04R, fog, vertical visibility 200 ft agl, temperature of 13 °C, dew point temperature of 13 °C, and an altimeter setting of 29.63 inHg. Remarks: automated station with a precipitation discriminator, surface visibility 1/4 miles, temperature 12.8 °C, dew point temperature 12.8 °C, maintenance is needed on the system.

KFRG was the intended destination airport, located in Farmingdale, New York. KFRG was located at an elevation of 81 ft, was 14 miles east-northeast of the accident site (figure 11), and had an ASOS whose reports were supplemented by air traffic control (ATC) when the tower was in operation.⁶ The following observations were taken and disseminated during the times surrounding the accident:

[1632 EDT] SPECI KFRG 142032Z 16007KT 1 3/4SM BR OVC003 13/13 A2978
RMK AO2 RAB09E20 P0000 T01330133=

[1653 EDT] METAR KFRG 142053Z 16007KT 1 1/4SM BR OVC003 13/13 A2977
RMK AO2 RAB09E20 SLP082 P0000 60000 T01330128 56033=

[1704 EDT] SPECI KFRG 142104Z 14006KT 2SM BR OVC002 13/13 A2977 RMK
AO2 T01330128=

⁶ ATC hours of operation were from 0700 to 2300 local.

[1712 EDT] SPECI KFRG 142112Z 16006KT 1SM BR OVC002 13/13 A2977 RMK
AO2 SFC VIS 3 T01330128=

[1729 EDT] SPECI KFRG 142129Z 17007KT 1/4SM BR OVC002 13/13 A2977 RMK
AO2 SFC VIS 3/4 T01330133=

[1753 EDT] METAR KFRG 142153Z 18008KT 1/4SM FG VV002 13/13 A2976 RMK
AO2 SLP077 T01330133=

[1841 EDT] SPECI KFRG 142241Z 19008KT 1/4SM FG VV003 14/14 A2973 RMK
AO2 SFC VIS 1/2 T01440139=

[1853 EDT] METAR KFRG 142253Z 19009KT 1/4SM FG VV003 14/14 A2973 RMK
AO2 SLP066 T01440144=

[1902 EDT] SPECI KFRG 142302Z 19010KT 1/4SM FG VV002 14/14 A2972 RMK
AO2 T01440144=

[1953 EDT] METAR KFRG 142353Z 19010KT 1/4SM BR OVC003 14/14 A2969 RMK
AO2 SFC VIS 1 1/4 SLP055 60000 T01440144 10156 20128 58027=

[2053 EDT] METAR KFRG 150053Z 19009KT 1/4SM FG VV002 13/13 A2968 RMK
AO2 SLP049 T01330133=

***[2153 EDT] METAR KFRG 150153Z 20008KT 1/4SM FG VV002 14/14 A2965 RMK
AO2 SFC VIS 1/2 PRESFR SLP039 T01390139=***

ACCIDENT TIME 2215 EDT

***[2253 EDT] METAR KFRG 150253Z 19009KT 1/4SM FG VV002 13/13 A2960 RMK
AO2 SFC VIS 1/2 PRESFR SLP023 T01330133 58031=***

[2348 EDT] SPECI KFRG 150348Z 20016G24KT 1/4SM OVC003 13/13 A2956 RMK
AO2 SFC VIS 9=

[2353 EDT] METAR KFRG 150353Z 19012G23KT 1/4SM BR OVC003 13/13 A2956
RMK AO2 SFC VIS 6 SLP009 T01280128=

KFRG weather at 2153 EDT, wind from 200° at 8 knots, 1/4 miles visibility, fog, vertical visibility 200 ft agl, temperature of 14 °C, dew point temperature of 14 °C, and an altimeter setting of 29.65 inHg. Remarks: automated station with a precipitation discriminator, surface visibility 1/2 miles, pressure falling rapidly, sea level pressure 1003.9 hPa, temperature 13.9 °C, dew point temperature 13.9 °C.

KFRG weather at 2253 EDT, wind from 190° at 9 knots, 1/4 miles visibility, fog, vertical visibility 200 ft agl, temperature of 13 °C, dew point temperature of 13 °C, and an altimeter setting of 29.60 inHg. Remarks: automated station with a precipitation discriminator, surface visibility 1/2 miles, pressure falling rapidly, sea level pressure 1002.3 hPa, temperature 13.3 °C, dew point temperature 13.3 °C, 3-hourly pressure drop of 3.1 hPa.

During the initial approach⁷ to KFRG the weather was 1/4 miles visibility and a vertical visibility 200 ft agl with a general flight category of LIFR conditions.⁸ KJFK and KFRG similarly had LIFR conditions at the accident time. An hour-by-hour view of general flight categories from 1710 EDT through 2215 EDT are documented in figures 12 through 18 for airports (figure 11) surrounding KFRG and KJFK with LIFR and IFR conditions present at airports directly surrounding the accident site. MVFR becoming IFR conditions were present at KTEB and KEWR around the accident time (KEWR was VFR at 1900 and 2000 EDT).

⁷ For more information on accident aircraft location please see the ATC data located in the docket of this investigation.

⁸ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

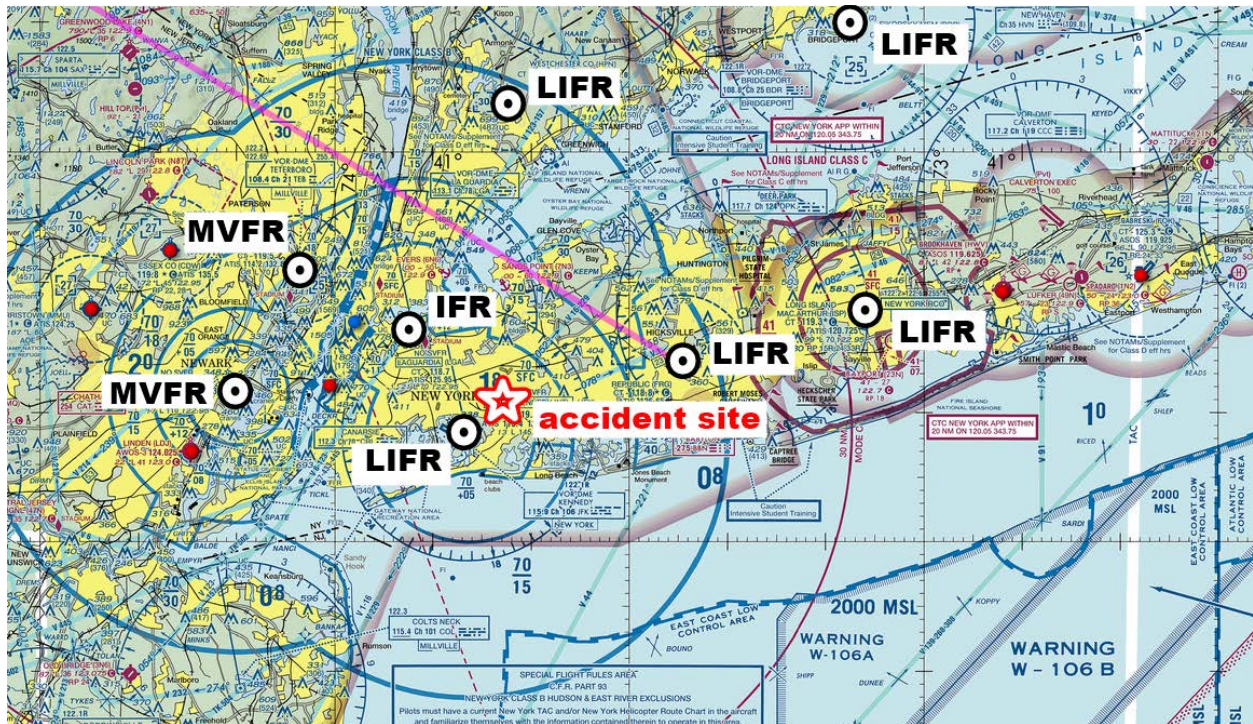


Figure 12 – Sectional chart of accident area with the general flight categories marked and observations valid at the time of departure from KIAG (around 1710 EDT)⁹

⁹ For more information on accident aircraft location please see the ATC data located in the docket of this investigation.

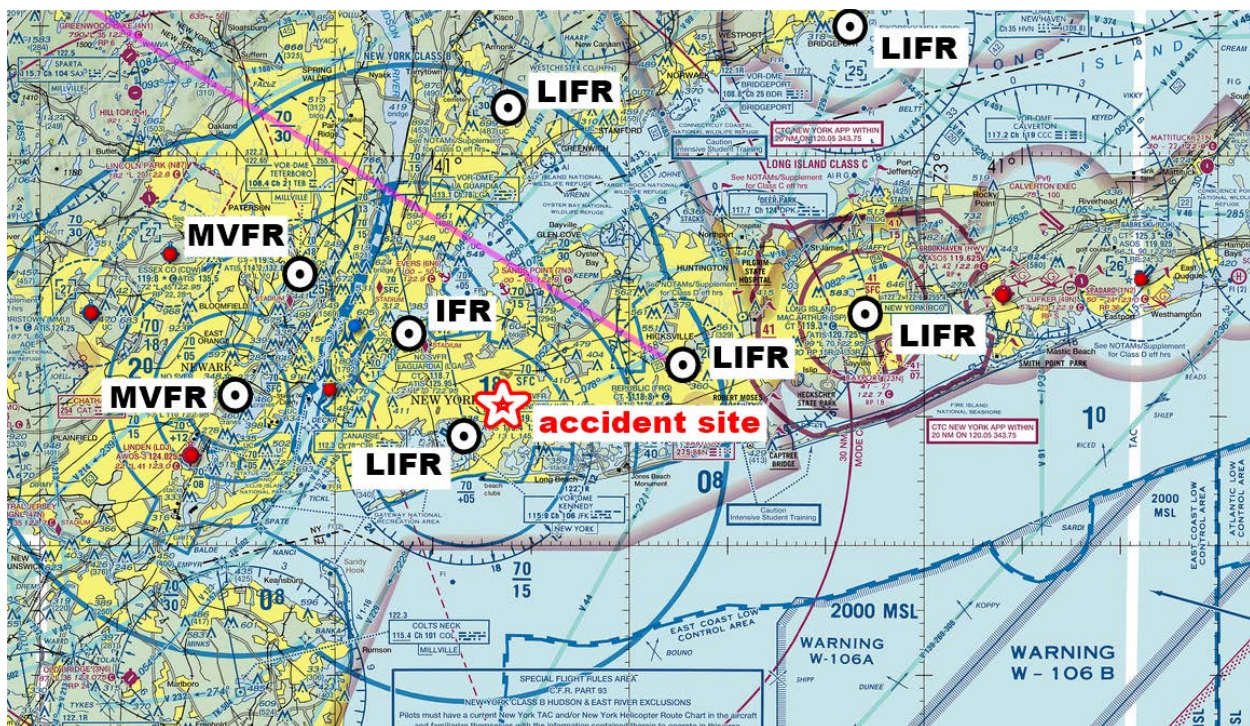


Figure 13 – Sectional chart of accident area with the general flight categories marked and observations valid at 1800 EDT

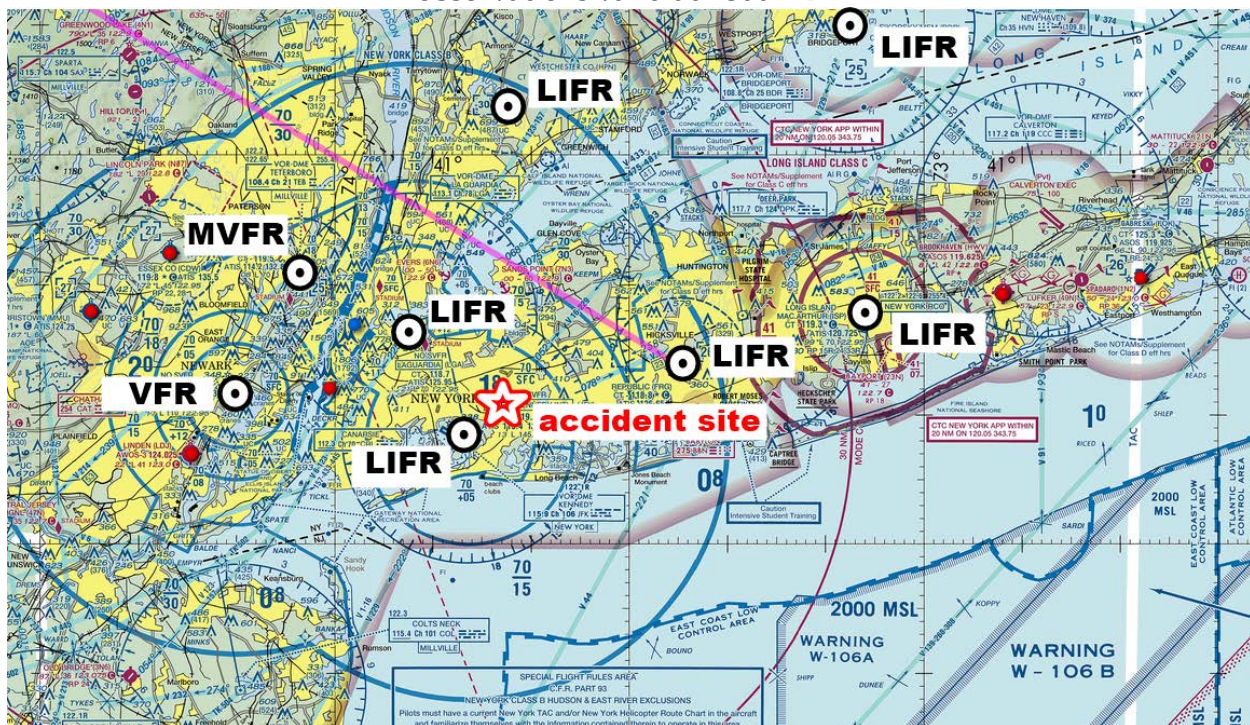


Figure 14 – Sectional chart of accident area with the general flight categories marked and observations valid at 1900 EDT

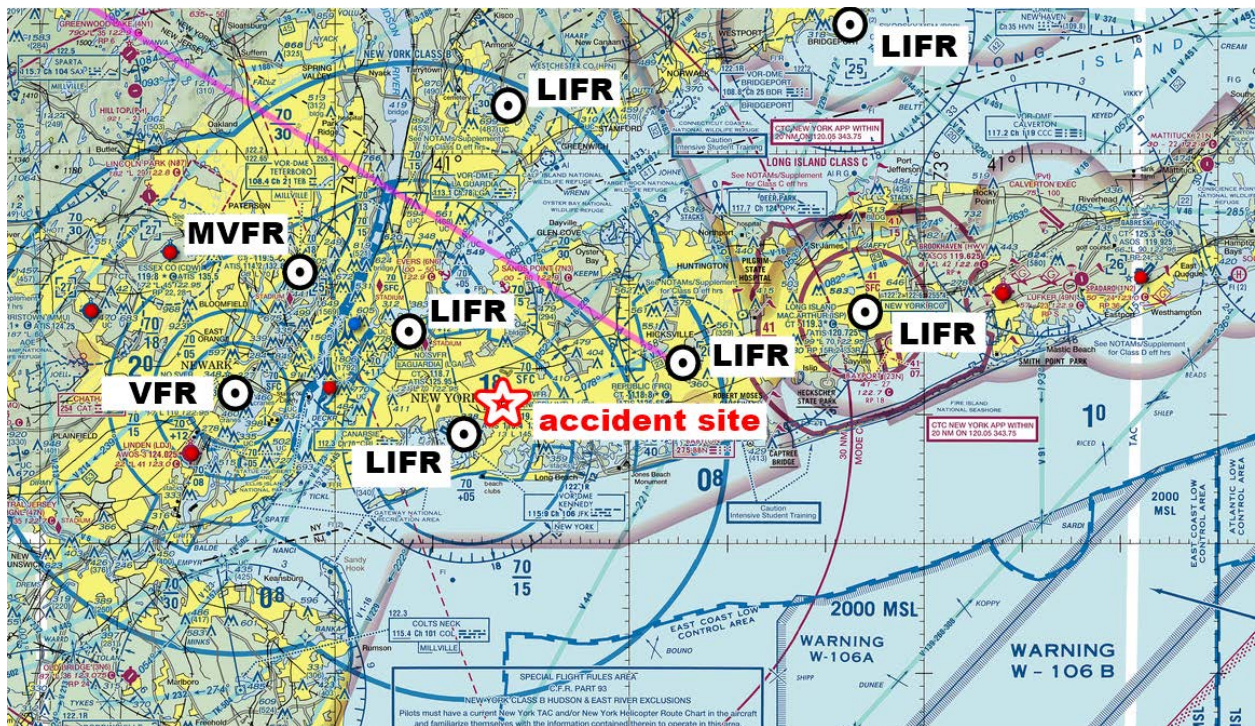


Figure 15 – Sectional chart of accident area with the general flight categories marked and observations valid at 2000 EDT

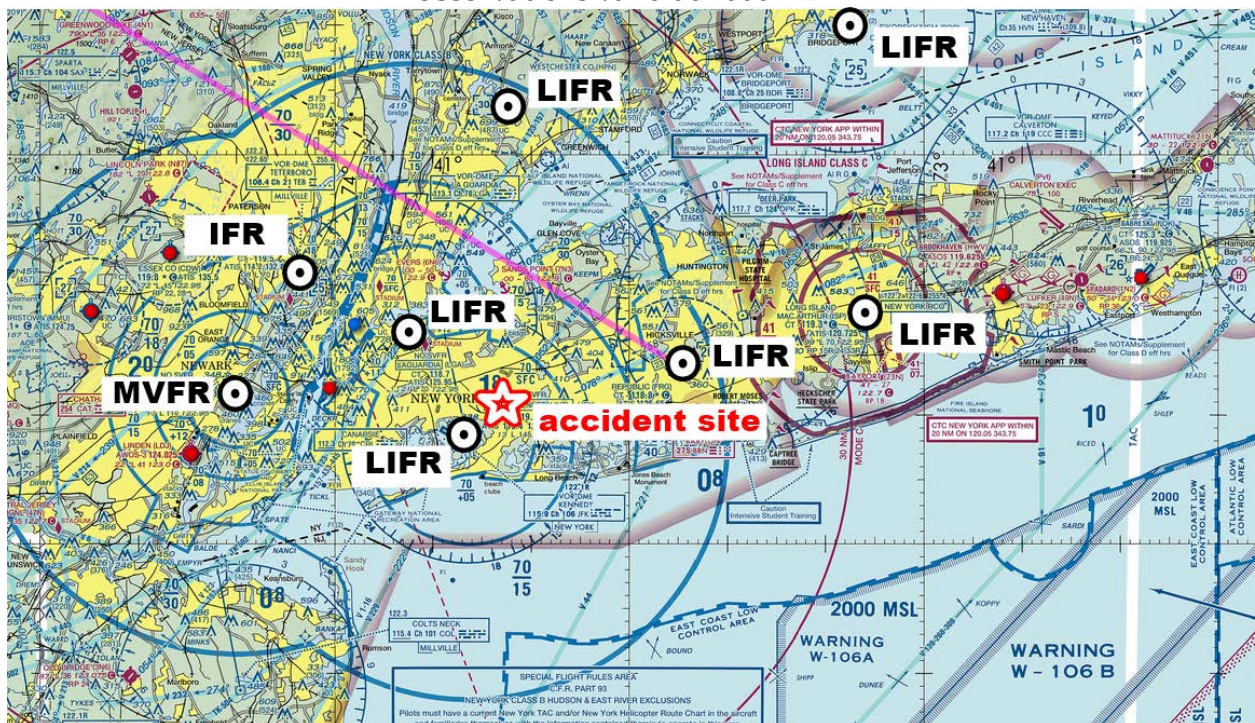


Figure 16 – Sectional chart of accident area with the general flight categories marked and observations valid at 2100 EDT

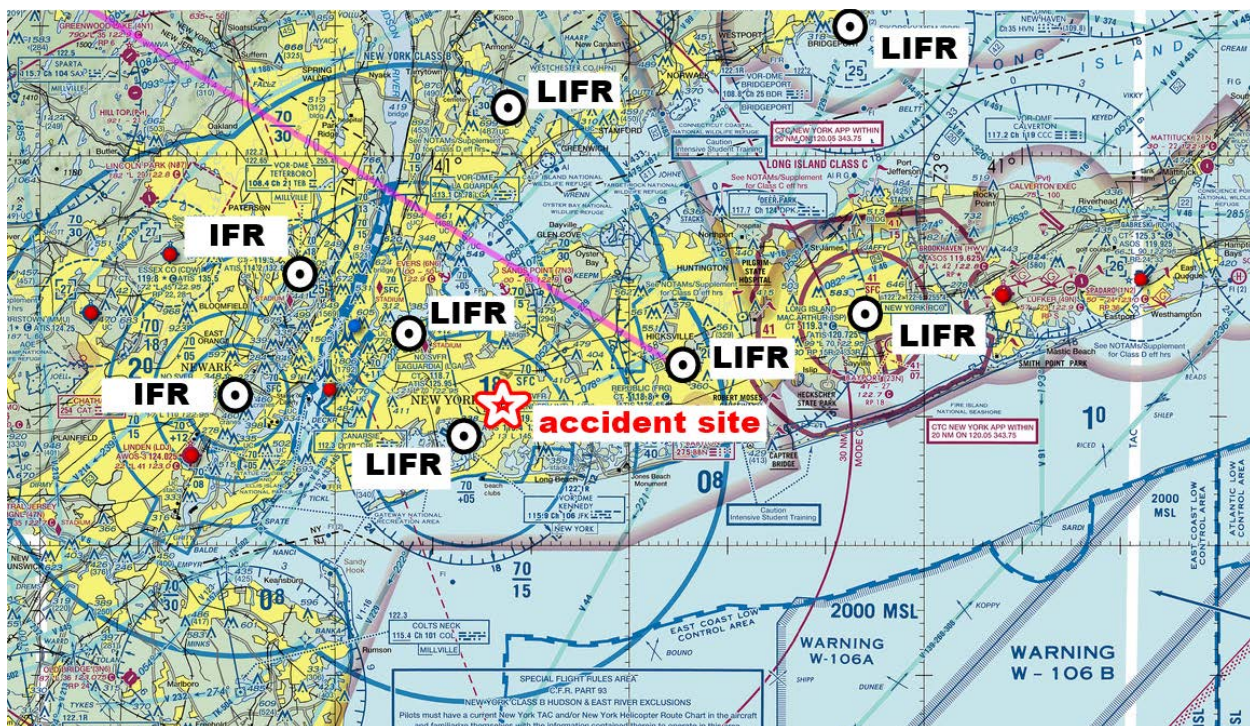


Figure 17 – Sectional chart of accident area with the general flight categories marked and observations valid at 2200 EDT

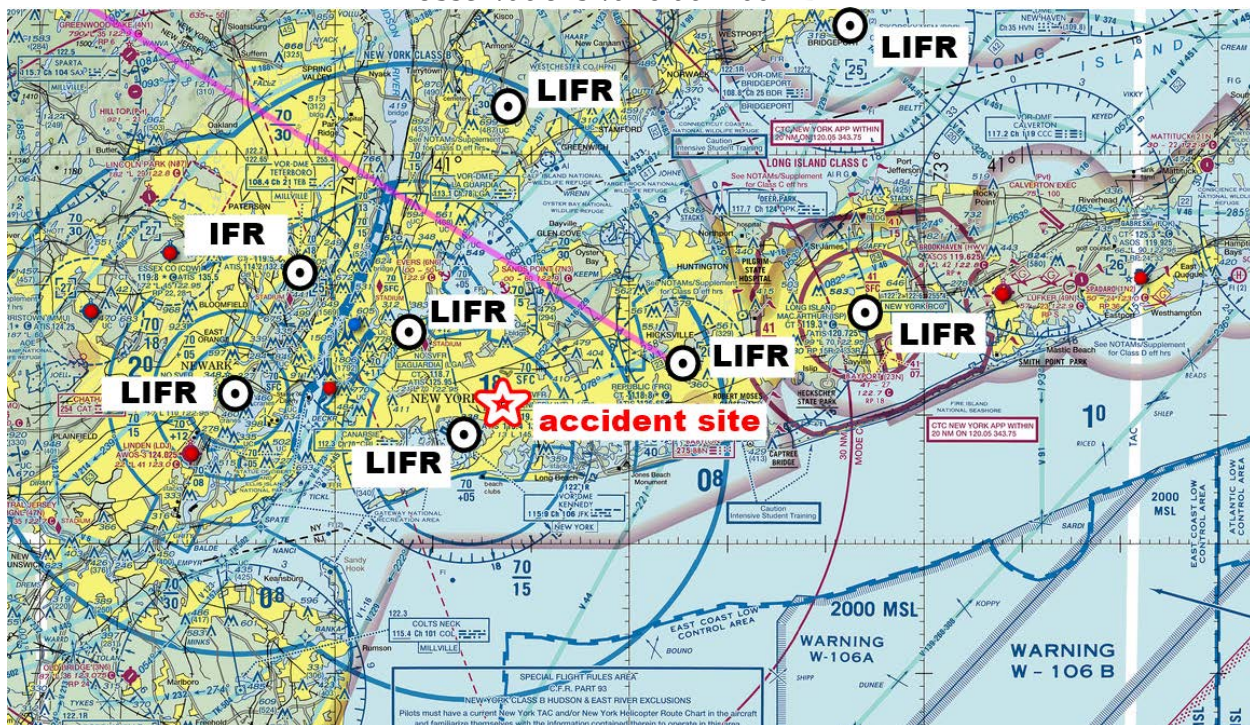


Figure 18 – Sectional chart of accident area with the general flight categories marked and observations valid at 2215 EDT

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Brookhaven, New York, KOKX, located 40 miles east-northeast of the accident site, with a site number of 72501 and an elevation of 66 ft. The 2000 EDT KOKX sounding was plotted on a standard Skew-T Log P diagram,¹⁰ and is included in figure 19 (with data from the surface to 600-hPa (or approximately 14,000 ft msl). This data was analyzed using the RAOB¹¹ software package. The sounding depicted the lifted condensation level (LCL)¹² at the surface (66 ft msl) and the convective condensation level (CCL)¹³ at 2,747 ft agl (2,813 ft msl). The sounding had a more than 95 percent relative humidity from the surface through 5,500 ft msl. The freezing level was located at 13,173 ft msl. The precipitable water value was 1.35 inches.

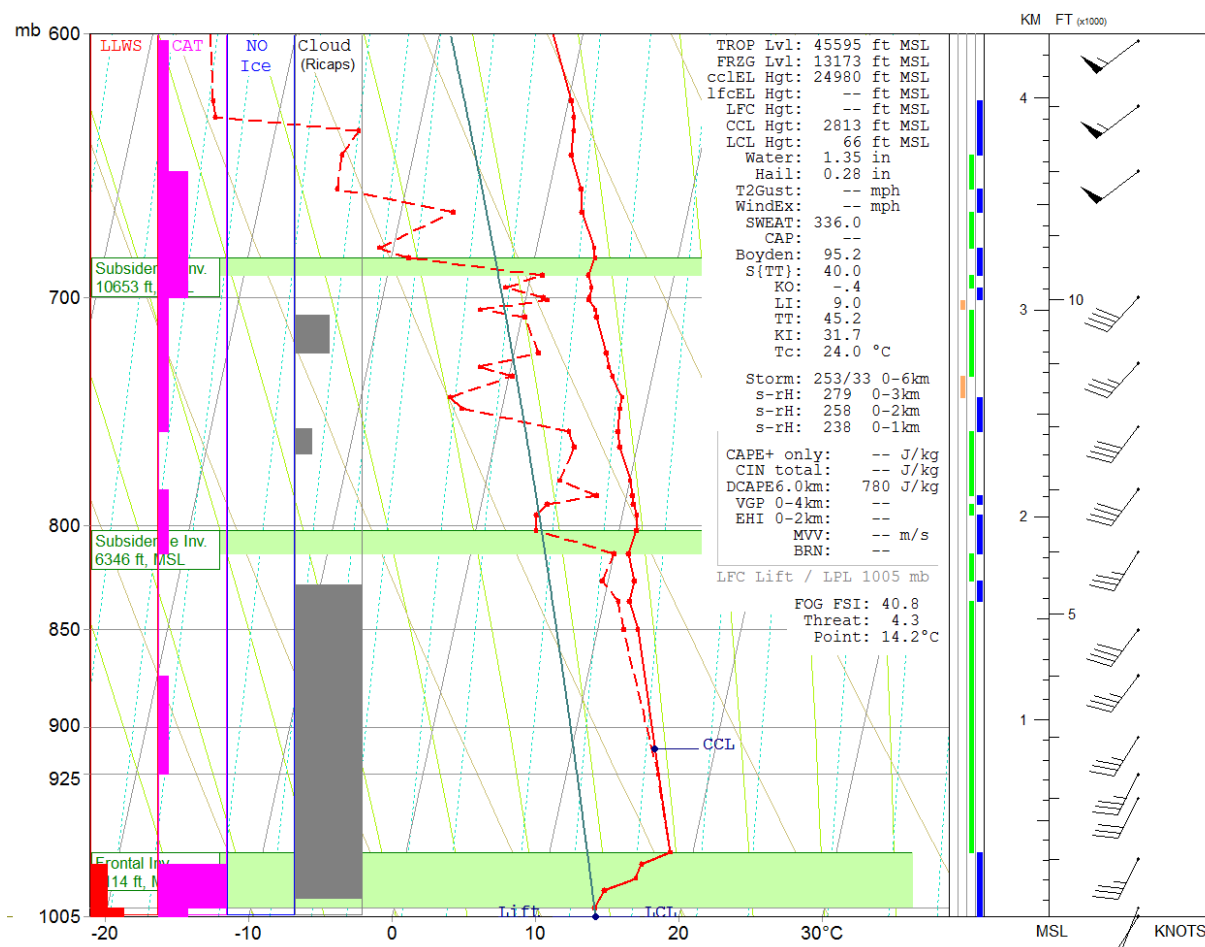


Figure 19 – 2000 EDT KOKX sounding

¹⁰ Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

¹¹ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹² LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹³ CCL – The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

The 2000 EDT KOKX sounding for the accident site indicated alternating layers of stable and conditionally unstable environments from the surface through 14,000 ft. RAOB identified the possibility of clouds from 100 ft agl through 6,000 ft msl. RAOB did not indicate the possibility of icing conditions below 14,000 ft msl. A frontal inversion¹⁴ was indicated at 1,114 ft msl, with subsidence inversions located at 6,346 and 10,653 ft msl. Inversions can act to “trap” moisture and clouds below the base of the inversion if no forcing mechanisms are present to lift or transport the moisture elsewhere (either in altitude or location).

The 2000 EDT KOKX sounding wind profile indicated a surface wind from 210° at 2 knots with the wind speed increasing to 33 knots by 911 ft msl. The wind remained from the southwest through 14,000 ft. The wind speed remained between 30 to 40 knots between 1,000 ft msl and 10,000 ft msl. RAOB indicated the possibility of moderate low-level wind shear (LLWS) between the surface and 1,000 ft agl. RAOB indicated the possibility of moderate or greater clear-air turbulence in several layers between the surface and 14,000 ft.

5.0 Satellite Data

Data from the Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible (band 2) and infrared (bands 13) imagery at wavelengths of 0.64 microns (μm) and 10.3 μm , respectively, were retrieved for the period. Satellite imagery surrounding the time of the accident, from 1800 EDT through 2300 EDT at approximately 5-minute intervals were reviewed, and the closest images to the time of the accident are documented here. Due to the time of day the visible imagery was not beneficial around the accident time.

Figures 20 and 21 present the GOES-16 infrared imagery from 2210 and 2220 EDT at 6X magnification and with a temperature enhancement curve applied with the accident site highlighted with a red square. Inspection of the infrared imagery indicated abundant cloud cover over the accident site at the accident time with the lowest brightness temperatures (blue and green colors, higher clouds) located above and surrounding the accident site in all directions. The cloud cover was moving from southwest to northeast. Based on the brightness temperatures above the accident site (220° Kelvin) and the vertical temperature profile provided by the 2000 EDT KOKX sounding, the approximate cloud-top heights over the accident site were 38,000 ft at 2220 EDT. It should be noted these figures have not been corrected for any parallax error.

¹⁴ Inversion – A departure from the usual decrease of the value of an atmospheric property with increasing altitude; also, the layer through which this departure occurs (the "inversion layer"), or the lowest altitude at which the departure is found (the "base of the inversion").

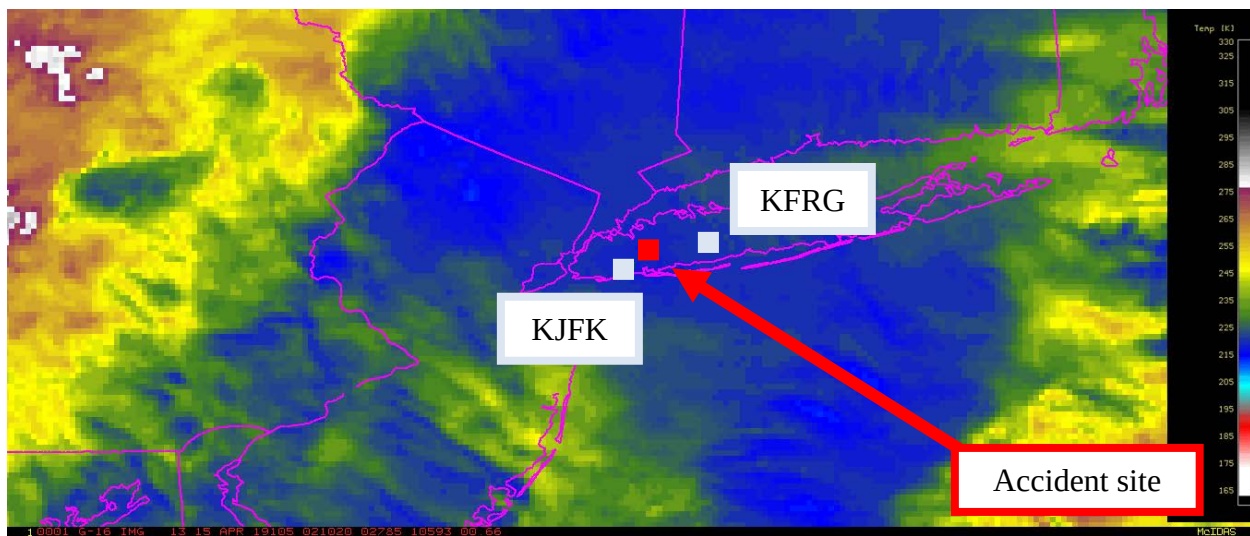


Figure 20 – GOES-16 infrared image at 2210 EDT

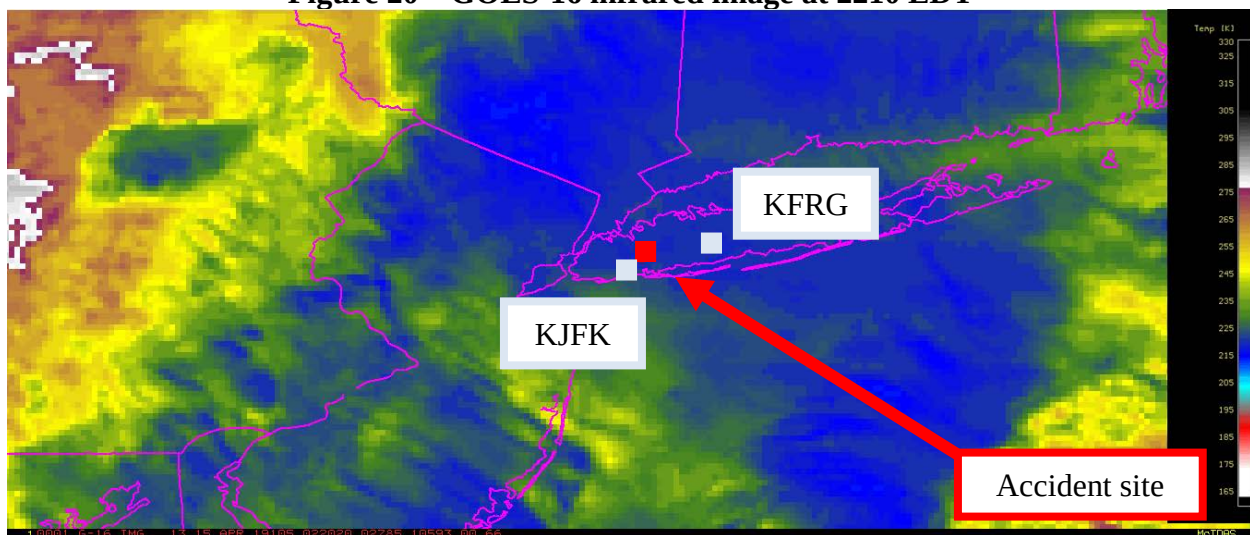


Figure 21 – GOES-16 infrared image at 2220 EDT

6.0 Regional Radar Imagery Information

A regional view of the NWS National Composite Radar Mosaic is included as figure 22 for 2215 EDT with the approximate location of the accident site marked within the red circle. The image depicted 15 to 25 decibel (dBZ¹⁵) echoes above the accident site.

¹⁵ dBZ – A non-dimensional “unit” of radar reflectivity which represents a logarithmic power ratio (in decibels, or dB) with respect to radar reflectivity factor Z.

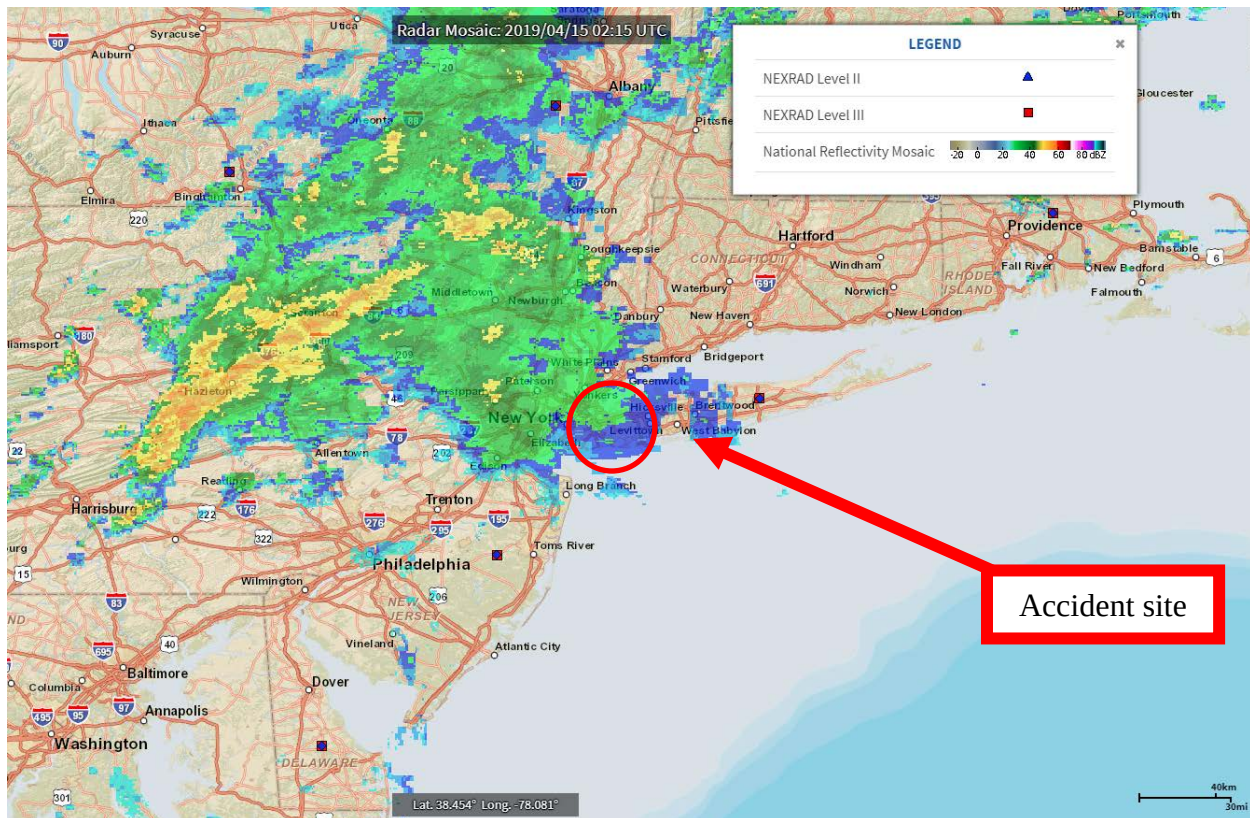


Figure 22 – Regional Composite Reflectivity image for 2215 EDT

7.0 Radar Imagery Information

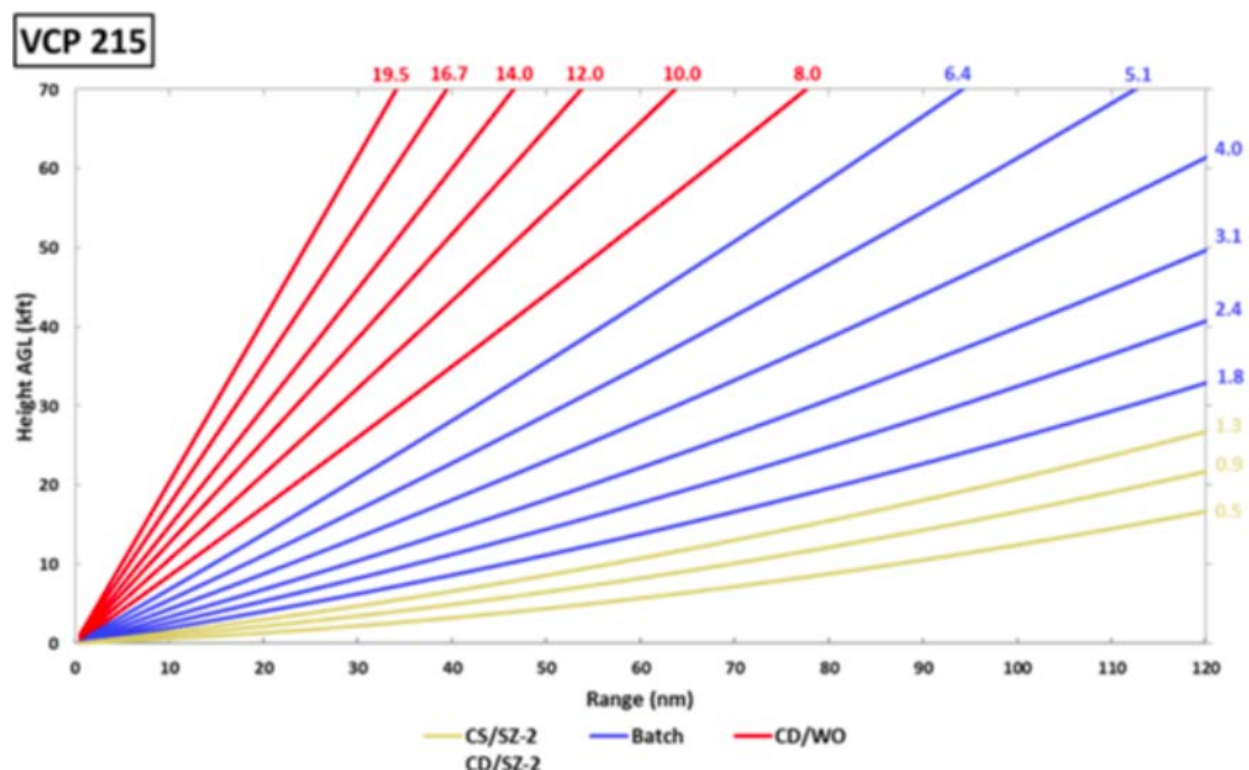
The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁶ to the accident site was KOKX. Level II archive radar data was obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

7.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available. Products that require data from multiple elevation scans are not available until the end of the five to ten-minute volume scan.

¹⁶ The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 15 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 215 (VCP-215). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten-minute period. During the period surrounding the accident, the KOKX WSR-88D radar was operating in the precipitation mode VCP-215. The following chart provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.



VCP-215 Precipitation Mode Scan Strategy¹⁷

¹⁷ Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured. Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values.

Batch Mode – Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.

W – With range unfolding (W)

WO – Without range unfolding (WO)

7.2 Beam Height Calculation

Assuming standard refraction¹⁸ of the WSR-88D radar beam with the antenna elevation at 198 ft (KOKX), and considering a beamwidth¹⁹ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KOKX 0.5°	3,480 ft	1,510 ft	5,450 ft

Based on the radar height calculations, the elevation scan listed in the above table depicted the conditions between 1,510 ft and 5,450 ft msl over the accident site and these scans “saw” the closest altitudes to the ground and the accident aircraft’s flight level.²⁰

7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²¹ it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in dBZ, and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C²², “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

¹⁸ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

¹⁹ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

²⁰ For more information please see ATC data located in the docket of this accident.

²¹ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth’s surface; also, any water particles blown by the wind from the earth’s surface. Hydrometeors are classified as; (a) Liquid or solid water particles suspended in the air: cloud, water droplets, mist or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) Solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth’s surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glazed ice.

²²

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible

7.4 Base Reflectivity and Lightning Data

Figures 23 and 24 present the KOKX WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 2056:28 and 2214:11 EDT, respectively, with a resolution of 0.5° X 250 m. The accident aircraft was not located in precipitation around the time of the first approach into KFRG (figure 23, attachment 1). Reflectivity values between 5 and 15 dBZ or very light intensity echoes (section 7.3) were located above the accident site at the accident time (figure 24). The reflectivity bands were moving from southwest to northeast (attachment 1).

There were no lightning strikes near the accident site at the accident time.²³

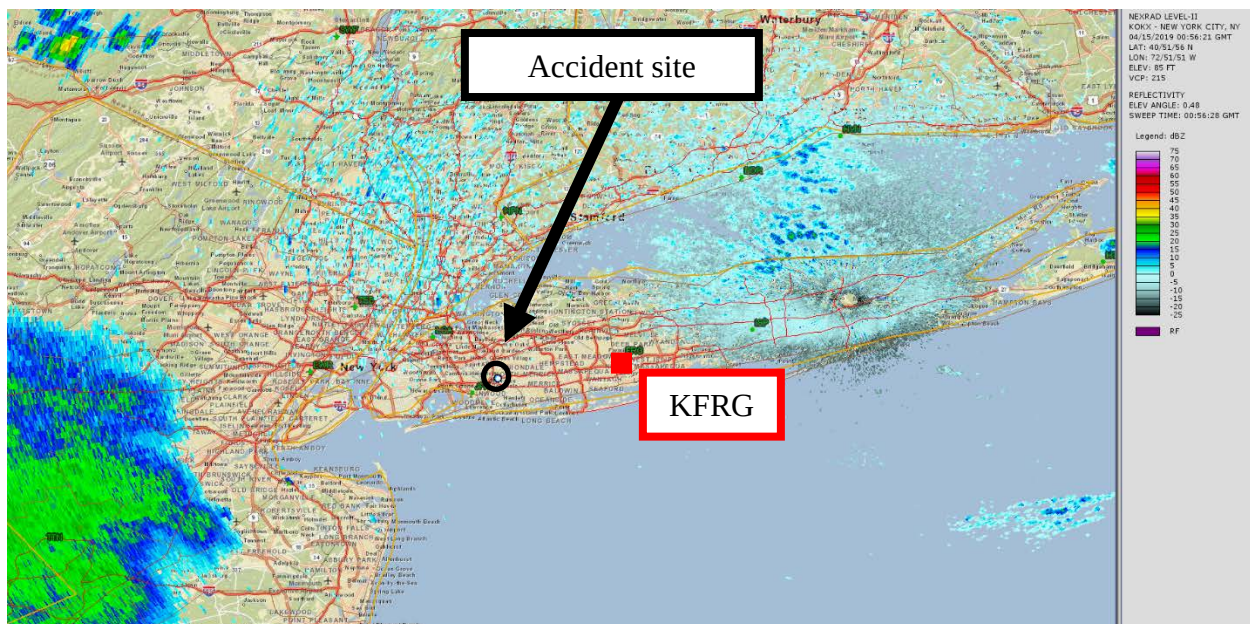


Figure 23 – KOKX WSR-88D reflectivity for the 0.5° elevation scan initiated at 2056:28 EDT with the accident site marked with black circle, the accident flight track in pink

²³ A review of Earth Networks Total Lightning network was done.

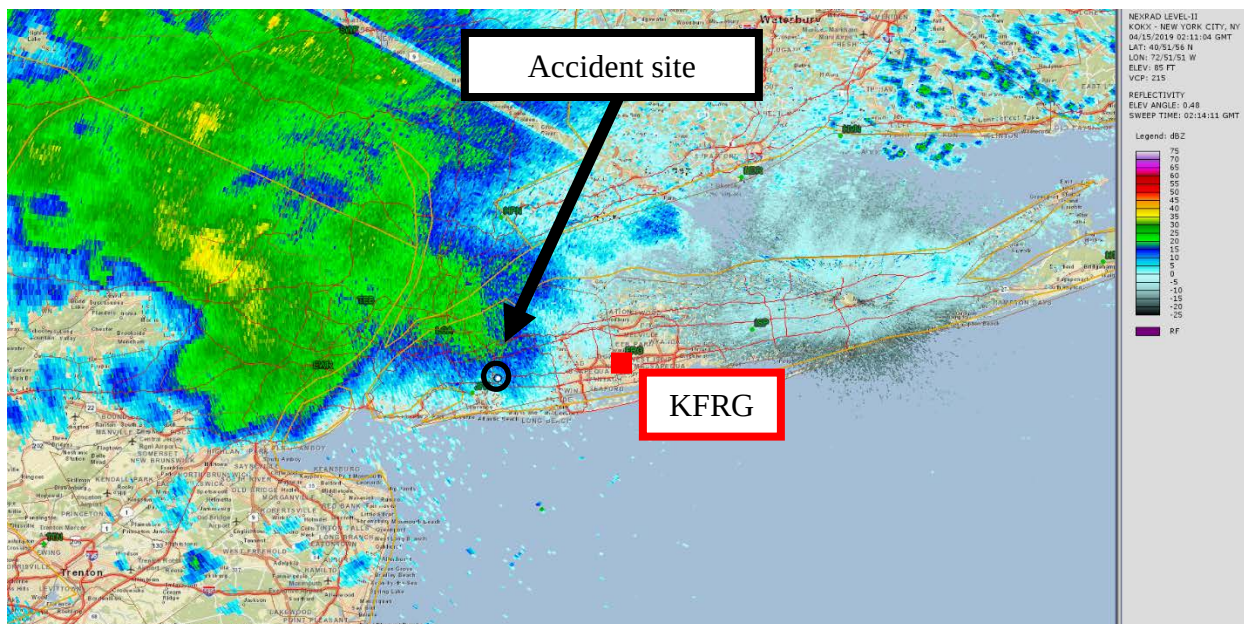


Figure 24 – KOKX WSR-88D reflectivity for the 0.5° elevation scan initiated at 2214:11 EDT with the accident site marked with black circle, the accident flight track in pink

8.0 Pilot Reports²⁴

All pilot reports (PIREPs) within 100 miles of the accident site from about three hours prior to the accident time to about two hours after the accident time for below FL200²⁵ are provided below:

LGA UA /OV FINAL RWY 22/TM 2331/FL0004/TP HA4T/SK BASES REPORTED 400 FT=

LGA UA /OV KLGA130003/TM 0336/FL010/TP E170/SK OVC003/RM DURC =

The reports in plain language taken from standard code and abbreviations, with cloud heights in msl, and time converted to local were as follows:

Routine pilot report (UA) LaGuardia Airport, New York (LGA); Over – Final runway 22; Time – 1931 EDT (2331Z); Altitude – 400 ft; Type aircraft – Hawker 4000; Sky – Cloud bases reported at 400 ft.

Routine pilot report (UA) LGA; Over – 3 miles from LGA on the 130° radial; Time – 2336 EDT (0336Z); Altitude – 1,000 ft; Type aircraft – Embraer ERJ-170; Sky – Overcast clouds at 300 ft; Remarks – During climb.

²⁴ Only pilot reports with the World Meteorological Organization (WMO) header UBNJ**, UBNY**, and UBCT** identifier were considered.

²⁵ Flight Level – A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25-hPa (29.92 inHg), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

9.0 SIGMET

There were no convective or non-convective Significant Meteorological Information (SIGMET) advisories valid for the accident site at the accident time.

10.0 CWSU Advisories

There were no Center Weather Service Unit (CWSU) Center Weather Advisories (CWA) or Meteorological Impact Statements (MIS) valid for the accident site at the accident time.

11.0 AIRMETs

There were Airmen's Meteorological Information (AIRMET) advisories Sierra, Tango, and Zulu that were issued at 1645 EDT and valid for the accident site at the accident time for below FL200. AIRMET Sierra warned of IFR conditions due to precipitation, and mist, while AIRMET Tango warned of moderate turbulence below FL180 and LLWS conditions. An AIRMET Zulu warned of moderate icing conditions between freezing level²⁶ and FL240. AIRMETs Sierra and Tango were updated at 1918 and 1832 EDT, respectively, with the same information as the previous issuances:

WAUS41 KKCI 142045

WA1S

-BOSS WA 142045

AIRMET SIERRA UPDT 7 FOR IFR AND MTN OBSCN VALID UNTIL 150300

.
AIRMET IFR...PA OH LE

FROM 50ESE ECK TO 40N CLE TO 20NE ERI TO CVG TO FWA TO 50ESE ECK
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.
**AIRMET IFR...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC AND CSTL WTRS**

**FROM 50ENE MSS TO 40SW MPV TO 100SSW YSJ TO 190SE ACK TO 50SSW
SBY TO CSN TO 20ENE GSO TO 40S RDU TO 30ESE CAE TO 40SE VXV TO
HNV TO HNN TO CVG TO 20NE ERI TO 30ESE YYZ TO 50ENE MSS
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.**

.
AIRMET MTN OBSCN...ME NH VT MA NY PA WV MD VA

FROM 70NW PQI TO MLT TO 20SSW CON TO 40SE ALB TO HAR TO 40SSW
LYH TO HNV TO HNN TO AIR TO 20SSW JHW TO SYR TO 20WSW MSS TO YSC
TO 70NW PQI

MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.
OTLK VALID 0300-0900Z

AREA 1...IFR ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC AND CSTL WTRS

BOUNDED BY 80NW PQI-40N PQI-40ESE HUL-200SE ACK-40SSE SBY-50SSE
ECG-70ENE ILM-30NNE FLO-30SE CAE-HNV-40SE AIR-20SSE EWC-30ENE
MSS-YSC-80NW PQI

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.

²⁶ Freezing level ranged from 4,000 to 11,000 ft msl.

AREA 2...IFR NY LO PA OH LE WV
BOUNDED BY 30ENE MSS-40ENE EWC-40ESE APE-20NNW HNN-CVG-FWA-DXO-
30SW BUF-20ESE YYZ-50NW SYR-30SE YOW-30ENE MSS
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.

....

WAUS41 KPCI 142045
WA1T
-BOST WA 142045
AIRMET TANGO UPDT 4 FOR TURB STG WNDZ AND LLWS VALID UNTIL 150300

.
...SEE SIGMET UNIFORM SERIES...

.
AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS
FROM 60ENE YQB TO 40ENE PQI TO 70SW YSJ TO 140SSE ACK TO 160SE
SIE TO 20NE ECG TO HNV TO HNN TO CVG TO FWA TO 30SE ECK TO YOW
TO YSC TO 60ENE YQB
MOD TURB BTN FL180 AND FL390. CONDS CONTG BYD 03Z THRU 09Z.

.
**AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA FL AND CSTL WTRS
FROM 40ENE YQB TO 30ENE HUL TO 90ESE ACK TO 160SE SIE TO 110ESE
ILM TO 20SSE ORL TO 40W CEW TO 50SW PZD TO GQO TO HNV TO HNN TO
CVG TO FWA TO 30SE ECK TO YOW TO YSC TO 40ENE YQB
MOD TURB BLW FL180. CONDS CONTG BYD 03Z THRU 09Z.**

.
AIRMET STG SFC WNDZ...NJ MD DE VA NC SC GA FL AND CSTL WTRS
FROM 60ESE CYN TO 150SE SIE TO 190ESE ECG TO 140SSE ILM TO 190SE
CHS TO 60E CRG TO 50SE ECG TO 60ESE CYN
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 00-03Z.
CONDS CONTG BYD 03Z THRU 09Z.

.
**LLWS POTENTIAL...NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA AND CSTL WTRS
BOUNDED BY 20NNE YSC-50SW ACK-50ESE SBY-80E ILM-20SSE SAV-40SE
ATL-30ENE GQO-HNV-HNN-CVG-FWA-30ESE ECK-YOW-20NNE YSC
LLWS EXP. CONDS CONTG BYD 03Z THRU 09Z.**

.
OTLK VALID 0300-0900Z
AREA 1...TURB ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS
BOUNDED BY 70NW PQI-60NE PQI-150ENE ACK-200SE ACK-160SE SIE-20NE
ECG-HNV-HNN-CVG-30SE ECK-YOW-YSC-70NW PQI
MOD TURB BTN FL180 AND FL390. CONDS CONTG THRU 09Z.

.
AREA 2...TURB ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA FL AND CSTL WTRS
BOUNDED BY 70NW PQI-60NE PQI-200SE ACK-160SE SIE-190ESE ECG-
130SSE ILM-180ENE OMN-50SW PZD-GQO-HNV-HNN-YYZ-YOW-YSC-70NW PQI
MOD TURB BLW FL180. CONDS CONTG THRU 09Z.

.
AREA 3...TURB NY LO PA OH LE WV MD VA NC SC GA
BOUNDED BY YYZ-20SW ERI-HNN-CVG-FWA-30SE ECK-YYZ
MOD TURB BLW 080. CONDS CONTG THRU 09Z.

.

AREA 4...STG SFC WND S ME NH MA RI CT NY NJ MD DE VA NC SC GA FL
AND CSTL WTRS
BOUNDED BY 100NE ACK-200SE ACK-160SE SIE-190ESE ECG-130SSE ILM-
220SE CHS-70ENE CRG-60SSE ECG-50ESE SBY-20S JFK-100NE ACK
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG THRU 09Z.

....

WAUS41 KPCI 142045

WA1Z

-BOSZ WA 142045

AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 150300

.

AIRMET ICE...OH LE

FROM 30SE ECK TO 20SSW ROD TO 50SE CVG TO CVG TO FWA TO 30SE ECK
MOD ICE BTN FRZLVL AND FL200. FRZLVL 010-050. CONDS DVLPG AFT
21Z. CONDS CONTG BYD 03Z THRU 09Z.

.

**AIRMET ICE...ME NH VT MA RI CT NY LO NJ PA OH LE AND CSTL WTRS
FROM 70NW PQI TO 60NE PQI TO 150ENE ACK TO 60E ACK TO HAR TO
40SSE JHW TO 30NW EWC TO 40N CLE TO 30E YYZ TO 40NNW SYR TO 20NNW
MSS TO 20E YSC TO 70NW PQI
MOD ICE BTN FRZLVL AND FL240. FRZLVL 040-110. CONDS CONTG BYD 03Z
THRU 09Z.**

.

OTLK VALID 0300-0900Z...ICE NY PA OH LE WV

BOUNDED BY 40NNE ERI-20SSE JHW-30ESE EWC-20SE EKN-20NNE

BKW-HNN-CVG-FWA-20ENE DXO-40NNE ERI

MOD ICE BTN FRZLVL AND FL200. FRZLVL SFC-040. CONDS CONTG THRU
09Z.

.

FRZLVL...RANGING FROM 015-140 ACRS AREA

MULT FRZLVL 040-100 BOUNDED BY 80NW PQI-30NE PQI-50SSE HUL-
30ESE YSC-80NW PQI

MULT FRZLVL 020-110 BOUNDED BY 30SE ECK-50NW ERI-20SSW APE-
50SSW AIR-50W GSO-20NNE LGC-GQO-HMV-HNN-CVG-FWA-30SE ECK
040 ALG 40E CVG-30E ROD-40ESE DXO-50E ECK

040 ALG 40ESE YQB-40E PQI

080 ALG 20S HNN-20SSW ERI-50S YYZ-70SSW YOW-60E MSS-60WSW YSJ

120 ALG 20NNE GSO-40W EMI-BDL-40ESE BOS-100ENE ACK-140E ACK

....

WAUS41 KPCI 142232 AAA

WA1T

-BOST WA 142232 AMD

AIRMET TANGO UPDT 5 FOR TURB STG WND S AND LLWS VALID UNTIL 150300

.

AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS

FROM 60ENE YQB TO 40ENE PQI TO 70SW YSJ TO 140SSE ACK TO 160SE
SIE TO 20NE ECG TO HMV TO HNN TO CVG TO FWA TO 30SE ECK TO YOW
TO YSC TO 60ENE YQB

MOD TURB BTN FL180 AND FL390. CONDS CONTG BYD 03Z THRU 09Z.

.

**AIRMET TURB...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA FL AND CSTL WTRS
FROM 40ENE YQB TO 30ENE HUL TO 90ESE ACK TO 160SE SIE TO 110ESE**

**ILM TO 20SSE ORL TO 40W CEW TO 50SW PZD TO GQO TO HNV TO HNN TO
CVG TO FWA TO 30SE ECK TO YOW TO YSC TO 40ENE YQB
MOD TURB BLW FL180. CONDS CONTG BYD 03Z THRU 09Z.**

.
AIRMET STG SFC WND...NJ MD DE VA NC SC GA FL AND CSTL WTRS
FROM 60ESE CYN TO 150SE SIE TO 190ESE ECG TO 140SSE ILM TO 190SE
CHS TO 60E CRG TO 50SE ECG TO 60ESE CYN
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS DVLPG 00-03Z.
CONDS CONTG BYD 03Z THRU 09Z.

.
**LLWS POTENTIAL...NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA AND CSTL WTRS
BOUNDED BY 20NNE YSC-50SW ACK-50ESE SBY-80E ILM-20SSE SAV-40SE
ATL-30ENE GQO-HMV-HNN-CVG-FWA-30ESE ECK-YOW-20NNE YSC
LLWS EXP. CONDS CONTG BYD 03Z THRU 09Z.**

.
OTLK VALID 0300-0900Z
AREA 1...TURB ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
AND CSTL WTRS
BOUNDED BY 70NW PQI-60NE PQI-150ENE ACK-200SE ACK-160SE SIE-20NE
ECG-HMV-HNN-CVG-30SE ECK-YOW-YSC-70NW PQI
MOD TURB BTN FL180 AND FL390. CONDS CONTG THRU 09Z.

.
AREA 2...TURB ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA FL AND CSTL WTRS
BOUNDED BY 70NW PQI-60NE PQI-200SE ACK-160SE SIE-190ESE ECG-
130SSE ILM-180ENE OMN-50SW PZD-GQO-HMV-HNN-YYZ-YOW-YSC-70NW PQI
MOD TURB BLW FL180. CONDS CONTG THRU 09Z.

.
AREA 3...TURB NY LO PA OH LE WV MD VA NC SC GA
BOUNDED BY YYZ-20SW ERI-HNN-CVG-FWA-30SE ECK-YYZ
MOD TURB BLW 080. CONDS CONTG THRU 09Z.

.
AREA 4...STG SFC WND...ME NH MA RI CT NY NJ MD DE VA NC SC GA FL
AND CSTL WTRS
BOUNDED BY 100NE ACK-200SE ACK-160SE SIE-190ESE ECG-130SSE ILM-
220SE CHS-70ENE CRG-60SSE ECG-50ESE SBY-20S JFK-100NE ACK
SUSTAINED SURFACE WINDS GTR THAN 30KT EXP. CONDS CONTG THRU 09Z.

....

WAUS41 KPCI 142318 AAA
WA1S
-BOSS WA 142318 AMD
AIRMET SIERRA UPDT 8 FOR IFR AND MTN OBSCN VALID UNTIL 150300

.
AIRMET IFR...OH LE...UPDT
FROM 30SE ECK TO 40N CLE TO 30WNW ERI TO CVG TO FWA TO 30SE ECK
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.
**AIRMET IFR...ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC GA AND CSTL WTRS...UPDT
FROM 40ENE MSS TO 50SW MPV TO 110SE BGR TO 200SE ACK TO 30SE SBY
TO 20SSW CSN TO 40SW LYH TO 20S RDU TO 30E CAE TO 30N ODF TO HNV
TO HNN TO CVG TO 20SE YYZ TO 30ESE YOW TO 40ENE MSS
CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.**

AIRMET MTN OBSCN...ME NH VT MA NY PA WV MD VA NC SC GA...UPDT
FROM 50NW PQI TO MLT TO CON TO 20NW SAX TO HAR TO CLT TO ATL TO
GQO TO HMV TO HNN TO JHW TO SYR TO MSS TO 20ESE YSC TO 50NW PQI
MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 03Z THRU 09Z.

.
OTLK VALID 0300-0900Z

AREA 1...IFR ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC DE VA
NC SC AND CSTL WTRS

BOUNDED BY 80NW PQI-40N PQI-40ESE HUL-200SE ACK-190SSE ACK-40SE
SBY-50S ECG-40ENE ILM-20SE CAE-HMV-20SSW ERI-20WSW YYZ-30N MSS-
YSC-80NW PQI

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.

.
AREA 2...IFR NY LO PA OH LE WV

BOUNDED BY 20WSW YOW-20ESE MSS-60S JHW-20NW HNN-60W HNN-CVG-FWA-
30SE ECK-20WSW YOW

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 09Z.

....

12.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products made available before the accident flight are shown in attachment 2. The GFA surface forecast products indicated LIFR conditions with a chance rain shower activity (30 to 60 percent chance) for 2000 EDT and likely (greater than 60 percent chance) rain shower activity at 2300 EDT. The surface wind was forecast from the south to southeast at 10 to 15 knots with gusts to 20 knots. The GFA cloud forecast products indicated a cloud ceiling at 300 ft msl with layered clouds through FL250 and cloud tops to FL450 with cirrus above. The GFA forecasts issued at 0905 EDT and 1203 EDT indicated similar forecasts for the accident site at the accident time. For more information please see attachment 2 along with the Graphical AIRMETs (G-AIRMETs)²⁷ valid at the forecast time, which are overlaid on the figures. The only human-generated information reflected in the two GFA products are the G-AIRMETs and the GFA is “human-over-the-loop.”

13.0 Terminal Aerodrome Forecast

KJFK was the closest site with an NWS Terminal Aerodrome Forecast (TAF). The KJFK TAF valid at the accident time was issued at 1922 EDT and was valid for a 30-hour period beginning at 2000 EDT. The 1922 EDT TAF for KJFK was as follows:

TAF KJFK 142322Z 1500/1606 **17016KT 1/2SM FG OVC002 WS020/20045KT**
FM150600 20018KT 2SM SHRA BR SCT003 OVC015 WS020/21055KT
TEMPO 1509/1511 1SM +TSRA BKN007 OVC040CB
FM151100 23013KT 6SM -SHRA BR BKN025 OVC080
FM151400 24018G29KT P6SM SCT025 BKN040
FM151700 28026G37KT P6SM BKN040
FM160500 30020G30KT P6SM SCT040=

²⁷ <https://aviationweather.gov/gairmet>

The TAF expected a wind from 170° at 16 knots, a half mile visibility and fog, and an overcast ceiling at 200 ft agl. LLWS forecast between the surface and 2,000 ft agl with the wind from 200° at 45 knots at 2,000 ft agl.

The KJFK TAF valid before departure was issued at 1633 EDT and was valid for a 27-hour period beginning at 1700 EDT. The 1633 EDT TAF for KJFK was as follows:

KJFK 142033Z 1421/1524 14010KT 3SM BR OVC004
FM142200 14013KT 2SM BR OVC003
FM150000 17016KT 1/2SM FG OVC002 WS020/20045KT
FM150600 20018KT 2SM SHRA BR SCT003 OVC015 WS020/21055KT
PROB30 1509/1511 1SM +TSRA BKN007 OVC040CB
FM151100 23013KT 6SM -SHRA BR BKN025 OVC080
FM151400 24018G29KT P6SM SCT025 BKN040
FM151700 28026G37KT P6SM BKN040=

The TAF expected from 2000 EDT through 0200 EDT (April 15) a wind from 170° at 16 knots, a half mile visibility and fog, and an overcast ceiling at 200 ft agl. LLWS forecast between the surface and 2,000 ft agl with the wind from 200° at 45 knots at 2,000 ft agl. Similar conditions were forecast in the 1335 EDT KJFK TAF, and the 1922, 1633, and 1409 EDT KISP TAFs.

14.0 NWS Area Forecast Discussion

The NWS Office in New York, New York, issued the following Area Forecast Discussion (AFD) at 2209 EDT (closest AFD to the accident time with an aviation section). The aviation section of the AFD discussed IFR or lower conditions persisting through the overnight hours with a gusty southerly surface wind:

FXUS61 KOKX 150209
AFDOKX

Area Forecast Discussion
National Weather Service New York NY
1009 PM EDT Sun Apr 14 2019

.SYNOPSIS...

A cold front approaches tonight and moves through late at night into Monday morning. High pressure returns Tuesday into Wednesday and then gradually gives way to a warm front approaching from the southwest. The warm front lifts north Friday morning, followed by a cold frontal passage late Saturday into Sunday.

&&

.NEAR TERM /THROUGH MONDAY/...

The fcst is on track. Another round of dense fog for the region, but mainly confined to the Connecticut Coast, Long Island, and perhaps southern portions of Westchester. These areas are under a Dense Fog Advisory. Elsewhere, the dense fog is forecast to be more patchy in nature. There is some uncertainty as to how quickly conditions improve as south winds strengthen through the night. However, locations along the

immediate coast will likely see advection fog through the night as warm, moist air moves across the cooler nearshore waters.

Strengthening low pressure moves from the Ohio Valley this evening to Upstate New York by late. LLJ helps push a warm front farther north, with the entire forecast area in the warm sector. A trailing cold front then reaches west of the Hudson towards daybreak. There's enough moisture and lift for chances of showers at any given point tonight, but high res models continue to key on the main focus for showers and thunderstorms after midnight. The main line of showers and thunderstorms will enter western zones 06z to 09z, and then quickly move across the NYC/NJ metro 09z to 12z, and then across eastern zones shortly thereafter. The line will be forced by convergence of a +3 to +4 standard deviation PWAT subtropical moisture plume ahead of the front as well as deep layered lift enhanced by upper jet dynamics.

Forecast rainfall amounts are generally 1/2 to 1 inch across the region with locally higher amounts possible. Much of this rain may come within the line of showers and thunderstorms. Minor urban and poor drainage flooding is the main threat. The relatively fast movement of the showers and thunderstorms should limit any flash flooding threat, but WPC does have marginal to slight risk for excessive rainfall from around NYC and points west.

SPC has placed portions of NE NJ, NYC, and the Lower Hudson Valley in a slight risk for severe thunderstorms. This is where there is some surface based CAPE progged by some models. The main threat appears to be damaging wind gusts. The environment is highly sheared with low CAPE, so there is potential for rotation, but the potential is very low. A stronger low-level inversion should limit the severe threat east of the Hudson River where instability is elevated.

&&

.SHORT TERM /MONDAY NIGHT/...

The line of showers and storms should be east of the forecast area by noon, however, lingering moisture along with a secondary cold front and strong shortwave could trigger a few more showers and even a thunderstorm.

It will become windy with a strong pressure gradient in place and cold air advection helping winds gust. Might eventually need a wind advisory for some coastal areas, whether it be from sustained winds or gusts, but still don't have enough confidence for a widespread event for any particular area. Best chances would be during mid-afternoon into the night. Sustained winds probably 20 to 30 mph and gusts of 40-45 mph likely.

High temperatures probably occur before the afternoon, and the strong cold air advection will have temperatures falling through the afternoon.

Dry for the nighttime with winds slowly subsiding, but still breezy even late at night.

&&

.LONG TERM /TUESDAY THROUGH SUNDAY/...

Upper flow briefly flattens out to start the period with an upper low departing from the Canadian Maritimes. At the same time, a trough moves into the desert southwest. Later in the week, this feature will interact with northern branch energy, sending a frontal system into the area for the end of the week into the weekend. There is very good agreement with the 12Z ECMWF and GFS with the extent of phasing of the two branches and the progression of the aforementioned frontal system. The GGEM is a bit more progressive, especially with the lead frontal band precipitation Friday night into Saturday morning.

A consensus forecast approach brings high pressure into the region Tuesday into Wednesday with a warm front approaching from the southwest. Prior to that time, gusty W winds will follow on the heels of deepening low pressure tracking northeast across the Canadian Maritimes. There could be some gusts up to 30 kt through early Tuesday afternoon as winds gradually subside with high pressure building in from the west.

There is a low chance of rain working in from the southwest Tuesday night. However, unlike 24 hours ago, it appears Wednesday will be dry as ridging builds in both aloft and at the surface. The northward progress of the warm front will likely be very slow due to an amplified ridge building along the eastern seaboard as the upper trough amplifies across the mid section of the country.

Warm frontal passage has trended faster in the global guidance, lifting north of the region by daybreak Friday. A deep-layered southerly flow develops along the east coast as the upper ridge slowly translates east Thursday into Friday. A strong low-level jet ahead of the approaching cold front supports moderate to heavy warm conveyor belt rains with embedded thunderstorms late Friday night into the first half of Saturday. There will likely be timing changes through the week as the Pac jet energy has yet to move onshore. Additionally, a strong onshore flow Friday into Saturday will likely result in areas of stratus and fog, especially east of the Hudson River. Dew points are forecast to be in the 50s, but this may be conservative.

Scattered showers may linger into Sunday depending on how quickly the upper trough/low passes through the area.

As for temperatures, daytime highs will be near seasonable levels through Thursday before a warm frontal passage Friday morning. Lows will be several degrees above normal due to onshore flow and potential for stratus/fog. Following the warm front, warmer, humid conditions are likely with areas away from the coast getting into the 70s.

&&

.AVIATION /02Z MONDAY THROUGH FRIDAY/...

A cold front will pass Mon mning.

IFR or lower tonight. Shwrs and tstms end with the fropa Mon morning. Varying MVFR to IFR conds expected with the shwrs and tstms. Possible tstm impacts to the morning push. VFR returns 12-16z.

S-SE 5-10 kt increase to 15-20 kt overnight. Could be a few gusts around 20 kt early, then 20-25 kt possible 06-12z (mainly coastal terminals) outside of any convection. Surface winds then shift to the S, then SW-W as the cold front moves through tonight. LLWS comes to an end with the fropa and W winds increase 15-25kt with gusts 25-35kt.

Strong WNW winds 17-19z Mon thru at least 4z Tue. Gusts up to 40 kt possible.

There could be some sct-isold shwrs Mon aftn, particularly N of NYC arpts. Any of these could produce GS. The prob and coverage however are too uncertain to include in the tafs atm.

.OUTLOOK FOR 00Z TUESDAY THROUGH FRIDAY...

.Monday night...VFR. Gusty winds gradually diminish to 20-30kt aft 4z.

.Tuesday and Wednesday...VFR. WNW gusts 25-30 kt Tues morning.

.Thursday...Chc shra and MVFR or lower.

.Friday...MVFR or lower possible in shra, iso tstms aftn & night. Gusty S winds possible.

&&

.MARINE...

The dense fog advisory has been extended through the overnight across all waters. Winds and seas increase tonight ahead of the next storm system. SCA in effect for all waters tonight, then have gone with a Gale Warning for Monday and Monday night as the cold front passage and cold air advection/gusty winds behind the storm have been progged to occur a little earlier than previous model runs.

Winds gradually weaken Tuesday, but could still be a SCA levels into early Tuesday afternoon. Ocean seas will be slow to subside through Tuesday. Sub-SCA conditions return on all waters Tuesday evening and should remain there into Thursday. Southerly winds ramp up Thursday into Friday with SCA conditions likely developing on the ocean waters Thursday night and continuing into Friday.

&&

.HYDROLOGY...

Rainfall of 1/2 to 1 inches is likely from this evening through Monday morning with locally higher amounts possible. Minor urban and poor drainage flooding is the main threat. Flashy small stream hydrologic impacts are possible, but the threat is low.

Minor flooding is possible on the Lower CT River by mid next week due to runoff from recent rainfall events and from upstream snow melt in VT and NH.

There is the potential for a significant rainfall event late Friday night into Saturday with a slow moving frontal system.

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.EQUIPMENT...

NYC NOAA Weather Radio Station KWO35 (162.55 MHz) remains off the air.

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.OKX WATCHES/WARNINGS/ADVISORIES...

CT...Dense Fog Advisory until 6 AM EDT Monday for CTZ009>012.

NY...Dense Fog Advisory until 6 AM EDT Monday for NYZ071-075-078>081-178-179.

NJ...None.

MARINE...Dense Fog Advisory until 6 AM EDT Monday for ANZ330-335-338-340-345-350-353-355.

Small Craft Advisory until 6 AM EDT Monday for ANZ330-335-338-340-345-350-353-355.

Gale Warning from 6 AM Monday to 6 AM EDT Tuesday for ANZ330-335-338-340-345-350-353-355.

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15.0 NWS Dense Fog Advisory

The NWS Office in New York, New York, issued the following dense fog advisory at 1956 EDT to warn of hazardous driving potential with one quarter mile or less visibilities into the following morning and this dense fog advisory was valid for the accident site at the accident time:

WWUS71 KOKX 142356
NPWOKX

URGENT - WEATHER MESSAGE
National Weather Service New York NY
756 PM EDT Sun Apr 14 2019

CTZ009>012-NYZ071-075-078>081-178-179-150830-
/O.NEW.KOKX.FG.Y.0005.190414T2356Z-190415T1000Z/
Southern Fairfield-Southern New Haven-Southern Middlesex-
Southern New London-Southern Westchester-Kings (Brooklyn)-
Northwestern Suffolk-Northeastern Suffolk-Southwestern Suffolk-
Southeastern Suffolk-Southern Queens-Southern Nassau-
756 PM EDT Sun Apr 14 2019

...DENSE FOG ADVISORY IN EFFECT UNTIL 6 AM EDT MONDAY...

The National Weather Service in Upton has issued a Dense Fog Advisory, which is in effect until 6 AM EDT Monday.

- * VISIBILITIES...One quarter mile or less at times.
- * TIMING...Overnight until dawn.
- * IMPACTS...Limited visibilities will make travel very difficult.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

A Dense Fog Advisory means visibilities will frequently be reduced to one quarter mile or less. If driving, slow down, use your fog lamps or low beam headlights, and leave plenty of distance ahead of you in case a sudden stop is needed.

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16.0 Winds and Temperature Aloft Forecast

The NWS 2200 EDT Winds and Temperature Aloft forecast valid for 0200 EDT (April 15) for the closest point to the accident site is included below:

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FBUS31 KWN0 150200
FD1US1
DATA BASED ON 150000Z
VALID 150600Z   FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT  3000    6000    9000   12000   18000   24000   30000   34000   39000

JFK 2258 2256+13 2258+06 2261+00 2370-11 2283-23 239938 731747 731557
```

The accident site was closest to the JFK²⁸ forecast point. The JFK forecast for use between 2200 EDT and 0500 EDT (April 15) indicated a wind at 3,000 ft from 220° at 58 knots, at 6,000 ft a wind from 220° at 56 knots with a temperature of 13 °C, and at 9,000 ft a wind from 220° at 58 knots with a temperature of 6 °C.

17.0 Pilot Weather Briefing

The accident pilot did not request an audio weather briefing through Leidos, but requested and received an IFR flight plan through Leidos at 0610 EDT (attachment 3). The accident pilot received a text weather briefing and GFA information for a flight earlier in the accident day from KFRG to KIAG with the weather information provided to the accident pilot at 0610 EDT (attachments 4 and 5). The Leidos weather information provided at 0610 EDT contained all the standard weather information for a flight from KFRG to KIAG. No weather information was requested through Leidos for the accident flight.

²⁸ Same forecast point as KJFK referenced back in section 3.0.

A check of ForeFlight was done and revealed that the accident pilot did not check weather conditions through ForeFlight. It is unknown if the accident pilot checked or received any additional weather information before or during the accident flight.

18.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on April 14, 2019, indicated the following:

SUN

Begin civil twilight	0551 EDT
Sunrise	0619 EDT
Sun transit	1256 EDT
Sunset	1934 EDT
End civil twilight	2002 EDT
Accident	2215 EDT²⁹

MOON

Moonset	0341 EDT
Moonrise	1359 EDT
Moon transit	2115 EDT
Accident	2215 EDT³⁰
Moonset	0423 EDT on the following day

The Moon phase was Waxing Gibbous with 71% of the Moon's visible disk illuminated. With the abundance of cloud cover and cloud tops height (sections 3.0 and 5.0), the Moon would not have been visible at the accident site at the accident time.

E. LIST OF ATTACHMENTS

Attachment 1 – Animation of KOKX WSR-88D base reflectivity images for the 0.5° elevation scans initiated between 2030 and 2235 EDT

Attachment 2 – GFA products available before the accident flight for around the accident time

Attachment 3 – IFR flight plan request through Leidos

Attachment 4 – Text weather briefing information provided by Leidos at 0610 EDT

Attachment 5 – GFA provided by Leidos at 0610 EDT

²⁹ Inserted accident time for reference and context.

³⁰ Inserted accident time for reference and context.

Submitted by:

Paul Suffern
Senior Meteorologist

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