



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
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Weather Study

METEOROLOGY

CEN16FA372

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A. ACCIDENT

Location: Alexandria, Minnesota
Date: September 17, 2016
Time: 0207 central daylight time
0707 Coordinated Universal Time (UTC)
Airplane: Agusta A109S, N91NM

B. METEOROLOGIST

Paul Suffern
Group Chairman
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On September 17, 2016, at 0207 central daylight time, an Agusta S.p.A A109S helicopter, N91NM, impacted trees and terrain near Chandler Field Airport (AXN), Alexandria, Minnesota. The commercial rated pilot and two crew members sustained serious injuries and the helicopter was destroyed. The helicopter was registered to North Memorial Health Care, Brooklyn Center, Minnesota, and operated by North Memorial Medical Center under the provisions of 14 *Code of Federal Regulations* Part 135 as a positioning flight. Night instrument meteorological conditions prevailed at the accident site and an instrument flight rules (IFR) flight plan had been filed. The helicopter departed Brainerd Lakes Regional Airport (BRD), Brainerd, Minnesota about 0135 and was destined for the Douglas County Hospital helipad, Alexandria, Minnesota.

D. 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 the NTSB's Washington D.C. office and from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are central daylight time (CDT) on September 17, 2016, and are based upon the 24-hour clock, where local time is -5 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 statute miles.

The accident site was located at latitude 45.87° N, longitude 95.40° W, at an approximate elevation of 1,405 feet.

E. 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-0045G CHG 2.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 0100 CDT is provided as figure 1 with the approximate location of the accident site marked by a red circle. The chart indicated the accident site was located between, two frontal systems, a cold front and a stationary front. The cold front was located across eastern Minnesota stretched northward into southern Canada and stretched south-southwestward into northcentral Iowa. The stationary front was located in eastern North Dakota and far northwestern Minnesota. The stationary front stretched southward into South Dakota then westward into eastern Montana. A surface low pressure center with a pressure of 1007-hectopascals (hPa) was located in southern Canada just north of the Minnesota border. The station models around the accident site depicted air temperatures in the mid to upper 50's degrees Fahrenheit (°F), with temperature-dew point spreads of 1° F or less, a southwest to west wind under 10 knots, cloudy skies, mist, and light rain. The accident site was located between two surface lifting mechanisms (stationary front and cold front) and these lifting mechanisms, along with the moist surface environment, would have aided in the formation of clouds and precipitation around the accident time around the accident site.

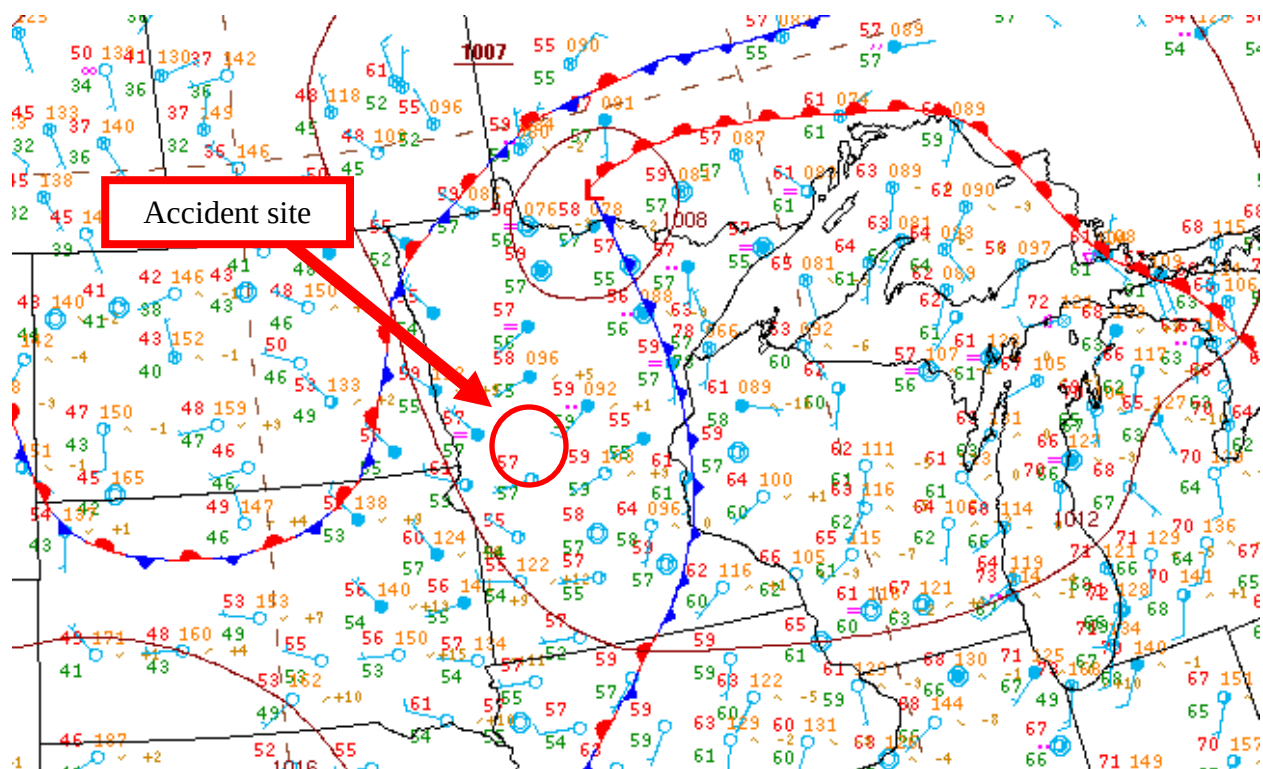


Figure 1 – NWS Surface Analysis Chart for 0100 CDT

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0700 CDT at 925-, 850-, 700-, 500-, and 300-hPa are presented in figures 2 through 6. The 925- and 850-hPa charts depicted a low-level trough¹ just east of the accident site located over eastern Minnesota and southward into central Iowa, while the 925-hPa chart also depicted an additional low-level trough west of the accident site located in North and South Dakota. Troughs typically act as lifting mechanisms where enhanced lift, gusty winds, fronts, clouds, and precipitation can occur. In addition, at 700- and 500-hPa, there was a mid-level trough east of the accident site (figures 4 and 5). There was sufficient low and mid-level moisture to allow for the formation of clouds (sections 3.0 and 4.0) and precipitation (section 6.4) around the accident site and the departure location at the accident time. There was a northwest to west wind between 15 and 20 knots at 925- and 850-hPa with the wind remaining westerly between 700- and 300-hPa with a wind speed between 30 and 45 knots.

¹ Trough – An elongated area of relatively low atmospheric pressure or heights.

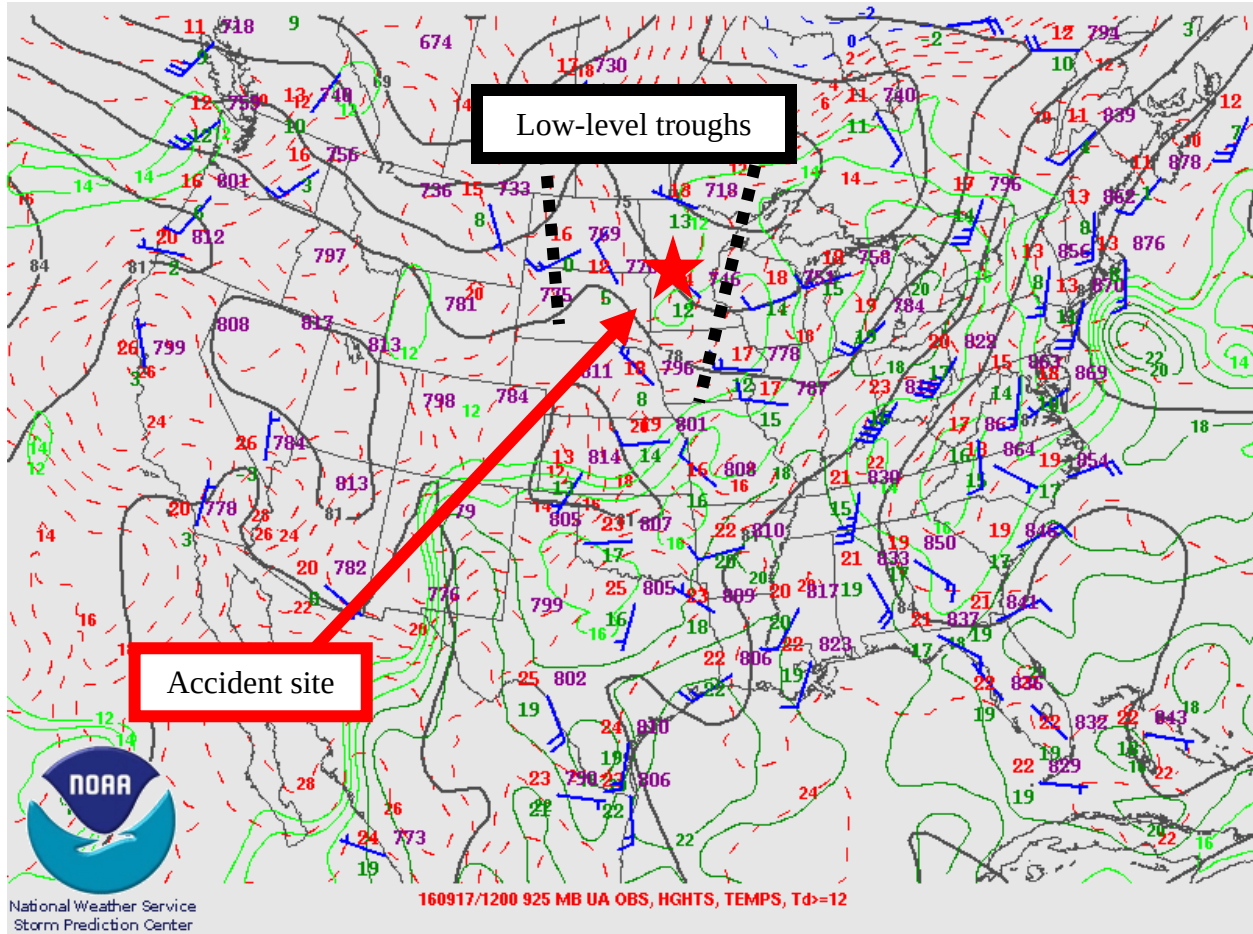


Figure 2 – 925-hPa Constant Pressure Chart for 0700 CDT

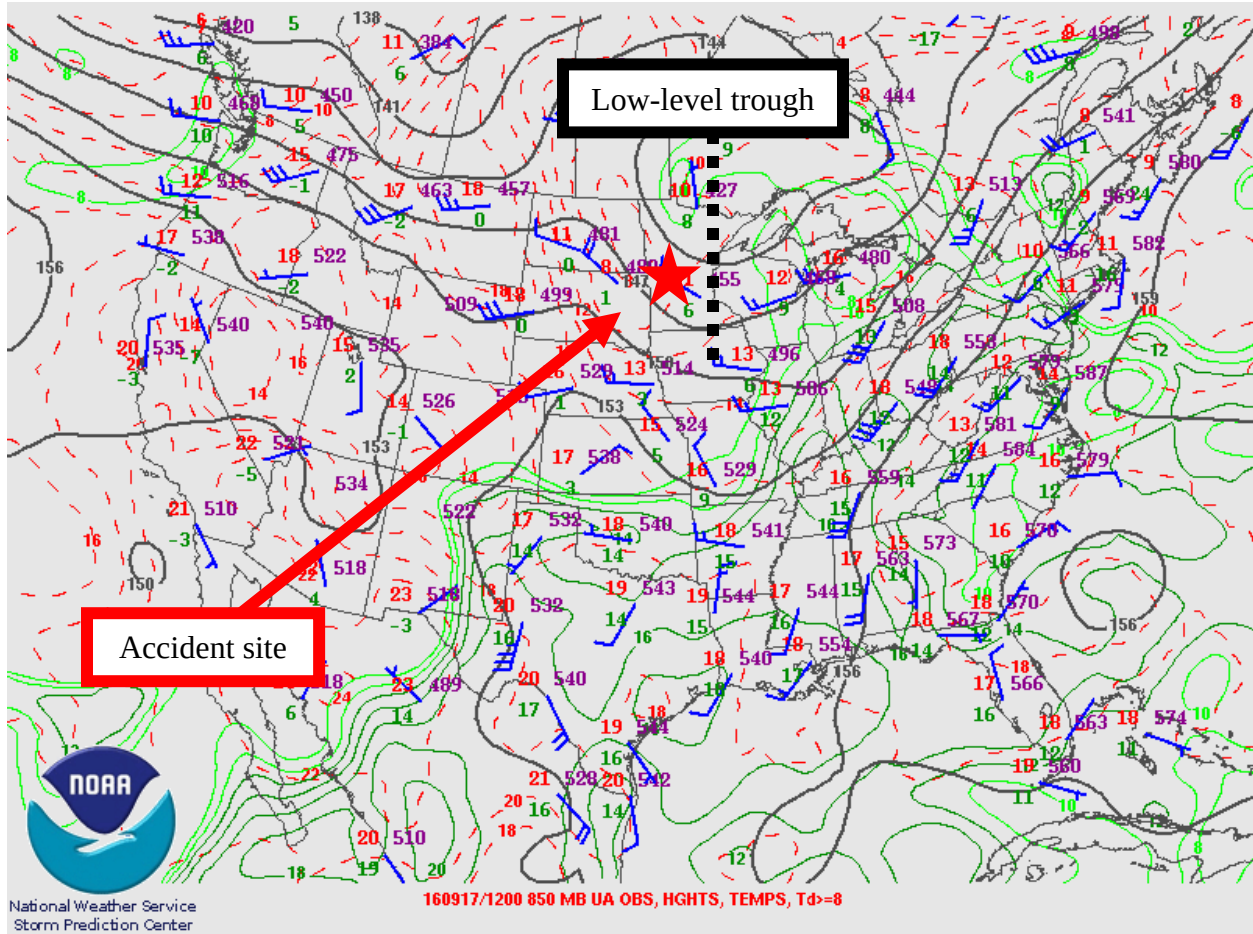


Figure 3 – 850-hPa Constant Pressure Chart for 0700 CDT

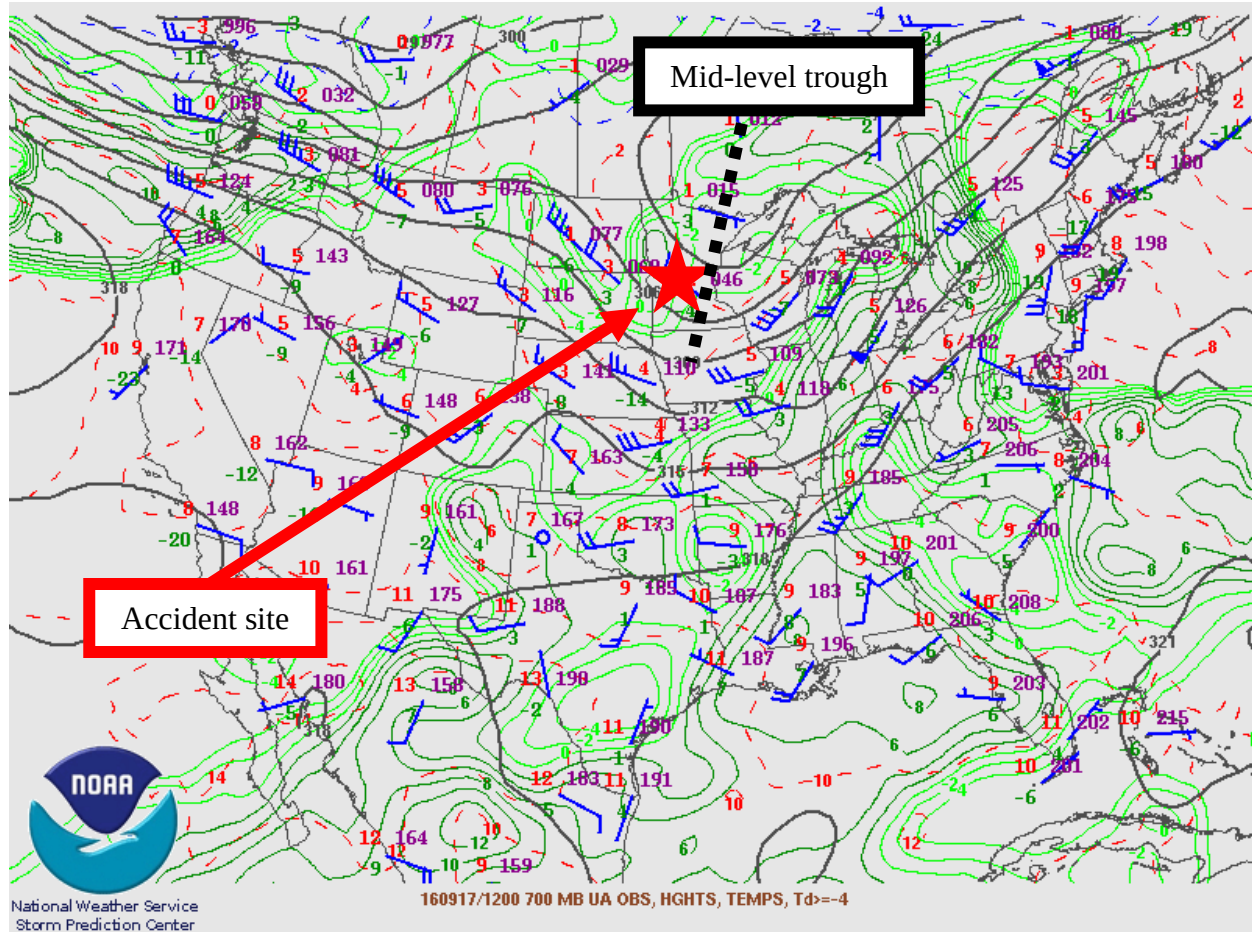


Figure 4 – 700-hPa Constant Pressure Chart for 0700 CDT

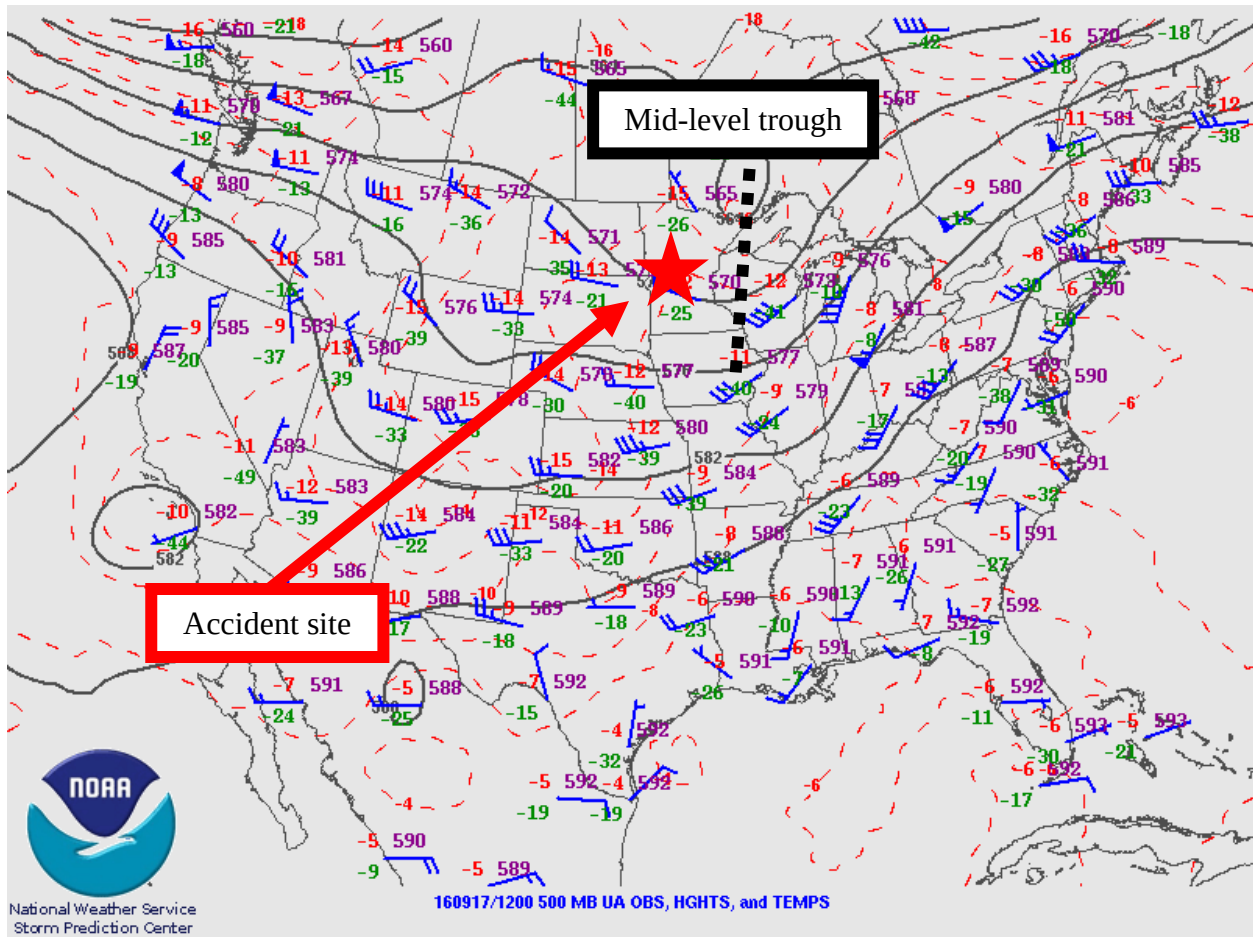


Figure 5 – 500-hPa Constant Pressure Chart for 0700 CDT

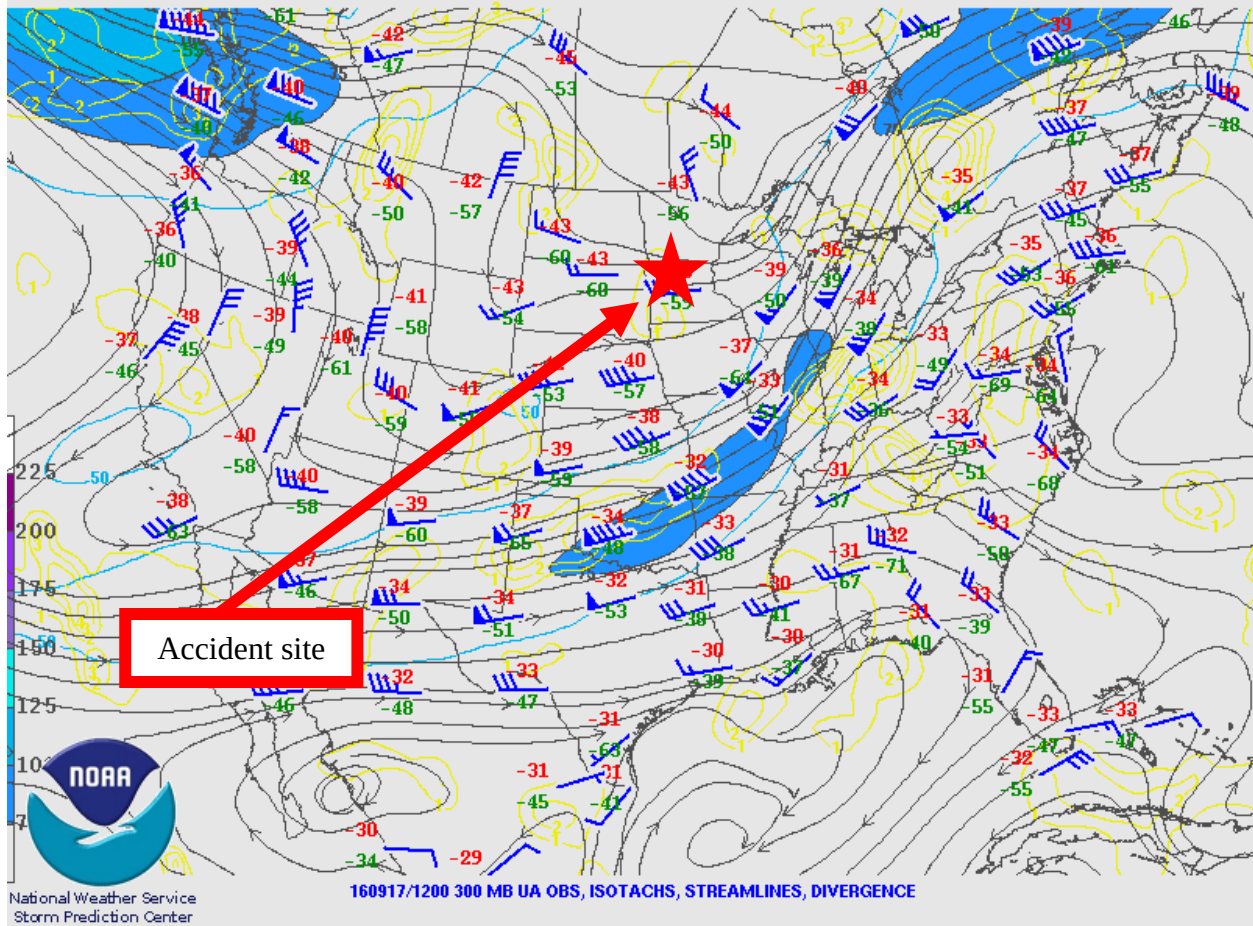


Figure 6 – 300-hPa Constant Pressure Chart for 0700 CDT

2.0 Storm Prediction Center Products

SPC issued the following Day 1 Convective Outlook at 1959 CDT on September 16 (figure 7) with areas of general thunderstorms forecast for the accident site. The precipitation and chance for thunderstorm activity had moved east of the accident site by the accident time (sections 4.0 and section 6.4):

SPC AC 170059

DAY 1 CONVECTIVE OUTLOOK
NWS STORM PREDICTION CENTER NORMAN OK
0759 PM CDT FRI SEP 16 2016

VALID 170100Z - 171200Z

...THERE IS A SLGT RISK OF SVR TSTMS ACROSS PORTIONS OF CENTRAL AND W TX AND INTO FAR SERN NM...

...THERE IS A MRGL RISK OF SVR TSTMS FROM THE OZARKS VICINITY SWWD INTO W TX/ERN NM...

...SUMMARY...

A FEW SEVERE STORMS WITH HAIL WILL CONTINUE THIS EVENING OVER PARTS OF SOUTHWEST TEXAS AND SOUTHEAST NEW MEXICO...WITH PERHAPS A SEVERE STORM OR TWO STILL POSSIBLE ACROSS OKLAHOMA INTO THE OZARKS.

...SRN HIGH PLAINS INTO THE OZARKS...

THUNDERSTORMS CONTINUE THIS EVENING FROM THE SRN IL/OZARKS VICINITY SWWD INTO W TX...WHILE MORE ISOLATED CELLS CONTINUE INTO ERN NM. THOUGH SEVERE RISK ACROSS OK AND INTO THE OZARKS WILL CONTINUE TO GRADUALLY DIMINISH THIS EVENING...POTENTIAL FOR ISOLATED SEVERE STORMS WILL CONTINUE FOR AT LEAST A FEW MORE HOURS OVER PARTS OF CENTRAL AND W TX. MODERATE INSTABILITY ACROSS THIS REGION ALONG WITH SHEAR SUFFICIENT FOR UPDRAFT ORGANIZATION/ROTATION SUGGESTS POSSIBILITY FOR LARGE HAIL AND LOCALLY DAMAGING WINDS WITH THE STRONGEST CELLS...BEFORE RISK BEGINS TO WANE LATER THIS EVENING/OVERNIGHT.

..GOSS.. 09/17/2016

CLICK TO GET WUUS01 PTSDY1 PRODUCT

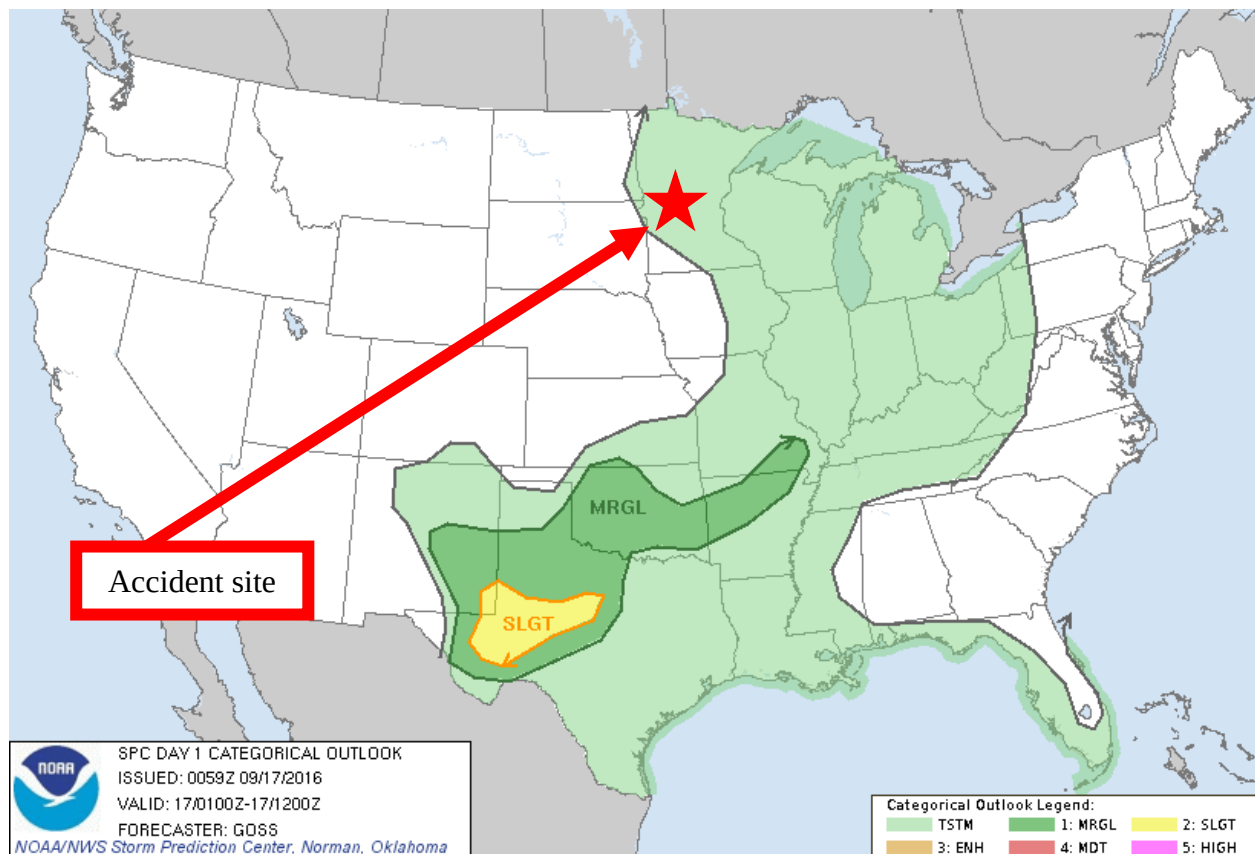


Figure 7 – Storm Prediction Center day 1 Convective Outlook valid at the time of the accident

3.0 Surface Observations

The area surrounding the accident site was documented utilizing official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 8 is a local sectional map of the region with the accident site and the closest weather reporting locations marked.

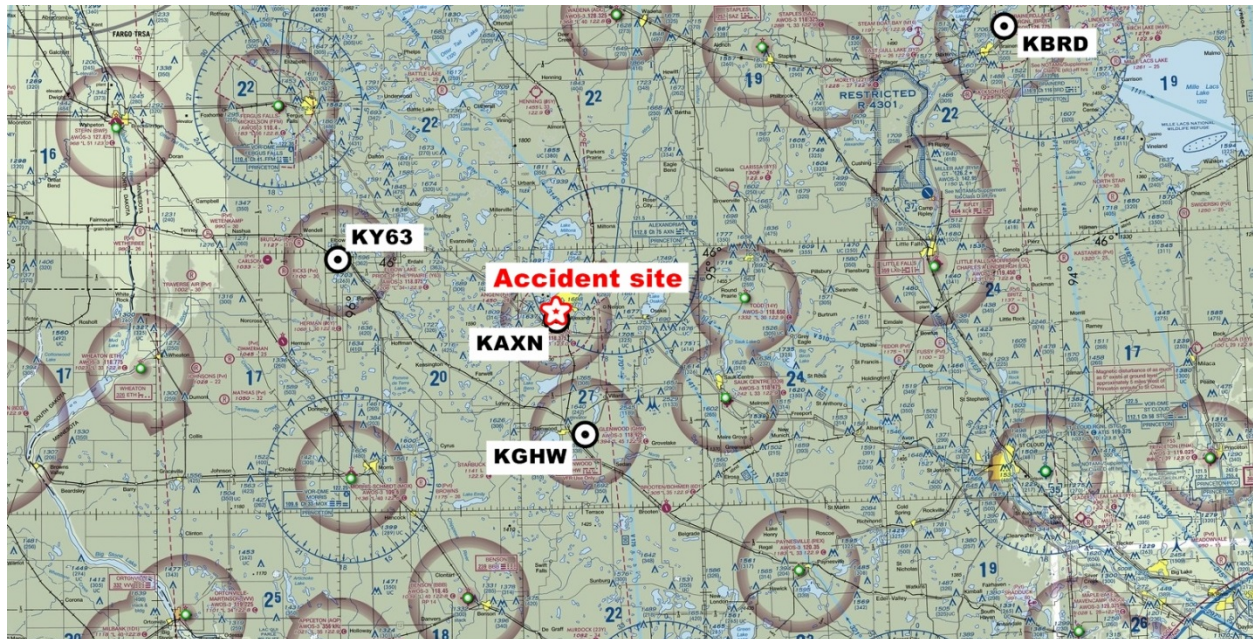


Figure 8 – Sectional Chart of central Minnesota with the location of the accident site and surface observation sites

Chandler Field Airport (KAXN) had the closest official weather station to the accident site and was located 2 miles southwest of Alexandria, Minnesota. KAXN had an Automated Surface Observing System (ASOS²) whose reports were not supplemented. KAXN was located within a mile of the accident site, at an elevation of 1,425 feet, and had a 4° easterly magnetic variation³ (figure 8). The following observations were taken and disseminated during the times surrounding the accident from 2253 on September 16 through 0240 CDT on September 17, 2016:⁴

[2253 CDT] KAXN 170353Z AUTO 29005KT 10SM SCT085 14/14 A2984 RMK AO2
SLP106 T01440144

² ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

³ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2000, latest measurement taken from <http://www.airnav.com/airport/KAXN>

⁴ The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that affected the accident location around the accident time. The local times in section 3.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[2353 CDT] KAXN 170453Z AUTO 26004KT 10SM FEW018 13/13 A2985 RMK AO2 SLP109 T01330133=

[0007 CDT] KAXN 170507Z AUTO 28004KT 10SM BKN020 14/14 A2985 RMK AO2 T01390139=

[0027 CDT] KAXN 170527Z AUTO 28005KT 10SM SCT022 14/14 A2986 RMK AO2 T01390139=

[0053 CDT] KAXN 170553Z AUTO 28006KT 10SM FEW010 BKN021 BKN036 14/14 A2986 RMK AO2 SLP112 T01440144 10156 20133 402280133 53008=

[0144 CDT] KAXN 170644Z AUTO 29008KT 10SM FEW022 FEW029 BKN036 14/14 A2986 RMK AO2 T01440144=

[0153 CDT] KAXN 170653Z AUTO 29009KT 10SM FEW022 SCT036 14/14 A2986 RMK AO2 SLP112 T01390139=

[0201 CDT] KAXN 170701Z AUTO 29010KT 9SM SCT004 BKN036 14/14 A2987 RMK AO2 T01390139=

ACCIDENT TIME 0207 CDT

[0209 CDT] KAXN 170709Z AUTO 29012KT 4SM BR BKN003 14/14 A2987 RMK AO2 T01390139=

[0213 CDT] KAXN 170713Z AUTO 29009KT 1 3/4SM BR BKN003 14/14 A2986 RMK AO2 T01390139=

[0218 CDT] KAXN 170718Z AUTO 29009KT 3/4SM BR VV002 14/14 A2986 RMK AO2 T01390139=

[0240 CDT] KAXN 170740Z AUTO 29007KT 1/2SM FG VV002 14/14 A2986 RMK AO2 T01390139=

KAXN weather at 0153 CDT, wind from 290° at 9 knots, 10 miles visibility, few clouds at 2,200 feet above ground level (agl), scattered clouds at 3,600 feet agl, temperature of 14° Celsius (C), dew point temperature of 14° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure 1011.2 hPa, temperature 13.9° C, dew point temperature 13.9° C.

KAXN weather at 0201 CDT, wind from 290° at 10 knots, 9 miles visibility, scattered clouds at 400 feet agl, a broken ceiling at 3,600 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 13.9° C, dew point temperature 13.9° C.

KAXN weather at 0209 CDT, wind from 290° at 12 knots, 4 miles visibility, mist, a broken ceiling at 300 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 13.9° C, dew point temperature 13.9° C.

KAXN weather at 0213 CDT, wind from 290° at 9 knots, 1 and three-quarter miles visibility, mist, a broken ceiling at 300 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 13.9° C, dew point temperature 13.9° C. For more information from the KAXN ASOS please see attachment 1.

Glenwood Municipal Airport (KGHW) was the next closest official observation site, located 3 miles east of Glenwood, Minnesota, and had an Automated Weather Observing System (AWOS⁵) whose reports were not supplemented. KGHW was located 14 miles south-southeast of the accident site, at an elevation of 1,394 feet, and had a 4° easterly magnetic variation⁶ (figure 8). The following observations were taken and disseminated during the times surrounding the accident:

[0014 CDT] KGHW 170514Z AUTO 24004KT 10SM CLR 14/13 A2985 RMK AO2=

[0034 CDT] KGHW 170534Z AUTO 25006KT 10SM CLR 14/14 A2985 RMK AO2=

[0054 CDT] KGHW 170554Z AUTO 26006KT 10SM SCT055 14/14 A2985 RMK AO2=

[0114 CDT] KGHW 170614Z AUTO 27007KT 10SM SCT022 14/14 A2986 RMK AO2=

[0133 CDT] KGHW 170633Z AUTO 28005KT 10SM SCT022 14/13 A2986 RMK AO2=

[0154 CDT] KGHW 170654Z AUTO 28004KT 10SM CLR 13/13 A2986 RMK AO2=

ACCIDENT TIME 0207 CDT

[0213 CDT] KGHW 170713Z AUTO 27006KT 10SM CLR 13/13 A2986 RMK AO2=

[0234 CDT] KGHW 170734Z AUTO 28008KT 5SM BR BKN003 13/13 A2986 RMK AO2=

[0254 CDT] KGHW 170754Z AUTO 28007KT 1 1/4SM BR OVC001 13/13 A2986 RMK AO2=

[0313 CDT] KGHW 170813Z AUTO 27003KT 3SM BR BKN001 OVC038 13/13 A2986 RMK AO2=

⁵ AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to twelve thousand feet, and altimeter setting.

⁶ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2000, latest measurement taken from <http://www.airnav.com/airport/KGHW>

KGHW weather at 0133 CDT, wind from 280° at 5 knots, 10 miles visibility, scattered clouds at 2,200 feet agl, temperature of 14° C, dew point temperature of 13° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station with a precipitation discriminator.

KGHW weather at 0154 CDT, wind from 280° at 4 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 13° C, dew point temperature of 13° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station with a precipitation discriminator.

KGHW weather at 0213 CDT, wind from 270° at 6 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of 13° C, dew point temperature of 13° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station with a precipitation discriminator.

KGHW weather at 0234 CDT, wind from 280° at 8 knots, 5 miles visibility, a broken ceiling at 300 feet agl, temperature of 13° C, dew point temperature of 13° C, and an altimeter setting of 29.86 inches of mercury. Remarks: automated station with a precipitation discriminator.

Elbow Lake Municipal Airport (KY63) was located 1 mile southwest of Elbow lake, Minnesota. KY63 had an AWOS whose reports were not supplemented. KY63 was located 26 miles west-northwest of the accident site, at an elevation of 1,206 feet, and had a 2° easterly magnetic variation⁷ (figure 8). The following observations were taken and disseminated during the times surrounding the accident from 2339 on September 16 through 0318 CDT on September 17, 2016:

[2339 CDT] KY63 170439Z AUTO 31004KT 1/4SM FG OVC002 13/13 A2985 RMK AO2 T01270127=
[2359 CDT] KY63 170459Z AUTO 31004KT 1/2SM FG OVC002 13/13 A2985 RMK AO2 P0001 T01330133=
[0018 CDT] KY63 170518Z AUTO 30006KT 1/4SM FG OVC002 14/14 A2986 RMK AO2 T01360136=
[0039 CDT] KY63 170539Z AUTO 30005KT 1/4SM FG OVC002 14/14 A2986 RMK AO2 T01380138=
[0059 CDT] KY63 170559Z AUTO 30005KT 1 1/2SM BR OVC002 14/14 A2986 RMK AO2 T01380138=
[0119 CDT] KY63 170619Z AUTO 32005KT 10SM OVC002 14/14 A2986 RMK AO2 T01370137=

⁷ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2015, latest measurement taken from <http://www.airnav.com/airport/Y63>

[0138 CDT] KY63 170638Z AUTO 31005KT 10SM OVC002 14/14 A2987 RMK AO2 T01400140=

[0159 CDT] KY63 170659Z AUTO 30006KT 1 1/4SM BR OVC002 14/14 A2987 RMK AO2 T01390139=

ACCIDENT TIME 0207 CDT

[0218 CDT] KY63 170718Z AUTO 30007KT 3/4SM BR OVC002 14/14 A2987 RMK AO2 T01400140=

[0239 CDT] KY63 170739Z AUTO 31008KT 7SM OVC002 14/14 A2987 RMK AO2 T01400140=

[0258 CDT] KY63 170758Z AUTO 30009KT 7SM OVC004 14/14 A2987 RMK AO2 T01410141=

[0318 CDT] KY63 170818Z AUTO 29008KT 10SM SCT004 OVC011 14/14 A2987 RMK AO2 T01370137=

KY63 weather at 0138 CDT, wind from 310° at 5 knots, 10 miles visibility, overcast ceiling at 200 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 14.0° C, dew point temperature 14.0° C.

KY63 weather at 0159 CDT, wind from 300° at 6 knots, 1 and a quarter miles visibility, mist, overcast ceiling at 200 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 13.9° C, dew point temperature 13.9° C.

KY63 weather at 0218 CDT, wind from 300° at 7 knots, three quarters of a mile visibility, mist, overcast ceiling at 200 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 14.0° C, dew point temperature 14.0° C.

KY63 weather at 0239 CDT, wind from 310° at 8 knots, 7 miles visibility, overcast ceiling at 200 feet agl, temperature of 14° C, dew point temperature of 14° C, and an altimeter setting of 29.87 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 14.0° C, dew point temperature 14.0° C.

Brainerd Lakes Regional Airport (KBRD) was the departure airport and was located 3 miles northeast of Brainerd, Minnesota. KBRD had an ASOS whose reports were not supplemented. KBRD was located 61 miles northeast of the accident site, at an elevation of 1,232 feet, and had a 3° easterly magnetic variation⁸ (figure 8). The following observations were taken and disseminated during the times surrounding the accident from 2304 on September 16 through 0453 CDT on September 17, 2016:

[2304 CDT] KBRD 170404Z AUTO 22005KT 10SM BKN012 OVC027 15/15 A2980 RMK AO2 T01500150=

[2335 CDT] KBRD 170435Z AUTO 21006KT 10SM SCT011 OVC070 15/14 A2980 RMK AO2 T01500144=

[2344 CDT] KBRD 170444Z AUTO 22005KT 10SM SCT007 OVC070 15/14 A2980 RMK AO2 T01500144=

[2353 CDT] KBRD 170453Z AUTO 22005KT 10SM BKN007 OVC070 15/14 A2981 RMK AO2 CIG 006V011 SLP093 T01500144=

[0053 CDT] KBRD 170553Z AUTO 23008KT 5SM -RA BR BKN005 BKN041 OVC075 15/15 A2981 RMK AO2 RAB45 CIG 004V008 SLP092 P0001 60097 T01500150 10189 20144 402170133 51001=

[0153 CDT] KBRD 170653Z AUTO 27006KT 10SM BKN004 OVC055 15/15 A2981 RMK AO2 RAE17 SLP093 P0000 T01500150=

[0204 CDT] KBRD 170704Z AUTO 27006KT 10SM OVC005 15/15 A2981 RMK AO2 T01500150=

ACCIDENT TIME 0207 CDT

[0253 CDT] KBRD 170753Z AUTO 28006KT 10SM BKN005 15/14 A2981 RMK AO2 SLP092 T01500144=

[0301 CDT] KBRD 170801Z AUTO 28007KT 10SM SCT005 15/14 A2981 RMK AO2 T01500144=

[0353 CDT] KBRD 170853Z AUTO 27006KT 10SM BKN008 14/14 A2981 RMK AO2 SLP092 60000 T01440139 50000=

[0453 CDT] KBRD 170953Z AUTO VRB04KT 10SM OVC008 15/14 A2981 RMK AO2 CIG 006V012 SLP093 T01500139=

⁸ Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1995, latest measurement taken from <http://www.airnav.com/airport/kbrd>

KBRD weather at 0053 CDT, wind from 270° at 6 knots, 10 miles visibility, a broken ceiling at 400 feet agl, overcast skies at 5,500 feet agl, temperature of 15° C, dew point temperature of 15° C, and an altimeter setting of 29.81 inches of mercury. Remarks: automated station with a precipitation discriminator, rain ended at 0117 CDT, sea level pressure 1009.3 hPa, one hourly precipitation of a trace, temperature 15.0° C, dew point temperature 15.0° C.

KBRD weather at 0204 CDT, wind from 270° at 6 knots, 10 miles visibility, an overcast ceiling at 500 feet agl, temperature of 15° C, dew point temperature of 15° C, and an altimeter setting of 29.81 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 15.0° C, dew point temperature 15.0° C.

KBRD weather at 0253 CDT, wind from 280° at 6 knots, 10 miles visibility, a broken ceiling at 500 feet agl, temperature of 15° C, dew point temperature of 14° C, and an altimeter setting of 29.81 inches of mercury. Remarks: automated station with a precipitation discriminator, sea level pressure, 1009.2 hPa, temperature 15.0° C, dew point temperature 14.4° C.

KBRD weather at 0301 CDT, wind from 280° at 7 knots, 10 miles visibility, scattered clouds at 500 feet agl, temperature of 15° C, dew point temperature of 14° C, and an altimeter setting of 29.81 inches of mercury. Remarks: automated station with a precipitation discriminator, temperature 15.0° C, dew point temperature 14.4° C.

The observations from KAXN, KGHW, KY63, and KBRD surrounding the accident time indicated IFR⁹ to LIFR¹⁰ ceilings and visibilities in mist. KBRD had IFR ceilings when the accident pilot received the notification for the accident flight as well as when the accident flight took off from KBRD. KAXN ceilings did not go IFR until 0205 CDT (attachment 1), but given the surface wind conditions, the observations at KY63, and no surface temperature and dew point temperature spreads, low clouds and fog were likely moving eastward towards the KAXN area when the accident pilot received the notification for the accident flight. Given the observations in time sequence from KY63, to KAXN, to KGHW, as well as the satellite observations (section 5.0), both advection and radiational fog were likely.

⁹ Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. IFR criteria means a ceiling below 1,000 feet agl and/or less than 3 miles visibility.

¹⁰ Low Instrument Flight Rules – Refers to the general weather conditions pilots can expect at the surface. LIFR criteria means a ceiling below 500 feet agl and/or less than 1 miles visibility.

4.0 Upper Air Data

The closest official upper air sounding to the accident site was from Chanhassen, Minnesota, (KMPX), located 99 miles southeast of the accident site, with a site number 72649, and an elevation of 942 feet. The 0700 CDT sounding was plotted on a standard Skew-T log P diagram¹¹ with the derived stability parameters included in figure 9 (with data from the surface to 700-hPa, or 10,000 feet msl.) This data was analyzed utilizing the RAOB¹² software package. The sounding depicted the Lifted Condensation Level (LCL)¹³ at 1,276 feet msl, a Convective Condensation Level (CCL)¹⁴ of 5,281 feet, and a Level of Free Convection (LFC)¹⁵ at 1,367 feet. The freezing level was located at 11,253 feet. The precipitable water value was 1.01 inches.

¹¹ 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.

¹² RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹³ Lifting Condensation Level (LCL) - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁴ Convective Condensation Level (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.

¹⁵ Level of Free Convection (LFC) – The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

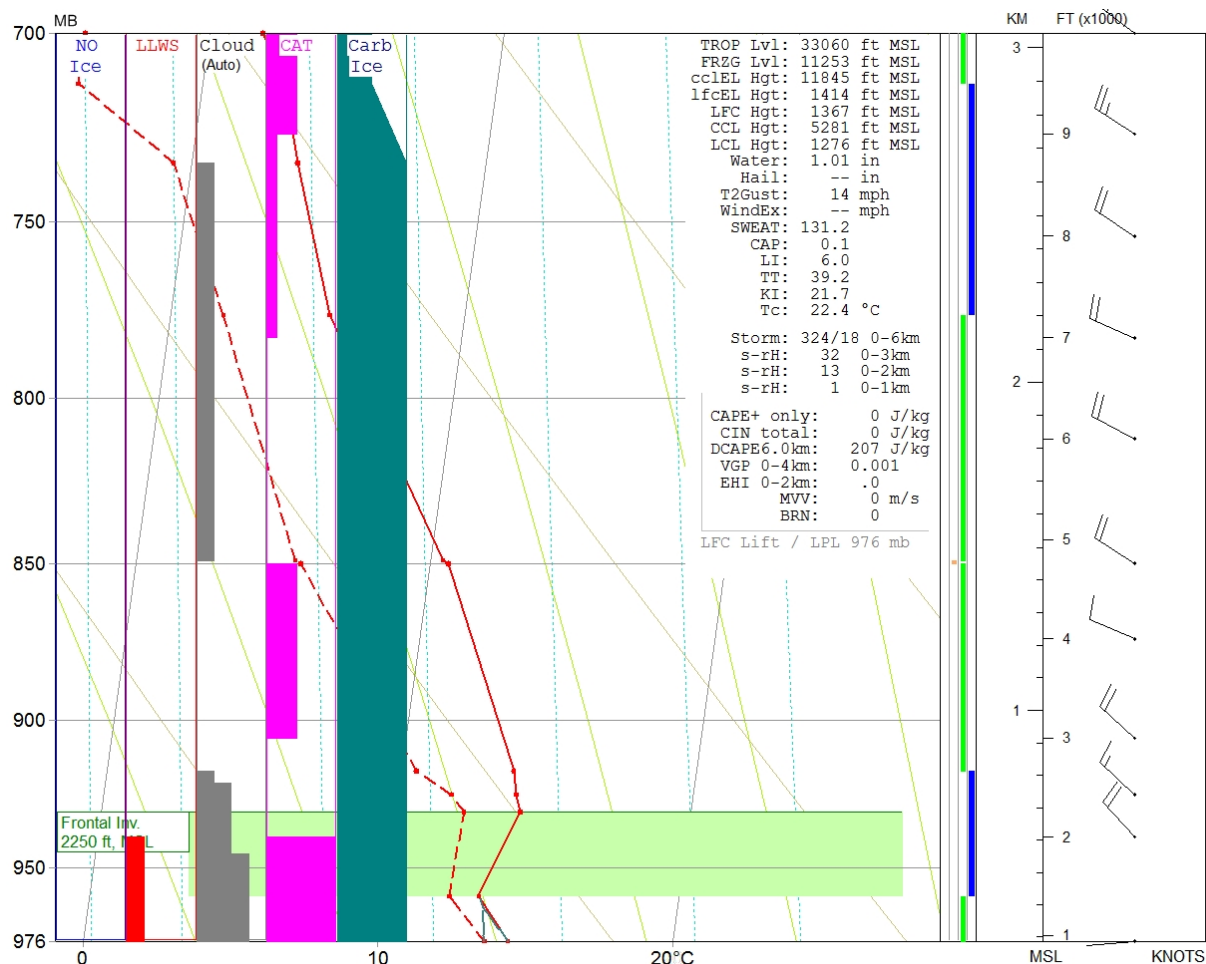


Figure 9 – 0700 CDT KMPX sounding

The 0700 CDT KMPX sounding indicated several layers of conditionally unstable environment between the surface and 10,000 feet with two stable layers between 1,500 and 2,750 feet msl, and 7,250 and 9,500 feet msl, respectively. The lower stable layer had an inversion¹⁶ which likely trapped any low clouds or fog that had formed below 3,000 feet msl. This environment would have been supportive of low cloud formation and fog due to the abundance of low-level moisture and an inversion. Near the lifting mechanisms in the area of the accident site at the accident time (sections 1.1 and 1.2), additional cloud cover and precipitation would have been likely.

¹⁶ Inversion – In meteorology, a departure from the usual decrease or increase with altitude of the value of an atmospheric property; 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").

The 0700 CDT KMPX sounding wind profile indicated a surface wind from 265° at 2 knots with the wind remaining west to northwesterly through 10,000 feet msl. The wind speed increased from 2 knots at the surface to 20 knots by 2,000 feet. The wind speed then remained between 10 and 25 knots all the way to 10,000 feet msl. The possibility of low-level wind shear (LLWS) was indicated by RAOB for the environment outside of thunderstorms between the surface and 2,000 feet msl, and several layers of possible clear-air turbulence were indicated between the surface and 10,000 feet.

5.0 Satellite Data

Visible and infrared data from the Geostationary Operational Environmental Satellite number 13 (GOES-13) 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 NTSB's Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-13 band 1 and 4) at wavelengths of 0.65 microns (μm) and 10.7 μm , respectively, were retrieved for the scene. Satellite imagery surrounding the time of the accident, from 2000 CDT on September 16 through 0400 CDT at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 10 and 11 present the GOES-13 infrared imagery from 0200 and 0215 CDT at 6X magnification with the accident site (and KAXN) highlighted with a red square. The infrared imagery indicated cooler brightness temperatures and cloud tops (yellow and green colors) located to the north and east of the accident site, and mainly north and east of KBRD. Attachment 2 indicated a general west to east movement of the cloud cover over Minnesota with the cooler brightness temperatures remaining north of the accident site between 0045 and 0315 CDT. Based on the brightness temperatures above the accident site and the vertical temperature profile provided by the 0700 CDT KMPX sounding, the approximate cloud-top heights over the accident site were 5,500 feet at 0200 CDT. It should be noted these figures have not been corrected for any parallax error.

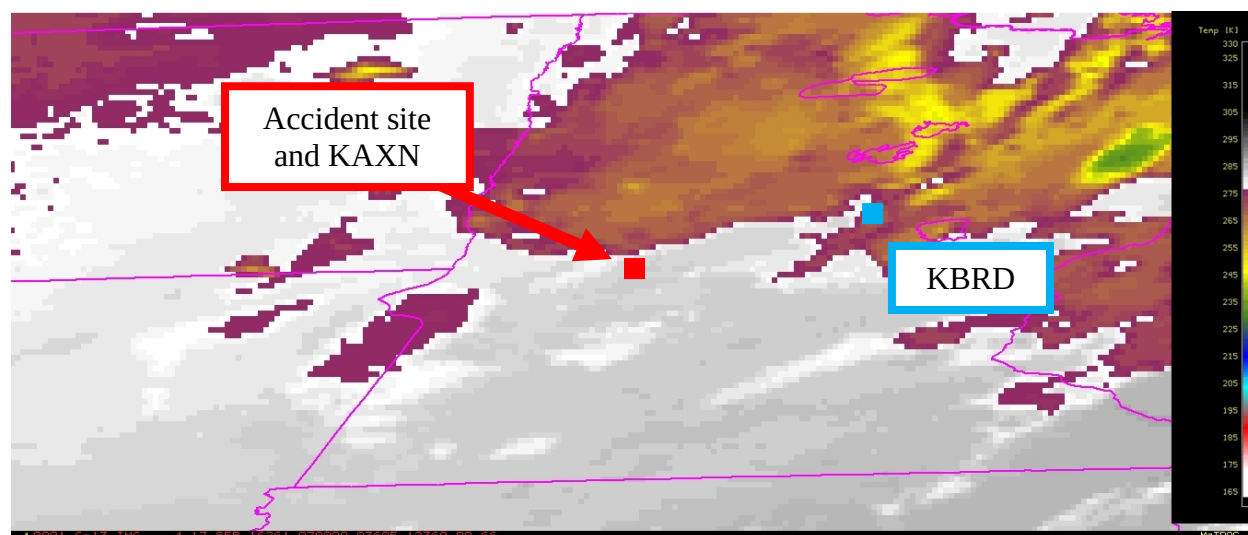


Figure 10 – GOES-13 infrared image at 0200 CDT

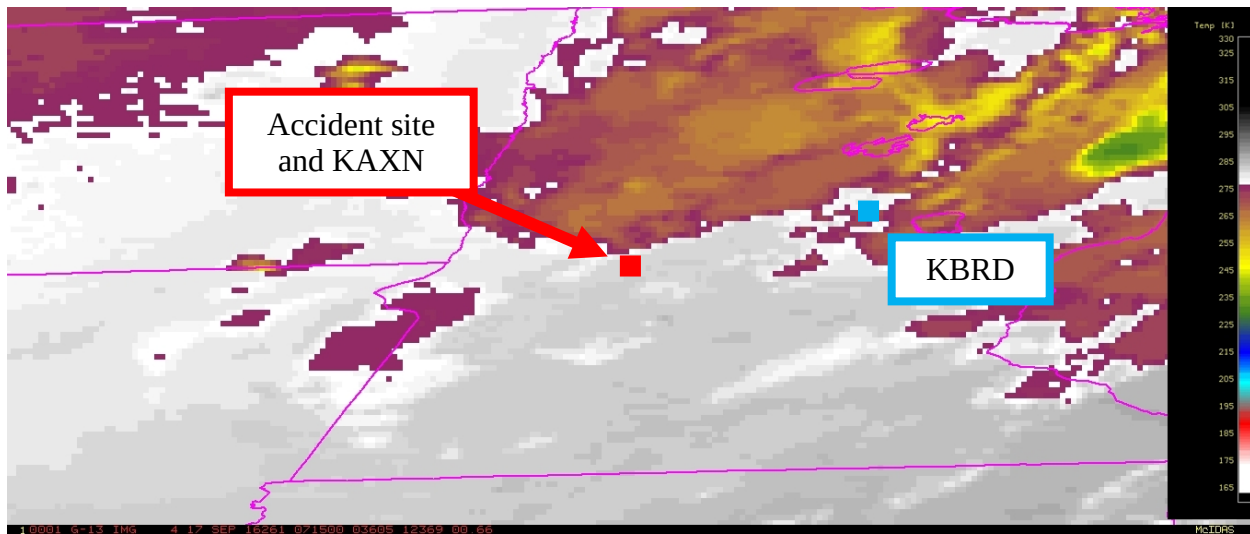


Figure 11 – GOES-13 infrared image at 0215 CDT

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁷ was KMPX. Level II and III 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.

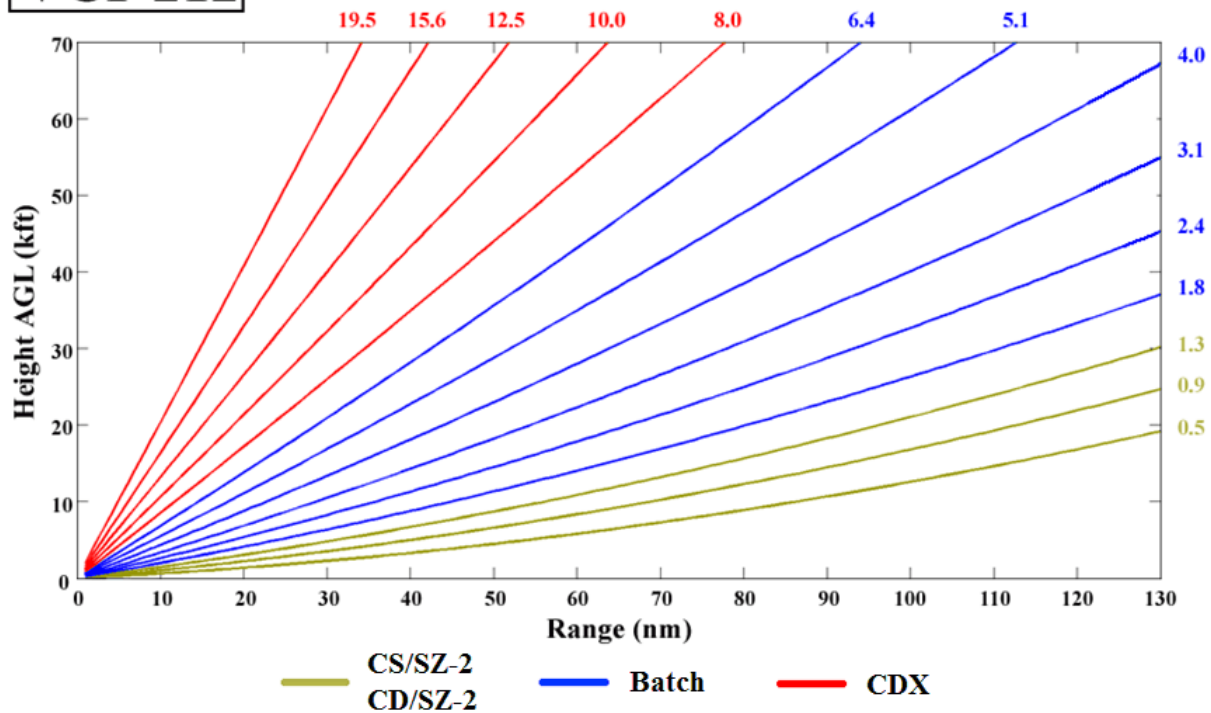
6.1 Volume Scan Strategy

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 on the WSR-88D's Principle Users Processor (PUP). Products that require data from multiple elevation scans are not available until the end of the four and a half to ten minute volume scan.

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 14 elevation scans from 0.5° to 19.5° every four and a half minutes. This particular scanning strategy is documented as volume coverage pattern 12 (VCP-12). 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 KMPX WSR-88D radar was operating in the precipitation mode (Mode A, VCP-212). 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.

¹⁷ 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.

VCP 212



6.2 Beam Height Calculation

Assuming standard refraction¹⁹ of the WSR-88D 0.95° wide radar beam, the following table shows the approximate beam height and width²⁰ information²¹ of the radar display over the site of the accident. The heights have been rounded to the nearest 10 feet.

¹⁸ Contiguous Surveillance (CS)--The low 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)

¹⁹ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²⁰ Beam width – A measure of the angular width of a radar beam.

²¹ Beamwidth values are shown for legacy resolution products. Super resolution products would have an effective beamwidth that would be approximately half these values.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP	BEAM WIDTH
0.5°	13,300 feet	8,420 feet	18,180 feet	9,760 feet

Based on the radar height calculations, the 0.5° elevation scan depicted the conditions between 8,420 feet and 18,180 feet msl over the accident site and these are the closest reflectivity values to the surface that were able to be obtained.²²

6.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²³ 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 decibels (dBZ²⁴), and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C, “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:

²² For more information please see the ATC data.

²³ 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.

²⁴ 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.

- 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.

6.4 Base Reflectivity and Lightning Data

Figure 12 presents the KMPX WSR-88D base reflectivity images for the 0.5° elevation scan initiated at 0205 CDT with a resolution of 0.5° X 250 m. There were no reflectivity targets above the accident site at the accident time, nor were there any reflectivity targets between the departure location and the accident site. All reflectivity targets were east of the departure location. There were no lightning strikes or flashes near the accident site at the accident time.

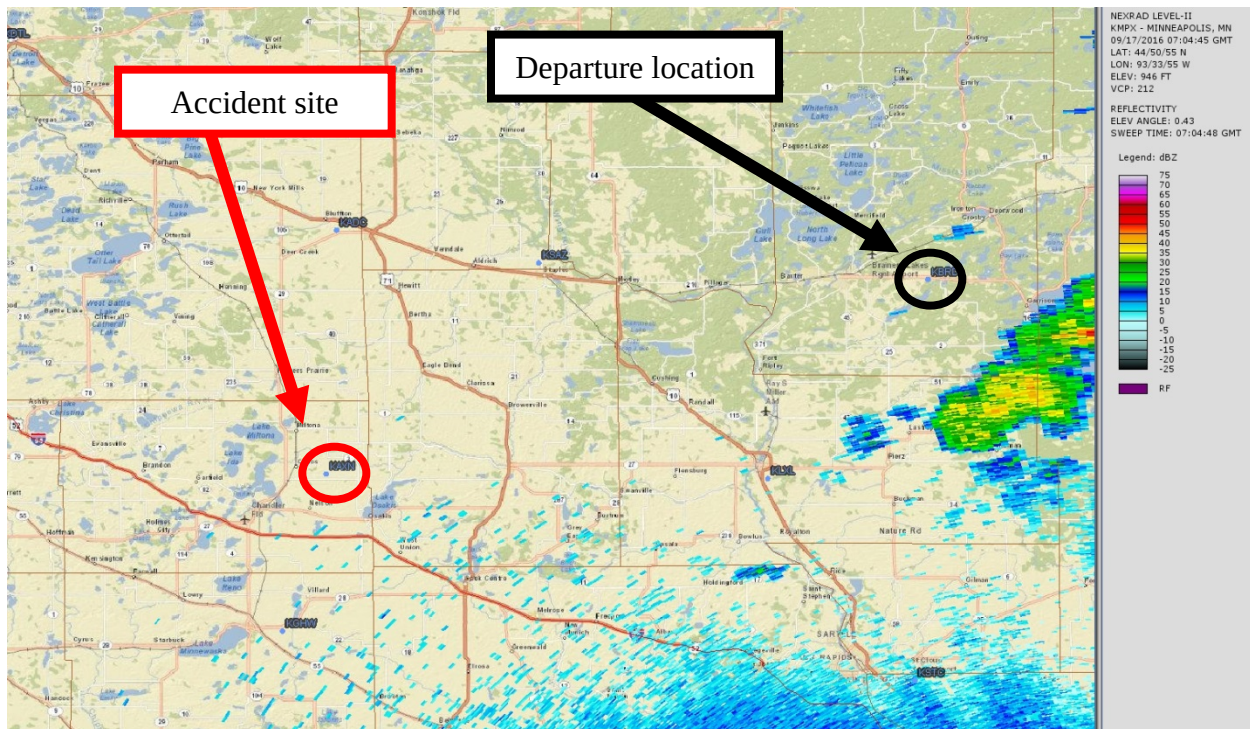


Figure 12 – KMPX WSR-88D reflectivity for the 0.5° elevation scan initiated at 0205 CDT

7.0 Pilot Reports

All pilot reports (PIREPs) near the accident site were reviewed for a 24-hour period surrounding the accident time. No PIREPs were made within the state of Minnesota from around four hours prior to the accident time to around four hours after the accident time.

8.0 SIGMET and CWSU Advisory

No SIGMET was valid for the accident site at the accident time.

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

9.0 AIRMETs

AIRMET Sierra for IFR conditions due to mist and precipitation was issued at 2145 CDT on September 16 and valid at the accident time. This AIRMET matched the observed weather conditions at the accident site and at the departure location:

WAUS43 KPCI 170245

WA3S

CHIS WA 170245

AIRMET SIERRA FOR IFR VALID UNTIL 170900

.
AIRMET IFR...ND MN WI LM LS MI LH IN

FROM 30N INL TO YQT TO 20E SSM TO DXO TO 50SW DXO TO 20W GIJ TO 30ENE GRB TO 40SSE RHI TO 30NNW MSP TO 60SSE FAR TO 70ESE BIS TO 80WSW GFK TO 60SSE YWG TO 30N INL

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 09Z THRU 15Z.

.
AIRMET IFR...KS MO IL IN OK AR

FROM TTH TO 50ESE FAM TO 20E ARG TO 30SE MLC TO 30WNW FSM TO 30N
END TO 20NW BUM TO 20N STL TO TTH

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG BYD 09Z ENDG 12-15Z.

.
OTLK VALID 0900-1500Z...IFR ND SD MN IA WI LM LS MI LH IL IN

BOUNDED BY 40NNW INL-YQT-30E SSM-20NNE ECK-20NE DXO-40SSW DXO-
20WSW GIJ-40SE EAU-30SSW MSP-60S RWF-30SSE ABR-50E GFK-40NNW INL

CIG BLW 010/VIS BLW 3SM PCPN/BR. CONDS CONTG THRU 15Z.

....

10.0 Area Forecast

The Area Forecast issued at 2045 CDT on September 16, valid at the accident time, forecasted a broken to overcast ceiling between 1,000 and 2,000 feet msl with cloud tops at 16,000 feet msl and widely scattered light rain showers:

FAUS43 KPCI 170145

FA3W

CHIC FA 170145

SYNOPSIS AND VFR CLDS/WX

SYNOPSIS VALID UNTIL 172000

CLDS/WX VALID UNTIL 171400...OTLK VALID 171400-172000

ND SD NE KS MN IA MO WI LM LS MI LH IL IN KY

.
SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN.

TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS.

NON MSL HGTS DENOTED BY AGL OR CIG.

.
SYNOPSIS...CDFNT CURVED FROM A LOW ALG THE MN/SWRN ONT BRDR ACRS

ERN MN..WRN IA..EXTRM SERN NEB AND S CNTRL KS INTO ERN NM. BY

20Z...CDFNT WILL CURVE FROM A LOW JUST E OF NRN LS ACRS WRN LWR

MI..NWRN IN..CNTRL IL..SWRN MO..NWRN AR AND SERN OK INTO EXTRM

SERN NM.

.

ND

WRN...SKC OCNL FEW100-120. OTLK...VFR.

ERN...CIGS BKN-OVC010-020 TOPS 100-120. BECMG 1114 SKC.

OTLK...VFR.

.

SD

WRN...SCT120-140. BECMG 0205 SKC. OTLK...VFR.

N CNTRL...BKN030 TOPS 090-110. BECMG 0508 SCT030. OTLK...VFR.

S CNTRL...SCT080-100. BECMG 0205 FEW CI. OTLK...VFR.

NERN...BKN060 TOPS 120-130. BECMG 0508 060-080. OTLK...VFR.

SERN...BKN060-080 TOPS 120-140. BECMG 0508 SKC. OTLK...VFR.

.

NE

PNHDL...SCT120-140. OTLK...VFR.

CNTRL...SKC OCNL FEW080-100. OTLK...VFR.

ERN...SCT040-050. BECMG 0205 SKC. OTLK...VFR.

.

KS

NWRN-N CNTRL...SKC. OTLK...VFR.

SWRN...

NWRN HLF...SKC. OTLK...VFR.

SERN HLF...BKN-SCT080 TOPS 100-120. OTLK...VFR.

NERN...SCT080-100 BKN-SCT CI. OTLK...VFR.

SERN...SCT040-050. BECMG 0811 CIGS BKN010 TOPS 020 VIS 3SM BR.

OTLK...VFR.

.

MN

NWRN...CIGS BKN-OVC010-020 TOPS 160. WDLY SCT -SHRA. OTLK...MVFR

CIGS.

NERN...BKN015-025 OVC050 LYRD FL200 OVC CI. WDLY SCT -TSRA/-SHRA

CB TOPS FL370. BECMG 0508 CIGS OVC010-020 VIS 3SM BR.

OTLK...IFR CIGS BR BECMG 1720 VFR.

SWRN...BKN040-050 TOPS 130-150. AFT 08Z OCNL CIGS OVC010-020.

OTLK...MVFR CIGS BECMG 1720 VFR.

SERN...SCT035-050 BKN CI. OTLK...VFR.

.

IA

NWRN...SCT080-100. BECMG 0508 SKC. OTLK...VFR.

REST OF AREA...SCT035-050 BKN CI. OTLK...VFR.

.

MO

NW OF SGF-COU-STL LN...BKN080-100 LYRD FL200. OTLK...VFR.

SE OF SGF-COU-STL LN...BKN020-030 OVC060-080 TOPS FL180 OVC CI

ABV. WDLY SCT -TSRA/-SHRA CB TOPS FL370. OCNL VIS 3-5SM BR.

ISOL -TSRA POSS SEV. BECMG 0508 CIGS OVC010-020. VIS 3SM BR.

OTLK...IFR CIGS BR BECMG 1417 MVFR CIGS.

.

WI MI LS LM LH

NWRN WI/WRN LS...BKN015-025 OVC050 LYRD FL200 OVC CI. WDLY SCT

-TSRA/-SHRA CB TOPS FL370. BECMG 0508 CIGS OVC010-020 VIS 3SM

BR. OTLK...IFR CIGS BR BECMG 1720 VFR.

UPR MI/REST OF LS...BKN015-025 OVC050 LYRD FL200 OVC CI. WDLY

SCT -SHRA BECMG 0508 CIGS OVC010-020 VIS 3SM BR. OTLK...IFR

CIGS BR BECMG 1720 VFR.

REST OF WI...SCT020-030 SCT-BKN080-100 TOPS FL200 BKN CI.
 OTLK...VFR.
 LM/LWR MI/LH...BKN015-025 BKN035-050 OVC080-100 LYRD FL200. WDLY
 SCT -TSRA/-SHRA CB TOPS FL340. OTLK...VFR.
 .
 IL
 NRN AND CNTRL...BKN-OVC020-030 OVC060-080 TOPS 160 BKN CI ABV.
 WDLY SCT -SHRA/ISOL -TSRA LWRG VIS 3-5SM. CB TOPS FL340.
 OTLK...MVFR CIGS.
 SRN...BKN020-030 OVC060-080 TOPS FL180 OVC CI ABV. WDLY SCT
 -TSRA/-SHRA CB TOPS FL350. OCNL VIS 3-5SM BR. BECMG 0508 CIGS
 OVC010-020. VIS 3SM BR. OTLK...IFR CIGS BR BECMG 1417
 MVFR CIGS.
 .
 IN
 NRN IN...BKN-OVC100-120 TOPS FL180 OVC CI ABV. BECMG 0508
 BKN-OVC020-030 OVC060-080 TOPS 160 BKN CI ABV. WDLY SCT
 -SHRA/ISOL -TSRA LWRG VIS 3-5SM. CB TOPS FL340.
 OTLK...MVFR CIGS.
 SRN IN...BKN-OVC100-120 TOPS FL180 OVC CI ABV. BECMG 0205
 BKN020-030 OVC060-080 TOPS FL180 OVC CI ABV. WDLY SCT -SHRA/
 ISOL -TSRA CB TOPS FL350. OCNL VIS 3-5SM BR. BECMG 0508 CIGS
 OVC010-020. VIS 3SM BR. OTLK...MVFR CIGS BR.
 .
 KY
 SCT-BKN050 BKN100 TOPS FL180. ISOL -TSRA CB TOPS FL350.
 OTLK...VFR TSRA/SHRA.

11.0 Terminal Aerodrome Forecast

KAXN was the closest site to the accident site with a NWS Terminal Aerodrome Forecast (TAF). The KAXN TAF valid at the time of the accident was issued at 0146 CDT and was valid for a 23-hour period beginning at 0200 CDT. The TAF for KAXN was as follows:

KAXN 170646Z 1707/1806 **29008KT P6SM OVC020**
 TEMPO 1708/1712 OVC008
 FM171800 29009KT P6SM SCT060=

The forecast expected a wind from 290° at 8 knots, greater than 6 miles visibility, and an overcast ceiling at 2,000 feet agl, with a temporary period from 0300 to 0700 CDT of an overcast ceiling at 800 feet agl.

The KAXN TAF was amended immediately after the accident at 0225 CDT to include a temporary period of a half mile in fog with a vertical visibility of 200 feet agl between 0200 and 0600 CDT.

TAF AMD KAXN 170725Z 1707/1806 29008KT P6SM OVC020
TEMPO 1707/1711 1/2SM FG VV002
 FM171800 29009KT P6SM SCT060=

The KAXN TAF valid before the accident flight and before the accident pilot received his weather briefing (section 14.0) was issued at 0020 CDT and was valid for a 24-hour period beginning at 0100 CDT. The 0020 CDT TAF for KAXN was as follows:

KAXN 170520Z 1706/1806 **29008KT P6SM SCT025 BKN070**
FM170800 29008KT P6SM OVC020
TEMPO 1708/1712 OVC008
FM171800 29009KT P6SM SCT060=

The forecast expected a wind from 290° at 8 knots, greater than 6 miles visibility, scattered clouds at 2,500 feet agl, and a broken ceiling at 7,000 feet agl.

The KBRD TAF valid before the accident flight took off was issued at 0040 CDT and was valid for a 24-hour period beginning at 0100 CDT. The 0040 CDT TAF for KBRD was as follows:

KBRD 170540Z 1706/1806 **24005KT P6SM VCSH OVC005**
FM170800 28007KT 2SM BR VCSH OVC015
FM171500 27008KT P6SM SCT008 BKN015
FM171800 28009KT P6SM BKN030
FM172000 28007KT P6SM SCT040
FM180000 VRB03KT P6SM SKC=

The TAF at the time of takeoff from KBRD expected a wind from 240° at 5 knots, greater than 6 miles visibility, vicinity²⁵ showers, and an overcast ceiling at 500 feet agl.

12.0 NWS Area Forecast Discussion

The NWS Office in Chanhassen, Minnesota, issued the following Area Forecast Discussion (AFD) at 2321 CDT on September 16 (closest AFD to the accident time). The aviation section of the AFD discussed expected MVFR²⁶ ceilings to develop across the TAF sites overnight, but forecaster was still on fence at time of AFD if IFR ceilings would develop or not:

FXUS63 KMPX 170421
AFDMPX
Area Forecast Discussion
National Weather Service Twin Cities/Chanhassen MN
1121 PM CDT FRI SEP 16 2016
.UPDATE...
Issued at 1115 PM CDT Fri Sep 16 2016
Updated to include 06z aviation discussion below.
&&
.SHORT TERM...(This evening through Saturday)
Issued at 415 PM CDT Fri Sep 16 2016
There is an upper low spinning over the Red River Valley this
afternoon with a broad and baggy area of low pressure out ahead of

²⁵ In the vicinity of the airport is defined as a weather phenomenon within 5-10 miles of the airfield, but not over the airfield.

²⁶ Marginal Visual Flight Rules – Refers to the general weather conditions pilots can expect at the surface. MVFR criteria means a ceiling between 1,000 and 3,000 feet agl and/or 3 to 5 miles visibility.

it across MN/WI with a cold front making slow, but steady progress in western MN. Within the upper low, there is a strong vort max approaching the MN/SD/ND border and this vort feature is the primary driver of scattered storms we have seen develop west of Alexandria that will work across central MN into the evening. This vort max will continue east across central MN today and this lift with 500- 1000 j/kg of MLCAPE that has developed will result in storms moving across central MN, staying mostly west and north of the Twin Cities. The idea of central MN seeing scattered activity has broad support from convective allowing and deterministic models alike, so have scattered thunderstorm mention here.

Mid level lapse rates are pretty poor outside of central/northern MN and think outside of there, the severe threat is pretty minimal. Current values of CAPE and weak convergence along the front would support low topped convection. Deep layer shear is around 40 kts, but 0-1km shear is barely 10 kts. Think our best hope for severe weather is for a stronger storm to produce hail near an inch or possibly a strong wind gust given steepening low level lapse rates where adequate heating has occurred, but otherwise it's mainly garden variety activity for us. One thing to watch though with the upper low, surface low, and front nearby is for the potential for a brief/weak spin up with the enhanced vorticity in the area. We like where SPC has the marginal risk in the Day 1 outlook, but the area delineated in the pre 16z outlooks looks better than the most recent couple, with those looking to be too far southeast with the threat given the mid level lapse rates southeast of the St. Cloud area.

Tonight, large area of stratus covering the eastern half of the Dakotas will be heading east with the surface and upper low. This low stratus will slowly slide east through the day on Saturday, with a mainly cloudy day expected for eastern MN and western WI, with afternoon sun for western MN. If we do end up as cloudy as the GFS would say we will be, could see highs Saturday being a few degrees cooler than what is forecast for eastern MN into western WI. Have also left a small area of slight chance of showers in our far northeast CWA Saturday as the upper low passes across Lake Superior, though support for precip here on Saturday gets smaller and smaller with each model cycle, so think even this is probably overdone, with dry weather looking like a good bet across the entire MPX area on Saturday.

.LONG TERM...(Saturday night through Friday)

Issued at 415 PM CDT Fri Sep 16 2016

By Saturday night, the aforementioned surface low will drift northeast of the Great Lakes and high pressure will build across the Mississippi River Valley. The winds on Sunday will be southwesterly, which should bring above normal temperatures to MN/WI along with a fair amount of sunshine. Another low deepens in the Northern Plains SUN-MON in response to a strong (140kt) westerly jet that quickly moves inland and toward MN/WI. The surface low lifts north into Canada and we'll likely remain dry with the jet directly overhead. As this jet lifts north Tuesday, the low level flow will increase and tap deeper moisture from the Southern Plains setting up a pronounced warm front in southern MN and western WI Tuesday night into Wednesday. The convergence along the front is very strong and the GFS/ECMWF are now in good

agreement in initiating robust convection along the warm front across the forecast area. This pattern remains active through the rest of the week with baroclinic zone nearby and an approaching upper trough.

&&

.AVIATION...(For the 06Z TAFS through 06Z Saturday night)

Issued at 1115 PM CDT Fri Sep 16 2016

VFR at all stations at initialization time but am expecting post-frontal early morning MVFR ceilings to develop between now and daybreak. MVFR ceilings will then last through early afternoon and possibly later. The main question is if IFR ceilings will develop at the sites. Model guidance still depicts as such. The key factor will be diminishing winds since moisture underneath the inversion will certainly be enough due to the drier air intrusion holding off well to the west. Conditions will improve to VFR by mid-to-late afternoon then prevail thereafter.

MSP...Have dropped conditions to 1500 ft by daybreak with MVFR conditions remaining in place through mid-afternoon. Model guidance still indicates a period of IFR ceilings just after sunrise so have opted to include a TEMPO group for late Saturday morning to account for this.

/OUTLOOK FOR KMSP/

Sun...VFR. S wind 10-15 kt.

Mon...VFR. W winds 5-10 kt...becoming NW.

Tue...VFR. SW winds 5kt.

&&

.MPX Watches/Warnings/Advisories...

WI...None.

MN...None.

&&

\$\$

UPDATE...JPC

AVIATION...JPC

13.0 Winds and Temperature Aloft Forecast

The NWS 2102 CDT on September 16 Winds and Temperature Aloft forecasts valid for the accident flight are included below:

FBUS31 KWN0 170202

FD1US1

DATA BASED ON 170000Z

VALID 170600Z FOR USE 0200-0900Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

AXN 3113 3012+08 3011+03 2912-02 2918-14 2927-26 292944 273849 254648

The AXN forecast indicated a wind at 3,000 feet from 310° at 13 knots, a wind at 6,000 feet from 300° at 12 knots with a temperature of 8° C.

14.0 Pilot Weather Briefing and Information

A search of official weather briefing sources, indicated the pilot used the ForeFlight application on his tablet at 0119 CDT and received official Lockheed Martin Flight Service (LMFS) weather briefing information in both text and graphical format (attachments 3, 4, and 5). The accident pilot did not call to receive a voice weather briefing, but received all his weather information via the ForeFlight mobile application. The official weather briefing information contained all valid AIRMETs, METARs, and TAFs valid in between the departure and destination at 0119 CDT with attachment 3 providing the graphical images that the accident pilot reviewed on his mobile application. There is no record of the accident pilot receiving or retrieving any other weather information before the accident flight.

15.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on September 17, 2016, indicated the following:

SUN

Begin civil twilight	0633 CDT
Sunrise	0703 CDT
Sun transit	1316 CDT
Sunset	1928 CDT
End civil twilight	1958 CDT

MOON

Moonrise	1940 CDT on preceding day
Moon transit	0143 CDT
Moonset	0756 CDT
Moonrise	2013 CDT

The Moon's phase was Waning Gibbous with 99% of the Moon's visible disk illuminated. However, given the mid-level cloud cover and instrument meteorological conditions at the time of the accident (sections 3.0 and 5.0), it is unlikely that the Moon was visible at the accident site at the accident time.

F. LIST OF ATTACHMENTS

Attachment 1 – 5 and 1 minute ASOS observations from KAXN surrounding the accident time

Attachment 2 – GOES-13 infrared satellite animation from 0045 to 0315 CDT

Attachment 3 – ForeFlight weather briefing graphical information from 0119 CDT

Attachment 4 – ForeFlight weather briefing text information from 0119 CDT

Attachment 5 – LMFS weather briefing text information from 0119 CDT (provided on ForeFlight mobile application)

Submitted by:

Paul Suffern
Senior Meteorologist

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