NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

May 26, 2017

Weather Study

METEOROLOGY

DCA17MR007

Table Of Contents

A. ACCIDENT

Location: Graettinger, Iowa
Date: March 10, 2017
Time: 0045 central standard time
0645 Coordinated Universal Time (UTC)
Vehicles: Union Pacific freight train derailed

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 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 standard time (CST) on March 10, 2017, and are based upon the 24-hour clock, where local time is -6 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 43.2179° N, longitude 94.7222° W, with approximate elevation of 1,225 feet.

D. WEATHER 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 Surface Analysis Chart

The NWS Surface Analysis Chart for 0000 CST on March 10, 2017, is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart depicted a cold frontal boundary located from southwestern Kentucky stretching westward into southern Oklahoma then northwestward into central Colorado. A surface high pressure center with a pressure of 1047-hectopascals (hPa) was located in southern Manitoba. The station models around the accident site depicted air temperatures in the mid teens to mid 20's degrees Fahrenheit (°F), dew point temperatures between 1 and 18 °F, a northwest wind between 10 and 20 knots, and mostly clear skies.

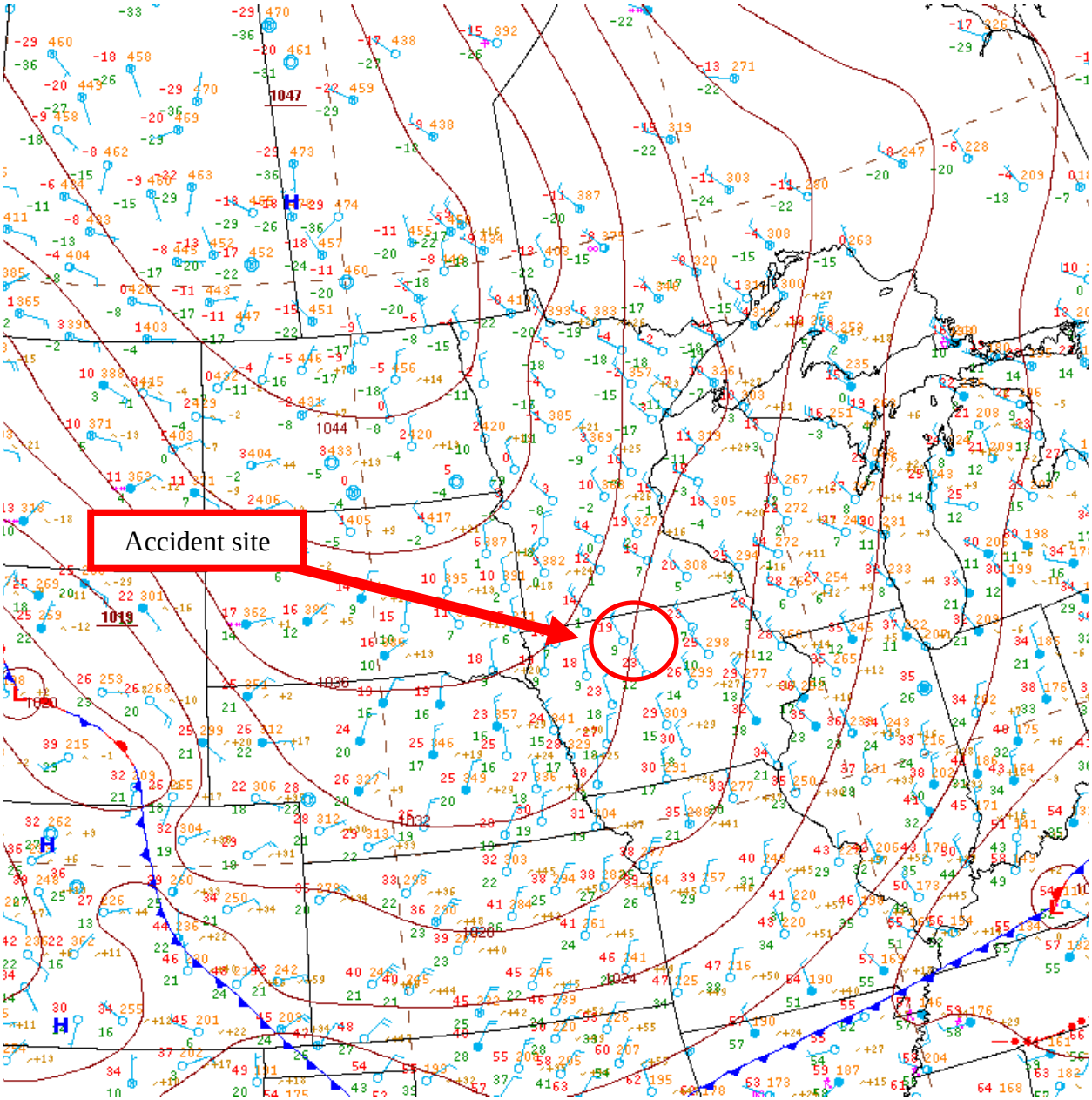

Figure 1 – NWS Surface Analysis Chart for 0000 CST

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 0600 CST at 925-, 850-, 700-, 500-, and 300-hectopascals (hPa) are presented in figures 2 through 6. The accident site was not located near any low or mid-level troughs[1] and therefore enhanced vertical motion, clouds, and precipitation would not be expected. There was a north wind of 20 to 30 knots at 925-hPa (figure 2). The wind became northwesterly by 700-hPa and the wind speed increased to between 40 and 50 knots (figure 4). The wind remained northwesterly through 300-hPa with the wind speed increasing to between 120 and 130 knots at 300-hPa (figure 6).

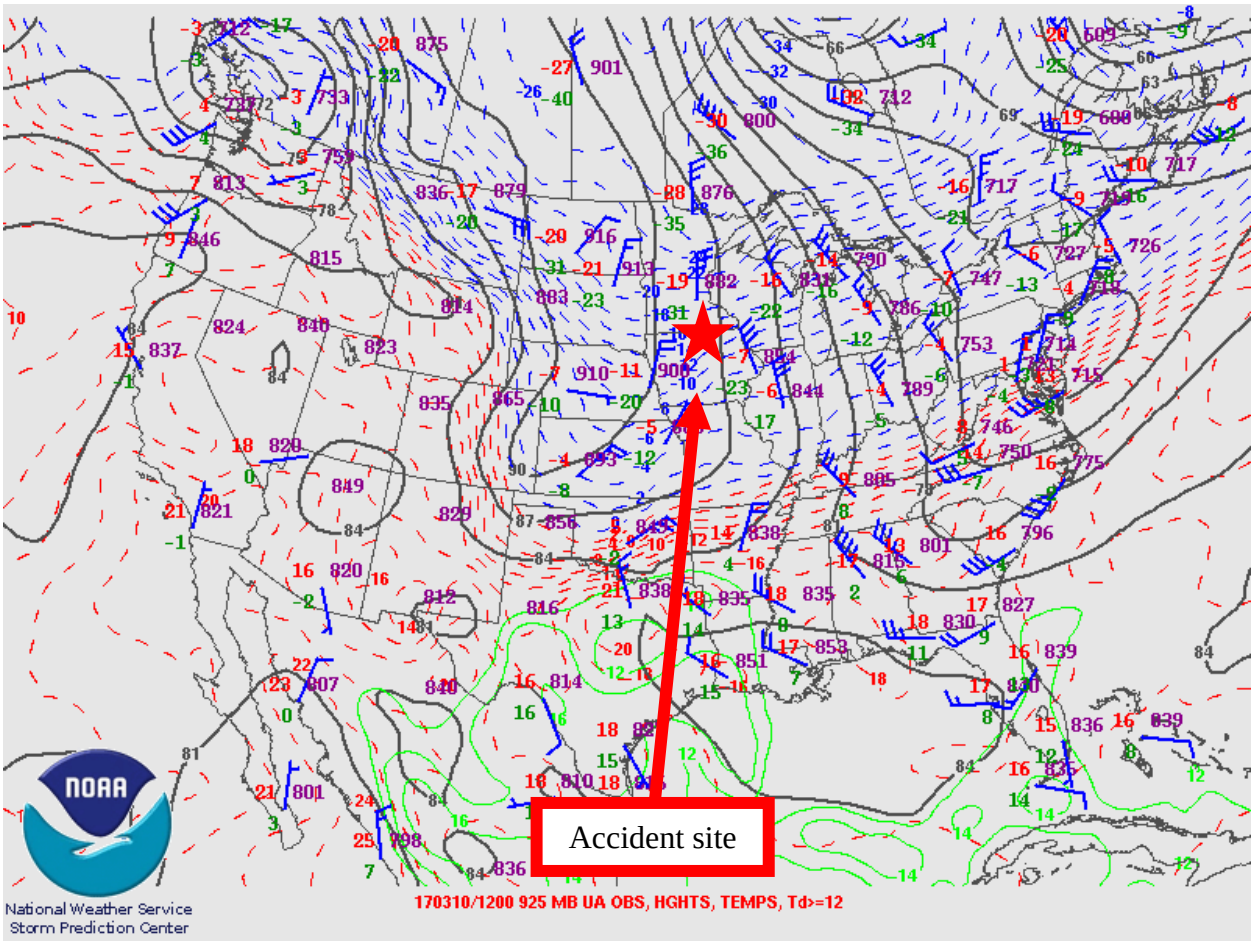

Figure 2 – 925-hPa Constant Pressure Chart for 0600 CST

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

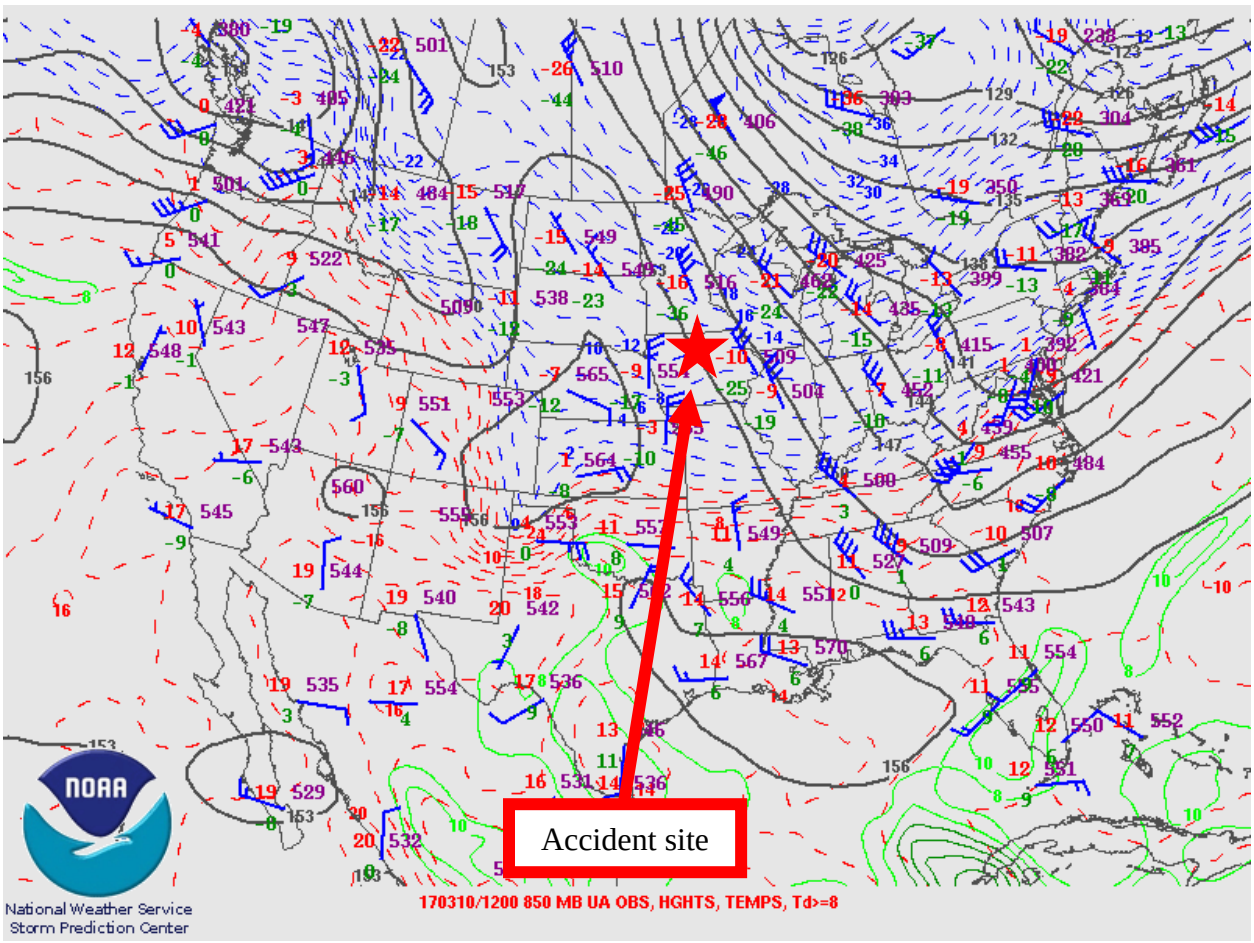

Figure 3 – 850-hPa Constant Pressure Chart for 0600 CST

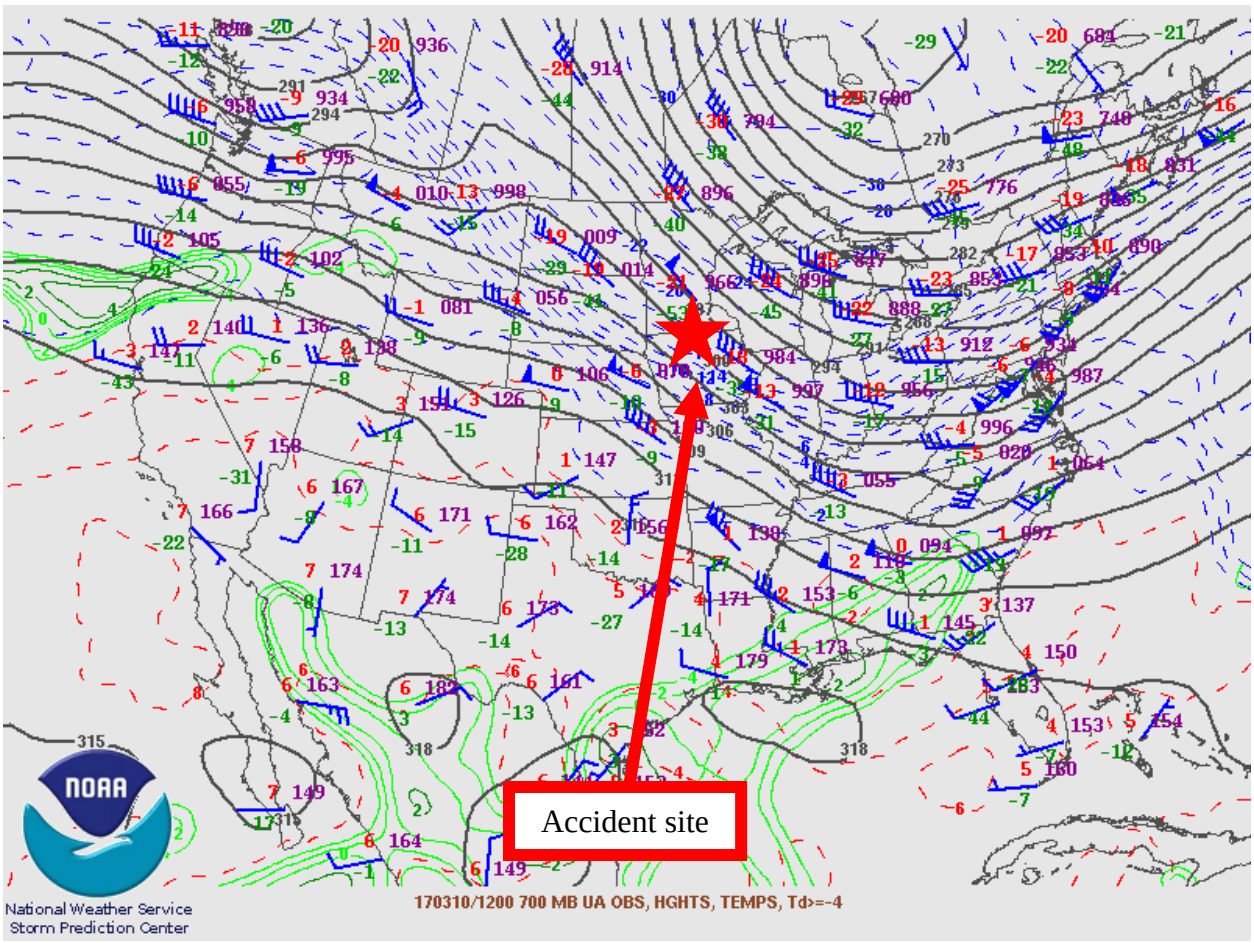

Figure 4 – 700-hPa Constant Pressure Chart for 0600 CST

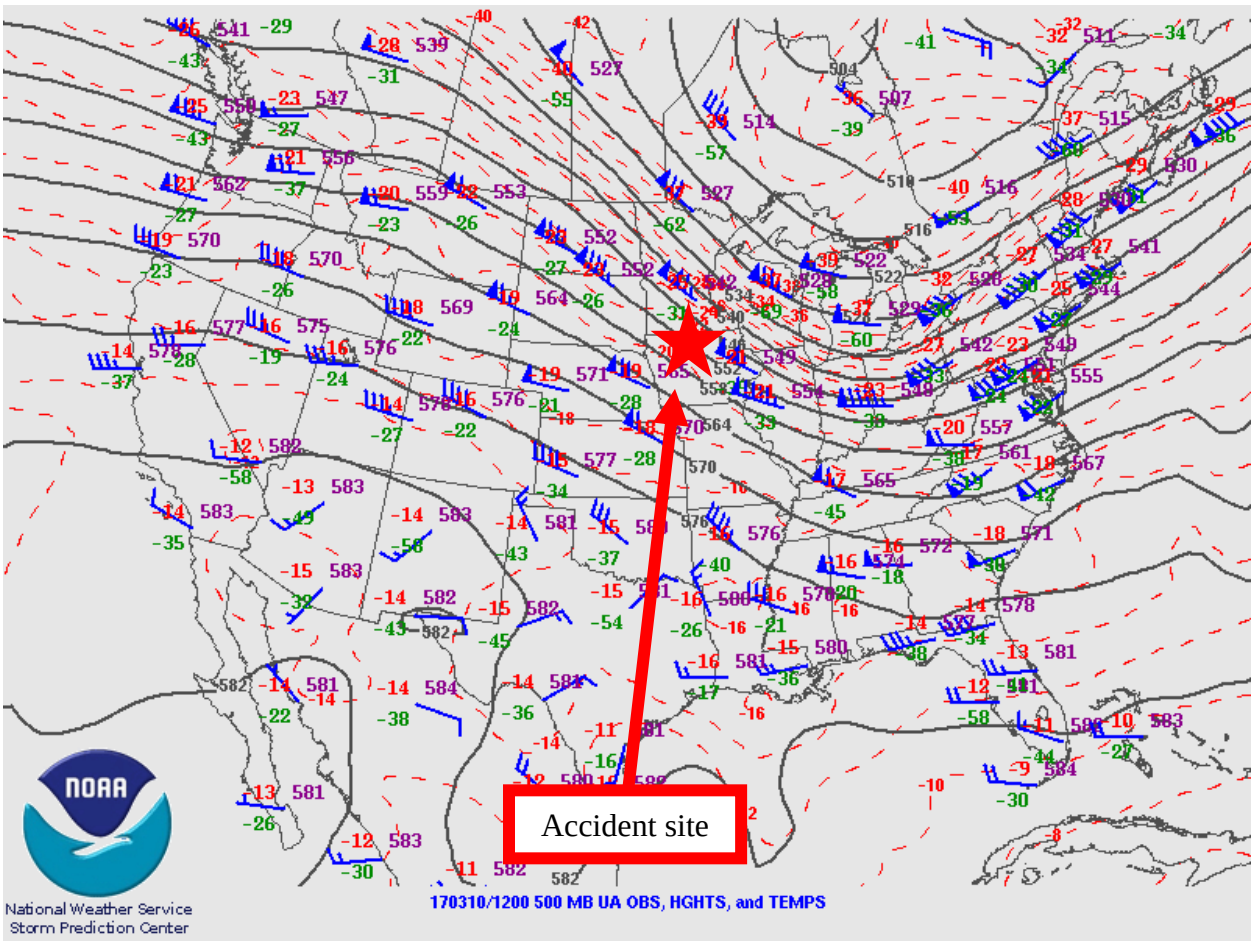

Figure 5 – 500-hPa Constant Pressure Chart for 0600 CST

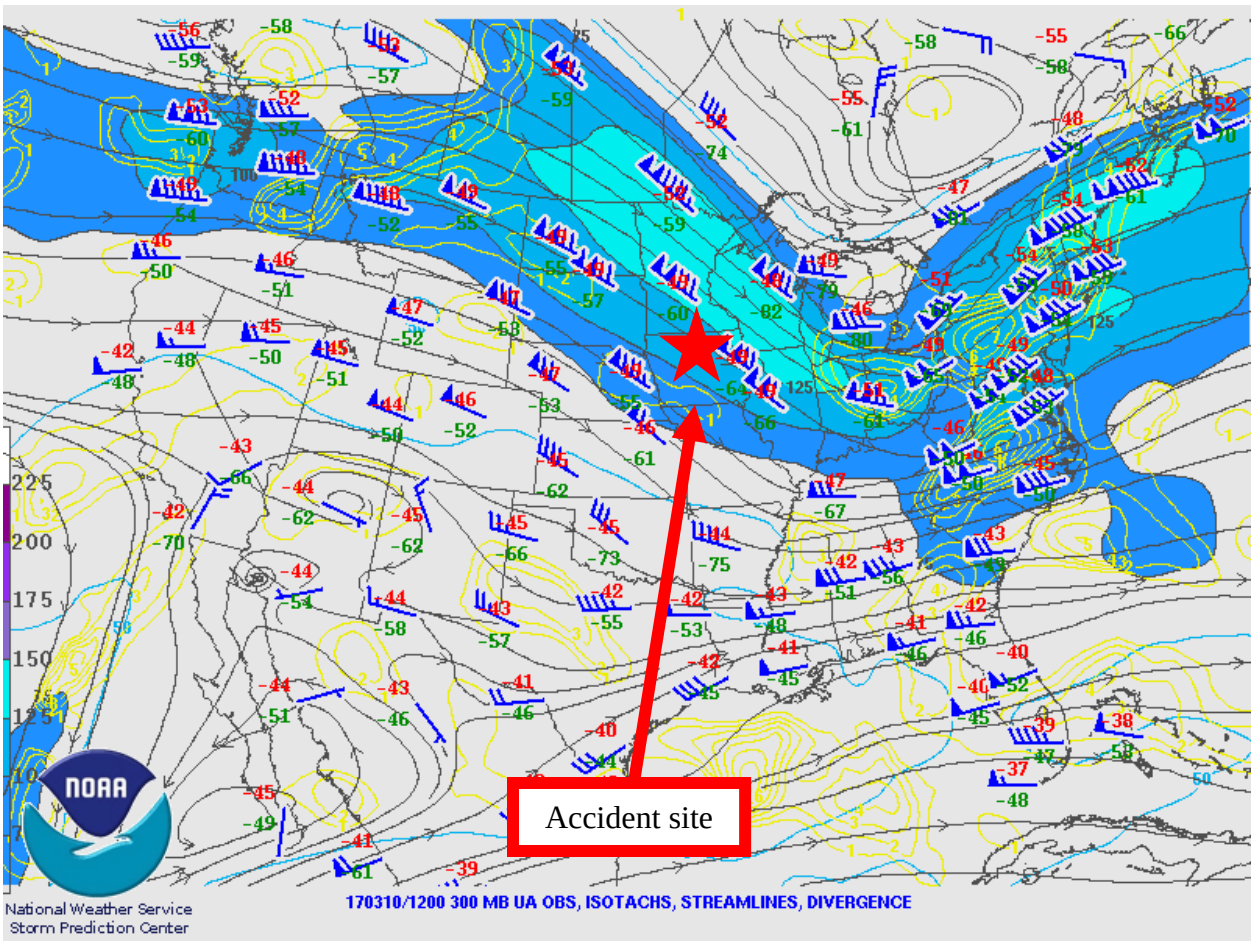

Figure 6 – 300-hPa Constant Pressure Chart for 0600 CST

2.0 SPC Products

There were no thunderstorms forecast for the accident site at the accident time.

3.0 Surface Observations

The area surrounding the accident site was documented using official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language with visibility reported in statute miles for this section. Figure 7 is a sectional map with the accident site and the closest weather reporting locations marked.

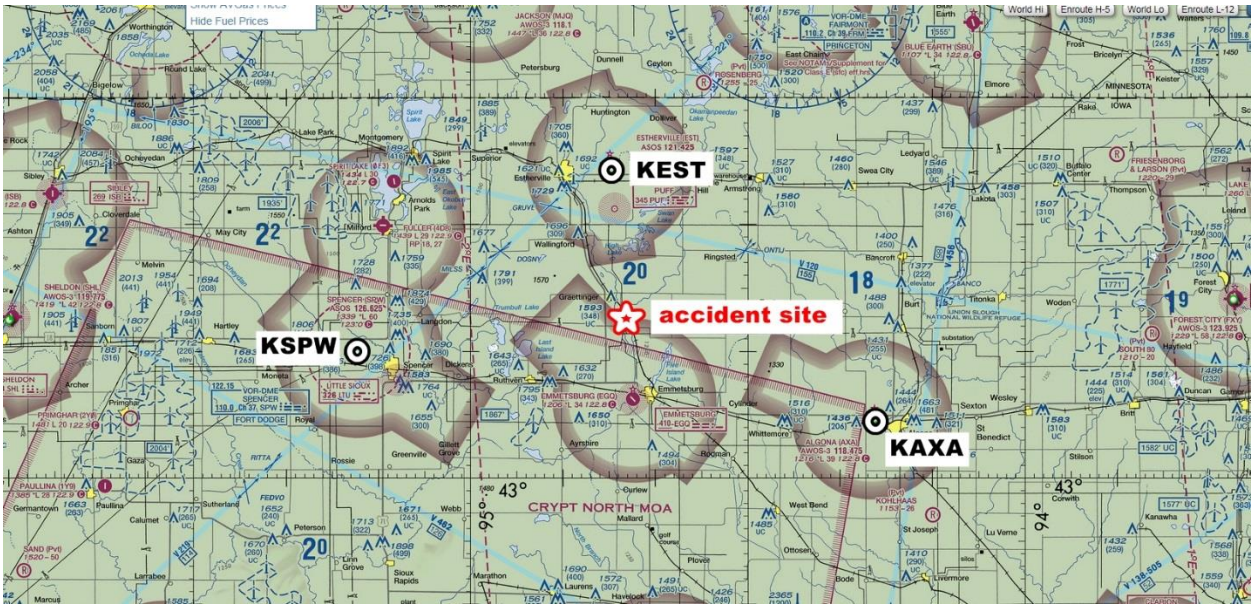

Figure 7 – Sectional chart of accident area with the location of the accident site and surface observation sites

Estherville Municipal Airport (KEST) was the closest official weather station to the accident site, located 4 miles east of Estherville, Iowa. KEST had an Automated Surface Observing System (ASOS[2]) whose reports were not supplemented. KEST was located 12 miles north of the accident site, at an elevation of 1,319 feet, and had a 6° easterly magnetic variation[3] (figure 7). The following observations were taken and disseminated during the times surrounding the accident with the times before 0000 CST being from March 9:[4]

[1852 CST] METAR KEST 100052Z AUTO 35018G23KT 10SM OVC110 M04/M10 A3035 RMK AO2 SLP298 T10391100=

[1952 CST] METAR KEST 100152Z AUTO 34017KT 10SM BKN120 M06/M09 A3039 RMK AO2 SLP310 T10561089=

[2052 CST] METAR KEST 100252Z AUTO 34020KT 10SM SCT090 M07/M11 A3043 RMK AO2 PK WND 34026/0251 SLP324 T10671106 53035=

[2152 CST] METAR KEST 100352Z AUTO 33016KT 10SM FEW110 M08/M13 A3045 RMK AO2 PK WND 34026/0312 SLP334 T10781128=

[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. 1980, latest measurement taken from http://www.airnav.com/airport/KEST

[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.

[2252 CST] METAR KEST 100452Z AUTO 34020G24KT 10SM FEW110 M09/M14 A3047 RMK AO2 SLP341 T10891139=

[2352 CST] METAR KEST 100552Z AUTO 33023G27KT 10SM CLR M09/M15 A3049 RMK AO2 PK WND 33027/0551 SLP344 T10941150 11033 21094 400001094 51020=

[0052 CST] METAR KEST 100652Z AUTO 33022KT 10SM CLR M11/M17 A3051 RMK AO2 PK WND 33026/0629 SLP353 T11061172=

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[0152 CST] METAR KEST 100752Z AUTO 34015G26KT 10SM CLR M12/M20 A3053 RMK AO2 PK WND 34030/0659 SLP362 T11171200=

[0252 CST] METAR KEST 100852Z AUTO 34019KT 10SM CLR M13/M20 A3053 RMK AO2 PK WND 34030/0822 SLP360 T11281200 50013=

[0352 CST] METAR KEST 100952Z AUTO 34016G25KT 10SM CLR M14/M22 A3053 RMK AO2 PK WND 35026/0908 SLP365 T11391217=

[0452 CST] METAR KEST 101052Z AUTO 34016KT 10SM CLR M14/M21 A3055 RMK AO2 SLP372 T11441211=

KEST weather at 2352 CST on March 9, automated, wind from 330° at 23 knots with gusts to 27 knots, 10 miles visibility, clear skies below 12,000 feet above ground level (agl), temperature of -9° Celsius (C), dew point temperature of -15° C, and an altimeter setting of 30.49 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 27 knots from 330° at 2351 CST on March 9, sea level pressure 1034.4 hPa, temperature -9.4° C, dew point temperature -15.0° C, 6-hourly maximum temperature of -3.3° C, 6-hourly minimum temperature of -9.4° C, 24-hour maximum temperature of 0.0° C, 24-hour minimum temperature of -9.4° C, 3-hourly pressure increase of 2.0 hPa.

KEST weather at 0052 CST on March 10, automated, wind from 330° at 22 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -11° C, dew point temperature of -17° C, and an altimeter setting of 30.51 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 26 knots from 330° at 0029 CST, sea level pressure 1035.3 hPa, temperature -10.6° C, dew point temperature -17.2° C.

KEST weather at 0152 CST, automated, wind from 340° at 15 knots with gusts 26 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -12° C, dew point temperature of -20° C, and an altimeter setting of 30.53 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 30 knots from 340° at 0059 CST, sea level pressure 1036.2 hPa, temperature -11.7° C, dew point temperature -20.0° C.

KEST weather at 0252 CST, automated, wind from 340° at 19 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -13° C, dew point temperature of -20° C, and an altimeter setting of 30.53 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 30 knots from 340° at 0222 CST, sea level pressure 1036.0 hPa, temperature -12.8° C, dew point temperature -20.0° C, 3-hourly pressure increase of 1.3 hPa.

Spencer Municipal Airport (KSPW) was located 3 miles northwest of Spencer, Iowa. KSPW had an ASOS whose reports were not supplemented. KSPW was located 21 miles west-southwest of the accident site, at an elevation of 1,339 feet, and had a 5° easterly magnetic variation[5] (figure 7). The following observations were taken and disseminated during the times surrounding the accident with the times before 0000 CST being from March 9:

[1853 CST] METAR KSPW 100053Z AUTO 01017KT 10SM BKN085 OVC100 M03/M11 A3037 RMK AO2 SLP304 T10281106 TSNO=

[1953 CST] METAR KSPW 100153Z AUTO 35015KT 10SM SCT110 M05/M09 A3040 RMK AO2 SLP316 T10501089 TSNO=

[2053 CST] METAR KSPW 100253Z AUTO 35019KT 10SM FEW080 BKN120 M06/M10 A3043 RMK AO2 PK WND 36027/0228 SLP327 T10611100 51036 TSNO=

[2153 CST] METAR KSPW 100353Z AUTO 35013G21KT 10SM FEW080 M07/M13 A3047 RMK AO2 PK WND 35027/0316 SLP339 T10721128 TSNO=

[2253 CST] METAR KSPW 100453Z AUTO 35017G20KT 10SM CLR M08/M14 A3048 RMK AO2 SLP343 T10831139 TSNO=

[2353 CST] METAR KSPW 100553Z AUTO 35017G24KT 10SM CLR M09/M16 A3050 RMK AO2 PK WND 35027/0501 SLP350 T10891156 11022 21089 400221089 51022 TSNO=

[0053 CST] METAR KSPW 100653Z AUTO 35017KT 10SM CLR M09/M16 A3051 RMK AO2 PK WND 35029/0641 SLP354 T10941156 TSNO=

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[0153 CST] METAR KSPW 100753Z AUTO 35021G31KT 10SM CLR M11/M18 A3053 RMK AO2 PK WND 36031/0731 SLP361 T11061178 TSNO=

[0253 CST] METAR KSPW 100853Z AUTO 35016G21KT 10SM CLR M12/M17 A3055 RMK AO2 PK WND 35028/0757 SLP370 T11171172 53017 TSNO=

[0353 CST] METAR KSPW 100953Z AUTO 34015KT 10SM CLR M13/M19 A3056 RMK AO2 PK WND 35029/0920 SLP372 T11281194 TSNO=

[5] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 1985, latest measurement taken from http://www.airnav.com/airport/KSPW

[0453 CST] METAR KSPW 101053Z AUTO 36015KT 10SM CLR M13/M21 A3056 RMK AO2 SLP373 T11331211 TSNO=

KSPW weather at 2353 CST on March 9, automated, wind from 350° at 17 knots with gusts to 24 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -9° C, dew point temperature of -16° C, and an altimeter setting of 30.50 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 27 knots from 350° at 2301 CST on March 9, sea level pressure 1035.0 hPa, temperature -8.9° C, dew point temperature -15.6° C, 6-hourly maximum temperature of -2.2° C, 6-hourly minimum temperature of -8.9° C, 24-hour maximum temperature of 2.2° C, 24-hour minimum temperature of -8.9° C, 3-hourly pressure increase of 2.2 hPa, lightning detection system not operating.

KSPW weather at 0053 CST on March 10, automated, wind from 350° at 17 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -9° C, dew point temperature of -16° C, and an altimeter setting of 30.51 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 29 knots from 350° at 0041 CST, sea level pressure 1035.4 hPa, temperature -9.4° C, dew point temperature -15.6° C, lightning detection system no operating.

KSPW weather at 0153 CST, automated, wind from 350° at 21 knots with gusts 31 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -11° C, dew point temperature of -18° C, and an altimeter setting of 30.53 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 31 knots from 360° at 0131 CST, sea level pressure 1036.1 hPa, temperature -10.6° C, dew point temperature -17.8° C, lightning detection system no operating.

KSPW weather at 0253 CST, automated, wind from 350° at 16 knots with gusts to 21 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -12° C, dew point temperature of -17° C, and an altimeter setting of 30.55 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 28 knots from 350° at 0157 CST, sea level pressure 1037.0 hPa, temperature -11.7° C, dew point temperature -17.2° C, 3-hourly pressure increase of 1.7 hPa, lightning detection system no operating.

Algona Municipal Airport (KAXA) was located 2 miles west of Algona, Iowa. KAXA had an Automated Weather Observing System (AWOS[6]) whose reports were not supplemented. KAXA was located 21 miles east-southeast of the accident site, at an elevation of 1,216 feet, and had a 3° easterly magnetic variation[7] (figure 7). The following observations were taken and disseminated during the times surrounding the accident with the times before 0000 CST being from March 9:

[2235 CST] METAR KAXA 100435Z AUTO 35014G22KT 10SM FEW085 M06/M12 A3044 RMK AO2=

[6] 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.

[7] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2000, latest measurement taken from http://www.airnav.com/airport/KAXA

[2255 CST] METAR KAXA 100455Z AUTO 35016KT 10SM CLR M06/M12 A3044 RMK AO2=

[2315 CST] METAR KAXA 100515Z AUTO 34014G22KT 10SM CLR M07/M12 A3045 RMK AO2=

[2335 CST] METAR KAXA 100535Z AUTO 34015G23KT 10SM CLR M07/M13 A3045 RMK AO2=

[2355 CST] METAR KAXA 100555Z AUTO 34014G24KT 10SM CLR M07/M13 A3046 RMK AO2=

[0015 CST] METAR KAXA 100615Z AUTO 35017G24KT 10SM CLR M08/M14 A3046 RMK AO2=

[0035 CST] METAR KAXA 100635Z AUTO 35019G26KT 10SM CLR M08/M14 A3047 RMK AO2=

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[0055 CST] METAR KAXA 100655Z AUTO 34019G28KT 10SM CLR M08/M14 A3048 RMK AO2=

[0115 CST] METAR KAXA 100715Z AUTO 34013G20KT 10SM CLR M09/M15 A3049 RMK AO2=

[0135 CST] METAR KAXA 100735Z AUTO 35018G26KT 10SM CLR M09/M15 A3049 RMK AO2=

[0155 CST] METAR KAXA 100755Z AUTO 34012G22KT 10SM CLR M09/M16 A3050 RMK AO2=

KAXA weather at 0015 CST, automated, wind from 350° at 17 knots with gusts to 24 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -8° C, dew point temperature of -14° C, and an altimeter setting of 30.46 inches of mercury. Remarks, station with a precipitation discriminator.

KAXA weather at 0035 CST, automated, wind from 350° at 19 knots with gusts to 26 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -8° C, dew point temperature of -14° C, and an altimeter setting of 30.47 inches of mercury. Remarks, station with a precipitation discriminator.

KAXA weather at 0055 CST, automated, wind from 340° at 19 knots with gusts to 28 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -8° C, dew point temperature of -14° C, and an altimeter setting of 30.48 inches of mercury. Remarks, station with a precipitation discriminator.

KAXA weather at 0115 CST, automated, wind from 340° at 13 knots with gusts to 20 knots, 10 miles visibility, clear skies below 12,000 feet agl, temperature of -9° C, dew point temperature of -15° C, and an altimeter setting of 30.49 inches of mercury. Remarks, station with a precipitation discriminator.

The observations from KEST, KSPW, and KAXA surrounding the accident time indicated no restrictions to visibility or ceilings and no precipitation. The surface winds all remained consistent through the accident time with the wind between 15 to 25 knots with gusts as high as 31 knots observed at KSPW.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)[8] model sounding was created for the accident site for 0100 CST. The 0100 CST sounding was plotted on a standard Skew-T log P diagram[9] with the derived stability parameters included in figure 8 (with data from the surface to 700-hPa, or 10,000 feet msl.) This data was analyzed utilizing the RAOB[10] software package. The sounding depicted the lifted condensation level (LCL)[11] at 3,205 feet msl and a convective condensation level (CCL)[12] of 19,167 feet. The freezing level at the surface. The precipitable water value was 0.16 inches.

[8] The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three kilometer grids with three kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one hour period.

[9] 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.

[10] RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamopras, Pennsylvania.

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

[12] 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.

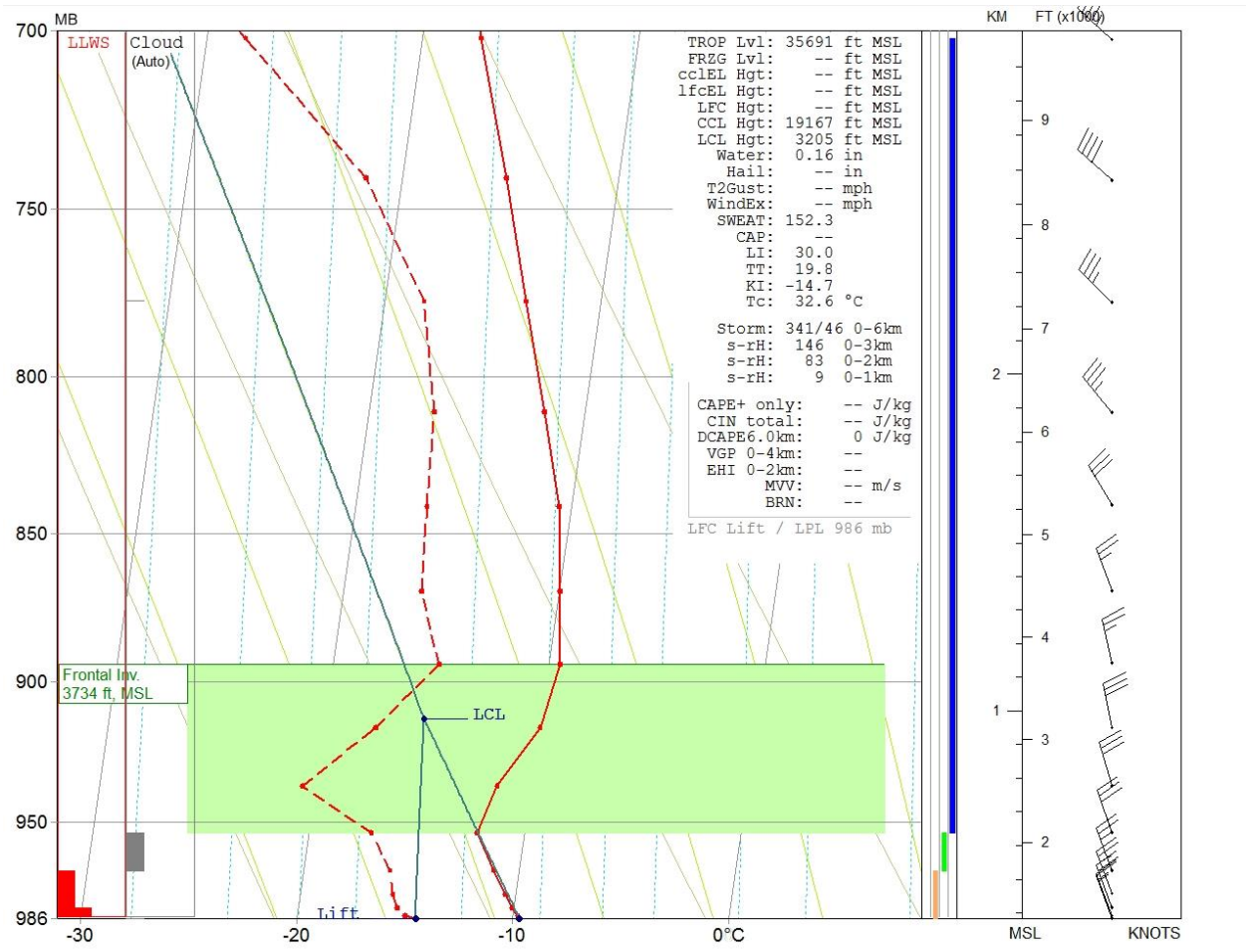

Figure 8 – 0100 CST HRRR sounding for the accident site

The 0100 CST HRRR sounding indicated an unstable to conditionally unstable layer between the surface and 2,000 feet. A stable layer was present from 2,000 feet through 10,000 feet. RAOB indicated that clouds were possible around 2,000 feet. There was insufficient moisture in the favored dendritic growth zone between -10° C and -20° C, and all the way to the surface, and therefore precipitation would not be expected at the surface.

The 0100 CST HRRR sounding wind profile indicated a surface wind from 341° at 15 knots with the wind remaining north to northwesterly through 10,000 feet. The wind increased in speed to 30 knots by 2,000 feet. The wind speed remained between 30 to 45 knots between 2,000 and 10,000 feet. Given the unstable to conditionally unstable layer between the surface and 2,000 feet, the strongest surface wind likely would have been 30 knots, which was similar to the wind speed reported in section 3.0.

5.0 Satellite Data

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 Man-computer Interactive Data Access System software. Infrared imagery (GOES-13 band 4) at wavelengths of 10.7 microns was retrieved for the period. Satellite imagery surrounding the time of the accident, from 0000 CST through 0200 CST at approximately 15-minute intervals was reviewed, and the closest images to the time of the accident are documented here.

Figure 9 and 10 presents the GOES-13 infrared imagery from 0045 and 0100 CST at 6X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated no cloud cover over and around the accident site at the accident time. It should be noted these figures have not been corrected for any parallax error.

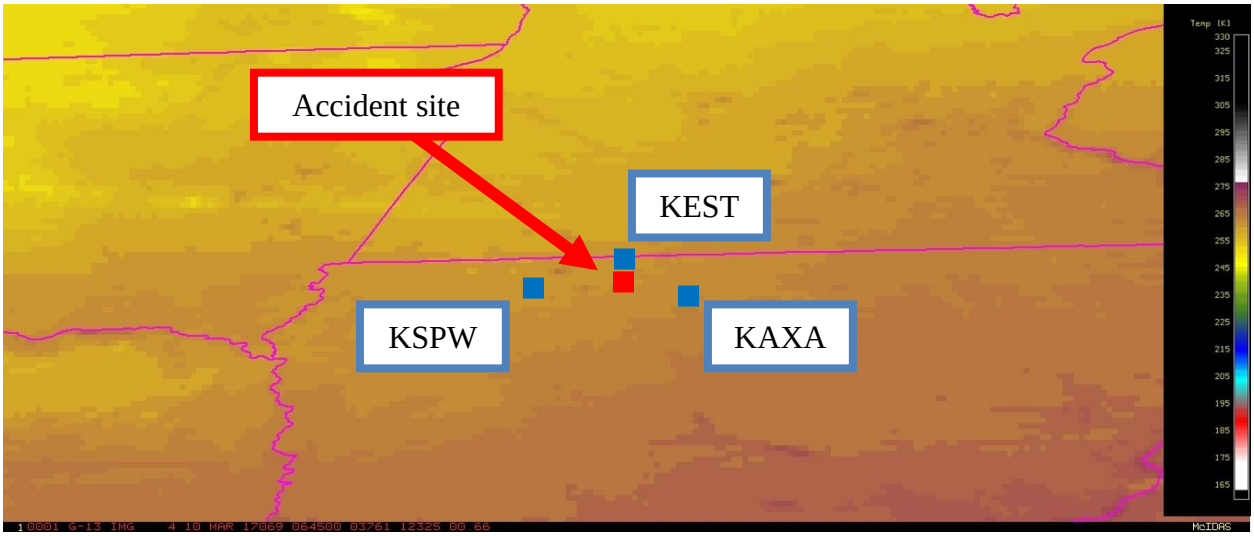

Figure 9 – GOES-13 infrared image at 0045 CST

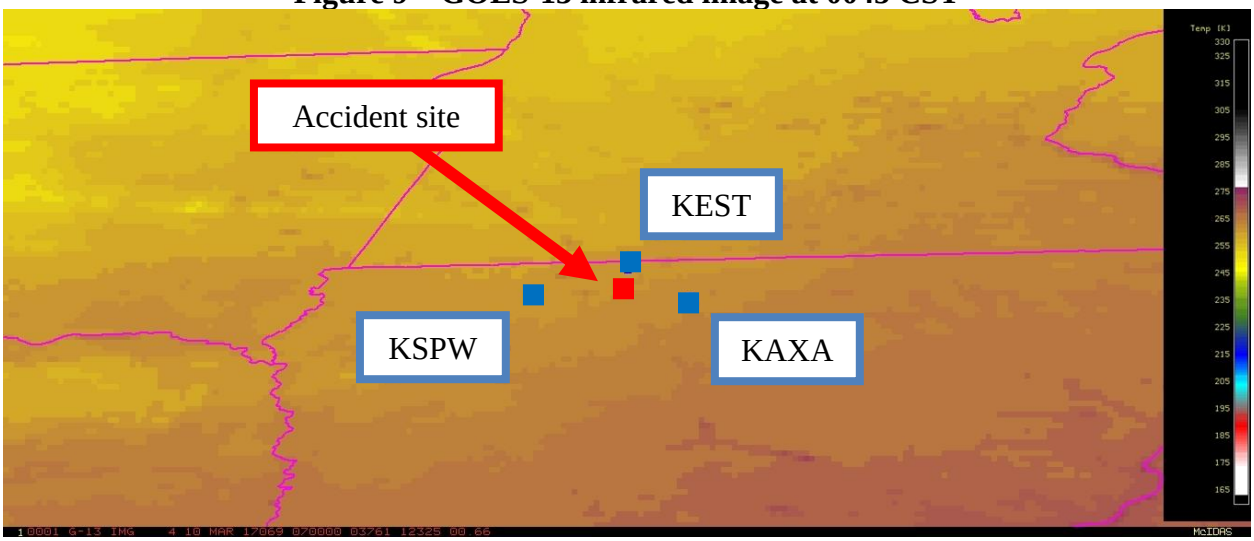

Figure 10 – GOES-13 infrared image at 0100 CST

6.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[13] to the accident site was the Des Moines, Iowa, radar (KDMX), which was located 99 miles south-southeast of the accident site at an elevation of 981 feet. Level II and III archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software. No precipitation targets were located above the accident site at the accident time.

7.0 NWS Area Forecast Discussion

The NWS Office in Des Moines, Iowa, issued the following Area Forecast Discussion (AFD) at 2344 CST on March 9 (closest AFD to the accident time). The AFD discussed the breezy conditions through tomorrow afternoon:

330
FXUS63 KDMX 100544
AFDDMX

Area Forecast Discussion
National Weather Service Des Moines IA
1144 PM CST Thu Mar 9 2017

.SHORT TERM.../Tonight through Friday/
Issued at 336 PM CST Thu Mar 9 2017

A secondary push of cold air punches across the state tonight as a 500mb vort max cuts south across Minnesota into Wisconsin and a large Canadian surface high pressure moves into the region. Should see some gusty winds with the subtle PV anomaly tonight, roughly between 00-03z Friday. Winds are likely to remain breezy until tomorrow afternoon when the surface high closes in on the forecast area and allows the pressure gradient to relax. Wind chill values should dip below zero across northern Iowa overnight into Friday morning as ambient temperatures are likely to drop into the single digits above zero.

.LONG TERM.../Friday night through Thursday/
Issued at 336 PM CST Thu Mar 9 2017

The overall flow regime will change little through at least much of the period. This will keep Iowa within some degree of NW flow aloft with a few precip windows, mainly for snow, the primary sensible weather concerns. The first of which will begin right away as a short wave currently well off the NW CONUS coast makes its way into the Northern Rockies and Northern Plains Friday Night. A broad, extended zone of warm advection is expected to develop well ahead of this feature through the MO Valley spreading snow into Iowa Friday Night and early Saturday. This system will be mainly thermodynamically

[13] 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.

driven with any kinematic contributions attendant to the wave itself and passing through the Upper MS Valley Saturday keeping light snow in the forecast south and west into the afternoon. The models are in fairly good agreement depicting 1-3" snowfall across the central and SW two-thirds of the forecast area. Static stabilities are fairly high so convection is not a concern. Where the max swath occurs may be interesting however and somewhat difficult to pin down, likely south and west of Des Moines but to what degree is uncertain. The depth of the dendritic growth zone /DGZ/ is fairly deep farther NE with the max omega removed to the south and west. There are hints that these two may phase in a narrow stripe so have depicted a subtle secondary max from Denison to Corydon which would be in addition to higher QPF driven amounts closer to Omaha. Wind amounts should be fairly light so blowing snow is not a concern.

The next system will follow close behind late Sunday into Monday. This snowfall potential is greater than the early weekend system, but confidence in the forecast is lower due to model to model track differences. The GFS and ECMWF both depict a zone of deep, phased forcing. The DGZ is not as deep but the lift is better aligned within. The CMC, ECMWF and its ensemble suggest a more north and east track while the GFS/GEFS suite shows farther southwest. Both suggest high end PoPs through this window, and this will likely be a headline event for somewhere in the forecast area, but SW-NE placement of the max axis and amounts will be better determined in the coming days.

Additional weak precip windows are quite possible into the middle of next week, but as one would expect model agreement with the strength and timing of individual short waves is not good as they try to handle the transition after the long wave trough passage Tue. The GFS is more bullish than the ECMWF and enough to warrant low end PoPs into midweek. The CMC is even stronger with a wave late Wed so the pattern will remain active to at least some degree. Temps will begin to moderate next week but nothing beyond getting back closer to normal after below normal readings around this weekend.

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.AVIATION.../For the 06Z TAFS through 06Z Friday night/
Issued at 1144 PM CST Thu Mar 9 2017

Few concerns this period. Wind early will diminish by 12z as high moves into the region. Winds most of period will be north northwest generally under 12kts. Next upstream system looks weaker with increasing mid/high level clouds through end of the period. With saturation possibly late in the period...held off with any mention of precipitation which is most likely at the south sites and aft 06z. /rev

&&

.DMX WATCHES/WARNINGS/ADVISORIES...
NONE.
&&

$$

8.0 NWS Zone Forecast Product

The NWS Office in Des Moines, Iowa, issued the following zone forecast product (ZFP), which included forecast for the accident site. The latest forecast valid at the accident time was issued at 2354 CST on March 9 and it indicated mostly clear skies, breezy conditions with a north wind of 15 to 20 mph and gusts to 30 mph, with low temperatures of +5 to +10° F. The ZFP valid before the 2354 CST March 9 ZFP was issued at 2324 CST on March 9. The 2324 CST March 9 ZFP indicated similar conditions to the 2354 CST March 9 ZFP. ZFP's valid from 1809 CST on March 9 through the accident time are included below:

IAZ015-101000-
Palo Alto-
Including the city of Emmetsburg
1154 PM CST Thu Mar 9 2017

.REST OF TONIGHT...Mostly clear. Breezy, colder. Low 5 to 10 above. North wind 15 to 20 mph with gusts to around 30 mph.
.FRIDAY...Mostly sunny in the morning then becoming mostly cloudy. Colder. High in the lower 20s. North wind 5 to 15 mph.
.FRIDAY NIGHT...Cloudy. A chance of light snow through midnight, then light snow likely after midnight. Snow accumulation around 1 inch. Low 10 to 15. Northeast wind 5 to 10 mph. Chance of snow 70 percent.
.SATURDAY...Cloudy with a 40 percent chance of light snow. High in the mid 20s. Northeast wind 5 to 10 mph.
.SATURDAY NIGHT...Mostly cloudy. Low around 15. Northeast wind 5 to 10 mph.
.SUNDAY...Cloudy. A chance of light snow in the morning, then snow in the afternoon. Light snow accumulations possible. High in the upper 20s. Chance of snow 80 percent.
.SUNDAY NIGHT...Light snow. Low around 20. Chance of snow 80 percent.
.MONDAY...Cloudy. A 30 percent chance of light snow in the morning. High in the mid 20s.
.MONDAY NIGHT...Mostly cloudy. Colder. Low 5 to 10 above.
.TUESDAY...Partly sunny. High in the upper 20s.
.TUESDAY NIGHT...Mostly cloudy with a 30 percent chance of light snow. Low around 15.
.WEDNESDAY...Partly sunny. A 20 percent chance of light rain and snow in the afternoon. High in the mid 30s.
.WEDNESDAY NIGHT...Mostly cloudy. A 20 percent chance of light snow through midnight. Not as cold. Low in the mid 20s.
.THURSDAY...Partly sunny. High in the lower 40s.

$$

IAZ015-101000-
Palo Alto-
Including the city of Emmetsburg
1124 PM CST Thu Mar 9 2017

.REST OF TONIGHT...Mostly clear. Breezy, colder. Low 5 to 10 above. North wind 15 to 20 mph.
.FRIDAY...Mostly sunny in the morning then becoming mostly cloudy. Colder. High in the lower 20s. North wind 5 to 15 mph.
.FRIDAY NIGHT...Cloudy. A chance of light snow through midnight, then light snow likely after midnight. Snow accumulation around 1 inch. Low 10 to 15. Northeast wind 5 to 10 mph. Chance of snow 70 percent.
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.WEDNESDAY NIGHT...Mostly cloudy. A 20 percent chance of light snow through midnight. Not as cold. Low in the mid 20s.
.THURSDAY...Partly sunny. High in the lower 40s.

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IAZ015-101000-
Palo Alto-
Including the city of Emmetsburg
1010 PM CST Thu Mar 9 2017

.REST OF TONIGHT...Mostly clear. Breezy, colder. Low 5 to 10 above. North wind 15 to 20 mph.
.FRIDAY...Mostly sunny in the morning then becoming mostly cloudy. Colder. High in the lower 20s. North wind 5 to 15 mph.
.FRIDAY NIGHT...Cloudy. A chance of light snow through midnight, then light snow likely after midnight. Snow accumulation around 1 inch. Low 10 to 15. Northeast wind 5 to 10 mph. Chance of snow 70 percent.
.SATURDAY...Cloudy with a 40 percent chance of light snow. High in the mid 20s. Northeast wind 5 to 10 mph.
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.MONDAY...Cloudy. A 30 percent chance of light snow in the morning. High in the mid 20s.
.MONDAY NIGHT...Mostly cloudy. Colder. Low 5 to 10 above.
.TUESDAY...Partly sunny. High in the upper 20s.
.TUESDAY NIGHT...Mostly cloudy with a 30 percent chance of light snow. Low around 15.
.WEDNESDAY...Partly sunny. A 20 percent chance of light rain and snow in the afternoon. High in the mid 30s.
.WEDNESDAY NIGHT...Mostly cloudy. A 20 percent chance of light snow through midnight. Not as cold. Low in the mid 20s.
.THURSDAY...Partly sunny. High in the lower 40s.

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IAZ015-101000-
Palo Alto-
Including the city of Emmetsburg
853 PM CST Thu Mar 9 2017

.REST OF TONIGHT...Mostly cloudy in the evening then clearing. Breezy, colder. Low 5 to 10 above. North wind 15 to 20 mph with gusts to around 30 mph.
.FRIDAY...Mostly sunny in the morning then becoming mostly cloudy. Colder. High in the lower 20s. North wind 5 to 15 mph.
.FRIDAY NIGHT...Cloudy. A chance of light snow through midnight, then light snow likely after midnight. Snow accumulation around 1 inch. Low 10 to 15. Northeast wind 5 to 10 mph. Chance of snow 70 percent.
.SATURDAY...Cloudy with a 40 percent chance of light snow. High in the mid 20s. Northeast wind 5 to 10 mph.
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.TUESDAY NIGHT...Mostly cloudy with a 30 percent chance of light snow. Low around 15.
.WEDNESDAY...Partly sunny. A 20 percent chance of light rain and snow in the afternoon. High in the mid 30s.
.WEDNESDAY NIGHT...Mostly cloudy. A 20 percent chance of light snow through midnight. Not as cold. Low in the mid 20s.
.THURSDAY...Partly sunny. High in the lower 40s.

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IAZ015-101000-
Palo Alto-
Including the city of Emmetsburg
609 PM CST Thu Mar 9 2017

.TONIGHT...Mostly cloudy in the evening then clearing. Breezy, colder. Low 5 to 10 above. North wind 15 to 20 mph with gusts to around 30 mph.
.FRIDAY...Mostly sunny in the morning then becoming mostly cloudy. Colder. High in the lower 20s. North wind 5 to 15 mph.
.FRIDAY NIGHT...Cloudy. A chance of light snow through midnight, then light snow likely after midnight. Snow accumulation around 1 inch. Low 10 to 15. Northeast wind 5 to 10 mph. Chance of snow 70 percent.
.SATURDAY...Cloudy with a 40 percent chance of light snow. High in the mid 20s. Northeast wind 5 to 10 mph.
.SATURDAY NIGHT...Mostly cloudy. Low around 15. Northeast wind 5 to 10 mph.
.SUNDAY...Cloudy. A chance of light snow in the morning, then snow in the afternoon. Light snow accumulations possible. High in the upper 20s. Chance of snow 80 percent.
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.WEDNESDAY...Partly sunny. A 20 percent chance of light rain and snow in the afternoon. High in the mid 30s.
.WEDNESDAY NIGHT...Mostly cloudy. A 20 percent chance of light snow through midnight. Not as cold. Low in the mid 20s.
.THURSDAY...Partly sunny. High in the lower 40s.

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9.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on March 10, 2017, indicated the following:

SUN	
Begin civil twilight	0611 CST
Sunrise	0639 CST
Sun transit	1229 CST
Sunset	1820 CST
End civil twilight	1848 CST

MOON	
Moonset	0538 CST
Moonrise	1631 CST
Moon transit	2326 CST
Moonset	0613 CST on following day

The phase of the Moon was Waxing Gibbous with 96% of the Moon's visible disk illuminated. Moonlight was likely illuminating the accident site at the accident time.

10.0 Iowa Climate Data

A summary of recent climate data from KEST and Iowa was gathered with temperature, precipitation, and snowfall values all measured against the recent climate record (data gathered via Midwestern Regional Climate Center). The daily maximum temperature, minimum temperature, and precipitation amount from KEST from January 1, 2017, through March 11, 2017, are provided in figure 11 with 5 days of precipitation observed during that timeframe. The mean temperature for the December, January, February (meteorological winter) from KEST for each of the past 22 years was plotted in figure 12 with the winter of 2016 through 2017 timeframe being warmer than average. While the mean winter temperature of 2016/2017 for KEST was above average, it remained 3.0° F below the record warmest winter (for the 22 year period measured) of 2001/2002 (figure 12). For the period of January 1, 2017, through March 11, 2017, the accumulated snowfall (figure 13) and accumulated precipitation amounts (figure 14) were near normal to 100 percent greater than the 30 year climatological mean. Figure 15 indicates that between 15 and 25 inches of snow fell in the accident area between January 1, 2017, through March 11, 2017. Figure 16 indicates that between 3 and 4 inches of precipitation fell in the accident area between January 1, 2017, through March 11, 2017.

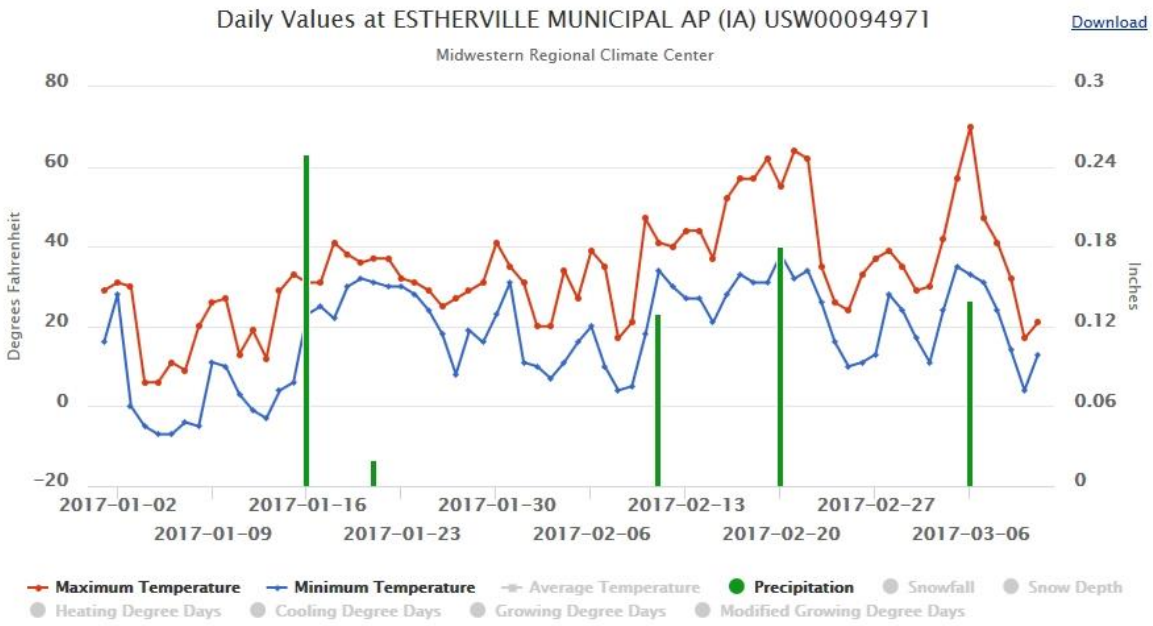

Figure 11 – Daily values of maximum temperature, minimum temperature, and precipitation for KEST from January 1, 2017, through March 11, 2017

Ranking of Winter (Dec to Feb) Mean Temperature from 1996 to 2017
ESTHERVILLE MUNICIPAL AP (IA)
USW00094971

Year	Value	Standard	Dense	Ordinal	Days Missing
2013-2014	11.0	1	1	1	0
2009-2010	11.7	2	2	2	0
2000-2001	12.2	3	3	3	1
2007-2008	13.6	4	4	4	0
1996-1997	14.1	5	5	5	3
2010-2011	14.3	6	6	6	4
2008-2009	14.7	7	7	7	1
2003-2004	18.5	8	8	8	0
2014-2015	18.8	9	9	9	0
2006-2007	19.4	10	10	10	2
2002-2003	19.7	11	11	11	0
2012-2013	20.0	12	12	12	0
2005-2006	21.5	13	13	13	0
2015-2016	21.8	14	14	14	0
1999-2000	22.9	15	15	15	0
*2016-2017	23.2	16	16	16	0
1998-1999	23.6	17	17	17	0
2011-2012	25.0	18	18	18	1
1997-1998	25.7	19	19	19	0
2001-2002	26.2	20	20	20	2

22 years total
20 years ranked
2 years missing: 2004-2005, 2017-2018

* current year
T = Trace

Midwestern Regional Climate Center
cli-MATE: MRCC Application Tools Environment
Generated at: 5/24/2017 1:17:02 PM CDT

Figure 12 – Last 22 year ranking values of mean temperature from KEST for the combined winter months of December, January, and February

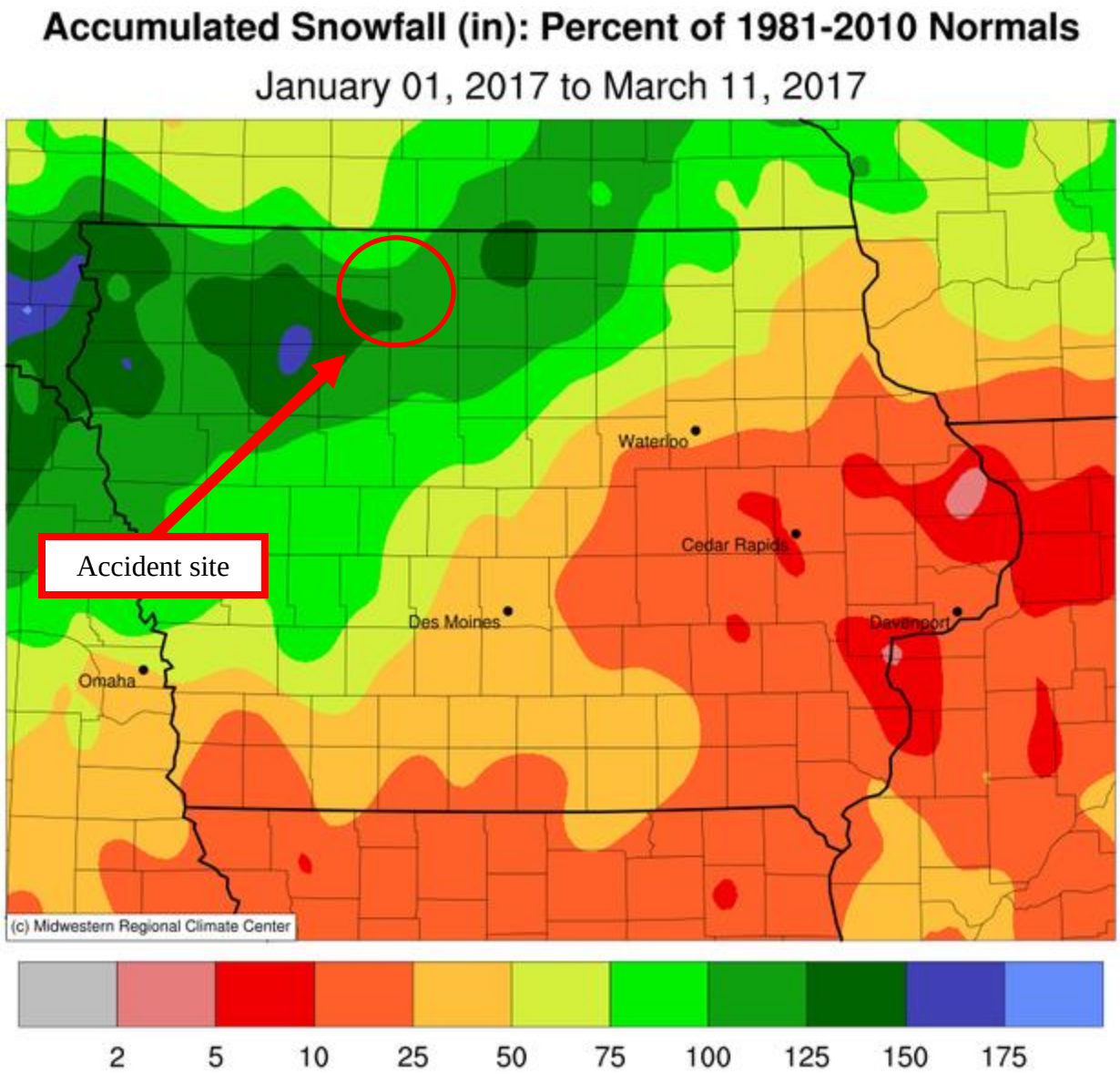

Figure 13 – Percent of mean of the accumulated snowfall for Iowa from January 1, 2017, through March 11, 2017

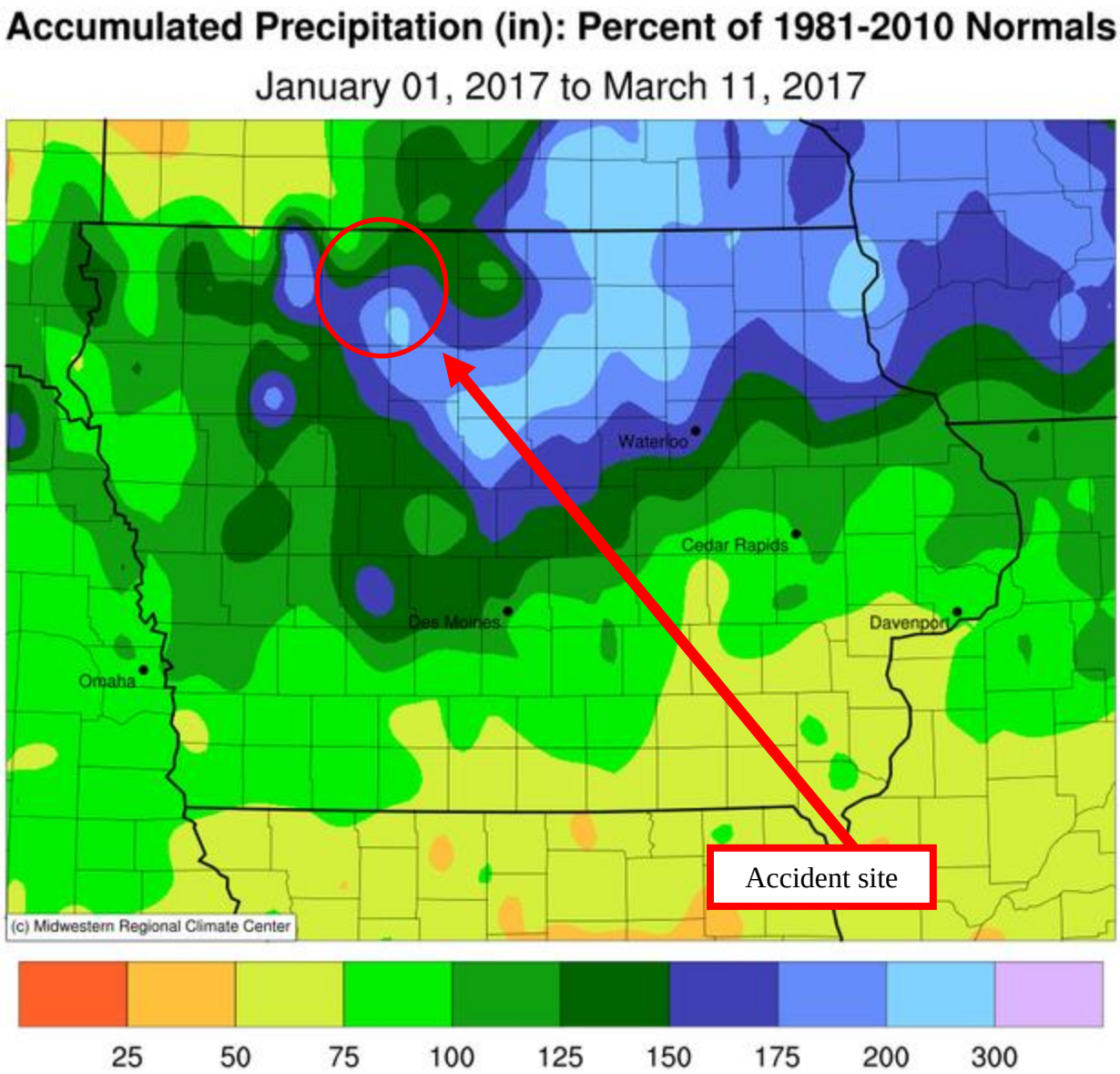

Figure 14 – Percent of mean of the accumulated precipitation for Iowa from January 1, 2017, through March 11, 2017

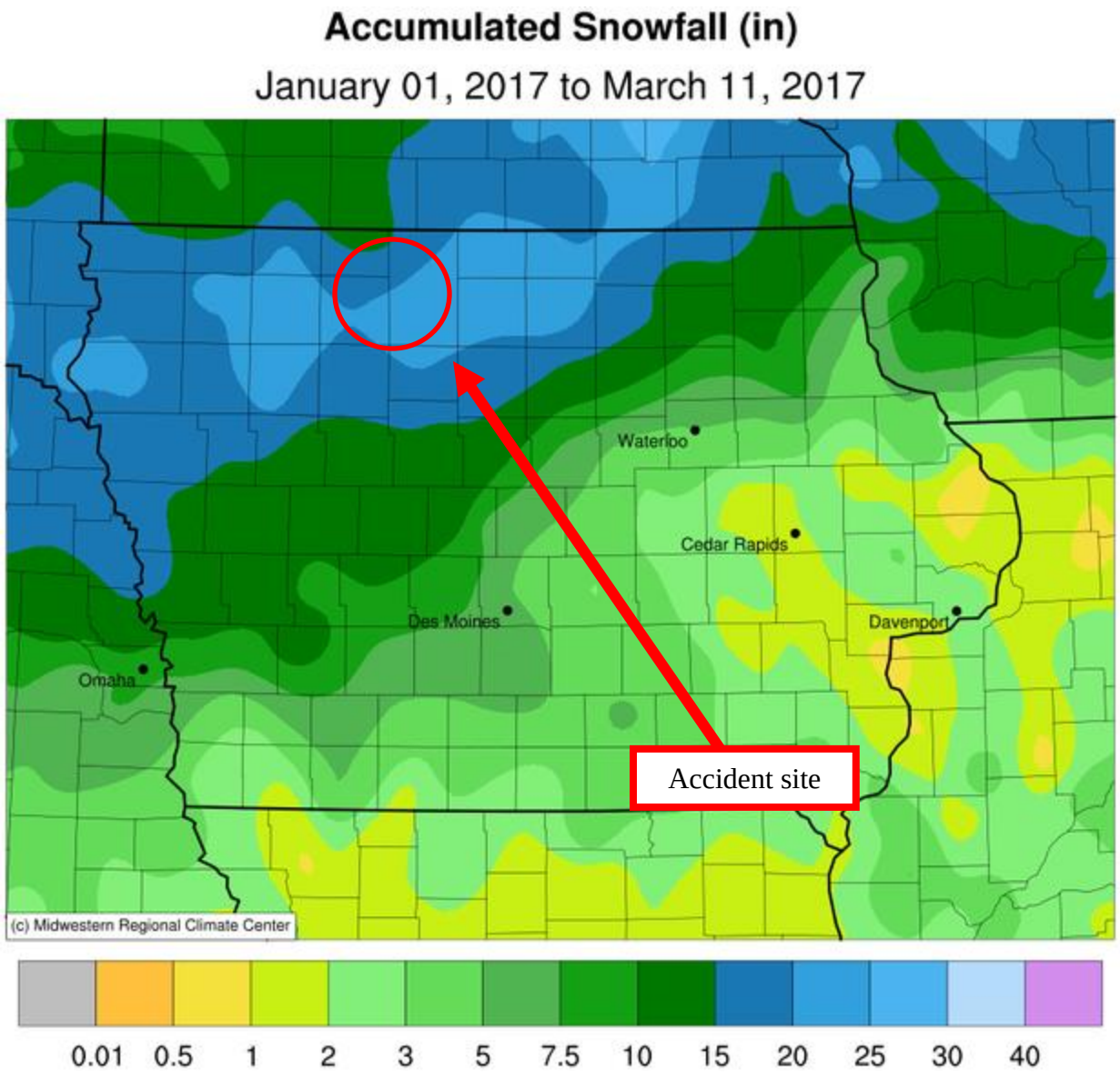

Figure 15 –Accumulated snowfall for Iowa from January 1, 2017, through March 11, 2017

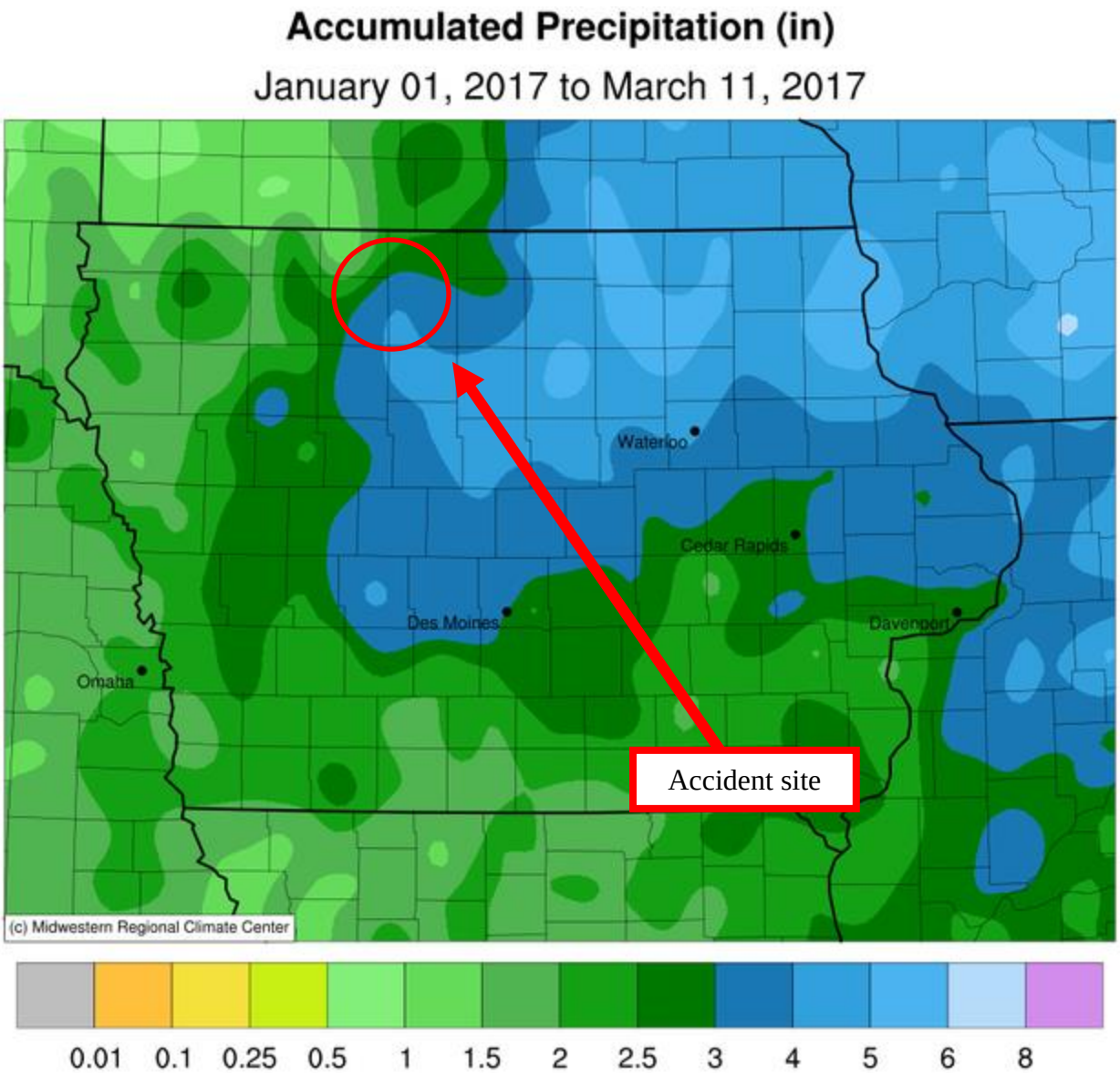

Figure 16 –Accumulated precipitation for Iowa from January 1, 2017, through March 11, 2017

E. LIST OF ATTACHMENTS

None.

Submitted by:

_____

Paul Suffern
Senior Meteorologist

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