NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

July 3, 2017

Group Chairman's Factual Report

METEOROLOGY

DCA16SH002

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A. ACCIDENT

Location:	New Martinsville, West Virginia
Date:	August 27, 2016
Time:	0800 eastern daylight time (1200 UTC[1])
Event:	Ruptured rail tank car and Chlorine gas leak

B. METEOROLOGY GROUP

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C. SUMMARY

On August 27, 2016, about 8:26 a.m., Eastern Daylight Time, a specification DOT 105J500W tank car, AXLX 1702, experienced a sudden shell crack shortly after being filled with liquefied compressed chlorine at the Axiall Corporation rail car loading facility in New Martinsville, West Virginia. The accident occurred on Axiall plant property adjacent to the tank car loading shed on Track 9. The tank car had not been offered into transportation at the time of the occurrence. Over a 2 ½ hour period, the entire 90-ton load of chlorine released from the crack and formed a large vapor cloud that migrated south from the Axiall facility along the Ohio River valley.

Chlorine presents a toxic inhalation hazard and may be fatal if inhaled or absorbed through the skin. After the release, 5 Axiall Corporation and 3 contractor employees were treated for exposure injuries and released, including 2 persons transported offsite to the hospital. Significant vegetation damage occurred downwind from the release. No water contamination was reported.

D. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are eastern daylight time (EDT) based upon the 24 hour clock, local time is +4 hours to UTC, and UTC=Z. 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.

[1] UTC – is an abbreviation for Coordinated Universal Time.

The accident site was located at latitude 39°44’52.35” N and longitude 80°51’13.65” W.

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 (NCEP) located in Camp Springs, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the latest joint NWS and Federal Aviation Administration (FAA) Advisory Circular AC-45 “Aviation Weather Services”.

1.1 Surface Analysis Chart

A portion of the NWS Surface Analysis Chart for 0800 EDT (1200Z) on August 27, 2016 centered over the accident site is included as figure 1 with the approximate accident site marked by a red star. The chart depicted a high pressure system at 1025-hectopascals (hPa) over the New York and Pennsylvania border immediately northeast of the accident site, with a cold front turning to a stationary front stretching across southern Virginia, West Virginia, and Ohio. South of the front another two high pressure systems at 1021-hPa were located over North Carolina. The resultant pressure gradient across the region resulted in light winds of 5 knots or less across West Virginia.

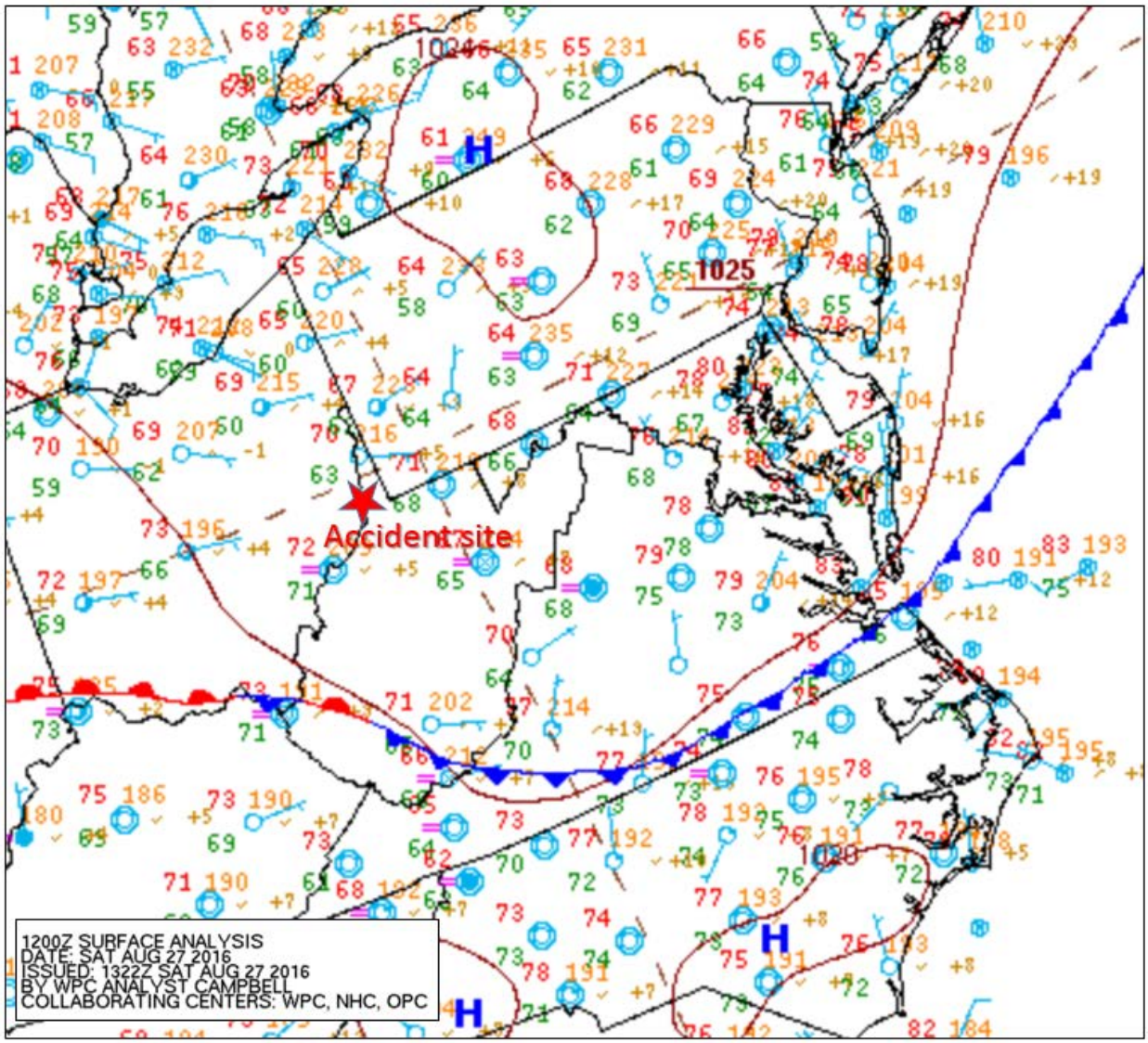

Figure 1 - NWS Surface Analysis Chart for 0800 EDT

The closest station model to the north of the accident site indicated a wind from the east at 5 knots, clear skies, temperature 70° Fahrenheit (F), with a dew point temperature of 63° F. Further southwest and southeast two other stations reported visibility restricted in mist.

A review of the NWS National radar mosaic for the period indicated no meteorological echoes over the region depicted in the map region above. An additional look at the closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D) from Pittsburgh (KPBZ), Pennsylvania also detected no significant meteorological echoes over the area surrounding the period.

2.0 Surface Observations

The official NWS Meteorological Aerodrome Reports (METARs) and special reports (SPECIs) and Remote Automated Weather Stations (RAWS) sites surrounding the period were documented for the area. The cloud heights are reported above ground level (agl).

2.1 OH035 RAWS – Hannibal, Ohio

The closest reporting station to the accident site was from an Ohio Department of Transportation RAWS site identified as OH035 (35-SR7) located at latitude 39.65839° N and longitude 80.86969° W, or approximately 5 1/2 miles south of the accident site near Hannibal, in Monroe County, Ohio near the intersection of the Ohio-River Scenic Byway Route 7 and the New Martinsville Bridge that spans over the Ohio River, with the sensor elevation of 1,181 feet.

The observation at 0805 EDT reported a wind from the north at 1 mile per hour (MPH), visibility 1 ¼ miles in mist, temperature 72° F, dew point temperature 67° F, with a relative humidity of 83%, and the road condition as dry.

A 24-hour plot of wind speed and direction from 2100 EDT on August 26 through 2100 EDT on August 27, 2016 is included as figure 2. The plot shows winds were generally less than 3 mph with a maximum wind gust of 6 mph from the northwest during the period after the Chlorine leak.

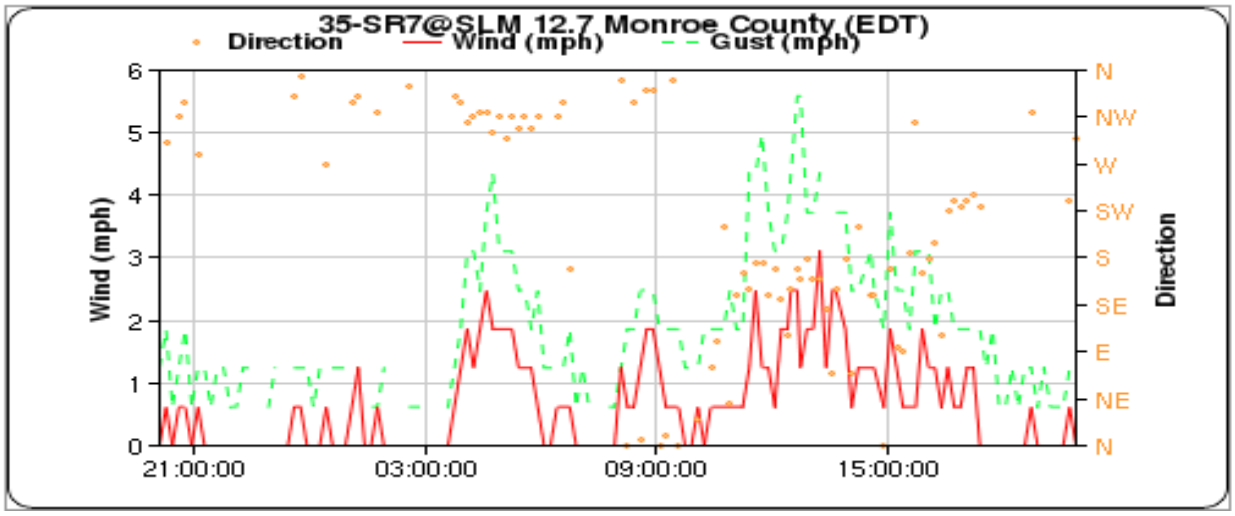

Figure 2 – OH35 Hannibal plot of wind

2.2 OH050 RAWS – Riverview, Ohio

Another Ohio Department of Transportation RAWS site identified as OH050 (58-IR470) was located at latitude 40.04843° N and longitude 80.73708° W or approximately 19 ½ miles north-northeast from the accident site located on entrance ramp from Route 7 and the Interstate Highway 470, in Riverview, Ohio with the sensors at an elevation of 737 feet.

RAWS site OH050 reported at 0755 EDT wind from the southwest at 0.6 mph, visibility 1 ¼ in mist, temperature 70° F, dew point temperature 67.5° F, with a relative humidity of 92% with the pavement indicator as dry conditions.

2.3 Wheeling Ohio County Airport, Wheeling, West Virginia

The next closest reporting location was from Wheeling Ohio County Airport (KHLG), located approximately 27 miles north-northeast of the accident site at an elevation of 1,194 feet, and a reported magnetic variation of 7° W. The airport had an Automated Surface Observation System (ASOS) and reported the following conditions at the approximate time of the accident.

Wheeling Ohio County Airport weather at 0800 EDT, wind from east or from 110° at 3 knots (3 ½ mph), visibility unrestricted at 10 miles, sky clear below 12,000 feet agl, temperature 70° F, dew point temperature 63° F, altimeter 30.19 inches of mercury (Hg).

The observations in table format from the time of the accident until midnight local were as follows:

ID	TIME (EDT)	T (°F)	TD (°F)	RH (%)	DIR	SPD (KT)	GST	ALT ("Hg)	SLP (hPa)	VIS (SM)	CIG	COV	WX	MAX (°F)	MIN (°F)
KHLG	0753	70	63	78	110	3		30.19	1021.6	10		CLR		72	68
KHLG	0853	73	63	71	100	5		30.19	1021.5	10		CLR			
KHLG	0953	76	65	69	100	5		30.20	1021.7	10		CLR			
KHLG	1053	81	68	65	140	3		30.19	1021.7	10		CLR			
KHLG	1153	84	69	61	140	6		30.18	1021.1	10		CLR			
KHLG	1253	86	68	55	0	3		30.18	1021.0	10		CLR			
KHLG	1353	87	68	53	0	4		30.17	1020.7	10		CLR		87	70
KHLG	1453	88	68	52	0	0		30.15	1020.0	10		CLR			
KHLG	1553	90	69	50	0	4		30.14	1019.6	10		CLR			
KHLG	1653	91	70	50	240	3		30.13	1019.4	10		CLR			
KHLG	1753	89	68	50	110	4		30.14	1019.8	10	49	FEW			
KHLG	1853	88	70	55	100	4		30.13	1019.6	10		CLR			
KHLG	1953	86	68	55	40	3		30.15	1020.0	10		CLR		91	86
KHLG	2053	82	70	67	70	7		30.16	1020.6	10		CLR			
KHLG	2153	77	70	79	100	6		30.16	1020.6	10		CLR			
KHLG	2253	80	69	69	100	3		30.16	1020.6	10		CLR			
KHLG	2353	77	70	79	0	0		30.17	1020.6	10		CLR			
KHLG	0053	76	70	82	0	0		30.17	1020.7	10		CLR		91	68

2.4 Mid-Ohio Valley Regional Airport, Parkersburg, West Virginia

The next closest weather reporting location was from Mid-Ohio Valley Regional Airport (KPKB) located approximately 38 miles west-southwest of the accident site in Parkersburg, West Virginia, at an elevation of 859 feet. The airport had an ASOS and reported the following conditions at the time of the accident.

Mid-Ohio Valley Regional Airport weather at 0753 EDT, wind calm, visibility 5 miles in mist, sky clear below 12,000 feet agl, temperature 72° F, dew point 71° F, altimeter 30.18 inches of Hg.

The observations in table format from 0553 through 0053 EDT on August 28, 2016 were as follows:

ID	TIME (EDT)	T (°F)	TD (°F)	RH (%)	DIR	SPD (KT)	GST	ALT (“Hg)	SLP (hPa)	VIS (SM)	CIG	COV	WX	MAX (°F)	MIN (°F)
KPKB	0553	72	70	93	0	0		30.17	1020.5	6		CLR	BR		
KPKB	0600	71	70	96	0	0		30.17		5	2	SCT	BR		
KPKB	0608	71	69	93	0	0		30.17		6	2	BKN	BR		
KPKB	0653	70	69	97	0	0		30.17	1020.7	0.5	1	X	F		
KPKB	0709	71	69	93	0	0		30.17		0.5	2	X	F		
KPKB	0746	72	70	93	80	3		30.17		3		CLR	BR		
KPKB	0753	72	71	97	0	0		30.18	1020.9	5		CLR	BR	73	70
KPKB	0853	75	72	90	0	0		30.18	1021.0	6		CLR	BR		
KPKB	0953	81	72	74	90	5		30.19	1021.4	10		CLR			
KPKB	1053	86	71	61	0	3		30.19	1021.3	10		CLR			
KPKB	1153	89	68	50	110	7		30.17	1020.8	10		CLR			
KPKB	1253	91	68	47	160	7		30.16	1020.4	10		CLR			
KPKB	1353	92	67	44	150	7		30.15	1020.0	10		CLR		93	72
KPKB	1453	93	67	43	0	5		30.13	1019.3	10	55	FEW			
KPKB	1553	94	67	41	0	5		30.12	1019.0	10	60	SCT			
KPKB	1653	95	67	40	260	7		30.11	1018.7	10		CLR			
KPKB	1753	94	67	41	180	6		30.12	1018.9	10		CLR			
KPKB	1853	93	66	41	200	3		30.12	1019.1	10		CLR			
KPKB	1953	88	69	54	0	0		30.13	1019.4	10		CLR		96	87
KPKB	2053	81	71	72	0	0		30.14	1019.9	10		CLR			
KPKB	2153	79	71	77	0	0		30.17	1020.8	10		CLR			
KPKB	2253	77	71	82	0	0		30.17	1020.8	10		CLR			
KPKB	2353	76	71	85	170	4		30.18	1020.9	10		CLR			
KPKB	0053	74	70	87	0	0		30.17	1020.8	10		CLR		96	70

Notes: Weather type: Mist (BR) and Fog (F)

2.5 Mesowest Observations

A plot of the NWS and other RAWS observation of wind and temperature across the tristate area surrounding the accident site for 0815 EDT are include in figure 3, and include the observation sites noted above. All the observations surrounding the area all reported calm to light north to east winds of 5 mph or less.

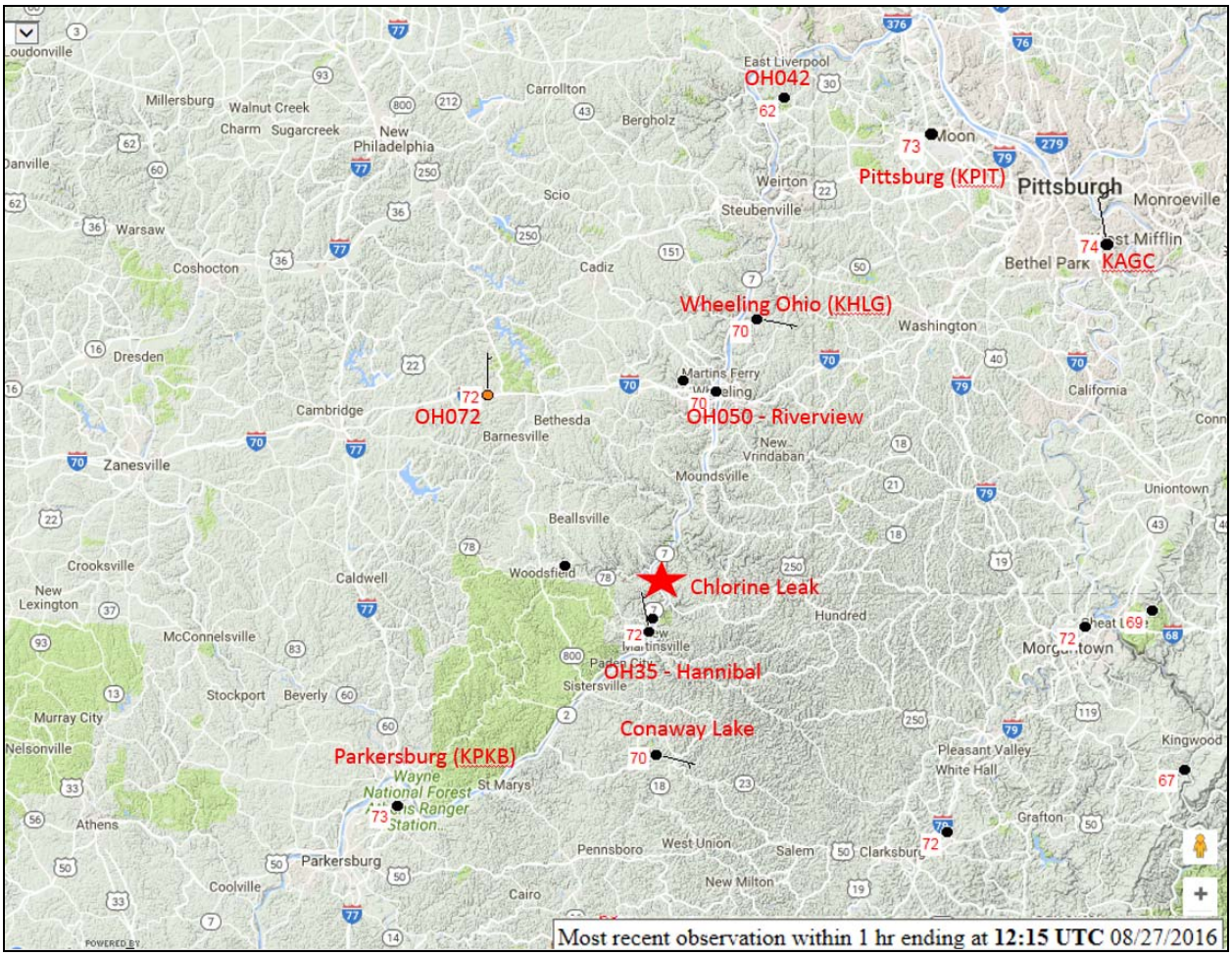

Figure 3 - Mesowest Plot of observations at 0815 EDT

3.0 Upper Air Data

The closest upper air sounding or rawinsonde observation (RAOB) to the accident site was documented to provide the observed upper level wind and for a vertical structure of the atmosphere at the time. In addition, a mesoscale numerical model was also run for the period over the accident site to provide a best guess forecast sounding. Both are documented in this section.

3.1 Pittsburgh Sounding

The closest NWS upper air sounding was from Pittsburgh (KPIT) Forecast Office, Pennsylvania, site number 72520, location approximately 53 miles north-northeast from the accident site at an elevation of 1,224 feet. The 0800 EDT (1200Z) sounding on August 27, 2016 was plotted on a standard Skew-T log P diagram[2] from the surface to 500-hPa or 18,000 feet utilizing RAOB software[3], and is included as figure 4.

[2] Skew T Log P diagram – is a standard meteorological plot or thermodynamic diagram 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.

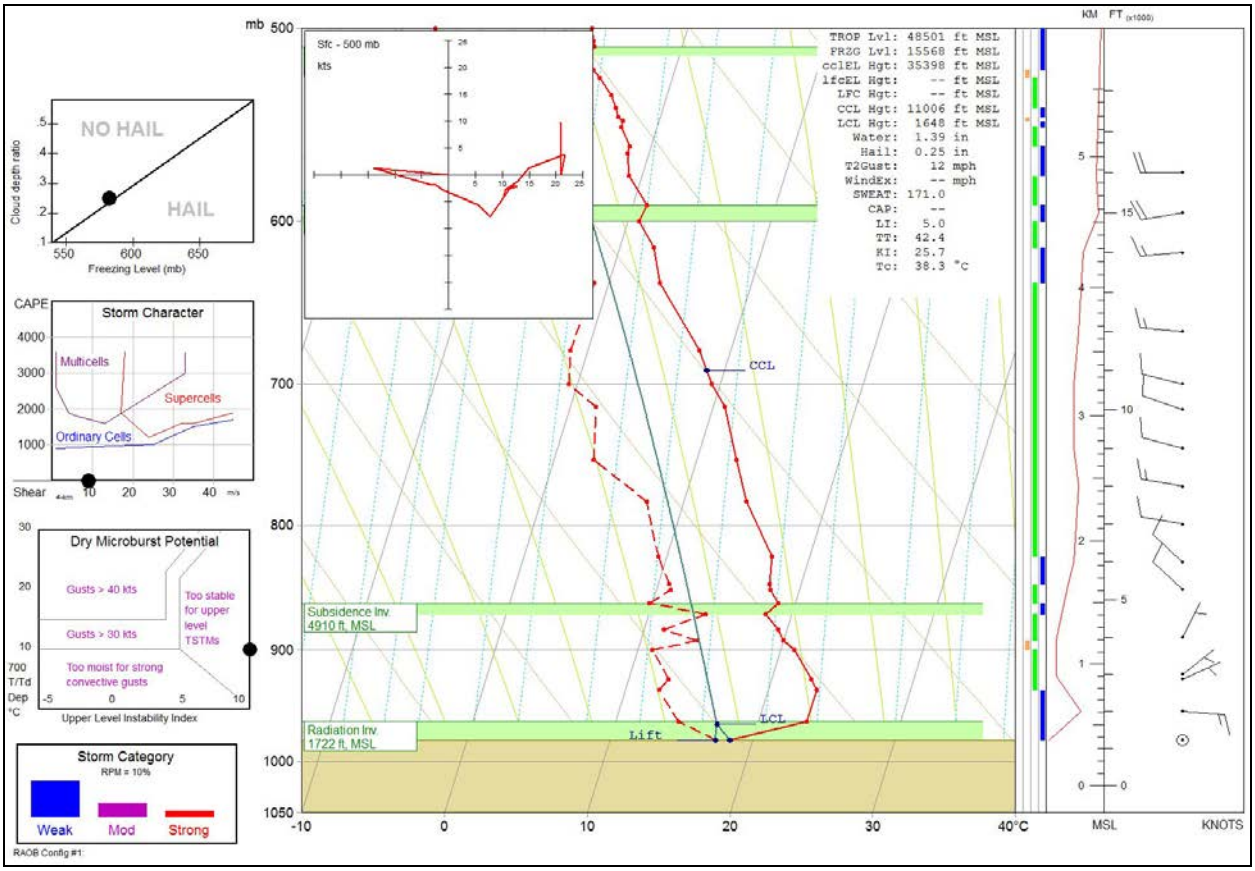

Figure 4 - Pittsburgh 0800 EDT sounding

The sounding reported a calm wind at the surface with a temperature of 65° F, a dew point temperature of 63° F, with a relative humidity of 94%. The vertical plot of temperature depicted a surface based temperature inversion due to radiational cooling to 498 feet agl (or 1,722 feet msl), where temperature increased with height and acted as a lid or stable layer restricting vertical motion. A second inversion was noted at 4,910 feet further restricting vertical motion, and another inversion at 15,188 feet. The resultant stability or Lifted Index (LI)[4] was 5.0, which characterized a stable atmosphere. The lifted condensation level (LCL)[5] was identified at 424 feet agl, and the convective condensation level (CCL)[6] at 9,780 feet agl.

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

[4] Lifted Index (LI) - A common measure of atmospheric instability. Its value is obtained by computing the temperature that air near the ground would have if it were lifted to 500-hPa or approximately 18,000 feet and comparing that temperature to the actual temperature at that level. Negative values indicate instability - the more negative, the more unstable the air is, and the stronger the updrafts are likely to be with any developing thunderstorms.

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

The sounding wind profile indicated a calm surface wind with wind increasing to 14 knots at 236 feet agl from the east, and decreasing in speed and backing to the northeast and north through 5,000 feet and then to the west with increasing height. The mean 0 to 6 kilometer or 18,000 feet winds were from 265° at 14 knots. A plot of the wind direction and speed is provided in the top left portion of the diagram as a hodograph, which would approximate a rising plume if not for the restricting temperature inversions, which restricted rising motion.

3.2 Numerical Model Sounding

The NOAA Air Resource Laboratory (ARL) archive data was accessed and the Global Data Assimilation System (GDAS) global numerical mesoscale model plotted over the accident site for the same period at 0800 EDT (1200Z). The GDAS model had a resolution of 0.5° and is included as figure 5 utilizing the RAOB software. While not an observation, it provided the best estimate of the winds and temperature structure over the accident site.

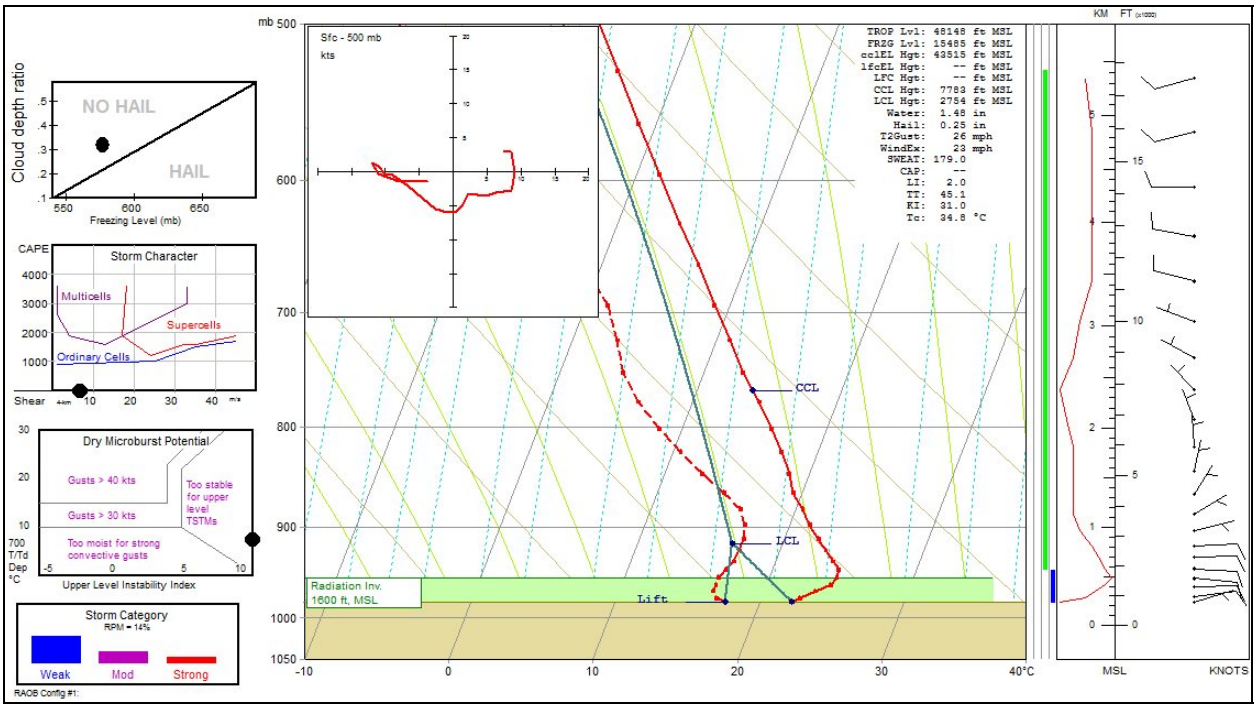

Figure 5 - GDAS numerical model sounding over the accident site at 0800 EDT

The GDAS model depicted similar conditions as the Pittsburgh sounding with a light surface wind from the east or from 070° at 4 knots, with a temperature of 72 F, a dew point of 63 F, and a relative humidity of 75%. A surface based temperature inversion was also indicated to 803 feet agl (1,600 feet msl). The LCL was identified immediately above the inversion at 1,957 feet agl,

[6] Convective Condensation Level (CCL) - The height to which a parcel of air, if heated sufficiently from below, will rise adiabatically until condensation starts. This is typically used to identify the base of cumuliform clouds, which are normally produced from surface heating and thermal convection.

with the LCL at 6,986 feet agl. The wind profile depicted easterly winds at low altitudes backing to the west with height through 10,000 feet.

A plot of the GDAS surface wind or at 30 feet (10 meters) at 0800 EDT centered over the accident site is included as figure 6. The plot shows a general light northeasterly wind flow over the area with wind speeds of 5 knots or less.

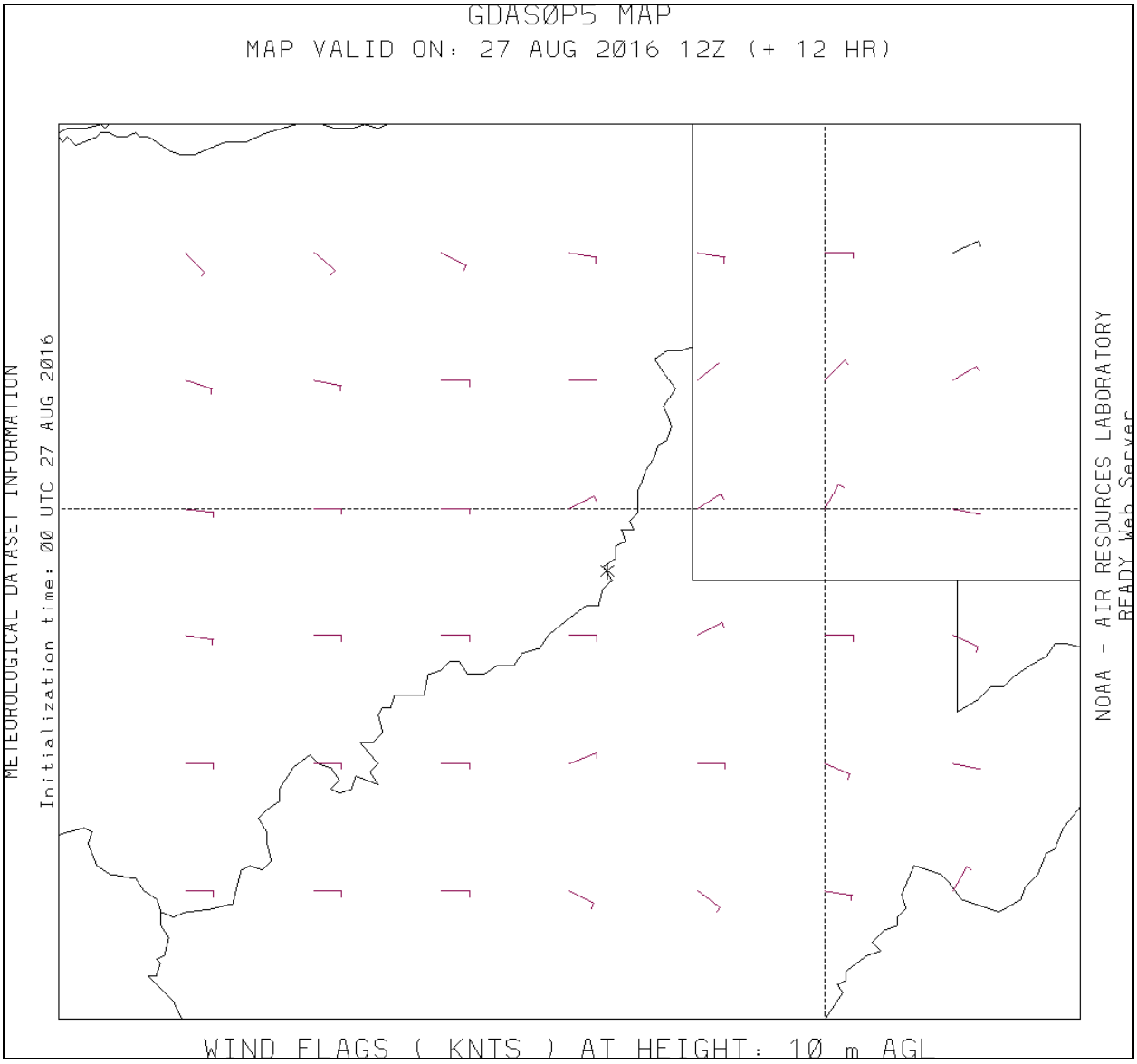

Figure 6 - GDAS surface wind plot for 0800 EDT

4.0 Satellite Data

The Geostationary Operational Environmental Satellite number 13 (GOES-13) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison (UW) in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. Both the infrared long wave and visible

band imagery were obtained surrounding the time of the accident. The infrared long wave imagery (band 4) at a wavelength of 10.7 microns (μm) provided standard satellite image with radiative cloud top temperatures with a resolution of 4 km. The visible imagery (band 1) at a wavelength of 0.65 μm provided a resolution of 1 km.

Figures 7 and 8 are the GOES-13 infrared and visible images for 0815 EDT on August 27, 2016 at 4X magnification and with the accident site marked. No images were available at 0800 EDT for technical reasons. The infrared image also had a standard MB temperature enhancement curve applied to highlight the higher and cooler cloud tops and depicted an area of mid to high altitude clouds extending from Ohio eastward through West Virginia and Pennsylvania, with some low stratiform clouds or fog over the West Virginia and western Virginia regions by the darker gray shading. The radiative cloud top temperature over the accident site was measured at 268° Kelvin or -5.16° Celsius (C), which corresponded to cloud tops near 18,000 feet and related to a layer of altostratus type clouds.

The visible image depicted some low stratiform clouds and/or fog with a mid-level layer of altostratus clouds over the region.

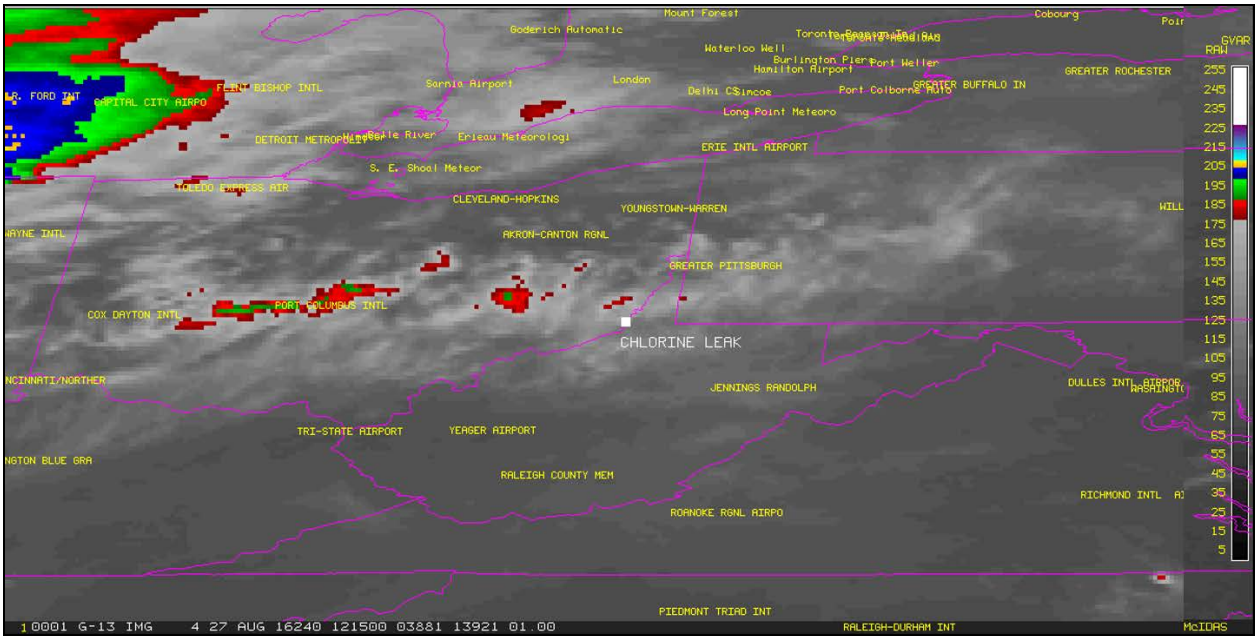

Figure 7 - GOES-13 infrared image at 0815 EDT with MB temperature enhancement curve applied

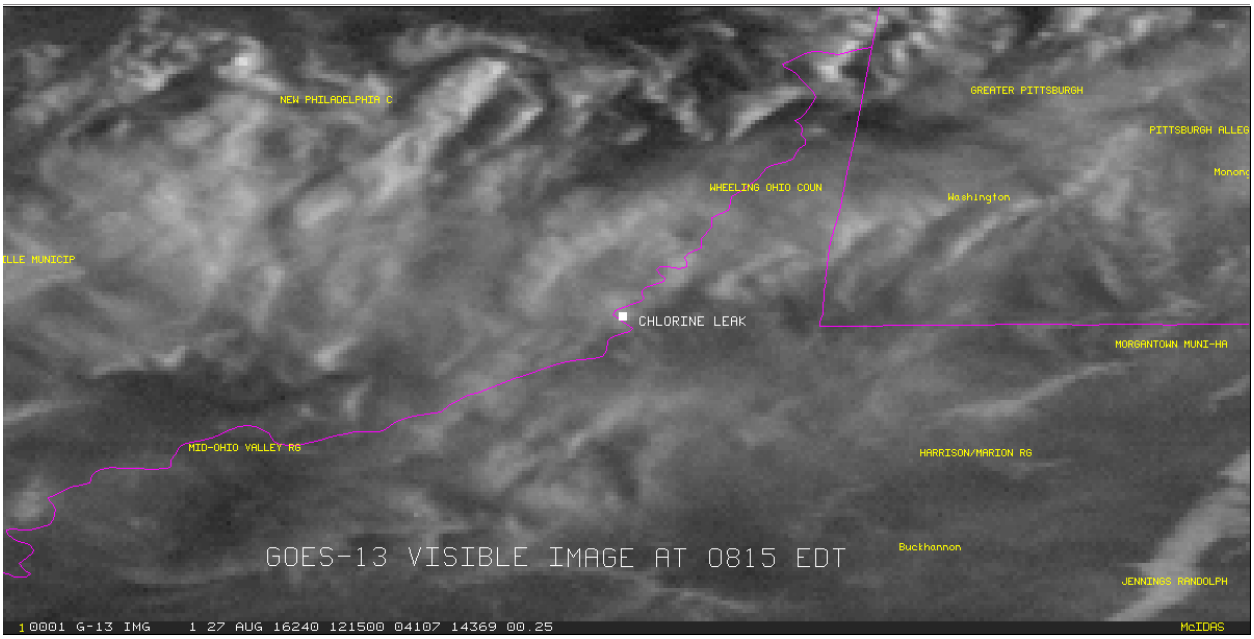

Figure 8 - GOES-13 visible image at 0815 EDT

5.0 Photographic Evidence

Several pictures were taken after the Chlorine gas leak from the Ohio side of the river looking towards the northeast, at a distance of slightly over 1/4 mile or approximately 1,720 feet. Figure 9 and 10 are two of those images which shows the water vapor from one of the cooling tower going upwards nearly vertical with a slight tilt to the south, although not related to the accident. The green to yellowish low cloud was the visible indication of the Chlorine gas leak, which remains close to the ground and slowly propagates to the south. Chlorine has a specific gravity of 2.67, which indicates that is more than 2.5 time heavier than air, and as a result will sink and spread downhill or pool in low lying areas. The stronger the concentration of the chlorine gas the deeper green in appearance the cloud will have. In figure 10, the greenish yellow chlorine gas appears in front of and below the water vapor cloud, which rises and is observed dissipating to the south, with the chlorine remaining at low levels.

Figure 9 - Panoramic view looking northeast from the Ohio side of the river

Figure 10 - Close up of the gas leak from the Ohio side of the river

6.0 Astronomical Data

The United Stated Naval Observatory website provided the following astronomical data for New Martinsville, Wetzel County, West Virginia on August 27, 2016:

SUN	
Beginning of civil twilight	0619 EDT
Sunrise	0647 EDT
Accident time	0800 EDT
Sun transit	1325 EDT
Sunset	2001 EDT
End of civil twilight	2029 EDT

Submitted by:

Donald Eick
NTSB Senior Meteorologist