NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 19, 2021

Weather Study

METEOROLOGY

DCA17FR012

A. ACCIDENT

Location: Upper Darby, Pennsylvania
Date: August 22, 2017
Time: 0011 eastern daylight time
0411 universal coordinated time (UTC)
Rail: SEPTA Light Rail Train Collision

B. METEOROLOGIST

Don Eick
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. SUMMARY

On August 22, 2017, about 12:11 a.m. eastern daylight time, a SEPTA light rail train with a single rail car #155 struck the rear of an unoccupied SEPTA light rail train with single rail car #148 that was stopped at the platform. The rear-end collision occurred on track 1 of the SEPTA Norristown High-Speed Line.

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 National Center for Environmental Information (NCEI). All times are eastern daylight time (EDT) based upon the 24-hour clock on August 22, 2017, local time is +4 hours to UTC, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted.

The accident site was identified at latitude 39.9633° North and longitude 75.2594° West.

E. WEATHER INFORMATION

1.0 Synoptic Conditions

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 located in College Park, 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 addition

of the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H.

1.1 Surface Analysis Chart

The NWS northeast section of the Surface Analysis Chart for 2300 EDT on August 21, 2017 issued immediately prior to the accident is included as figure 1. The chart depicted a high-pressure system at 1023-hectopascals (hPa) off the New Jersey coast with another high-pressure area over South Carolina at 1022-hPa, dominating the mid-Atlantic region. A stationary front was located on the south side of the high pressure area off the North Carolina coast, with another stationary front over Canada well to the north. A weak pressure gradient was noted over the area with calm to light southerly winds. The closest station model for Philadelphia International Airport (KPHL) indicated mostly cloudy skies, a wind from the south at about 5 knots, a temperature of 78° Fahrenheit (F), and a dew point temperature of 73° F. At the time of the chart several station models over northern and western Pennsylvania, West Virginia, and Virginia were reporting visibility restrictions in mist or fog.

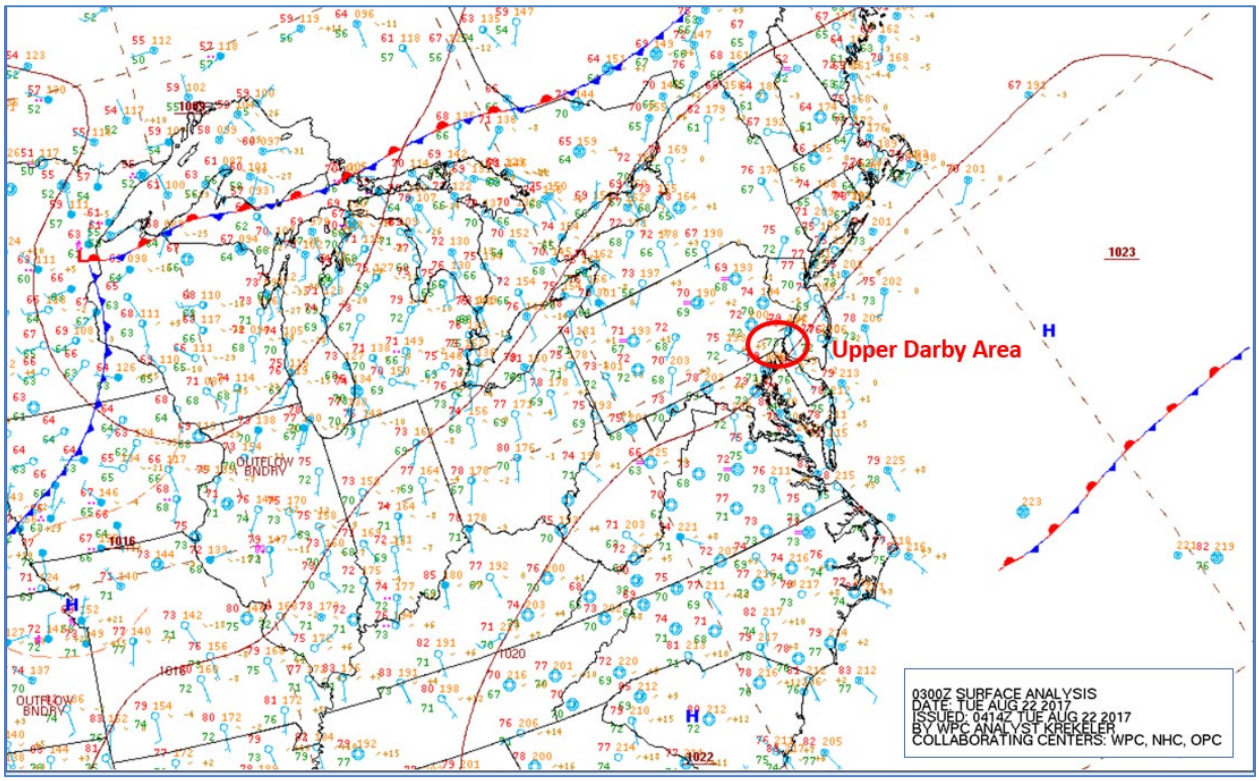

Figure 1 - northeast section of the Surface Analysis Chart for 2300 EDT on August 21, 2017

2.0 Surface Weather Observations

The closest official NWS observation site to the accident site was from Philadelphia International Airport (KPHL), Philadelphia, Pennsylvania, located about 5 1/2 miles south of the accident site at an elevation of 36 feet. The airport had a federally installed and maintained

Automated Surface Observation System (ASOS) and reported the following conditions immediately surrounding the time of the accident:

KPHL observation at 2254 EDT, wind from 190° at 7 knots, visibility 10 miles or more, scattered clouds at 5,500 feet agl[1], ceiling broken at 20,000 feet, temperature 78° F, dew point 73° F, altimeter 30.12 inches of mercury (Hg). Remarks; automated observation system with a precipitation discriminator, lightning distant[2] west and northwest, sea level pressure 1019.7-hPa, occasional lightning-in-cloud distant northwest, cumulonimbus clouds distant northwest moving east.

KPHL observation at 2354 EDT, wind from 240° at 7 knots, visibility 10 miles or more, scattered clouds at 5,000 feet agl, scattered clouds at 10,000 feet, ceiling overcast at 25,000 feet, temperature 78° F, dew point 72° F, altimeter 30.12 inches of Hg. Remarks; automated observation system, sea level pressure 1020.0-hPa.

KPHL special observation at 0003 EDT, wind from 250° at 7 knots, visibility 10 miles or more, ceiling broken at 1,700 feet agl, broken at 10,000 feet, overcast at 20,000 feet, temperature 79° F, dew point 73° F, altimeter 30.12 inches of Hg.

Accident 0011 EDT.

KPHL special observation at 0012 EDT, wind from 220° at 6 knots, visibility 10 miles or more, scattered clouds at 1,700 feet agl, ceiling broken at 2,400 feet, broken at 10,000 feet, and overcast at 25,000 feet, temperature 79° F, dew point 73° F, altimeter 30.12 inches of Hg.

KPHL special observation at 0021 EDT, wind from 210° at 7 knots, visibility 10 miles or more, a few clouds at 1,700 feet agl, scattered clouds at 2,500 feet, ceiling broken at 17,000 feet, and overcast at 25,000 feet, temperature 79° F, dew point 73° F, altimeter 30.12 inches of Hg.

A review of the 24-hour conditions prior to the accident indicated no rain recorded at the KPHL during the period. Thunderstorms were reported in the distance west and northwest of KPHL prior to the accident, which were an interest to this investigation. The relative humidity during the period surrounding the accident was greater than 80%, with the temperature of approximately 79° F.

A table of the observations converted to local time from 24-hours prior to and about 8 hours after the accident are included below. A period of restricted visibility in mist (BR) was reported after the accident between 0400 and 0800 EDT, with visibility lowering to 1 1/2 statute miles.

[1] Cloud heights are reported above ground level (agl).

[2] Distant – refers to more than 10 miles but less than 30 miles from the station.

Philadelphia International Airport Weather Observations

AUG 21, 2017

ID	TIME	T	TD	RH	DIR	SPD	GST	ALT	SLP	VIS	CIL	COV	WX	PR6
KPHL	0054	73	67	81	240	4		019	224	10	250	FEW		
KPHL	0154	72	65	79	210	3		019	223	10	250	FEW		
KPHL	0254	71	66	84	0	0		019	222	10	250	SCT		
KPHL	0354	70	64	81	0	0		019	222	10	250	SCT		
KPHL	0454	69	63	81	0	0		019	222	10	250	BKN		
KPHL	0554	69	64	84	0	0		021	228	10	280	BKN		
KPHL	0654	69	66	90	0	0		021	231	10	280	BKN		
KPHL	0754	72	67	84	200	3		023	234	10	300	BKN		
KPHL	0854	76	65	69	0	0		021	230	10	300	BKN		
KPHL	0954	79	65	62	160	3		021	228	10	300	BKN		
KPHL	1054	82	63	53	190	5		022	232	10	55	BKN		
KPHL	1154	84	65	53	160	5		020	226	10	55	BKN		
KPHL	1254	85	66	53	200	7		018	218	10	280	BKN		
KPHL	1354	86	68	55	180	8		017	215	10	39	BKN		
KPHL	1454	84	67	57	180	9		015	208	10	37	BKN		
KPHL	1554	84	66	55	190	9		015	207	10	37	OVC		
KPHL	1654	84	68	59	180	8		014	206	10	43	BKN		
KPHL	1754	84	69	61	190	7		012	199	10	37	SCT		
KPHL	1854	83	70	65	170	6		012	197	10	250	BKN		
KPHL	1954	81	71	72	180	6		012	198	10	200	OVC		
KPHL	2054	80	72	76	180	6		013	202	10	80	BKN		
KPHL	2154	79	72	79	180	5		013	202	10	250	BKN		
KPHL	2254	78	73	85	190	7		012	197	10	200	BKN		
KPHL	**2354**	**78**	**72**	**82**	**240**	**7**		**012**	**200**	**10**	**250**	**OVC**		

AUG 22, 2017

ID	**TIME**	**T**	**TD**	**RH**	**DIR**	**SPD**	**GST**	**ALT**	**SLP**	**VIS**	**CIL**	**COV**	**WX**	**PR6**
KPHL	**0003**	**79**	**73**	**82**	**250**	**7**		**012**		**10**	**17**	**OVC**		
KPHL	**0012**	**79**	**73**	**82**	**220**	**6**		**012**		**10**	**24**	**OVC**		
Accident 0015 EDT														
KPHL	**0021**	**78**	**73**	**85**	**210**	**7**		**012**		**10**	**170**	**OVC**		
KPHL	0054	78	73	85	200	5		011	196	10	250	OVC		
KPHL	0154	77	73	88	190	6		009	188	10	110	OVC		
KPHL	0254	76	73	91	190	7		007	183	10	250	BKN		
KPHL	0337	76	73	91	190	6		006		10	14	OVC		
KPHL	0354	76	73	91	200	7		006	179	10	14	OVC		
KPHL	0401	76	73	91	190	7		006		8	10	OVC		
KPHL	0408	76	73	91	190	6		006		6	10	OVC	BR	
KPHL	0451	75	73	94	200	7		005		6	90	OVC	BR	
KPHL	0454	75	73	94	200	7		005	175	6	90	OVC	BR	
KPHL	0504	75	73	94	200	5		005		5	190	OVC	BR	
KPHL	0541	75	73	94	190	6		005		4	210	BKN	BR	
KPHL	0551	75	73	94	200	5		005		4	6	BKN	BR	
KPHL	0554	75	73	94	200	5		005	174	4	6	BKN	BR	
KPHL	0608	75	73	94	200	6		005		2.5	6	OVC	BR	
KPHL	0625	75	74	96	210	6		005		1.5	6	OVC	BR	
KPHL	0644	76	74	94	190	7		005		2.5	6	OVC	BR	
KPHL	0654	76	74	94	200	6		005	174	2.5	6	OVC	BR	
KPHL	0720	76	74	94	200	7		005		3	6	OVC	BR	
KPHL	0754	77	74	90	210	7		005	174	4	6	OVC	BR	
KPHL	0804	77	74	90	210	6		005		4	7	OVC	BR	

3.0 Weather Radar Imagery

The closest Weather Surveillance Radar 1988 Doppler (WSR-88D) was from Philadelphia NWS forecast office located in Mount Holly, New Jersey, with the antenna located at Fort Dix (KDIX) located about 39 miles east of the accident site. The Level II and III weather radar files immediately surrounding the time of the accident were downloaded from NCEI website and displayed utilizing the NWS Weather and Climate Toolkit software.

The WSR-88D is a S-band 10-centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width.

3.1 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeor, 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 (dBZ[3]) and is a general measure of echo intensity. The chart below relates the NWS video integrator and processor (VIP) intensity levels versus the WSR-88D's display levels, precipitation mode reflectivity in decibels, and rainfall rates.

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LEVEL	PREC MODE DBZ	RAINFALL
0	0 1 2	< 5 5 to 9 10 to 14	
1 Very Light	3 4 5	15 to 19 20 to 24 25 to 29	.01 in/hr .02 in/hr .04 in/hr
2 Light to Moderate	6 7	30 to 34 35 to 39	.09 in/hr .21 in/hr
3 Strong	8	40 to 44	.48 in/hr
4 Very Strong	9	45 to 49	1.10 in/hr
5 Intense	10	50 to 54	2.49 in/hr
6 Extreme	11 12 13 14 15	55 to 59 60 to 64 65 to 69 70 to 74 > 75	>5.67 in/hr

The general terminology used to describe the intensity of the precipitation is referenced in Advisory Circular AC00-24C – "Thunderstorms" is as follows:

[3] dBZ – 10 Log Ze

Reflectivity (dBZ) Ranges	Weather Radar Echo Intensity Terminology
< 30 dBZ	Light
30 – 40 dBZ	Moderate
>40 – 50 dBZ	Heavy
>50 dBZ	Extreme

3.2 Base reflectivity Images

The KDIX WSR-88D base reflectivity image at 2254 EDT on August 21, 2017 that correlated to the observation from KPHL reporting lightning in the distance west and northwest, with cumulonimbus clouds northwest moving east at 10 to 15 knots is included as figure 2. The image depicted a west-to-east band of echoes across southern Pennsylvania, immediately west of the accident site. The SEPTA light rail track is overlaid in white along with the weather reporting locations. The echo tops were in the range of 30,000 to 32,000 feet, with the 2nd main cell west of the SEPTA tracks with the cell immediately northeast of the station identified as "40N" or Chester County Airport, Coatesville, PA, was observed to produce multiple cloud-to-ground lightning strikes at the time.

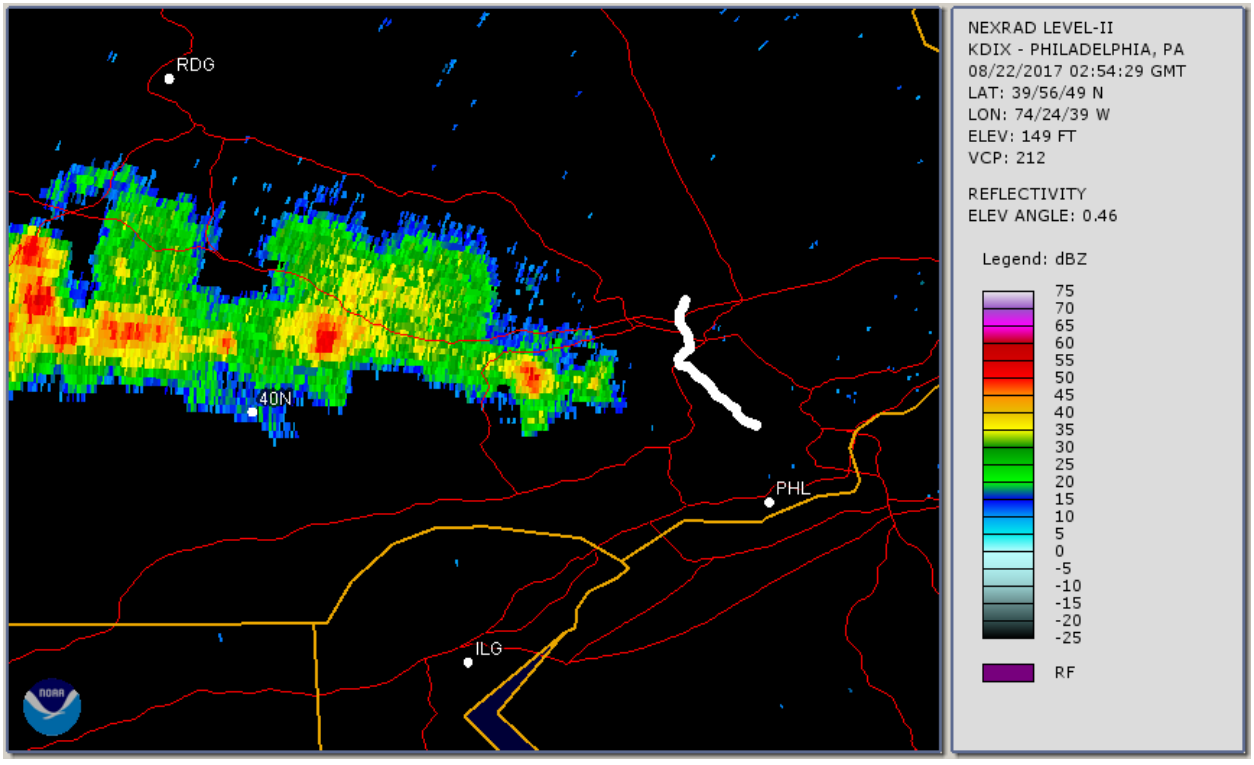

Figure 2 - KDIX WSR-88D base reflectivity image at 2254 EDT

Figures 3 through 22 are the KDIX WSR-88D 0.5° base reflectivity images from 2305 through 0015 EDT every 4 minutes when the echoes of interest were over the SEPTA light rail tracks, with figure 25 the image at the approximate time of the accident. Echoes less than 10.0 dBZ have been eliminated from the images. The images depicted light rain moving over the northern section of

the SEPTA tracks between 2305 and 2331 EDT, when one of the strong cells moves over the southern portion of the tracks and moves over the accident site with reflectivity values of 40 to 60 dBZ between 2345 and 2356 EDT. With no significant echoes over 15 dBZ identified over the SEPTA rail network between 0000 and 0015 EDT.

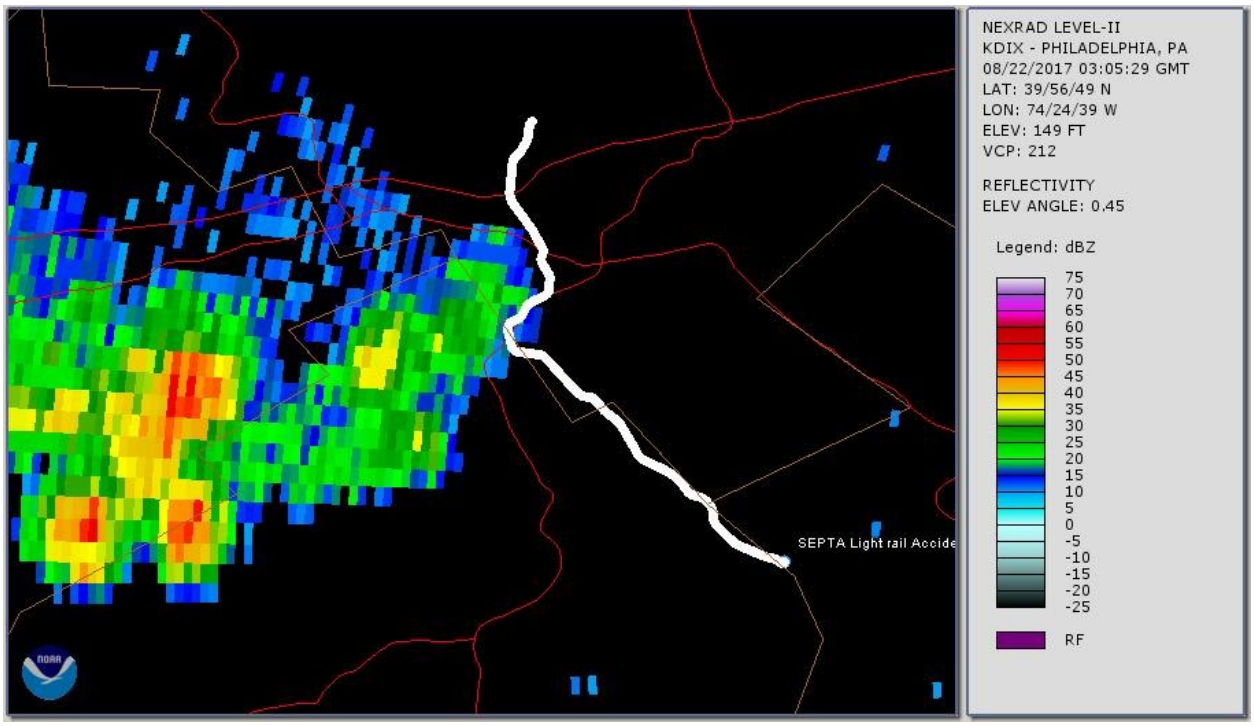

Figure 3 - KDIX WSR-88D base reflectivity image at 2305 EDT

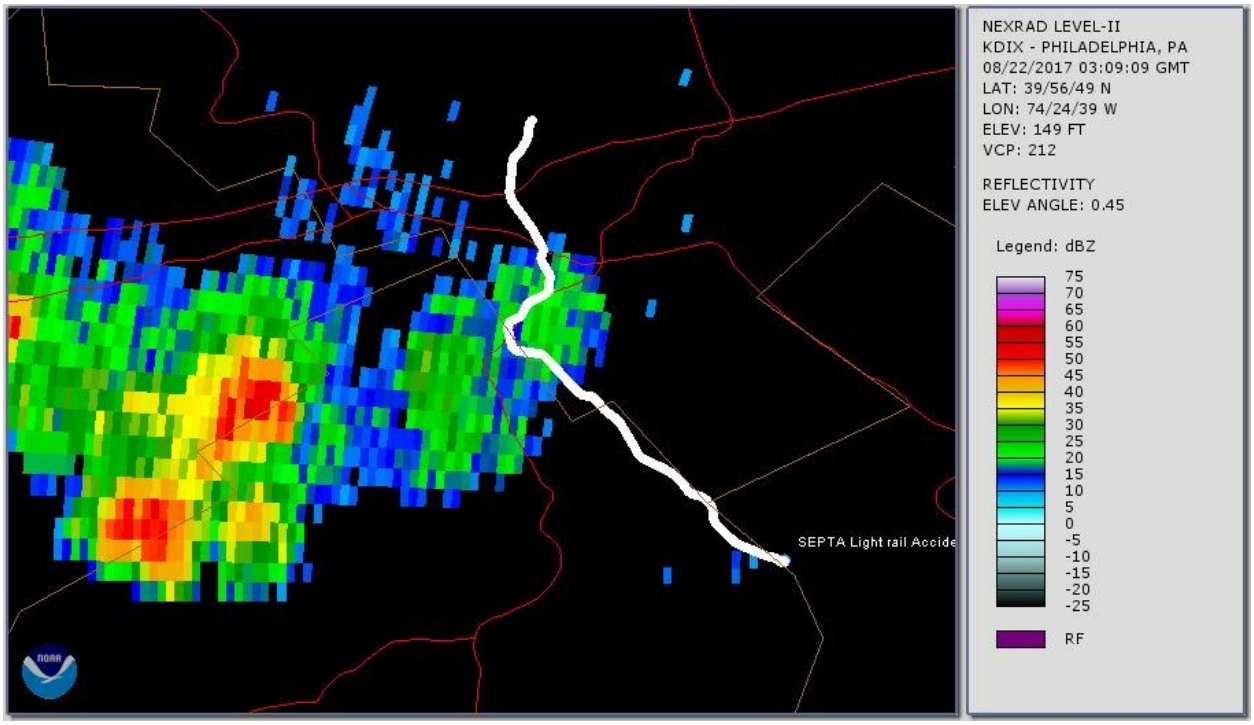

Figure 4 - KDIX WSR-88D base reflectivity image at 2309 EDT

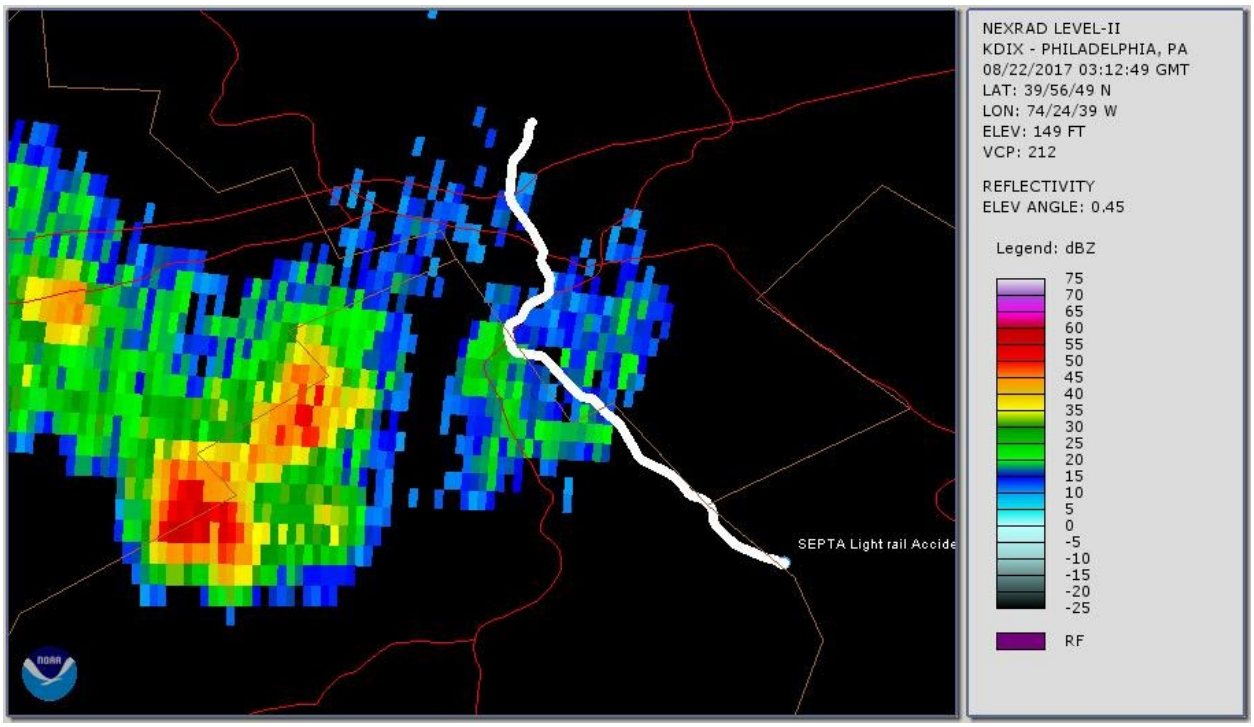

Figure 5 - KDIX WSR-88D base reflectivity image at 2312 EDT

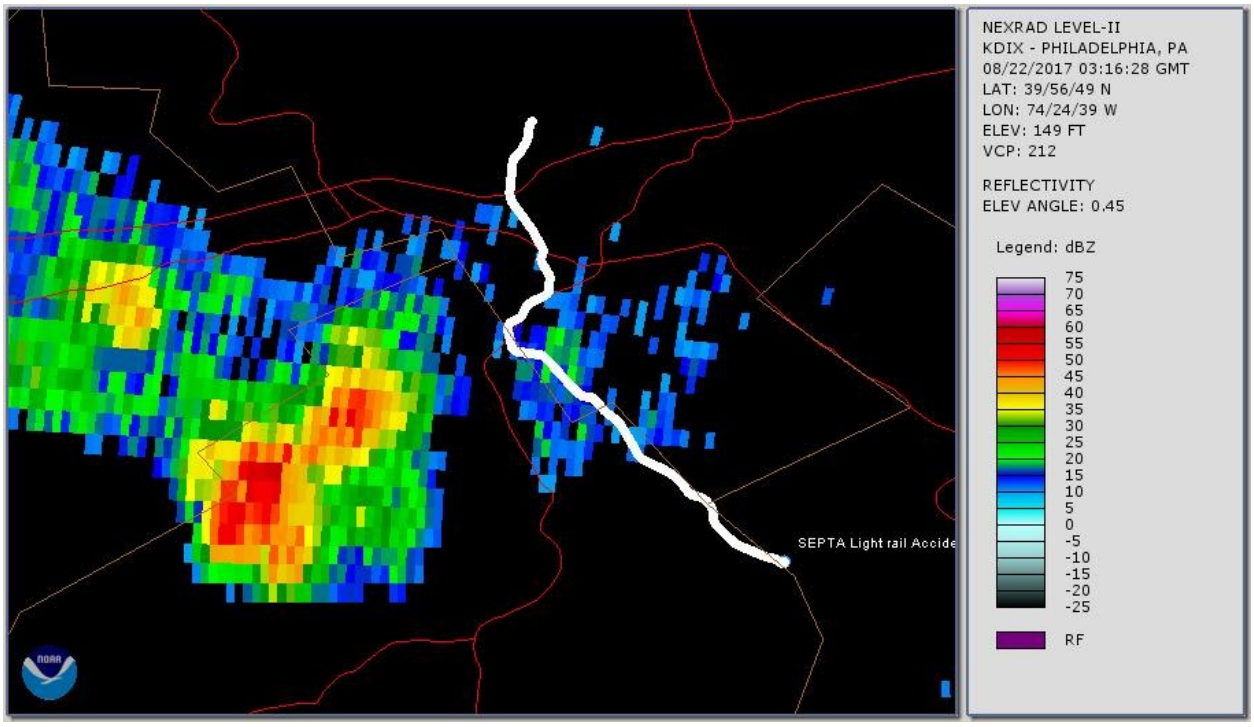

Figure 6 - KDIX WSR-88D base reflectivity image at 2316 EDT

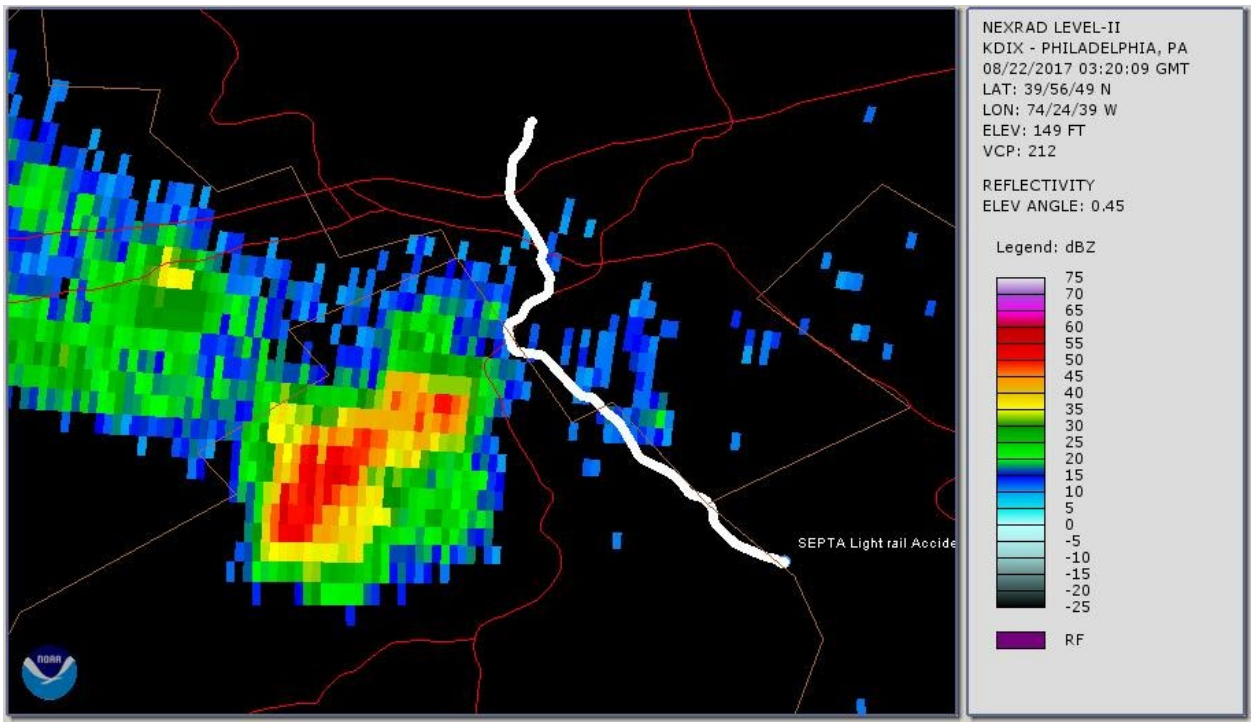

Figure 7 - KDIX WSR-88D base reflectivity image at 2320 EDT

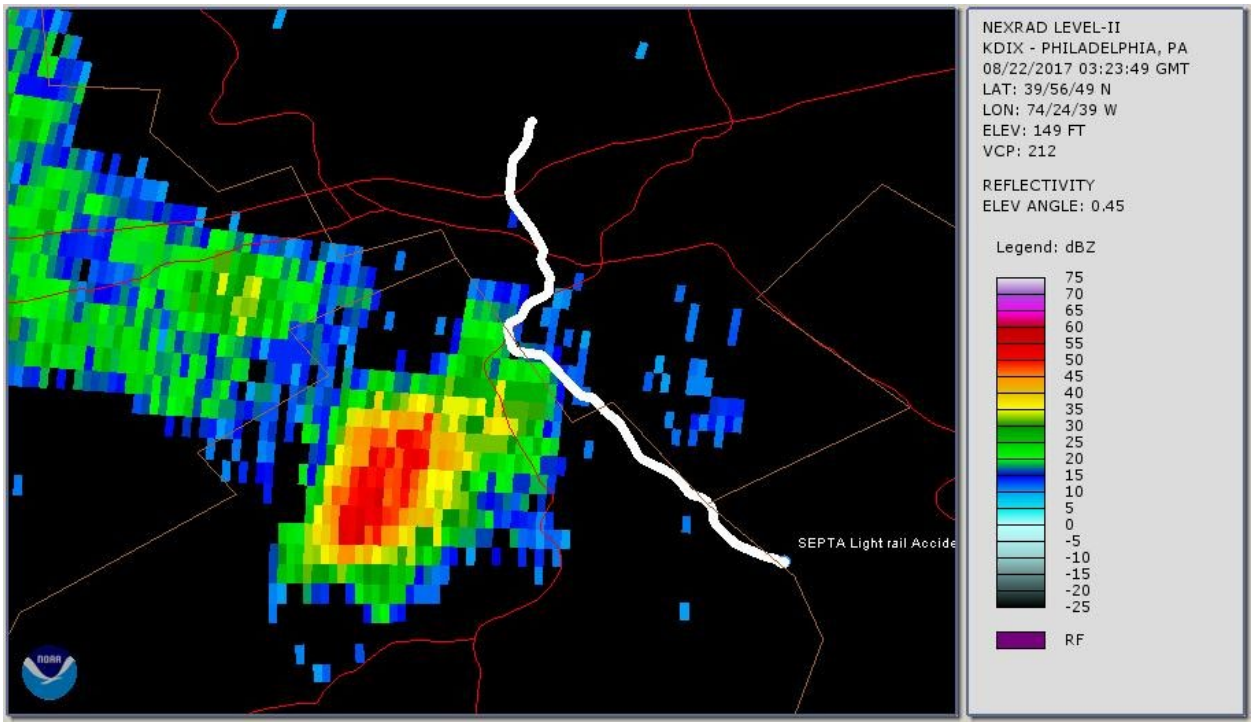

Figure 8 - KDIX WSR-88D base reflectivity image at 2323 EDT

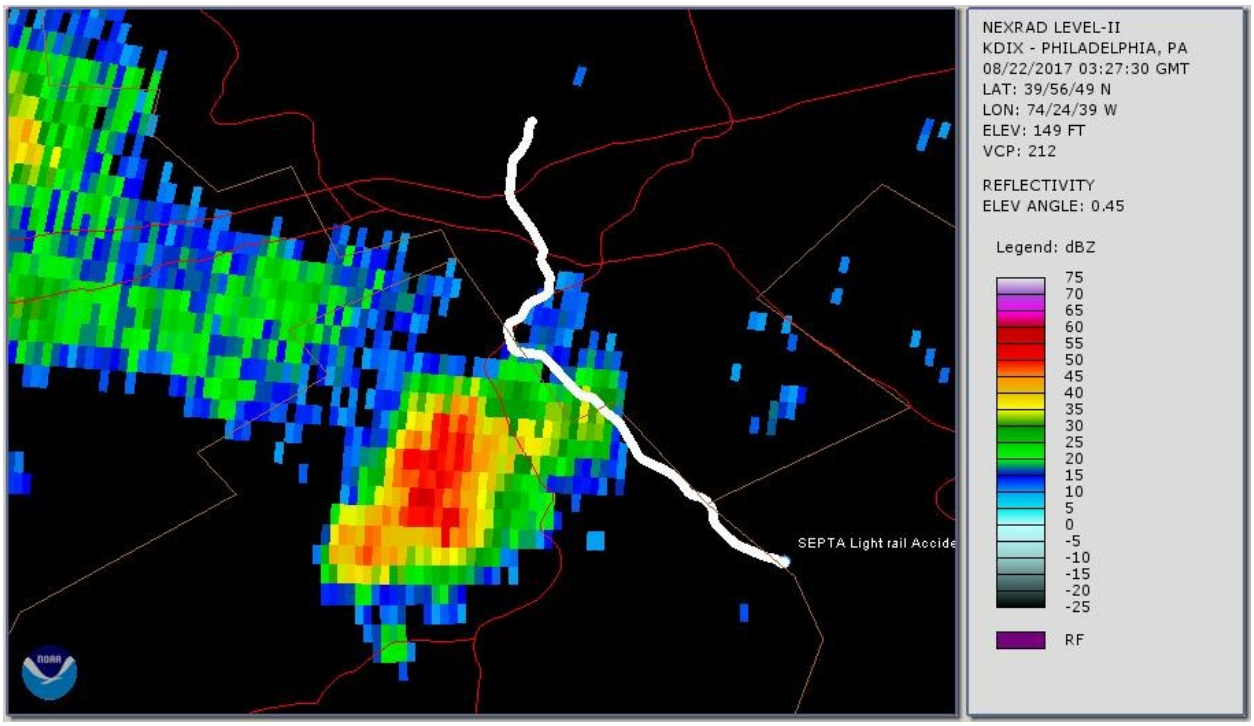

Figure 9 - KDIX WSR-88D base reflectivity image at 2327 EDT

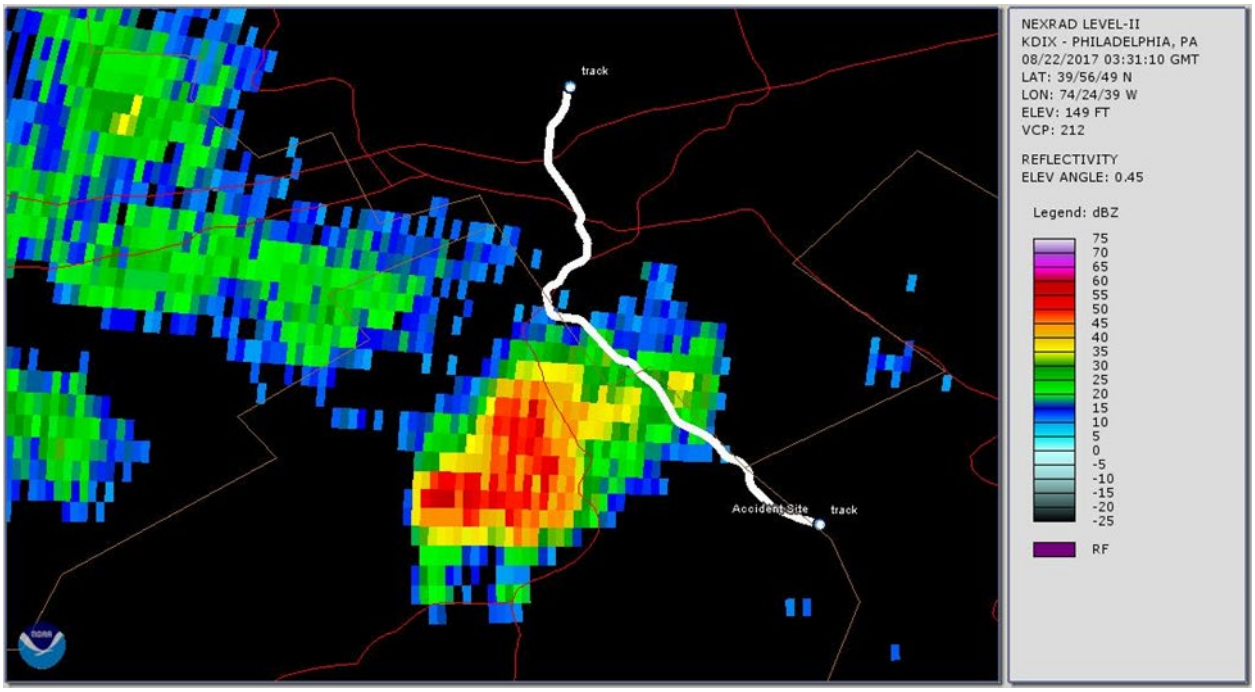

Figure 10 - KDIX WSR-88D base reflectivity image at 2331 EDT

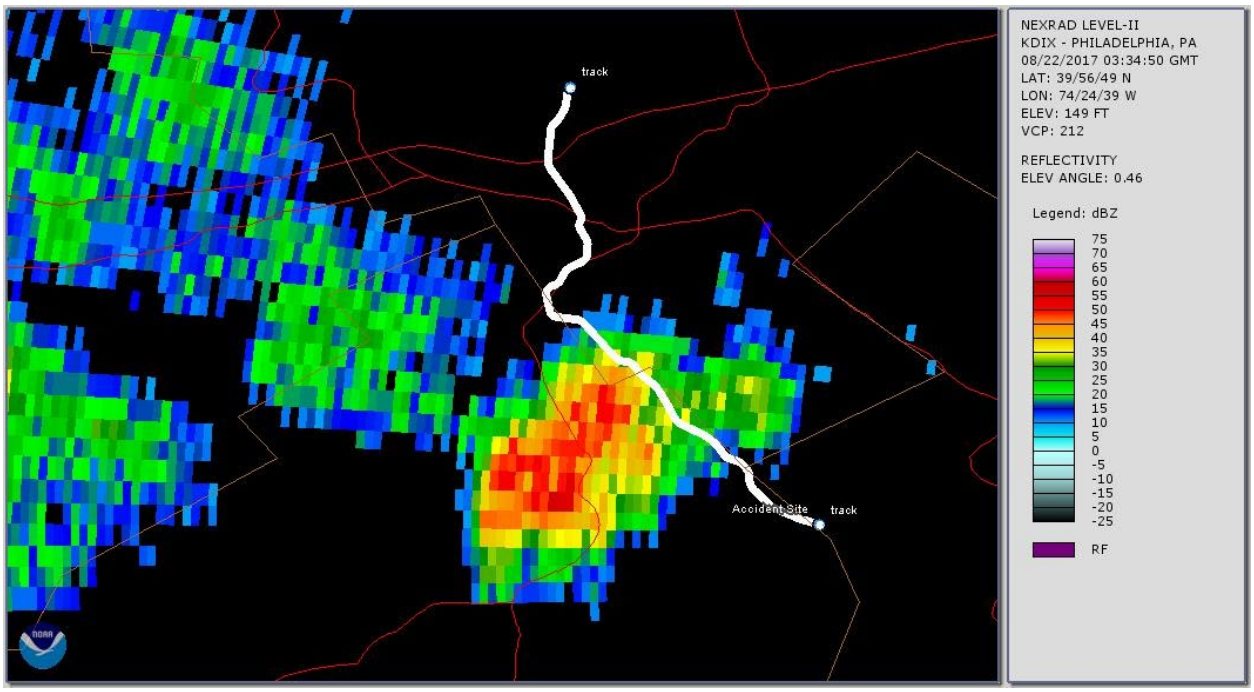

Figure 11 - KDIX WSR-88D base reflectivity image at 2334 EDT

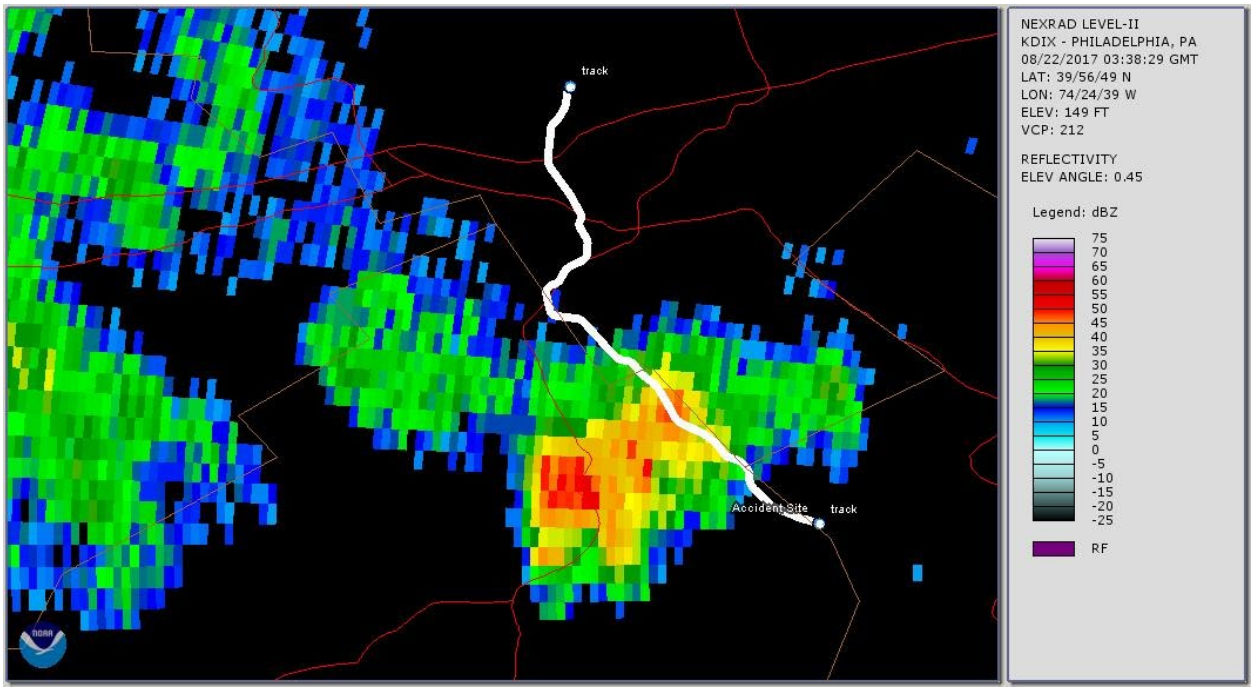

Figure 12 - KDIX WSR-88D base reflectivity image at 2338 EDT

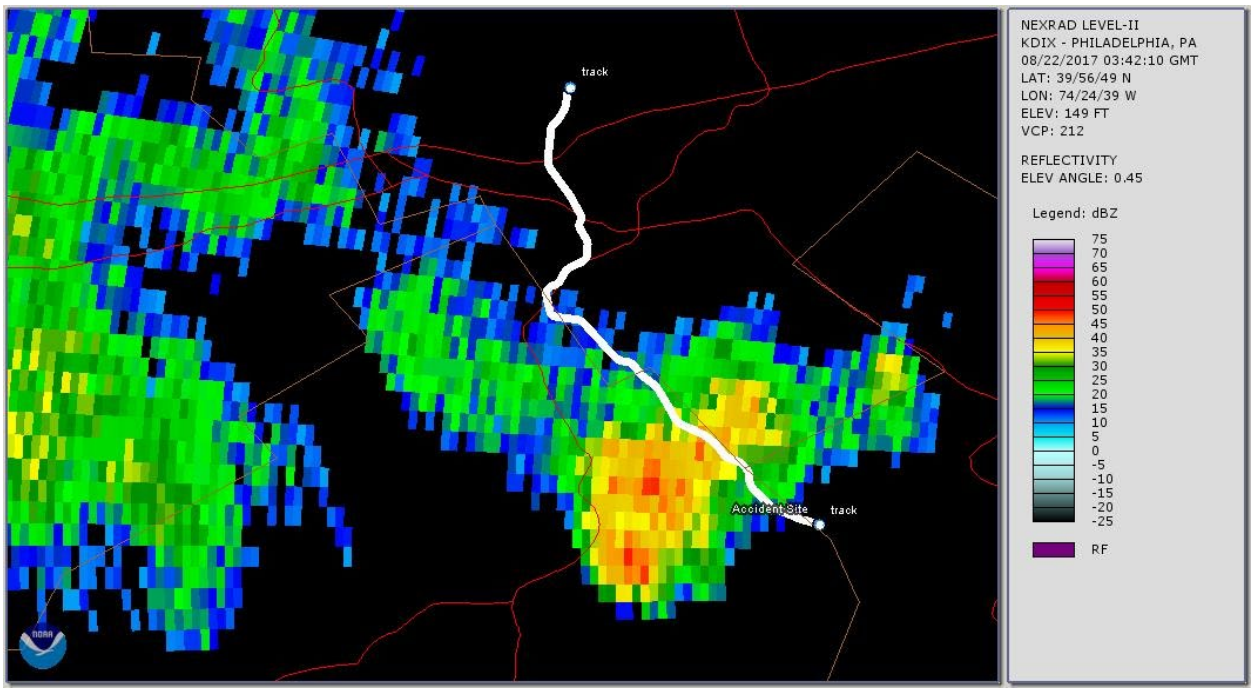

Figure 13 - KDIX WSR-88D base reflectivity image at 2342 EDT

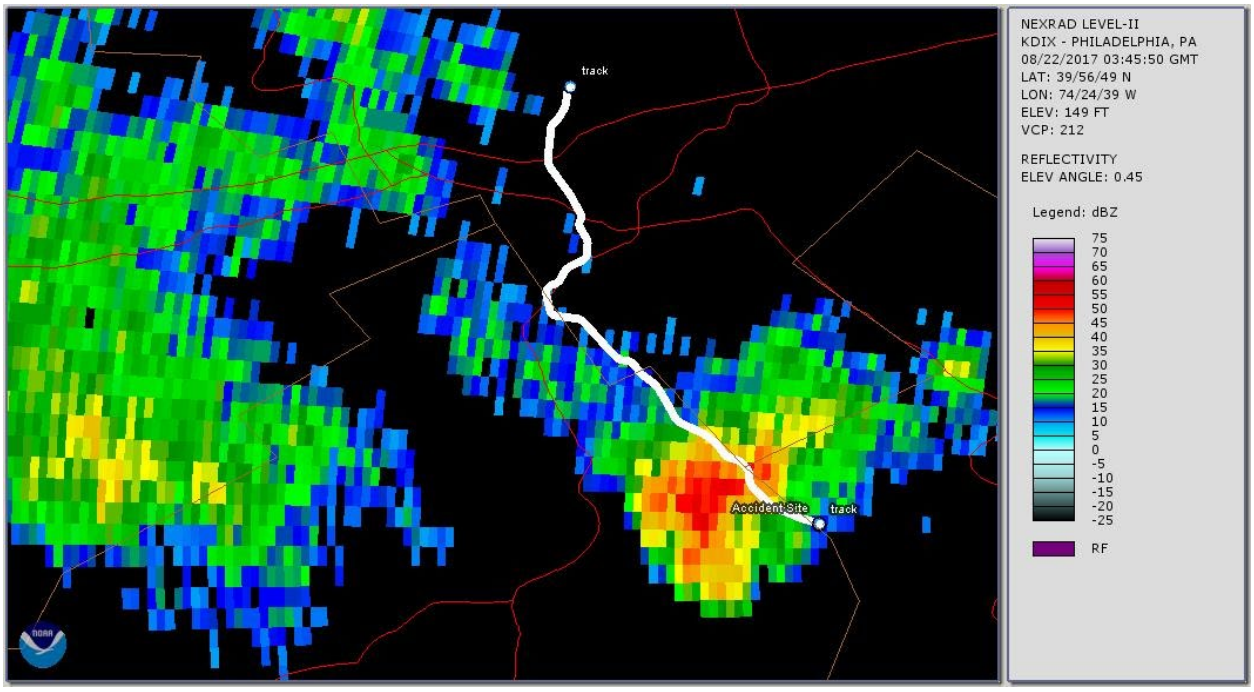

Figure 14 - KDIX WSR-88D base reflectivity image at 2345 EDT

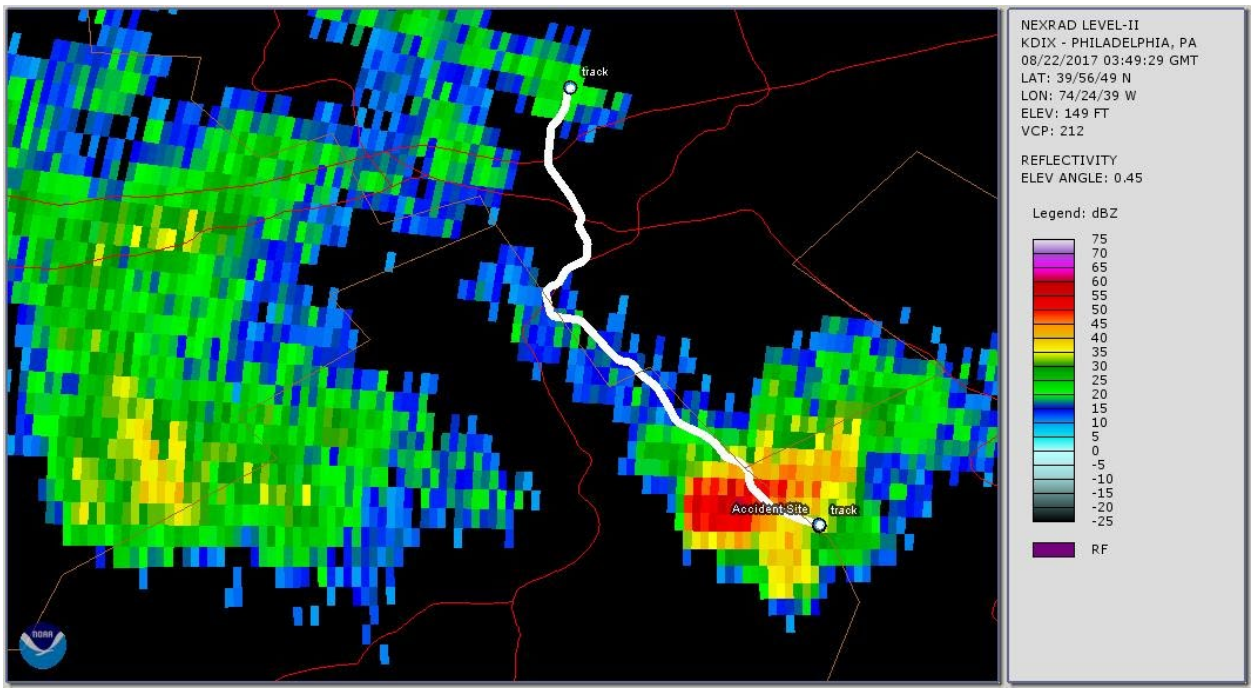

Figure 15 - KDIX WSR-88D base reflectivity image at 2349 EDT

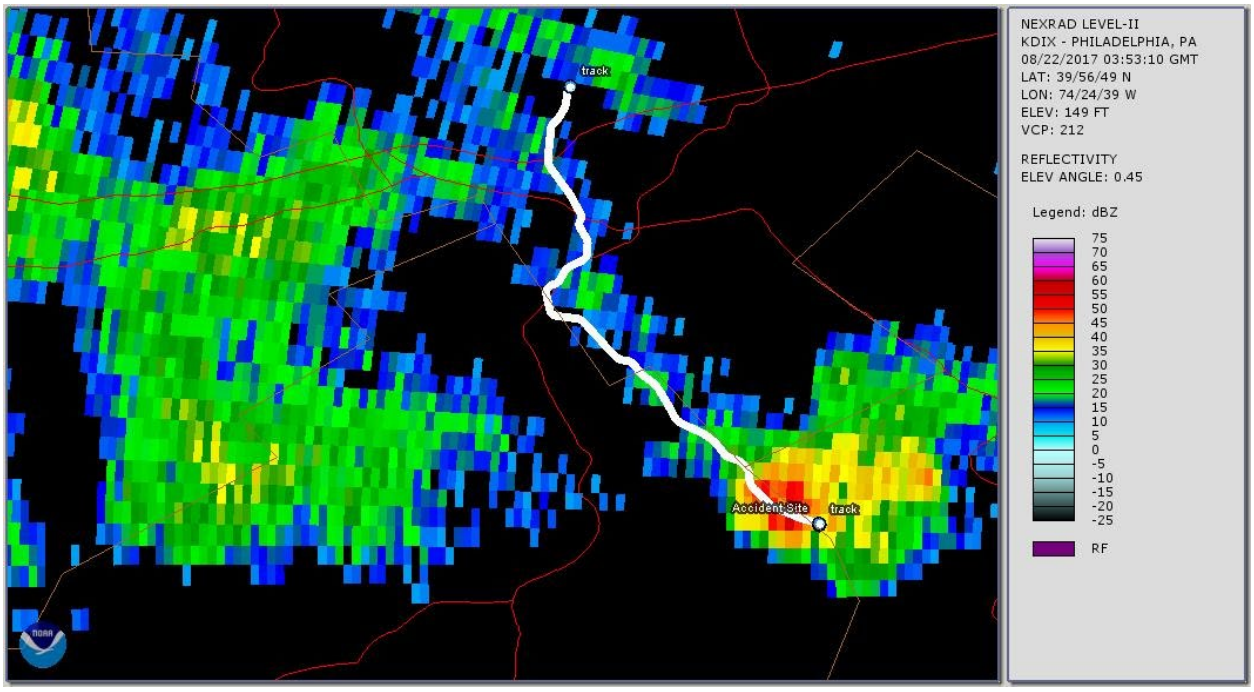

Figure 16 - KDIX WSR-88D base reflectivity image at 2353 EDT

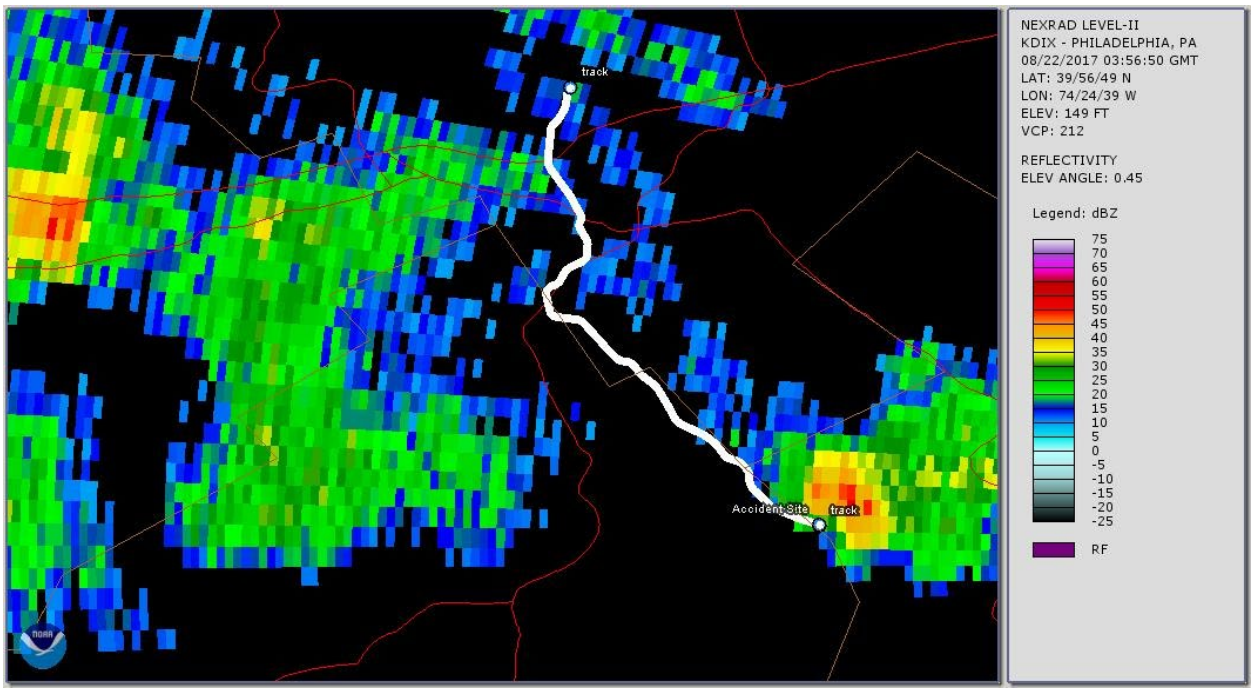

Figure 17 - KDIX WSR-88D base reflectivity image at 2356 EDT

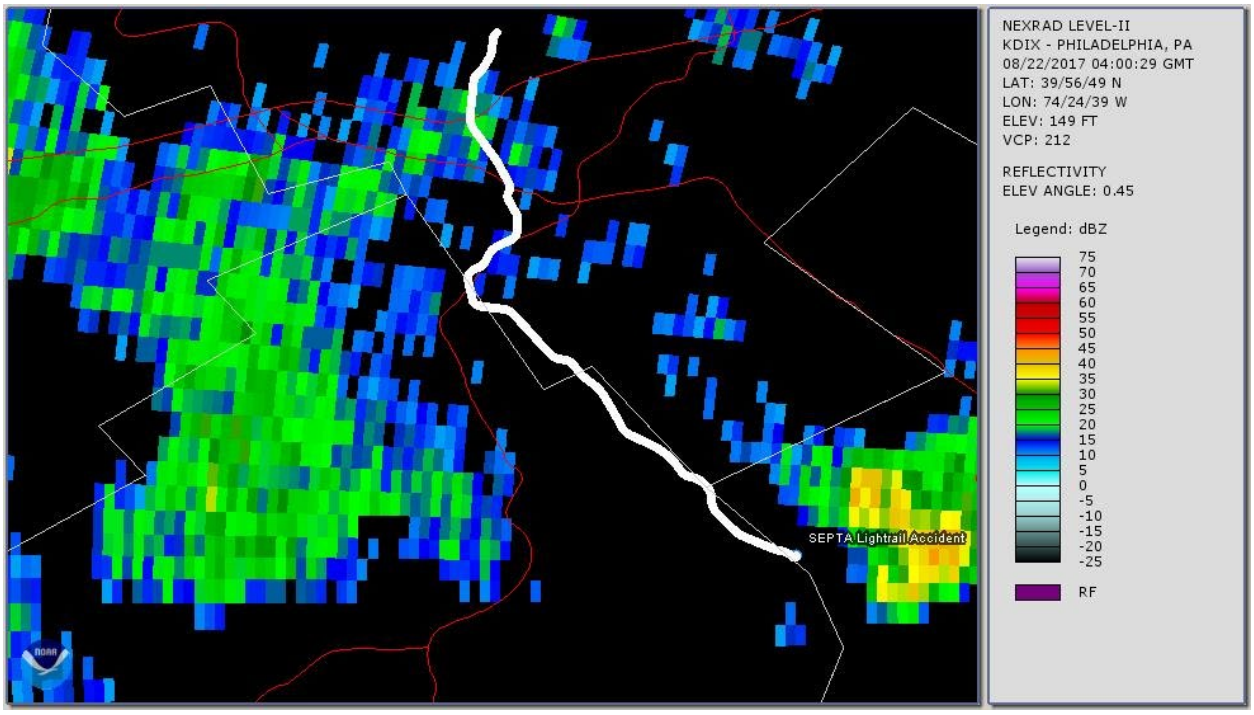

Figure 18 - KDIX WSR-88D base reflectivity image at 0000 EDT

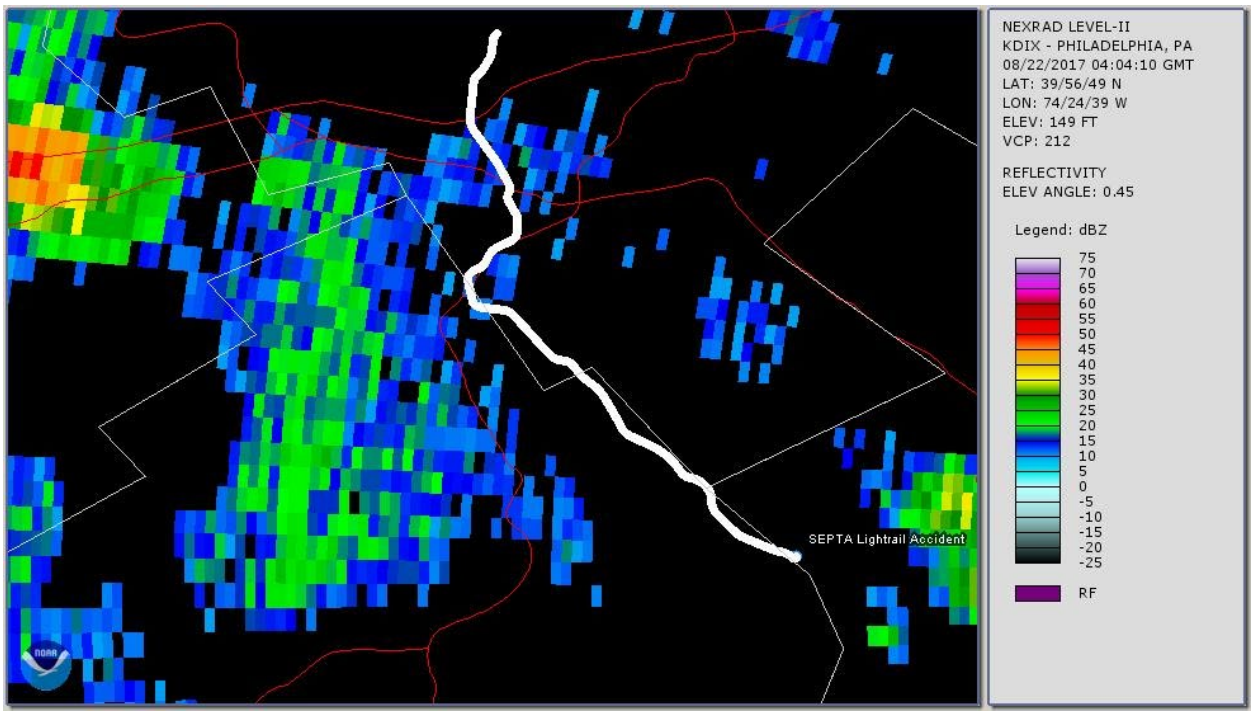

Figure 19 - KDIX WSR-88D base reflectivity image for 0004 EDT

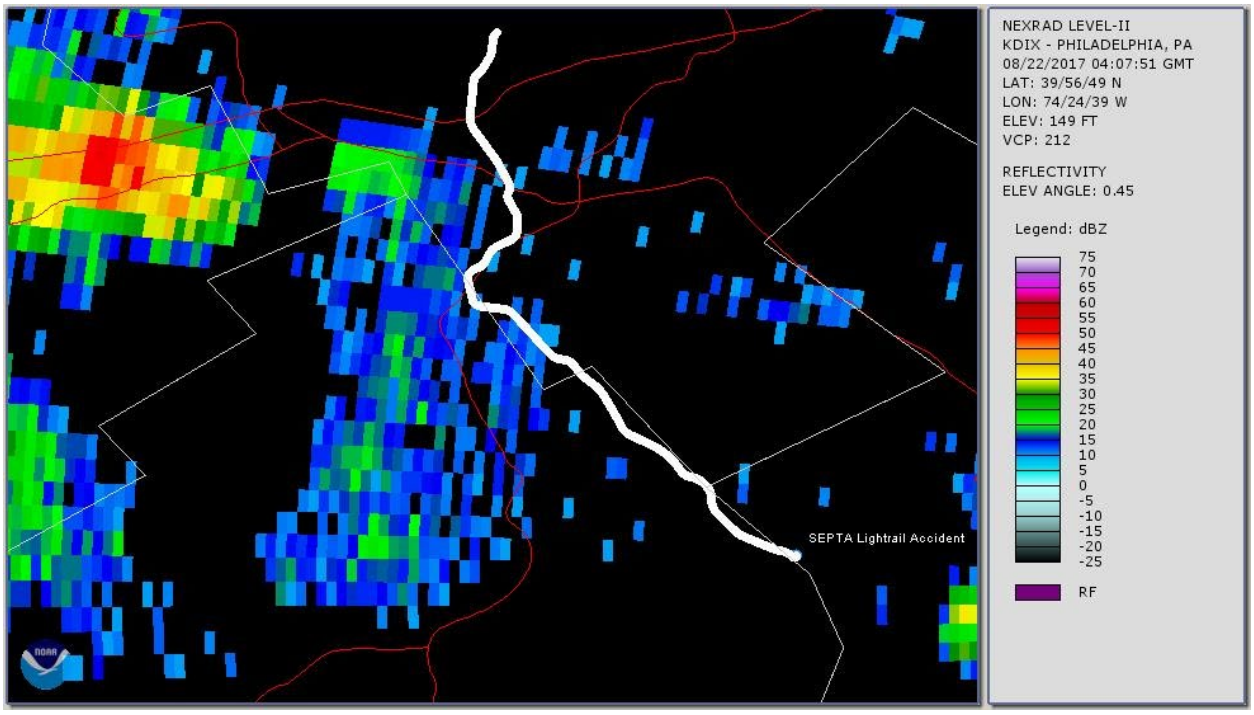

Figure 20 - KDIX WSR-88D base reflectivity image for 0007 EDT

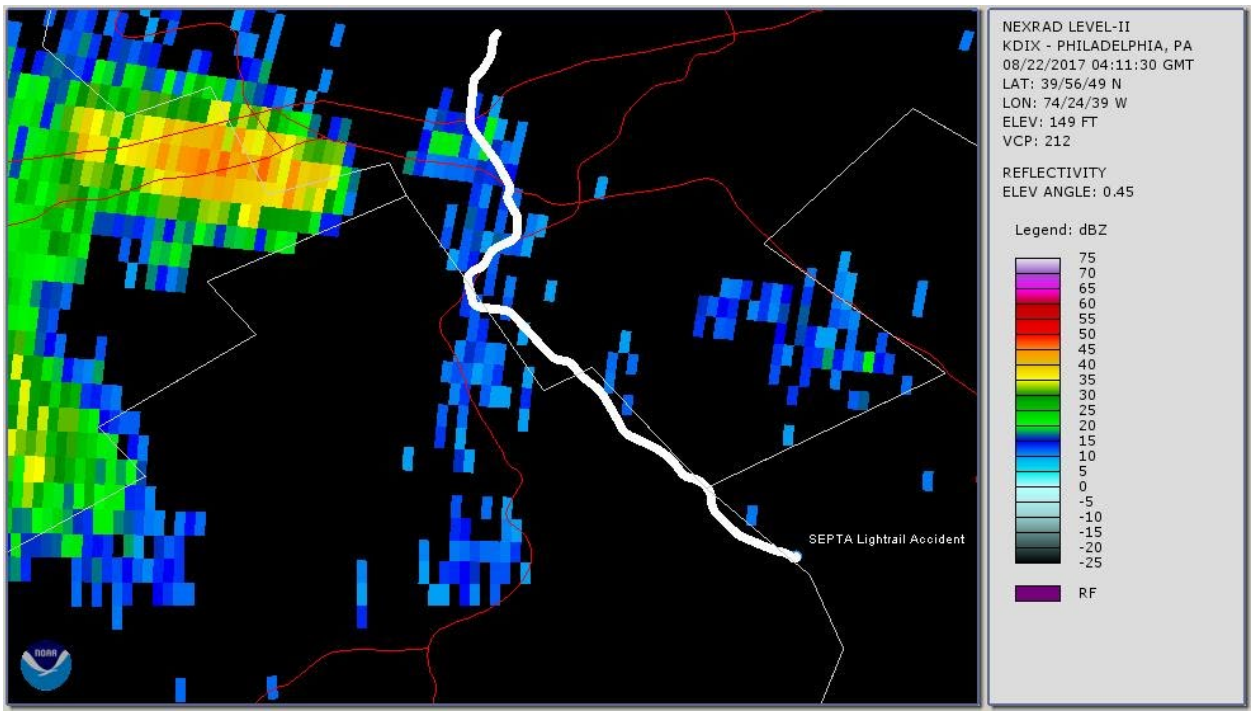

Figure 21 - KDIX WSR-88D base reflectivity image for 0011 EDT

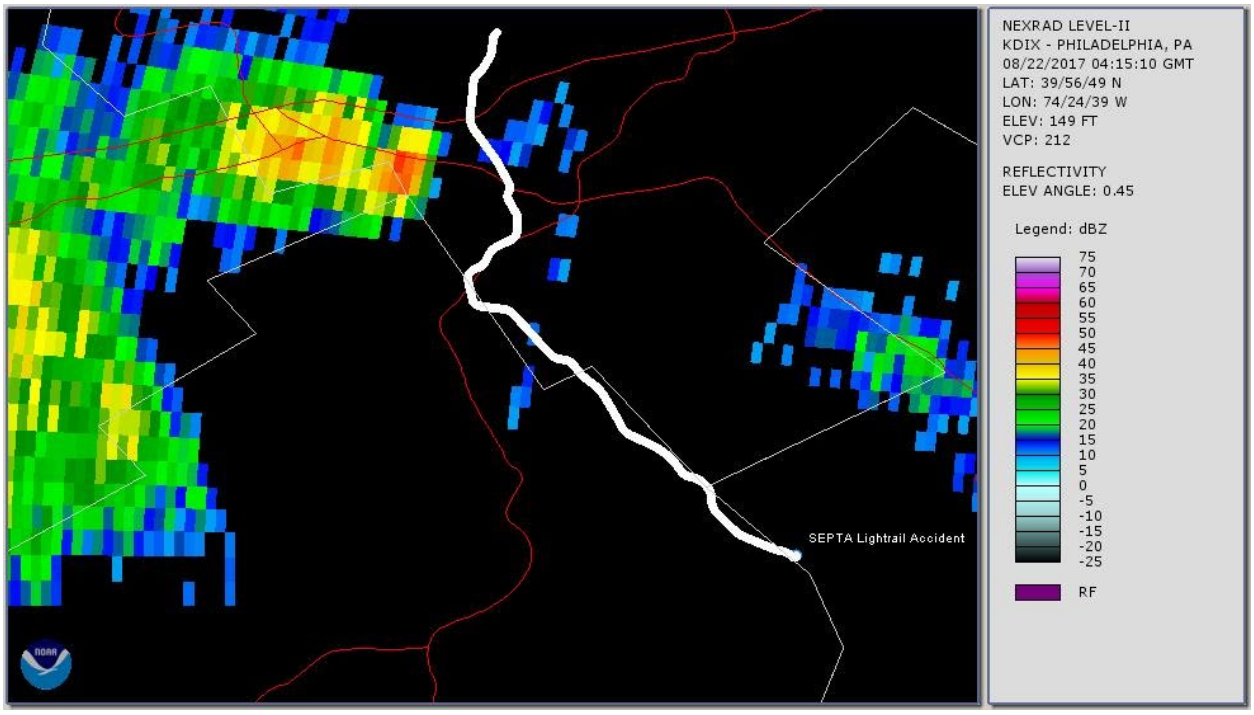

Figure 22 - KDIX WSR-88D base reflectivity image at 0015 EDT

A review of KDIX WSR-88D Level III one hour precipitation total imagery indicated between 0.25 and 0.50 inches of rainfall was noted within the last mile of track to the accident site, with the main echo core height of 32,000 feet over the accident site during the period of heavy precipitation. No lightning was observed in this cell.

4.0 Astronomical Data

The astronomical data was obtained from the United States Naval Observatory's website (http://aa.usno.navy.mil/index.php) for the period August 21-22, 2017:

Sunset	1948 EDT
Moonset	1954 EDT
End of civil twilight	2017 EDT
Accident	***0011 EDT***
Begin of civil twilight	0551 EDT
Sunrise	0619 EDT
Moonrise	0708 EDT

At the time of the accident both the Sun and Moon were more than 15° below the horizon and provided no illumination.

Submitted by:

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Don Eick
Senior Meteorologist