



## FORENSIC ANALYSIS

### CLAIM

Location: 123 Sample Parkway, Cincinnati, OH

Event Date(s): August 28, 2016

Prepared for: Sample Properties

Scope: Determine the possibility of a high-impact flood event affecting the Property on June 29, 2015.

All data, observations and conclusions included in this report are based on the following data and materials:

- Historical KILN Doppler Radar located in Wilmington, OH accessed via GR2Analyst and GRLevel3
- Historical TCVG Doppler Radar located south of Independence, KY accessed via GRLevel3
- Watches, warnings and storm reports issued by the National Weather Service (NWS) in Wilmington, OH accessed via Iowa Environmental Mesonet (IEM)
- NWS hourly reporting stations accessed via IEM

### OVERVIEW

Sample Properties has requested a professional meteorological analysis of a series of heavy rain events that led to a wall collapse on August 28th, 2016 at 123 Sample Parkway, Cincinnati, Ohio (Figure 1). We refer to this location as “the Property” in this report.

Based on our analysis, the Property was subject to multiple heavy rain events in the month of August. August 2016 landed on the top 10 list of the wettest Augusts on records. One of the heaviest rain events occurred on the date of the incident (August 28th, 2016). That day, a series of thunderstorms produced torrential downpours that dropped over 4” of rain in the area within a few hours and resulted in many flash flood events (Figure 2). A Flash Flood Emergency was in effect that evening, which is reserved for only extremely dangerous, life-threatening flooding events by the National Weather Service. An intense rain event like this occurring over very saturated soils likely contributed to the wall collapse on August 28th, 2016.



*Figure 1. Wall collapse at the Property on August 28th, 2016. Source: Sample Law Group.*

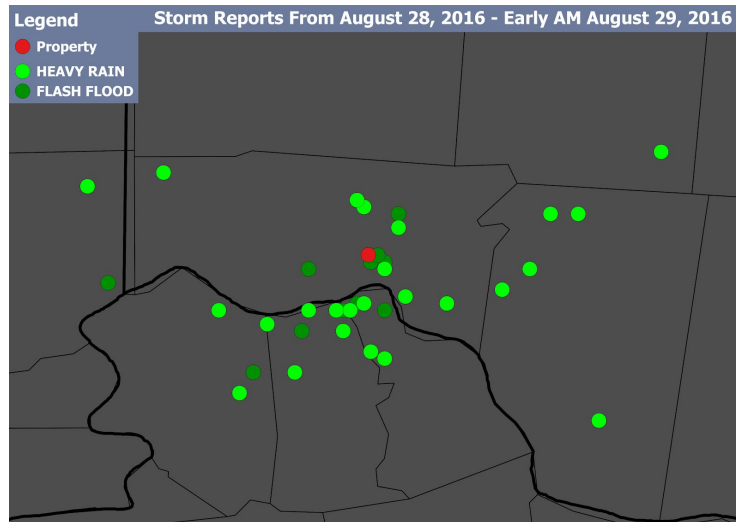


Figure 2. Storm reports showing widespread flooding in the area on August 28th, 2016.  
Source: NWS Wilmington, Ohio.

In this report, we use data from two nearby airports: Cincinnati International Airport (located in Covington, Kentucky, 12.6 miles from the Property) and Cincinnati Lunken Airport (located 5 miles from the Property). See Figure 3 below.



Figure 3. Map showing the location of Cincinnati International Airport (CVG), Cincinnati Lunken Airport (LUK) and the Property.

## WEATHER ANALYSIS

**August Rainfall Summary:** August 2016 was an unseasonably wet month. Cincinnati International Airport (CVG) reported 5.92" of rain, which placed that August as the 10th wettest on record. Similarly, Lunken Airport (LUK) also reported unusually high precipitation. The total at Lunken for August 2016 was 7.74", which came in at the 5th wettest August on record. Both airport locations had record rainfall events during the middle of August. Cincinnati International Airport recorded record rain on August 15th (1.79"). Lunken recorded record rain on August 15th (2.00") and August 17th (1.54"). Figure 4 and 5 below show the top rain events in August for both airports. A full review of August 2016's rainfall can be found in the appendix.

Top August Rainfall Events (CVG Airport) in 2016	
Day	Precipitation
August 15	1.79" (Record)
August 17	1.30"
August 20	1.12"
August 28	0.82"

Figure 4. Wettest days in August 2016 at the Cincinnati International Airport. Source: CVG Airport

Top August Rainfall Events (LUK Airport) in 2016	
Day	Precipitation
August 15	2.00" (Record)
August 17	1.54" (Record)
August 20	0.61"
August 28	1.37"

Figure 5. Wettest days in August 2016 at the Cincinnati Lunken Airport. Source: LUK Airport

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The monthly rainfall analysis for August 2016 highlights the unusually wet pattern that occurred in Cincinnati. The Cincinnati International Airport, which keeps track of the climatological data for the Cincinnati area, recorded above average precipitation--especially for the second half of the month (Figures 6). The blue line on the graph below represents rain accumulation at the CVG airport, which is well above average (red line) for the second half of the month shown.

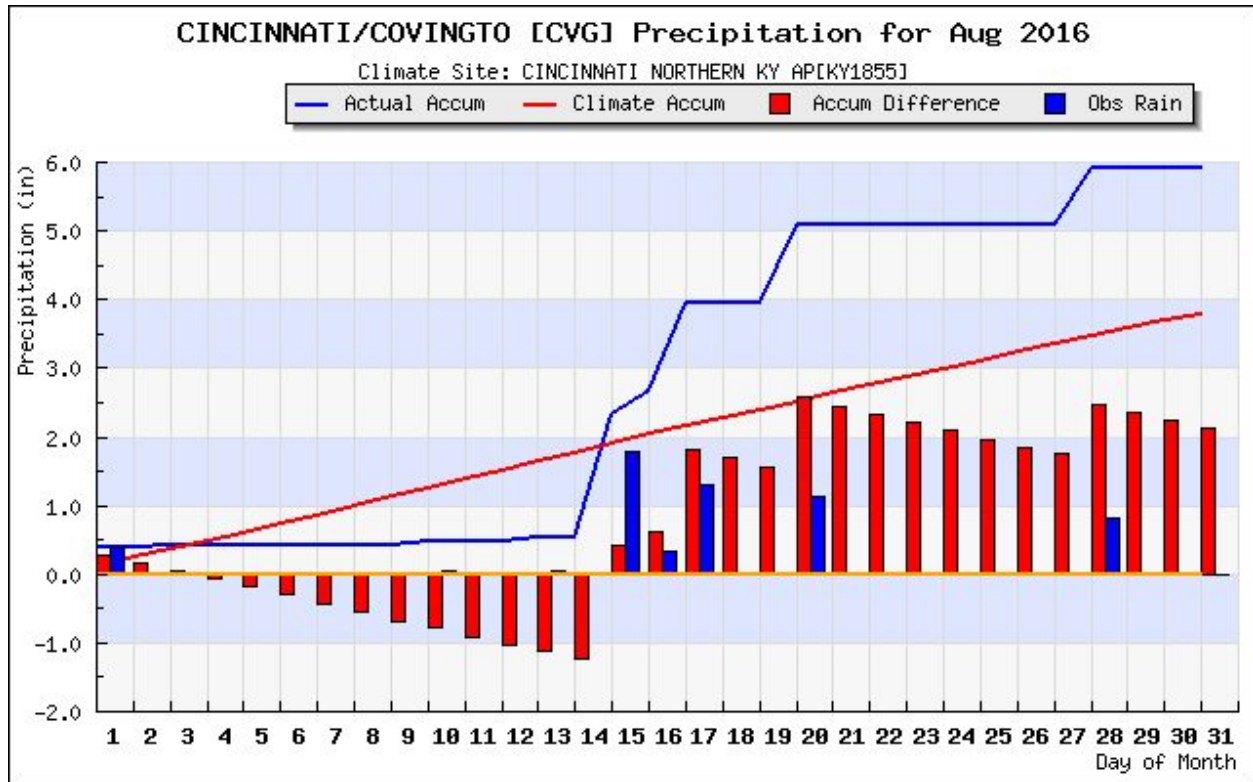


Figure 6. Precipitation analysis for August 2016 at the Cincinnati International Airport showing above average precipitation starting August 15th. Source: CVG Airport/IEM.

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Cincinnati Lunken Airport's precipitation record for August 2016 also shows how the bulk of the rain fell in the second half of the month (Figure 7). This airport does not track climate data.

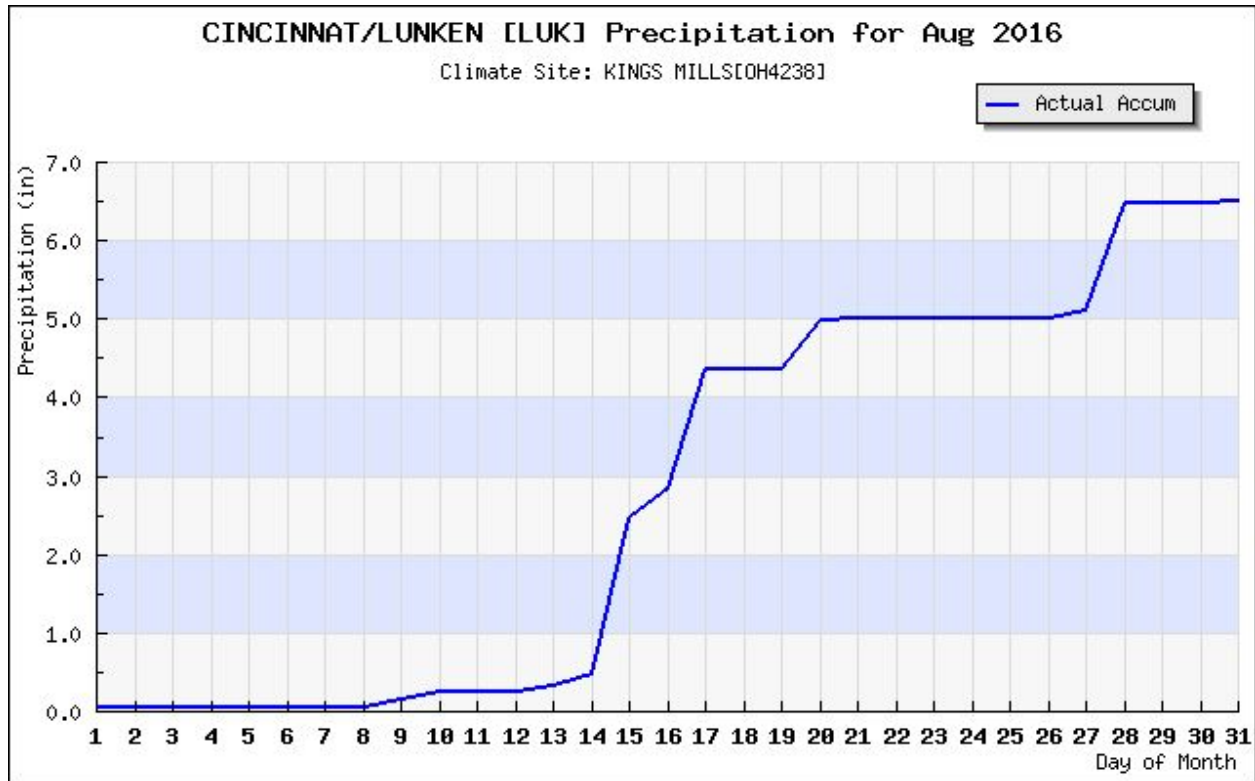
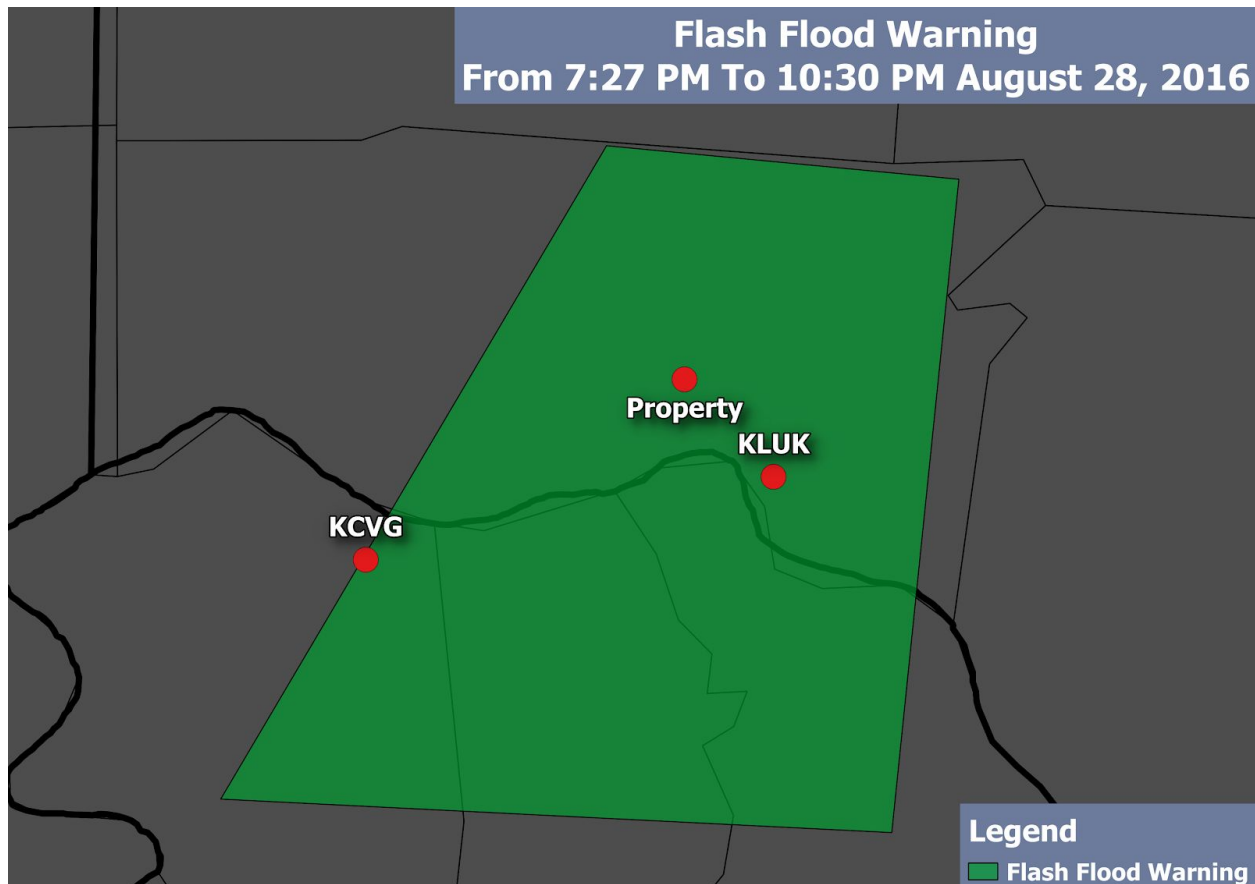


Figure 7. Precipitation analysis for August 2016 at the Cincinnati Lunken Airport showing how the bulk of the precipitation fell during the second half of the month. Source: LUK Airport/IEM.

These repeated heavy rain events contributed to a very saturated ground, resulting in life-threatening and destructive flooding on August 28th, 2016 when yet another extreme rain event occurred in the Cincinnati area.

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**Flood Event on August 28th, 2016:** Multiple, slow-moving storms produced repeated torrential downpours that began impacting the Cincinnati area on the evening of August 28th, 2016. At 7:27PM EDT, The National Weather Service in Wilmington, Ohio (NWS Wilmington) issued a Flash Flood Warning until 10:30PM EDT for eastern Hamilton County, including the Property (Figure 8). The warning stated that nearly stationary storms had already produced 1.5" to 2.5" of rain with an additional 1" to 2" expected (Figure 9). Flash flooding was expected.



*Figure 8. Illustration of the Flash Flood Warning issued on August 28, 2016 at 7:27PM EDT which included the Property. Source: NWS Wilmington.*

BULLETIN - EAS ACTIVATION REQUESTED  
FLASH FLOOD WARNING  
NATIONAL WEATHER SERVICE WILMINGTON OH  
727 PM EDT SUN AUG 28 2016

THE NATIONAL WEATHER SERVICE IN WILMINGTON HAS ISSUED A

- \* FLASH FLOOD WARNING FOR...  
KENTON COUNTY IN NORTHERN KENTUCKY...  
NORTHERN CAMPBELL COUNTY IN NORTHERN KENTUCKY...  
CENTRAL BOONE COUNTY IN NORTHERN KENTUCKY...  
EASTERN HAMILTON COUNTY IN SOUTHWESTERN OHIO...
- \* UNTIL 1030 PM EDT.
- \* AT 725 PM EDT...RADAR INDICATED THAT NEARLY STATIONARY THUNDERSTORMS HAD PRODUCED HEAVY RAIN ACROSS THE WARNED AREA. DOPPLER RADAR ESTIMATES INDICATES THAT 1.5 TO 2.5 INCHES OF RAIN HAS FALLEN ACROSS PARTS OF THE AREA SINCE 630 PM. HEAVY RAIN CONTINUES TO FALL WITH ANOTHER 1 TO 2 INCHES POSSIBLE. RUNOFF FROM THIS EXCESSIVE RAINFALL WILL CAUSE FLASH FLOODING TO OCCUR.
- \* SOME LOCATIONS THAT WILL EXPERIENCE FLOODING INCLUDE...  
CINCINNATI...COVINGTON...FLORENCE...INDEPENDENCE...NORWOOD...FOREST PARK...ERLANGER...FORT THOMAS...NEWPORT...SHARONVILLE...BLUE ASH...  
SPRINGDALE...READING...MONTGOMERY...NORTH COLLEGE HILL...MADEIRA...  
EDGEWOOD...ALEXANDRIA...ELSMERE AND WYOMING.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOVE TO HIGHER GROUND NOW. ACT QUICKLY TO PROTECT YOUR LIFE.

TO REPORT FLASH FLOODING...GO TO OUR WEBSITE AT [WEATHER.GOV/ILN](http://WEATHER.GOV/ILN) AND SUBMIT YOUR REPORT VIA SOCIAL MEDIA...WHEN YOU CAN DO SO SAFELY.

*Figure 9. Flash Flood Warning issued on August 28, 2016 at 7:27PM EDT.*

*Source: NWS Wilmington.*

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At 8:10PM EDT, NWS Wilmington issued a Flash Flood Emergency, reserved for only the most dangerous flooding events for the same area. This was in effect until 10:30PM EDT (Figure 10). The updated warning text stated that radar-estimated rainfall of 3" to 5" had occurred since 6PM and that an additional 2" was expected. It was also stated that this was an "extremely dangerous and life-threatening situation."

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FLASH FLOOD STATEMENT
NATIONAL WEATHER SERVICE WILMINGTON OH
810 PM EDT SUN AUG 28 2016

KYC015-037-117-OHC061-290230-
/O.CON.KILN.FF.W.0044.000000T0000Z-160829T0230Z/
/00000.0.ER.000000T0000Z.000000T0000Z.000000T0000Z.00/
KENTON KY-CAMPBELL KY-BOONE KY-HAMILTON OH-
810 PM EDT SUN AUG 28 2016

...THIS IS A FLASH FLOOD EMERGENCY FOR KENTON...NORTHERN CAMPBELL...
CENTRAL BOONE AND EASTERN HAMILTON COUNTIES...

...A FLASH FLOOD WARNING REMAINS IN EFFECT UNTIL 1030 PM EDT...

AT 807 PM EDT...RADAR INDICATED THAT EXTREMELY HEAVY RAIN HAD FALLEN
ACROSS SOUTHERN HAMILTON...NORTHERN KENTON AND NORTHERN CAMPBELL
COUNTIES. DOPPLER RADAR ESTIMATES INDICATE THAT 3 TO 5 INCHES OF
RAIN HAVE FALLEN SINCE 6 PM. HEAVY RAIN CONTINUES TO FALL WITH
ANOTHER 2 INCHES POSSIBLE. FLASH FLOODING IS OCCURRING AND WILL
CONTINUE THROUGH 1000 PM.

SOME LOCATIONS THAT WILL EXPERIENCE FLOODING INCLUDE...
CINCINNATI...COVINGTON...FLORENCE...INDEPENDENCE...NORWOOD...
FOREST PARK...ERLANGER...FORT THOMAS...NEWPORT...SHARONVILLE...
BLUE ASH...SPRINGDALE...READING...MONTGOMERY...NORTH COLLEGE HILL...
MADEIRA...EDGEWOOD...ALEXANDRIA...ELSMERE AND WYOMING.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

MOVE TO HIGHER GROUND NOW. THIS IS AN EXTREMELY DANGEROUS AND LIFE
THREATENING SITUATION. DO NOT ATTEMPT TO TRAVEL UNLESS YOU ARE
FLEEING AN AREA SUBJECT TO FLOODING OR UNDER AN EVACUATION ORDER.

TO REPORT FLASH FLOODING...GO TO OUR WEBSITE AT WEATHER.GOV/ILN AND
SUBMIT YOUR REPORT VIA SOCIAL MEDIA...WHEN YOU CAN DO SO SAFELY.
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Figure 10. Update to the Flash Flood Warning issued on August 28, 2016 at 8:10PM EDT.  
Source: NWS Wilmington.

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Airport hourly observations confirm torrential rain beginning around 7:00PM with the heaviest precipitation generally occurring between 7:00PM and 9:00PM. Observations at the Cincinnati International Airport (CVG) recorded a total of 0.79" in 2 hours (between 6:52PM and 8:52PM), shown in Figure 11.<sup>1</sup> Furthermore, observations at the Cincinnati Lunken Airport recorded a total of 1.3" in approximately 2 hours (Figure 12).<sup>2</sup> Rain rates of this magnitude can easily lead to rapid ground saturation and flooding.

Hourly Precipitation on Aug. 28th, 2016 (CVG Airport)	
Time	Precipitation
6:52PM	0.01"
7:52PM	0.63"
8:52PM	0.15"
9:52PM	0.00"
10:52PM	0.03"
11:52PM	0.00"

Figure 11. Hourly precipitation observations on August 28th, 2016 at the Cincinnati International Airport.  
Source: CVG Airport

Hourly Precipitation on Aug. 28th, 2016 (LUK Airport)	
Time	Precipitation
6:53PM	0.00"
7:53PM	0.98"
8:40PM	0.32"
9:53PM	0.00"

Figure 12. Hourly precipitation observations on August 28th, 2016 at the Cincinnati Lunken Airport.  
Source: LUK Airport

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Doppler radar is able to estimate rainfall totals from storm events. In this case, radar confirmed torrential rainfall with the storms that impacted the area on August 28th. Storm total, radar-derived rainfall estimates showed values up to 5.50" (Figure 13). Dual-polarization radar, which, in theory, can provide more accurate precipitation estimates<sup>3</sup> also confirmed impressive rainfall between 4" and 5" in the Cincinnati area (Figure 14).

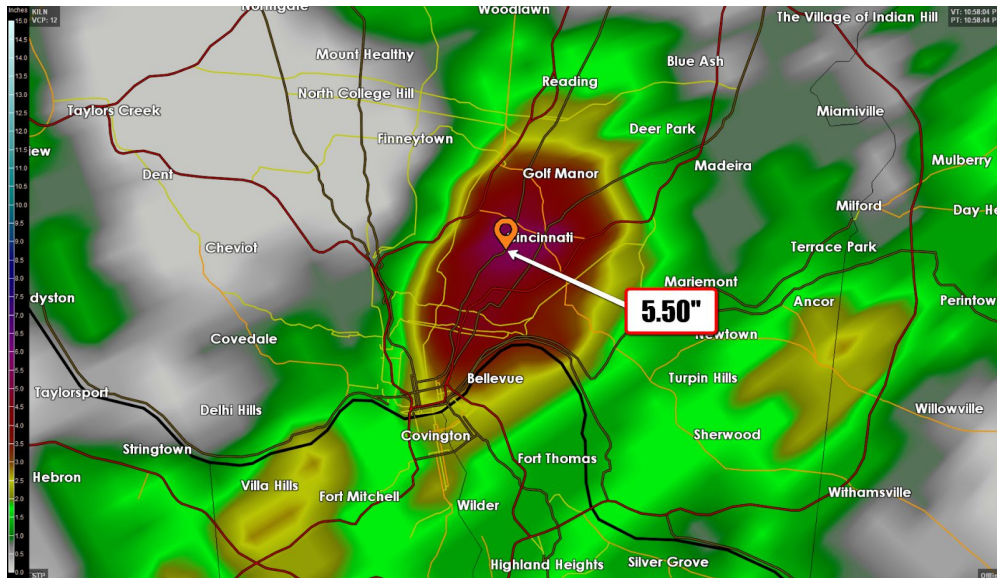


Figure 13. Radar estimated storm total precipitation from August 28th, 2016. Source: KILN

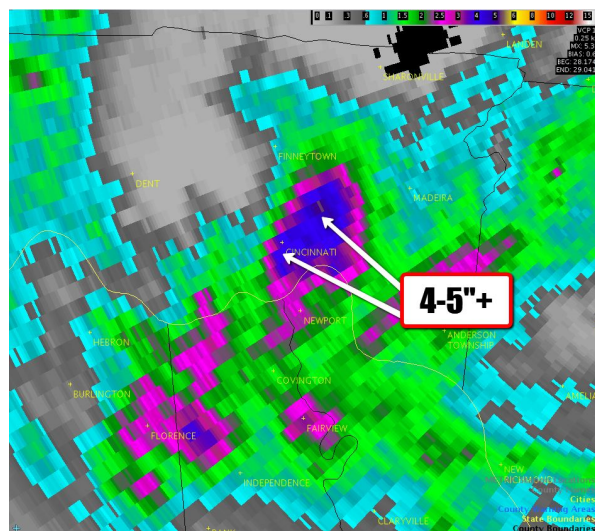


Figure 14. Dual-polarization radar estimated storm total precipitation from August 28th, 2016. Source: KILN<sup>4</sup>

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While radar is unable to accurately measure rainfall, storm reports from trained spotters on the ground provide a more accurate assessment of rain totals. Most official storm reports for this event exceeded 1" and even 2" of rain (Figure 15). The top report, which was the nearest official report to the Property, showed an impressive 4.41". It should be noted that marker locations are approximate and are not accurate to street level, but still accurately reflect the impact of the storm in the immediate area.

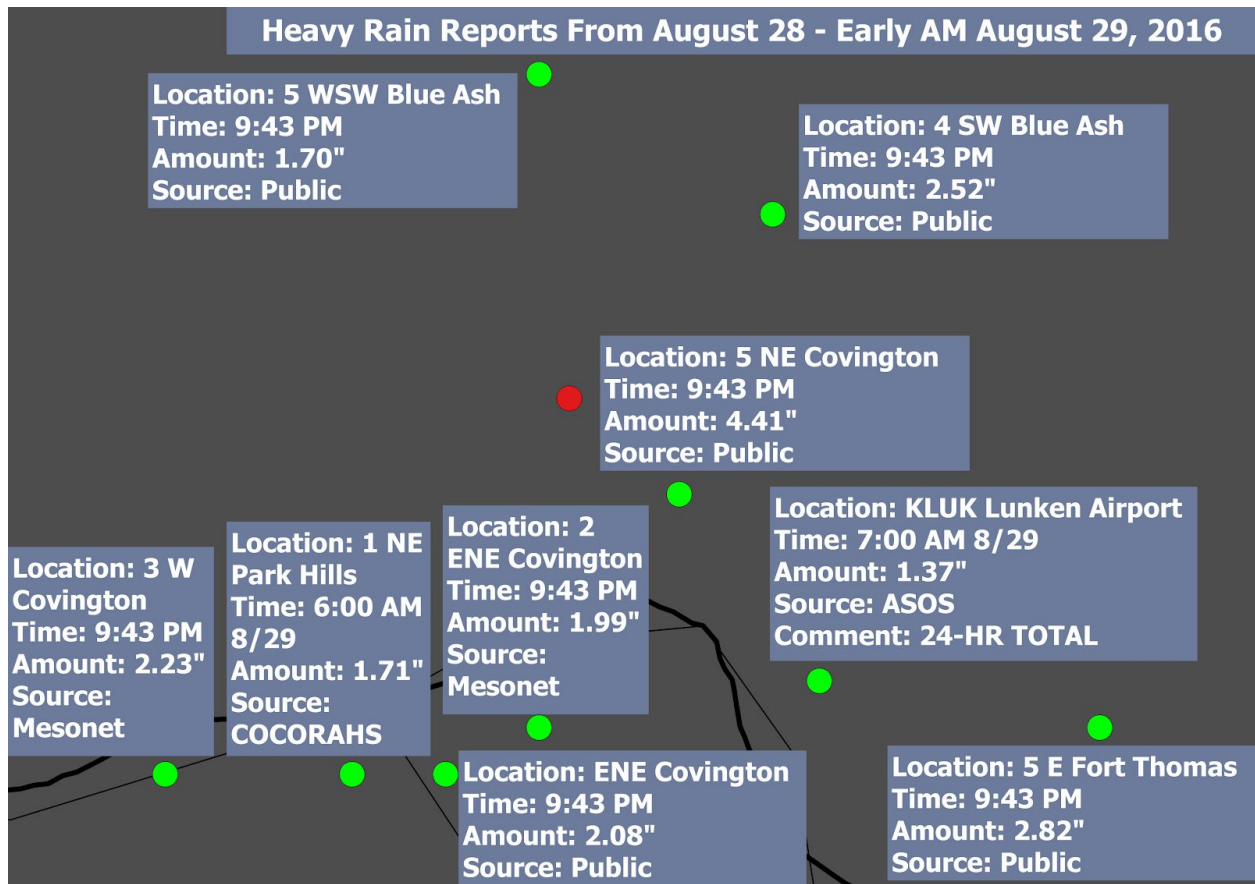


Figure 15. Summary of heavy rain reports in and around the property on August 28-29th, 2016.  
Source: NWS Wilmington.

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Flood reports were also widespread (Figure 16 & 17). Reports included submerged vehicles, water covered roads and flooded apartments near the Property. The flooding also shut down portions of Interstate-71.<sup>5</sup>

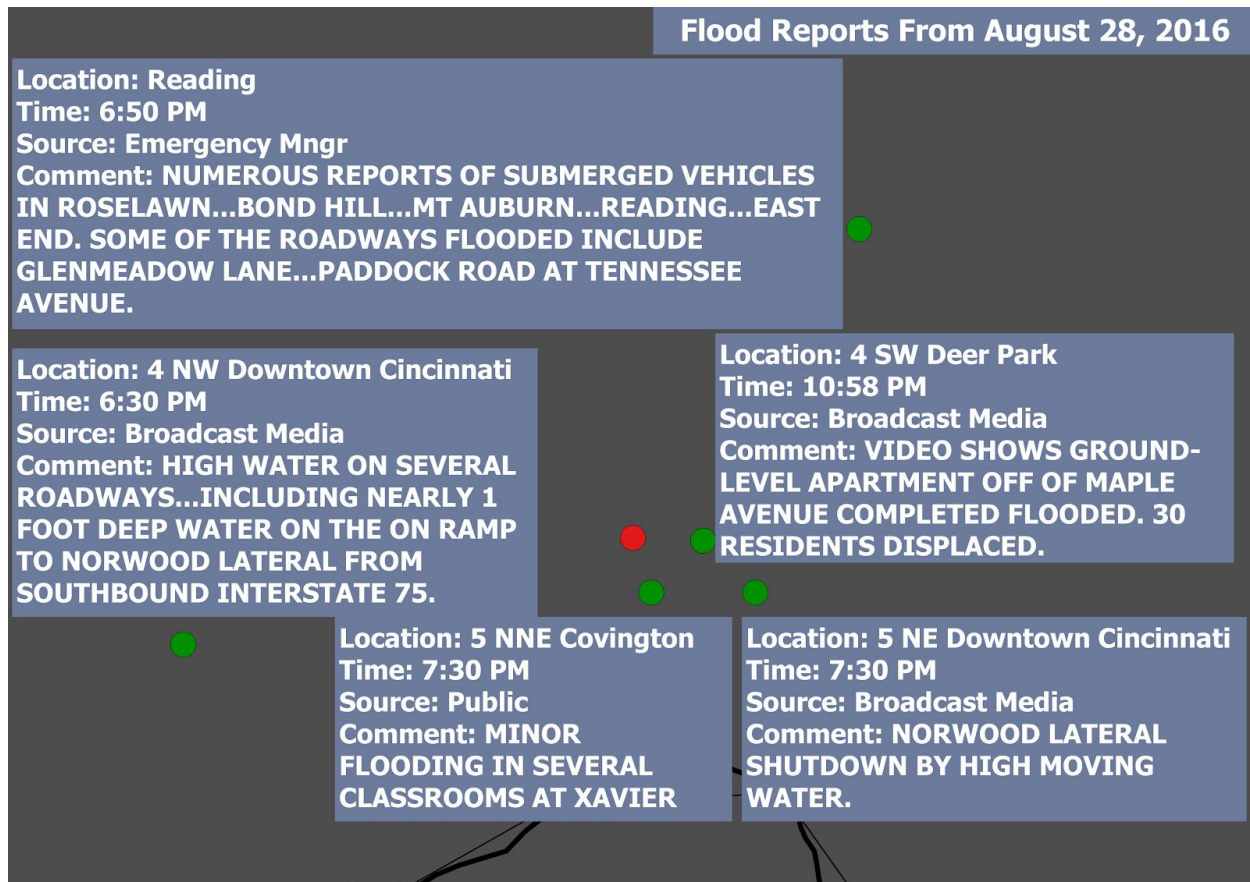
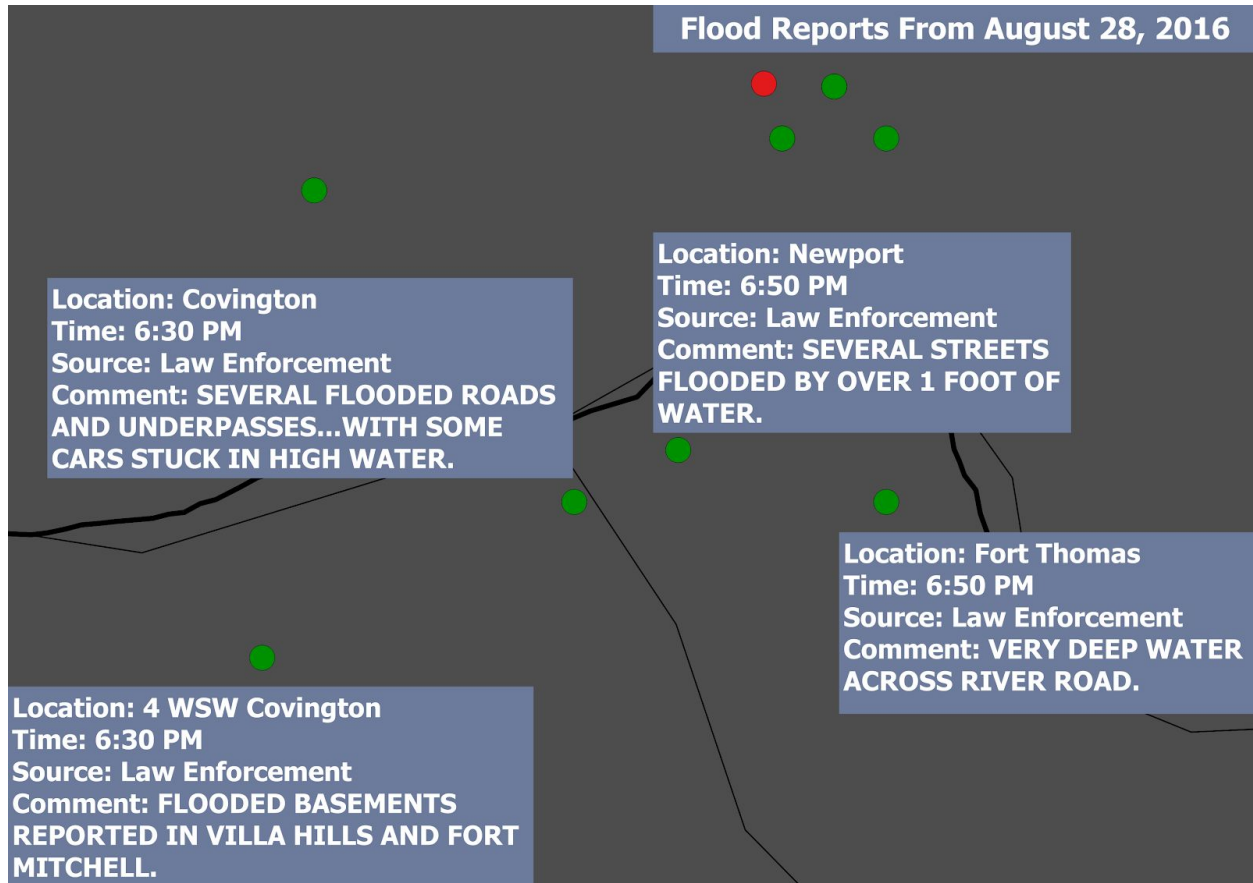


Figure 16. Summary of flood reports in and around the property on August 28th, 2016.  
Source: NWS Wilmington.

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*Figure 17. Summary of flood reports in and around the property on August 28th, 2016.  
Source: NWS Wilmington.*

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In addition to the intense precipitation, gusty winds were observed in the area. Cincinnati International Airport (CVG) recorded gusts over 25 mph between 6:43PM and 7:52PM, with the gusts peaking at 41 mph at 6:52PM and 7:01PM (Figure 18).

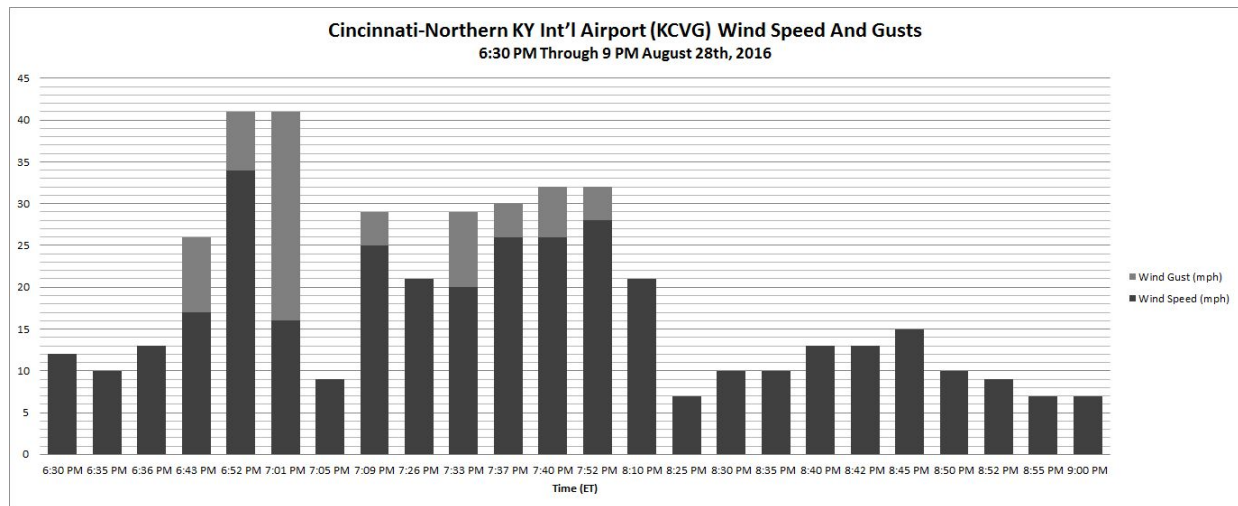


Figure 18. Graph of wind speed and gusts reported at the KCVG airport between 6:30PM and 9 PM August 28th, 2016. Source: NWS/IEM.

Cincinnati Lunken Airport (LUK) also recorded gusty winds (below 30 mph). As shown in Figure 19, a gust of 29 mph was recorded at 7:12PM and 22 mph at 7:53PM. It should be noted that the winds speeds and gusts experienced this evening were below the National Weather Service's severe criteria (58 mph).<sup>6</sup>

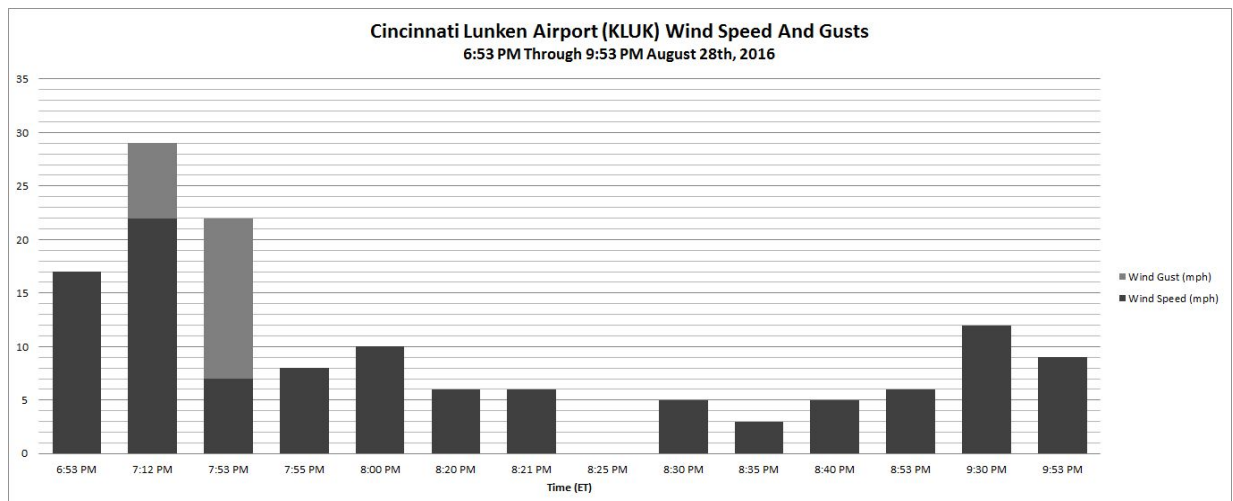


Figure 19. Graph of wind speed and gusts reported at the KLUK airport between 6:53PM and 9:53PM August 28, 2016. Source: NWS/IEM.

### CONCLUSION

After exhaustive analysis of credible, industry-standard meteorological databases, including archived Doppler radar reports, airport observations, National Weather Service products, and professional storm spotter summaries, we can conclude that the torrential downpours experienced on August 28th, 2016 likely contributed to the wall collapse experienced on that date at the Property.

An unusually wet August resulted in a low threshold for flash flooding due to elevated ground moisture. Record daily rainfall was reported in the area a few weeks prior to the incident on August 15th and August 17th. Over a half inch of rain was then reported on August 20th, followed by the torrential rainfall experienced on August 28th.

There is no question that the magnitude of the rain event on August 28th would be impactful for the area and, specifically, the Property. A Flash Flood Warning, upgraded to a Flash Flood Emergency, was issued for the Property on that date due to the dangerous flooding that was occurring in the area--enough to shut down parts of a major interstate. Doppler radar rainfall estimated 4" to 5"+ of rain that evening. Storm reports confirmed the incredible rainfall with official ground reports of 2" to 4"+ in a matter of a few hours, which strains infrastructure. It is not unusual to see washed-out roads and mud slides in this kind of event. Officials at the Metropolitan Sewer District of Greater Cincinnati stated that the amount of rain on August 28th, 2016 qualified for a 100-year storm, meaning that a rain event like this occurs once in 100 years on average (1% chance).<sup>7</sup> This was a significant event.

This torrential rain would have certainly added stress to the wall that collapsed as the ground was likely completely saturated (exacerbated by the unusually wet pattern in the second half of August 2016). Additionally, strong wind gusts were occurring in the area with these thunderstorms, which adds as yet another stressor even though the wind gusts were well below severe criteria. For example, it's not unusual for non-severe wind gusts to topple trees during or after an intense rain event as the ground "loosens" from being saturated.

After analyzing all available credible meteorological data, I can confirm, with a reasonable degree of meteorological certainty, that the flash flooding event of August 28th, 2016 contributed to the wall collapse at the Property. It is my professional opinion that our analysis confirms that the intensity of rain caused significant damage across the Cincinnati area, leaving behind a well-documented trail of flooding, recorded by NWS Doppler radar scans, airport observations, trained National Weather Service storm spotters and advisories.

Paul Douglas, Certified Broadcast Meteorologist, Founder and Senior Meteorologist, Praedictix



Paul Douglas is Minnesota's first AMS-Certified Broadcast Meteorologist, with a 40 year career in television, print and radio. He is Founder and President of Praedictix Weather, with offices and TV studios in Minneapolis, Minnesota. In 2011 his on-air team and engineers helped to launch WeatherNation TV, a new 24/7 national weather channel dedicated to meteorology and storm coverage across the USA. His firm specializes in custom weather solutions for media and corporate weather briefings, helping to aid in productivity, efficiency and safety for weather-sensitive businesses, including forensic meteorological consulting. Douglas is also a founding investor and senior manager at AerisWeather, specializing in high-resolution weather data streams and APIs, available to power businesses worldwide.

Douglas has a meteorology degree from Penn State, where he sits on the Meteorology Advisory Board. In his television career he appeared on the CBS Evening News, Nightline, MSNBC and CNN. His broadcast meteorology positions took him from the New York City area and Chicago to the Twin Cities, his current home. In 2004 he wrote a book about extreme weather, "Restless Skies", for Barnes and Noble. In 2016 Douglas released a book focused on climate change, "Caring for Creation: The Evangelicals Guide to Climate Change and a Healthy Environment," highlighting not only the science, but the spiritual case for addressing climate volatility.

Previous companies include "EarthWatch Communication," which invented 3-D weather graphics licensed to television stations worldwide – and featured in Steve Spielberg's movies "Jurassic Park" and "Twister". His last venture was "Digital Cyclone", the first company in the world to put an app on a cellular phone in 2001. He sold that company to Garmin in 2007 to focus on his latest ventures.

Douglas writes a daily print and online column for the Star Tribune and the St. Cloud Times and WeatherNation. He contributes to the CSRRT, The Climate Science Rapid Response Team, and is a member of the board of EEN, the Evangelical Environmental Network. TV meteorologist, author and teacher, Douglas speaks to corporations about severe weather and climate trends - and his entrepreneurial ride launching 4 start-up companies. He is active in Boy Scouts and SAVE, Suicide Awareness, Voices of Education. Married to a professional architect for 33 years, Douglas has two sons:

a digital marketing specialist and a Naval Academy graduate and helicopter pilot, currently based in San Diego.

### APPENDIX

<sup>1</sup>: Hourly observations on August 28th, 2016 at Cincinnati International Airport:

[https://mesonet.agron.iastate.edu/sites/obhistory.php?station=CVG&network=KY\\_ASOS&year=2016&month=8&day=28](https://mesonet.agron.iastate.edu/sites/obhistory.php?station=CVG&network=KY_ASOS&year=2016&month=8&day=28)

<sup>2</sup>: Hourly observations on August 28th, 2016 at Cincinnati International Airport:

[https://mesonet.agron.iastate.edu/sites/obhistory.php?station=LUK&network=OH\\_ASOS&year=2016&month=8&day=28](https://mesonet.agron.iastate.edu/sites/obhistory.php?station=LUK&network=OH_ASOS&year=2016&month=8&day=28)

<sup>3</sup>: "What is Dual-Polarization Radar and What Can It Do for Me?" NWS Louisville. Accessed 15 June 2017.

[https://www.weather.gov/media/lmk/soo/Dual\\_Pol\\_Overview.pdf](https://www.weather.gov/media/lmk/soo/Dual_Pol_Overview.pdf)

<sup>4</sup>: "Severe Weather And Flash Flooding On August 28, 2016" NWS Wilmington. Accessed 5 June 2017.

<https://www.weather.gov/iln/20160828>

<sup>5</sup>: "Flash Flood Emergency Shuts Down Interstate 71 in Cincinnati..." The Weather Channel. Accessed 14 June 2017. <https://weather.com/news/weather/news/flash-flood-emergency-cincinnati-ohio>

<sup>6</sup>: "Frequently Asked Questions: How does the NWS define a severe thunderstorm?" Storm Prediction Center. Accessed 14 June 2017. <http://www.spc.noaa.gov/faq/#4.2>

<sup>7</sup>: "Torrential Downpour was 100-year Storm." Cincinnati.com. Accessed 15 June 2017.

<http://www.cincinnati.com/story/news/2016/08/29/torrential-downpour-100-year-storm/89539302/>

### Other Links

#### Severe Watch & Warnings

- August 2016 Rainfall (CVG Airport):  
[https://mesonet.agron.iastate.edu/sites/hist.phtml?station=CVG&network=KY\\_ASOS&year=2016&month=8](https://mesonet.agron.iastate.edu/sites/hist.phtml?station=CVG&network=KY_ASOS&year=2016&month=8)
- August 2016 Rainfall (LUK Airport):  
[https://mesonet.agron.iastate.edu/sites/hist.phtml?station=LUK&network=OH\\_ASOS&year=2016&month=8](https://mesonet.agron.iastate.edu/sites/hist.phtml?station=LUK&network=OH_ASOS&year=2016&month=8)

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- Flash Flood Warning issued at 7:27PM August 28th, 2016:  
<http://mesonet.agron.iastate.edu/vtec/#2016-O-NEW-KILN-FF-W-0044/USCOMP-NOQ-201608282330>

### Storm Reports

- August 28th, 2016:  
<https://mesonet.agron.iastate.edu/lsr/#ILN/201608280500/201608291700/0100>

**National Weather Service (NWS) Wilmington, OH:** Local National Weather Service office responsible for issuing forecasts and warnings for the Property.



Figure A1. National Weather Service county responsibility map. Source: NWS