

USING A LIGHTNING SAFETY TOOLKIT FOR OUTDOOR VENUES

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Abstract

The threat of fatal lightning strikes at outdoor venues continues to be a pressing concern for event managers. Several delays were documented in 2010 and 2011 in which spectators did not have enough time to evacuate, or chose to wait out delays in unsafe locations. To address this issue, the National Weather Service (NWS) developed a lightning safety toolkit and recognition program to help meteorologists work with venue officials to encourage sound and proactive decisions when thunderstorms threaten their venue.

1. Introduction and Background

Every year, hundreds of outdoor venue managers are challenged to determine when an event delay is necessary due to thunderstorm hazards. In 2000, "ninety-two percent of National Collegiate Athletic Association (NCAA) Division I athletic departments responding to a survey did not have a formal, written lightning-safety policy" (Walsh et al. 1997). Thus, it was clear venue managers needed easily accessible and adaptable plans. With commercial lightning detection services available, some venue managers have become more proactive with enforcing delays. Despite delays, there is still a lag in spectator response, as patrons often choose to stay in open areas where they are vulnerable to lightning. To address this issue, the NWS unveiled a new voluntary recognition program in May 2010. This program helps large venues better protect performers, staff, and patrons from the dangers of lightning.

This program provides venue management the means to develop proper plans for a lightning delay. The process involves implementing a toolkit with

guidelines that are used as a template for creating a new plan or enhancing an existing plan. The toolkit was developed within the framework of NCAA Guideline 1d. The NWS used plans from the University of Tampa, the University of Maryland, and Vanderbilt University along with guidance from emergency management at the University of Tennessee and Florida State University as assistance to develop the toolkit.

Guidelines established for venue management include: redundant data reception sources; effective decision support standards; multiple effective communication methods; a public notification plan; protection program with shelters; and education of staff and patrons. The toolkit template safety plan helps venues meet these guidelines by providing steps to follow before, during, and after the event.

To create a safety plan or enhance an existing one, management can complete the template by filling in the location's site-specific information. The resulting written lightning safety document can then be easily and quickly referred to when there is an impending lightning threat to an event. With this information, locations can ensure they have taken proper lightning safety measures.

2. Delays in Large Venues

In 2010 and 2011 there were lightning delays during football games at four National Football League (NFL) games, 39 collegiate games, and at high school games in 34 states (Figures 1 and 2). This includes four injuries from lightning strikes at high school games. Observations from the following four games led to modifications in the toolkit.

Tennessee faced Oregon on September 11, 2010, in a game with 102,035 fans in attendance at Neyland Stadium in Knoxville, Tennessee. Event officials tracked a thunderstorm as it approached the

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stadium, and called for an evacuation of the stadium when the storm was within six miles. The University of Tennessee Director of Emergency Management determined that this was not sufficient time to safely evacuate spectators. This incident resulted in the university restructuring its lightning delay policy. Evacuation routes were mapped along with shelters near the stadium concourse. Also, the University opted to use an eight mile minimum radius for National Lightning Data Network (NLDN) detections or flash-to-bang distance estimates for lightning proximity instead of the NCAA and Southeastern Conference (SEC) rule of six miles.



FIGURE 1- Lightning delays at football games in 2011.



FIGURE 2- Lightning delays at football games in 2010.

Many venue managers across the country are mistaken to believe that NCAA Guideline 1d requires venues to begin mandatory evacuations when lightning is observed within a six-mile radius of the stadium; however, step 5a within the guideline states that “As a minimum, lightning safety experts strongly recommend that by the time the monitor observes 30 seconds between seeing the lightning flash and hearing its associated thunder, all individuals should have left the athletics site and reached a safer structure or location” (Bennett et. al, 2). Using the flash-to-bang method, this equates to an approximate radius of six miles from the location. This distance was deemed the most appropriate, although not completely safe, as it accounts for around 80% of flashes within a

thunderstorm (Lopez and Holle, 1999; Murphy and Holle, 2005). Thus, the guideline infers that spectators *must already be cleared from the stands* when lightning is observed at six miles from the venue.

On September 3, 2011, there were two game delays within 150 miles of each other. One occurred at the University of Michigan in Ann Arbor, Michigan, the other at the University of Notre Dame in South Bend, Indiana. Both events were nationally televised and well documented. Lightning strikes occurred just behind Notre Dame Stadium while fans were still in the stands. This raised the concern of spectators not exiting the stands in a timely fashion with an impending storm. Further downstream at Michigan, officials called for a delay at Michigan Stadium with 110,506 spectators in the stands. With the call for the delay, radar imagery was posted on the stadium's video display boards. This was effective as most people look for a second source of information before taking action (Mileti and Sorenson, 1990). In this case, the first source was the announcement on the stadium's public address system, and the radar display was the verifying (second) source. Following two delays lasting one hour and twenty minutes, officials called the game before it was completed. The Michigan game was shortened, with each team's athletic director agreeing in the abbreviated result. Meanwhile, at Notre Dame Stadium, the game resumed and was completed after the two delays lasted a total of 2 hours and 33 minutes.

In July of 2011, NWS officials met with West Virginia University venue management to enhance plans for delays at sporting events. These plans were put to the test on September 4, 2011, when the “Friends of Coal Bowl” was played between Marshall University and West Virginia in Morgantown, West Virginia. During the third quarter, 60,758 fans were in the stands at Milan Puskar Stadium when officials delayed the game. West Virginia venue management took exemplary actions leading up to and during the delay, yet this event provided many lessons. Announcements were made both at halftime and during the third quarter, stating that thunderstorms were developing in the area and that a delay would be possible. This allowed spectators to prepare for the potential of a delay. When thunderstorms began back-building toward the stadium, officials announced the delay and instructed spectators to evacuate to the nearby practice facility, their vehicles, and the concourses. Spectators were again slow to exit, with some refusing to leave their seats. Television cameras documented a cloud-to-ground lightning strike directly behind the stadium while spectators remained in the upper deck on that side of the venue. Fortunately, no one was injured in this near miss; however, the threat was taken more seriously after this strike. The combination of this strike and a

sweep completed by West Virginia State Police officers cleared the stands. After conducting a post-event review of this delay, West Virginia University event management officials determined that the elderly and disabled did not have enough time to exit the venue before the thunderstorms arrived. In addition, spectators who gathered in the concourse area said they could not hear announcements or view radar imagery from closed circuit televisions. Officials have addressed these issues in their revised plans.

3. Eligibility

Any organization that manages a large gathering of patrons at an outdoor venue can utilize the lightning safety toolkit. Venues include, but are not limited to: golf courses, fairgrounds, stadiums, concert pavilions, water parks, raceways, beaches, and amusement parks. The flexible toolkit can be modified for use at all levels of competitive sports (from little league to professional).

4. Guidelines and Site Preparation Checklists

The toolkit includes recommendations for: 1) effective weather information reception; 2) a written lightning safety plan; 3) emergency management and NWS contacts; 4) a public notification plan; 5) a protection plan to shelter patrons; and 6) lightning safety education for venue patrons. To create a safety plan or enhance an existing one, venue management can fill in the toolkit template with the location's site-specific information. The resulting lightning safety document can then be easily and quickly referred to when lightning threatens an event. These recommendations are described in further detail:

- 1) To fulfill the information reception guidelines, the venue must install a locally-run lightning detection system with a display unit on site or subscribe to a commercial notification system. The facility must also have a NOAA Weather Radio on location.
- 2) The decision support standards indicate that the venue must have a written lightning safety plan that includes directions on when to initiate evacuation protocol during an event.
- 3) The local emergency management contacts need to be readily available along with information of how to contact commercial weather data providers and the NWS.
- 4) The venue must have several means to notify its patrons that a lightning threat exists. Options include a public address system, internal television/radio broadcast, text/email

message alerts, use of social media, and staff announcements.

- 5) For protection, the venue must have means to shelter patrons. This would include a written emergency operations safety plan to evacuate the venue, signs indicating where shelters are located, substantial structures on venue property (e.g. golf courses could use restrooms and club house facilities which are easily accessible from a majority of the course). The venue should investigate lightning protection equipment that diverts strikes to the tallest object and away from patrons and staff.
- 6) The NWS can provide lightning safety education materials. The venue should ensure it informs patrons of lightning precautions it has taken and the actions patrons should take when notified of a lightning threat.

5. Using the Toolkit

The toolkit includes three parts: actions to take before, during, and after the event.

Before the Event: For the toolkit to be effective, a designated weather watcher will be assigned to ensure a situational awareness plan is in place the day before and the day of the scheduled event. Staff members are encouraged that if thunderstorms are forecast for the day of the event, officials will review the safety plan before the event and identify the responsible officials and chain of command to implement the safety plan. Specifically, officials will designate a weather watcher for the event who will notify officials of the status of any thunderstorm that may threaten the safety of the event. If thunderstorms are in the forecast, officials will notify patrons at the venue prior to the event beginning. In addition, lightning safety guidelines and evacuation procedures will be printed in event programs.

Shelters need to be designated in the planning period well before an event. Evacuation routes should be mapped, similar to the example provided by the University of Tennessee (Figure 3). If a substantial building is not available, enclosed motor vehicles can provide shelter as long as patrons do not touch the metal framework during the thunderstorm. No place outside is safe if lightning is in the vicinity. Partially enclosed vending areas and picnic shelters are not safe. If no safe shelter is available, direct patrons to stay away from the tallest objects (trees, light poles, flag poles), metal objects (fences or bleachers), standing pools of water, and open fields. If patrons are still in transit to the venue, encourage

them via local radio broadcast to remain in their vehicles until the lightning threat has ended.

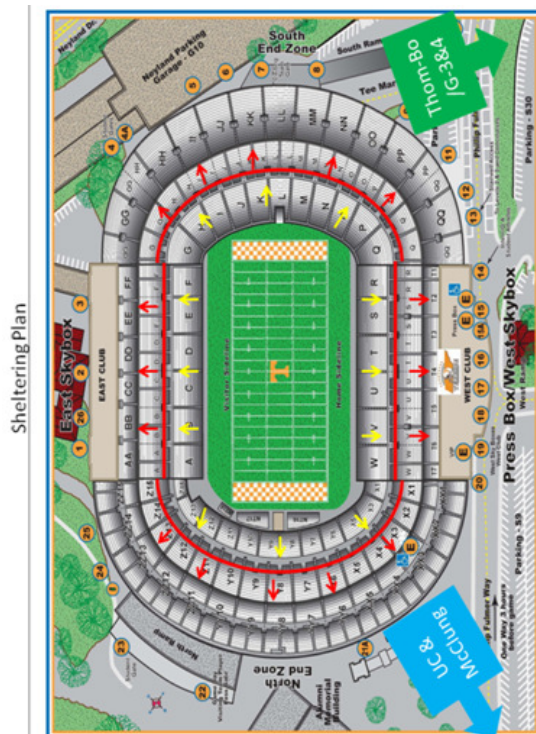


FIGURE 3- Evacuation map for Neyland Stadium in Knoxville, TN.

During the Event: The weather watcher will use weather monitoring and lightning detection tools along with local observations to help determine the proximity of lightning and which safety actions to implement. Local observations in the toolkit are taken from NOAA's recommendation that:

"The best course of action is to practice, *'When Thunder Roars, Go Indoors!'* The Flash/Bang method can also be utilized. To use this, the observer begins counting at the sight of the lightning flash. Counting is stopped at the sound of related thunder. The count is then divided by five to determine the distance (miles) that the lightning strike is from the venue. Large venues with long evacuation times should consider a longer count." The direction and speed of an approaching thunderstorm should be accounted for along with locally developing storms that may form nearby or overhead."

If lightning is in the vicinity, lightning radii distance actions need to be referenced. The radii recommended are eight, 12, and 15 miles (Figure 4). Eight miles was used instead of the NCAA minimum of six miles based on feedback from the University of Tennessee and Florida State University. This is also to

account for the fact that 20% of strikes occur beyond the six mile radius (Lopez and Holle 1999; Murphy and Holle 2005). Venues need to also take into consideration phenomena referred to as bolts from the blue. A bolt from the blue is "lightning which comes out of the side of the updraft, travels a significant distance in the horizontal away from the parent updraft from which it originated, then turns down towards the ground and strikes the ground" (Hodanish, 1996). These strikes have been observed from as far as 20 miles from a thunderstorm.

The radii are recommended based on best practices used at the example universities referenced earlier (Vanderbilt, Tampa, Tennessee, Florida State, and Maryland). The toolkit is worded, however, to allow for the flexibility of each individual venue. Thus, the radii can be changed to fit a specific venue's needs. The action points with the radii are as follows:

When lightning is detected within (15) miles of the venue:

- Weather watcher notifies management of elevated lightning monitoring. Management notifies the event officials.
- Venue management notifies all staff members of the potential for a delay. Designated staff members are stationed to direct patrons to the proper shelters.
- An evacuation of the facility will begin if it appears the thunderstorm is moving toward the venue. If a more organized thunderstorm or cluster of thunderstorms (supercells, squall lines, bow echoes) are headed for the venue, a 30 minute lead-time or more should be considered for an evacuation. These are the major impacting events with high lightning counts where an advanced delay or postponement of the event is justified. In these cases, the weather watcher or lightning detection system operator should estimate the speed and direction of the storm movement to determine when they will enter an (8) mile radius of the venue. Public address system announcements are made.

When lightning is detected within (12) miles of the venue:

- Weather watcher notifies venue management of impending lightning threat. Management notifies the event officials.
- Venue management informs all event staff of an impending delay. Staff members are

stationed to direct the crowd to the proper shelters.

- An evacuation of the facility begins or continues. If more organized thunderstorms (supercells, squall lines, and bow echoes) are headed for the venue, an evacuation will be necessary. Public address system announcements are made.

When lightning is detected within (8) miles of the venue:

- Weather watcher notifies venue management of nearby lightning threat and an event delay is implemented. Management notifies the event officials. Event officials suspend activities.
- Venue management informs all event staff that the event has been suspended due to lightning in the area. Staff members are positioned to direct the crowd to the proper shelters.
- An evacuation of the venue begins and public address system announcement are made.
- All patrons are directed to the nearest lightning-safe shelter.
- All event performers and officials will be evacuated to pre-designated safe shelter areas.

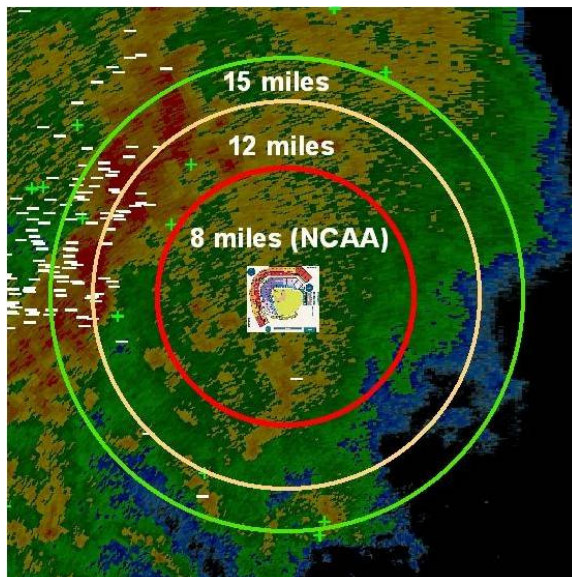


FIGURE 4- Recommended lightning radii for large outdoor venues.

Following the radii decision points, prepared statements are listed for the public address announcer

to use to announce the potential for an evacuation and when an evacuation is in place. In addition, the definitions of severe thunderstorm and tornado watches/warnings are explicitly defined to prevent confusion for the venue operations team.

After the Event: The weather watcher is instructed to remain on duty until post-event operations come to an end. A review of the weather's impact on event operations and the effectiveness of the safety plan is recommended to occur in the hours after the event. As found after the West Virginia University delay, these conversations between the weather watcher and venue operations management can lead to sharing best practices and improvements in a venue's lightning safety plan.

6. Voluntary Recognition Program

The NWS recognizes organizations that use the toolkit to establish a lightning safety plan. Venue managers submit their plan to their local Warning Coordination Meteorologist for review. Successful venues are presented with two "When Thunder Roars, Go Indoors" signs at a ceremony.

In August of 2011, the Georgia Institute of Technology (Georgia Tech) submitted a completed lightning safety toolkit. After the submission was approved, the school became the first organization to be recognized for completing a lightning safety toolkit. During their recognition ceremony, they were awarded signs from the NWS Weather Forecast Office (WFO) in Peachtree City, GA (Figure 5).



FIGURE 5- Officials from Georgia Tech are recognized for completing the toolkit by Lans Rothfusz, Meteorologist-in-Charge, NWS Peachtree City, GA.

7. Future Work

The NWS will use a three phase outreach plan to approach venue managers with the toolkit.

Phase one targets large outdoor venues, specifically at the professional level and within the NCAA. These venues are most vulnerable due to the high human capacity (often 50,000+) on game days. Organizations approached in the past year include the NCAA, International Association of Venue Managers (IAVM), and the Stadium Managers Association (SMA). Future outreach also is planned with the National Association of Collegiate Directors of Athletics (NACDA), the National Center for Spectator Sports Safety and Security (NCS4), the NFL, the National Association for Stock Car Auto Racing (NASCAR), and Major League Baseball (MLB).

Phase two includes medium-sized venues (10,000-50,000 capacity) during their major events. Fairgrounds, amusement parks, water parks, golf courses, and concert venues are included in this phase. A modified version of the toolkit was made for fairs and amusement parks to account for separate challenges of notifying patrons of a lightning threat over a large area. This version of the toolkit has been endorsed by the International Association of Fairs and Expositions (IAFE). At golf courses, the toolkit can be used for delays which impact both daily play and for tournament play when thousands of patrons are on the course.

Phase three focuses on small venues (<10,000 capacity) such as most high school and little league facilities. This phase is last due to the sheer number of facilities this encompasses and the various levels in state, county, district, and municipality governments.

8. Conclusions

Since lightning injuries and fatalities during outdoor activities continue to be a concern, as evident by the cases documented herein, the lightning safety toolkit can help venue managers develop a safety plan to inform staff and patrons on the threats of lightning and reduce the risk of injury or death. The program also will increase public awareness of lightning hazards and enhance relationships with event operations staff, emergency managers, and the NWS.

The toolkit can be applied locally anywhere across the United States, and emergency managers and meteorologists are encouraged to pinpoint local vulnerable venues and event locations. They can then work with their NWS office to develop plans using the toolkit. Through proactive measures from the large professional level to the smaller local level, this recognition program is available to help outdoor venues mitigate the risks of a disaster from a lightning strike.

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