



LIGHTNING, OUTDOOR STADIUMS, AND SPECTATOR SAFETY

Joel Gratz

with Erik Noble & Ryan Church

Wednesday, January 21st, 2004

LIGHTNING STORIES...



LIGHTNING STORIES...

JUNE 6TH, 1998

WASHINGTON D.C. – RFK STADIUM

1 WOMAN STRUCK

MANY INJURED

CHAOTIC EVACUATION OF 50,000 PEOPLE...

AFTER THE STRIKE

Blacksburg, VA

August 27th, 2000

8:05 pm





Virginia Tech

What happened?

- Lightning struck the ground, 6/10-mile
- During next ten minutes, 16 strikes occurred within one mile of the center of the stadium

Fans?

- Reacted immediately
 - Ran out of the stands
 - Crowded stadium tunnels and exits
 - Braved the elements

Virginia Tech

▶ *Carol Hart- Roanoke Times Columnist*

“What I saw disturbed me. The tunnels leading from the stands to the concourse were packed solid, Ushers, emergency, or security should have been clearing those people out. Some fans tried leaving the stadium, but could not get through the tunnels. They were forced to find protection in the open.”



How did this occur?

- ▶ Game management did not heed threat of approaching storm
- ▶ Police and ushers were still tending tickets
- ▶ Inadequate loud speaker system
- ▶ There was no stadium lightning evacuation policy.



Lightning strikes (22)

1 mile

Blacksburg

Virginia Polytechnic Institute

Lane Stadium

Lane Stadium

GATE AIRPORT

460

460

460

460

SR 601

SR 414

US 460 Byp

US 460 BYP

PATRICK HENRY

HA FOSTING

SR 27

SR 26

SR 25

SR 24

LIGHTNING STORIES...

AUGUST 27TH, 2000

BLACKSBURG, VA – VIRGINIA TECH

16 STRIKES < **1** MILE FROM STADIUM

CHAOTIC & INEFFECTIVE EVACUATION
OF 50,000 PEOPLE...

DURING & AFTER THE STRIKES

LIGHTNING STORIES...

AUGUST 20TH, 2003

DENVER, CO – INVESCO FIELD (CU vs. CSU)

MULTIPLE CLOSE LIGHTNING STRIKES

PLAYERS RAN FROM FIELD

FANS GIVEN NO DIRECTION

2003

**INVESCO FIELD – NO DIRECTION GIVEN TO
SPECTATORS**

2000

**VIRGINIA TECH –
MASS CONFUSION/UNCONTROLLED CROWD
MOVEMENT**

1998

RFK STADIUM – SPECTATOR STRUCK

The Problem

Large outdoor stadiums face a significant and growing vulnerability to lightning due to increased size and frequency of events. This growth is not paralleled in the knowledge and management of spectator safety.



University of Oklahoma

September 14th, 2002, OU vs UTEP

- 1st quarter
 - Lightning struck within 6 miles
- Officials removed players from field
- Management informed crowd of 75,000
 - Crowd evacuated
- Some fans stayed in seats, exits very crowded



University of South Carolina

September 14th, 2002, University of South Carolina vs. Georgia

- 1st quarter
 - Lightning struck 5 miles away
- Officials removed players from field
- Management asked crowd of 84,227 fans to exit stadium
- Crowd evacuation very slow
- Many fans stayed in seats while lightning flashed overhead



University of Florida

September 14th, 2002, UF vs. Ohio University

- 1st quarter, football staff located lightning within 6 miles using lightning detection software
- Game officials notified
 - halted game within one minute
- Players were removed from field
- 84,000 fans were given an option to leave stadium



University of Alabama

September 27th, 2003, University of Alabama vs. University of Arkansas

- Just before kickoff
 - Lightning struck 3 miles away
- Warning issued to management by National Weather Service
- Officials removed players from the field
- Fans asked to leave
 - most were already leaving
- Fans crowded tunnels and blocked some exits

NCAA Division-I Football Attendance

- ▶ Total Attendance in 2002 was 34,384,264 people
- ▶ Attendance increased 7.38% annually since 1999
- ▶ 117 teams in Division-I football
 - more than 16% of them have reported 100% or higher attendance at home games through November 2003.
 - 42.7% of schools averaged over 90% of capacity through November 2003.

NCAA Division-I Football Event Frequency

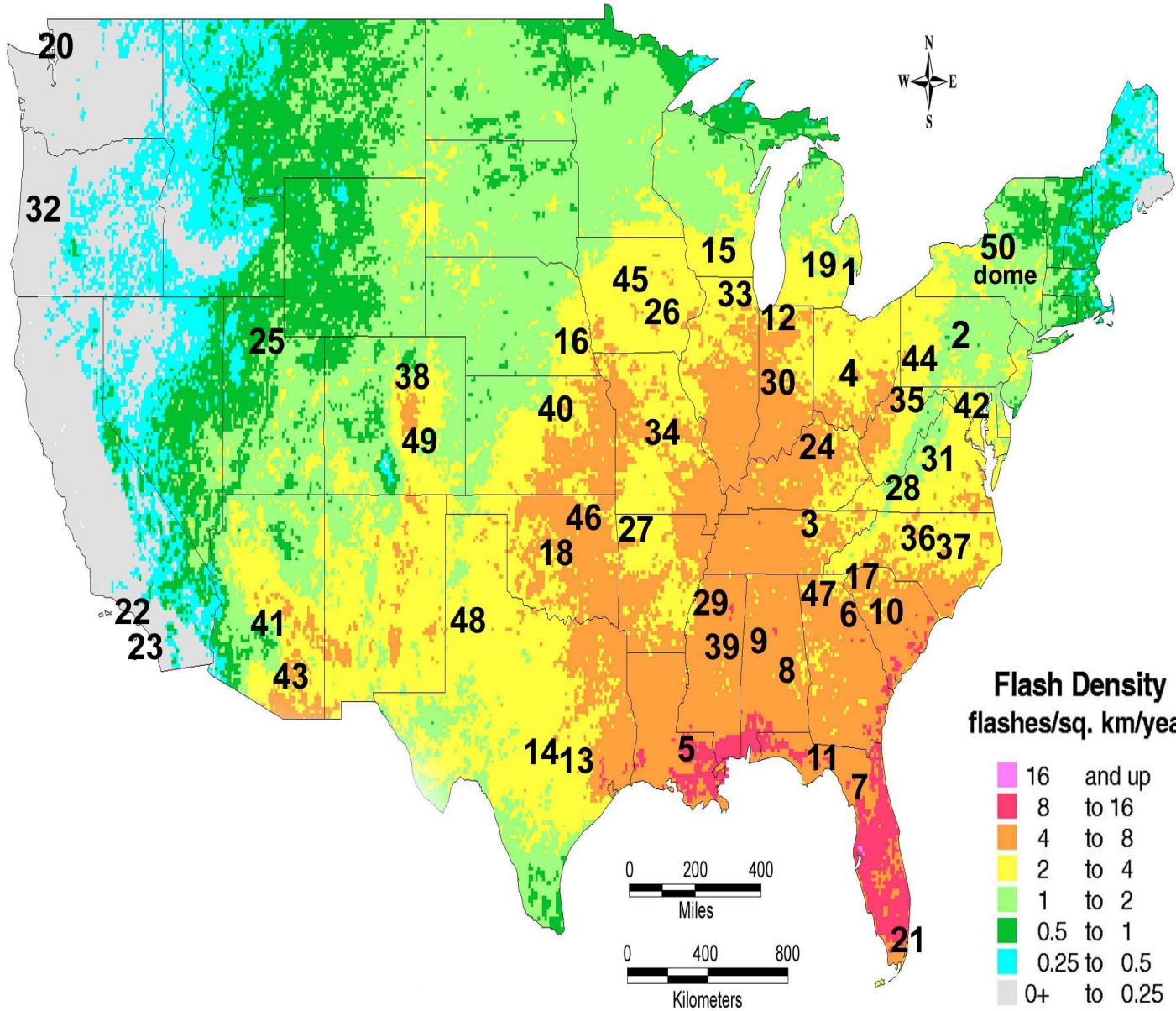
- ▶ 117 teams in Division-I football in 2002
 - 775 home games
- ▶ 3 teams added to D-I football since 2001
 - 668 games in 2001.



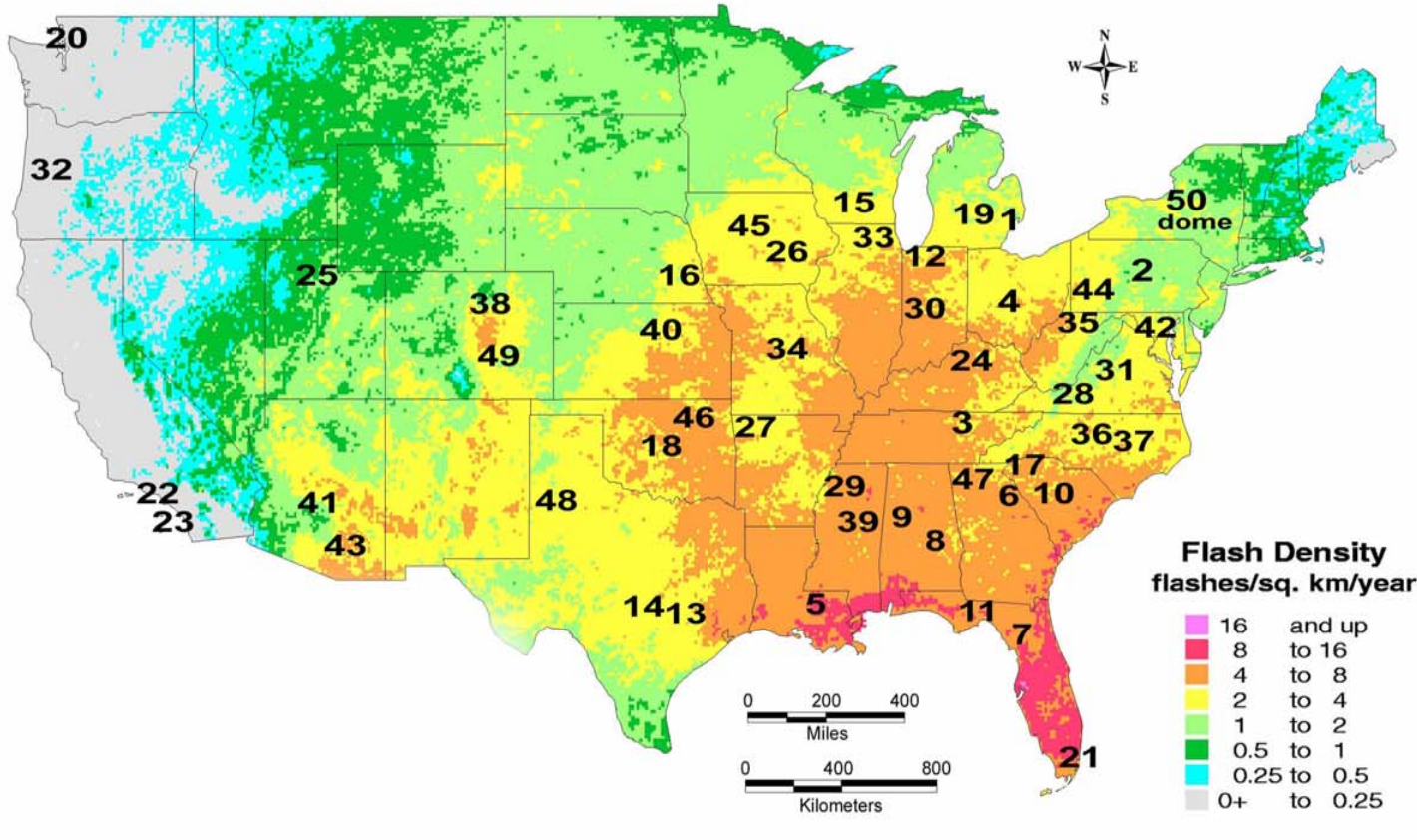
Men's Football



5-year Flash Density Map — U.S. (1996–2000)



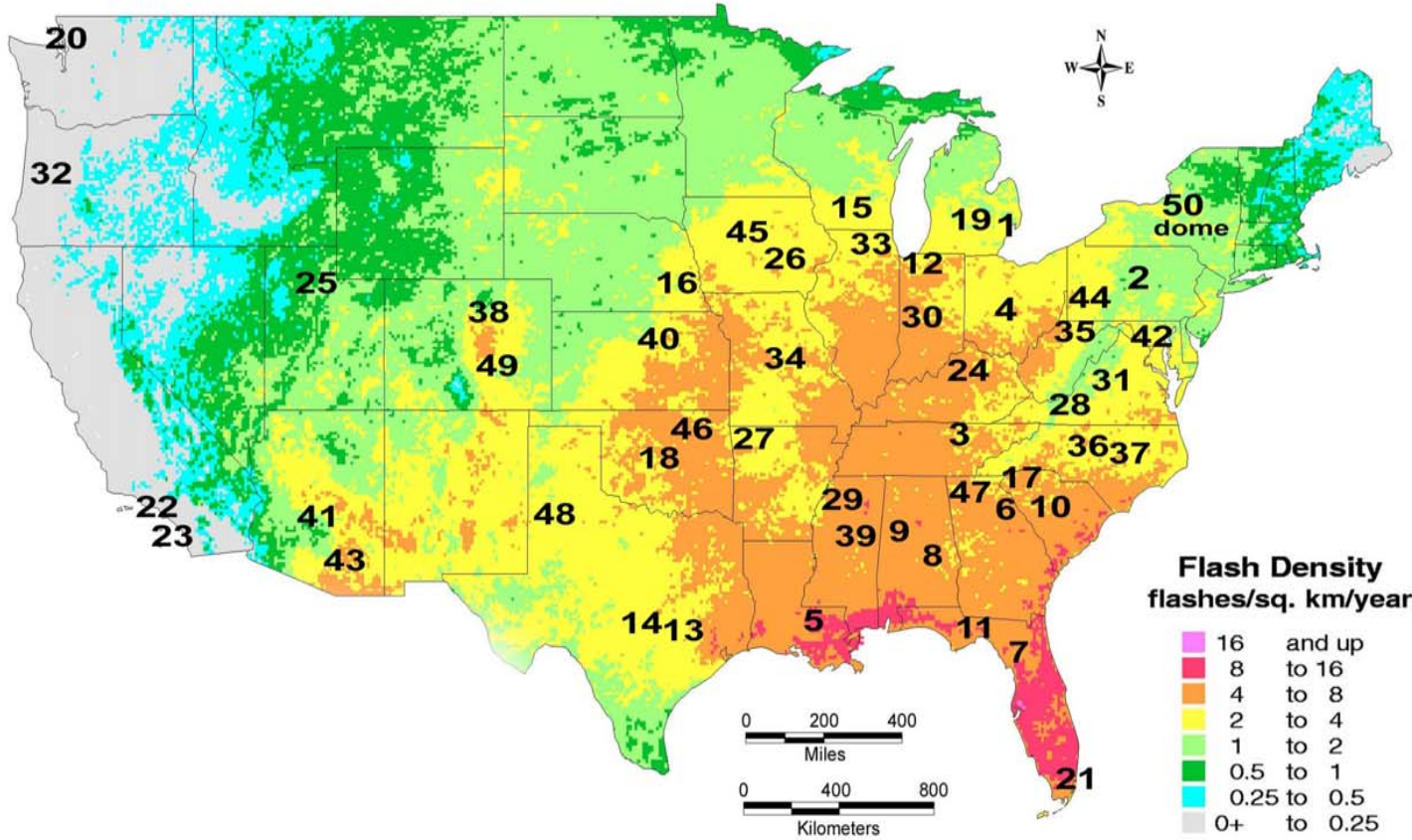
1=biggest			
RANK	SCHOOL	RANK	SCHOOL
1	Michigan	26	Iowa
2	Penn State	27	Arkansas
3	Tennessee	28	Virginia Tech
4	Ohio State	29	Mississippi
5	Louisiana State	30	Purdue
6	Georgia	31	Virginia
7	Florida	32	Oregon
8	Auburn	33	Illinois
9	Alabama	34	Missouri
10	South Carolina	35	West Virginia
11	Florida State	36	North Carolina
12	Notre Dame	37	North Carolina State
13	Texas A&M	38	Colorado
14	Texas	39	Mississippi State
15	Wisconsin	40	Kansas State
16	Nebraska	41	Arizona State
17	Clemson	42	Maryland
18	Oklahoma	43	Arizona
19	Michigan State	44	Pittsburgh
20	Washington	45	Iowa State
21	Miami	46	Oklahoma State
22	Southern California	47	Georgia Tech
23	UCLA	48	Texas Tech
24	Kentucky	49	Air Force
25	BYU	50	Syracuse (dome)



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17	Clemson	42	Maryland
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Flash Density (flashes/km ² *yr.)	Annual flashes per year in a 6-Mile Radius during games	Annual flashes in the seating area of Bryant-Denny stadium during games
6	4.8127	0.0012



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Flash Density (flashes/km ² *yr.)	Flash probability for total NCAA attendance during play	Probability of <i>one or more</i> flashes for NCAA attendance during play over the next 20 years
6	0.0591	0.7041

NCAA Guidelines

- ▶ Recommend that all individuals should have left the athletics site and reached a safe structure or location by the time the monitor obtains a flash-to-bang count of 30 seconds.
 - Lightning can 'jump' six miles from strike to strike

**NCAA Guidelines are
recommendations**

**In-house policies/procedures
are highly variable and do not
always follow NCAA
recommendations!**

ALTERNATIVES

A

**Make existing NCAA
guidelines
MANDATORY**

All persons in safe place
BEFORE LIGHTNING IS 6
MILES AWAY

B

In-Situ protection



Retrofit stadiums to protect
all areas – no evacuation
necessary

A

Make existing NCAA guidelines MANDATORY

CROWD DYNAMICS

Can you fit people in safe locations?

3 ft² per person = involuntary contact

How long will it take to move people?

Lightning Detection lead time > Evacuation time

SAFETY ACHIEVED BEFORE LIGHTNING WITHIN 6 MILES

B

In Situ Protection

AUGMENT EXISTING STRUCTURAL PROTECTION

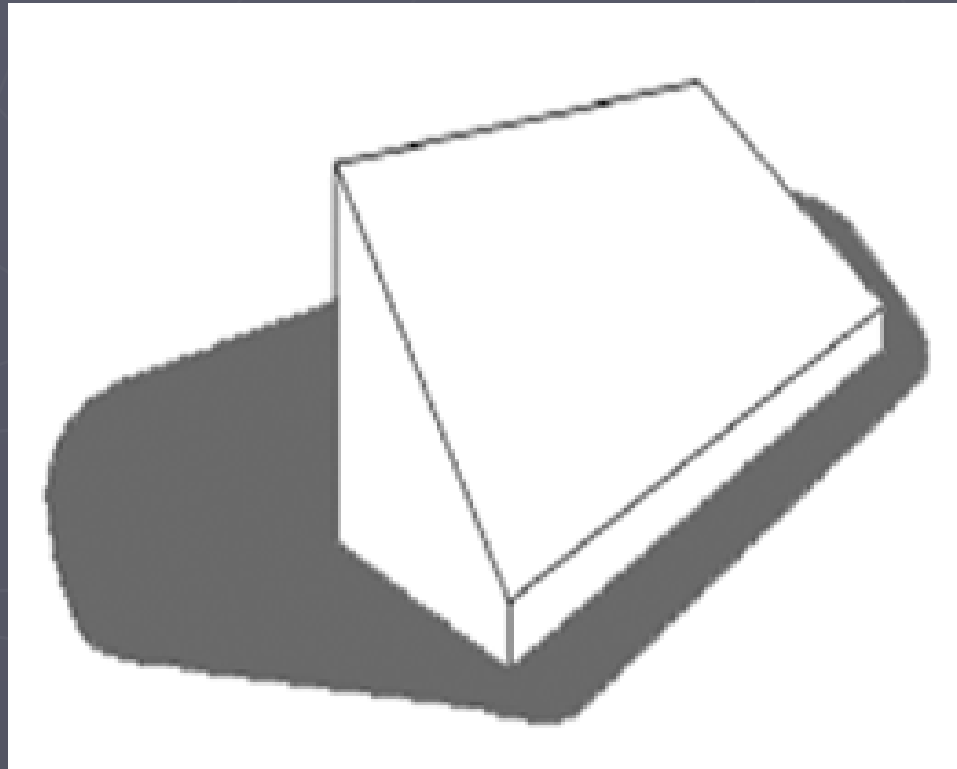
Additional Lightning Rods

Suspended Thin Wires over Open Locations

STADIUM PROTECTED = SPECTATORS DO NOT MOVE

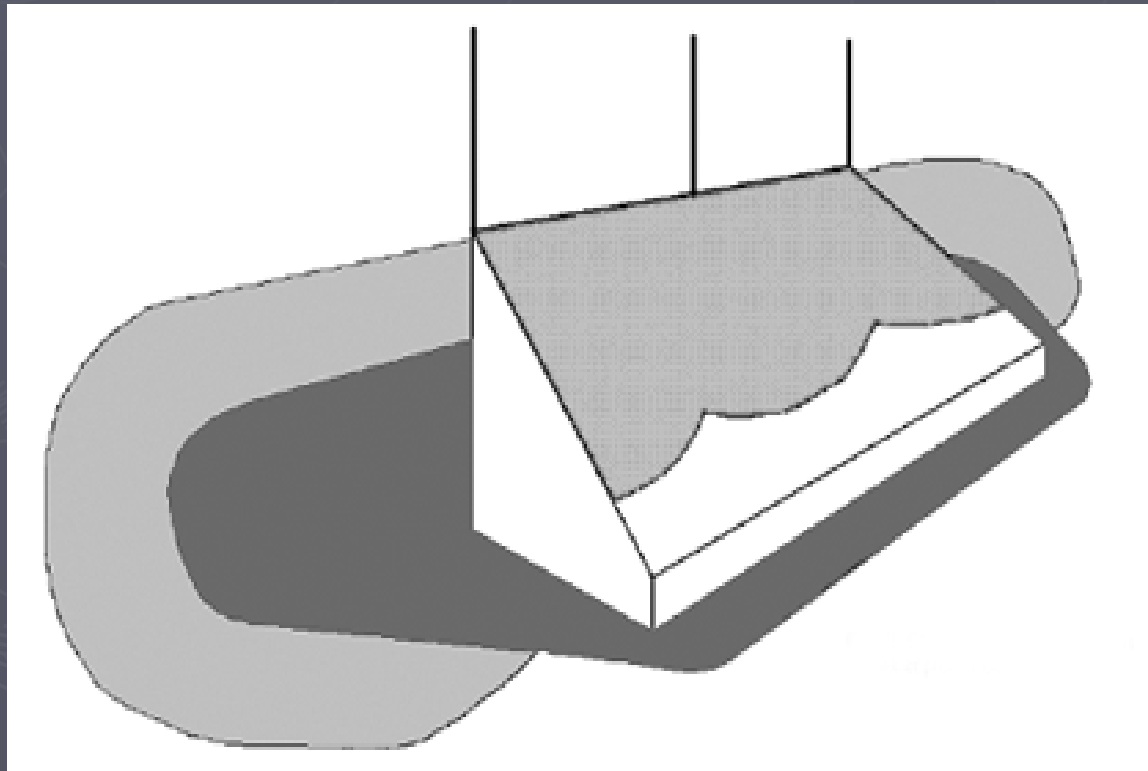
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In Situ Protection



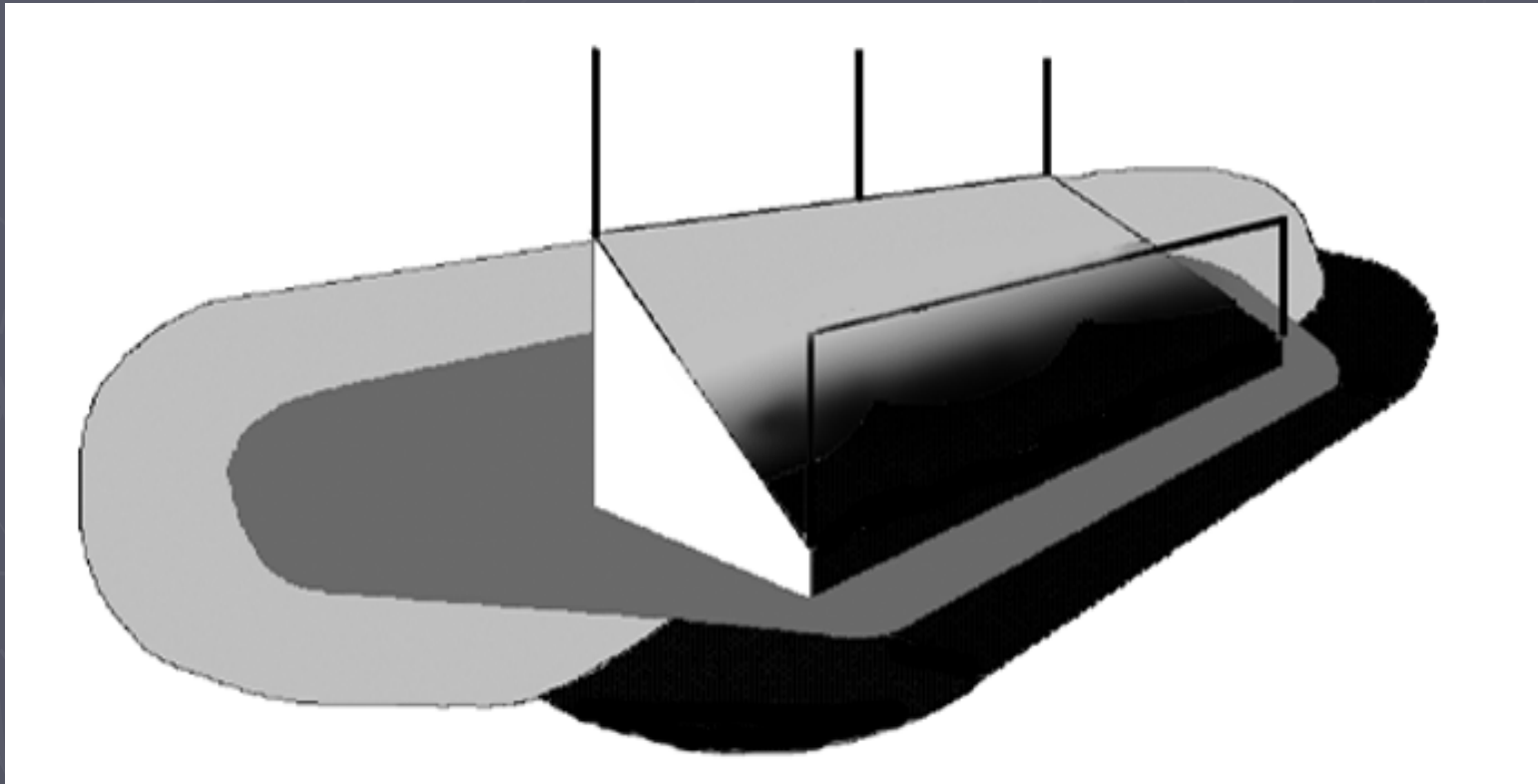
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In Situ Protection



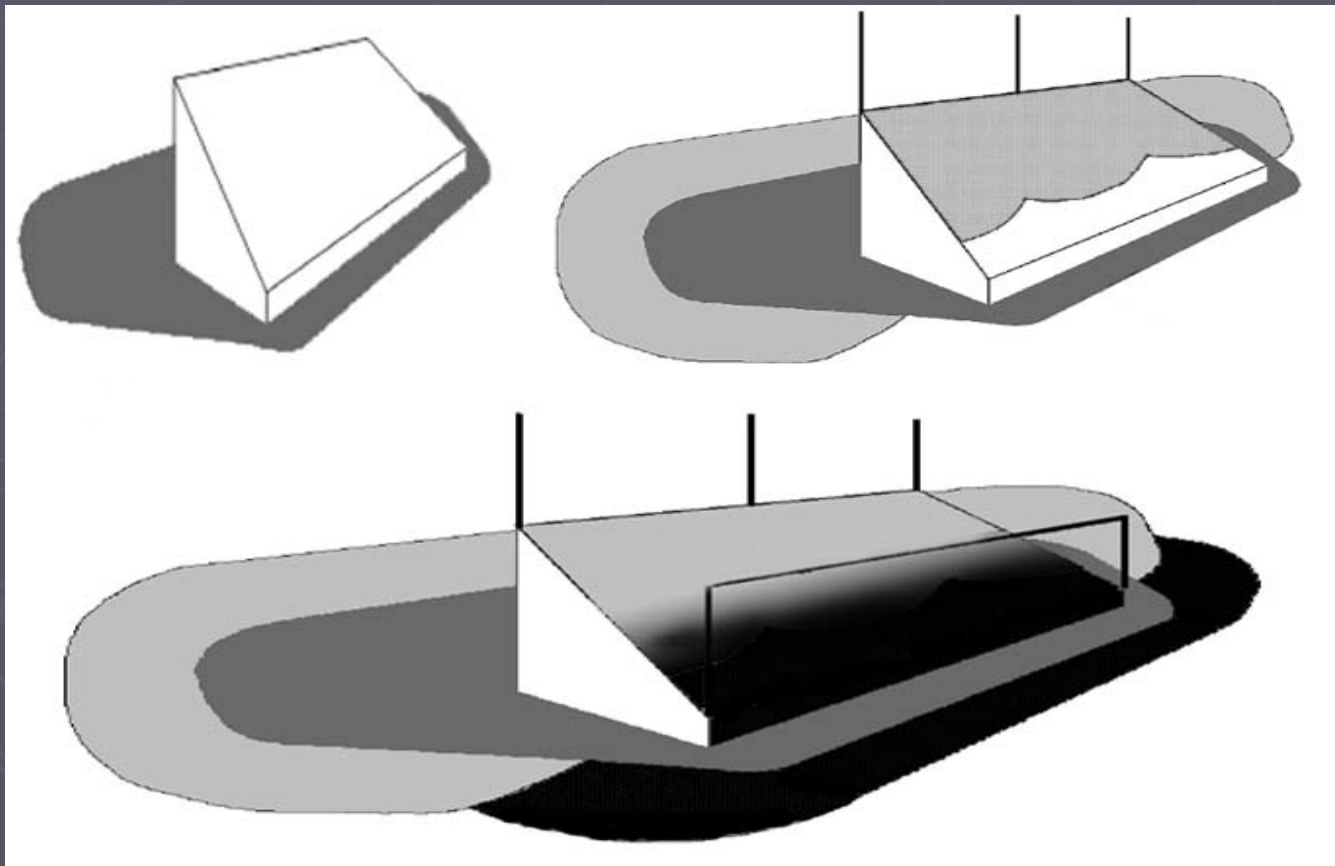
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In Situ Protection



B

In Situ Protection



RECOMMENDATION

NCAA guidelines

Fear of Repeat from Past
Lightning Problems

Satisfies Human Desire to
Seek Shelter

A

← **USER
DECISION** →

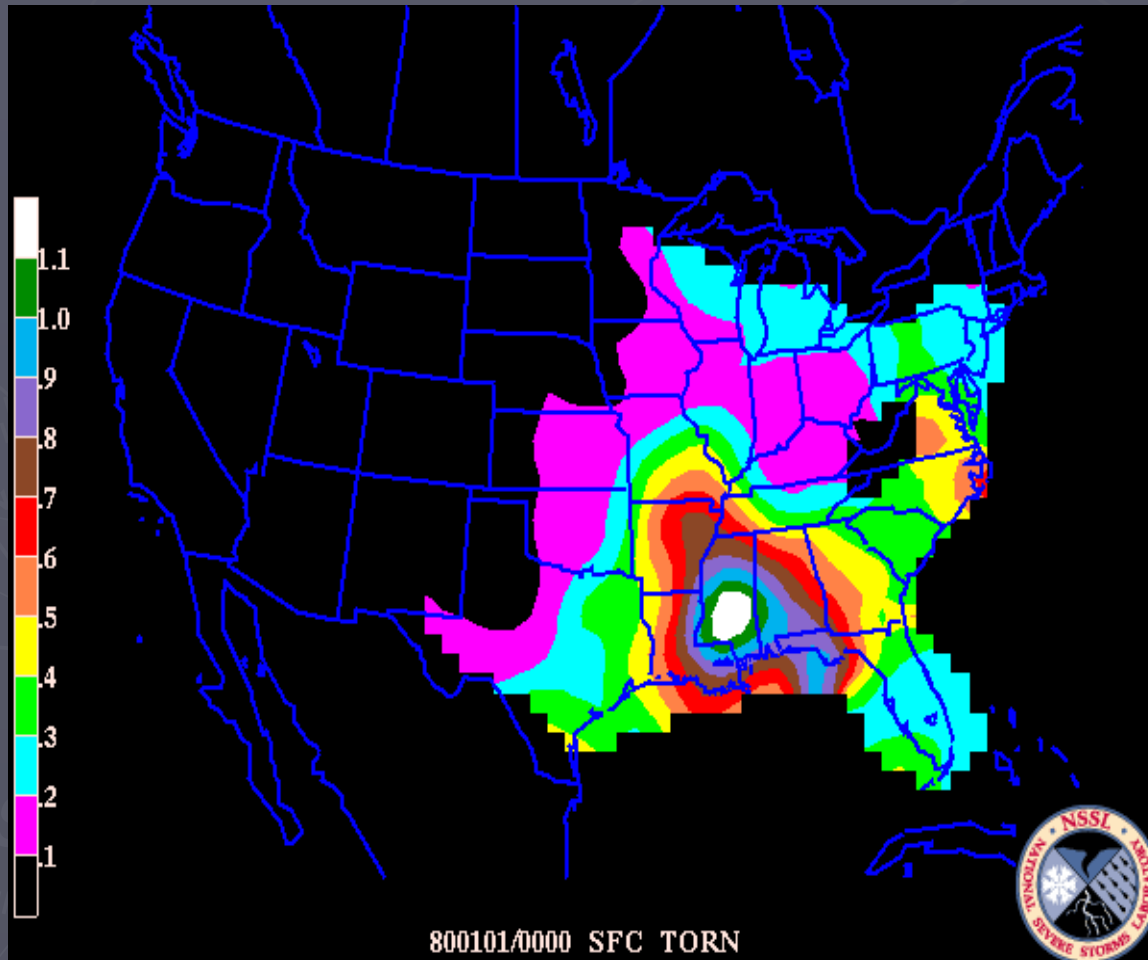
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In-Situ Protection

No Planning/Resources for
Crowd Control

Leverages Inertia: Fans
Won't Move Anyway

WHEN THINGS "FALL" INTO PLACE



Probability of
Tornado
(Oct-Dec)

Probability of
Tornado
(Jan-Sept)

STADIUM LIABILITY

“...a **SLIGHT CHANCE** of a **GREAT HARM** can be condemned as an unreasonable risk, especially where the **burden of adequate precautions...is relatively slight.**”

YOU CAN HELP...(yourself)

- **Contact local stadiums**

- **Jr / Sr High school**

- **College** (most colleges have athletic facilities far beyond a single large stadium)

- **Professional Teams** (baseball, football)

- **Inquire about their weather planning**

- **Do they have on-site warning equipment?**

- **Do they have an emergency plan for weather?**

- **What can you/your station do to help?**

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