

Weather Ready Schools:

*Should School Hallways As Storm Shelters Be
the Next Weather Safety Recommendation to be Retired?*



Presenting Author:

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Oklahoma Climatological Survey

AMS Meeting in Atlanta, GA

3 Feb 2014

Weather Ready Schools is an initiative of the Oklahoma Climate Survey. It began after an event in Norman when a tornado moved through town with two middle schools, an elementary, one high school, the police department and a hospital in its direct path. This occurred at middle school dismissal and less than 30 minutes before high school dismissal.

OCS has worked for over 15 years with both teachers and emergency managers, but the two groups were never brought together to work on common issues. Weather Ready Schools is exploring how best to meet the overlapping needs of both groups.

Hallways serve as the main shelter areas in schools.



Photo – Danny Mattox

The point of this talk is not to exclude all hallways but instead evaluate all spaces of a school campus to determine the best shelter options.

Interior hallways have been the standard shelter area for many schools. However, there are specific design components that make some hallways less safe.

Typically, survey teams assess school hallways post damage.



Larry W. Smith/European Pressphoto Agency

In the past 10 years, several school campuses have been significantly damaged by tornadoes.

Most of these storms hit when school was not in session.

Assessment teams have documented missing roofs, collapsed walls, and debris left in hallways.

Fatalities have occurred in these recommended hallways.

7 children found dead at Oklahoma school wrecked by tornado, officials say

*By Tracy Connor, Staff Writer, NBC News
Mon May 20, 2013 7:02 PM EDT*

NBCNews.com

Enterprise, Alabama - 8 students killed when tornado hit high school; deaths in Georgia take storm's toll to 20

"We were in a hall in the middle of the school," she said. "I always thought a hall in a school was one of the safest places to be during a tornado." – mother of Enterprise, Alabama student

Unfortunately, fatalities have occurred in hallways.

In May 2013, seven students were lost at Plaza Towers Elementary in Moore, Oklahoma.

Back in 2007, eight students died at a middle school in Enterprise, Alabama.

Schools need expert help to identify safer shelter options.



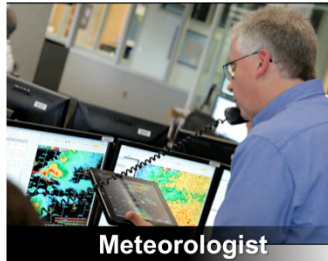
Architect



Emergency Manager



Engineer



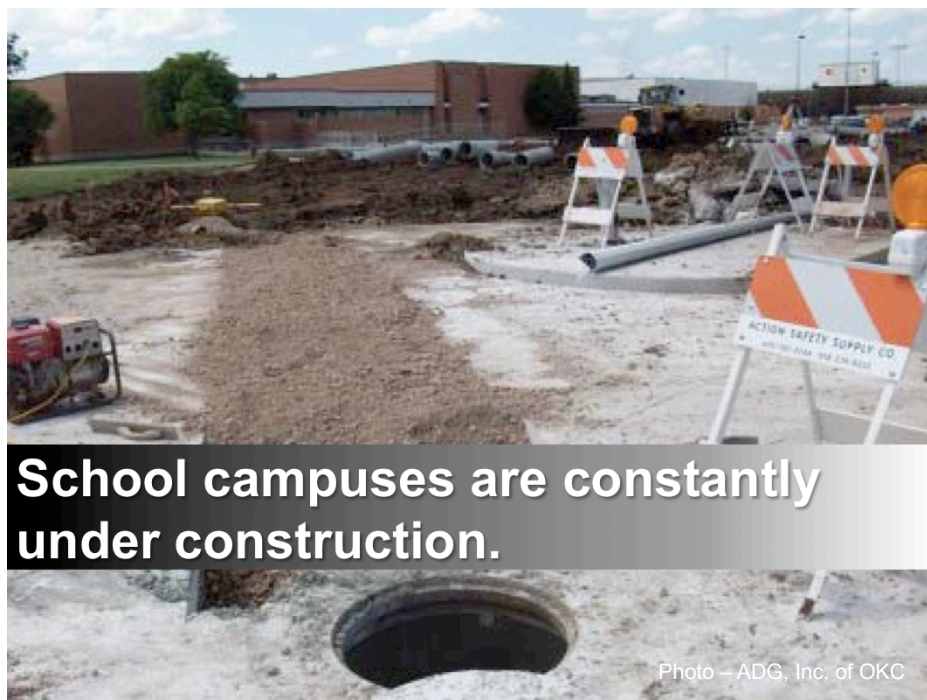
Meteorologist

Photos – istockphotos.com; NOAA NWS Norman and David McDaniel – The Oklahoman

School officials are desperate to find outside support.

Professionals need to make the first move.

The majority of us have children in schools. It is in our best interest to help schools be better prepared.



Lets look at a few challenges schools face solely from a weather safety point-of-view.

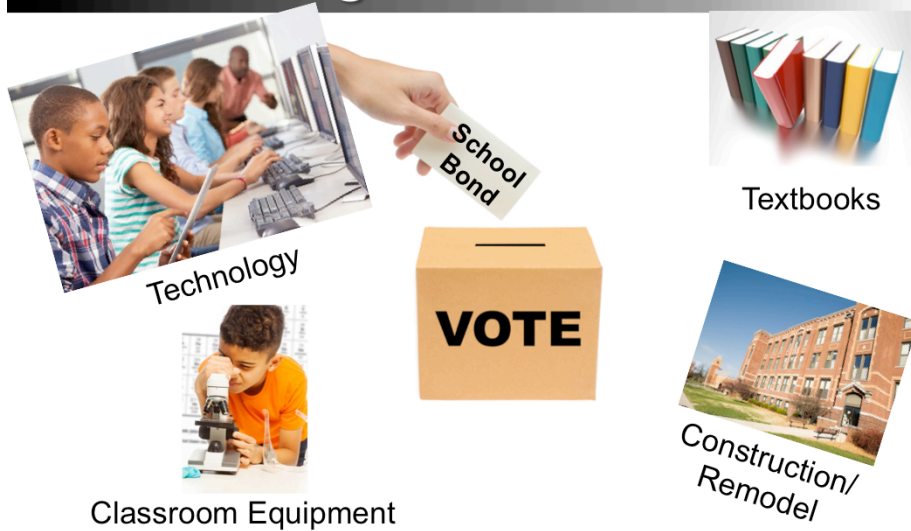
Construction Projects

Schools are fighting just to have enough space for a growing population. During the baby boom years, students were dispersed in small towns across the country.

Now our population is moving to urban areas. The urban schools are no longer one building for everyone.

New additions are always under construction. Even before one project is finished, the next expansion is on the drawing table.

School improvement projects are funded through bond issues.



Photos – istockphotos.com

Schools use bonds approved by the community to fund large construction projects.

Most school bond elections require a super majority to pass.

In Oklahoma during the 80's and 90's, school bond elections failed repeatedly.

With each failed vote, school needs continued to grow while improvements and maintenance were put on hold until funds could be obtained.

Schools are built in pieces over time.

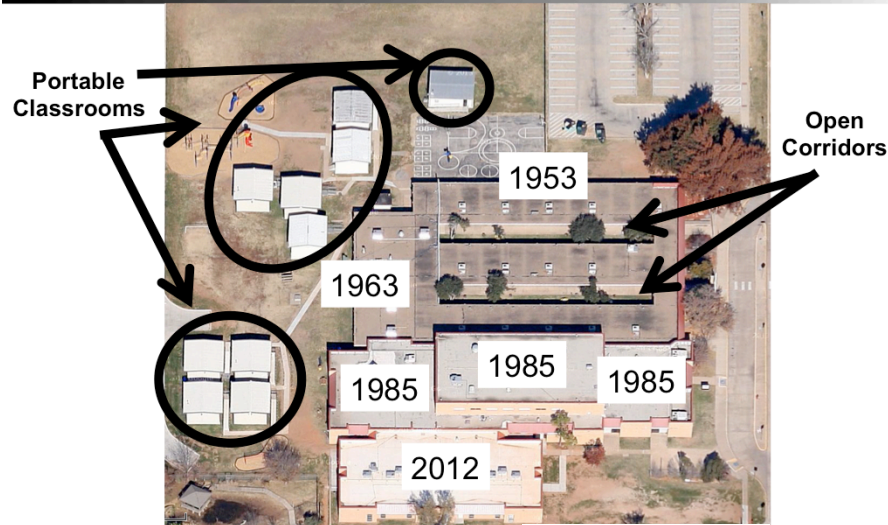


Photo – Google Maps

The age of school buildings in Oklahoma range from the early 1900's to under construction.

Here is an aerial photo of an Oklahoma elementary school. The original part was built in 1953 and the last addition in 2012.

Notice the portable classrooms which are no more than metal storage units with furniture.

These two areas are “outside corridors”. Nearly all classrooms have two exterior walls and large windows. The few interior hallways within the school are lined with sky lights. The school sheltering plan is to remain in the classrooms.

This school illustrates how many school campuses do not have enough life-protecting options to safely shelter the entire school population.

No building codes exist to withstand tornado hazards for high occupancy buildings.



National building codes exist to address earthquake and hurricane hazards. Codes exist for construction of safe rooms to withstand high wind events.

However, no standard building codes exist to specifically address tornado hazards (e.g., extreme high winds or wind-borne debris) for high occupancy buildings like schools and hospitals.

Code level wind speeds are lower than EF3 or greater tornadoes.

In the technical investigation report of the 2011 Joplin tornado, the National Institute of Standards and Technology (NIST)

“recommends that nationally accepted performance-based standards for tornado-resistant design for buildings and infrastructure be developed in model codes and adopted in local regulations to ensure the resiliency of communities to tornado hazards.”

Lack of significant shelter options revealed.



When you walk around a school campus looking for possible shelter areas, you begin to wonder how school staff are able to get a good night sleep.

When schools were small, it was much easier to identify shelter areas for small groups.

Now school populations are huge and have limited shelter options to keep everyone safe.

Hallways located on exterior perimeter with large windows.



Photo – Danny Mattox

For years, schools have been built to be more inviting.

The need for more natural light results in hallways with big windows or sky lights.

Classrooms include clerestory windows along the top edge of the interior walls, reducing the connection strength between the wall and roof.

Glass insets in the classroom doors allow classes to be viewed from the hallway.

The type of glass used in school buildings varies widely from shatter-resistant to single-pane.

These modifications cause the hallways to be less safe from a sheltering standpoint.

Open layouts create large, interior rooms or cosmetic walls added later.



Open space designs were very popular in school layouts for a period.

Later, remodeling projects resulted in the addition of sheetrock walls instead of the typical reinforced concrete masonry units seen in new construction. The wall additions may not be structurally connected to the roof or foundation.

The open spaces rely more on pillars or columns to support the weight of the roof.

The result is a structure with a long-span roof. Once the roof is compromised, these walls do not offer much protection. The walls become crushing hazards as they collapse onto anyone nearby.

Portable buildings handle the overflow as school populations grow.



While waiting for new construction funds, schools are forced to find more space. Low cost solutions include portable classroom buildings.

On severe weather days, teachers and administrators need to be aware of conditions so these students can be moved inside the main building.

With portables, the weather risks go beyond tornadoes. High wind, lightning, and large hail all have the potential to cause injuries to occupants.

Weather radios and outdoor sirens would not alert staff to a potential problem. These situations are below warning criteria but still could cause damage or injuries.

What is the minimum weather literacy needed by school staff to recognize these threats?

Security cameras and post event surveys capture damage in hallways.



Photo – istockphotos.com

Recent years, pictures and videos show disturbing damage from tornadic storms revealing how vulnerable school buildings are.



At this Joplin school, the roofing material has fallen into the hallway.

Moore, OK– May 20, 2013



This image from Plaza Towers Elementary comes from the preliminary NIST report.

Aerial view

Plaza Towers campus consisted of multiple unconnected buildings.

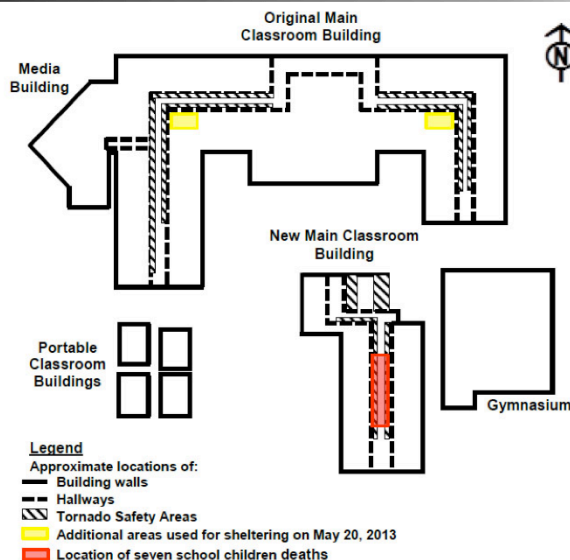
The main building was constructed in the 1970's. The report did not provide dates for the remaining buildings.

The campus included four portable buildings.

All buildings were one-story.

The school did not have a basement as is typical in Oklahoma schools.

Moore, OK– May 20, 2013



This image from Plaza Towers Elementary comes from the preliminary NIST report.

Sheltering Diagram

Solid lines show exterior walls.

Dashed lines indicate the hallways.

The hatched areas represent the approved shelter locations.

Yellow areas show where occupants relocated out of hallways into bathrooms during the event.

The red section shows where the fatalities occurred.

Roof failure throughout the building led to collapsed interior walls.

Hallways are about the only interior spaces that existed at this campus. The school was not at full capacity during the event as many students were picked-up early.

Shadeland, IN - Nov 17, 2013



This video* shows what happened inside Southwest Middle School as a tornado tears through the unoccupied building on a Sunday.

Roof debris falling into hallways. Winds pushing debris down hallways. Damage to gym and cafeteria.

The school's tornado plan did NOT use the hallways for sheltering.

Video retrieved from

<http://www.wishtv.com/news/indiana/surveillance-video-shows-exact-moment-tornado-hit-school> in January 2014.

*Video was edited for time. Audio removed for convenience of speaker.

How do schools find experts that will provide recommendations of better sheltering options?



Photo – istockphotos.com

Schools are feeling the heat. Parents are demanding better shelter options. Unfortunately it takes time and money to get engineered shelters built.

After the Plaza Towers tragedy, some Oklahoma schools stopped their approved construction projects to reevaluate and determine if engineered shelters could be included.

Oklahoma Representative Joe Dorman has introduced a bill to require safe rooms in new school construction. A non-profit, Shelters Oklahoma Schools (SOS), has begun raising money for school safe rooms.

In the meantime, schools are dealing with low attendance on severe weather days or parents pulling students out early. Unfortunately, some parents wait until the storm is at the school then demand to get their children. This puts staff at risk as they cannot be in shelter while managing incoming parents.



Schools need expert help to identify safer shelter options.

Photo – istockphotos.com

Weather Ready Schools began in 2012. We brought personnel from three school districts and one tech center* in our county together to meet their local emergency managers. OCS staff approached these schools to determine their concerns and offer possible solutions.

Solutions started small with superintendents getting more connected with the local Warning Coordination Meteorologist (WCM), Rick Smith, through participation on email lists for stakeholders and weather briefing conference calls.

Meanwhile, a second initiative began when Rick and Dr. Harold Brooks (National Severe Storms Lab) conducted a walk through with the principal to evaluate sheltering options at their local school.

Next, they met with the City Emergency Manager to discuss their findings. The emergency manager and assistant superintendent decided to expand these visits to all Norman schools. Other Weather Ready Schools were included.

Local Norman professionals formed teams to review school safety plans and visit campuses. We visited the final Norman school last week. An After Action Report summarizing the teams findings is currently in progress. The last step will be a presentation to all school principals.

* Weather Ready Schools - Moore Public Schools, Norman Public Schools, Little Axe Public Schools, and the Moore-Norman Technology Center

Schools are unprepared for severe weather sheltering.



Photo – Danny Mattox

This photo was staged to show how the school sheltered before two concerned teachers revised the plan.

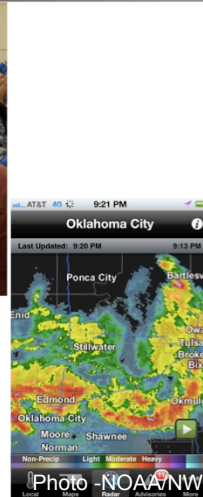


Photo – Andrea Dawn Melvin

Weather Radio Turned Off



Photo – NOAA/NWS

Unsure what action to take or how soon

Oklahoma requires by law every school to conduct at minimum of two tornado drills and a total of ten safety drills each year. Oklahoma schools are required to review their school safety plans and provide a copy to the local emergency manager annually.

When these plans are analyzed by experts, however, major flaws are revealed.

Floor plans may not be an accurate layout of the facility. Tornado procedures may describe what to do during a drill.

However, the procedures do not include who is responsible for monitoring weather conditions, how to handle parents picking up students early, how to handle sheltering for an extended time, and what to do in the event of damage while buildings are occupied.

Re-evaluate shelter areas in school facilities.



Photos – Danny Mattox

Floor plans and procedures tend to be passed down from staff to staff with little modification. No one remembers why this location is used for sheltering and another is not.

Plans may not be reevaluated as new buildings are added to campus.

Districts may not have the original structural design plans or blueprints that describe building materials and connection methods used. This makes it very difficult to determine safe locations with any confidence.

However, assessment teams have seen the damage. We can use this knowledge to advise schools on better locations.

If your hallways have a single set of exterior doors at each end, you could be at risk of a wind tunnel effect. Find areas with no glass. Find rooms with small roof spans. Know whether interior walls are supported by gravity loads of the roof or if they will remain intact even with total or partial roof failures.

Determine how much debris, what type of debris, and where the debris is likely to come from.

Get involved. Tour school premises. Review school plans. Voice your concerns.



Photo – Raylene Somerlott

We as experts in weather hazards, emergency planning, disaster recovery, and construction cannot sit on the sidelines and second guess decisions made by schools.

Approach school staff with an attitude of joining their team. Find out their concerns. Discuss positives and negatives of their current weather safety plans. Work together to improve each school's plan.

The Oklahoma Department of Emergency Management (OEM) has begun a program called Safe Schools 101. They are currently offering training courses on how to conduct school assessments.

Part 1 is a 2-day course focused on learning how to use the checklists in FEMA 361 and reviewing school structural plans. After the course is completed, participants are divided into teams.

During Part 2, teams then visit a local school to determine the best shelter options. Finally, the team is responsible for writing a formal assessment of their recommendations to be returned to the state office.



Co-authors

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S. L. Stalker – Oklahoma Climatological Survey;

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and R. Smith – NOAA National Weather Service
Norman Forecast Office

In closing, Sarah and Melissa have posters on Weather Ready School topics later this afternoon. Sarah has a Weather Ready School talk on Tues at 2:30 in the Weather Ready Nation session.

Rick is involved with a poster and a couple of talks on Tues related to the May 20th and 31st, 2013 events covering communication, lead-time, and damage assessment findings.



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Thank you.

Related Publications

- Corbett, M. K., S. L. Stalker, K. A. Kloesel, C. A. Fiebrich, J. Hocker, and A. Melvin. 2014: *Weather Ready Schools and Weather Education: What are our students being taught?* Preprints, 23rd Symposium Education, Atlanta, Georgia. American Meteorological Society. February 2-7.
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- Garfield, G. S., R. Smith. 2014: Sheltering Behavior during 2 Major Tornadoes in 2013: Is More “Lead Time” Better? 9th Symposium on Policy and Socio-Economic Research, Atlanta, Georgia. American Meteorological Society. February 2-7.
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- McPherson, R.A., K. Crawford, J.M. Wolfenbarger, A.D. Melvin, and D.A. Morris, 1999: *From Rags to Riches -- Seven Years in the Life of a Climate Office’s Educational Programs.* Preprints, 8th Symposium on Education, Dallas, Texas. American Meteorological Society. January 10-15.
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- Melvin, A. D., K. A. Kloesel, 2001: *Example Damage to School Structures from the 3 May 1999 Tornado Outbreak: How Safe is Your School’s Tornado Emergency Plan?* Preprints, 10th Symposium on Education, Albuquerque, New Mexico. American Meteorological Society. January 14-19.
- NIST (National Institute of Standards and Technology), 2013. *Preliminary Reconnaissance of May 20, 2013, Newcastle-Moore in Oklahoma.* NIST Special Publication 1164. Gaithersburg, MD,

Related Publications

- NIST (National Institute of Standards and Technology), 2013. *Technical Investigation of the May 22, 2011, Tornado in Joplin, Missouri. NIST NCSTAR 3 (Draft) – For Public Comment*. Gaithersburg, MD, November.
- NWS (National Weather Service) 2011. *NWS Central Region Service Assessment Joplin, Missouri, Tornado – May 22, 2011*. Silver Spring, MD.
- NWS (National Weather Service) 2013. *Examples of Storm Damaged Schools*. NWS La Crosse, Wisconsin Accessed January 15, 2014.
<http://www.crh.noaa.gov/arx/?n=schoolprep2>.
- Ortega, K. L., D. W. Burgess, G. S. Garfield, C. Karstens, J. G. LaDue, T. P. Marshall, T. C. Meyer, B. R. Smith, R. Smith, D. Speheger, and G. J. Stumpf. 2014: *Damage Survey and Analysis of the 20 May 2013 Newcastle-Moore, OK, EF-5 Tornado*. Preprints, Special Symposium on Local Storms: The Current State of the Science and Understanding Impacts, Atlanta, Georgia. American Meteorological Society. February 2-7.
- Stalker. S. L., T. Cullen, K. A. Kloesel, M. K. Corbett, J. E. Hocker, A. Melvin, and D. E. Mattox. 2014: *Weather Ready Schools: Using Problem Based Learning to Train School Decision Makers on Weather Decisions*. Preprints, 2nd Symposium on Building a Weather-Ready Nation: Enhancing Our Nation's Readiness, Responsiveness, and Resilience to High Impact Weather Events, Atlanta, Georgia. American Meteorological Society. February 2-7.
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- Smith, R. 2014: *The Historic 2013 Oklahoma Tornadoes: Highlights and Success Stories from WFO Norman*. 2nd Symposium on Building a Weather-Ready Nation: Enhancing Our Nation's Readiness, Responsiveness, and Resilience to High Impact Weather Events, Atlanta, Georgia. American Meteorological Society. February 2-7.

Safe Schools 101

Enrollments should be directed to:

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FEMA Courses for School Officials

E361 – Multi- Hazard Emergency Planning for Schools

<http://training.fema.gov/emiacourses/crsdetail.asp?cid=E361&ctype=R>

Schools Toolkit

<http://www.training.fema.gov/EMIWeb/emischool/EL361Toolkit/Start.htm>

Plaza Towers, Aerial, Post Damage – NIST Report



Source: NOAA. Enhancements by NIST.

Figure 4-5. Post-tornado aerial view (looking northeast) of the Plaza Towers Elementary School taken May 21, 2013. Much of the debris had already been moved by the time of this photograph as part of the search and rescue operations. The area circled in red shows the approximate location in the hallway of the new main classroom building where the 7 fatalities occurred.

Plaza Towers, Main Classroom and Hallway– NIST Report



Figure 4-6. Damage to the hallway and classrooms of the new main classroom building (complete loss of roof and many walls) where the 7 fatalities occurred (most of the debris has already been removed). This hallway area was a “designated area of safety.”

Plaza Towers, Main Classroom Building, Southwest Wing – NIST



Figure 4-7. Collapsed southwest wing of original main classroom building.

Plaza Towers, Gym – NIST Report



Figure 4-9. Collapsed Gymnasium building (Note the interior Gymnasium Office surrounded by a reinforced CMU wall remained standing).

Damage to Schools from Weather Events

Date	Location	Schools	Weather Hazard	Fatalities	Description
May 20, 2013	Moore, OK	2 elementary, 1 junior high	EF5	7 students	
May 19, 2012	Council Bluffs, IA	Heartland Christian	SVR Storms		Roof damage
May 2, 2012	Blair, WI	Elementary and high	Bow echo		Roof damage; roof over gym and commons
April 3, 2012	Forney, TX	Crosby Elementary	EF3	None	Roof damage; vehicle lofted 300 yds away from school
Mar 2, 2012	Henryville, IN	Elementary middle and high	EF4 Tornado		Cafeteria destroyed, buses thrown

Damage to Schools from Weather Events

Date	Location	Schools	Weather Hazard	Fatalities	Description
Mar 2, 2012	Wolfe County, KY	High school	Hail		Hall damaged roof
Feb 29, 2012	Smithville, TN	Middle and high school	Rear flank downdraft and straight-line winds		Exterior and roof damage
May 23, 2011	Joplin, MO	10 schools	EF5 Tornado	None in school buildings, 161 in event	Many schools totally destroyed
April 23, 2011	Ryland, KY	Elementary	EF1 Tornado		Minor damage

Damage to Schools from Weather Events

Date	Location	Schools	Weather Hazard	Fatalities	Description
Nov 22, 2010	Rockford, IL	School Bus	EF2 Tornado	Bus occupied, 0 fatalities	Bus blown over
Sep 16, 2010	Powell, OH	High School	EF0 Tornado		Roof of gym
Jun 17, 2012	Wadena, MN	High School	EF4 Tornado		Heavy damage to school and school buses
Jun 15, 2010	Maysville, KY	High School	Microburst		Minor roof damage
Jun 5, 2010	Wood Co., OH	High School	EF3 Tornado		

Damage to Schools from Weather Events

Date	Location	Schools	Weather Hazard	Fatalities	Description
Jan 10, 2008	Caledonia, MS		EF3 Tornado	0 with 3 injuries of 1900	Destroyed gym and school buses
Jan 6, 2008	Avenal, CA	High school	High winds		Roof damage
Aug 26, 2007	Northwood, ND		EF2/EF3 damage		Total destruction
May 30, 2007	Wilmington, OH	High school	High winds		
Mar 1-2, 2007	Enterprise, AL	High school	EF4 Tornado	8 with 50 injuries	Collapsed hallway wall, roof damage