



A GUIDE TO DEVELOPING A SEVERE WEATHER EMERGENCY PLAN FOR SCHOOLS

This guide was written by **Barbara McNaught Watson**, Warning Coordination Meteorologist with the **National Weather Service, Baltimore-Washington Forecast Office**. It has been adapted for use by the National Weather Service around the country with help from other Warning Coordination Meteorologists. While it is designed specifically for schools, the principles used can be applied to any facility that is used by people including businesses, shopping malls, depots, hotels and hospitals.

TABLE OF CONTENTS:

- **INTRODUCTION**
 - Purpose and general layout of Guide
 - Who will Develop Your Plan?
- **SECTION 1 - Understanding the Danger: Why an Emergency Plan is Needed**
 - Lightning
 - Flooding
 - Severe Thunderstorms - Hail, Downbursts, and Tornadoes
 - Conclusions
- **SECTION 2 - Designing Your Plan**
 - How to Get Emergency Weather Information?
 - How will the School Administration Alert Teachers and Students to Take Action?
 - Determining Tornado and High Wind Safety Zones in Your School
 - Determining When to Activate Your Plan and When it is Safe to Return to Normal Activities
 - Determining when to Hold Departure of School Buses
 - School Bus Actions
 - Special Considerations for Other Weather Hazards
 - Need for Periodic Drills and Severe Weather Safety Instruction
- **SECTION 3 - Thunderstorms and Severe Weather Spotting**
 - Basic facts about Thunderstorms
 1. What makes a typical thunderstorm?
 2. The thunderstorm life cycle
 3. What causes thunder?
 - The Severe Thunderstorm
 1. Hail

2. Supercells
3. Downbursts
- o Some Basic Severe Thunderstorm and Tornado Spotting Techniques
- o [NWS Methods of Detecting and Tracking Severe Weather.](#)

APPENDICES - Reference Materials.

- A. [National Weather Service Products](#) (What to listen for)
- B. [Glossary of Weather Terms](#)
- C. [General Severe Weather Safety](#)
 1. Tornadoes and Severe Winds
 2. Hail Lightning
 3. Flooding
 4. Hurricanes and Storm Surge
 5. Winter Storms
 6. Extreme Cold
 7. Extreme Heat
- D. [NWS Contact Information](#)
- E. [NOAA Weather Radio](#)
- F. [Emergency Alert System](#)
- G. [Emergency Management Contacts and the American Red Cross](#)
- H. [School Severe Weather Check List](#)

ACKNOWLEDGEMENTS:

I would like to thank Bill Bunting, Warning Coordination Meteorologist with the National Weather Service in Pleasant Hill, MO. Bill gave me a copy of the guide he developed for Oklahoma Schools when he worked at the Oklahoma Forecast Office. I was able to use his guide as a foundation to develop this one. I would also like to thank the Virginia Department of Emergency Services for their overall support on this project in its development phase.



A GUIDE TO DEVELOPING A SEVERE WEATHER EMERGENCY PLAN FOR SCHOOLS

The purpose of this guide is to provide assistance to school administrators and teachers in designing a severe weather emergency plan for their school. While not every possible situation is covered by the guide, it will provide enough information to serve as a strong starting point and a general outline of actions to take. The majority of material focuses on thunderstorms

and the hazards they produce - lightning, hail, tornadoes, and flash floods. Thunderstorms can occur suddenly, with little or no warning. To insure safety, actions must occur quickly and be planned for in advance. This will become more apparent in Section 1: "Understanding the Danger: Why an Emergency Plan is Needed."

Once you comprehend the scope of the problem, you can begin to address how to reduce the potential hazards. Section 2 of the guide, "Designing Your Plan", details more specifically how to get weather information, how teachers and students can be alerted to the emergency, and what actions under what circumstances should be taken to reduce the danger. Safety is always the foremost concern. The ultimate goal is to "quickly inform teachers and students anywhere on the school grounds to the threat of severe weather and to move them as quickly as possible to a pre-designated shelters." This section also discusses school bus actions in severe weather.

For any plan to work efficiently, it must be practiced. It is recommended that schools conduct semi-annual drills and that severe weather safety instruction be part of this phase. It is important to understand why certain actions are being taken, to know the weather terms that are being used, and to know what visual clues can signal you to potential dangers ahead. Section 3 of the guide will provide some basic severe weather background on how thunderstorms evolve, what signals to watch, and how the National Weather Service (NWS) detects and tracks severe weather.

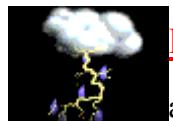
The appendices in this guide are loaded with reference materials to assist you in both designing your plan and gathering educational materials for severe weather instruction. There is a glossary of weather terms, an NWS products list, and safety tips for the various types of weather hazards (not just thunderstorms). There is a list of local NWS and state emergency management contacts if more assistance is needed.

Who will Design Your Guide?

Before you begin, it is recommended that one person be designated as the "Severe Weather Coordinator". Such a person may be a teacher or administrator with an interest in weather who is willing to attend local NWS spotter training programs (no fee). The coordinator would also be responsible for developing the plan and working with the local school board, administrators and teachers to implement the plan.



SECTION 1 - UNDERSTANDING THE DANGER: WHY AN EMERGENCY PLAN IS NEEDED



Lightning

It's a warm afternoon and the football team is on the field practicing. Some parents and a few other spectators sit in the bleachers watching the play. The sky to the west is darkening and a warm breeze has picked up. The rumble of thunder can be heard in the distance. Keeping a watchful eye to the sky, the coach figures he can get through most of the practice before the rain comes. There is a big game on Saturday and only one practice left. He can't afford to let up now.

The practice continues, the thunder gets louder and the sky a bit darker. A cool, gusty wind now blows in from the west, but still no rain. A parent walks over to the coach and asks about the chance of practice being called early. The coach smiles and says, "I've been watching that storm and it appears to be passing north of us now." The sky begins to lighten to the west and a couple sun rays beam down from beneath the towering clouds. Suddenly, a white streak hits the uprights in the end zone with a deafening roar. Players, near that end of the field, tumble to the ground.

There is confusion. What happened? Where did the lightning come from? The storm was at least 5 miles away and none of the previous strokes were anywhere near the school. It seemed to just come out of the blue! In 1988, eleven players on the Silver City, NM football team where taken to the hospital after lightning struck their practice field. Fortunately none where killed, but four were seriously injured. Every year lightning hits ball fields during little league and soccer games. Many games are not called until the rain begins, and yet it is not the rain that is dangerous. Ball fields provide a lot of potential lightning targets such as poles, metal fences, and metal bleachers. The fields themselves are wide open areas where players are often the tallest objects around.

Maryland, District of Columbia, and Virginia average between 30 and 40 thunderstorm days each year. Lightning is the most common thunderstorm threat. Nationally, lightning kills an average of 85 and injures 250 people each year. This number may not seem high, yet when you look at the individual cases, most could have been prevented. The basic rule of thumb is "If you can hear thunder, you are close enough to the storm to be struck!" Thunderstorms extend 5 to 10 miles into the atmosphere. Winds aloft can blow the upper portion (anvil) of the storm many miles downstream. Lightning can come out of the side or anvil of the storm striking the ground 10 to 15 miles away from the rain portion of the cloud.



Flash Floods

Heavy rains from thunderstorms had been occurring all day in the Virginia foothills and the National Weather Service issued a Flash Flood Watch around noon. The rain had let up by the time the children loaded the buses at Hillboro Elementary School. With a full load of children, Fred started the bus and pulled out.

Fred had been driving this route for over five years and had never encountered any flood problems. He didn't expect any today. About halfway through his route, he turned onto Dark Hollow Road. The road crosses a small stream and this afternoon, the stream was out of its banks and flowing across the road. Fred slowed the bus as he approached the water. If he turned around, it would take him an extra hour to get the remaining children home. The water looked less than a foot deep. Certainly, the bus could safely cross that. He decided to move forward.

The bus moved easily through the water, but as it approached the bridge, the front tires fell into a hole. With the water over the road, Fred hadn't seen that the pavement had been undermined. He attempted to back out, but the bus wouldn't budge. What was worse, the water was continuing to rise and was now more than a foot and a half above the road! Fred knew he better act fast. There was still eleven children on the bus.

About fifty yards away was higher ground, a hillside. They would head there. The current was picking up. He would have to carry the smaller ones. His third and last trip from the bus to the hill was a hard one. In just ten minutes, the water had risen to waist deep and he could barely keep his footing. Grabbing onto to trees and bushes along the way, he pulled himself and the last child to the hillside and out of the water. He was exhausted. He wouldn't have made it if he had to carry one more. As he turned around to look back at the bus, the bus overturned and washed into the raging waters.

Floods occur every year in Maryland and Virginia. Nationally, it is the number one weather-related killer averaging 150 deaths per year. Half of these deaths occur in automobiles. NEVER ENTER FLOODED WATERS! If caught in rising water, abandon your vehicle immediately and

move to higher ground. Fred and the children were lucky. He acted quickly and got them to safety, but he never should have attempted to cross the flooded area to begin with.



Severe Thunderstorms: Hail, Downbursts, and Tornadoes

It is 1:30 pm and the principal has just learned that the National Weather Service has issued a Severe Thunderstorm Watch. Thunderstorms are building to the west and are expected to hit the school district in less than an hour. He decides to cancel all outdoor activities and make an announcement to inform the teachers and staff.

At 2:05 pm, it begins to get very dark outside and there is a rumble of thunder. The principal steps out to have a look. The sky appears as if its boiling and has taken on a green tinge. The wind picks up and the trees begin to sway. A cool blast hits him and a cloud of dust blows across the parking lot. "This storm doesn't look good." He reenters the building and is told the National Weather Service has just issued a Severe Thunderstorm Warning for their county. Suddenly, he hears a roar of wind and a crash. The storm has let loose a downburst - a sudden, strong rush of wind.

He rushes toward the source of the noise. A branch from a nearby tree shattered a window in a classroom. A few children were injured from the flying glass. Two will need stitches. He evacuates the classrooms on the windward side and moves the children into the interior music room which has no windows. They will be safe in there.

Hail begins to fall and grow larger in size. The physical education instructor is barely heard above the roar of the hail striking the gymnasium roof and skylights. She moves the students into the locker rooms where it is safer. Large hail can impact at 100 mph. Suddenly, the skylights shatter.

The principal decides to play it safe and move all students into the interior hallways. The lights flicker and the power goes out. He can't announce it on the PA system so he grabs a bull horn and begins rapidly moving through the school. The students and teachers empty out of the classrooms, a little confused. Some are excited by the commotion and some are scared by the storm. The hallways are noisy with anxious voices, but quiet down when a roar, similar to the sound of a train drowns them out. Teachers yell "Get down! Drop to your knees and cover your head!" Glass is heard breaking somewhere in the building.

It was all over in just a couple minutes. Only ten minutes had passed since the thunder began. A tornado struck the school. The classrooms on the south side of the school were destroyed. The cafeteria and gymnasium roofs were gone. Children and teachers were shaken, but injuries were relatively minor. Because the principal in this scenario took the proper actions, lives were saved. No one was killed.

On May 2, 1929, four schools were destroyed in Virginia in a tornado outbreak. Two of the schools were in session when the tornadoes struck. Fourteen students and teachers were killed and over 60 injured. On April 1, 1973, a strong tornado struck Woodson High School in Fairfax Virginia. Fortunately it was Sunday. The same school was struck by another tornado just six years later. On November 9, 1926, at 2:30 p.m., a tornado struck a school house in La Plata, Maryland.

Sixty children and two teachers were inside. The building was lifted off its foundation and smashed into trees 50 feet away. Fourteen students were killed; the other 48 people were injured. Debris was found up to 25 miles away.

Conclusions

Flash floods, severe thunderstorms, and tornadoes occur with rapid onset and perhaps, no warning. Decisions must be made fast and actions taken immediately. One can not wait for the storms to strike to plan what must be done to save lives. Get prepared now and develop an emergency action plan for your school.

Schools may want to consider what to do when hurricanes, winter storms, excessive cold or excessive heat is expected to affect the school district. This type of weather, however, is usually predicted at least a day in advance allowing more time to make decisions about the operations of the school. These weather hazards are discussed further in Section 2, Part G.

Having a clear weather policy lets parents, teachers and students know what to expect. Because this policy is based on a safety issue, there is less likelihood of problems implementing it, even if it means delaying or canceling a championship sports event due to lightning. A clear policy leads to consistent actions and hence less confusion or doubt about actions to take. A clear policy makes it easier to make the hard decisions when the time comes and to make them quickly if necessary.



SECTION 2 - DESIGNING YOUR PLAN

How to get Emergency Weather Information:

Because tornadoes and severe thunderstorms occur with little, if any, warning, minutes and even seconds can mean lives. In just five minutes, a tornado may travel two to four miles on the ground. From the time the National Weather Service (NWS) issues a warning, to the time you receive that warning via radio or television, ten minutes may have elapsed. Also, you must be listening at the critical moment that the warning is announced or an even greater amount of time will pass!



The fastest, most accurate and reliable means of receiving critical weather information at your school is through a NOAA Weather Radio with a "tone alert" feature. You will receive the warning directly from the National Weather Service in just a couple of minutes from its issuance. These radios can be purchased in electronic stores and generally cost between \$40 and \$80. When NWS issues a tornado warning, the "tone alert" (1050 Hertz) is instantly sounded followed by warning information.

In addition to the tone-alert, a digital burst of information is sent out. In some cases, such as a tornado warning, television and radio stations use this digital information for activation of the Emergency Alert System (EAS). You can now program special NWR receivers that use the digital burst to only warn you when weather is to affect your county. The National Weather Service refers to this digital burst as "Specific Area Message Encoding" (SAME).

The radio's "tone alert" feature and SAME is used for the issuance of all weather warnings as well as severe thunderstorm, flash flood, hurricane, and tornado watches. (See the [appendix for Watch/Warning definitions](#)). NOAA Weather Radio (NWR) broadcasts 24 hours a day, seven days a week with the latest weather information from daily forecasts to special weather statements about sudden shifts in the weather patterns or the development of potentially hazardous weather. (For more information on [NWR see the appendix](#)).

If your school is not in a reliable NWR listening area (due to interference from mountains or other sources) and attaching your radio to an exterior antenna does not help, then below are some suggested alternatives -

1. If you have cable television access, The Weather Channel uses NWS products and broadcasts warnings immediately upon receipt from NWS via a satellite link. Warnings are continuously scrolled across the bottom of the screen.
2. Some cable companies include a channel with a local NWS radar display and use NOAA Weather Radio as a voice-over.
3. Monitor your local news radio station for EAS messages and special statements from the National Weather Service. EAS operates on a cooperative agreement between broadcasters and federal, state, and local government agencies. EAS is activated for tornado warnings and severe flash flooding.

Phone "call-down" systems used in some counties are **not** advised for receipt of warning information due to

1. time elapsed in relaying information,
2. chance of incorrect or incomplete information being passed,
3. lack of reliability of phone systems during storms, and
4. the NWS advises people not to use telephones during an electrical storm.

Your radio or television should be located in the main office or near the person(s) responsible for enacting the plan. Main offices are good because generally there is always a number of people around who could hear the alert, and in a quick emergency, it is close to the public address (PA) system. If using a NWR, the radio should be set at all times in "Alert" mode. Some radios will automatically turn on when an alert sounds while others must be manually turned on after the tone is heard. It is probably better to have the type that automatically turns on in case you are out of the room when the tone is activated. If using NWR, the information cycles every few minutes, so if you don't get all the information you need the first time through, it will repeat shortly. More expensive NWR models include features such as a tie in to your PA system, ability to set off a pager or telephone someone, flashing lights for new warnings and a button to play the warning back with a date/time stamp.

Listen for the type of watch or warning and where it is in effect. The person(s) monitoring must know what action they should take based on this information. It is suggested you have a map nearby for easy reference to counties and towns to locate storms and their movement in reference to your school. There is no need to take emergency action if the warning is not for your location. It should, however, heighten your awareness to the potential for severe weather to affect your school district, especially if the warning is for a county near you and the storms are moving your way!

How will the School Administration Alert Teachers and Students to Take Action?

Most schools utilize a public address (PA) system to talk directly to students and teachers. In some cases, electricity may be lost during a storm before you have activated your plan. Therefore, it is critical to have a back-up alerting device such as a [compressed air horn or megaphone](#).

If your school has mobile classrooms or detached gymnasiums that are not part of a public address or intercom system, then special arrangements must be made to notify these areas. Sending "runners" outside to mobile classrooms is not advisable due to the danger posed by lightning and the approaching storm. Wireless communication devices are an effective means for such communication. "Walkie-talkies" may be the least expensive.

Handicapped or learning-disabled students may also require special attention. You may want a teacher to be assigned to each student requiring special attention to see that the student moves to the appropriate place of safety. Any students that are in a position not to hear the warning must be taken into account.

To insure appropriate action and understanding of your "Call to Action," you must exercise your plan. A section entitled "Need for Periodic Drills and Severe Weather Instruction" will follow later in this section.

Determining Tornado and High Wind Safety Zones in Your School:

This may be the most time consuming and important phase of designing your plan. Schools are sufficiently complex and diverse in design that it is impossible to describe a plan that will apply to every school. Due to this complexity, it is recommended that this phase of the plan be accomplished with the help of an engineer or architect familiar with the school's design. You can also contact your local NWS office and ask the Warning Coordination Meteorologist for help. Below, you will find some general guidelines and basic concepts to help you.

The greatest threat from high winds (caused by tornado, hurricane, thunderstorm downburst, or a strong pressure surge behind a cold front) are -

1. roof failure
2. breaking glass, and
3. flying debris (airborne missiles)

The most dangerous locations are generally large rooms with big expansive roofs such as cafeterias, gymnasiums, and auditoriums. The collapse of the room's outer load-bearing wall can lead to the failure of the entire roof. Roofs tend to rely on gravity to keep them attached. When strong winds act on a structure, pressure differences are created causing outward pressures forces that act to lift the roof.

Rooms with large windows that may shatter from being struck by airborne missiles or from pressure stresses are also extremely dangerous. While windows on the side of the school facing the storm are most susceptible, as the storm passes, any windows could potentially shatter.

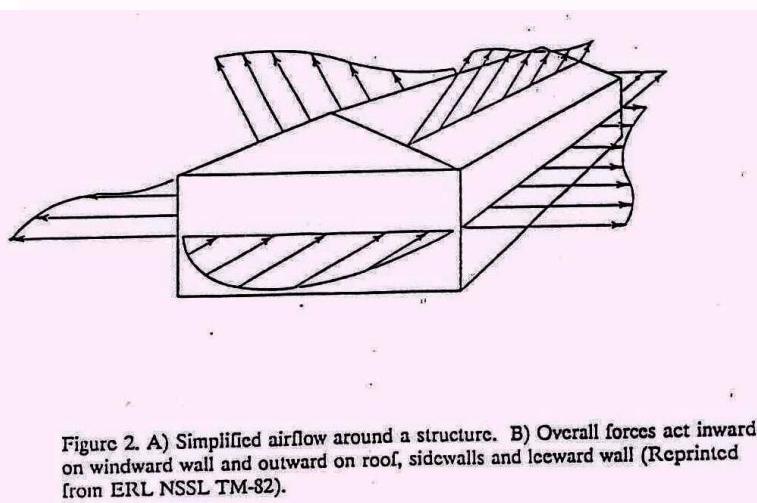
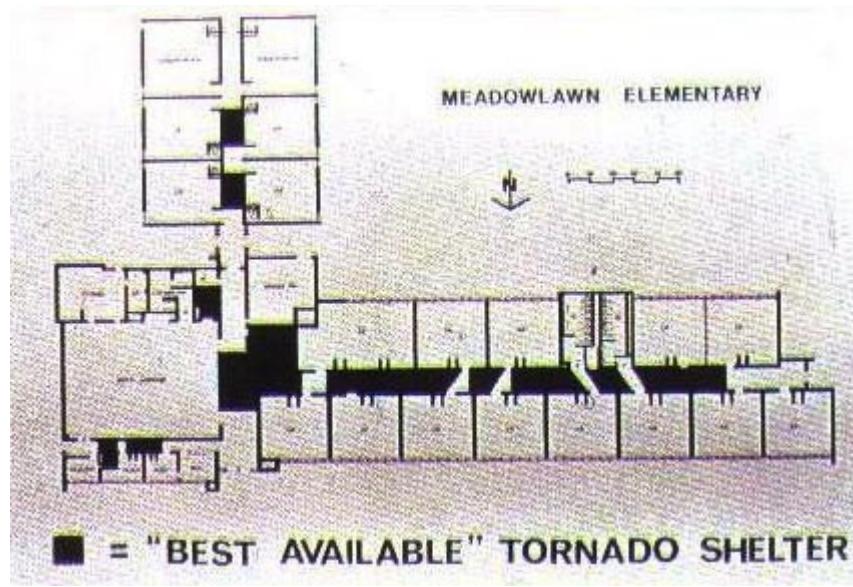


Figure 2. A) Simplified airflow around a structure. B) Overall forces act inward on windward wall and outward on roof, sidewalls and leeward wall (Reprinted from ERL NSSL TM-82).

Once winds enter a building, additional damage is likely and can be like a domino effect. This is one of the reasons that YOU NEVER OPEN WINDOWS WHEN A STORM APPROACHES! Greater damage may occur from this action and valuable time that should be used getting to safety is often lost.



Small interior rooms, bathrooms, and windowless, interior hallways that are away from exterior doors offer the best protection. All doors should be closed, if possible. Interior load-bearing walls (with short roof spans) provide better protection than temporary or non-load-bearing walls and structures. If your school has more than one level, evacuate the upper floor of the school. The lowest level is always the safest.

Schools designed for the "open classroom" concept used in the early 1970s have a difficult task of finding safe areas due to a lack of interior load-bearing walls, large spanning roofs and the use of a lot of glass. You may not be able to find enough "ideal" space to occupy your whole student body. It may be a matter of determining the lesser of evils. Below is a list beginning with the highest probability of failure:

1. Mobile Classrooms
2. Rooms with large roof spans (gymnasium, auditorium, cafeteria)
3. Windows on exterior walls
4. Roof
5. Exterior walls of upper level
6. Interior walls of upper level; exterior walls of lower level; interior glass and interior, lower level, non-load-bearing walls.

Fortunately, the majority of tornadoes will not destroy well constructed buildings and damage in about 75% of cases should not go beyond #4 and 90% of cases should not go beyond #5. Using these considerations you may want to rank areas according to safety. Then begin by filling the safest areas first with students and continue until you have found space for the entire student body.

Again, it is best to have an engineer or architect advise your school on the safest areas since schools are built with varied designs and purposes. The priorities listed above are based on broad generalities.

Determining When to Activate Your Plan ; When it is Safe to Return to Normal Activities:

When deciding to activate a plan, you must use as much information as possible about the type of storms, expected impact and time of impact on your school district to access the risk. A plan may work best with phases of activation. For instance, outdoor activities will be the most

susceptible to weather hazards with lightning being the greatest threat. If thunder is heard or lightning is seen, outdoor activities should be delayed with students and spectators moved to safety immediately. Do not wait for the rain. The delay in activities should last until the storm has safely passed. This means that thunder is not heard and lightning is seen for 15 minutes.

In a tornado or severe thunderstorm watch, outdoor activities should be postponed. As the storms approach, you may want to move students from the most susceptible areas of your school, such as mobile classrooms and gymnasiums, to safer areas as a precaution even though a warning has yet to be issued. You might also do this for "High Wind Warnings". For potentially severe thunderstorms, you may want to post teachers or school personnel **trained** in spotting severe weather to watch the storms as they approach for the need to take special actions (see section 3 on severe weather spotter training).

If a severe thunderstorm warning is issued, all of the above actions are warranted. In addition to strong damaging winds, severe thunderstorms may contain large hail and students should be moved out of areas with skylights. If you have areas where large exterior windows may be struck by the storm's winds, it is advised to keep students out of these areas as well until the storm passes.



If a tornado warning is issued and you have determined that your school is in the path of this storm, an immediate and complete "Call to Action" is needed. If the storm has not yet reached your school, move students from unsafe areas as listed above and post a trained teacher or school employee to keep an eye on the storm's approach. From your drills you should know approximately how long it will take to move students into "tornado safe areas."

As the tornadic storm begins to hit, all students should be in the designated tornado safe areas. If winds pick-up outside the school, if a roar like that of a freight train is heard, if large hail is falling, or you hear breaking glass, everyone should drop into the protective position immediately (see picture).

Winds may pick-up at the onset of the storm and may or may not drop off prior to the tornado. It may get very dark out. Rain, lightning, and/or hail may, or may not, be occurring. Large hail is a signal that you are near the part of the storm in which the tornado would occur.

If there has been no warning and students and teachers are still in their classrooms when that freight train is heard or the sound of breaking glass or structure failure (whether from wind or even a bomb), the safest thing for everyone to do is to drop beneath their desks and take the position shown in the picture.

Once the storm has past, students may return to classrooms. Stay alert for the possibility of additional storms.

One complication to activating a full "Call to Action" plan is if it occurs during class changes when the halls are crowded and students may not know where to go. It may be best to hold classes beyond regular dismissal time until the severe weather threat has passed. Likewise, at the end of the school day, students may need to be held from boarding busses until the danger has passed.

You should have at least a couple people who know how to shut off the main power (electricity) and gas (if applicable). If a tornado or severe thunderstorm has significantly damaged your school, shut off the gas and electricity for safety purposes. Inform

Determining When to Hold Departure of School Buses:

You will want to consider holding the departure of students to buses whenever watches or warnings are in effect. There are two primary considerations:

1. Upon departure, how long will it take before all students have been deposited safely at home. Include time for the students to walk from their bus stop to their home.
2. How much time do you have before the storms impact your district. Severe thunderstorm and tornado watches are sometimes issued a couple hours in advance of thunderstorm development. Watches are generally issued for large areas, so even once storms have developed, it may be a couple hours before the storms reach you. On the other hand, it may be a rapidly developing situation with less than an hour before the storms impact.

If condition 2 is less than condition 1, then a delayed departure is recommended. Busses provide no protection from severe storms. The next section will discuss what bus drivers should do if faced with a tornado approaching or flood waters in their path.

It is not advisable for parents to be running to the school to pick up their children in severe weather. They should be made to understand that the child is far safer at the school with the severe weather plan in place than on the road when a storm strikes. Other considerations may include if a large number of children from your district live in mobile homes. The school would provide a far safer environment. Mobile homes are extremely susceptible to high winds (even when properly anchored and tied down). A storm that would produce very minor damage to a school could completely destroy a mobile home and kill its occupants.

School Bus Actions:

All school bus drivers should be trained on how to handle severe weather situations. Two primary concerns are flooding and tornadoes. Additional thought might be given to high wind situations (thunderstorm or other), unexpected heavy snow or ice, extreme heat or extreme cold and wind chill. In most situations, these events are forecast in advance, but there are times when it may catch you by surprise.

TORNADOES - NEVER ATTEMPT TO OUTRUN A TORNADO! If a bus driver has reason to believe a tornado is approaching, the following steps should be taken.

1. If you have the time to get the students to a well-constructed building, then certainly do so as fast as possible. Move them into the interior or basement of the building away from windows and doors.
2. If no well-constructed building is available for shelter, then look for a ditch or low lying area (preferably without water). Stop the bus downwind from the location you have selected. You do not want the wind to roll the bus toward where the students will be. Unload the students and move them to the ditch or low-lying area and have them get in the protective position with their hands over the head.



FLOODING - NEVER ATTEMPT TO DRIVE THROUGH FLOOD WATERS!

If your bus route takes you across small streams and creeks or along a river, you need to have either determine an alternate route to travel or have a contingency plan to return to the school once

flood waters are encountered. Major river flooding and coastal flooding generally is well forecast with warnings issued early enough that schools and drivers can plan their strategy prior to placing the students on the bus. However, flash flooding a sudden, dramatic and dangerous rise in water levels, usually does not occur with much warning. It is this type of flooding for which drivers need to understand what to do and what not to do, well in advance.

In general, a shallow ponding of water on the roadway is usually not a problem. As soon as the depth of the water comes into question such that you can no longer see the road, do not enter. The road may have been undermined or the water may be deep enough to stall the bus and place all of its occupants in danger. Do not enter underpasses that are filling with water. If the water appears to be flowing (moving across the road), do not enter. The bus will act as a barrier and the water will



attempt to lift and move the bus. If water is flooding over or around a bridge, do not cross it, it might collapse from the weight of the bus. The foundation of the bridge may have been compromised.

Water levels can rise extremely rapidly and the force of that water against an automobile or a bus can be amazingly powerful. If the driver is caught in an unavoidable situation, seek higher ground immediately. If the bus stalls, and water is rising, abandon the bus and seek higher ground before the situation gets out of

control.

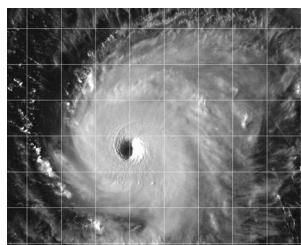
EXPOSURE - TOO COLD OR TOO HOT

Children awaiting the school bus in the morning, standing exposed to a cold wind without proper clothing for protection, may develop hypothermia. School bus drivers as well as teachers should be taught to recognize symptoms of hypothermia and frost bite described in the appendix.

On hot, humid days, where the heat index exceeds 100 °F in May or June, some children may have difficulty handling the heat. They may be boarding the bus from an athletic event or coming from a hot classroom. A child may be dehydrated and starting to show signs of heat exhaustion. Again, drivers should be taught to recognize symptoms of heat stress. See appendix.

Special Considerations for Other Weather Hazards:

1) HURRICANES -



A hurricane is a large spiraling complex of thunderstorms up to 300 miles in diameter. Hurricanes and tropical storms have produced extreme coastal flooding, flash flooding, and river flooding. This flooding is responsible for the majority of hurricane related fatalities. Winds can gusted over 100 mph and hurricanes may spawn tornadoes. These are the major concerns.

By listening to statements from your local National Weather Service Office and your local emergency management, you should know what is expected to occur in your school district prior to the storm striking and can make your decisions accordingly. If school is in process when a hurricane or tropical storm strikes, then the threat and actions to take are similar to those mentioned for flooding, lightning, and strong damaging winds. Schools susceptible to river or coastal flooding may be asked to evacuate. Other schools may become shelters for people in flood prone areas or those living in mobile homes. Actions taken by those sheltered at the school should be the same as if the school were in session.

2) WINTER STORMS AND EXCESSIVE COLD -



About 60 percent of deaths in winter storms occur in vehicle accidents on icy and snowy roads. Some deaths occur from exposure to the cold, whether trapped out in the storm or caught indoors without heat or electricity. Those most susceptible to the cold are young children (under 2 years old) and elderly (over 60 years old). Some deaths occur from fires started by improper use of alternative heat and light sources such as fireplaces, candles, wood stoves, and space heaters. When the National Weather Service issues a Winter Storm Warning, people should not venture out. Proper preparedness, wearing appropriate winter clothes, and following safety procedures will save lives. See appendix C on winter storm safety.

In addition to Winter Storm Warnings, schools need to also be concerned about exposure to cold as students stand awaiting buses to pick them up or during an outdoor recess. The degree of exposure the student will experience will be a function of the temperature, the wind, the clothes they wear, and the amount of time they are exposed. The National Weather Service issues Wind Chill Warnings when the wind chill temperature is expected to reach -30°F or colder. At -30°F , exposed flesh can become quickly frost bitten. If the morning temperature is 5°F and the wind is blowing 15 mph; the wind chill temperature is -25°F . The National Weather Service issues Wind Chill Advisories when the wind chill is expected to reach -15°F or colder.

In cases of extreme cold, proper clothing is very important and needs to be stressed to the students. Teachers should be taught to recognize symptoms of frost bite and hypothermia. See part 7 of Appendix C. Outdoor activities should be canceled. Delaying school hours may or may not solve the problem of students standing at bus stops in the cold if the temperature rises enough. Bus stop shelters would help protect the students from the exposure to wind.

3) EXCESSIVE HEAT -

While most heat waves hit when school is out, temperatures can occasionally soar into the 90°s in May and June. Like wind to cold, humidity adds to the effects of heat. A "heat index" is used to combine these effects. The National Weather Service headlines the heat index in its forecasts when it is expected to reach 100°F . At temperatures of 105°F and greater, a Heat Advisory is in effect and heat disorders such as cramps, heat exhaustion, and heatstroke are possible. Students should be kept out of the sun and strenuous activities should be eliminated. Encourage students to drink lots of water and wear light-colored, light-weight clothing. Teachers should learn what are the symptoms of heat disorders and first aid procedures. See appendix C.8.

Need for Periodic Drills and Severe Weather Safety Instruction:

In order to have an effective severe weather emergency plan, you must have periodic severe weather drills and severe weather safety training. Drills not only teach students and instructors the actions they need to take, but will allow you to evaluate your plan's effectiveness. Did everyone hear the message, did they understand what to do, and were they able to get to the designated areas of safety in a reasonable amount of time? It is suggested that you conduct drills in conjunction with a severe weather education and awareness programs so that students and teachers understand the dangers of severe weather and better comprehend the actions that they are asked to take.

The NWS in conjunction with the state office of emergency management runs a statewide weather awareness campaigns. Tornadoes are usually addressed the last week in March before the

onset of the severe weather season. This campaign is coordinated through the local government emergency management agencies and the news media and usually includes a proclamation from the governor. This may be an opportune time for your school to conduct a drill and program.

You can contact your local NWS office or emergency management office if you would like a speaker to come to your school and discuss severe weather safety. It also suggested that a tornado drill is conducted in September, the beginning of the school year and then again in March. The September drill will instruct new students of procedures and act as a refresher for returning students. The March drill will get everyone ready for the start of the thunderstorm season.

While severe thunderstorms and tornadoes are often advertised as a "springtime or summertime" event, in the Mid-Atlantic and Southeast, outbreaks of severe thunderstorms and tornadoes often have occurred in October and November.



SECTION 3 - Thunderstorms and Severe Weather Spotting

Nature provides clues that can help one realize that threatening weather is approaching and that action needs to be taken. Understanding these clues can be the difference in getting to safety in time when weather suddenly turns for the worst.

Basic Facts about Thunderstorms

Thunderstorms occur in all 50 states. They can occur, at any time, day or night, throughout the entire year. Thunderstorms are most common in the late afternoon and evening during the warm months. Approximately 1800 thunderstorms are in progress at any given moment around the world and lightning strikes the earth 100 times every second. Thunderstorms are basically beneficial providing necessary rainfall. In the United States, only about five percent of thunderstorms become severe and only about one percent of thunderstorms produce tornadoes.

What makes a typical thunderstorm:

Thunderstorms range between 5 and 25 miles in diameter making it a very localized storm. There are three essential ingredients necessary to grow a thunderstorm:

- 1) Moisture** - Moisture is necessary to form the cloud and rain.
- 2) Instability** - Warm air is less dense (lighter) than cold air. The sun warms the ground and the ground warms the air above it. Evaporation of moisture from the ground or bodies of water increase the humidity. The warming of the air and the increase in humidity cause the air mass to destabilize. If there is cooler, drier air above, the tendency would be for the air to want to overturn with the cooler air sinking and the warmer air rising. This is instability.
- 3) Lift** - This is the trigger that starts air rising and focuses storms. Examples of Lift -- 1) air moving up a mountain; or 2) air colliding with a front. A front is a boundary between two different air masses. Where the air masses collide, the less dense air (warmer or more humid) will rise over the other. 3) Cool air blowing from an ocean or lake can form a sea-breeze front as it collides with

the warmer air inland. 4) The cool outflow from a thunderstorm forms a "gust front" which may in turn cause the development of a new thunderstorms. These are all sources of lift. If instability and moisture is the fuel, than lift is the spark that ignites the storm.

The thunderstorm life cycle:

1) Towering cumulus stage - Imagine a parcel of air like a balloon. If the air in the balloon is warmer than the environment around it, it will rise. As the balloon (air parcel) rises, the air cools, eventually cooling to its condensation point. A cloud becomes visible. As the air condenses, heat is released which helps the air parcel remain warmer than its surrounding environment, and so, it continues to rise, building up speed. This rising air forms the updraft, a thermal. A towering cumulus cloud has grown with crisp, hard edges forming a puffy or cauliflower look to the cloud. The height of the cloud is usually equal to or greater than the width of the cloud's base.

2) Mature thunderstorm stage - The warm air continues to rise until eventually it has cooled to that of its surrounding environment. This is often not until it hits the tropopause and the more stable air of the stratosphere. The storm may now have reached a height of 5 to 10 miles above the ground. The rising air has been moving at speeds near 40 mph. Now as it slows, the upper level winds begin to fan out the cloud forming the anvil. With strong winds aloft and longer lasting storms, anvils can spread 100 miles downwind.

A thunderstorm's updraft can carry 8000 tons of water aloft per minute! The water vapor condenses to cloud droplets which collide and grow in the rising updraft. Eventually, the weight of the droplet overcomes the rising air and it falls. The falling rain droplets begin to drag the air down around them and a downdraft forms. The rain also is falling into unsaturated air and so some evaporation occurs. Evaporation is a cooling process (your body cools when sweat evaporates from your skin). This rain-cooled air is now cooler than its surrounding environment and it sinks, helping to form and intensify the downdraft. A thunderstorm with concurrent updrafts and downdrafts is considered mature. As little as 20 minutes has elapsed since the cloud began to form.

3) Dissipating stage - As the downdraft hits the ground, the rain-cooled air begins to spread out in all directions. Eventually, this more stable air (since it is cool) chokes off the warm inflow that was driving the storm's updraft. With no new fuel to keep the storm alive, it dies. The downdraft dominates and the storm rains itself out. Sometimes, all that is left is the anvil.

This entire thunderstorm life cycle from the growing cumulus cloud to the dissipated storm can take only 30 minutes. This is why thunderstorms can strike so quickly and with little if any warning. The National Weather Service predicts the likelihood of thunderstorms to develop, but does not warn for lightning nor general thunderstorms.

What causes thunder?

A lightning stroke carries an electrical potential of 100 million volts. This tremendous release of energy is converted to heat. Air around the lightning channel explosively expands as it is heated to nearly 50,000°F! After the discharge, the air rapidly cools and contracts. This sudden expansion and contraction of air molecules produces the sound wave which we identify as "thunder." Because the speed of light is a million times faster than that of sound, we see a lightning stroke before we hear it.

You can estimate the distance (in miles) to a lightning stroke by counting the number of seconds between seeing the lightning and hearing the thunder, then divide by five. Just remember that lightning can come from the anvil portion of the thunderstorm and strike the ground 10 to 15 miles from the rain portion of the storm. So, just because you are estimating lightning at a distance of 2 or 4 miles away, doesn't mean that the next strike won't be right next to you!

Understanding the Dangers of Lightning:

If you are outside and there are thunderstorms within 10 miles, you are at risk of being struck. In rare cases, lightning has been known to travel as far as 15 miles from the storm. There are four different types of lightning: 1) within cloud, cloud-to-cloud, cloud-to-air, and cloud-to-ground. Lightning can occur from any portion of the thunderstorm cloud. Thunderstorms can extend up to 10 miles high in the atmosphere and they are often tilted by stronger winds aloft. High clouds above you may be part of a thunderstorms anvil. Often during the dissipating stage of a thunderstorm, lightning will strike from the upper reaches of the storm including the anvil.

A study on lightning conducted in Florida found that the average distance between one lightning strike hitting the ground and the next was two to three miles. That means that (using the technique described in the section on thunder above) you may have just seen a lightning stroke in the distance and it took a full 15 seconds before the thunder reached you. It seemed a long way away and yet, on average, the next strike could be right next to you.

The most common mistake made by people is to let an outdoor activity continue because it appears as though a thunderstorm is too far away to be a danger. Many people think that if it is not raining, then they are okay, yet it is not the rain that can kill them. People who have been struck by lightning have noted that they heard some distant thunder, but there was blue sky overhead and so they perceived no threat.

The rule is simple: If you can see or hear thunder, take action

immediately. The activity can be resumed when it appears as though the storms have passed and lightning has not been seen nor thunder heard for at least 15 minutes.

Shelter: Every one needs to move inside a building or a car. In buildings, do not remain standing in the door way and close windows and doors. Do not use telephones and computers. In a car, truck, or bus, windows and doors need to be closed. Convertibles, even with the tops up, are not protected. If an activity is postponed to let the storm pass, try not to allow spectators to linger in unprotected areas. At a Lacrosse game in the District of Columbia, the game was called as a thunderstorm squall line rolled into the city. The teams went inside to the locker rooms to wait out storm. A group of spectators who had been watching the game, took cover under a tree. The tree was struck. A 16 year old boy was killed and 10 others were injured.

Lightning will be attracted to the tallest object. Tall trees are a prime example. Sports fields are a high risk area. The tallest object may be the players, or goal posts. Lightning may strike both players and goal posts at once. Metal bleachers, tall lights for night-time play, and metal fences around ballfields are all at risk of being struck. Even the dugout are not safe.

Thunderstorm Clues:

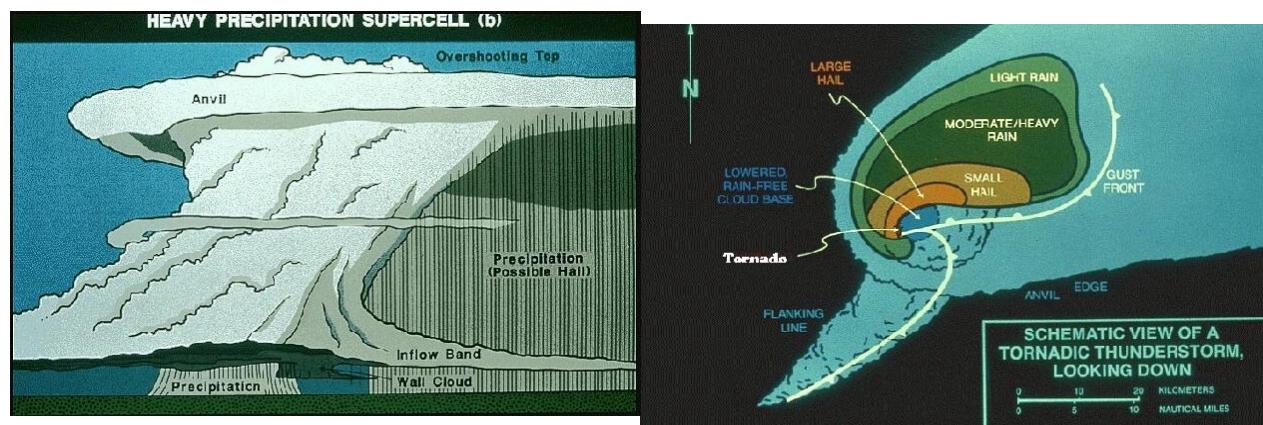
1. Static on your AM radio
 2. A sudden increase in wind or a sudden change in the wind direction. Leaves on trees may flip over so you see their underside. You might smell rain before it arrives or feel a sudden drop in temperature with the breeze.
 3. Darkening and billowing clouds or darkening haze.
 4. Distant flashes of lightning or the sound of thunder.
-

The Severe Thunderstorm

The more unstable the air mass and the stronger the lifting mechanism, the stronger the thunderstorm updraft becomes and the more likely the storm will be severe. Increasing winds with height also help to the storms ability to maintain itself. The longer a storm lasts, the greater chance it has of becoming severe. The National Weather Service defines a severe thunderstorms as a storm producing three-quarter inch or larger hail and/or winds greater than 58 mph. When thunderstorm updrafts reach speeds of 70 mph, they can support the growth of hailstones.

A hailstone is a lump of ice that falls from a thunderstorm. It can range from pea size to the size of grapefruit. Such large hail can impact the ground at nearly 100 mph demolishing crops, breaking windows, and damaging roofs, cars and airplanes. Hail begins as rain droplets which are carried by strong updrafts to high altitudes (well above the freezing level) where they are frozen into ice pellets. The ice pellets collide with more water droplets which freeze to the surface of the developing hail stone increasing its size. The stone continues to grow until the updraft can no longer suspend its weight and the hail falls to the ground.

Long-lasting thunderstorms, sometimes referred to as **supercells**, are more likely to be severe. For a thunderstorm to last, it must be able to sustain both its updraft and its downdraft. One way that this occurs is with increasing winds with height. If the horizontal wind, blowing into the storm, is stronger in the mid and upper reaches of the storm, the rising updraft becomes tilted. Now the rain is carried downwind of the updraft instead of collapsing upon it. Another important factor is if the horizontal wind, blowing into the storm, veers with height (changes direction in a clockwise motion), the storm's updraft may begin to rotate. The combination of veering and increasing winds with height can produce a tilted and rotating updraft. This rotating thunderstorm, called a **mesocyclone**, is able to maintain its updraft and warm inflow region independent of the storms rain-cooled outflow. The rotating updraft of this type of thunderstorm is where the tornado can form and descend to the ground.



The Downburst: So far, we have discussed how strong updrafts can produce hail and rotating updrafts can produce tornadoes, but what about downbursts or damaging straight-line winds from thunderstorms? A **downburst** is a powerful, concentrated downward burst of air, that occurs in the downdraft region of the thunderstorm. Looking at the mapview of a severe thunderstorm above, it tends to occur in the moderate to heavy rain region of the storm. One theory for how downbursts originate is that a layer of drier air, between perhaps 10 and 20 thousand feet high, is entrained into the thunderstorm. As rain falls through this drier air, it evaporates, rapidly cooling the air. This cold ball of air, now denser than its surrounding environment, descends toward the ground. The momentum of the winds in this mid-level dry layer (the wind blowing into the storm) is now tilted downward and is accelerated by gravity. The burst of rain-cooled air smacks the ground and spreads outward. Wind speeds produced by downbursts can reach over 100 mph and produce damage similar to a tornado. However, downbursts damage paths are usually broader than tornado paths.

The term **straight-line wind** when referring to a thunderstorm wind is the rain-cooled air of the downdraft as it spreads out and away from the thunderstorm. The wind is moving in a straight-line as opposed to rotating like a tornado. Therefore, straight-line damaging winds from a thunderstorm is generally caused by a downburst. In aviation, the term wind shear is used. **Wind shear** is the change of wind speed and direction. A downburst is extremely dangerous to aircraft on takeoff and landings because of the strong wind shear. Wind speed and direction is in constant flux and the pilot can not compensate fast enough. A **microburst** refers to a small downburst (less than 2 miles across). A downburst larger than that would be called a macroburst.

Some Basic Severe Thunderstorm and Tornado Spotting Techniques

Your local National Weather Service Office provides severe weather spotter training under a program called SKYWARN. It is provided free of charge with the request that when you do encounter severe weather, you report it to the National Weather Service. The spotter training class includes 100 slides that help you learn how to pick out visual clues from clouds to help determine the severity of a storm. It is highly recommended that at least one person from your school, preferably the "Severe Weather Coordinator" for your school emergency plan, take the training. The following information is not a substitute for official training.

Color: A very dark (black) thunderstorm or one taking an eerie look (brownish, green, or yellow cloud colors) may be an indication of a severe thunderstorm. The colors and darkness of the cloud are caused by the storm's massive size and the blockage of sunlight. This storm may bring hail, very heavy rain, and damaging winds. Take protective action immediately.

Sound: The sound of a freight train is the roar of wind as it moves through trees and buildings. It may indicate an approaching tornado or severe downburst. The rapid rotation of winds in a tornado also sometimes make a high pitch whistling or whirling noise. In any of these cases, you should take protective action immediately.

Swirling Debris: Tornadoes are sometimes obscured by rain, low clouds, trees, or buildings that block your view of the funnel. A visible funnel need not even be touching the ground (it may only extend half or two-thirds of the way from the cloud toward the ground). But even with weak tornadoes, swirling debris or debris rising up in the air can often be seen. This is a sure sign of significant damaging winds and protective action must be immediate.

Shelf Cloud / Roll Cloud: The rain-cooled air flowing out of a thunderstorm forms the gust front.



Warm air ahead of the gust front rises up into the storm forming a wedged-shape cloud called a "shelf cloud" on the leading edge of the storm. The sharper or more defined that this cloud is, the stronger the winds are below. As the cool wind continues to blow out ahead of the storm, the shelf cloud can become detached from the storm forming a "roll cloud". This horizontal cloud is not a tornado. It marks the gust front (the gust front is the leading edge of the rain-cooled outflow from the thunderstorm). If you see a well-defined roll cloud rolling toward you, prepare for strong and possibly damaging winds as it passes.

Mammatus Clouds (also known as Mamma): These clouds hang down from the anvil portion of the thunderstorm. They look like breasts (hence the Latin term) or like a cumulus cloud turned upside down. Mammatus clouds are often an indication that the storm is severe. Prepare for possible hail and damaging winds.

Rotating storms: Sometimes it is possible to see the entire thunderstorm rotating. Generally, to see this you are located south of the storm or behind it. The storm is usually then moving away from you. A rotating thunderstorm is likely severe and may produce a tornado. If the storm is, by chance, moving toward you, prepare for severe winds and hail. Otherwise, report your sighting to the National Weather Service.



Rotating Wall Cloud: This is a lowering of clouds from the rain-free cloud base (updraft region) of the storm. It is circular in shape and can be seen slowly rotating. Sometimes a tail forms from the wall cloud toward the rain area of the storm. Air is moving in and rising up into this portion of the cloud. This is a sign of a tornadic thunderstorm. If a tornado is to form it will generally descend from the storm near or within the wall cloud. Take cover immediately if this is approaching you.

Otherwise, contact the National Weather Service with your sighting.

Funnel / Tornado: A funnel is a small rotating funnel-shaped cloud. It does not touch the ground. If the funnel-shaped cloud is touching the ground, it is a tornado. Only about 50 percent of funnels turn into tornadoes. It is possible for the rotating column of damaging winds from a tornado to be on the ground with the visible funnel only extending half-way to the ground. Look for debris, leafs and dust rising into the air and listen for the sound of a freight train.



Waterspouts: When a tornado moves over water, it is called a waterspout. Waterspouts can also occur in more benign situations and these are not severe but still may have winds of 35 to 50 mph.

Squall lines: Sometimes thunderstorms form a solid line of storms called a "squall line". The squall line thunderstorm can also become severe and is unlike the supercell thunderstorm discussed earlier (see diagram showing side and map views of a typical severe thunderstorm under section B). The supercell storm has its updraft on the right-rear quadrant of the storm. With a squall line, the warm air feeding the storm is all out ahead of it, so the updraft on the front (approaching) portion of the storm dominates.

When a squall line approaches, you will see the shelf cloud which is the leading edge of the storm (see discussion on shelf clouds). Tornadoes rarely occur with squall lines and they tend to be less severe than those with supercell storms. Still, winds can reach 100 mph which is enough to damage roofs, break windows and drop trees. The tornado in this case will precede the rain. The tornado would be found in the updraft region of the storm behind the shelf cloud.

For additional information severe weather spotting, try the following links:

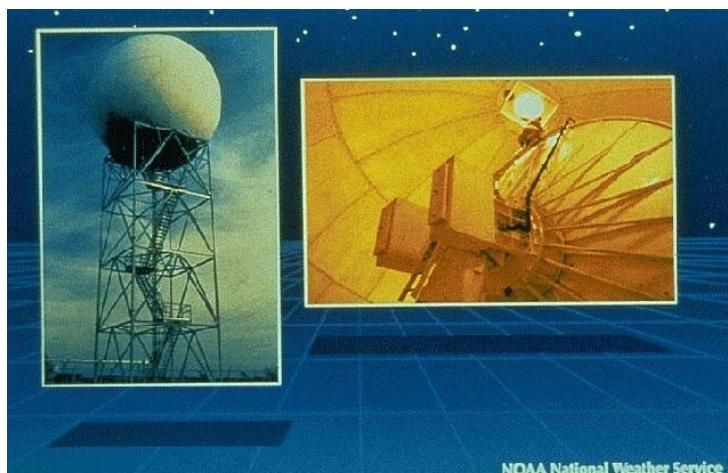
([our skywarn page](#))
([nws spotter's guide](#))



SECTION 3 - Thunderstorms and Severe Weather Spotting

D. NWS Methods of Detecting and Tracking Severe Weather

The National Weather Service uses a combination of radar, satellite, lightning detection, and surface observations including volunteer spotter reports for detecting and tracking severe weather. NWS Doppler radars installed around the country in the early 1990s have greatly increased the National Weather Service's ability to pinpoint severe thunderstorms and possible tornadoes and warn the public as to where these severe storms are moving. Spotter reports give forecasters the ground truth that verifies what the radar is showing and adds details such as the size of hail, the amount of rain, the depth of flood waters over a road, if wind damage is occurring, or if a tornado is sighted.

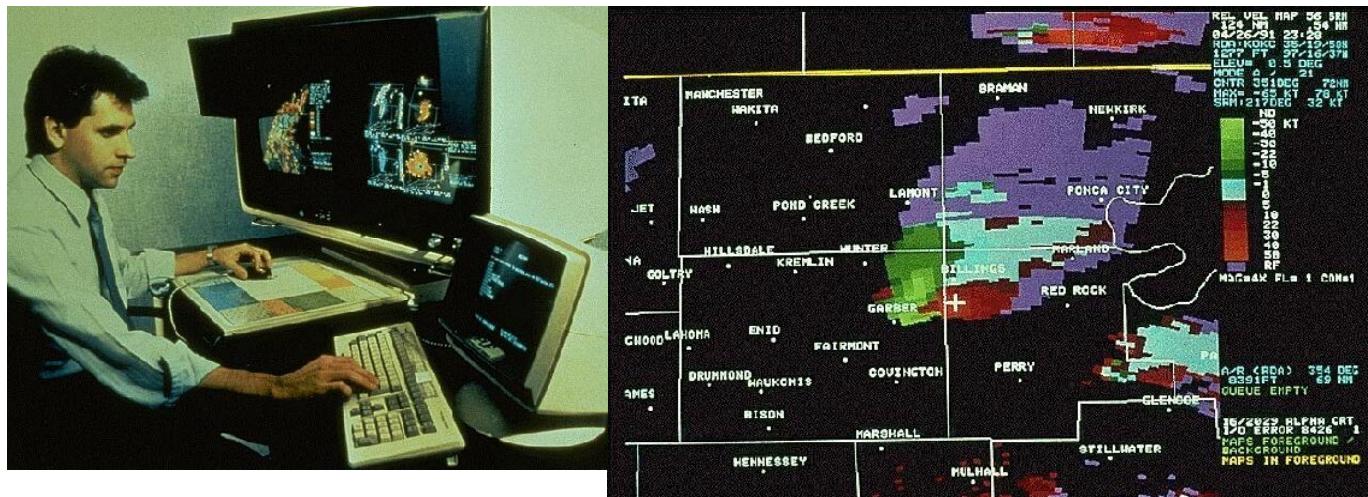


1) Doppler Weather Radar:

The WSR-88D (Weather Surveillance Radar - 1988 Doppler) is the radar system used by NWS and the Department of Defense (DOD). It is a very powerful radar designed specifically for the detection of weather phenomena and in particular, violent tornadoes. The computers that compile the radar data can produce as much as 100 different radar products every 5 minutes for forecaster to look at.

Typically radar has been used to tell meteorologists where precipitation is occurring, how intense it is, and where it is

moving. The ability of Doppler radars to detect radial velocity (movement of radar targets, such as rain, toward or away from the radar-derived from the "Doppler Effect") allows meteorologists to see rotation of thunderstorm updrafts and sometimes the development of the tornado vortex.



Mesocyclones displaying strong radar signatures such as storm rotation (bright red nest to bright green in the picture) can sometimes mean 10 to 15 minutes lead-time on warning for a tornado before it touches down. Computer and mapping skills with this radar combined with automated rainfall gauges help meteorologists determine maximum rainfall amounts and pinpoint areas with potential flash flood problems.

Like all technology, radars have their limitations. Radar beams can not see through mountains. This means that weather within the valleys on the other side will not always be detected. Because of the curvature of the earth, as the radar beam moves away from its source, it gets higher and higher in the atmosphere and is no longer sampling the lower portion of the storm clouds. The NWS compensates by using trained severe weather spotters which help forecasters to fill in the gaps.

2) Satellites :



Geostationary satellites (stationary above a point over the equator) and polar orbiting satellites allow meteorologists to watch the development of clouds and weather systems. Satellites are extremely useful for tracking weather systems over the vast ocean areas where there is no radar and few surface observations. For example, satellites greatly improved meteorologists' ability to detect the formation and movement of hurricanes over the tropical waters. Satellites also help meteorologists to track movement of air masses that are either

very dry (such as off the mountains) or very moist (such as northward from the Gulf of Mexico). This can greatly influence a storm's development. Cloud patterns also tell forecasters about the strength and movement of the jet stream which plays a large role in storm development.

Meteorologists can watch the formation of cumulus clouds along boundaries and their growth into thunderstorms. They can watch the change in cloud top temperatures to help determine if thunderstorm complexes are growing or weakening.

While satellites provide meteorologists with much information, they too have their limitations. A satellite is viewing a cloud from above. Only in very rare cases can you tell that a tornado has formed below. You can not know from a satellite that winds are blowing down trees or that softball size hail is falling or water is flooding a bridge.

3) Lightning Detection :

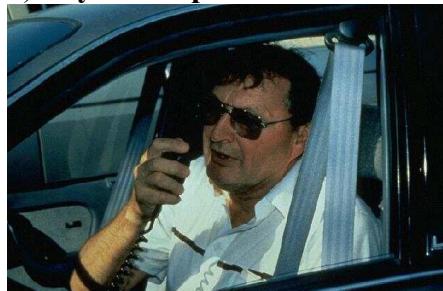
Lightning detection systems map where cloud-to-ground lightning strokes are occurring. While this

allows meteorologists to know that thunderstorms are indeed in progress and the frequency of lightning strokes, it tells little about the severity of the thunderstorm.

4) Surface Observations:

Surface observation are the "ground truth" for tools such as radar and satellite. Because thunderstorms are very localized (the severe weather portion of the storm may only affect an area a mile wide), it would be impossible to have weather observers everywhere. Most surface observations are automated and these automated sensors give you temperature, humidity, pressure and wind information, but do not tell you hail size, do not see tornadoes nearby, or thunderstorm clouds.

5) Skywarn Spotters:



Skywarn is a volunteer program of trained severe weather spotters. Some are also amateur radio operators who use their added skills to pass information on to the NWS. They provide critical details to forecasters about what the storms are doing. Skywarn training is conducted by the National Weather Service at no cost and all are welcome to take the basic spotter training class. For more information about Skywarn, check out our [webpage](#) or contact your local NWS office.

Summary:



It is the combination of surface reports from automated sensors and spotters and remote sensing tools such as radar, satellite and lightning detection that bring the entire picture together for forecasters and increases their ability to issue effective, informative, and timely warnings. While new technology has enhanced the meteorologist's ability to issue a timely warning, it will be of little use if the people do not receive the warning or receive the warning but do not know what safety actions to take.

APPENDIX A



NATIONAL WEATHER SERVICE PRODUCTS (What to listen for)

- 1. WARNINGS** - The hazard (tornado, flash flood, etc) is imminent. The probability of occurrence is extremely high. Warnings are issued based on eyewitness reports or clear signatures from remote sensing devices such as radar and satellite. Lead-time for

thunderstorm type events is generally 30 minutes or less. Lead-time for hurricanes, river floods, and winter storms can be 6 to 18 hours.

2. WATCHES - Meteorologists have determined that conditions appear right for the development of the hazard. Probability of occurrence is greater than 60% in the watch area. Watches generally cover larger areas than warnings. In the case of thunderstorms, less than 30% of the watch area may experience the hazard. However, with larger storms such as hurricanes and winter storms, the entire watch area may be affected. Severe thunderstorm and tornado watches are usually issued 1 to 2 hours before the event begins. With flash floods, it can be 3 to 12 hours. For hurricane, river flood, and winter storm watches, lead-times are usually 12 to 36 hours.

3. ADVISORIES - An advisory is issued for weather that is expected to be a disruption to the normal routine and an inconvenience, but it is not expected to be life-threatening. Advisories are issued for 1 to 3 inches of snow, dense fog, minor street flooding, etc. The time frame is similar to that of a warning.

4. STATEMENTS - statements are issued to update current weather situations or highlight significant changes to come. Statements are also used to explain why watches, advisories, or warnings have been issued. Three special types of statements are ...

a) **"Outlooks" or "Potential " Statements** - During the warm season, the NWS Forecast Office issues "Thunderstorm Potential Statements" each morning discussing where and if storms will develop that afternoon and how intense they may be. When a winter storm may develop in the next 2 to 4 days, "Winter Storm Potential Statements" are issued. Outlooks may also be issued for possible heavy rain and flood events. The National Hurricane Center issues "Tropical Outlooks" for the potential for tropical storm and hurricane development. The National Severe Storms Forecast Center issues special statements when there is the potential for a severe thunderstorm or tornado outbreak.

b) **Short-Term Forecasts** - These statements discuss the short-range forecasts for the next 1 to 6 hours. During active weather, these statements may be issued hourly.

c) **Public Information Statements** - These statements provide information of special interest such as a summary of recent records set, snowfall, weather safety information, special activities (weather related) that may be occurring, etc.

5. FORECASTS - general weather information provided daily.

a) 1 to 2 day forecasts for specific counties and cities are issued four times per day at approximately 4 AM, 11 AM, 4 PM, and 10 PM. Special weather events are highlighted with headlines at the top of the forecasts such as ...

"Heat index is expected to reach 105 to 110 degrees today."

"Wind chill temperatures will drop to 30 below zero tonight."

"Flash flood watch is in effect until 8 AM EDT Wednesday."

b) "Short-Term Forecasts" are issued to highlight forecast conditions over the next 1 to 6 hours. These forecasts are also for specific counties and cities and are updated on a weather driven basis.

c) 3 to 5 day extended forecasts are primarily updated twice a day (4 AM and 4 PM) as part of the zone forecast product.

d) State Forecast are issued twice a day (5 AM and 5 PM) and provide a generalized forecast for days 1 through 5 for the entire area designated.

APPENDIX B



GLOSSARY OF WEATHER TERMS

Weather terms are listed by topic.

THUNDERSTORM TERMS:

1. **Cumulus cloud** - a cauliflower shaped cloud with a flat base and sharp edges. Tufts are rising columns of air condensing. As the cloud and cloud droplets grow in size, the base will begin to gray.
2. **Towering cumulus cloud** - a cumulus cloud that continues to grow so that its height is taller than or equal to its width. It is first stage to growing into a thunderstorm. It may be producing a shower.
3. **Thunderstorm (cumulonimbus)** - the towering cumulus cloud has continued to grow in height and width and now lightning is occurring. The storm may extend 5 to 10 miles high into the atmosphere and 5 to 25 miles across. Heavy rains and gusty winds often accompany the storms.
4. **Precipitation shaft** - a visible column of rain or hail falling from the base of the cloud.
5. **Hail** - Precipitation in the form of balls or clumps of ice.
6. **Squall line** - a solid line or band of active thunderstorms.
7. **Anvil** - The spreading out (by strong winds) of the upper portion of the thunderstorm. It usually has a fibrous or smooth appearance. With long lasting thunderstorms, the anvil may spread 100 miles downwind.
8. **Mammatus (or mamma clouds)** - these clouds appear to be hanging, rounded protuberances or pouches on the underside of the cloud. With thunderstorms, it is usually seen under the anvil and often accompany severe thunderstorms.
9. **Gust front** - the leading edge of the thunderstorm's downdraft of air as it spreads out away from the storm. It is usually felt as a change to gusty cool winds and often precedes the thunderstorm's rain by several minutes.
10. **Shelf cloud** - a low-level, wedge-shaped cloud attached to the thunderstorm. It forms above the gust front as warm air ahead of the storm rides over the cool outflow from the thunderstorm.
11. **Roll cloud** - on rare occasions, a shelf cloud may turn into a roll cloud. The motions of the warm air riding up and over the cool air moving down and under creates a swirling of air or an eddy. The cloud takes on the shape of a horizontal tube that appears to be rolling. It is detached from the thunderstorm on its leading edge.
12. **Rain-free base** - the dark underside of a cloud (its base) that has no visible precipitation falling from it. This marks the updraft of a thunderstorm.
13. **Wall cloud** - this cloud appears as an abrupt lowering of the cloud base from the relatively flat rain-free base. It is attached to a thunderstorm and may be rotating. This is the portion of the thunderstorm from which the tornado often descends.

14. **Funnel cloud** - a funnel-shaped cloud extending from a towering cumulus or thunderstorm. It is associated with a rotating column of air that has condensed to form a cloud.

15. **Tornado** - a violently rotating column of air in contact with the ground and extending to the thunderstorm base often seen extending from near the wall cloud. It can be a few yards across to a mile wide.

16. **Flanking line** - A line of cumulus clouds connected to and extending outward from the most active portion of a parent cumulonimbus, usually found on the southwest (right, rear) side of a storm. The cloud line has roughly a stair step appearance with the taller clouds adjacent to the parent cumulonimbus. It is most frequently associated with strong or severe thunderstorms.

17. **Hook echo** - A radar pattern sometimes observed in the southwest (right, rear) quadrant of a tornadic thunderstorm. The rain echo forms the hook pattern as air rotates around the strong updraft. The updraft is the hollow portion of the hook (looks like a backwards "J" or a 6) and is where the tornado would most likely be found (if the storm were to produce one).

18. **Scud clouds** - Low cloud fragments often seen in association with and behind thunderstorm gust fronts. These clouds are ragged and wind torn and are not usually attached to the thunderstorm. 19. **Updraft** - Warm, moist, rising air. As the air rises, it condenses into a visible cumulus or cumulonimbus cloud. The updraft fuels the storm. In an ordinary thunderstorm, air rises at 40 mph and in a severe thunderstorm speeds may reach over 100 mph.

20. **Downdraft** - A column of cool air that sinks toward the ground. It is most often accompanied by rain.

21. **Downburst** - A sudden rush of cool air toward ground that can impact with speeds over 70 mph and produce damage similar to that of a tornado. It usually occurs near the leading edge of the storm or may occur in heavy rain.

22. **Microburst** - A small downburst effecting an area less than 2.5 Km in diameter.

23. **Macroburst** - A larger downburst effecting an area greater than 2.5 Km in diameter.

24. **Severe thunderstorm** - A thunderstorm producing damaging winds or winds greater than 58 mph and/or hail three-quarter of an inch or greater.

HURRICANE TERMS:

1. **Tropical disturbance** - A moving area of thunderstorms in the Tropics that maintains its identity for 24 hours or more.

2. **Tropical depression** - A cluster of thunderstorms in the tropics that maintains its identity and shows rotary circulation at the surface with constant wind speeds of 38 mph or less.

3. **Tropical storm** - Evolves from a tropical depression or may be a hurricane in its dissipating stage. Rotary circulation is distinct and constant wind speeds range from 39 to 73 mph.

4. **Hurricane** - Evolves from a tropical storm. Rotary circulation has become pronounced and an eye is detectable. Constant wind speeds are 74 mph or greater.

5. **Eye** - The center of the hurricane where winds are light and skies are clear to partly cloudy. The eye is rimmed by massive thunderstorms producing torrential rains and extreme winds.

6. **Eye wall** - A wall of thunderstorms around the eye.

7. **Spiral bands** - Bands of thunderstorms that appear to spiral in toward the hurricane's center.
8. **Storm surge** - a dome of water often 50 miles wide that comes sweeping across the coastline near the area where the eye of the hurricane makes landfall.

FLOOD TERMS:

1. **Flash flood** - a flood that occurs suddenly during or shortly following heavy rains or from a sudden release of water as in a dam break. Small streams and creeks usually react the fastest to heavy rains and rise several feet in hours or even minutes.
2. **River flood** - a flood on large river such as the Potomac take a tremendous amount of rain and usually develops over a period of one to two days. Rain water first runs into the small streams which flow into the larger branches and eventually end up in the main stem of the river. A flood crest from heavy rains in West Virginia may take 2 days or more to reach Washington, D.C.
3. **Coastal flood** - high tides, persistent onshore winds or a hurricane storm surge can cause flooding along coastal areas.
4. **Urban flood** - pavement which causes rapid runoff (rain can't soak into the ground so it runs downhill) and poor drainage can lead to flooded roadways and underpasses and even become deadly.
5. **Bankfull** - the maximum height of the river before it overflows its banks.
6. **Flood stage** - the height of the river at which property damage begins to occur. Often differs from bankfull. The river may overflow its banks into flood plain without reaching flood stage.
7. **Flood crest** - the highest height that the river reaches during a flood event.

WINTER WEATHER TERMS:

1. **Snow** - Refers to a steady fall and accumulation of snow for several hours or more. It may be modified by terms such as "light," "intermittent," or "occasional" to indicate intensity or periodic snow.
2. **Snow flurries** - light snow falling for short durations. No accumulation to a light dusting (or trace) is expected.
3. **Snow showers** - snow falling at varying intensities for brief time periods. Some accumulation is possible.
4. **Snow squalls** - brief, intense snow showers, accompanied by strong, gusty winds. Accumulations may be significant.
5. **Drifting snow** - winds are strong enough to blow falling snow or loose snow on the ground into mounds causing uneven snow depths. The wind carries the snow near the ground causing no restriction to visibility.
6. **Blowing snow** - Wind-driven snow that causes reduced visibility and sometimes significant drifting. Blowing snow may be snow that is falling or snow that was once loose on the ground and picked up by the wind.

7. **Heavy snow** - Snow accumulating to six inches in 24 hours. These values will be a couple inches higher for mountainous regions, New England, or near the Great Lakes where higher snowfall is more common.
8. **Blizzard** - strong winds (greater than 35 mph) and heavy snow or blowing snow combine to produce very poor visibility.
9. **Sleet** - ice pellets or granules of frozen rain. Occurs when rain falls into a layer of air with temperatures below freezing. Sleet usually bounces when hitting a surface and does not stick, but can accumulate on roadways causing a hazard to motorists.
10. **Freezing rain** - rain that falls onto a surface with a temperature below freezing causing it to freeze to the surface forming a coating of ice or glaze.
11. **Freezing drizzle** - drizzle that falls onto a surface with a temperature below freezing causing it to freeze to the surface forming a thin coating of ice or rime. Drizzle is a very light precipitation with little accumulation, but even a small amount of ice can sometimes cause a problem.
12. **Ice storm** - significant and possibly damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations are usually accumulations of .25 inches or greater, but may vary from region to region across the country.
13. **Wind chill** (Wind chill factor) - combines the rate of heat loss caused by wind and lowering temperature. As the wind rises, heat is carried away from a person's body at a more accelerated rate driving down the body temperature.
14. **Freeze** - used when temperatures at or near the surface (ground) are expected to be 32°F degrees or below. Sometimes used with adjectives "Killing," "severe," or "hard". A freeze may or may not be accompanied by frost.
15. **Frost** - the formation of ice crystals in the forms of scales, needles, feathers, or fans, which develop under conditions similar to dew, except that the temperature has dropped to at least 32°F.
16. **Hypothermia** - when the body temperature drops below 95°F.
17. **Frost bite** - frozen body tissue.

APPENDIX C



GENERAL SEVERE WEATHER SAFETY

TORNADOES AND SEVERE (DAMAGING) WINDS

The greatest danger is from flying debris (airborne missiles) and the collapse of a building's roof and/or wall structure. The following actions are designed for protection from these dangers. Take action if a tornado approaches or a tornado warning is issued.

In a building (home, school, etc.) move to the basement. If no basement, move to a small, interior room or hallway on the lowest level. Stay away from windows and exterior doors. If at all possible, get under something (such as a table) and place something over your head (such as a pillow, mattress, blanket, or coat) for added protection.

DO NOT STAY IN A MOBILE HOME OR ANY TYPE OF TEMPORARY SHELTER. If in a mobile home or temporary shelter, get out. Move away from the shelter so that the debris does not fall on you. Look for a low area preferably a ditch or ravine if nearby. Take the protective position on your elbows and knees with your hands over your head.

DO NOT TRY TO OUTRUN A TORNADO IN A CAR, BUS OR TRUCK. If in a car, truck or bus, STOP. Get out. Move away from the vehicle so it does not topple on you. Find a low area preferably a ditch or ravine if nearby. Take the protective position on your elbows and knees with your hands over your head.

If on foot with no well constructed shelter nearby, find a low area preferably a ditch or ravine if near by. Take the protective position on your elbows and knees with your hands over your head.

After the storm, if a tornado has struck your neighborhood, turn off gas at the main switch to your building. If live electrical wires are down, turn off power at the main switch. Instruct people not to touch loose electrical wires or broken utility lines. Do not touch electrical equipment in wet areas until it has been dried and tested. Food, clothing, shelter, and first aid will be available at Red Cross shelters.

HAIL (FROM THUNDERSTORMS)

The greatest danger comes from the high velocities with which large hail can impact a surface (speeds greater than 100 mph). To avoid getting hit with hail, one needs only to move inside. However, there are other considerations such as staying away from skylights. Hailstones can go through a vehicle's windshield. Hailstones driven by a storm's high winds may shatter a building's side windows.

A last consideration is that large hail is a sign that this is a powerful and potentially dangerous storm. Hail falls from the same area of a thunderstorm where the tornado is found. Large hail does not always imply a tornado, but if a tornado is associated with that storm and you are currently experiencing hail, then you may be very close to the tornado.

LIGHTNING

All thunderstorms produce lightning, by definition. **If you can hear thunder, you are close enough to the storm to be struck. Take protective actions. Move inside.** It need not be raining! Lightning can strike 10 to 15 miles away from the rain portion of the storm! These lightning strokes come out of the upper portions of the thunderstorm cloud which extends 5 to 10 miles into the atmosphere.

In general, lightning will travel the easiest route from the cloud to ground which means that it often strikes the highest object. Therefore, a simple rule is **do not make yourself the tallest object or stand near the tallest object in your immediate surrounding.** For instance, do not stand in an open field, on a beach, or on a hill top. Do not stand under an isolated or large tree or near a pole. Do not stay out on a boat.

When lightning strikes, the current will travel through the object, along the ground, along wire, metal, and water. Most lightning related injuries occur in this matter. The electrical current will travel the easiest route. **Stay away from metal objects** such as fences, poles, equipment, pipes, etc. Get rid of metal objects on your body such as coins, money clips, hair pins, jewelry, etc. **Stay away from water. Inside, stay away from electrical appliances, televisions, and telephones.** Only use the phone in an emergency.

If caught outside and a thunderstorm approaches:

1. Move into a building. Stay away from doors and windows.

2. If a building is not available, get inside a car (hardtop not a convertible) and keep the windows rolled up.
3. If there are no cars or buildings, a) in a forest, look for a low area under thick growth of small trees. b) in an open area, go to a low place preferably a ravine or valley.
4. If in a group of people, spread out, keeping several yards apart from each other.
5. If you feel your hair stand on end, you are in immediate danger of being struck.

Unless you can instantly jump inside a shelter, drop to a crouching position bending forward and keeping your feet close together with your hands on your knees. The object is to be as low to the ground as possible and yet have as little of your body surface touching the ground.

First Aid

If a person is struck by lightning, check to see if the person is breathing. If not, begin mouth-to-mouth resuscitation. If no pulse is present, begin CPR (Cardiopulmonary resuscitation). Lightning often has a paralyzing effect that is temporary. Even though a person appears dead, they may be resuscitated. Victims may experience temporary paralysis of legs, be stunned and disoriented, or have burns on their body. Give first aid for shock and stay with the victim until help arrives.

After the storm, instruct people not to touch loose electrical wires or broken utility lines. Do not touch electrical equipment in wet areas until it has been dried and tested.

FLOODING

Flash floods are the most dangerous. A flash flood is rapid rise of flood waters allowing little time for action. Flash floods can move at tremendous speeds tearing out trees and moving boulders. The debris moves with the flood wave and sometimes destroys buildings and bridges in its path. Debris may cause a temporary dam and when broken a wall of water moves downstream. Walls of water (such as in Virginia with the remnants of hurricane Camille) can reach 10 to 20 feet. Floods and flash floods are the number one weather-related killer in the United States.

When a flood warning is issued or the moment you first realize that a flash flood is coming, act quickly to save yourself. You may only have seconds.

Get out of areas subject to flooding. This includes dips, low spots, canyons, washes, areas along streams and creeks. This also includes urban areas where storm drains become clogged with debris and rain, unable to be soaked up by the paved ground, rapidly builds the flow of runoff. Some underpasses can be extremely dangerous, rapidly filling with water.

DO NOT ENTER FLOOD WATERS. DO NOT ATTEMPT TO CROSS FLOWING WATER IN A CAR OR TRUCK. FIND AN ALTERNATE ROUTE. Almost half of all flood deaths occur in automobiles. Water depths can be very deceptive; the road beneath may even be undermined. The force of flowing water on a vehicle is very powerful and a foot of water may be all it takes to drag a car into deeper waters or flip it over. Many cars stall once entering the water. Electrical systems in the car may fail causing electrical window and doors to not operate trapping the victim inside as the water continues to rise.

If the vehicle stalls, abandon it immediately and seek higher ground. Rapidly rising water may engulf the vehicle and sweep it away.

After the storm, if a flood has struck your neighborhood, turn off gas at the main switch to your building. If live electrical wires are down, turn off power at the main switch. Instruct people not to touch loose electrical wires or broken utility lines. Do not touch electrical equipment in wet areas until it has been dried and tested. Do not touch fresh food that has come in contact with flood

waters. Boil drinking water before using until water has been tested for purity. Food, clothing, shelter, and first aid will be available at Red Cross shelters.

HURRICANES AND STORM SURGE

Hurricanes are essentially large complexes of thunderstorms. Therefore, they include all of the dangers that can come with thunderstorms: lightning, flash floods, downbursts, tornadoes. For coastal areas, the added threat is flooding from high tides and the storm surge. The storm surge is a dome of water (perhaps only 2 feet high or maybe 15 to 20 feet high and often 50 miles across) that comes sweeping across the coastline just to the right (north) of the area where the eye of the hurricane makes landfall.

Preparations for a hurricane should begin well in advance of the storm. Contact your local Emergency Management or National Weather Service for more information of Hurricane Preparedness. Listen to local authorities and evacuate when requested. Know your evacuation routes before the hurricane comes.

Hurricanes can produce widespread damage with trees and flood waters blocking roads, cutting off communications and electricity for days. Have at least a 3 day supply of food (non-perishable) and water (fill bathtub and other containers). Have plenty of batteries for use in flashlights and portable radios or televisions. Have a first-aid kit and extra baby supplies or prescription medicines, if needed.

If caught in the storm, follow safety rules described above for tornadoes/severe (damaging) winds, lightning, and flooding. Stay away from dangling or downed electrical wires and turn off gas (there could be a leak).

WINTER STORMS

The most severe winter storm is generally considered to be a blizzard (strong winds and blinding snow), but any heavy snow storms or ice storms can become life threatening. Most winter storm related deaths (about 60%) occur in automobiles. Some occur from exposure to cold (see extreme cold section), heart attacks from overexertion, fires from improper use of heaters, and other types of accidents.

Be prepared for the storm before it strikes. Listen to NOAA Weather Radio. If a Winter Storm Warning is issued, stay at home or, if need be, at work or school. Do not venture out into the storm. Winter storms (ice and snow) can close roads and knock out phones and electrical power for hours or a couple days in a bad storm. Have extra batteries, flashlights and a battery-powered, portable radio on hand. Have plenty of food (non-perishable, ready to eat) and water. Have a first-aid kit and extra medicines. Winterize your vehicles at the start of the season and keep your gas tank near full so ice doesn't form in the fuel lines. Have extra supplies in the vehicle in case you become stranded.

If caught in the storm, try to stay dry and warm. If in a car, bus, or truck, stay there, unless shelter can be seen just yards away. Disorientation in cold and snow occurs rapidly. Run the motor sparingly for heat. Open windows slightly to prevent carbon monoxide poisoning. If trapped at home, school, or work, and without heat, close off unneeded rooms. Stuff towels, rags or extra clothes in cracks under doors. Cover windows at night. If using an alternate heat source, such as a fireplace, woodstove, space heater, etc., follow directions, use fire safeguards, and ventilate properly.

If caught outside without shelter, make one. Dig a snow cave. Find an area protected from wind. Build a lean-to or wind break out of sticks and branches. Build a fire and place stones around the

fire to absorb and reflect back heat. Do not eat snow for water. It will drop your body temperature.

You must melt it first. Exercise periodically, by rapidly moving arms, legs, fingers, and toes to keep blood circulating and to keep warm. If there is more than one person, sleep in shifts and help keep each other warm.

EXTREME COLD

The people most often effected by cold are elderly and babies. However, if proper precautions are not taken, anyone can find him/herself suffering from hypothermia or frostbite.

Wind chill combines the rate of heat loss (from exposed skin) caused by wind and cold temperatures. As the wind increases, heat is carried away from a person's body at an accelerated rate driving down the body temperature. A 20 degree F temperature combined with a 20 mph wind produces a wind chill of -10 degrees F.

Hypothermia occurs when the body temperature drops. Warning signs are uncontrollable shivering; loss of memory; disorientation; incoherence; vague, slow, slurred speech; frequent stumbling; drowsiness; apparent exhaustion or inability to get up from rest. If a person's body temperature drops below 95 F degrees, seek medical help immediately.

If unable to get medical help, wrap the person in a warm blanket covering the head and neck. Do not give the person alcohol, drugs, hot liquid or hot food (warm is better). The person needs to be warmed slowly. **Do not warm extremities (arms, legs, hands, etc.) first!** This drives the cold blood toward the heart and can lead to heart failure. Warm the body core first. If needed, use your own body heat to help.

Frostbite is when the body tissue freezes, damaging the tissue. Frostbite causes a loss of feeling and a white or pale appearance in extremities, such as fingers, toes, ear lobes, or the tip of the nose. If symptoms are detected, get medical help immediately. If you must wait for help, slowly rewarm affected areas.

To prevent hypothermia and frost bite, stay inside during extreme cold spells or heavy snow storms. If you must go out, dress appropriately. Wear loose-fitting, light-weight, warm clothing in several layers. Trapped cold air insulates. Avoid overexertion. The strain from the cold and hard labor (such as shoveling wet snow, walking through drifts, etc) may lead to a heart attack. Sweating can lead to a chill and hypothermia. By wearing layers of clothes, if perspiration occurs, layers can be removed and then added back when needed. Outer garments should be tightly woven, water repellent, and hooded. Wear a hat. Half of your body heat loss can be from your head. Cover your mouth (using a scarf, etc.) to protect your lungs from extreme cold. Mittens, snug at the wrist, are better than gloves for protecting the hands. Try to stay dry.

EXTREME HEAT

The human body dissipates heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and (as the last extremity is reached) by panting when blood is heated above 98.6 degrees. The skin handles about 90 percent of the body's heat dissipating function. However, sweating does not cool the body unless the water is evaporated. Evaporation is a cooling process.

On hot days where the temperature is above 90°F and the relative humidity is high, evaporation slows. The body attempts to do everything it can to maintain 98.6°F inside. The heart is pumping a torrent of blood through dilated circulatory vessels; the sweat glands are pouring liquid, including essential dissolved chemicals like sodium and chloride, onto the surface of the skin.

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop.

Other factors:

1. Cities can add to the hazard. Stagnant air conditions trap pollutants in urban areas and add the stresses of severe pollution to the already dangerous stresses of hot weather. Temperatures over large paved areas are much warmer than that of parks and grassy areas.
2. Sunburn can significantly retard the skin's ability to shed excess heat.
3. People on certain medication or drugs (such as tranquilizers and anticholinergics) and people overweight or with an alcohol problem are particularly susceptible.

What should one do to prevent heat disorders:

1. **Slow down.** Reduce, reschedule, or eliminate strenuous activity.
2. **Dress for the summer.** Wear lightweight, light-colored clothing.
3. **Drink plenty of water.**
4. **Do not get too much sun.**

Heat index combines the effects of high temperature and relative humidity. Using the current temperature and relative humidity, calculate the heat index using the chart provided. Exposure to full sun can increase these values by up to 15 degrees. When the NWS is expecting the heat index to exceed 105 degrees, this will be headlined in the forecast. At Heat Indices above 105 degrees, possible heat disorders include heat cramps or heat exhaustion. Heatstroke is possible with prolonged exposure and/or physical activity.

First Aid

- 1) **Heat cramps** are painful spasms usually in muscles of legs and abdomen. Use firm pressure on cramping muscles, or gentle massage to relieve spasm. Give sips of water unless nausea occurs.
- 2) **Heat exhaustion** symptoms include heavy sweating; weakness; cold, pale clammy skin; and/or thready pulse. Fainting or vomiting may occur. Get the victim out of the sun. lay them down and loosen clothing. Apply cool wet cloths. Give sips of water unless nausea occurs. If vomiting continues, seek immediate medical attention.
- 3) **Heatstroke** (sunstroke) is when the body temperature reaches 106 degrees. Symptoms are hot dry skin and rapid and strong pulse. Person may become unconscious. Heatstroke is a severe medical emergency; summon medical help immediately or take to a hospital. While awaiting medical help, move the victim to a cooler environment. Reduce the body temperature with a cold bath or sponging. Use fans or air conditioners. Do not give fluids.

APPENDIX D

NATIONAL WEATHER SERVICE CONTACTS



For weather information and preparedness materials, contact the local weather office for your county or city. This is the office that has "warning responsibility" for your area (see map next page)

for assistance). You can also order weather hazard brochures through your local chapter of the American Red Cross.

WCM = Warning Coordination Meteorologist

Virginia NWS Operational Areas Map

National Weather Service, Baltimore-Washington Warning & Forecast Office (LWX)

44087 Weather Service Road, Sterling, Virginia 20166

(703) 260-0107 ext. 223 Barbara McNaught Watson, WCM

Web site: <http://www.nws.noaa.gov/er/lwx>

National Weather Service, Wakefield Warning & Forecast Office (AKQ) (SE Virginia)

10009 General Mahone Highway, Wakefield, VA 23888

(757) 899 - 4200 ext. 223 Bill Sammler, WCM

Web site: <http://www.nws.noaa.gov/er/akq>

National Weather Service, Blacksburg (Roanoke) Warning & Forecast Office (RNK)

VA Tech Corp. Research Center, 1750 Forecast Drive, Blacksburg, VA 24060

(540) 552-0084 ext. 223 Mike Emlaw, WCM

Web site: <http://www.bev.net/weather>

National Weather Service, Knoxville/Tri-Cities Warning & Forecast Office (TRI)

(423) 586-9040 ext. 223 Steve Hunter, WCM

Web site: <http://www.srh.noaa.gov/MRX>

National Weather Service, Philadelphia (Mt. Holly) Warning & Forecast Office (PHI)

732 Woodlane Road, Mt. Holly, NJ 08060

(609) 261-6600 ext. 223 Joe Miketta, WCM

Web site: <http://www.nws.noaa.gov/er/phi>

National Weather Service, State College Warning & Forecast Office (CTP)

227 West Beaver Avenue, Suite 402, State College, PA 16801-4821

(814) 234-9412 ext. 223 Ton Dunham, WCM

Web site: <http://bookend.met.psu.edu>

National Weather Service, Pittsburgh Warning & Forecast Office (PBZ)

192 Shafer Road, Coraopolis, PA 15108

(412) 262-1591 ext. 223 Rich Kane, WCM

Web site: <http://www.nws.noaa.gov/er/pit>

National Weather Service, Charleston Warning & Forecast Office (RLX)

400 Parkway Road, Charleston, WV 25309

(304) 746-0173 ext. 223 Dan Barthoff, WCM

Web site: <http://www.nws.noaa.gov/er/rlx>

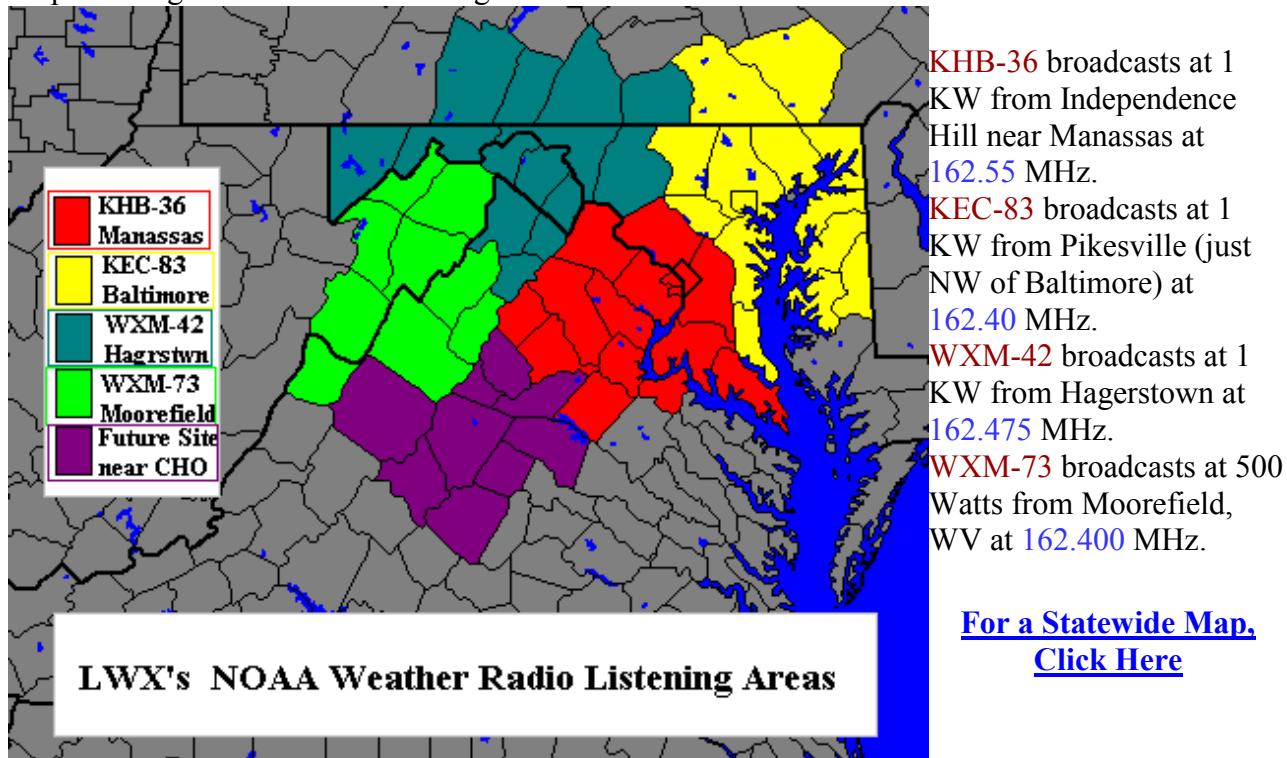
Appendix E



NOAA Weather Radio: Continuous broadcast of weather, 24 hours a day, 7 days per week. All warnings are tone alerted as well as Tornado, Severe Thunderstorm, and Flash Flood Watches.

Link to the NOAA Weather Radio Web Site: <http://www.nws.noaa.gov/nwr>

Map showing the Baltimore-Washington NWS Office's NOAA Weather Radio transmitter



APPENDIX F. PRIMARY EMERGENCY ALERT SYSTEM (EAS) STATIONS [Weather Radio/EAS regions in Virginia](#)

VIRGINIA

1. WGH (AM-1310) / WAFX (FM-106.9): Eastern VA - Virginia Beach, Portsmouth, Chesapeake, Suffolk, Isle of Wight, Surry, Norfolk, Newport News, Hampton, York, James City, Gloucester, Matthews, Poquoson, Williamsburg, Northampton, Accomack, Southampton, City of Franklin.

2. WRVA (AM-1140) / WRVQ (FM-94.5): Richmond Extended - Franklin County, Greensville, Emporia City, Sussex, Dinwiddie, Prince George, Petersburg, Colonial Heights, Hopewell, Charles City, Richmond City, Chesterfield, Powhatan, Henrico, Amelia, Goochland, New Kent, Hanover, Louisa, King William, King and Queen, Caroline, Middlesex, Essex, Richmond County, Lancaster, Northumberland, Westmoreland.

3. WFLS (FM-93.3) / WBQB (FM-101.5): Fredericksburg - King George, Stafford, City of Fredericksburg, Spotsylvania, Fauquier.

4. WTOP (AM-1500) / (FM-107.7): Northern VA - Loudoun, Fairfax County, City of Fairfax, Arlington, City of Falls Church, City of Alexandria, Prince William, Cities of Manassas and Manassas Park.

- 5. WJMA (FM-96.7) / WCUL (FM-103.1):** Culpeper - Culpeper, Orange, Madison.
- 6. WCHV (AM-1260) / WWWV (FM-97.5):** Charlottesville - City of Charlottesville, Albemarle, Greene, Fluvanna, Nelson.
- 7. WFLO (FM-95.7) / WXJK (FM-101.3):** Farmville - Cumberland, Prince Edward, Buckingham.
- 8. WVGO (FM104.7) / WSVS (AM-800):** Southside - Nottoway, Lunenburg, Mecklenburg, Brunswick.
- 9. WAKG (FM-101.3) / WBTM (AM-1330):** Danville-South Boston - Danville City, Pittsylvania, Halifax, Charlotte.
- 10. WPVR (FM-94.9) / WSLQ (FM-99.1):** Roanoke Extended - Clifton Forge City, Alleghany, Covington City, Craig, Bath, Highland, Botetourt, Giles, Rockbridge, Lexington City, Buena Vista City, Bedford City, Salem City, Roanoke City, Franklin County, Radford City, Pulaski, Montgomery, Floyd, Patrick, Henry, Martinsville City, Amherst, Bedford County, Lynchburg City, Amherst, Appomattox, Campbell.
- 11. WQPO (FM-100.7) / WMRA (FM-90.7):** Shenandoah Valley - Augusta, Cities of Staunton and Waynesboro, Rockingham, City of Harrisonburg, Page, Shenandoah.
- 12. WINC (FM-92.5) / WFTR (FM-95.3):** Winchester - Frederick, City of Winchester, Clarke, Warren.
- 13. WMEV (FM-93.9) / WBRF (FM-98.1):** Marion - Tazewell, Bland, Smyth, Wythe, Grayson, Galax City, Carroll.
- 14. WXQB (AM-980 / FM-96.9):** Northeast TN / Western VA - Buchanan, Dickenson, Wise, Norton City, Russell, Washington, Bristol, Scott, Lee.

MARYLAND and DC

- 1. WTOP (AM-1500) / WMAL (AM-630):** Washington DC Area - District of Columbia, Prince Georges and Montgomery Counties in Maryland.
- 2. WBAL (AM-1090) / WIYY (FM-97.9):** Baltimore Area - Baltimore City, Baltimore County, Carroll County, and Howard County.
- 3. WFMD (AM-930) / WFRE (FM-99.9):** Frederick - Frederick County.
- 4. WJEJ (AM-1240) / WWMD (FM-104.7):** Hagerstown - Washington County.
- 5. WTBO (AM-1450) / WKGO (FM 106.1):** Cumberland - Allegany County.
- 6. WFRB (AM-560 / FM-105.3):** Garrett - Garrett County.
- 7. WXTR (FM-104.1) :** Southern Maryland - Charles, St. Marys, and Calvert Counties.
- 8. WNAV (AM-1430) / WHFS (FM-99.1) :** Annapolis - Anne Arundel County.
- 9. WAMD (AM-970) :** Northeast MD - Harford and Cecil Counties.
- 10. WCEI (AM-1460 / FM-96.7):** Upper Eastern Shore - Kent, Queen Annes, Talbot, and Caroline Counties.

11. WCEM (AM-1240 / FM-106.3): Dorchester - Dorchester County.

12. WLVW (AM-960) / WQHQ (FM-104.7): Lower Eastern Shore - Wicomico, Somerset, and Worcester Counties.

NORTH CAROLINA

1. WMIT (FM-106.9) / WKSF (FM-99.9): Asheville Local Area - Cherokee, Clay, Buncombe, Macon, Madison, McDowell, Henderson, Polk, Rutherford, Haywood, Mitchell, Yancy, Burke, Transylvania and Avery.

2. WLNK (FM-107.9) / WSOC (FM-103.7): Charlotte Local Area - Stanly, Montgomery, Anson, Richmond, Union, Mecklenburg, Cabarrus, Catawba, Lincoln and Gaston.

3. WRSF (FM-105.7) / WNHW (FM-92.5): Columbia Local Area - Tyrell, Bertie, Hertford, Gates, Chowan, Washington, Perquimans, Pasquotank, Camden, Currituck and Dare.

4. WQSM (FM-98.1) / WKML (FM-95.7): Fayetteville Local Area - Scotland, Robeson, Bladen, Hoke, Sampson, Duplin and Cumberland.

5. WRDU (FM-106.1) / WKTC (FM-96.9): Goldsboro Local Area - Wilson, Nash, Edgecombe, Halifax, Northampton and Wayne.

6. WQDR (FM-94.7) / WDCG (FM-105.1): Raleigh Local Area - Moore, Chatham, Lee, Harnett, Johnston, Wake, Durham, Orange, Person, Granville, Warren and Franklin.

7. WFMX (FM-105.7) / WKBC (FM-97.3): Statesville Local Area - Rowan, Iredell, Davie, Alexander, Wilkes, Alleghany, Ashe, Watauga and Caldwell.

8. WPCM (FM-101.1) / WTQR (FM-104.1): Triad Local Area - Alamance, Caswell, Randolph, Guilford, Rockingham, Stokes, Forsyth, Davidson, Yadkin and Surry.

9. WERO (FM-93.3) / WRNS (FM-95.1): Washington Local Area - Martin, Beaufort, Pitt, Greene, Lenoir, Jones, Carteret, Craven, Pamlico and Hyde.

10. WMNX (FM-97.3) / WKOO (FM-98.7): Wilmington Local Area - Brunswick, Columbus, New Hanover, Pender and Onslow.

APPENDIX G



Other Agency Contacts

Virginia Department of Emergency Services

Janet Clements, Public Information Officer
10501 Trade Court
Richmond, Virginia 23236
(804) 897 - 6500

Web site: <http://www.vdes.state.va.us>

Maryland Emergency Management Agency

Butch Kinerney, Public Information Officer
2 Sudbrook Lane East
Pikesville, Maryland 21208
(410) 486 - 4422

Web site: <http://www.mema.state.md.us>

District of Columbia, Office of Emergency Preparedness

Darryl Claggett, Public Information Officer
2000 14th Street, N.W. 8th Floor
Washington, D.C. 20009
(202) 727 - 6161

Web Site: <http://www.fema.gov/DC-OEP/>

West Virginia Office of Emergency Services

Building 1, Room EB-80
1900 Kanawha Boulevard, East
Charleston, WV 25305-0360

Federal Emergency Management Agency

Web Site: <http://www.fema.gov>

National Weather Service (National site)

Web Site: <http://www.nws.noaa.gov>

American Red Cross

Web Site: <http://www.redcross.org>



APPENDIX H

SEVERE WEATHER SAFETY PLAN CHECKLIST

Use the following checklist for the evaluation or design of a severe weather safety plan for your school. The plan should be designed so that teachers and students anywhere on the school grounds can be quickly alerted and follow a preset plan of action to maximize safety.

- Who is responsible for activating the plan? Is there a back-up person?

- What is/are the primary means of receiving severe weather information? NOAA Weather Radio with an alert feature is recommended
- What method do you employ to alert teachers and students? Is there a back-up that does not require electricity?
- Make provisions for the following problem areas:
 1. Students that are in mobile classrooms away from the main building and disconnected from an intercom system.
 2. Students that are in the cafeteria or gymnasium during the storm.
 3. Any students with disabilities who may be in a position to either not hear the warning or be able to respond to it on their own accord. Assign a teacher to each student who needs special attention to ensure that the student arrives at a place of safety.
 4. Students who are outside, including after-school activities. Remember, if you hear thunder, it is time to take action. Also, students who are outside are at risk from the dangers of large hail and severe thunderstorm winds.
- Five main problems for schools in a tornado:
 1. Forces caused by winds and the airflow around the building.
 2. Forces caused by other objects (debris) impacting school walls.
 3. Pressure differences caused by a tornado (secondary to first two).
 4. Gas leaks and electrical hazards after the storm. Have someone knowledgeable in turning off gas and electricity at the school during school hours.
 5. "Wind Tunnel Effect" - When blown by tornado-strength winds, debris (such as fragments of glass, wood, and metal) can cause serious injury when accelerated by relatively narrow hallways in schools.
- Other thunderstorm hazards: Are you prepared?
 1. Lightning may pose a threat well before strong winds/rain affect the area. Athletic teams out on open fields need to be especially cautious.
 2. Large hail - the largest hail usually occurs near the most dangerous area of the storm for the development of tornadoes. Large hail can break windows.
 3. Heavy rains/flooding - Are there flood-prone areas near the school?
 4. Damaging "straight-line" winds - A thunderstorm does not have to produce a tornado to pose a threat to schools and students.
- Safest places to be in a school: (assuming no underground shelter)
 1. Interior hallway on the lowest level.
 2. Away from windows.
 3. If possible get in a hallway that is at a right angle to the approaching tornado's path (to avoid the wind tunnel effect).
 4. In a small room, such as a bathroom, surrounded by load-bearing walls.
 5. In a room without small objects that can serve as projectiles.
- Some other aspects of designing a plan:
 1. Practice your plan. Have drills semi-annually (Fall and Spring).

2. Include Severe Weather Safety Instruction as part of the drill period.
 3. Encourage teachers and administrators to develop a plan for their families at home. The knowledge that their families know what to do at home will enable them to focus their attention on the students. The American Red Cross has brochures on developing a "Family Protection Plan."
 4. Educate school administrators about the structure of severe thunderstorms and the basic sequence of events as a storm approaches. Explain the concepts of rotating wall clouds and the preferred locations for these features within the storm. (Attend the NWS SKYWARN severe spotter training class - no fee). Emphasize the variability that may exist with each storm and the need to understand basic storm structure to assist in determining the degree of threat at a school.
 5. For optimum planning purposes, an engineer and a member of the local school board should participate in the design of an emergency plan.
 6. Encourage administrators to contact the nearest National Weather Service Office or Local Emergency Services Coordinator for assistance in answering ANY questions that may arise in developing a plan.
-