

Weather 101: Damage Surveys & The EF-Scale

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Audio Check!

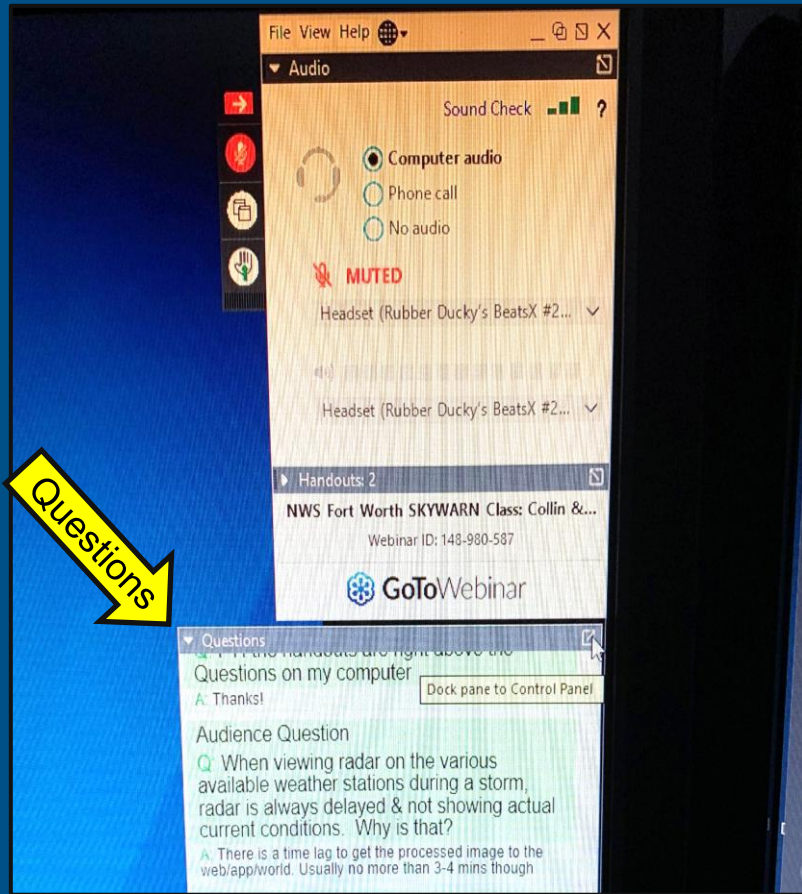
The next 1-2 minutes will be used to make sure YOU can hear OUR audio.

If you cannot hear us, check your volume, speakers, and/or check if there is a dialogue box hidden behind this screen

If you still cannot hear us, we are sorry but there is not much other support we can provide.

The Questions Box

- Questions are not being answered “Live”; they will be answered after the presentation.
- Questions can be typed into the Questions Box in the Control Interface.
- Depending on time, I may be able to unmute microphones after the presentation for verbal questions.
- Unfortunately You will not see the questions other people ask.



Overview of Today's Topics



**Damage
Surveys**



**Enhanced
Fujita Scale
(EF-Scale)**



**Examples &
You're in the
Hot Seat!**

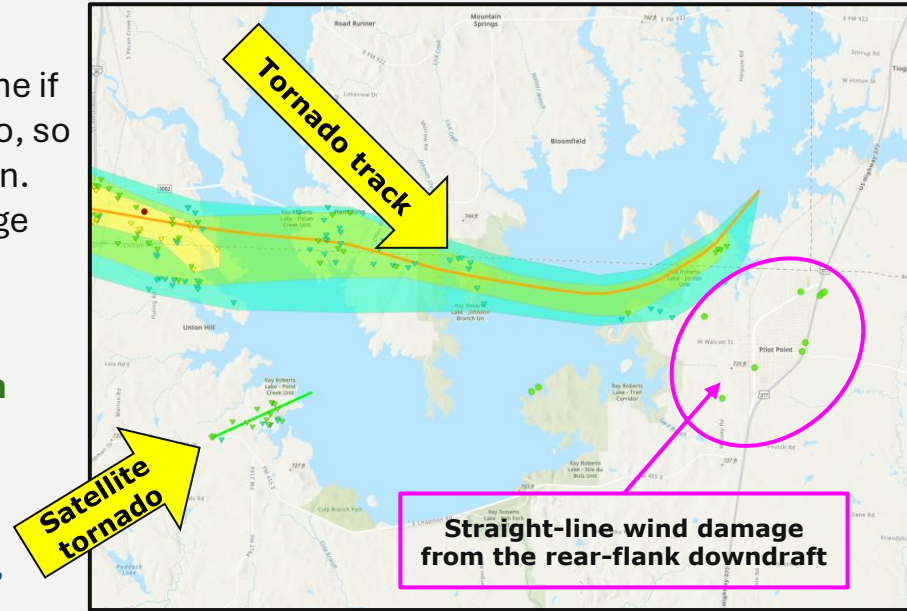
Damage Surveys

After a Storm Event: Damage Surveys

- **After severe weather occurs, NWS meteorologists are working to:**
 - Provide support to post-storm recovery efforts
 - Gather reports and follow up on significant damage
 - Coordinate with local officials on the need for damage surveys and determine areas with the most significant damage
 - Perform post-event radar analysis and determine need for any additional surveys
 - Fulfill media requests
- **We conduct damage surveys to:**
 - Determine whether damage was caused by a tornado or straight-line winds (if this information is not known)
 - If there was a tornado, we must determine the strength of the tornado and path of damage
 - Provide a wind speed estimate for straight-line wind damage, if no tornado
- Coordination with storm survey and damage experts is often done when there is significant damage, potentially indicating an EF4 or EF5 tornado rating.
- Damage surveys can at times be conducted remotely through coordination with local officials and thorough review of radar, damage photos, videos, and/or hi-res drone footage when available.

Straight-Line Winds or Tornado?

- **Not all wind damage is tornado damage.**
 - Sometimes, we don't have good radar data to determine if damage was caused by straight-line winds or a tornado, so we must survey the damage to make this determination.
 - Intense straight-line winds can (and DO!) cause damage consistent with EF0 or EF1 tornadoes!
- **What we're looking for...**
 - Straight-line winds: Damage in generally **one direction**
 - Tornadoes: **Convergent** damage pattern
 - But it's not always that simple either...sometimes tornado damage can be all in one direction in weaker tornadoes and straight-line winds can "twist" damage, too.
- "Twisted trees" are not necessarily indicative of tornado damage.
 - Trees can "twist" on themselves due to the heavy branches or winds funneling around a building.
 - Must look at the damage pattern as a whole!



Determining what type of wind caused the damage can be challenging at times, especially when we have both tornado damage and straight-line wind damage from the rear-flank downdraft in close proximity to each other. 7

Damaging Winds or Tornado?



Straight-Line winds are unidirectional

Damaging Winds or Tornado?

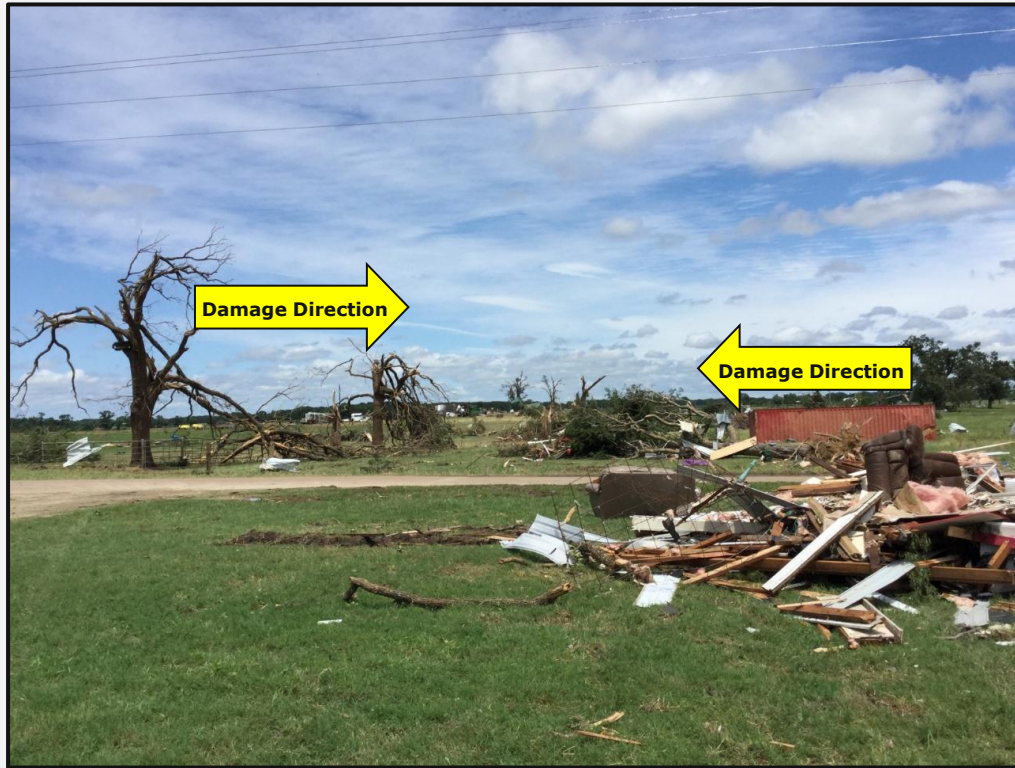


Straight-Line winds are unidirectional

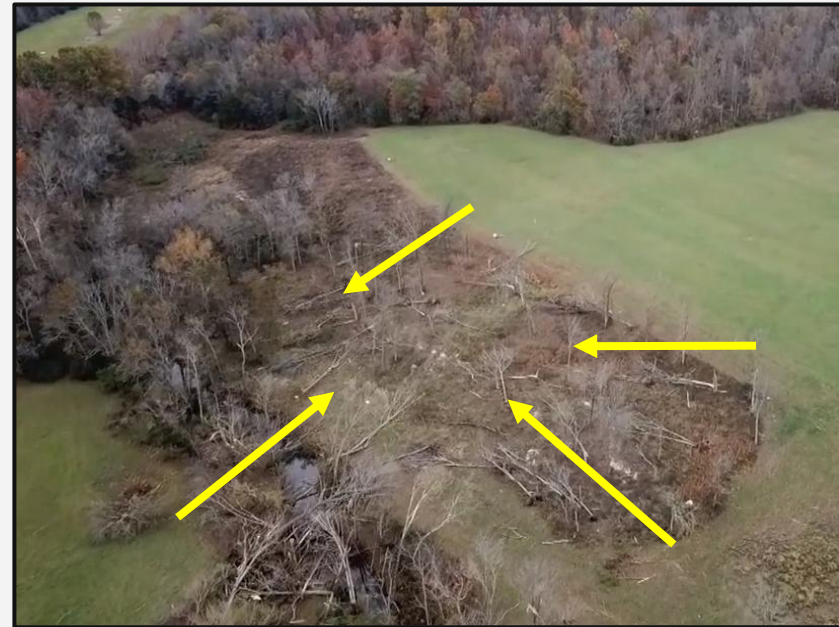


Microburst winds diverge
or fan out

Damaging Winds or Tornado?



Tornado winds converge along a concentrated path of damage

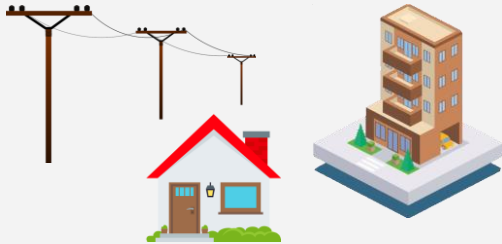


EF-Scale

Enhanced Fujita (EF) Scale

- Operational since February 1st, 2007
 - Original scale was first used in the early 1970s.
 - Revised version of the original Fujita (F) Scale to better approximate wind speed from associated wind damage.
 - Another update is in the works.
- Used to assign a tornado a “rating” based on **estimated** wind speeds **determined by the related damage**.
 - It is not a measurement of wind speed!
 - There must be damage to determine the EF rating.
- Comprised of **28 Damage Indicators (what was damaged?)**, each with multiple **Degrees of Damage (how much damage was done?)** that correspond to a range of wind speeds.

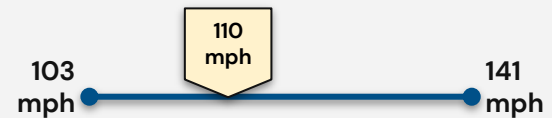
How do we estimate a wind speed during a damage survey?



Select damage indicator
(type of structure, tree,
power pole, etc.)

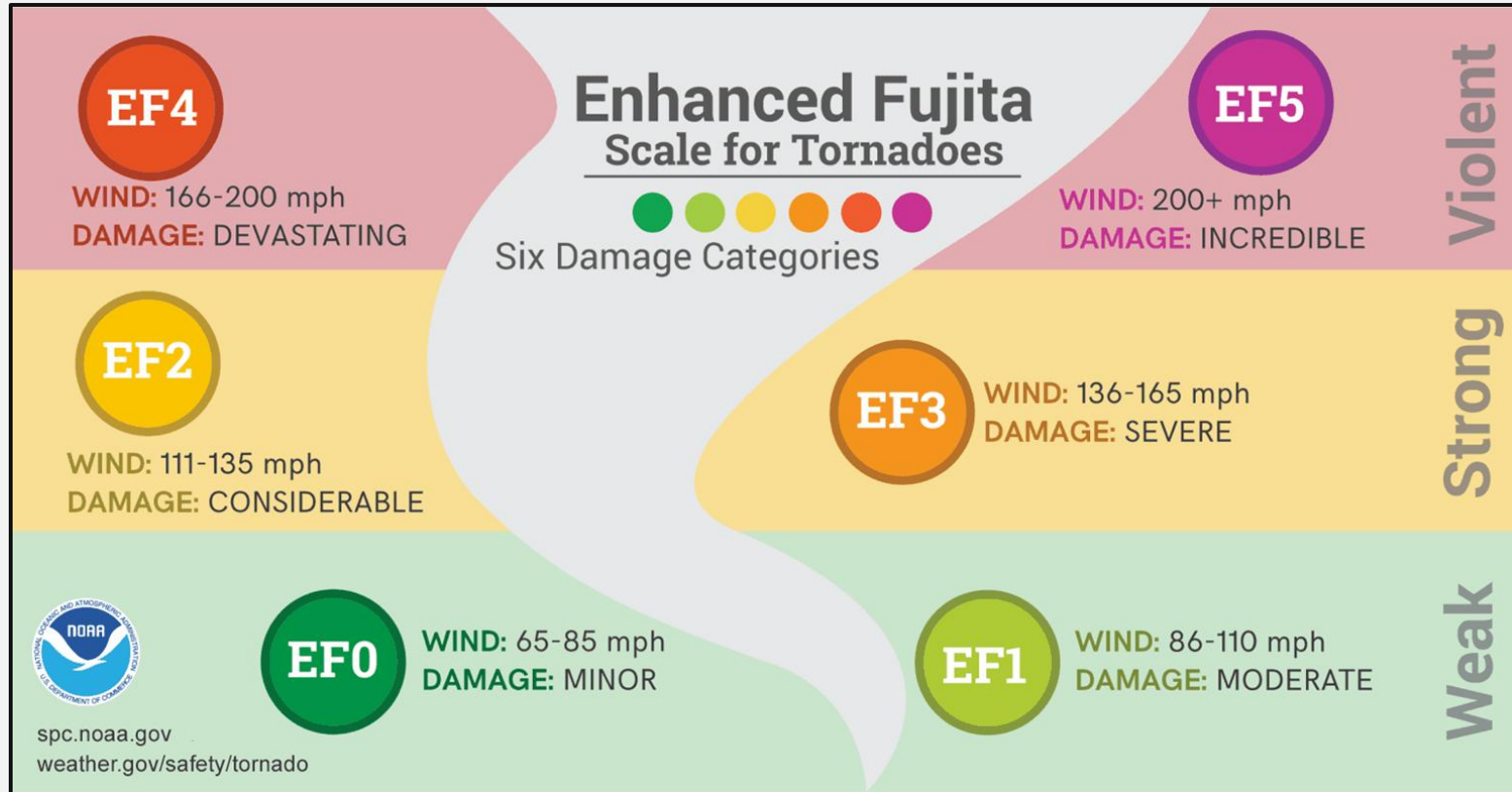


Select the degree of
damage for the chosen
damage indicator



Assign wind speed rating
based on the given wind
speed range

Enhanced Fujita (EF) Scale



A final rating is assigned to the tornado after all the damage has been assessed. The highest estimated wind speed determined during the damage survey will be the assigned rating of the tornado.

Damage Indicators (DIs)

When classifying damage, there are 28 Damage Indicators to choose from:

1	Small barns, farm outbuildings
2	One- or two-family residences
3	Single-wide mobile home
4	Double-wide mobile home
5	Apt, condo, townhouse (3 stories or less)
6	Motel
7	Masonry apt. or motel
8	Small retail building (fast food)
9	Small professional (doctor office, branch bank)
10	Strip mall
11	Large shopping mall
12	Large, isolated ("big box") retail bldg.
13	Automobile showroom
14	Automotive service building

15	School - 1-story elementary (interior or exterior halls)
16	School - jr. or sr. high school
17	Low-rise (1-4 story) bldg.
18	Mid-rise (5-20 story) bldg.
19	High-rise (over 20 stories)
20	Institutional bldg. (hospital, govt. or university)
21	Metal building system
22	Service station canopy
23	Warehouse (tilt-up walls or heavy timber)
24	Transmission line tower
25	Free-standing tower
26	Free standing pole (light, flag, luminary)
27	Tree - hardwood
28	Tree - softwood

Additional information is provided in our EF-scale guide to help us determine the best DI for various types of construction and materials.

What is not on this scale?

Transportation of any kind (cars, trains, semis)

Degree Of Damage (DOD)

- Once a DI has been chosen, the next step is to choose the degree of visible damage.
- Each DI contains 5-10 DOD options to choose from (on average).
- A wind speed range is provided for each DOD (lower bound, upper bound, and an expected value).
 - These ranges were determined through extensive research and engineering expertise based on how each type of structure behaves when impacted by wind speeds of varying magnitudes.
- The surveyor will have to determine where the estimated wind speed falls in the provided range for the chosen Degree of Damage.
 - Factors to consider:
 - Quality of construction, anchoring of walls, etc.
 - Any weak points in the structure of the building or home that may have easily been compromised
 - Age of structure (different building code requirements)

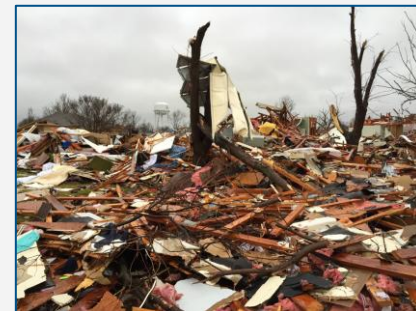
2. ONE-AND TWO-FAMILY RESIDENCES (FR12) (1000 – 5000 sq. ft.)

Typical Construction

- Asphalt shingles, tile, slate or metal roof covering
- Flat, gable, hip, mansard or mono-sloped roof or combinations thereof
- Plywood/OSB or wood plank roof deck
- Prefabricated wood trusses or wood joist and rafter construction
- Brick veneer, wood panels, stucco, EIFS, vinyl or metal siding
- Wood or metal stud walls, concrete blocks or insulating-concrete panels
- Attached single or double garage

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney, garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage



Damage Assessment Toolkit (DAT)

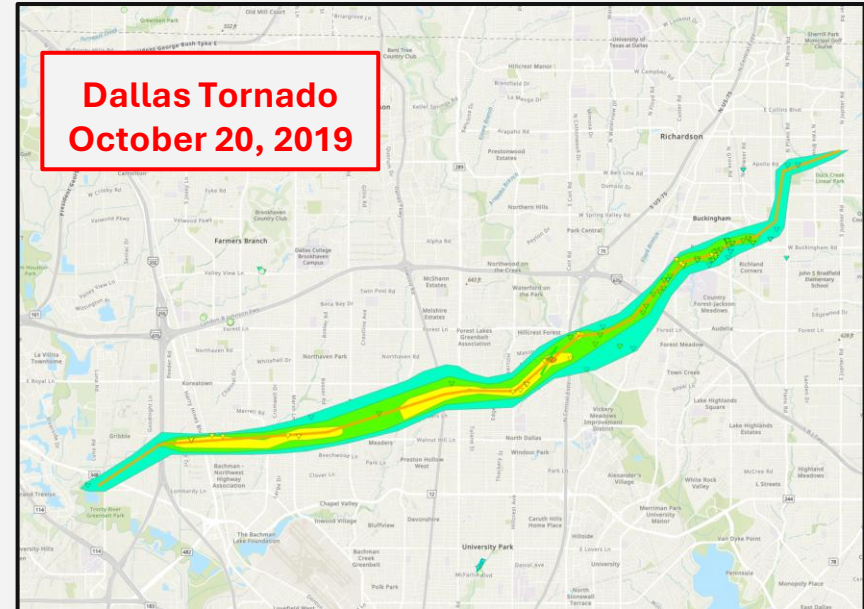
When we're surveying damage in person, we utilize a GIS-based collection app to collect geotagged damage points.

- Everything can be collected by our smartphones or any similar device!
- Not every damaged structure, tree, etc. will be collected during our damage survey.

What we're trying to capture:

- The most significant damage
 - Magnitude
 - Location
- Path of damage
 - Length
 - Width

The damage points populate into the Damage Assessment Toolkit (DAT) where we quality control and finalize the damage points, path, etc. after the damage survey.



Examples

Damage Points: Examples



Photo courtesy of NWS Fort Worth, not for distribution



Estimated Winds: 130 mph

2. One- And Two-Family Residences				
DOD*	Damage Description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
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Damage Points: Examples

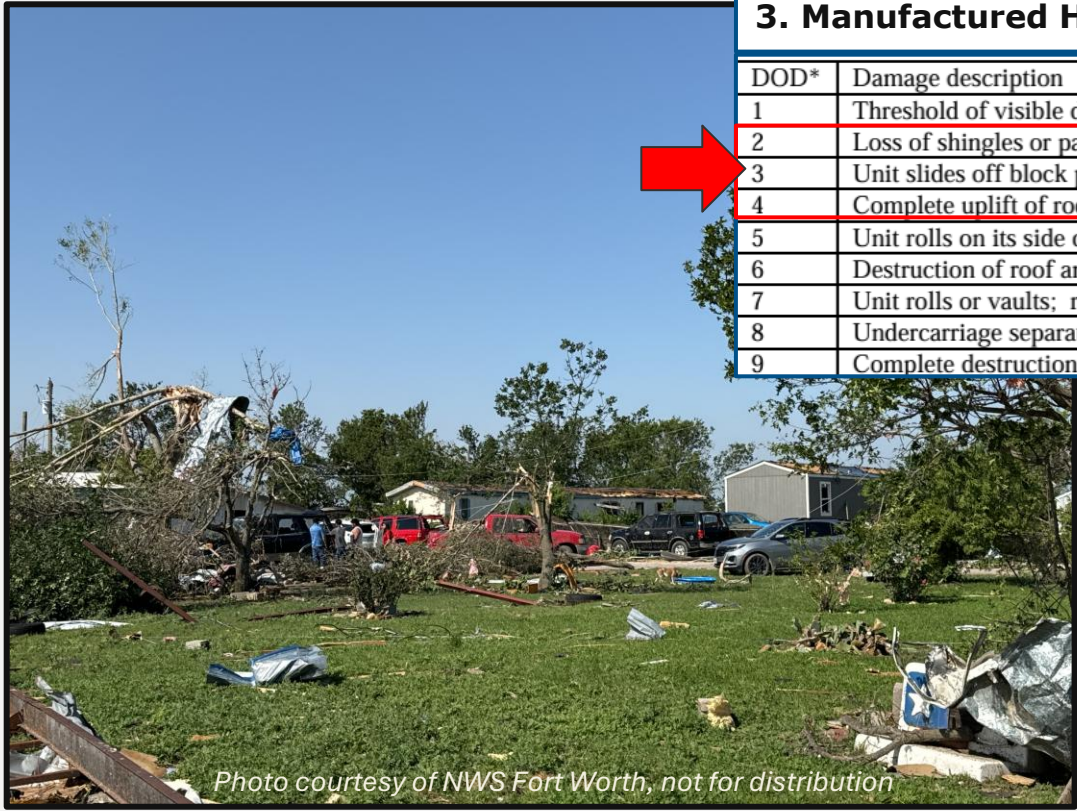


Photo courtesy of NWS Fort Worth, not for distribution

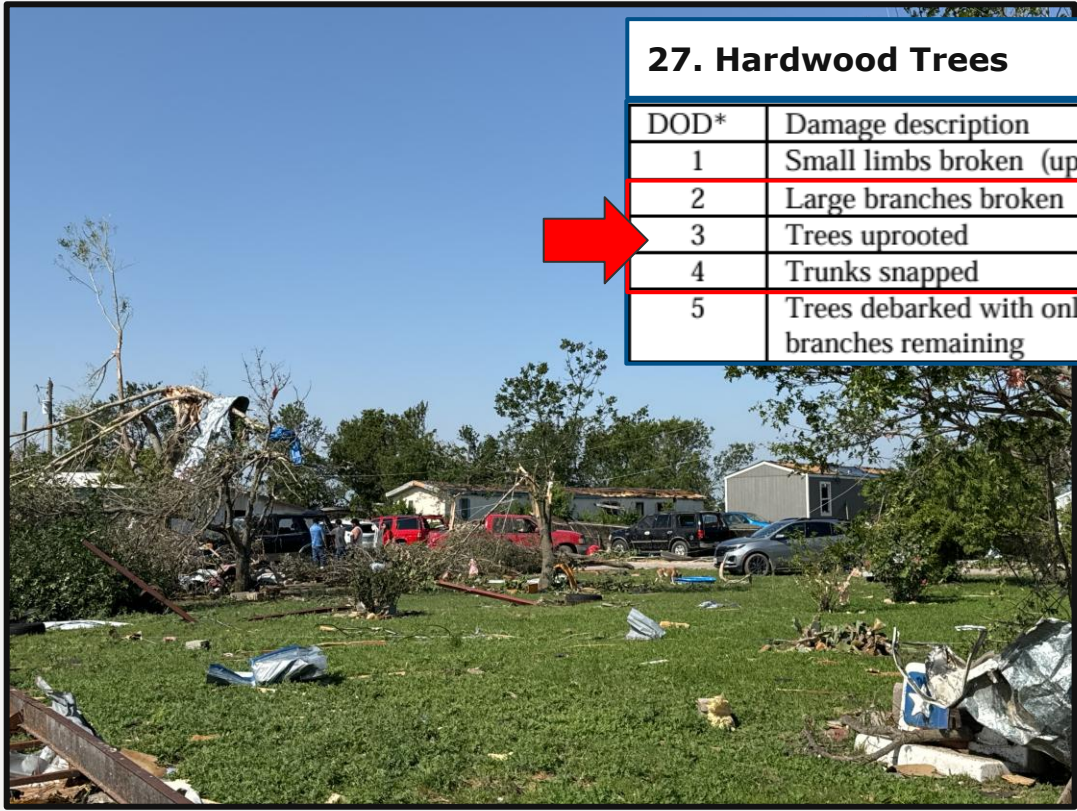
3. Manufactured Home – Single Wide

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	61	51	76
2	Loss of shingles or partial uplift of one-piece metal roof covering	74	61	92
3	Unit slides off block piers but remains upright	87	72	103
4	Complete uplift of roof; most walls remain standing	89	73	112
5	Unit rolls on its side or upside down; remains essentially intact	98	84	114
6	Destruction of roof and walls leaving floor and undercarriage in place	105	87	123
7	Unit rolls or vaults; roof and walls separate from floor and undercarriage	109	96	128
8	Undercarriage separates from unit; rolls, tumbles and is badly bent	118	101	136
9	Complete destruction of unit; debris blown away	127	110	148

This damage falls in between DOD #2 and DOD #4. The entire roof isn't gone, but a considerable amount of the covering is lost.

Let's see what rating the trees give us...

Damage Points: Examples



27. Hardwood Trees

DOD*	Damage description	EXP	LB	UB
1	Small limbs broken (up to 1" diameter)	60	48	72
2	Large branches broken (1"-3" diameter)	74	61	88
3	Trees uprooted	94	76	118
4	Trunks snapped	107	93	134
5	Trees debarked with only stubs of largest branches remaining	143	123	167

Trunks are snapped on some (smaller) trees with large tree branches broken on others.

Damage Points: Examples


3. Manufactured Home – Single Wide

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1	Threshold of visible damage	61	51	76
2	Loss of shingles or partial uplift of one-piece metal roof covering	74	61	92
3	Unit slides off block piers but remains upright	87	72	103
4	Complete uplift of roof; most walls remain standing	89	73	112
5	Unit rolls on its side or upside down; remains essentially intact	98	84	114
6	Destruction of roof and walls leaving floor and undercarriage in place	105	87	123
7	Unit rolls or vaults; roof and walls separate from floor and undercarriage	109	96	128
8	Undercarriage separates from unit; rolls, tumbles and is badly bent	118	101	136
9	Complete destruction of unit; debris blown away	127	110	148

Considering the other damage around this location was rated EF1, this location was also rated low-end EF1.

27. Hardwood Trees

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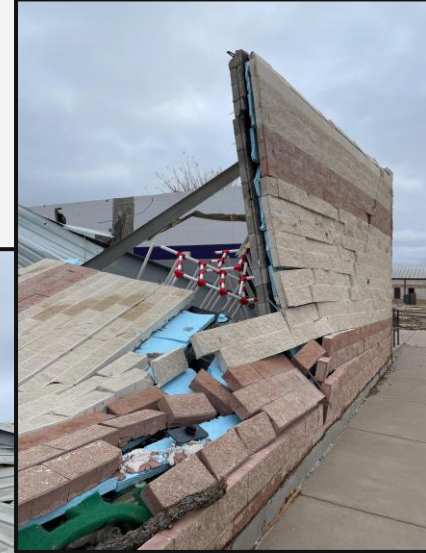


**Estimated Winds:
85-90 mph**

Damage Points: Examples

Jack County, TX
3/21/2022

Elementary School



Damage Points: Examples



Photo courtesy of NWS Fort Worth

EF3

**Estimated Winds:
148 mph**

15. Elementary School

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	47	80
2	Loss of roof covering (<20%)	79	66	99
3	Broken windows	87	71	106
4	Exterior door failures	99	85	118
5	Uplift of some roof decking; significant loss of roofing material (>20%); loss of rooftop HVAC	101	82	121
6	Damage to or loss of wall cladding	108	92	127
7	Uplift or collapse of roof structure	125	108	148
8	Collapse of non-bearing walls	139	117	162
9	Collapse of load-bearing walls	153	130	180
10	Total destruction of a large section of building or entire building	176	152	203



Winds entered the facility once the roof over the gym (widespan roof) was torn open, causing the additional damage.

Amazingly no one was injured! Students, staff and parents were taking shelter in a reinforced hallway not far from the gym. Staff had enough lead time to get everyone to that area and get parents out of cars.

Your Turn!

Damage Survey: Your Turn!



Photo courtesy of NWS Fort Worth, not for distribution

Let's conduct a survey and create a damage point at this home.

Notice that all interior walls have collapsed and hardly any of the exterior walls remain intact. Also notice the trees on the left side of the image are only large stumps.

Damage Survey: Your Turn!

2. One- And Two-Family Residences

DOD*	Damage Description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney, garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
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8	Most Walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

*DOD is Degree of Damage

Taking a look at the DOD table for the single family home DI, select which DOD is the most appropriate for the damage at this home.

Examining from far away, we can see all walls are collapsed at this home, so DOD #9 would be the best choice.



Damage Survey: Your Turn!

2. One- And Two-Family Residences

DOD*	Damage Description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
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*DOD is Degree of Damage

DOD #9 gives you the following wind speed range:

- Lower Bound: 142 mph
- Upper Bound: 198 mph
- Expected Wind Speed: 170 mph

Next, we need to choose an estimated wind speed somewhere within this range.

Upon closer examination, here are some additional details we found that need to be considered:

- This house was built 50-60 years ago
- The walls were not anchored
- The quality of the construction had some integrity issues

Knowing these details... we probably want to side on the lower end of the range, but we're still a little uncertain.

Let's investigate a bit further!

Damage Survey: Your Turn!

28. Trees (Softwood)

DOD*	Damage Description	EXP	LB	UB
1	Small limbs broken (up to 1" diameter)	60	48	72
2	Large branches broken (1" - 3" diameter)	75	62	88
3	Trees uprooted	87	73	113
4	Trunks snapped	104	88	128
5	Trees debarked with only stubs of largest branches remaining	131	112	153

*DOD is Degree of Damage

There is a Damage Indicator for trees, so let's take a look at that to compare. These damaged trees are right next to the house.

While it's difficult to tell whether these trees are debarked, we can definitely tell that only stubs of the largest branches remain, so let's select DOD #5. This gives us the following wind speed range:

- Lower bound: 112 mph
- Upper bound: 153 mph
- Expected Wind Speed: 131 mph



This increases our confidence that the estimated wind speed may be on the lower end of the range, given this DI gives us a lower range of wind speeds.

Photos courtesy of NWS Fort Worth, not for distribution

Damage Survey: Your Turn!

2. One- And Two-Family Residences

DOD*	Damage Description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
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*DOD is Degree of Damage

Let's look at one more nearby structure to see if we can narrow down our wind speed estimate even further...



Photo courtesy of NWS Fort Worth, not for distribution

In this single family home, most exterior walls collapsed, but a few interior walls remain standing. This home is also constructed better than the first home we looked at. DOD #8 would be the most appropriate choice here.

Damage Survey: Your Turn!

Let's compare the wind speed ranges from all of our damage points...

First Home:

142 - 198 mph

Expected: 170 mph

Tree Damage:

112 - 153 mph

Expected: 131 mph

Second Home:

127 - 178 mph

Expected: 152 mph

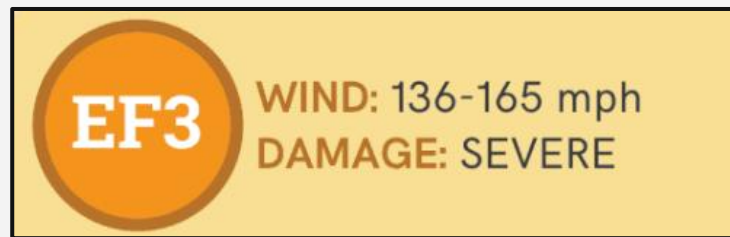
What estimated wind speed would you assign to this tornado based on the damage we reviewed?

Anywhere within the 145-155 mph range is certainly reasonable, but each person's answer will likely slightly differ from the next!

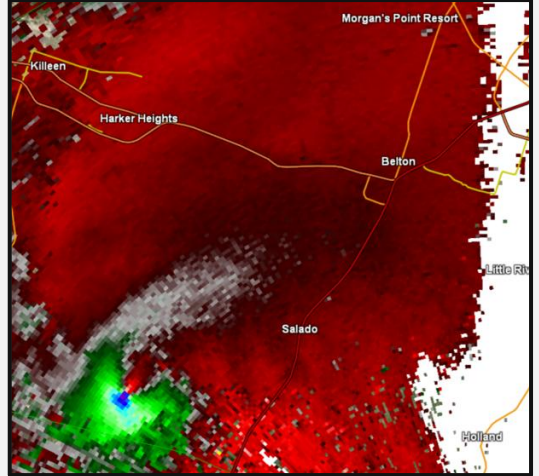
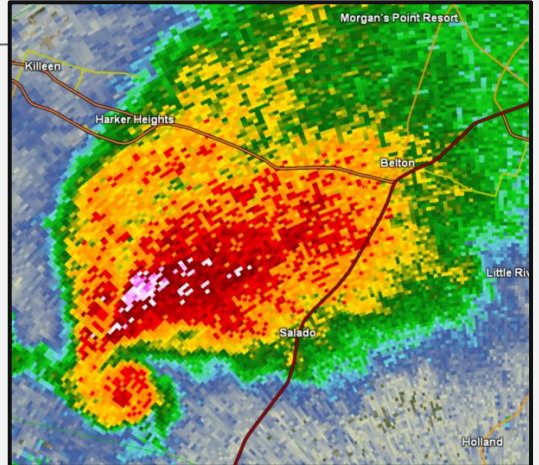
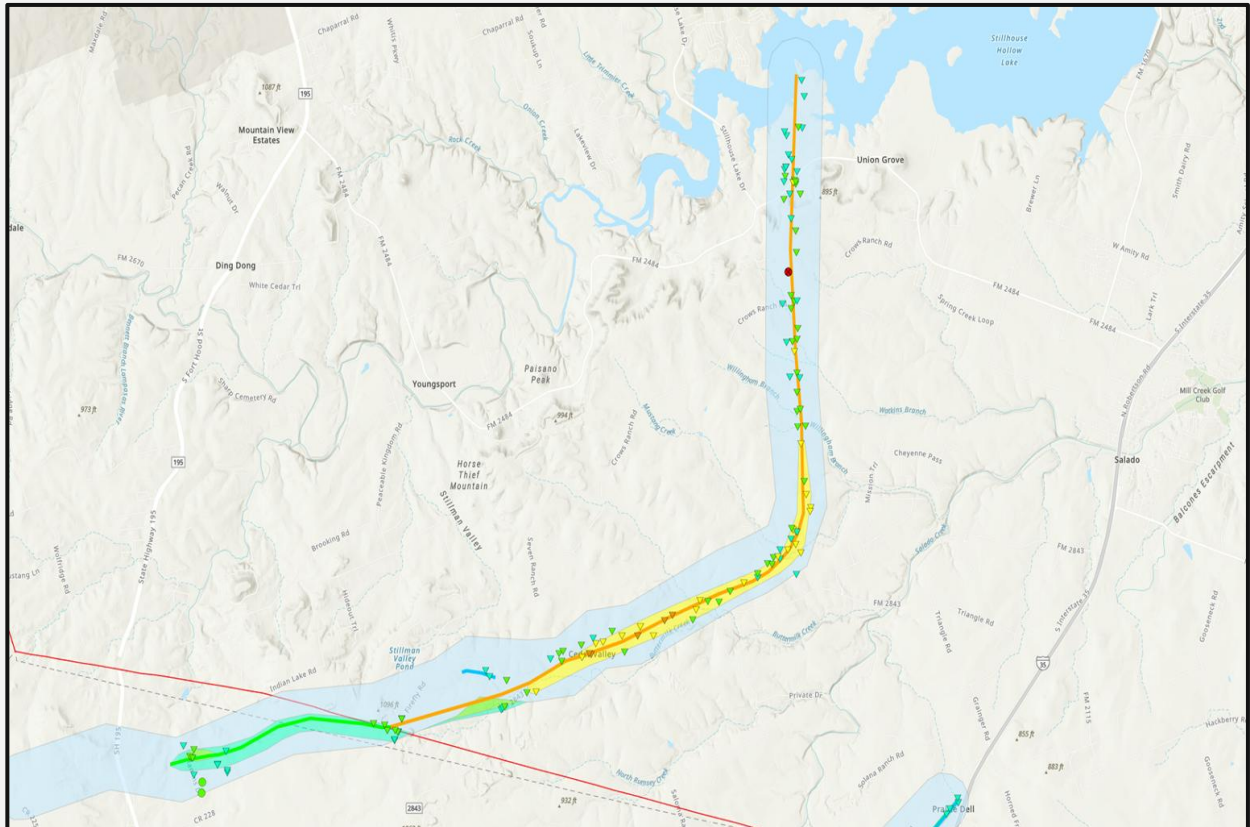
What tornado rating would this be on the EF Scale?

An EF3!

But notice, if you didn't factor in the construction of the first home, and the other surrounding damage, we could have incorrectly labeled this an EF4 tornado. This is why it's so important to consider all factors when doing a damage survey!



Salado EF3 Tornado (4/12/22)



Before We Wrap Up...

Answer in the Pop-Up Box if you can;
Don't type your response unless your answer is 5+.

How many people (including you and kids) are attending this training class?

A. 1

B. 2

C. 3

D. 4

If 5 or more, please type the exact number in the Questions Box

Damage Survey Takeaways

- ❖ Damage surveys are a team effort in any NWS Office.
- ❖ Not all parts of a storm survey are clear-cut.
- ❖ Outside experts will be consulted when appropriate and available.
- ❖ Sometimes it takes a few days to visit, collect, and review all the data.
- ❖ Not all wind damage is tornado damage.

Damage Survey Takeaways

Damage Surveys are a puzzle!

Can't just look at one damage site and give it a rating... there is usually more that needs consideration.

You also can't just look at one picture/video and give it a rating.



Questions?

**Thanks for Attending.
Slides will be shared on the Weather 101 website.**

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National Weather Service

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