25-HDP

(Released April 2024)

HURRICANE DATA PROVISIONS (HDP)

2025 AND SUCCEEDING CROP YEARS

These provisions document the procedures for determining the counties where a loss is triggered for *Hurricane Insurance Protection-Wind Index* (HIP-WI) Endorsement and the *Tropical Storm* (TS) Option. The county loss trigger is determined using data provided from the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Census Bureau. The data may be modified in the actuarial documents or special provisions of insurance.

1. Data

HIP-WI uses three external datasets to determine a loss trigger: the location and wind field of the cyclone are taken from the International Best Track Archive for Climate Stewardship (IBTrACS) data, the geometry of the counties, and the counties which are adjacent are from the U.S. Census Bureau. The TS Option uses an additional precipitation dataset to determine loss triggers from NOAA Climate Prediction Center (CPC). The following table summarizes the location of the external data sources. All times for all datasets are Universal Time Coordinated (UTC).

Table 1: Cyclone Data Provisions External Data Sources

Data Set	Data Location (or successor website)
Cyclone Tracks and Wind Extents (IBTrACS)	https://www.ncei.noaa.gov/products/international-best-track-archive
US County Shapefile	https://www.census.gov/cgi-bin/geo/shapefiles/index.php
US County Adjacency	https://www2.census.gov/geo/docs/reference/county_adjacency/
Gridded Precipitation	https://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_CONUS/

Hurricane and Tropical Storm Track Data

The data used for determining if a hurricane or tropical storm intersects a county is the IBTrACS dataset from the National Climatic Data Center within the National Hurricane Center operated by NOAA. The table below shows the variables used to develop the wind extents and determine the trigger counties. The 64-knot wind speeds are associated with a hurricane weather event, while the 34-knot wind speeds are associated with a tropical storm weather event.

Variable	Column Name	Units
Season	SEASON	Year
Name	NAME	N/A
Time	ISO_TIME	UTC (YYYY-MM-DD HH:MM:SS)
Latitude	USA_LAT	Degrees North
Longitude	USA_LON	Degrees East
Maximum Sustained Winds	USA_WIND	Knots
Hurricane Category	USA_SSHS	Saffir-Simpson Wind Scale
Wind Extents Northeast	USA_R64_NE / USA_R34_NE	Nautical Miles
Wind Extents Southeast	USA_R64_SE / USA_R34_SE	Nautical Miles
Wind Extents Southwest	USA_R64_SW / USA_R34_SW	Nautical Miles
Wind Extents Northwest	USA_R64_NW / USA_R34_NW	Nautical Miles

IBTrACS generally records new values for these variables in three-hour intervals. RMA will use all available data from NOAA. If data is missing, RMA will coordinate with NOAA to fill in the missing data. If NOAA is unable to provide the missing data, the missing data will be interpolated, averaged, or projected using the best available data from NOAA as determined by RMA. Data is missing if none of the fields are available. For example, if a quadrant is missing from the wind extents, is not considered to be missing if at least one other wind extent is available.

County Data

The county boundary shapefile (TIGER/Line) from the U.S. Census Bureau is used to determine if the cyclone corridor intersects the county boundary. Adjacent counties are determined using the county adjacency file from the U.S. Census Bureau. RMA has modified the adjacency file to allow for counties that are less than 100 meters apart to become adjacent. Census county boundaries may also be modified by special provisions of insurance. Due to the timing of the contract change dates, the shapefile and county adjacency file used will have a two-year lag behind the reinsurance year. County adjacency is shown in the actuarial documents.

Rainfall Data

The precipitation dataset used to determine the county rainfall is the CPC Unified Gauge-Based Analysis of Daily Precipitation over Continental United States (CONUS). This is a 0.25-degree latitude by 0.25-degree longitude grid of precipitation. The rainfall of a county is determined by the weighted mean of the fractional area that each grid cell contributes to the county's rainfall based on the U.S. Census Bureau shapefile.

2. Hurricane and Tropical Storm Wind Corridor Construction

The hurricane and tropical storm wind corridors are constructed in the same manner. For hurricanes, the 64-knot wind extents are used, and for tropical storms, the 34-knot wind extents are used. This section will provide the methodology used to determine the cyclone center points, wind extent buffers, and cyclone corridors. The wind corridor is used to determine which counties the storm intersects. The wind corridor is constructed from convex hulls of the wind buffer radii which are centered around the storm center points.

	HIP-WI	**TS Option**
Wind Threshold	USA_WIND >= 64	USA_WIND >=34
Wind Extents (Cyclone Buffer)	USA_R64_NE, USA_R64_SE, USA_R64_SW, USA_R64_NW	USA_R34_NE, USA_R34_SE, USA_R34_SW, USA_R34_NW

Storm Center Points

IBTrACS uses World Geodetic System 1984 longitude and latitude coordinates which locate the center of the cyclone. When wind speeds reach or exceed 64 knots (USA_WIND >= 64), the storm center point is a hurricane center point. In addition, RMA will calculate a hurricane center point between the last tropical storm center point and the first hurricane center point (i.e., when a tropical storm strengthens to a hurricane) and another hurricane center point between the last hurricane center point and the first tropical storm center point (i.e., when a hurricane weakens to a tropical storm). A tropical storm center point by itself <u>does not</u> constitute a hurricane center point for determining a county loss trigger.

Tropical storm center points will be determined in a similar manner. When wind speeds reach or exceed 34 knots, the storm center point is a tropical storm center point. RMA will calculate an interpolated tropical storm center point between transitions to a tropical depression and from a tropical depression. A tropical depression center point by itself <u>does not</u> constitute a tropical storm center point for determining a county loss trigger.

Wind Buffer Creation

The maximum of the 34-knot or 64-knot wind radii extents are used to determine a buffer around the cyclone. The wind radii extents describe the maximum distance at which the given wind speed existed in the four quadrants (northeast, northwest, southwest, southeast). The maximum over the quadrants is used for the buffer.

Hurricane Buffer = $Max(USA\_R64\_NE, USA\_R64\_SE, USA\_R64\_SW, USA\_R64\_NW)$

Tropical Storm Buffer = $Max(USA\_R34\_NE, USA\_R34\_SE, USA\_R34\_SW, USA\_R34\_NW)$

Example:

Suppose the maximum distance of the hurricane wind extents from the storm center point is 35 nautical miles (nm) for the northeast quadrant, 25 nm for the southeast quadrant, 10 nm for the southwest quadrant, and 30 nm for the northwest quadrant. In this case, the maximum distance of the hurricane wind extents from the storm center is 35 nm (northwest quadrant). The hurricane buffer is then a 35 nm radius circle around the storm center point.

Estimated Hurricane and Tropical Storm Center Point and Buffer

A hurricane ceases to exist at some point between where the last hurricane center point is measured and when the first tropical storm center point is measured. The maximum sustained winds (USA_WIND) value is used to calculate where the estimated hurricane center point and wind extents are measured. For purposes for this document, a similar calculation is made for a tropical storm to and from a depression or to and from a hurricane. The term transitional cyclone centerpoint is used when transitioning between hurricanes, tropical storms and tropical depressions.

The estimated cyclone center point and buffer are calculated based on the last cyclone center point (USA_LAT and USA_LON) and maximum sustained wind speeds (USA_WIND_{hurr}) and the transitional cyclone center point (USA_LAT and USA_LON) and maximum sustain wind speeds (USA_WIND_{ts}). The following examples are when a hurricane transitions to a tropical storm, but similar calculations are used between a tropical storm and a tropical depression.

A bearing is calculated between the two cyclone center points and the bearing and distance ($Distance_{full}$) is used to calculate the estimated center point. The distance is calculated using the following formula:

$$Distance = Distance_{full} * \frac{USA\_WIND_{hurr} - 64}{USA\_WIND_{hurr} - USA\_WIND_{ts}}$$

The estimated buffer is calculated using the last hurricane buffer ($HurricaneBuffer_{last}$) and the following formula:

$$Buffer = Max\left(\frac{HurricaneBuffer_{last}}{2}, HurricaneBuffer_{last} * \left(1 - \frac{USA\_WIND_{hurr} - 64}{USA\_WIND_{hurr} - USA\_WIND_{ts}}\right)\right)$$

A similar calculation is used during the formation of a hurricane, using the last tropical storm center point and the first hurricane center point, or the formation of a tropical storm using the last tropical depression center point and the first tropical storm center point.

Example:

Given the table below:

SEASON	NAME	ISO_TIME	USA_LAT	USA_LON	USA_SSHS	USA_WIND	USA_R64_NE	USA_R64_SE	USA_R64_SW	USA_R64_NW
2020	HURRICANE	9/29/20 0:00	21.3000	-74.0000	0	60				
2020	HURRICANE	9/29/20 3:00	21.6999	-74.5877	1	65	15			
2020	HURRICANE	9/29/20 6:00	22.1000	-75.1000	1	70	25	15		20
2020	HURRICANE	9/29/20 9:00	22.5072	-75.5228	1	75	30	15	15	20
2020	HURRICANE	9/29/20 12:00	22.9000	-75.9000	1	80	35	25	10	30
2020	HURRICANE	9/29/20 15:00	23.2574	-76.3003	1	90	35	20	11	30
2020	HURRICANE	9/29/20 18:00	23.6000	-76.7000	1	80	30	20	11	25
2020	HURRICANE	9/29/20 21:00	23.9649	-77.1001	1	75	20	15		20
2020	HURRICANE	9/30/20 0:00	24.3000	-77.5000	1	70	10			
2020	HURRICANE	9/30/20 3:00	24.5650	-77.9152	0	60				

The last hurricane center point occurs on September 30th at 0:00 hours and the first tropical storm center point occurs on September 30th at 3:00 hours. The maximum sustained wind speeds are 70 knots and 60 knots, respectively. Figure 1 below shows the estimated hurricane center point and buffer.

A depiction of an estimated center point and cyclone buffer for a fictional cyclone is provided below in Figure 1.

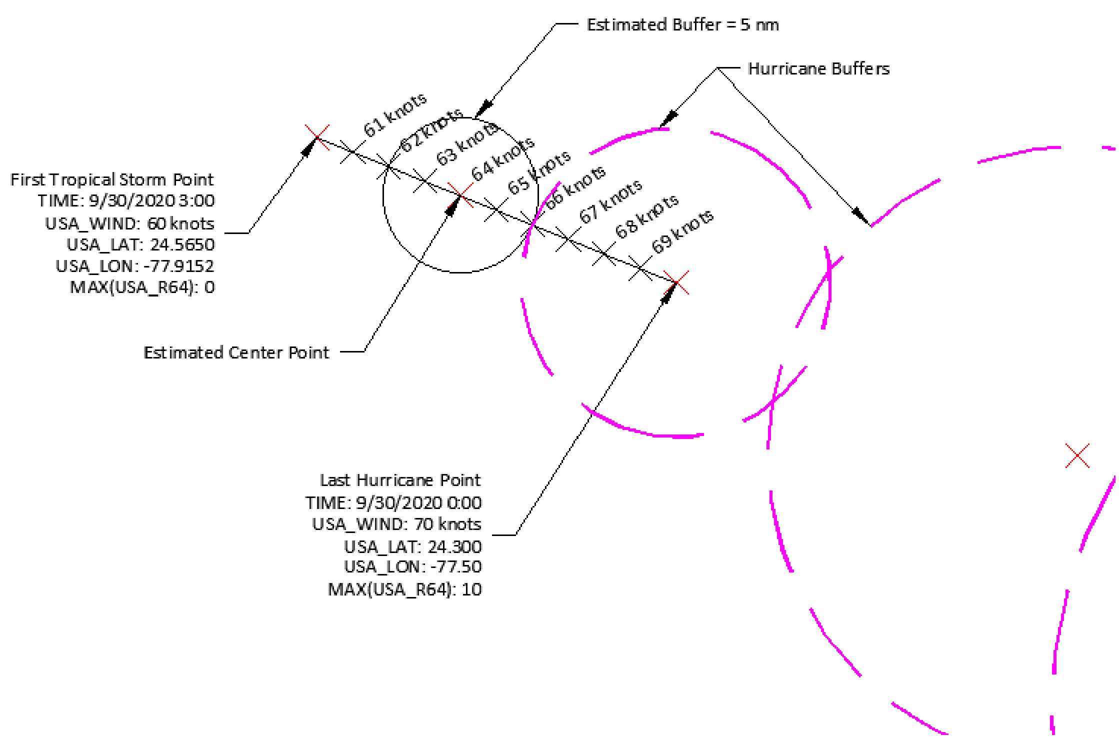


Figure 1: Example Estimated Center Point and Buffer for Fictional Cyclone

Cyclone Corridor Construction

When the cyclone center points and corresponding cyclone buffers are plotted, the result is a series of (often overlapping) circles. A convex hull is calculated for each pair of adjacent buffers which results in a series of ovals. Figure 2 below shows the convex hulls for the adjacent buffers. A corridor is then made of all the convex hulls of a cyclone and is used to determine the county intersections. The county intersections and triggers for the HIP-WI Endorsement (excluding the TS Option) are described in Section 3.

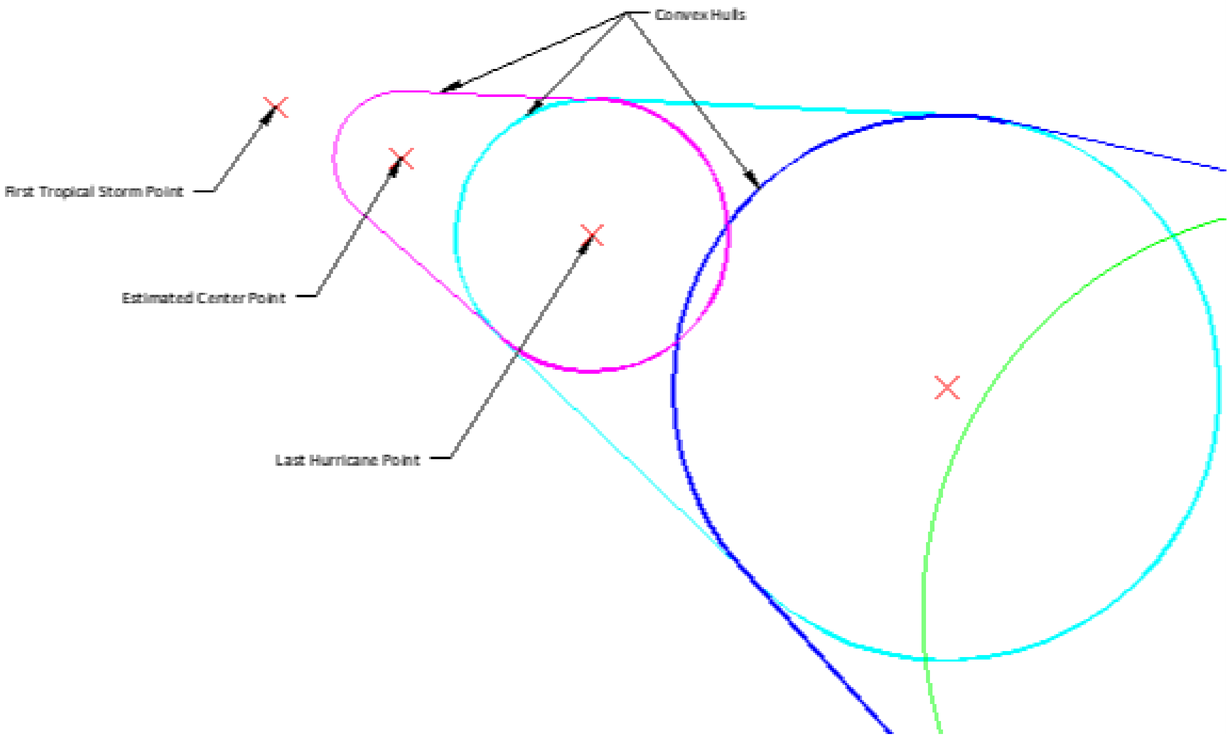


Figure 2: Example of Convex Hulls for Fictional Cyclone

3. Determining County Loss Triggers for HIP-WI (Excluding TS Option)

Once the convex hulls are calculated, county loss triggers are determined. The convex hulls and the county shapefile are mapped in the same coordinate reference system. Any county shape that intersects the convex hulls meets the county loss trigger. Any county that is adjacent (according to the U.S. Census Bureau County Adjacency File) to a county that is intersected by the convex hulls will also meet the county loss trigger.

The county loss trigger and date will be published in the actuarial documents. The date will be the date that the cyclone corridor intersects the county for direct triggers, or the first date that the county was indirectly triggered.

Payments will be issued in accordance with the HIP-WI Endorsement. NOAA publishes IBTrACS datasets approximately two weeks following the occurrence of a hurricane landfall. Once published, RMA will obtain the IBTrACS dataset and determine whether a county is triggered. If NOAA publishes an updated final IBTrACS dataset following the hurricane season, RMA will process the updated data to determine if any additional counties are triggered. Counties previously identified as being triggered, will remain triggered.

RMA will use the R programming language to implement these provisions. Sample computer code to determine triggered counties can be found at: https://www.rma.usda.gov/Topics/Hurricane-Insurance-Protection-Wind-Index.

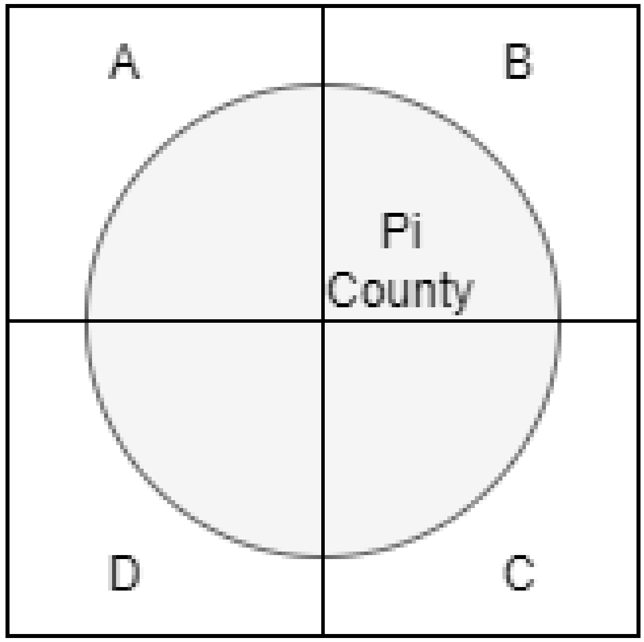
4. NOAA CPC Gridded Rainfall

The precipitation data set used is the NOAA Climate Prediction Center (CPC) Unified Gauge-Based Analysis of Daily Precipitation over the continental United States (excluding Alaska and Hawaii). The grid is 0.25-degree latitude by 0.25-degree longitude, a square approximately 16 miles in length. Additional information of the grid is available at:

https://ftp.cpc.ncep.noaa.gov/precip/CPC_UNI_PRCP/GAUGE_CONUS/ (or successor website).

The gridded dataset is converted into a county average precipitation by determining the area that each grid intersects the county shapefile, and then calculating a weighted average of the area and grid rainfall for a 4-day period. The period used for the TS Option is the day the cyclone corridor intersects the county, plus a 1-day lag (prior day) and a 2-day lead (subsequent days), with a threshold of 6 inches. Counties which have a Final Rainfall Amount of 5.900 inches and above will be rounded to 6 inches.

A fictious example for Pi County, is shown below. Four grids intersect the county and their cumulative precipitation over a period of 4 days is shown below. The weighted average for the county is shown in the table below.



Grid	Area	Rainfall Lag Day (in.)	Rainfall Wind Intersect Day (in.)	Rainfall Lead Day 1 (in.)	Rainfall Lead Day 2 (in.)	Total 4-day Period (in.)
A	25	0.2	1.0	2.5	2.0	5.7
B	25	1.0	1.0	3.0	1.5	6.5
C	25	0.0	1.0	2.0	2.0	5.0
D	25	0.3	1.0	3.0	3.0	7.3
Weighted Average		0.375	1.0	2.625	2.125	6.125

The weighted average for Day 1 is determined as the area of grid A times the rainfall amount of grid A plus the area of grid B times the rainfall amount of grid B and so on, divided by the total area. For Day 1 it is (25 × 0.2 + 25 × 1 + 25 × 0.0 + 25 × 0.3) / (25 + 25 + 25 + 25) = 0.375. The 4-day cumulative rainfall is 0.375 + 1.0 + 2.625 + 2.125 = 6.125 in.

5. Determining County Loss Triggers for the TS Option

A tropical storm triggers occur when:

1. The 34-knot corridor intersects the county;
2. Precipitation in the county equals or exceeds 5.900 inches during a four-day interval (the day the 34-knot corridor intersects the county, the preceding 1 day (lagging) and the following 2 days (leading); and
3. No hurricane trigger occurs.

A county can be triggered directly or through county adjacency (according to the actuarial documents). A direct trigger occurs when the triggering requirements are satisfied; an indirect trigger occurs when the county is adjacent to a county that is directly triggered.

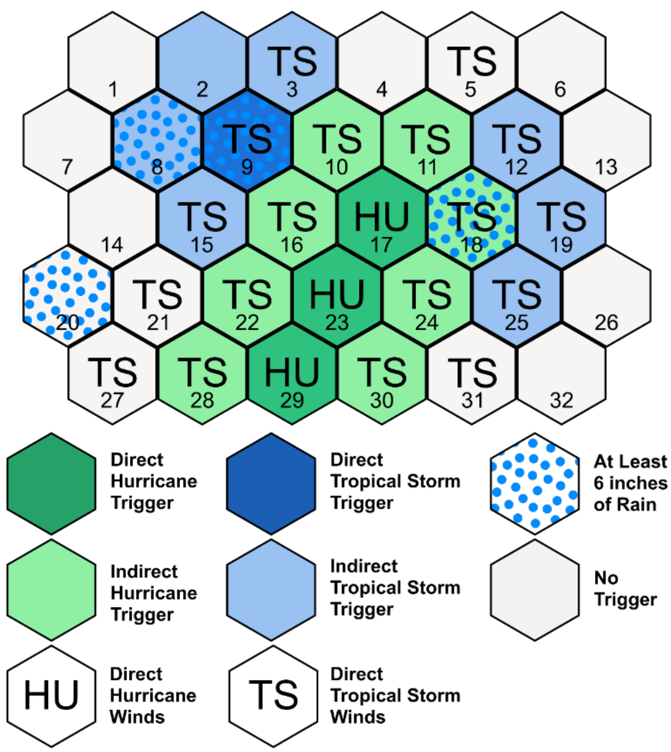
The county loss trigger and date will be published in the actuarial documents. The date will be the date that the cyclone corridor intersects the county for direct triggers, or the first date that the county was indirectly triggered. Payments will be issued in accordance with the TS Option.

NOAA publishes CPC data daily and IBTrACS datasets approximately two weeks following the occurrence of a cyclone landfall. Once published, RMA will obtain the datasets and determine whether a county is triggered.

If NOAA publishes an updated final IBTrACS dataset following the hurricane season, or if CPC data is modified in accordance with Section 8 of the HIP-WI Endorsement, RMA will process the updated data to determine if any additional counties are triggered. Counties previously identified as being triggered will remain triggered.

6. Hurricane and Tropical Storm Option Trigger (Fictitious Example)

The figure below is used to demonstrate different scenarios where counties and adjacent counties will be triggered under the HIP-WI Endorsement and TS Option. Wind speeds (either hurricane or tropical storm) are noted by either an HU (hurricane) or TS (tropical storm) within the hexagonal county shape.



Hurricane Triggers

Counties and adjacent counties triggered by a hurricane under the HIP-WI Endorsement are shown in shades of green. The dark green counties are triggered by sustained hurricane force winds of 64 knots or greater as determined by NOAA and in accordance with these HDP. The light green counties are triggered because they are adjacent to the directly triggered counties in accordance with the U.S. Census Bureau adjacency file.

Tropical Storm Option Triggers

Blue raindrops signify counties which equaled or exceeded the 5.900 inches of cumulative precipitation. Counties filled in with blue or light blue are Tropical Storm Option triggers. Several distinct trigger scenarios are described below.

1. County 18 is triggered as an adjacent HIP-WI hurricane trigger, so it is due a full indemnity. It also experienced sustained tropical storm force winds and received at least 5.900 inches of cumulative rain. Therefore, it triggers its adjacent counties (12, 9, and 25) under the TS Option.
2. County 9 received sustained tropical storm force winds and at least 5.900 inches of cumulative rain, which triggers itself and its adjacent counties (2, 3, 8, and 15).
3. County 8 was triggered due to its adjacency to County 9. It also received 5.900 inches of cumulative rainfall. However, since it did not receive sustained tropical storm force winds, it does not trigger any additional adjacent counties.
4. County 20 received 5.900 inches of cumulative rainfall but did not receive tropical storm force winds. Therefore, it does not trigger itself, nor its adjacent counties.
5. Counties 5, 21, 27, and 31 all received sustained tropical storm force winds, but did not receive at least 5.900 inches of rainfall and therefore do not trigger themselves or adjacent counties.