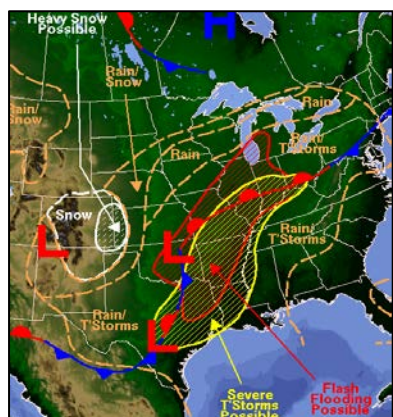


A complex weather pattern led to widespread flooding, severe thunderstorms and blizzard conditions across central sections of the United States this week. At least 18 people were killed and more than 70 others were injured. Significant flooding was cited in the Mississippi River watershed as excessive rainfall fell for consecutive days (April 28-30) in parts of the Plains, Midwest and Mississippi Valley. Some of the most significant floods – both flash flood (pluvial) and riverine (fluvial) – were cited in Missouri, Oklahoma, Illinois and Arkansas. The convective storm component to the event (April 28 – May 1) additionally led to major hail, straight-line wind and major tornado damage in multiple states as well. Two especially strong tornadoes (EF4 and EF3) struck Van Zandt County, Texas within hours of each other on April 29 that led to extensive damage and casualties. Beyond the flood and convective impacts, the broad system also prompted heavy snow and blizzard conditions from the Rockies into the Plains and Upper Midwest.

States of emergency were declared in Oklahoma, Missouri, Arkansas, and Mississippi as the event unfolded to expedite relief and recovery efforts.

Meteorological Recap

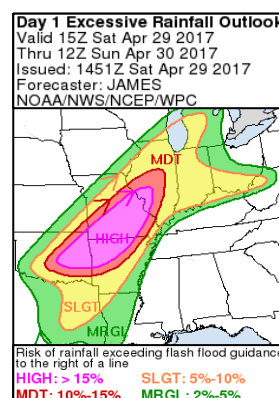


Surface map, April 29 (Source: NOAA)

Both the Storm Prediction Center (SPC) and Weather Prediction Center (WPC) began forecasting the threat of a significant outbreak of severe weather and extensive flooding across the Plains, Midwest, Southeast and Mississippi Valley on April 23; several days in advance of the actual multi-day outbreak. The forecast computer models were also consistent in projecting a complex atmospheric set-up given a series of surface-based and upper level areas of low pressure traversing an area from the Rockies towards the East Coast. The broader pattern was additionally influenced by a strong ridge of high pressure centered over central and eastern Canada that forced systems to track over the same areas for consecutive days from April 28 to April 30. The event finally ended on May 1, though rivers were forecast to continue rising through early May in the Mississippi Valley.

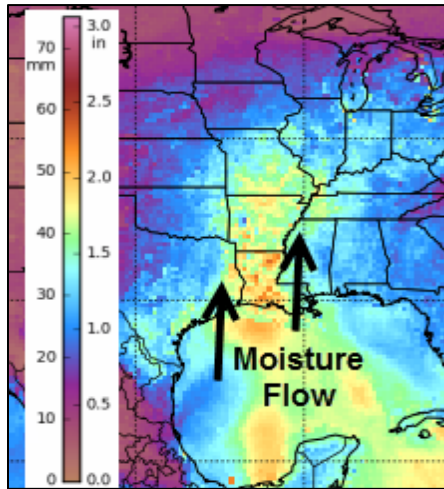
April 28

During the morning hours on April 28, the SPC noted a mid-level disturbance tracking through the central Plains and Midwest would combine with a developing surface area of low pressure to provide initial destabilization of the atmosphere. With a meandering warm front and separate frontal boundary extending from the Ohio Valley to Texas – and ample warmth and moisture along these boundaries – this prompted the SPC to declare a lengthy Enhanced Risk of severe weather that stretched from central Kentucky to the Texas/Oklahoma border. As the afternoon and evening unfolded, powerful supercell thunderstorms prompted up to baseball-sized hail and straight-line winds gusting beyond 80 mph (130 kph) in the greater Oklahoma City, OK metro area. Other reports of storms affected Arkansas, Missouri, Illinois, Indiana and Ohio.



By late on April 28 into April 29, concerns considerably grew regarding the risk of a major severe weather outbreak and extensive flooding resulting from excessive rainfall (see the graphic above from the WPC).

April 29



Precipitable Water on April 30 (Source: CIMSS)

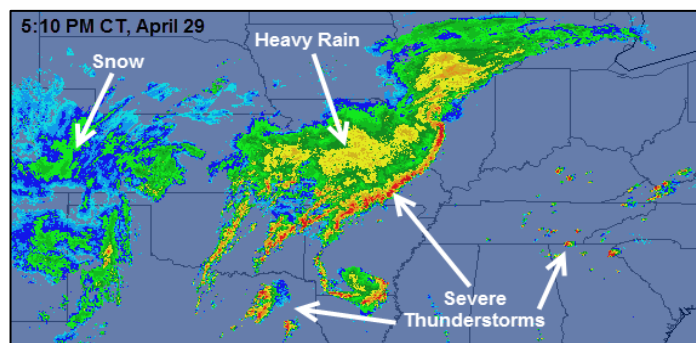
The primary driver of the prolific rainfall was a large upper level area of low pressure that slowly migrated eastward out of the Rockies into the Plains and Mississippi Valley. This upper low helped to pull a very moist plume of air out of the anomalously warm Gulf of Mexico that would eventually moisten most layers of the atmosphere. Dew point levels into the low 70s (F) were registered into Missouri and Illinois. The presence of a surface area of low pressure and associated warm and cold fronts combined with the upper level low to create ideal conditions for considerable rainfall.

Precipitable water (PWAT) values were above 2.00 inches (51 millimeters) across the Lower and Mid-Mississippi Valley, which further indicated just how moist the atmosphere was during the day. (*Reminder: Precipitable water is the amount of moisture contained in a column of the atmosphere that would accumulate if*

precipitated to the surface as rain.) Rainfall rates of several inches per hour were recorded as continuous bands of rain crossed multiple states. Flash flooding and overflowing rivers led to damage and dozens of high water rescues across parts of eastern Oklahoma, southern Missouri, and Arkansas. Local National Weather Service (NWS) offices issued numerous flood-related advisories, watches and warnings.

During the afternoon and evening hours of April 29, the convective storm portion of the event became more prevalent as destabilization occurred along the advancing cold front. With fairly strong low-level winds interacting with veering winds with height, this enhanced the risk of a tornado and straight-line wind damage from northeast Texas into the Mid-Atlantic. Multiple pre-frontal supercell thunderstorms developed before later coalescing into elongated squall lines. Several confirmed tornadoes touched down, though the most significant occurred in the Texas county of Van Zandt. At least four confirmed twisters left major damage – including two preliminarily rated EF3 near the town of Canton. Beyond the tornadic activity, there were dozens of reports of large hail and winds gusting beyond 70 mph (110 kph).

It is also worth mentioning that on the western edge of the storm system was significant snow accumulation across the Rockies and the Plains as temperatures were at or below the freezing mark. Heavy snow was recorded in parts of Colorado, New Mexico, Wyoming, Montana, Nebraska, Kansas, Oklahoma, and Texas. The radar image on the right shows the broad swath of precipitation during the day on April 29.

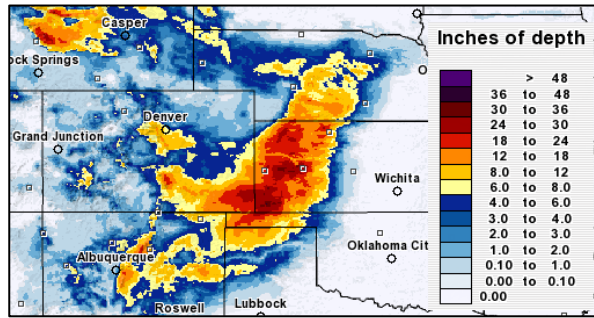


Radar imagery on April 29 (Source: NOAA)

April 30

A similar weather pattern as April 29 occurred as the broad storm system slowly started to shift eastward through the Mississippi Valley into the Southeast, Midwest and Mid-Atlantic. With copious amounts of Gulf of Mexico moisture fueling the storm system, heavy rainfall continued to cause rivers to swell across the Mississippi River watershed as several states issued evacuation orders given several rivers reaching major flood stage.

Powerful early morning thunderstorms spawned nearly a dozen tornadoes in Mississippi, Louisiana and Alabama. Most of the tornadoes were associated with an elongated line of thunderstorms that accompanied the leading edge of the cold front. The greatest volume of storm reports were associated with straight-line winds that gusted to nearly 70 mph (110 kph) as the storm cluster tracked across parts of Louisiana, Mississippi, Alabama, Tennessee, and Kentucky. Singular storm cells well out ahead of the frontal boundary led to wind damage in Ohio, Pennsylvania and West Virginia.



72-hour snow totals ending April 30 (Source: NOAA)

Heavy snow continued to fall across parts of the central and northern Plains as the main upper level low meandered east-northeastward. With a tightening pressure gradient, this led to gusty winds that topped 50 mph (80 kph) in Kansas and Nebraska. Blizzard warnings were declared as blinding snow caused dangerous driving conditions along interstates and main thoroughfares. The one and two-day snow totals were among the heaviest on record in the month of April throughout the Plains.

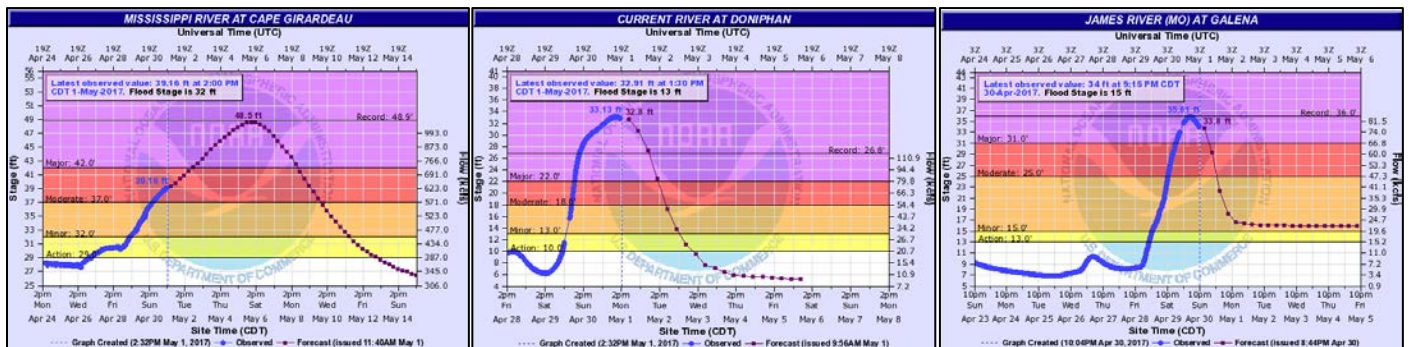
May 1

The final day of the storm system saw the severe weather threat shift into the Mid-Atlantic and Northeast. As both the surface and upper level lows tracked east-northeastward through the Great Lakes, a surge of warmth and moisture continued to occur out ahead of the primary cold front. As daytime heating commenced, this destabilized the atmosphere enough to spawn numerous individual thunderstorm cells and an eventual linear cluster of storms. Damaging straight-line winds were recorded in parts of Ohio, New York, Pennsylvania, Virginia, and West Virginia. There were multiple tornado warnings issued as the line quickly pushed eastward.

Heavy snow tracked into the Upper Midwest – triggering several inches of snow accumulation – as winter weather advisories and winter storm warnings were declared in South Dakota and Minnesota.

River Heights

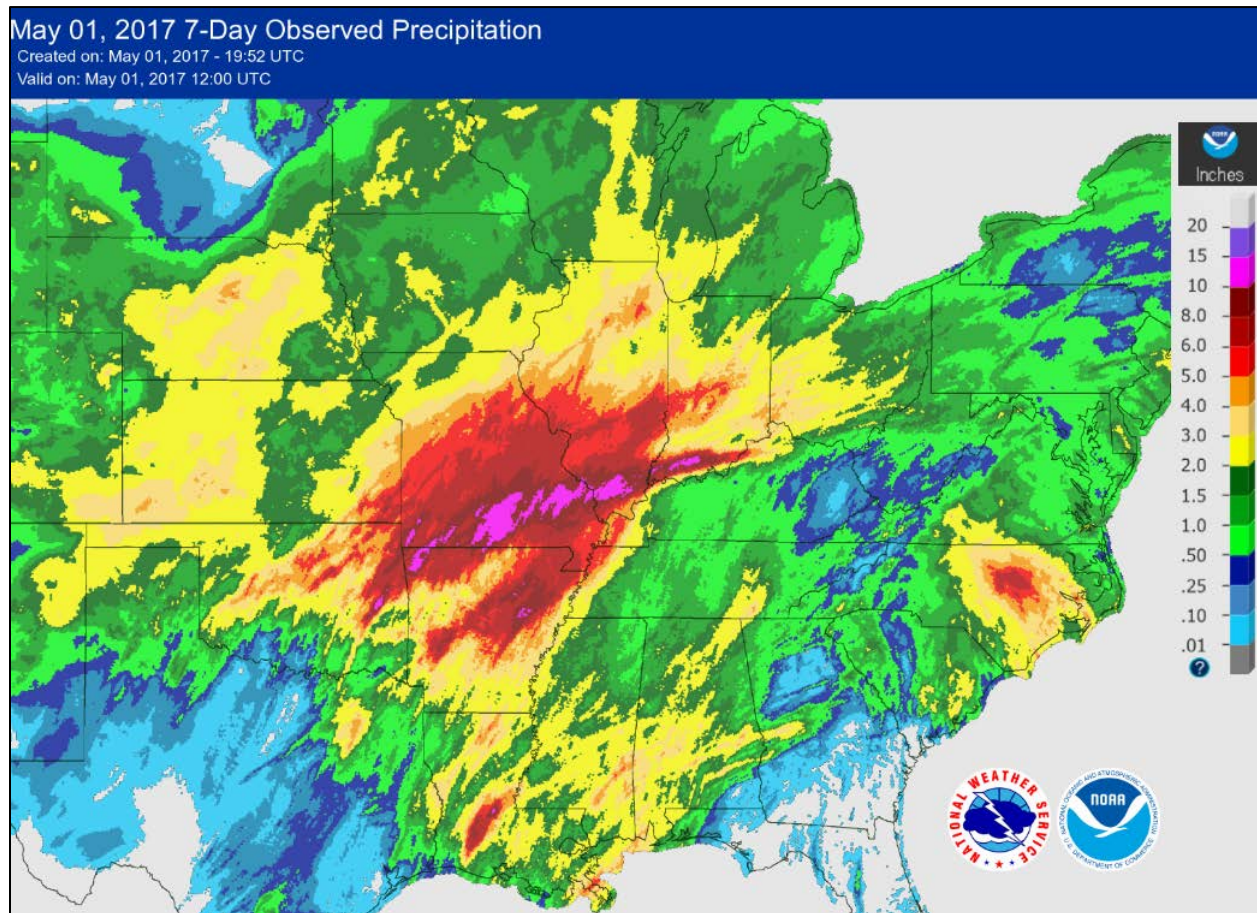
Below are select river gauge maps from NOAA. Some locations along the Mississippi River and its tributaries were not expected to see a full crest until the upcoming weekend.



Rainfall Data

The below rainfall data (April 28 to May 1) for selected locations is taken from the Weather Prediction Center. The rainfall graphic comes via NOAA.

Location	Rainfall (in.)	Location	Rainfall (in.)	Location	Rainfall (in.)
Houston, MO	11.15	Schnelleville, IN	8.74	Owensville, IL	7.95
Rogers, AR	10.54	Savoy, AR	8.50	Mountain Grove, MO	6.95
Bunkie, LA	10.00	Tahlequah, OK	8.45	West Frankfurt, IL	5.72
Springdale, AR	9.66	Stendal, IN	8.32	La Grange, KY	5.54
Bixby, MO	9.40	Granby, MO	8.22	Middleton Corner, OH	3.60



Local Storm Reports

The below Local Storm Reports (LSRs) are taken from the Storm Prediction Center. These reports have been filtered to remove duplicates.

Type	April 28	April 29	April 30	May 1
Tornado	3	11	22	0
Wind	48	128	151	184
Hail	51	58	5	3
TOTAL	102	197	178	187

Snowfall Totals

The below snowfall data (April 28 to May 1) for selected locations is taken from the Weather Prediction Center.

Location	Snowfall (in.)	Location	Snowfall (in.)
San Isabel, CO	39.0	Colby, KS	17.0
Lander, WY	33.0	Tres Ritos, NM	16.0
Colorado City, CO	29.0	Texline, TX	12.0
Genesee, CO	25.1	Felt, OK	11.0
Jackson Hole, WY	23.0	Newport, NE	10.0
Fishtail, MT	17.0	Chester, SD	6.7

Event Details

Flooding

Extensive flooding was reported across multiple states; notably Missouri, Oklahoma, Illinois, Indiana and Arkansas. Much of the flooding occurred after rivers and creeks within the Mississippi River watershed overflowed their banks following considerable rainfall. Local NWS offices in the region declared flash flood emergencies given the tremendous volume of water falling in a short amount of time, and there were nearly 270 reports of flooding or flash flooding across eight states on April 29 and April 30. No fewer than 10 individual river gauge locations set all-time record water crest heights during the event:

- Current River at Doniphan, Missouri (*previous record: March 1, 1904*)
- Current River at Van Buren, Missouri (*previous record: March 26, 1904*)
- North Fork White River near Tecumseh, Missouri (*previous record: August 1, 1915*)
- St. Francis River at Patterson, Missouri (*previous record: December 3, 1982*)
- Jacks Fork at Eminence, Missouri (*previous record: November 15, 1993*)
- Meramec River near Steelville, Missouri (*previous record: July 27, 1998*)
- Big Piney at Ft. Leonard Wood, Missouri (*previous record: March 19, 2008*)
- Gasconade River near Hazelgreen, Missouri (*previous record: March 19, 2008*)
- Illinois River near Watts, Oklahoma (*previous record: December 28, 2015*)
- Gasconade River at Jerome, Missouri (*previous record: December 30, 2015*)

Several additional locations were expected to see water heights elevate to record levels (or near-record levels) in the coming days. Some rivers with locations still seeing rising heights included the Mississippi River, Black River, White River, Illinois River, Big Muddy River, Meramec River, St. Francis River, and Gasconade River across parts of Missouri, Arkansas, and Illinois. In Missouri, there were minimally 143 reported water rescues as flash floods left motorists trapped and residents isolated. At the peak of the event, more than 350 roads in the state were closed due to debris or high water – including a 57-mile (91.7-kilometer) section of Interstate 44 between St. Louis and Springfield. One levee was reportedly overtopped in a rural area located to the west of St. Louis.

Physical damage reports were cited to a number of neighborhoods and businesses in Missouri, Oklahoma, Arkansas, Illinois, Indiana and Ohio after incurring water inundation. Some areas sustained damage despite residents furiously filling sandbags to prevent water entry. The oversaturation of soils in these states also coincided with the arrival of strong-to-severe thunderstorms that led to wind gusts making trees more susceptible to falling. Tens of thousands of power outages were additionally reported as trees fell onto power lines. Beyond physical damage to homes, businesses and vehicles, the agricultural sector in multiple states was just beginning to take stock of the total damage impact to crops.

Severe Convective Storms

CONFIRMED TORNADO COUNT (April 28 – May 1): EF0 (7); EF1 (13); EF2 (1); EF3 (1); EF4 (1); EF5 (0)

The most catastrophic tornado damage occurred in Texas on April 29. National Weather Service (NWS) meteorologists determined that separate long-track EF4 and EF3 tornadoes tore through the west and east sides of the city of Canton in Van Zandt County within 90 minutes of each other. The first tornado – an EF4 with peak winds of 180 mph (290 kph) along a 22.0-mile (35.4-kilometer) path – destroyed numerous single-family homes, manufactured homes, and vehicles in west Canton. The second tornado – with peak winds of 145 mph (235 kph) along a 40.0-mile (64.4-kilometer) path – caused considerable damage in east Canton. At least four people were killed and more than 50 others were injured in the tornadoes.



Tornado damage near Canton, TX (Source: NOAA)

Much media attention was rightly given to the devastating tornadoes however the bulk of the damage inflicted during the severe weather outbreak was due to powerful straight line winds and large hail.

On April 28 a swath of damage was reported from the Texas-Oklahoma border extending to the east-northeast across the extreme northwestern corner of Arkansas, across southern portions of Missouri, Illinois, Indiana, and Ohio, clipping the extreme northern counties of Kentucky, and into central West Virginia. Damage attributed to tornado touchdowns were reported from Sumner, Illinois, Cameron, Oklahoma, and Goshen, Kentucky. A handful of homes were damaged while several mobile homes and outbuildings were destroyed. Additional damage to trees, power lines, and vehicles was also noted from the impacted areas. Across all affected areas to homes, vehicles, and greenhouses was reported due to up to baseball-size hail (2.75 inches (70.0 millimeters) in diameter). Additionally, powerful straight-line winds toppled trees and power lines which caused damage to homes and vehicles and blocked numerous roads.

Aside from the Canton tornadoes, additional tornadic damage was reported in Oklahoma, Illinois, Missouri, Arkansas, and Louisiana on April 29. Much of the damage reported was to trees and power lines. However, isolated damage to homes and other property were reported from near Kampville, MO, near Miles Station, IL, near Natural Dam, AR, and near Oak Ridge, LA. Non-tornadic winds caused widespread damage to agricultural infrastructure in Logan and Marion Counties, IL, Labette County, KS, and Mississippi and Clay Counties, AR.

Typical damage reported included toppled silos, significant damage to outbuildings, roofs blown from structures, and numerous trees, large branches and power lines downed. Several reports were also made of high-sided vehicles being blown over on interstates and highways by strong wind gusts while train cars were derailed near Pawnee, IL, as the result of high winds. Across a swath of the southern Plains, Mississippi Valley and into the Midwest damage to homes, businesses, and vehicles were reported as a result of winds gusting in excess of 70 mph (113 kph) on April 29.

Through April 30, the focus of the severe weather shifted eastwards over eastern and southern Mississippi Valley states. Isolated reports of damages were also noted in Ohio, Pennsylvania, and West Virginia. Tornado touchdowns in the Gulf States prompted isolated damages in Louisiana and Alabama while more extensive damages were reported in Mississippi. Isolated reports of large hail were lodge on April 30 in West Virginia and Mississippi however powerful straight line wind gusts left an extensive swath of damage across Kentucky, Tennessee, Alabama, Mississippi, and Louisiana. Wind gusts in excess of 70 mph tore down trees and toppled power lines and caused extensive structural damage to homes, mobile homes, businesses, vehicles, and other structures. At least one person was injured in Alabama while one was killed in Tennessee as the result of downed trees. Widespread disruption to travel and tens of thousands of power outages, including 11,500 in Alabama, resulted from the severe wind damage.

Straight line winds left an extensive damage footprint throughout Ohio, the Mid-Atlantic, and the Northeast on May 1. Of the 180 reports lodged with the SPC on Monday, 177 pertained to damaging wind gusts. Thousands of trees and power lines were downed causing extensive damages to homes and vehicles throughout the affected states. Damages were reported from Ohio, the Carolinas, Virginia, West Virginia, Maryland, Pennsylvania, and New York.

Heavy Snow

Heavy snowfall prompted widespread disruption across portions of the Rockies and Plains. Colorado, Wyoming, and Kansas saw the highest accumulations with several localities reporting more than two feet (61.0 centimeters) of snow while parts of Montana, New Mexico, and Texas saw accumulations in excess of one foot (30.5 centimeters). Among the worst affected areas was western Kansas where a 130-mile (209-kilometer) stretch of Interstate 70 was closed for a period on April 30. The National Guard responded to approximately 40 calls for help from stranded motorists. More than 35,000 customers across Kansas were without power on April 30; 25,000 of who were in western Kansas. Local media reports indicated that hundreds of power lines and poles had been toppled and that the electricity supply for numerous communities would not be restored for several days.

In Nebraska, a stretch of Interstate 80 was closed on April 30 while Interstates 40 and 25 in New Mexico were closed on April 29. Several smaller roads and highways were also subject to closures due to whiteout conditions across the affected states, including Highway 64 in New Mexico and Highways 10 and 16 in Colorado. Also in Colorado, some 9,200 customers in Pueblo County were without power on April 30.

Financial Loss

Given the significant multi-peril footprint across more than one dozen states, it remains far too early to provide an exact economic or insured loss estimate at this time. With several rivers and streams additionally forecast to crest in the coming days, it will take weeks until the full scope of the event is realized. At a minimum, the total economic and insured loss impact is expected to reach into the hundreds of millions (USD).

Additional and updated details will be found in this week's Weekly Cat Report.

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