

**Annual Report to the
North Carolina General Assembly**

Drought Management Advisory Council Report

July 1, 2018 – June 30, 2019

Division of Water Resources



**NORTH CAROLINA
DEPARTMENT OF ENVIRONMENTAL QUALITY**

**N.C. Department of Environmental Quality
Division of Water Resources**

**N.C. Drought Management Advisory Council Annual Report
July 1, 2018 – June 30, 2019**

Introduction

The N.C. Drought Management Advisory Council (DMAC), created as required by North Carolina General Statute 143-355.1, coordinates drought monitoring, assessment, and response activities between State and Federal agencies, public water systems, and water users. The objective of the DMAC is to provide consistent and accurate information on drought conditions to the U.S. Drought Monitor, the Environmental Management Commission, the Secretary of the N.C. Department of Environmental Quality, the N.C. Environmental Review Commission, and the public in order to manage and mitigate the harmful effects of drought. In accordance with statutory requirements, the council must submit an annual report to the Secretary of the N.C. Department of Environmental Quality, the Governor and the N.C. Environmental Review Commission by October 1 of each year.

Drought Overview 2018 – 2019

Climate Summary – State Climate Office (Rebecca Ward, Corey Davis)

Overall Summary

The July 1, 2018 to June 30, 2019 period in North Carolina saw its fourth warmest and first wettest year on record since 1895. Eight out of the 12 months saw temperatures that were above average or much above average. Notably, September 2018 and May 2019 ranked as the second warmest September and May, respectively, on record for the state. Both months saw upper level ridging — or high pressure — that ushered in hotter temperatures while suppressing shower activity. This high pressure ridging even influenced Hurricane Florence, which impacted the state in September 2018. The storm was steered by the Bermuda High Pressure (a semi-permanent anticyclone located over the Atlantic Ocean) toward the coast and then became stalled beneath an upper-level ridge, leading to very slow forward movement over the Carolinas. Statewide average precipitation in 2018 was 71.77 inches, 22.5 inches more than the state's 1981 to 2010 average precipitation.

While North Carolina, as a whole, has seen above-normal or much-above normal rainfall for the June 2018 to July 2019 period, the southern coast consistently missed out on precipitation for the first half of 2019, contributing to the emergence of drought conditions in this part of the state beginning in February.

Seasonal Breakdown

Summer 2018

The June, July, and August 2018 period ranked as the ninth warmest summer on record. Despite finishing warmer than average, the state, as a whole, saw few heatwaves and the season's near-normal precipitation meant there were minimal concerns for dryness or drought over the period.

Fall 2018

North Carolina saw its wettest fall on record in 2018, driven in large part by tropical cyclone activity in the state. Perhaps the most notable event over the July 2018 to June 2019 period was Hurricane Florence, which made landfall as a Category 1 storm near Wrightsville Beach, NC, on the morning of September 14, 2018. During the approximately one-week period that Hurricane Florence or its remnants were present over the state, nearly every part of North Carolina was impacted by the storm's wind, rain, and/or flooding. Southeastern N.C. was impacted the most, with substantial areal flooding that continued for days after the storm cleared from the state.

Approximately one month after Hurricane Florence, Hurricane Michael made landfall along the Florida Panhandle as a Category 5 storm on October 10, 2018. A mere 24 hours later, the storm's center was over North Carolina. Despite being downgraded to a tropical storm by this time, the storm's winds still packed a powerful punch that toppled trees and powerlines throughout North Carolina's Piedmont region.

These events resulted in record one-day rainfall amounts in many locations and contributed to 2018 being the wettest year overall for many locations. Thirteen stations recorded more than 24 inches of rain from Florence. Michael added to these totals resulting in continued widespread flooding.

Winter 2018-2019

Fall storms gave way to a milder winter. An early snowstorm which occurred December 8-10, 2018, blanketed most of the state outside the coast with several inches of snow. While the mountains saw snowfall throughout the winter, amounts were generally less than the long-term average. Mount Mitchell, for example, saw 71.5 inches of snowfall for the 2018-2019 winter, more than 20 inches below its normal wintertime accumulation of 92.3 inches. With the exception of one small event on March 5 that brought up to three

inches of snowfall in Onslow County, the state saw few wintry weather events during the winter season. That said, the state did see above normal precipitation amounts, ranking as the ninth wettest winter since record keeping began in 1895.

Spring 2019

As winter transitioned to spring, the state saw its share of severe weather events. Notably, one event on April 19, 2019 spawned 12 tornadoes across the state and caused damaging straight line winds and heavy rainfall. The end of spring saw the reemergence of drought along the southeastern coast of N.C. — marking the first time this part of the state has seen a widespread summer drought since 2011. The months since Hurricane Florence have been dry along eastern North Carolina, and a late spring heat wave, driven by upper-level ridging, led to rapid drying and the development of drought. Interestingly, Wilmington — which saw it's wettest year on record in 2018 with 102.4 inches of precipitation — had received a mere 13.83 inches for the year to date as of June 30, 2019, ranking this period as the second driest on record (records from the Wilmington International Airport COOP Station, <https://climate.ncsu.edu/cronos/?station=319457>).

Streamflow and Groundwater – USGS (Curtis Weaver)

Streamflow conditions during much of the annual period (July 1, 2018, through June 30, 2019) were commonly characterized by normal and above-normal conditions. During early and mid-July, USGS WaterWatch streamflow maps depicted a large area of below-normal conditions (less than 25th and 10th percentiles) across much of central North Carolina. Beneficial rainfalls across the State in late July improved conditions into the normal and above-normal ranges at most USGS streamgages across state. These conditions continued into September when Hurricane Florence made landfall near Wilmington on September 14, 2018, dropping copious amounts of rainfall across parts of the southern Coastal Plain. With above-normal rainfalls continuing after the hurricane's passage across the Carolina's region, a range of conditions between above, much-above, and record-high streamflow (for the calendar date) remained in effect across the State through the end of January 2019. Beginning in early February 2019, a hint of dryness was observed through below-normal streamflow conditions at several isolated USGS streamgages widely scattered across the State. However, late winter and early spring rainfalls quickly resulted in above-normal streamflow conditions across the State from later February through mid-May. A larger extent of dryness settled across parts of eastern North Carolina from late May into early June resulting in streamflow conditions below the 25th percentile. The return of rainfalls, however, across the State during mid-June again resulted in increased streamflows across much of the State by the end of the annual period.

Figure 1 shown below indicates the percentage of USGS streamgages in North Carolina with 7- day flows less than the 25th, 10th, and 1st percentiles (or record-low for the calendar date) during the annual period.

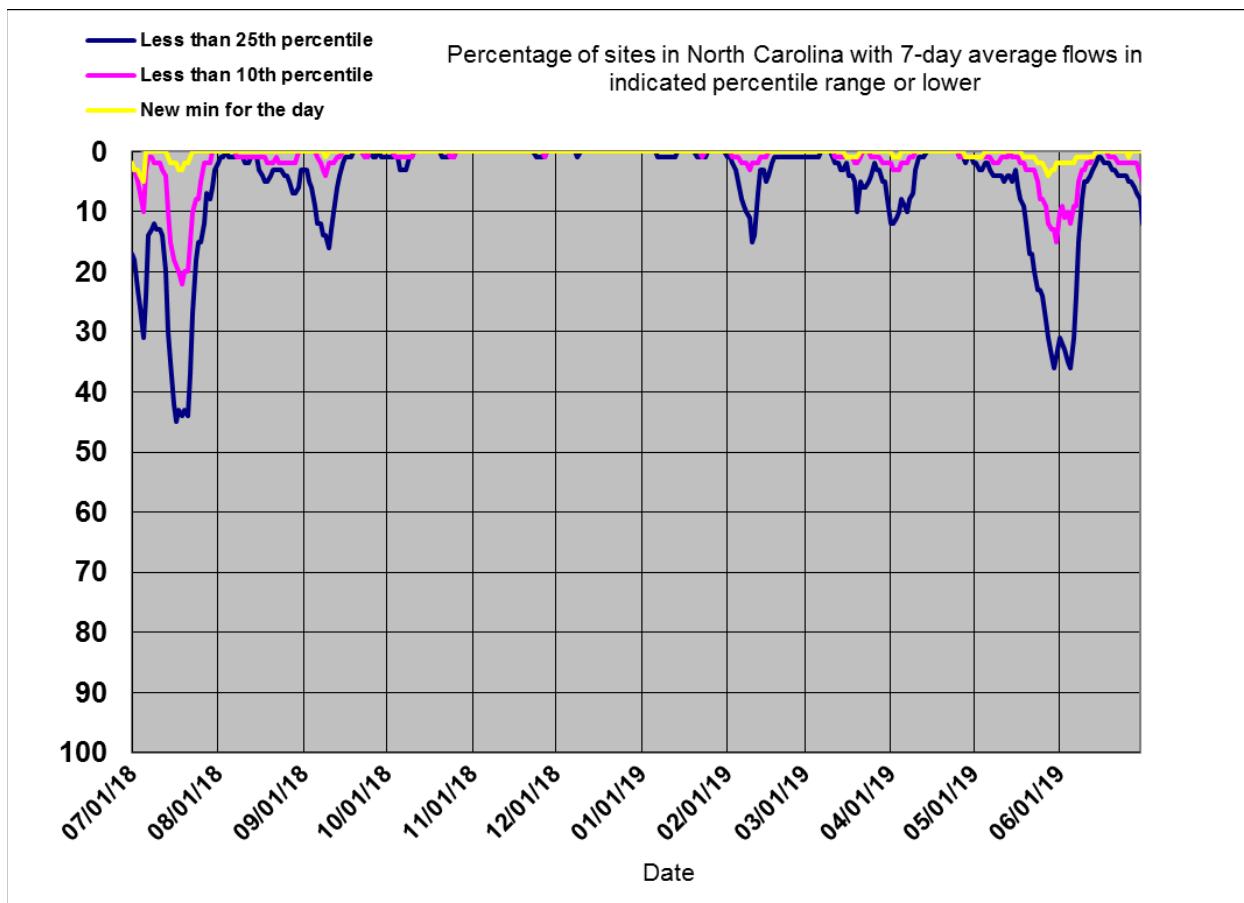


Figure 1. 7-day Flow Percentiles for USGS Streamgages in North Carolina

Below-normal streamflow conditions were measured in some streams during the early summer season with the percentages of USGS streamgages across North Carolina having 7-day average streamflow percentiles below the 25th and 10th percentiles reaching 45 and 22 percent, respectively, in mid-July 2018, the maximum for the annual period. These percentages are substantially lower than the maximum values (90 and 75 percent, respectively) observed during the previous annual period (2017–2018). However, heavy rainfalls associated with the landfall of Hurricane Florence on September 14 followed by continued above-normal precipitation marked the beginning of an extended period of almost statewide above-normal streamflows through the end of January 2019. During this period, the percentage of sites with 7-day average streamflows less than the 25th percentile remained at or less than 1 percent. Beginning

in early February, isolated below-normal conditions returned to some North Carolina streams resulting in the percentage of sites with 7-day average streamflows less than the 25th percentile increasing to as much as 15 percent from February through mid-May. A more extensive pattern of dryness began to affect NC streams in mid-May with the percentage of below-normal sites reaching as high as 36 percent in late May and early June. Rainfalls across parts of the State in mid-June quickly helped improve streamflow conditions such that the percentage of sites with 7-day average streamflows less than the 25th percentile was less than 10 percent during latter June 2019.

Examination of approved (2018 water year) and provisional (2019 water year) daily discharge data indicates new period of record minimum daily mean discharges were set at two USGS streamgages in North Carolina during the annual period. The first occurred at USGS Sta. 02146600 at McAlpine Creek at Sardis Road near Charlotte in Mecklenburg County when a daily mean discharge of zero flow was observed on July 4-5, 2018. This record minimum superseded the previous record of 0.01 ft³/s observed on August 14, 2002. The second record minimum daily mean discharge was observed on September 17-18, 2018, at USGS Sta. 02087183 at Neuse River near Falls in Wake County. Located immediately downstream from Falls Lake, the daily mean discharges of zero flow on these two days superseded the previous record of 5.2 ft³/s observed on September 24, 1980. However, it should be noted this new minimum record for the Neuse River streamgage was not a reflection of dry conditions but rather closure of the release gates at the upstream Falls Lake dam to prevent exacerbation of downstream flooding in the lower Neuse River basin following the rainfalls from Hurricane Florence. Similarly, new record minimum 7-day average discharges were set at the McAlpine Creek streamgage on July 3-5, 2018, superseding the previous record set in July 1986. Provisional new record minimum 7-day average discharges were also set at USGS Sta. 02092500 at Trent River at Trenton in Jones County on May 23-30, 2019, superseding the previous minimum record set in May 1986. No new periods of record minimum monthly average discharge were set for any of the USGS streamgages within the State during the annual period.

Groundwater levels at the 16 USGS observation wells within the USGS North Carolina Climate Response Network were commonly in the normal and above-normal ranges during the annual period from July 1, 2018, through June 30, 2019. Water levels in the wells reflect the climate conditions (occurrence of precipitation), but temporal changes are also affected by individual well characteristics (e.g. well depth, surrounding material through which the water moves).

Water levels at the four Blue Ridge observation wells in this network were generally sustained in the normal and above-normal ranges throughout much of the annual

period. Among these four wells, the only instance of observed below-normal water levels was at the USGS well at Marble in Cherokee County during which the water levels fell below the 10th percentile during the month of February. Provisional monthly record high water levels were noted for the Pisgah Forest and Blantyre wells (Transylvania County) in at least 7 of the 8 months from November 2018 through June 2019. Provisional period of record high water levels was set in December 2018 at the Pisgah Forest well and in mid-March 2019 at the Blantyre well.

Water levels at the five Piedmont wells in this network were likewise generally sustained in the normal and above-normal ranges throughout much of the annual period. During September 2018, the water levels at the Oak Ridge well in Guilford County declined into the “less than 25th percentile range”. Provisional monthly record high water levels were noted for a varying number of months during the annual period at the Langtree well in Iredell County (6 months), the Piedmont Research Station (RS) well in Rowan County (12 months), and the Oak Ridge well in Guilford County (5 months). Provisional period of record high water levels was also set at 4 of the 5 Piedmont wells (Langtree, Piedmont RS, Oak Ridge, and Duke Forest well in Durham County) during the 2019 late winter or spring seasons.

Water levels in the Marston well in Scotland County (Sandhills region) were in the “less than 25th percentile” range in mid-September 2018 just prior to the Hurricane Florence’s landfall. Following an increase of nearly 4 feet in late September, the water levels remained in the much-above normal ranges for the duration of the annual period. Both provisional monthly record and period of record (January 2019) high water levels were set at this well during the annual period.

Among the six wells in the Coastal Plain, water levels varied widely during the annual period. Conditions were commonly in the normal and above-normal ranges during the first half of the period (particularly after Hurricane Florence) with levels gradually descending into the below-normal ranges for varying number of months during the latter half of the period. The wide variations reflect the quick response of water levels to climatic conditions in shallow wells common in the Coastal Plain. New provisional record monthly minimum water levels were observed at two of the six wells (Hoke well in Washington County, Elizabeth City in Pasquotank County) during May 2019. Multiple instances of new monthly record high water levels were observed at five of the six wells (Grantham well in Wayne County, Southport well in Brunswick County, Comfort Research Station well in Jones County, Simpson well in Pitt County, and Elizabeth City well). New period of record high water levels was also set at these same five wells during the annual period, with the new records being set during September 2018 at four of the wells as a result of heavy rainfalls from Hurricane Florence.

Forest Resources – NC Forest Service (Cabe Speary, Kelley Oten, PhD)

Weather impacts had some effect on forestry and wildfire operations across the state during the past year. Hurricane Florence disrupted forestry operations for much of the fall and winter in the coastal plain and Sandhills region. In addition to the flooding rains, many river systems remained at flood stage for much of the winter. The traditional spring fire season was dampened by above normal precipitation until mid-May when the coastal plain, eastern piedmont, and Sandhills experienced a “flash drought.” Severity resources, personnel and equipment sent to an area experiencing high fire danger, were dispatched from other parts of the state to assist in the east until early June when conditions eased.

From July 1, 2018 to June 30, 2019, the N.C. Forest Service responded to 2,842 wildfires across the state that burned approximately 6,976 acres on state and private lands. The number of fires decreased by approximately 35 percent, while the number of acres decreased by approximately 45 percent over the previous year. The number of fires was approximately 26 percent less than the 10-year average. The total number of acres burned was 64 percent lower than the 10-year average. Calendar year 2018 fire acreage of 10,994 is the 3rd lowest on record since the NCFS fire record keeping began in 1928. There were 77,969 acres on state and private lands which were treated with prescribed fire during the past fiscal year, a 9 percent increase from the previous year.

Forest health was greatly impacted by extreme wet followed by drought-like conditions in eastern North Carolina. In September 2018, Hurricane Florence caused flooding in many areas in the southeast. Areas reported 15-35 inches of rainfall and floodwaters took some time to recede. Immediately following, from late fall through mid-spring, above average rainfall impacted the region, with many events occurring every 5-7 days, keeping the soil saturated. These events led to a decrease in fine roots and an increase in fungal diseases such as Phytophthora root rot. In May and June, most areas had significant precipitation deficits and abnormally high temperatures. By mid-June, this change from one extreme to another led to tree mortality across eastern North Carolina. Primary impacts were to oak trees, but pines, dogwoods, ornamental conifers, and a number of other species were also affected.

Agriculture - North Carolina Cooperative Extension (Mike Yoder)

Late summer 2018 was a relatively normal weather pattern with spotty showers through July and normal crop development reported across much of the state. Early August brought substantial rains across much of the state, limiting agricultural activity.

The impacts of weather on the North Carolina agricultural community, from July 2018 to June 2019, will be highlighted by the excessive rains, associated with Hurricane Florence, that fell on south-eastern and south-central parts of the state during mid-September. Farmers lost crops and livestock due to flooding from the storm. While many agricultural commodities were moved off-farm in the 72 – 96 hours preceding the storm, many more commodities were lost, jeopardizing the livelihood of North Carolina farmers. The effects of hurricane Florence are still being felt by agricultural producers today.

Winter 2019 rains slowed field preparation and planting operations into mid-March. By the third week in March, conditions had dried enough to allow planting of corn in much of the eastern and central parts of the state. During late April and May, dry conditions started to develop in eastern counties like Pasquotank, Camden, and Currituck, as well as farther south in Pamlico, Carteret, Craven and Pender. The dry conditions in most of the latter counties persisted into late June. This resulted in lower than normal yields for corn. The planting of soybeans in several central North Carolina counties was also delayed due to dry conditions in May.

Many wheat stands were thin, with reduced production due the timing and amounts of early winter rains, followed by semi-dry periods in the eastern and Piedmont regions. Hay production was generally good across the state once soils dried enough in April and May to begin harvest of first cutting hay.

While dry conditions were realized in some of our southeastern, north-central and south-central counties during the spring/summer 2019 months, most of the damage done to agriculture during the past year was associated with the rains of Hurricane Florence.

Drought Condition Summary – Division of Water Resources (Klaus Albertin)

The July 1, 2018 to June 30, 2019 period began with only a small area of the state in abnormally dry (D0) and no areas in drought (D1 to D4) conditions and saw little dryness throughout the annual report period (see Figure 2).

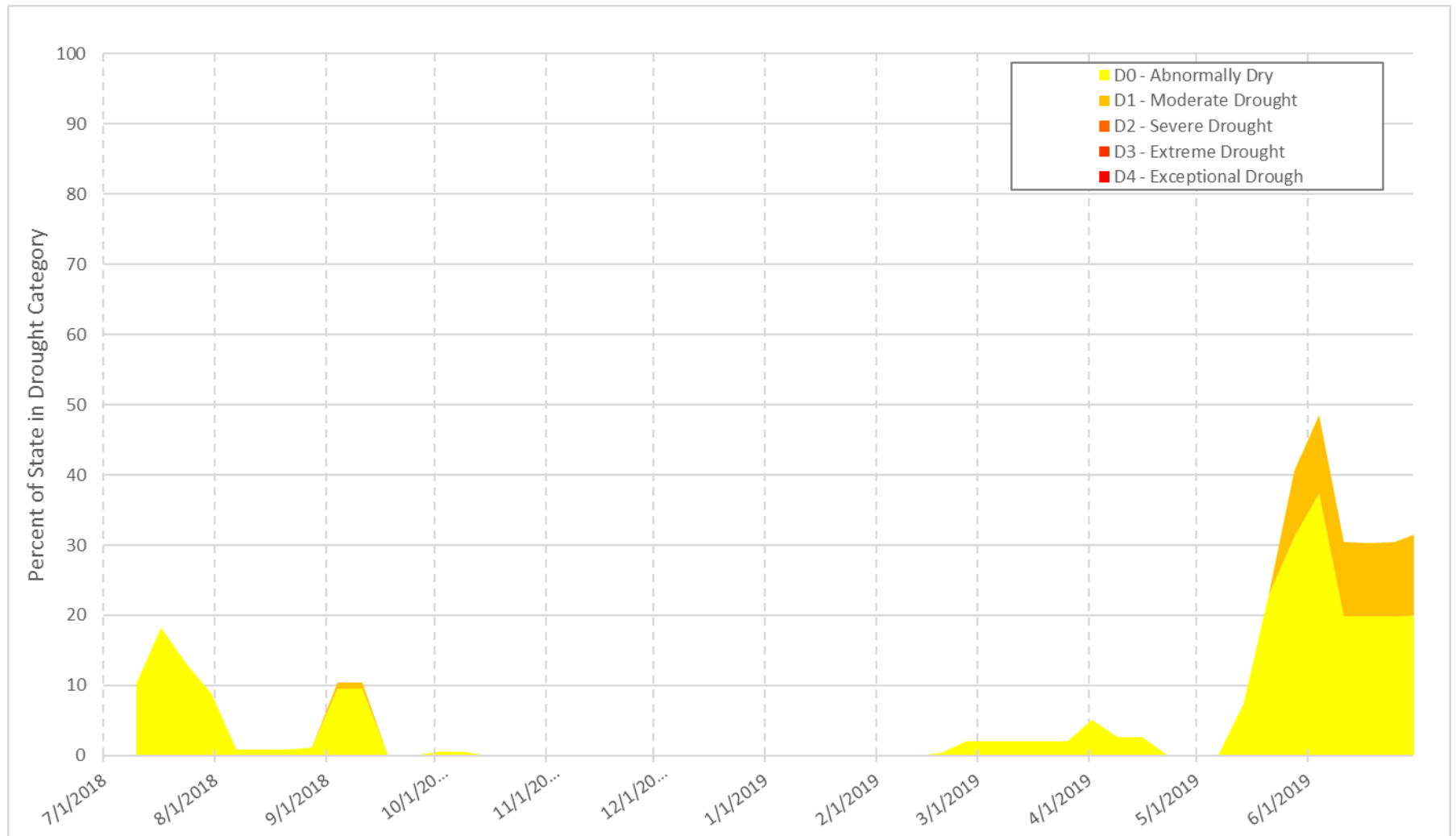


Figure 2. Drought Levels from July 1, 2018 through June 30, 2019

The dry conditions that were seen in July 2018 were of limited extent and severity. A small area (less than 1 percent) was classified as being in drought on September 4th (see Figure 3). This and the abnormally dry classification through the Sandhills were erased with the occurrence of Hurricane Florence on September 14th.

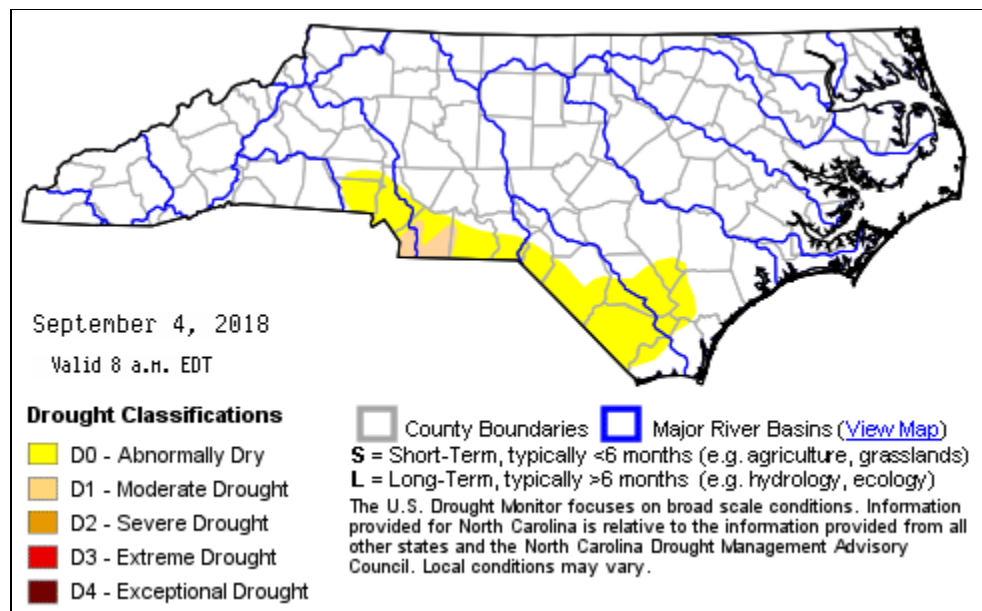


Figure 3. North Carolina Drought Classification (early September 2018)

Hurricane Florence began a period of wetness across the state. Rainfall was below normal across the southern coastal plain for the early part of 2018, but drought conditions were delayed since the exceptional rains from the later part of 2018 left conditions exceptionally wet. and no areas were even considered to be abnormally dry until February 19th, 2019 (See Figure 4).

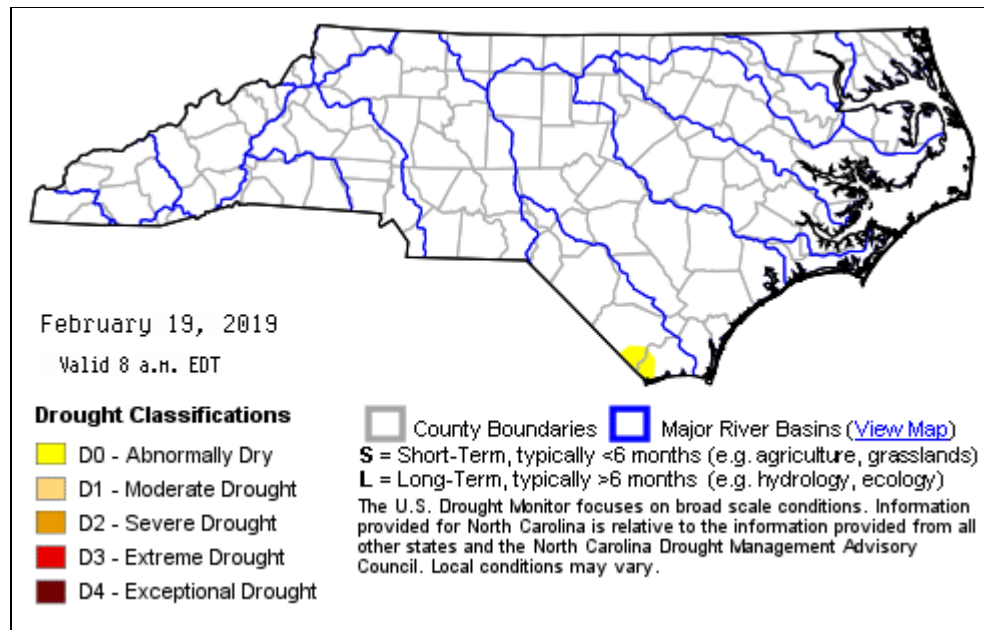


Figure 4. North Carolina Drought Classification (February 2019)

The area of persistent dryness which began in Columbus County in February slowly spread to almost half of the state by mid-June (Figure 5). Approximately 11 percent of the state was classified as D1 on June 4th.

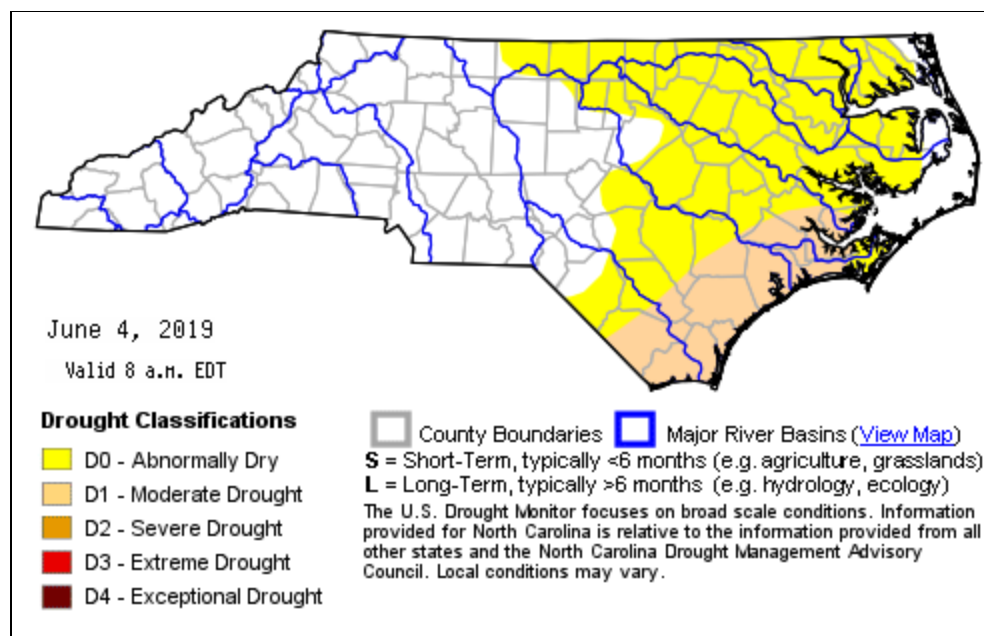


Figure 5. North Carolina Drought Classification (early June 2019)

The D0 area began to decrease by the end of June 2019 dropping from approximately 37 percent on June 4th to 20 percent on July 2, 2019. The D1 area remained near 11 percent. No areas in the state reached the severe drought (D2) stage during the annual report period.

The most significant impact to water supply was seen during and following the Memorial Day holiday when several coastal water systems initiated voluntary water restrictions, mainly due to a spike in demand and the outlook of dry conditions. Other systems in the Piedmont, such as Johnston County, also implemented voluntary reductions in their water supply. The USACE, TVA, and Duke Energy reservoirs were all able to maintain water storage during the annual report period.

Agriculture in the coastal plain was negatively affected by drought. The tropical cyclones and associated flooding severely impacted harvest in 2018 with large crop losses. The extended dryness in the coastal plain during the planting season delayed or limited early plant growth. This back to back flooding and then abnormal dryness has affected two growing seasons for a number of farmers.

Historical Perspective

Due to the natural variability of climate, drought may occur at some location in the state. In recent history, 2003 was the only year where no drought occurred in any part of the state. More typically, we see a moderate part of the state with abnormally dry conditions and a much smaller area in moderate drought. Severe drought or worse conditions do occur in many years, but the extent is often limited. The areas that are affected also shift throughout the year as localized rainfall either hits or misses locations. In this context, the 2018 – 2019 period was on the low side for drought conditions.

Analysis using one of the standard drought assessment metrics, the Palmer Drought Hydrologic Index (PDHI), provides insight into long-term drought conditions for North Carolina (See Figure 6). Similar to the standard deviation of a normal distribution in statistics, PDHI values within +/- 2 reflect typical conditions. Values outside of this range show either very wet (positive) or very dry (negative) conditions. Values above +4 and below -4 reflect very extreme conditions.

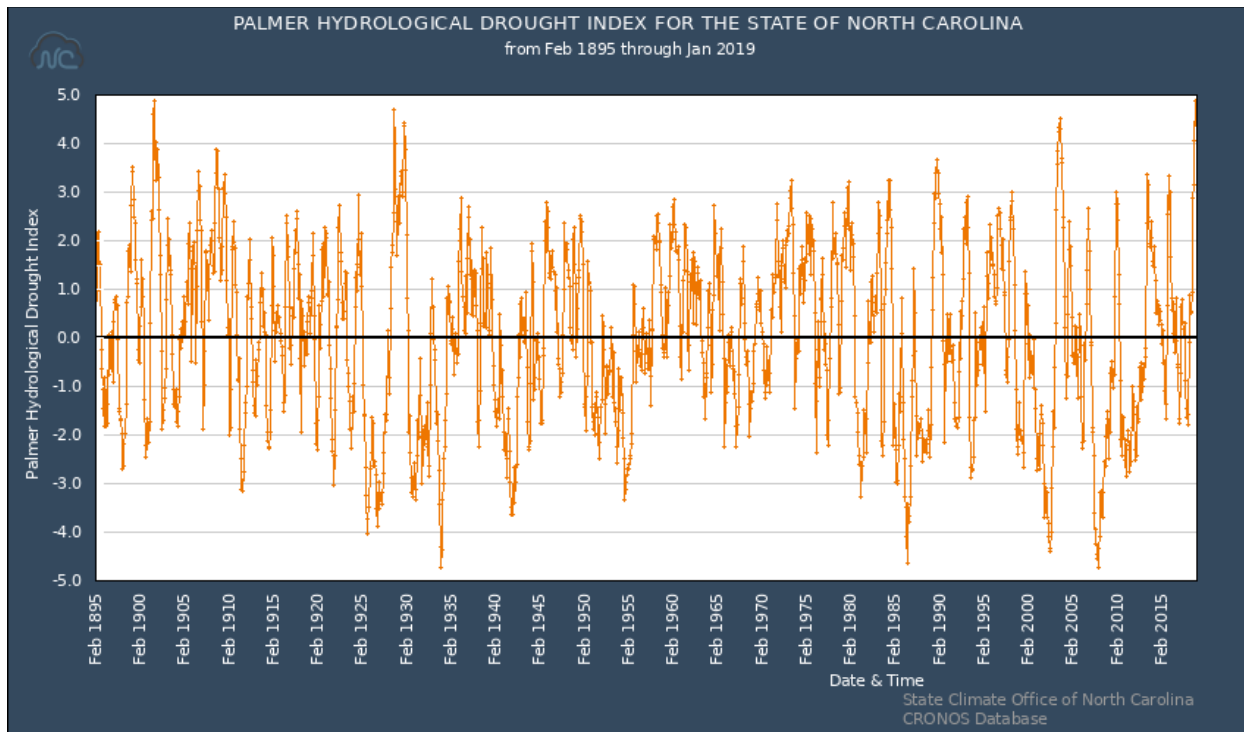


Figure 6. Palmer Hydrologic Drought Index since 1895. Source: NC SCO, 2019

North Carolina experienced extreme drought conditions from 1925 through 1927 with PDHI values reaching -4.1 at one point. A very wet period followed and then an extreme drought occurred in 1932 - 1933. This extreme drought period saw the lowest individual monthly PDHI value of -4.74. Occasional, moderate droughts occur in the 1940's and 1950's but it wasn't until the late 1980's that extreme drought returned. The PDHI reached a low of -4.6 in July 1986. Moderate to wet conditions returned in the 1990's but two of the most extreme droughts in North Carolina's recorded meteorological history occurred between 2000 and 2010. One of the wettest years also occurred during this period. Since 2010, conditions have been less extreme but highly variable swinging from moderately wet to moderately dry. No clear trend is seen but it does appear that more extreme swings in conditions are likely. This conclusion is supported by the fact that 2018 was the wettest year on record for North Carolina. The North Carolina PDHI values peaked at 4.88 in December 2018 (NOAA, 2019).

Drought Management Advisory Council Meetings

Drought conditions in North Carolina are updated weekly through an audio-video telecom with a Technical Drought Advisory Team, which is a sub-group of the NC DMAC. The team consists of experts on climate, weather, hydrology, water supply, forestry, and agriculture that report each week on streams flows, groundwater levels, reservoirs levels, wildfire activity, water supplies, and crop conditions. Based on this

information, the team makes a recommendation to the U.S. Drought Monitor author on the state's drought conditions for that week. Those recommendations are used to draw the national drought map each Thursday. To see or download a copy of the current drought map, go to the state's official drought website at: www.ncdrought.org.

The Technical Drought Advisory Team only met intermittently from late September through late May due to the excessively wet conditions seen statewide. Conditions were still monitored weekly and the Chair of the DMAC communicated with the US Drought Monitor program but since conditions remained wet across the state, no regular weekly call was required. This was the first time the regular weekly call was suspended in several years.

The DMAC is required by law to meet in person at least once each calendar year. The annual council meeting was held April 4, 2019 at 10 a.m. Thirty-one representatives and associates of the council attended despite the lack of drought conditions. Items discussed at the meeting included current conditions on stream flow and ground water levels, lake and reservoir levels, agriculture, forestry and public water systems. The effect of the tropical cyclones on water resources was a subject of interest. Michael Yoder from the North Carolina State Extension Service gave a presentation on how the record wet 2018 and abnormally dry conditions at the coast in early 2019 had significant impacts on farmers.

References:

NOAA. 2019. Climate at a Glance. National Oceanographic and Atmospheric Administration. Website : <https://www.ncdc.noaa.gov/cag/divisional/mapping/31/phdi/201711/1/value> . Accessed August 23, 2019.

NC SCO. 2019. nClimDiv Climate Division Data. North Carolina State Climate Office. Website: <http://climate.ncsu.edu/climate/climdiv> . Accessed August 23, 2019.