Preserving

2023 Water Quantity Report

THE MIAMI CONSERVANCY DISTRICT

Executive Summary

To track changes in water availability in the Great Miami River Watershed, the Miami Conservancy District records precipitation, runoff, and groundwater levels to estimate water inflows and outflows for an area of more than 3,630 square miles.

The average annual precipitation recorded in the Great Miami River Watershed during 2023 was 36.91 inches. This amount was 5.01 inches below the 30-year average precipitation (1991 – 2020) for the watershed. Long-term precipitation data shows average annual precipitation is trending upward in recent decades.

Estimated runoff for the Great Miami River in 2023 was 11.04 inches. This amount was 5.17 inches below the 30-year average (1991 – 2020) runoff for the watershed. As in the case of precipitation, average annual runoff in the Great Miami River Watershed is also increasing.

The Miami Conservancy District flood protection system stored high water 15 times during 2023. The average annual number of storage events for the five storage basins, over the entire life of the system, is 20. None of the storage events that occurred in 2023 were large enough to exceed Miami Conservancy District's top-10 storage event ranking.

Groundwater levels measured in 2023 ended the year at or close to the levels measured at the beginning of the year. Average annual groundwater levels measured in all index wells have been stable over the long term. Since the 2000s, total water withdrawals have declined from 600 million to around 300 million gallons of water per day.

Long-term trends in precipitation, runoff, and streamflow are increasing while groundwater levels in the buried valley aquifer system remain stable in most locations. These trends reflect climatic variability coupled with declining water use.

Background

The Miami Conservancy District is a conservancy district - a political subdivision of the State of Ohio. Miami Conservancy District works as a regional government agency throughout the Great Miami River Watershed (see figure 1). Formed in 1915, Miami Conservancy District provides flood protection, water stewardship, and recreation.

To track natural water resource conditions, Miami Conservancy District operates automated and observer precipitation stations as well as extensive stream gaging and observation well networks to record precipitation, streamflow, and groundwater levels.

Miami Conservancy District operates the stream gaging network with the U.S. Geological Survey (USGS) under a cooperative agreement that has been in place since 1931.

Partnering with a variety of federal, state, and local governments, Miami Conservancy District conducts surface water and groundwater quality and quantity studies.

Tracking Water Quantity

Miami Conservancy District tracks changes in water availability - including precipitation, runoff, and groundwater level data through partnerships with USGS and a network of citizen observers.

Water data from these partnerships provide estimates of water inflows and outflows for the Great Miami River Watershed upstream of the Hamilton stream gaging station (the most downstream gage), an area of more than 3,630 square miles.

These data also allow for comparisons between current hydrologic measurements and historical measurements to evaluate trends in water quantity entering and leaving the watershed, as well as trends in aquifer storage.

The trends can be useful for planning related to water supply, flood protection, construction, agriculture, commerce, and industry.

Water Cycle

All water coming into the Great Miami River Watershed arrives as precipitation.

Precipitation falls on the land surface of the Great Miami River Watershed as rain, snow, or ice.

Some of the precipitation flows by gravity toward streams and rivers and becomes surface runoff which eventually reaches the Great Miami River (see figure 2).

Some of the precipitation infiltrates the ground and percolates through the soil until it reaches the water table. This water provides groundwater recharge to the aquifers and helps sustain the abundant water resources in the Great Miami River Watershed.

Water in the aquifer either remains underground and in storage for an extended period or stays close to the ground surface and seeps into nearby streams or rivers as base flow.

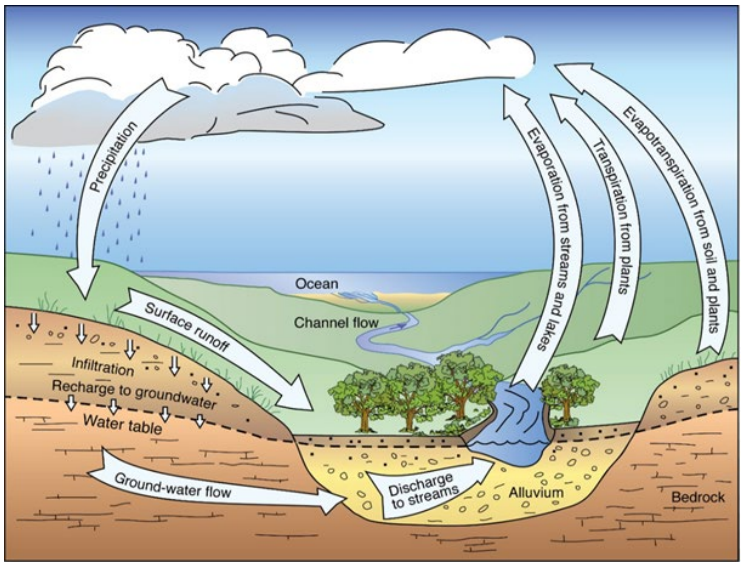


Figure 2 - Water Cycle

As a result, many streams and rivers in the Great Miami River Watershed can sustain flow, even during periods of prolonged drought, because the underlying buried valley aquifer provides base flow to the streams and rivers.

Observing Precipitation

To track precipitation amounts, Miami Conservancy District maintains a network of 42 stations staffed by citizen observers who record daily precipitation amounts (see figure 3).

The observers make daily measurements of precipitation collected in standard National Weather Service rain and snow gages (see figure 4) and send the readings to Miami Conservancy District via mail or electronic submittal. Miami Conservancy District uses the data to calculate annual precipitation for the watershed by averaging annual precipitation totals measured at each of the stations.

Figure 4 - A National Weather Service standard rain gage.

Annual Precipitation & Trends

The average annual precipitation recorded by Miami Conservancy District during 2023 was 36.91 inches.

Monthly precipitation in the Great Miami River Watershed was above average during January, March, July, and August (see Figure 5). March recorded the highest monthly precipitation total in 2023 at 6.35 inches. Below average precipitation occurred in February, April, May, June, September, October, November, and December. September recorded the lowest precipitation total in 2023 at 0.94 inches.

The highest annual total precipitation amount of 44.39 inches was recorded at Miami Conservancy District's West Liberty observer station, while the lowest amount of 30.68 inches was recorded at the Ft. Loramie observer station.

The year 2023 started out with the entire Great Miami River Watershed under abnormally dry to moderate conditions. Drought conditions gradually diminished through January and February and the entire region was drought free by the end of February. Drought conditions redeveloped near the end of May and persisted in at least southern portions of the watershed through early August. Above normal precipitation in August brought a brief respite from the drought. Nevertheless, drought conditions reestablished in early to mid-September and remained over much of the watershed throughout the rest of the year (see Figure 6).

Despite the below-average amount of precipitation recorded for 2023, the average annual precipitation is still trending upward (see Figure 7). Average annual precipitation for the 30-year timespan of 1951 – 1980 was 37.29 inches. For the 30-year timespan of 1991 – 2020 average annual precipitation climbed to 41.92 inches showing an increase of 4.63 inches over 40 years.

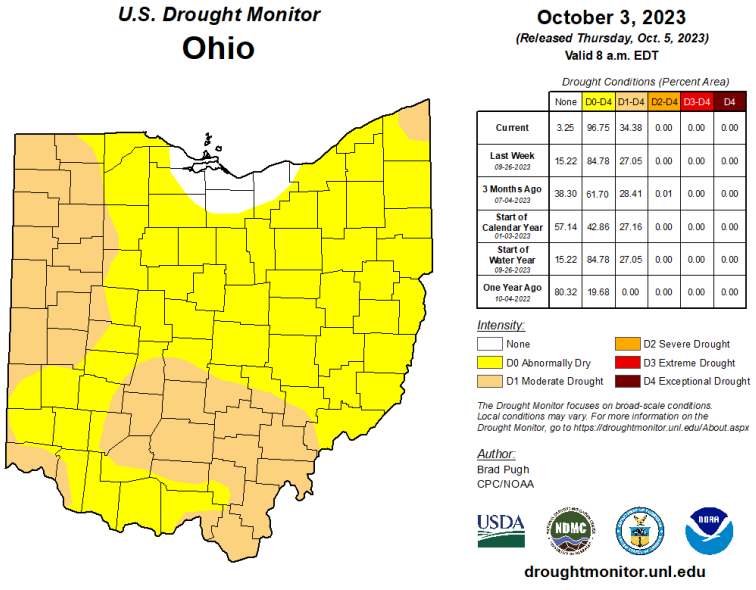


Figure 6 - US Drought Monitor

Measuring Streamflow

Miami Conservancy District, in cooperation with USGS, maintains a network of 24 stream gages equipped with telemetry (see Figure 8). Each stream gage transmits data to the USGS National Water Information System (NWIS). A streamgage records the water level or stage of the river or stream at the gage location. NWIS estimates discharge for a given water level through a rating which is a mathematical relationship between water level and discharge. USGS derives this mathematical relationship from field measurements of discharge across a range of water levels. The stream gage network allows Miami Conservancy District to estimate annual runoff for the Great Miami River Watershed and track storage events at each of the five Miami Conservancy District flood protection dams.

Estimated Runoff & Trends

Nearly all the water leaving the Great Miami River Watershed exits through the processes of evapotranspiration and runoff. Miami Conservancy District does not measure evapotranspiration directly but does measure runoff. Runoff includes all the water that flows across the land and enters streams, as well as water discharged from aquifers into streams.

Miami Conservancy District estimates annual runoff amounts by the following process:

- Determine the average daily flow (ft^3/sec) for the Great Miami River at Hamilton gage for a particular month;
- determine the monthly flow volume of water (ft^3) by multiplying the average daily flow (ft^3/sec) for the month times the number of days in that month using a conversion factor;
- divide the monthly volume of water (ft^3) by the entire watershed area (3,630 mi^2) upstream of the gage using a conversion factor to determine water depth in inches;
- sum the water depths for each month of the year to get total annual runoff in inches.

Estimated runoff for the Great Miami River in 2023 was 11.04 inches. This amount is 5.17 inches less than the 30-year (1991 to 2020) average for the watershed.

Monthly runoff was significantly above average in the month of March. Runoff was below average for all the other months in 2023 (see Figure 9).

Like precipitation, the 30-year average annual runoff is trending upward (see Figure 10). Average annual runoff for the 30-year timespan of 1951 - 1980 was 12.23 inches. For the 30-year timespan of 1991 – 2020 average annual runoff climbed to 16.22 inches showing an increase of 3.99 inches over 40 years.

Flood Storage Events

The five Miami Conservancy District dams have a combined peak storage capacity of 841,000 acre-feet, or about 274 billion gallons of water (see Figure 11).

During times of high precipitation and runoff, the dams reduce downstream flows on the Stillwater, Great Miami, and Mad rivers and on Loramie and Twin creeks. This allows the channels and levees downstream to safely accommodate the river flow. The dams accomplish this by temporarily storing floodwater over the land behind the dams.

A storage event occurs when the pool elevation behind the dam reaches a minimum stage at which the conduits begin to reduce the flow of water downstream of the dam (see Table 1). The storage event continues until the pool elevation drops below that minimum stage. Miami Conservancy District records storage events at each of the dams separately. If all five dams are in storage at the same time, Miami Conservancy District records five storage events.

Construction of the five flood protection dams in the Miami Conservancy District flood protection system was completed by 1922. Since that time, Miami Conservancy District has recorded each of the storage events that have occurred.

Miami Conservancy District recorded a total of 15 storage events during 2023. The average number of annual storage events for the five retention basins, over the entire life of the dams, is 20. None of the storage events that occurred in 2023 were large enough to exceed Miami Conservancy District's top-10 storage event ranking.

Of the 15 storage events that occurred in 2023, 11 events occurred during March, 3 events occurred in April, and 1 event in May (see Figure 12).

The total number of storage events per decade has increased in recent decades (see Figure 13). Miami Conservancy District recorded 175 storage events during the decade of the 1980s. Since that time Miami Conservancy District recorded 242, 273, and 324 storage events respectively during the decades of the 1990s, 2000s, and 2010s.

Groundwater Levels in the Buried Valley Aquifer System

Miami Conservancy District maintains a network of 92 observation wells in the Great Miami River Watershed. Of these wells, 57 are installed in the buried valley aquifer system.

The Ohio Department of Natural Resources (ODNR) Division of Water Resources also supports a network of observation wells in the Great Miami River Watershed system which includes 26 wells.

To track groundwater levels, eight observation wells (6 Miami Conservancy District and 2 ODNR) were selected as index wells for the buried valley aquifer system between the mouth of the Great Miami River and the Dayton region (see Figure 14). An index well is installed in a representative part of the surrounding buried valley aquifer system that can allow for measuring and interpreting hydrologic responses at local scales. Data trends in index wells provide a strong indication of buried valley aquifer responses to changes in human water use as well as shifts in local climate.

The depths of each of the index wells are displayed on Table 2. All the index wells are equipped with vented or non-vented pressure transducers for logging groundwater levels and telemetry. The pressure transducers measure the depth-to-water below ground surface every hour and send the data to NWIS allowing the data to be accessed in near real-time.

Groundwater levels measured at the eight index wells in 2023 ended the year at slightly lower levels than at the beginning of the year (see Figure 15). Average groundwater levels for 2023 were lower in all wells when compared with 2022 averages. The lowest groundwater levels (greatest depths to groundwater) at all but one index well occurred in December. Highest groundwater levels occurred in March or April.

Average annual groundwater levels have been relatively stable over the long term showing an even balance between groundwater recharge and groundwater discharge (see Figure 16).

Water Use in the Great Miami River Watershed

Through its water withdrawal facilities registration program, ODNR tracks water use in the Great Miami River Watershed. The Ohio Revised Code requires any owner of a facility, or combination of facilities, with the capacity to withdraw water at a quantity greater than 100,000 gallons per day (GPD) to register such facilities with the Ohio Department of Natural Resources (ODNR) Division of Water. Water use information for 2023 was not available at the time of this report and so 2022 water use information is reported instead. Given recent water use trends it's likely the differences between 2022 and 2023 water use data are negligible.

In 2022, surface water withdrawals in the Great Miami River Watershed averaged 26 million gallons of water per day. Groundwater withdrawals averaged 231 million gallons of water per day. Groundwater withdrawals make up 90 percent of total water use in the Great Miami River Watershed. Total groundwater withdrawn during 2022 was approximately 84 billion gallons of water. Most of this water was returned to the Great Miami River and its tributaries by discharge from water reclamation facilities.

Water withdrawn by public water suppliers accounted for 73 percent of total groundwater use (see Figure 17). The remaining groundwater withdrawals included industry, miscellaneous (mainly for open loop geothermal systems), mineral extraction, and agricultural irrigation.

Water use trends in the Great Miami River Watershed show total water withdrawals peaked during the decade of the 2000s at around 600 million gallons of water per day (see Figure 18). Since that time, total water withdrawals have declined to approximately 257 million gallons of water per day. Surface water withdrawals declined more than groundwater.

Surface water withdrawals peaked at 261 million gallons of water per day in 2005 and declined to 26 million gallons of water per day in 2022. About 74 percent of this decrease occurred because of the closure of four power-generating stations which used surface water for cooling. Groundwater withdrawals peaked in 2002 at 330 million gallons of water per day. In 2022, groundwater use was down to 231 million gallons of water per day.

Summary

Precipitation delivered to the Great Miami River Watershed in 2023 fell below the 30-year average, while runoff was also below the 30-year average. The Miami Conservancy District flood protection system recorded 15 separate storage events during the year. Average groundwater levels in the buried valley aquifer system were lower in 2023 when compared with 2022. In 2023, groundwater levels in the buried valley aquifer system tended to reach their highest levels in March and dropped to their lowest levels during December.

Average annual precipitation and average annual runoff amounts recorded in the Great Miami River Watershed are trending upward. These upward trends are resulting in an increased number of storage events per decade at the Miami Conservancy District flood protection dams.

Groundwater levels in the buried valley aquifer system are stable over the long term. Water use in the Great Miami River Watershed has declined since the 2000s. Most of the decline was in surface water withdrawals, but groundwater withdrawals have also declined significantly.

Long-term hydrologic trends likely reflect regional climatic shifts coupled with declining water use.

Acknowledgements

This report compiles and summarizes Miami Conservancy District data along with streamflow and runoff data from the U.S. Geological Survey, Water Resources Division, and groundwater level and water use data from the Ohio Department of Natural Resources, Division of Water Resources.

Table 1—Miami Conservancy District Dam storage stages

Dam	Stage Where Storage Begins (ft.)
Germantown	12
Englewood	11.6
Lockington	12
Taylorsville	15
Huffman	11

Table 2—Index Well Depths

Index Well	Well Depth (ft.)
BU-32	234
BU-70	54
BU-179	43
BU-282	74
H-1	124
MT-49	220
MT-73	95
W-10	51

Figure 1 – Great Miami River Watershed, Ohio

Figure 3 - *MCD's observer precipitation stations*

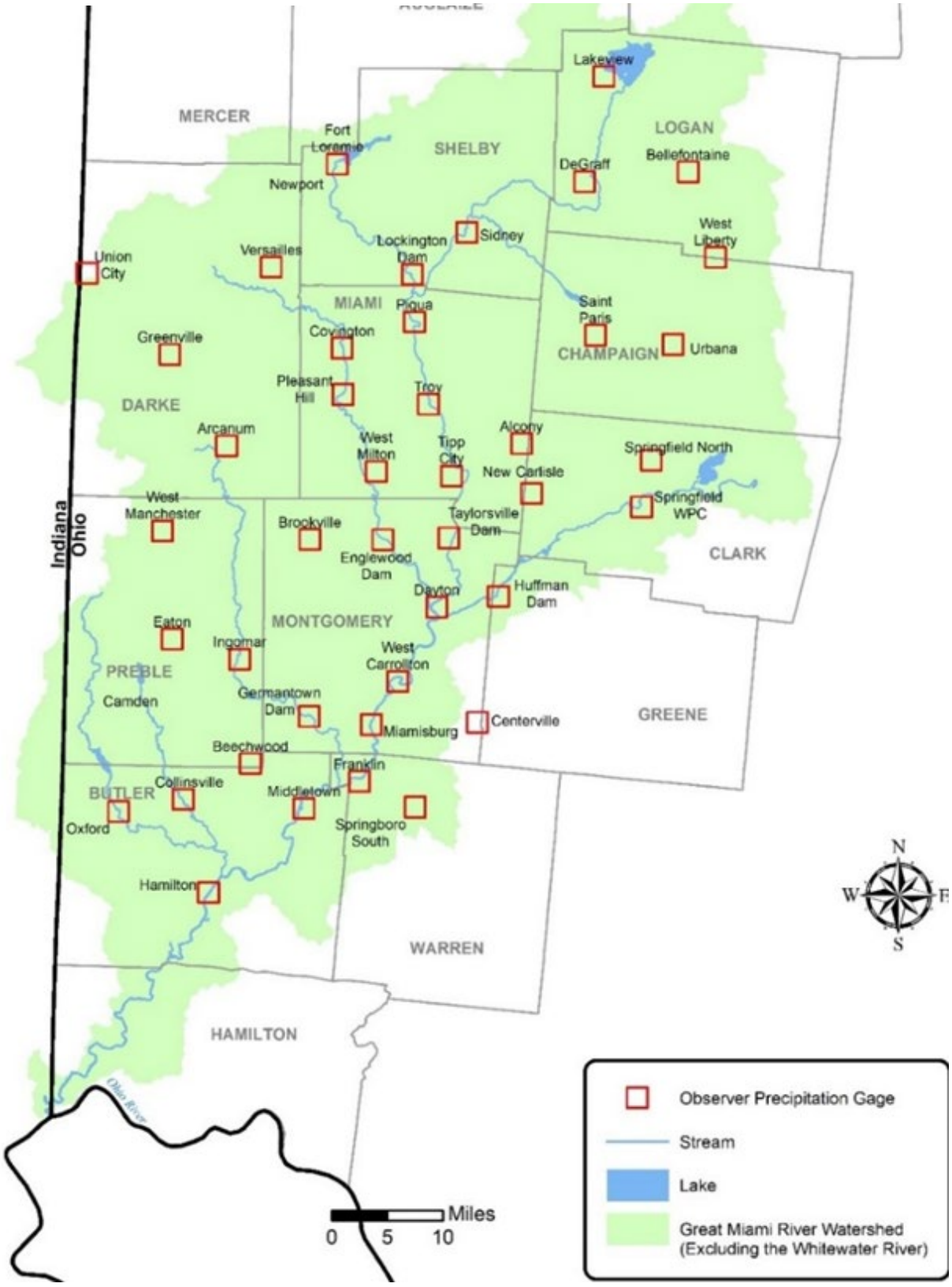


Figure 5 - *Monthly precipitation compared to 30-year averages for the Great Miami River Watershed*

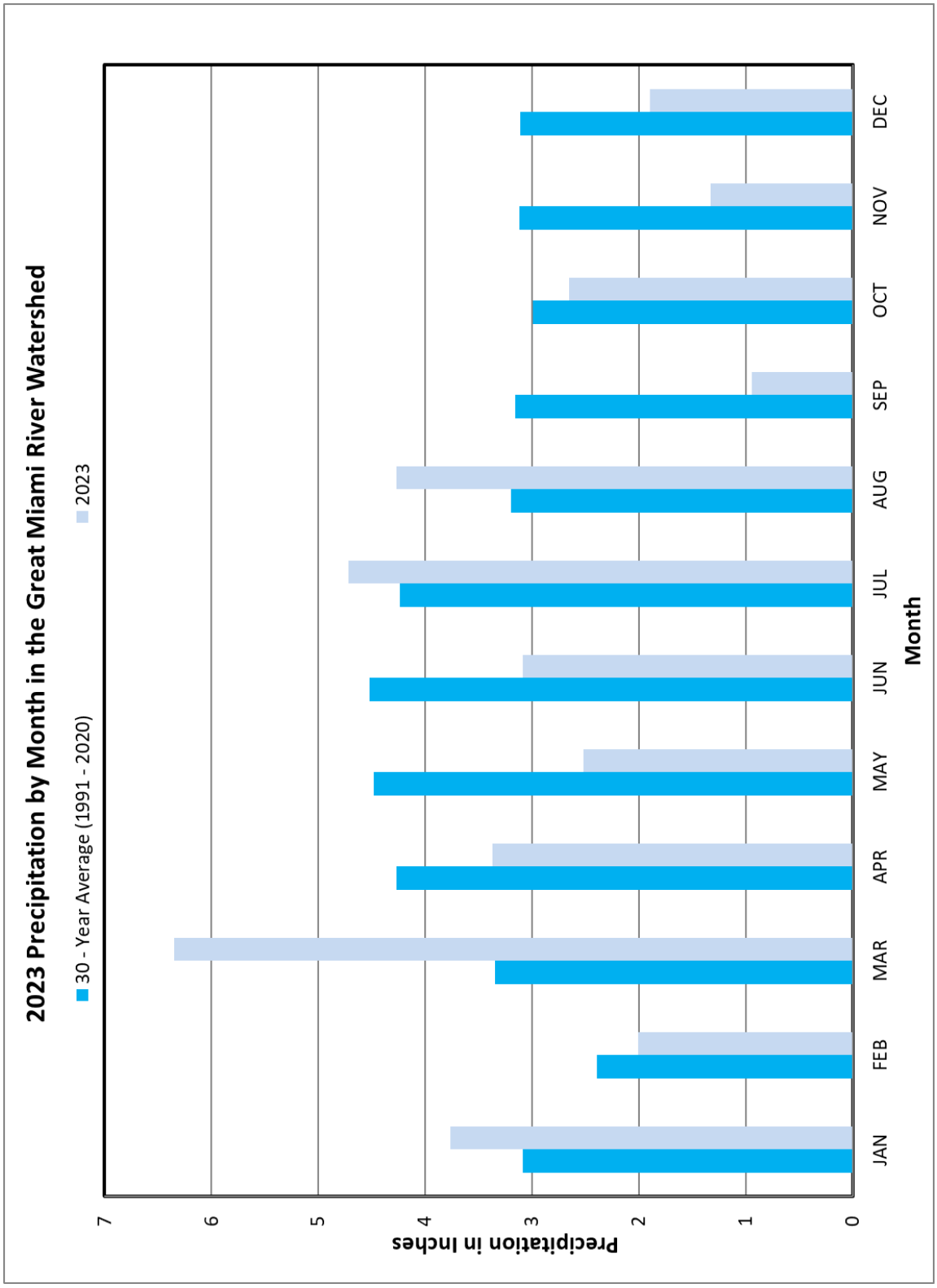


Figure 7 – Moving 30-year mean annual precipitation for the Great Miami River Watershed

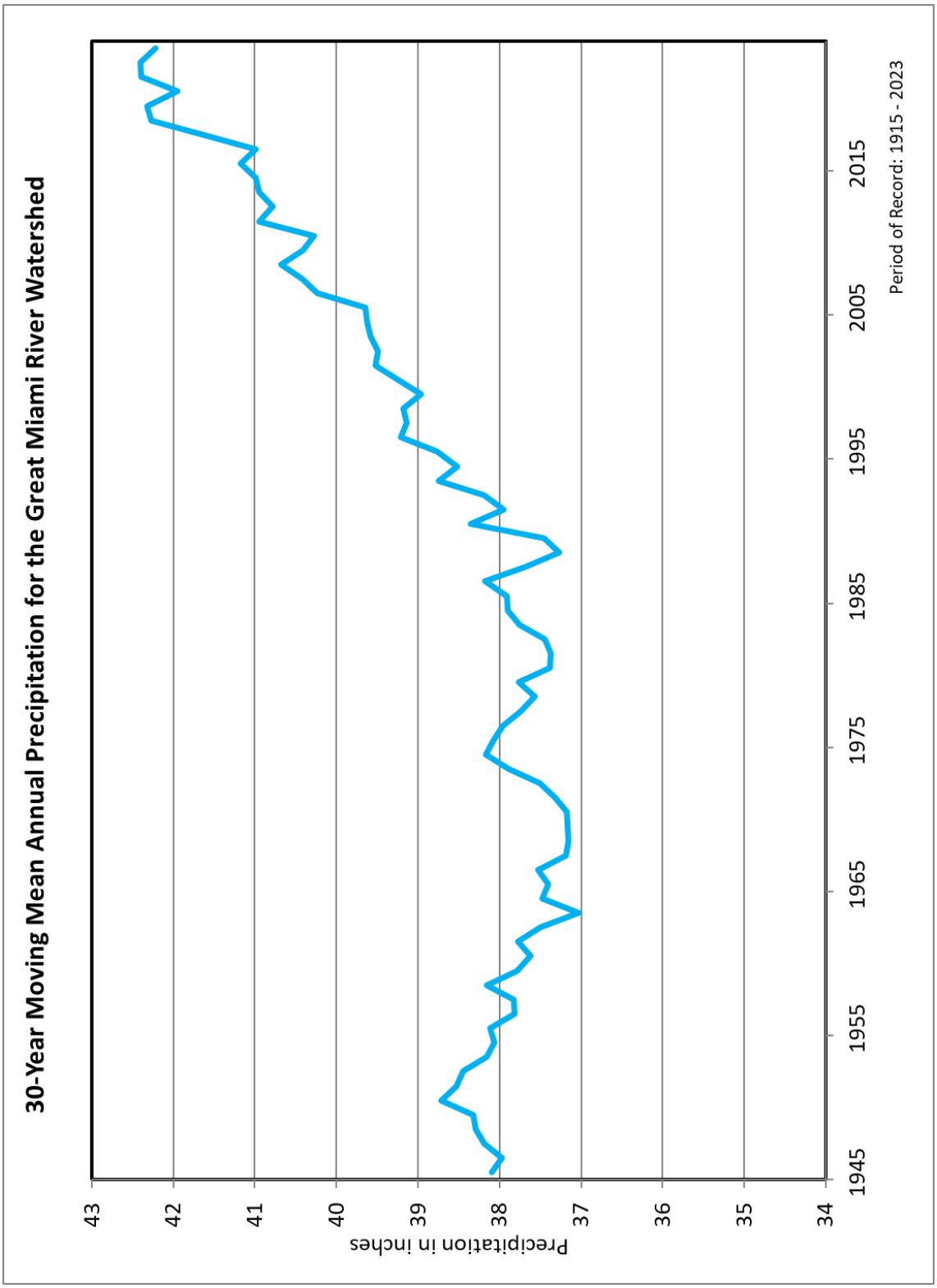


Figure 8 – Location of stream gages

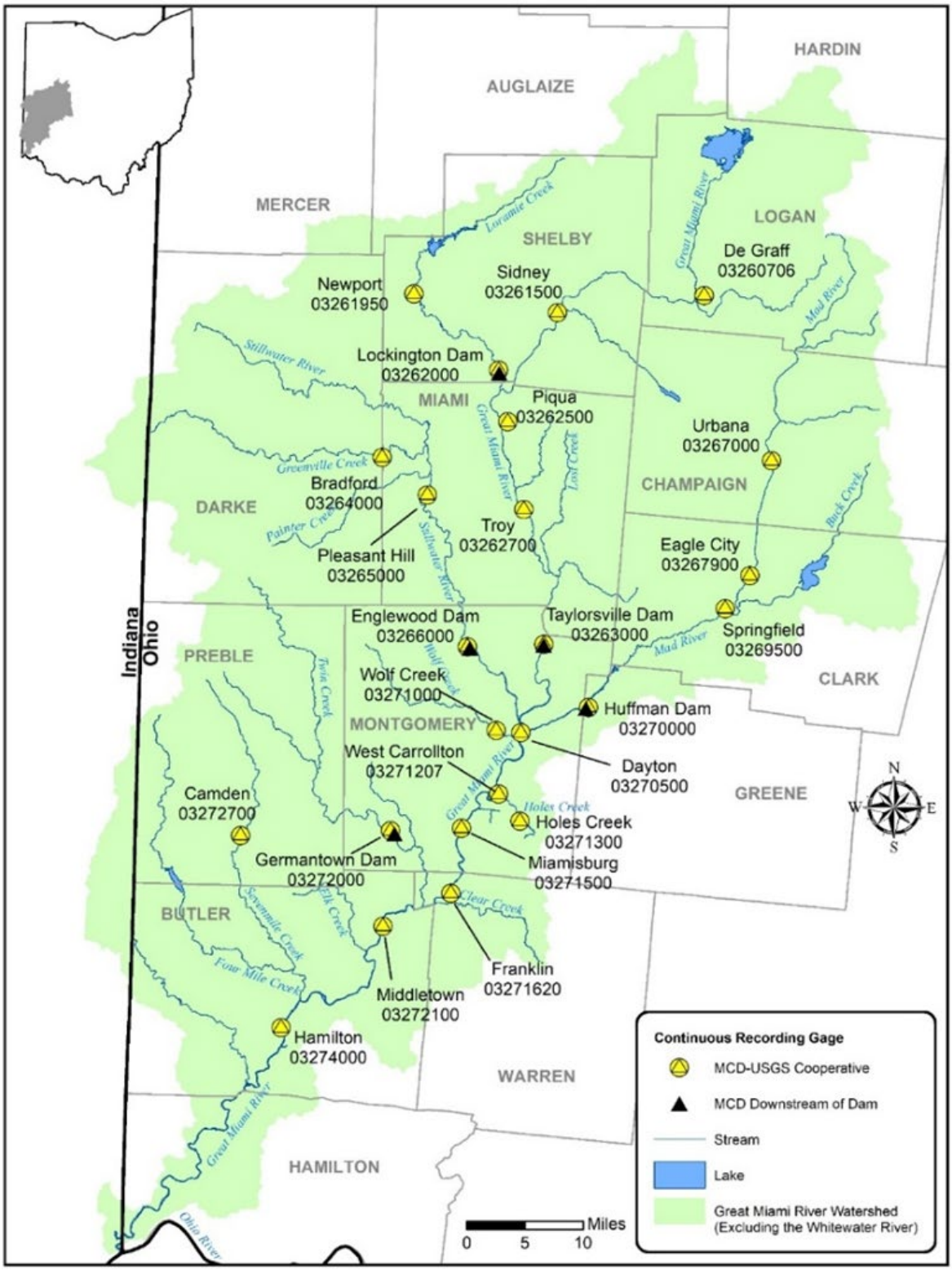


Figure 9 - Monthly runoff compared with 30-year averages for the Great Miami River Watershed

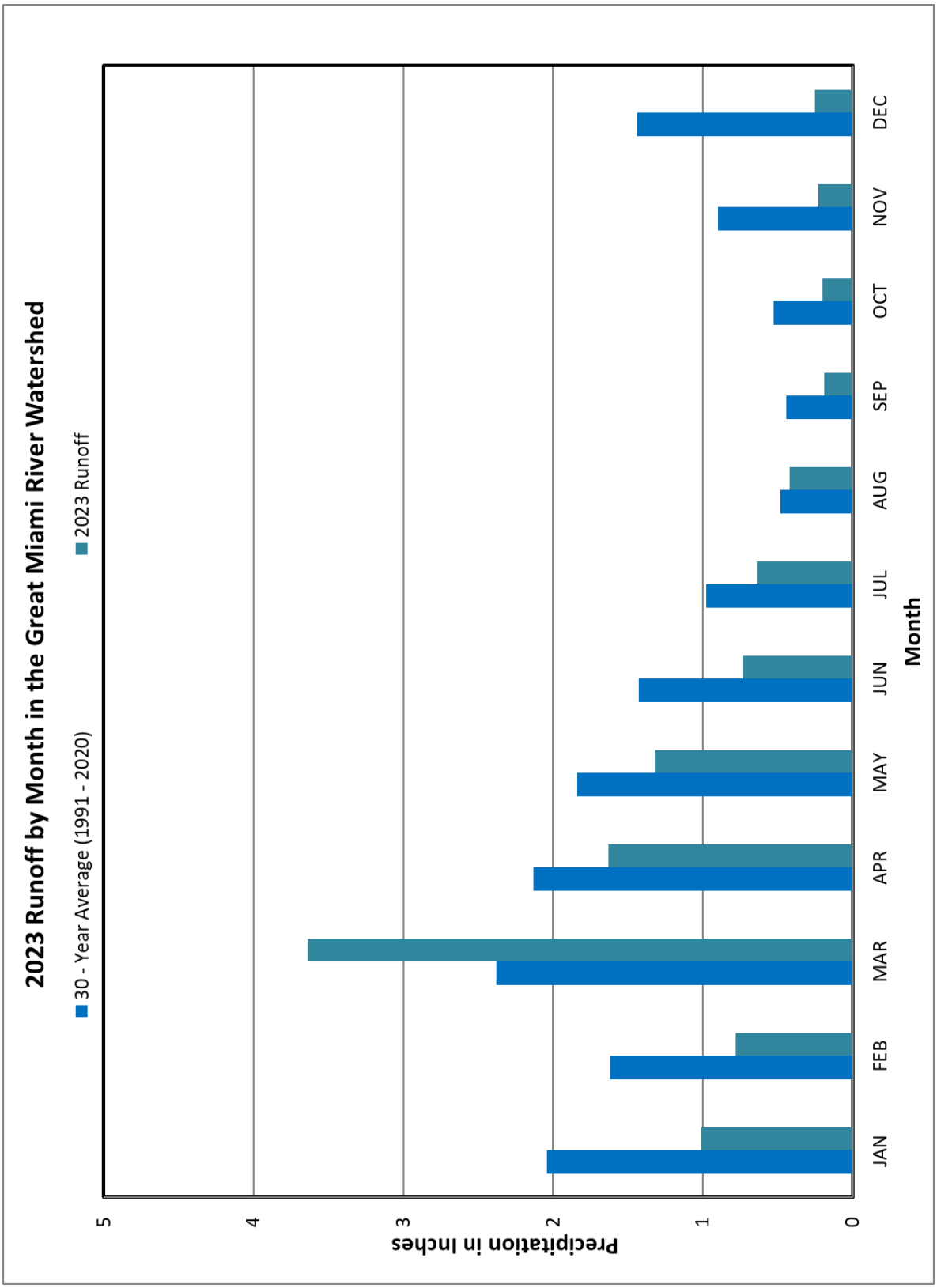


Figure 10 – Moving 30-year mean annual runoff for the Great Miami River Watershed

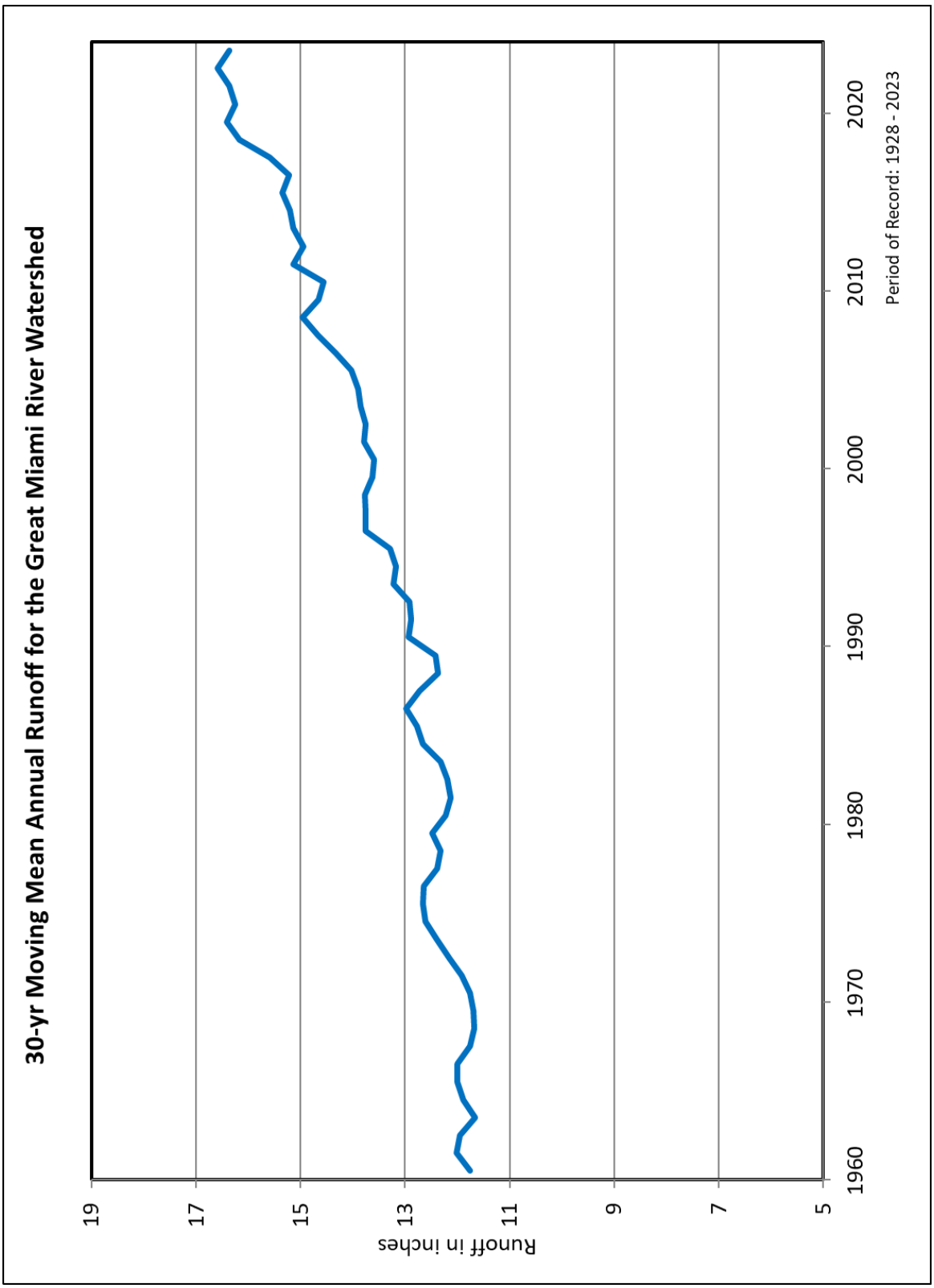


Figure 11 - Map showing locations of Miami Conservancy District flood protection dams, storage basins, and levees

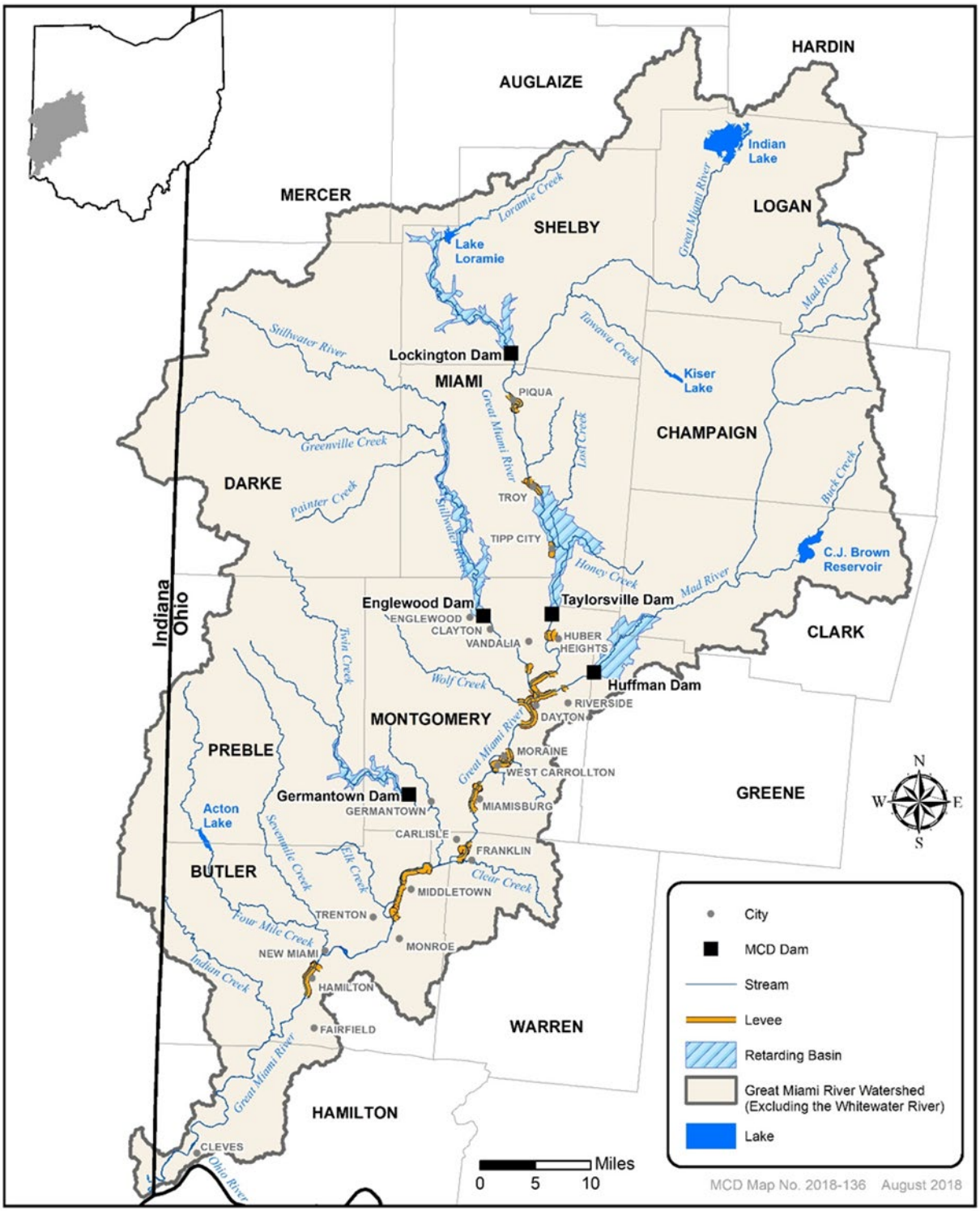


Figure 12 - Number of storage events by month

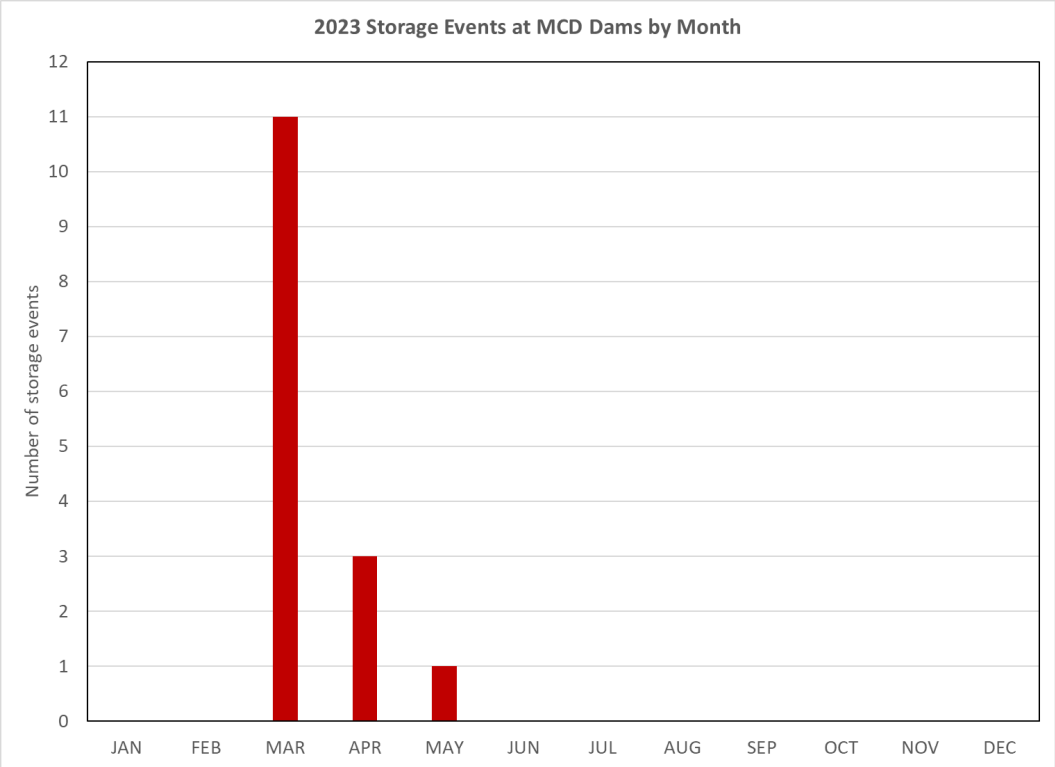


Figure 13 - Number of storage events recorded by Miami Conservancy District for each decade

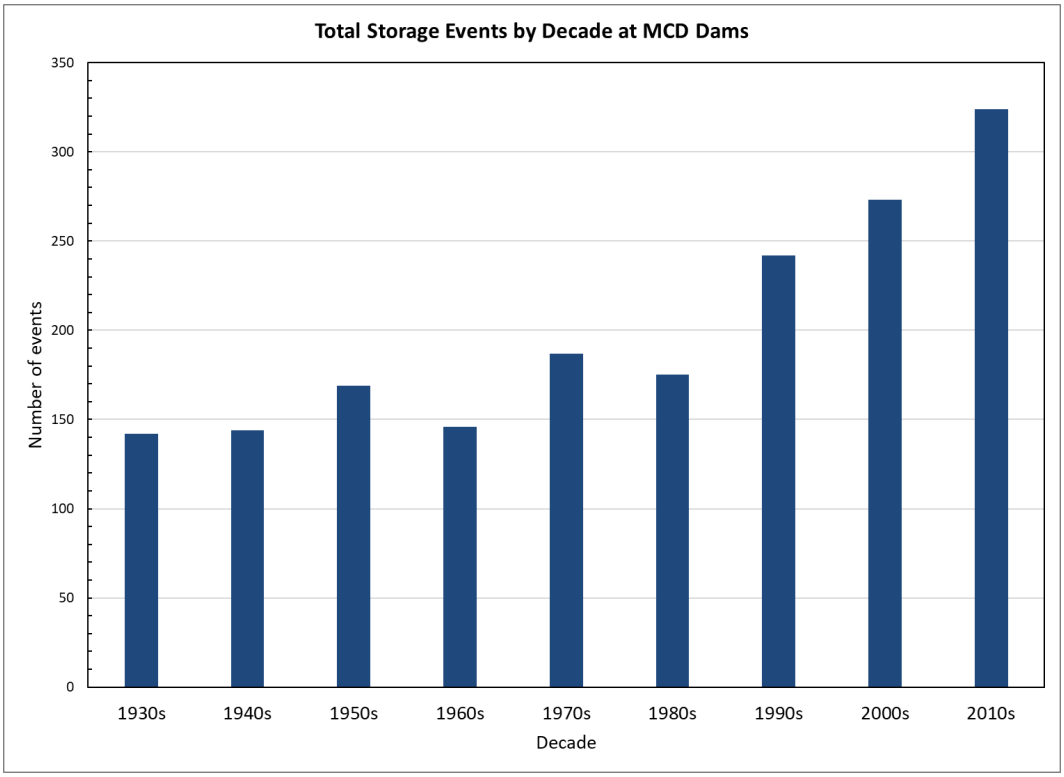


Figure 14 - Map showing Locations of index observation wells

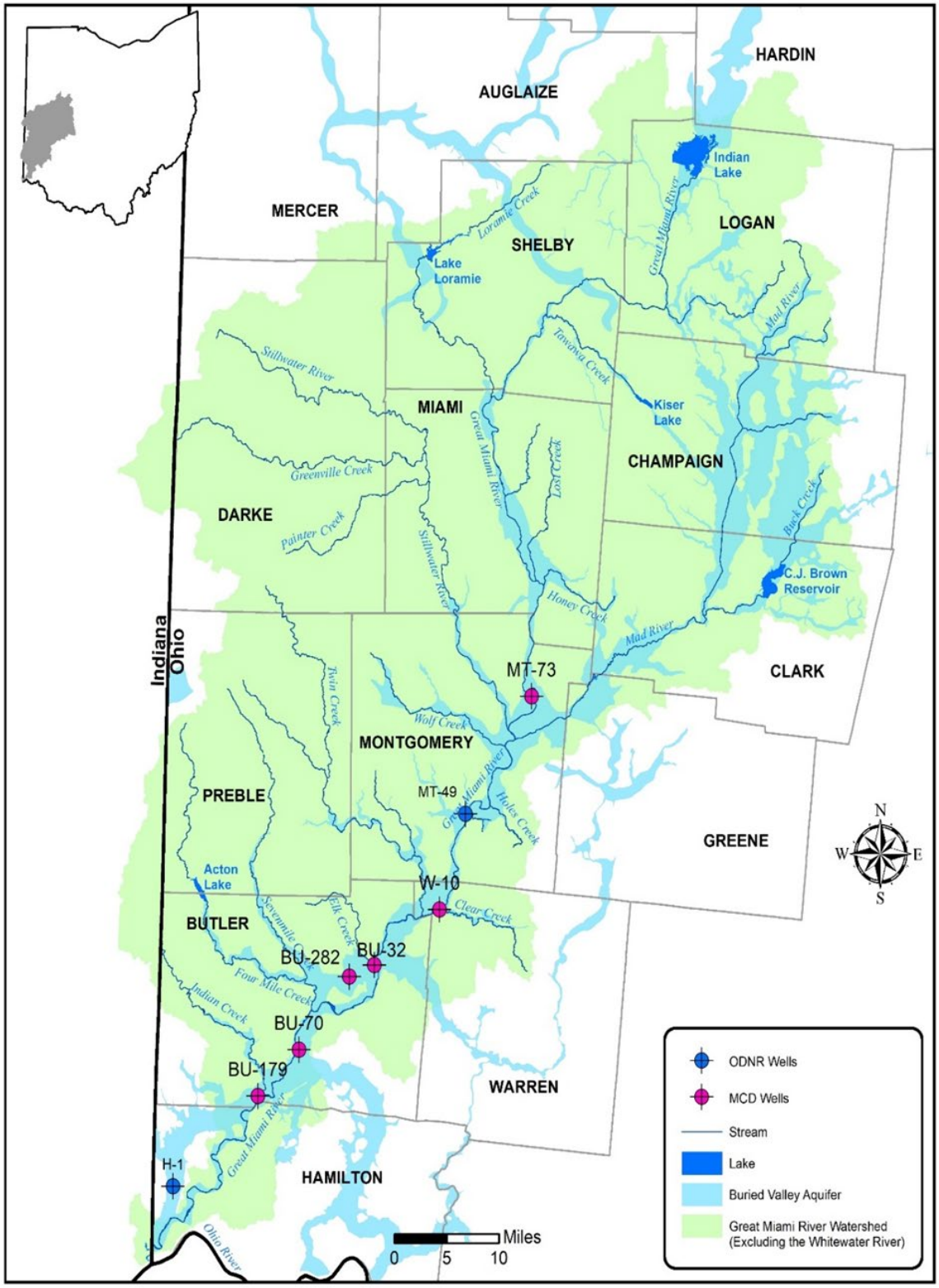


Figure 15 - Depth below ground surface measured at buried valley aquifer observation wells in 2023.

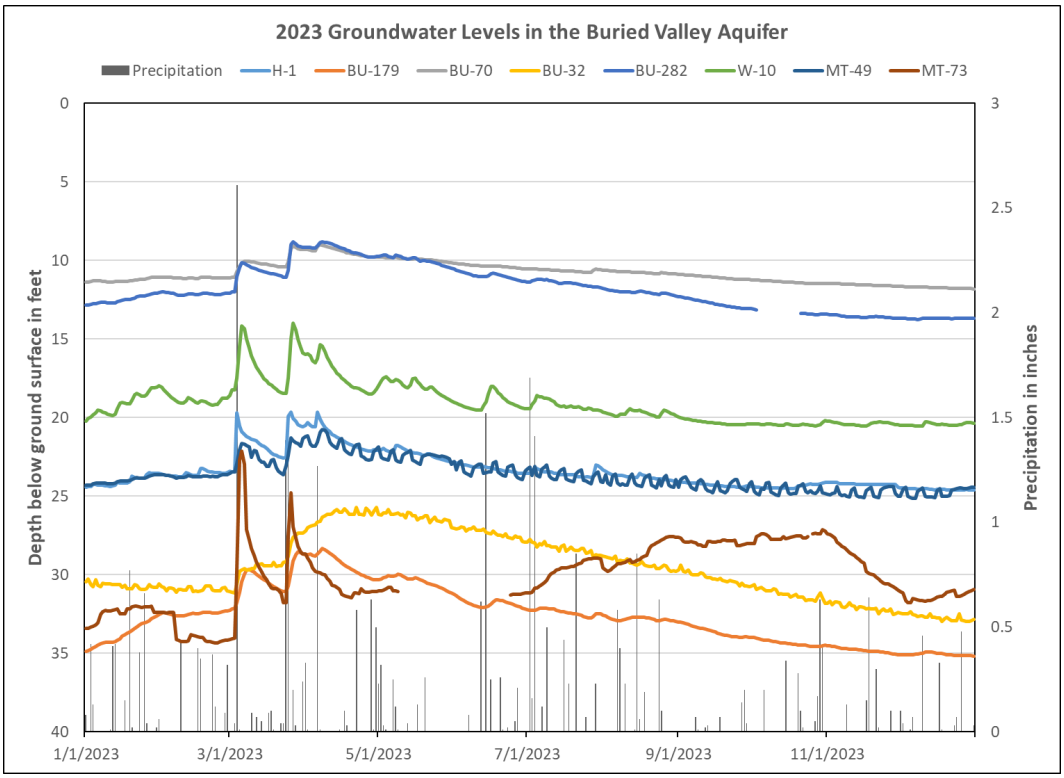


Figure 16 - Average annual depths to groundwater at eight buried valley aquifer observation wells

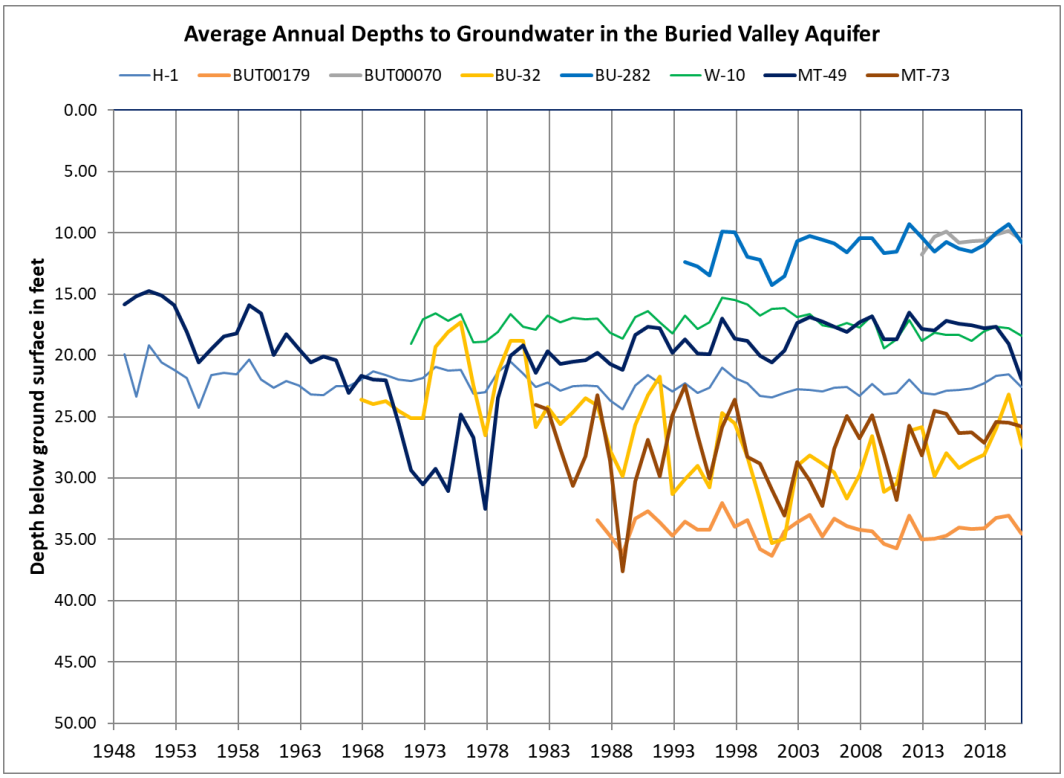


Figure 17 - Groundwater use in the Great Miami River Watershed during the year 2022.

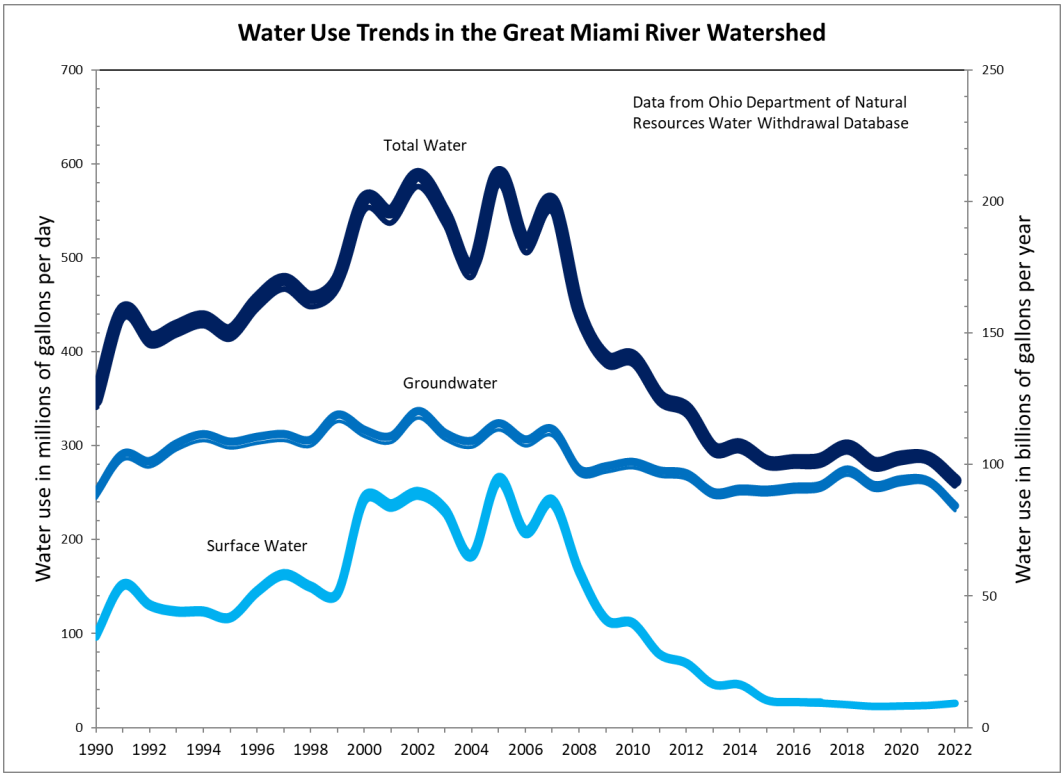
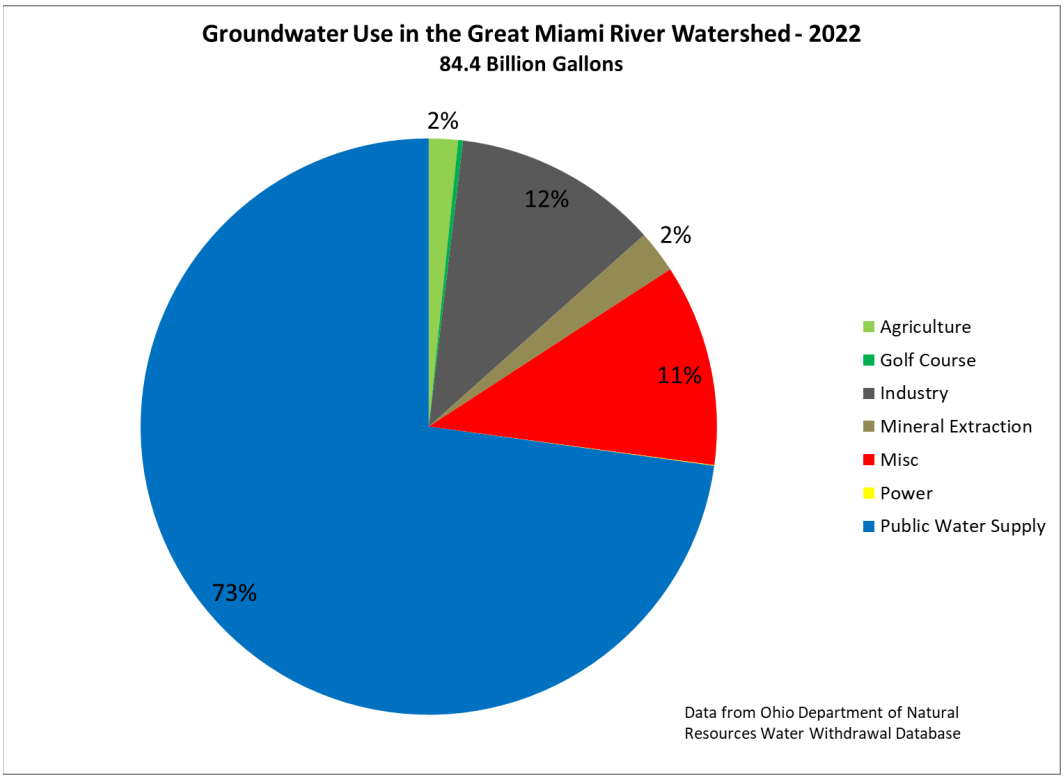


Figure 18 - Total water, surface water, and groundwater withdrawals between 1990 and 2022



Keeping the promise since 1915

The Miami Conservancy District protects communities in southwest Ohio from flooding, preserves water through stewardship, and promotes the enjoyment of our waterways.