MIAMI CONSERVANCY DISTRICT

2022 WATER QUANTITY REPORT
FOR THE GREAT MIAMI RIVER WATERSHED

Abstract

This report is a summary of data collected to track changes in water availability in the Great Miami River Watershed. MCD uses precipitation, runoff, and groundwater levels to estimate water inflows and outflows for an area of more than 3,630 square miles.

The MCD flood protection system recorded a total of 42 storage events during 2022. The average number of annual storage events for the five retention basins, over the entire life of the system, is 20. None of the storage events that occurred in 2022 were large enough to exceed MCD's top-10 storage event ranking.

The average annual precipitation recorded in the Great Miami River Watershed during 2022 was 40.16 inches. This amount was 1.76 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 2022 was 17.94 inches. This amount was 1.73 inches above 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 increasing.

Groundwater levels measured in 2022 ended the year at or close to the levels measured during 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 are stable. These trends reflect climatic variability coupled with declining water use.

FRONT COVER: MCD staff member, Krystal Lacy, measuring streamflow using an acoustic Doppler current profiler (ADCP) on the Stillwater River at Englewood Dam in Montgomery County, Ohio

CONTENTS

BACKGROUND

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

To track water quality and quantity conditions, MCD operates automated and observer precipitation stations as well as extensive stream gaging and observation well networks to record precipitation, streamflow, and groundwater levels.

MCD has operated the stream gaging network with the U.S. Geological Survey (USGS) under a cooperative agreement since 1931.

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

Great Miami River Watershed

Figure 1 – Great Miami River Watershed, Ohio

TRACKING WATER QUANTITY

Changes in water availability - including precipitation, runoff, and groundwater level data – are tracked through a partnership between MCD, USGS, and a network of citizen observers.

The data is used to estimate 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 analyses 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.

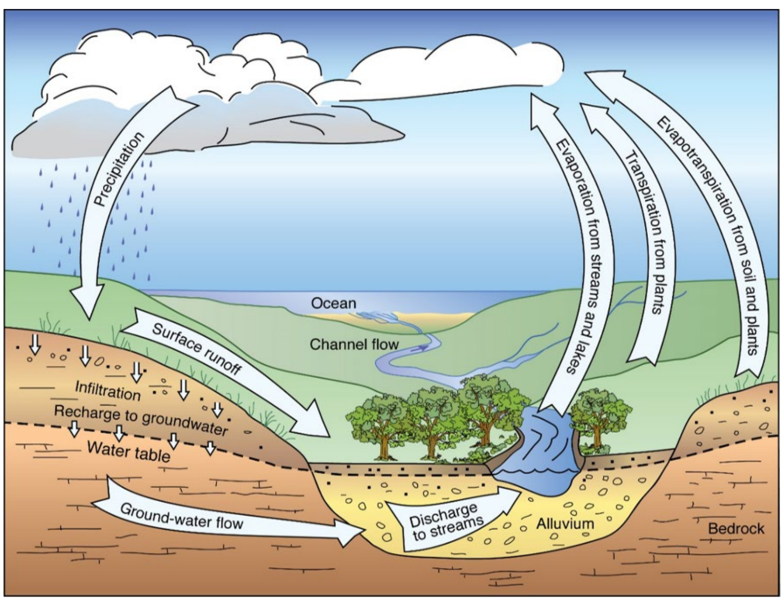


Figure 2 - Water Cycle

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.

As a result, some 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, MCD maintains a network of 42 stations staffed by citizen observers who record daily precipitation (see figure 3).

They read the amounts collected at standard National Weather Service rain and snow gages (see figure 4) and send the readings to MCD via mail or electronic submittal.

MCD uses the data to calculate annual precipitation for the watershed by averaging annual precipitation totals measured at each of the stations.

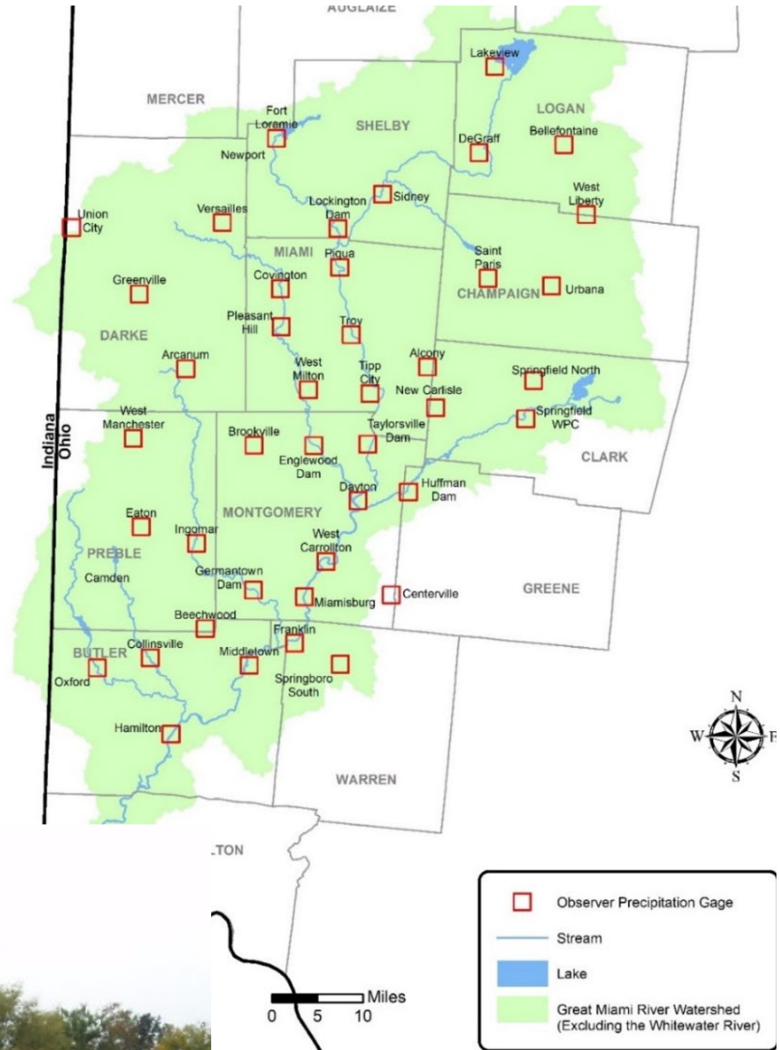


Figure 3 - *MCD's observer precipitation stations*

Figure 4 - A citizen observer standing to the right of a standard rain gage. The gage on his left is a drum recorder station that has been used since the 1970s. It uses a paper chart and has been kept running with borrowed parts.

ANNUAL PRECIPITATION TRENDS

The average annual precipitation recorded by MCD during 2022 was 40.16 inches.

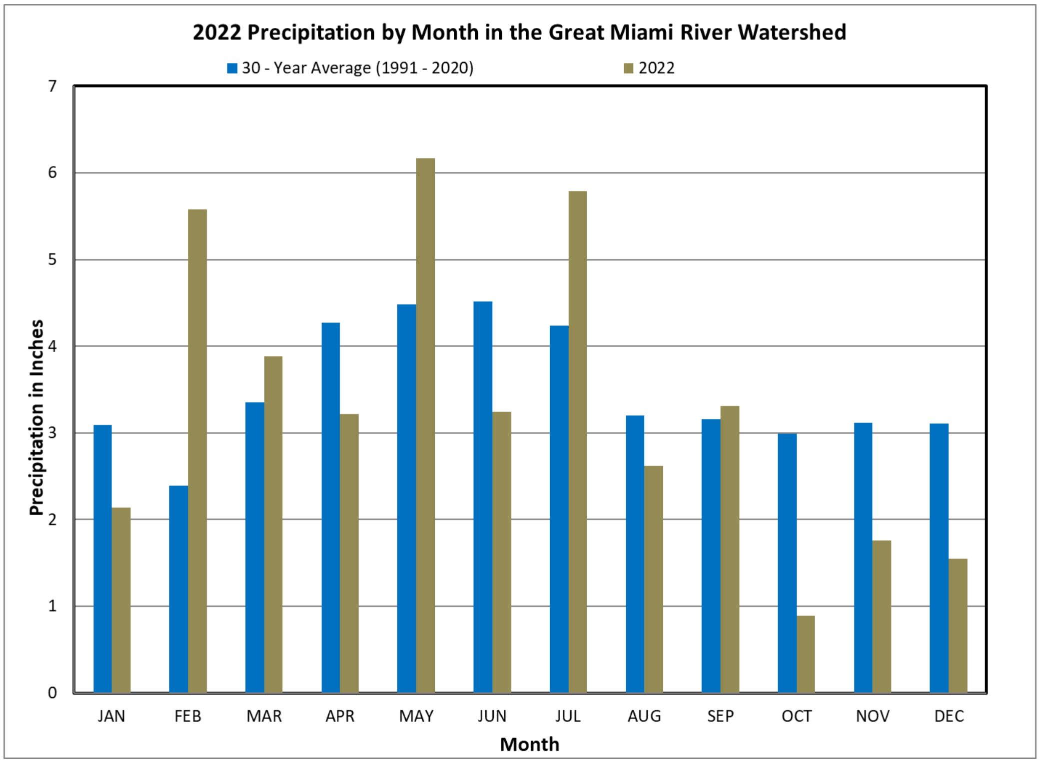


Figure 5 - *Monthly precipitation compared to 30-year averages for the Great Miami River Watershed in 2022.*

Monthly precipitation in the Great Miami River Watershed was above average during the months of February, March, May, July, and September (see Figure 5). May recorded the highest monthly precipitation total in 2022 at 6.17 inches. Below average precipitation occurred in January, April, June, August, October, November, and December. October recorded the lowest precipitation total in 2022 at 0.89 inches.

The highest annual total precipitation amount of 49.75 inches was recorded at MCD's Springfield North observer station, while the lowest amount of 34.03 inches was recorded at the Versailles observer station.

Drought conditions began to take hold in early October based on U.S. Drought Monitor assessments (see Figure 6). By late October moderate drought conditions existed across the entire watershed and remained throughout the rest of the year.

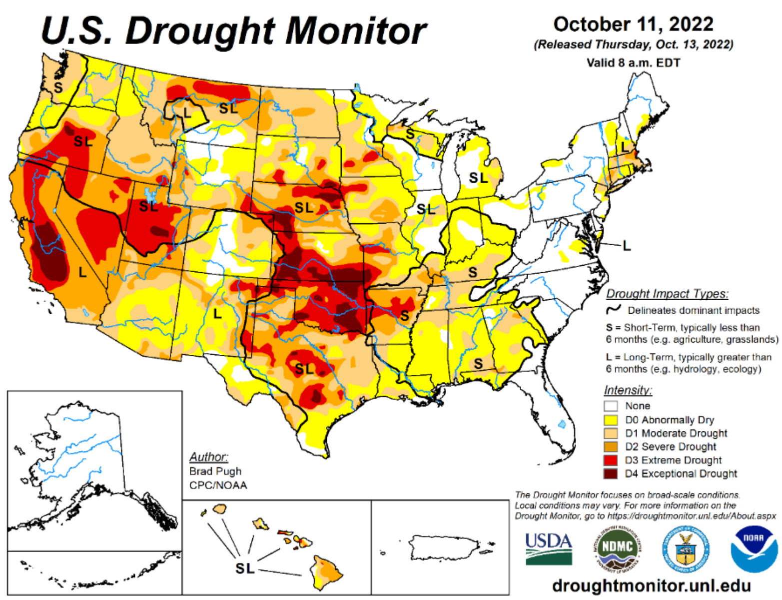


Figure 6 - US Drought Monitor

Despite the below-average amount of precipitation recorded for 2022, the average annual precipitation is still trending upward (see Figure 7).

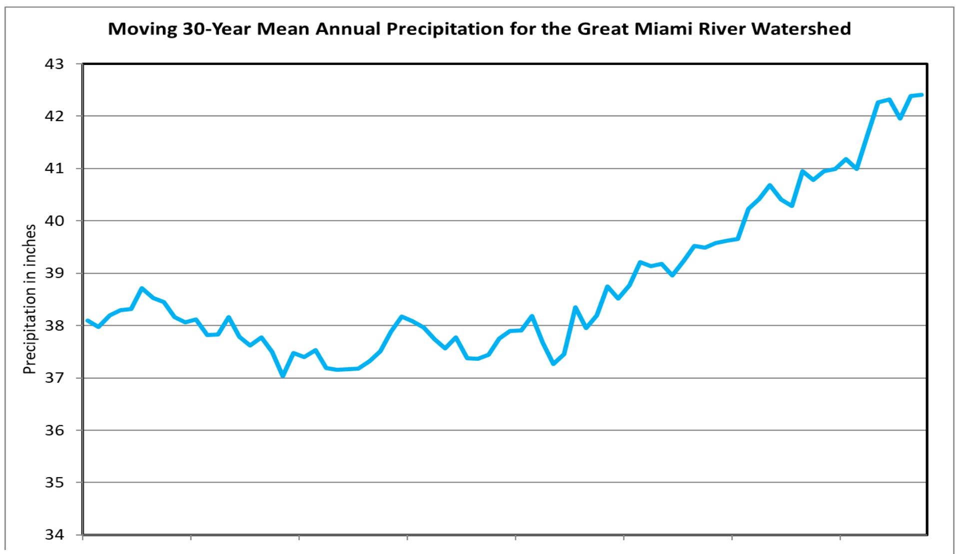


Figure 7 - Monthly precipitation compared to 30-year averages for the Great Miami River Watershed in 2022

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.

> "…average annual precipitation is trending upward in the Great Miami River Watershed".

MEASURING STREAMFLOW

MCD, 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).

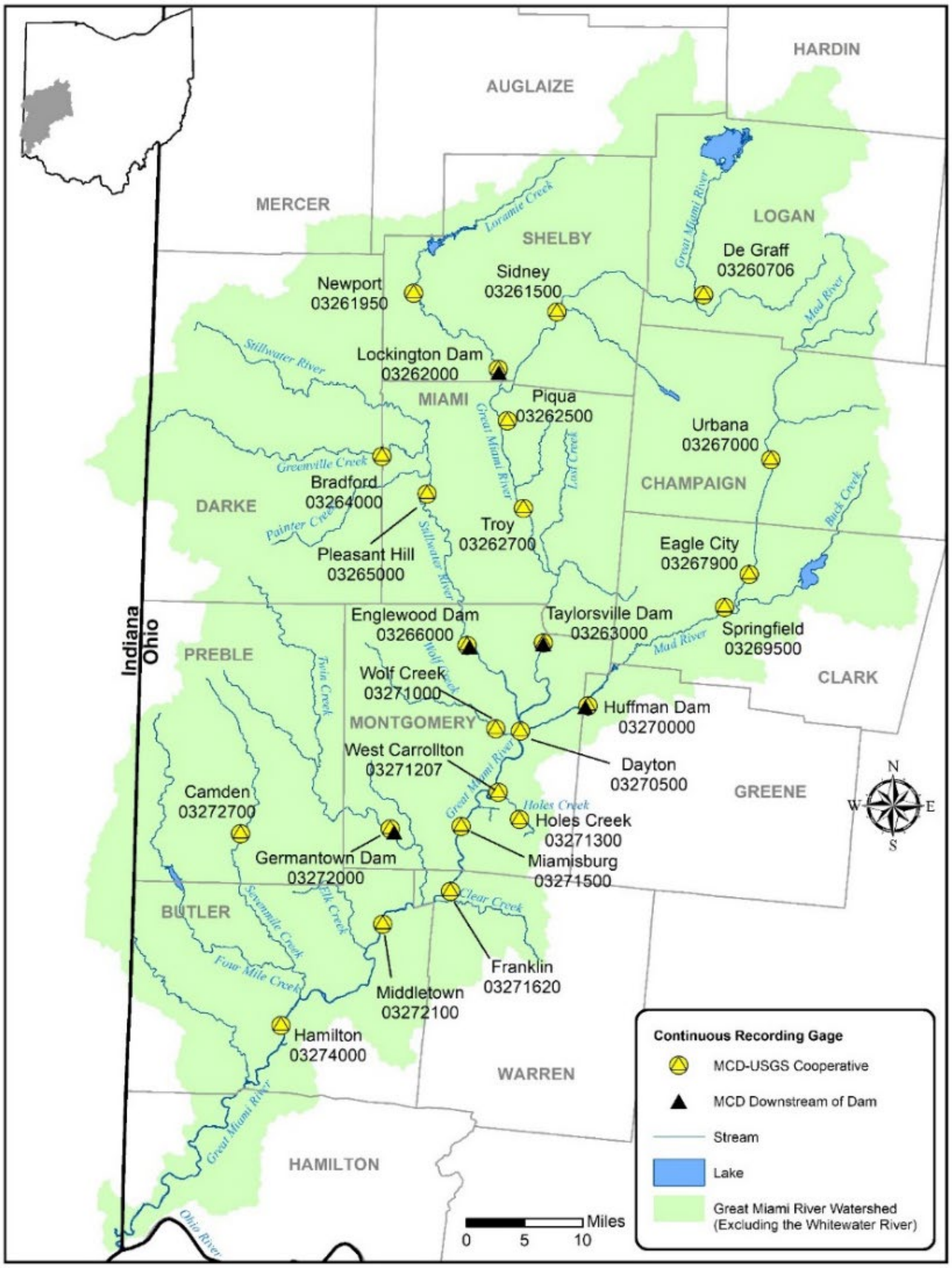


Figure 8 – Location of stream gages.

Annual Runoff Trends

Estimated runoff for the Great Miami River in 2022 was 17.94 inches. This amount was 1.72 inches more than the 30-year (1991 to 2020) average for the watershed.

Like recorded precipitation, monthly runoff amounts were significantly above average in the months of February, March, and May, and significantly below average in October, November, and December of 2022 (see Figure 9).

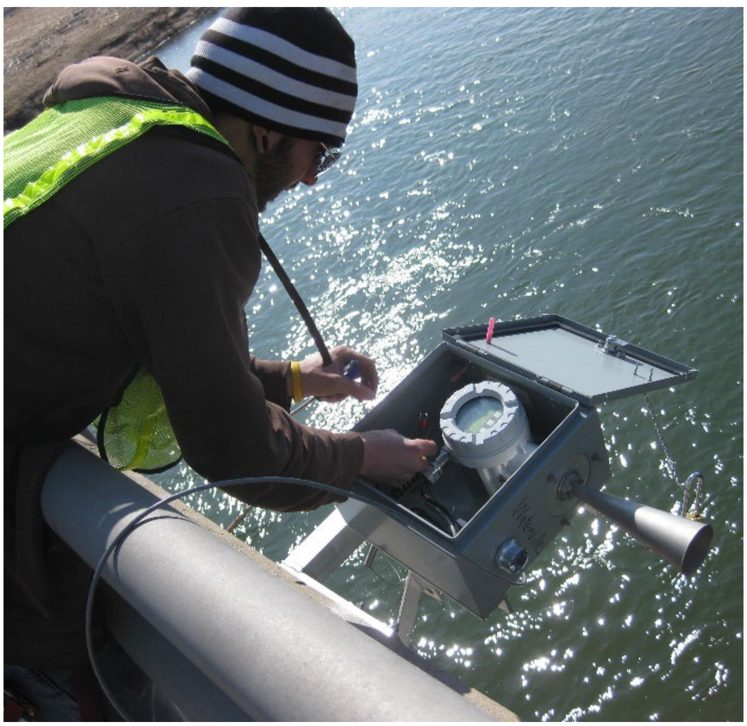


Figure 8 - MCD measures runoff using a network of stream gages.

Measuring Runoff

Nearly all the water leaving the Great Miami River Watershed exits through the processes of evapotranspiration and runoff. MCD does not measure evapotranspiration directly, but it 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.

MCD estimates annual runoff amounts by the following process:

- Sum the volume of water that flows past the Great Miami River at Hamilton gage for the year;
- apply the volume of water over the entire watershed area (3,630 mi^2) upstream of the gage;
- determine the water depth in inches.

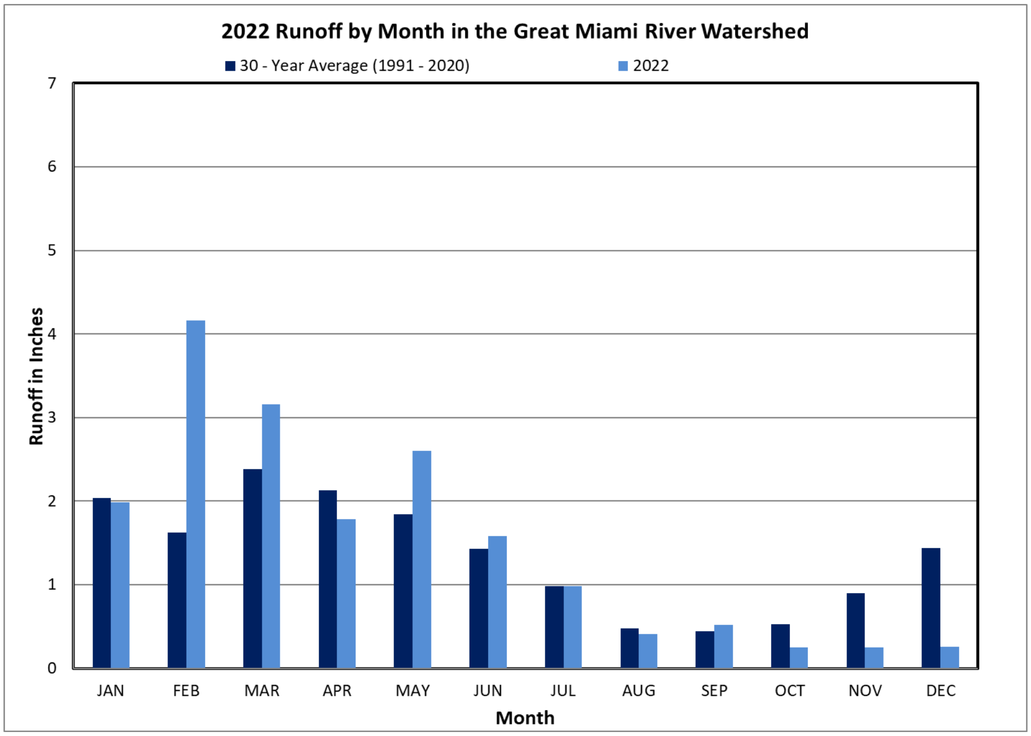


Figure 9 - Monthly runoff compared with 30-year averages for the Great Miami River Watershed in 2022.

Also, 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.

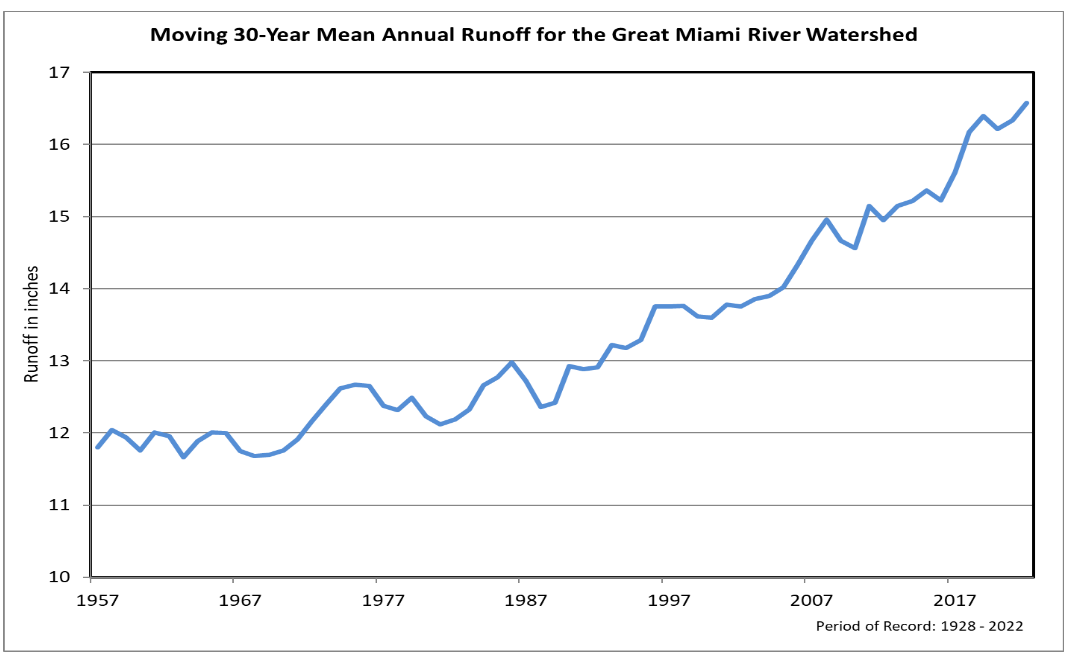


Figure 10 - Plot showing the moving 30-year mean runoff for the Great Miami River Watershed.

Flood Storage Events at MCD Dams

MCD recorded a total of 42 storage events during 2022. 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 2022 were large enough to exceed MCD's top-10 storage event ranking.

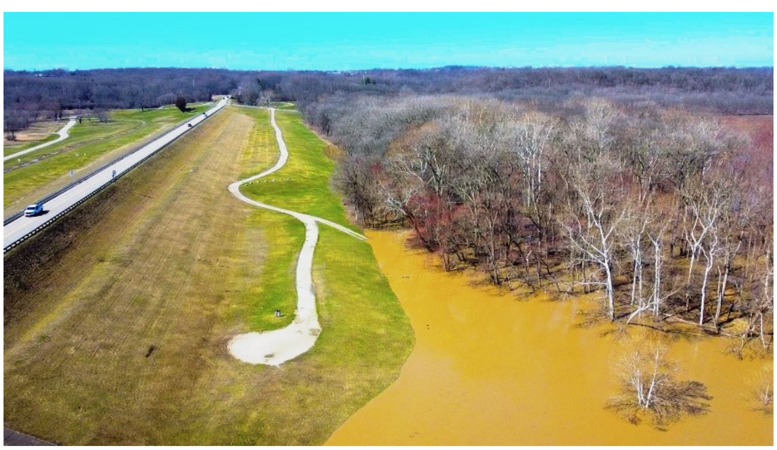
Of the 42 storage events that occurred in 2022, 13 events occurred during April, 9 events occurred in May, and 6 events in March (see Figure 12).

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

Table 1—MCD Dam storage stages

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

The total number of storage events per decade has increased in recent decades (see Figure 13). MCD recorded 175 storage events during the decade of the 1980s. Since that time MCD recorded 242, 273, and 324 storage events respectively during the decades of the 1990s, 2000s, and 2010s. Taylorsville Dam storing floodwaters pictured below.



STORING FLOODWATER

The five MCD 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 accommodate the river flow without being overtopped.

The dams accomplish this by temporarily storing floodwater in the land behind the dams.

A *floodwater storage event* is recorded when the pool elevation 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. Storage events at each of the dams are recorded separately. So, if all five dams are in storage at the same time, it is counted as five storage events.

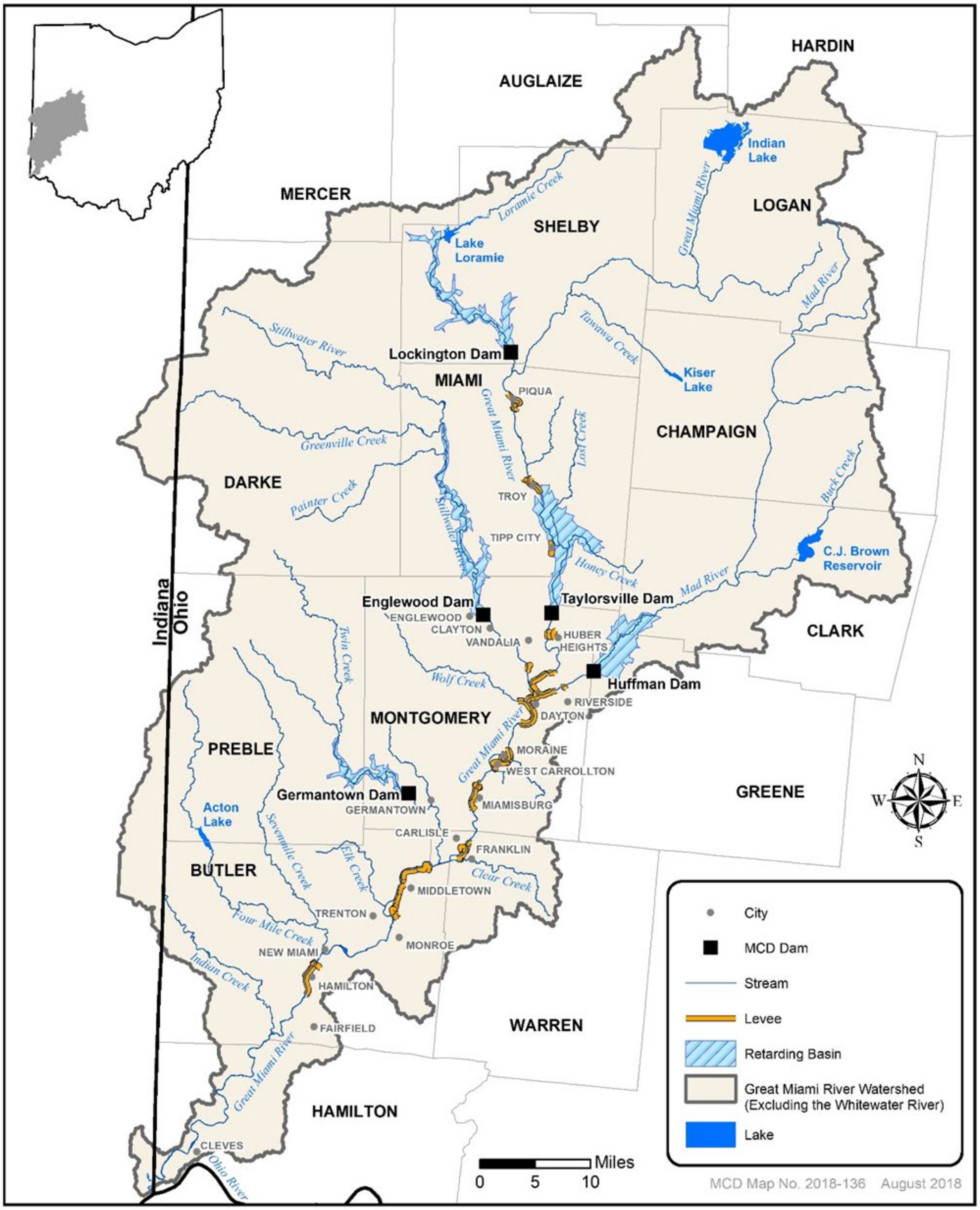


Figure 11 - Map showing locations of MCD flood protection dams, retention basins, and levees.

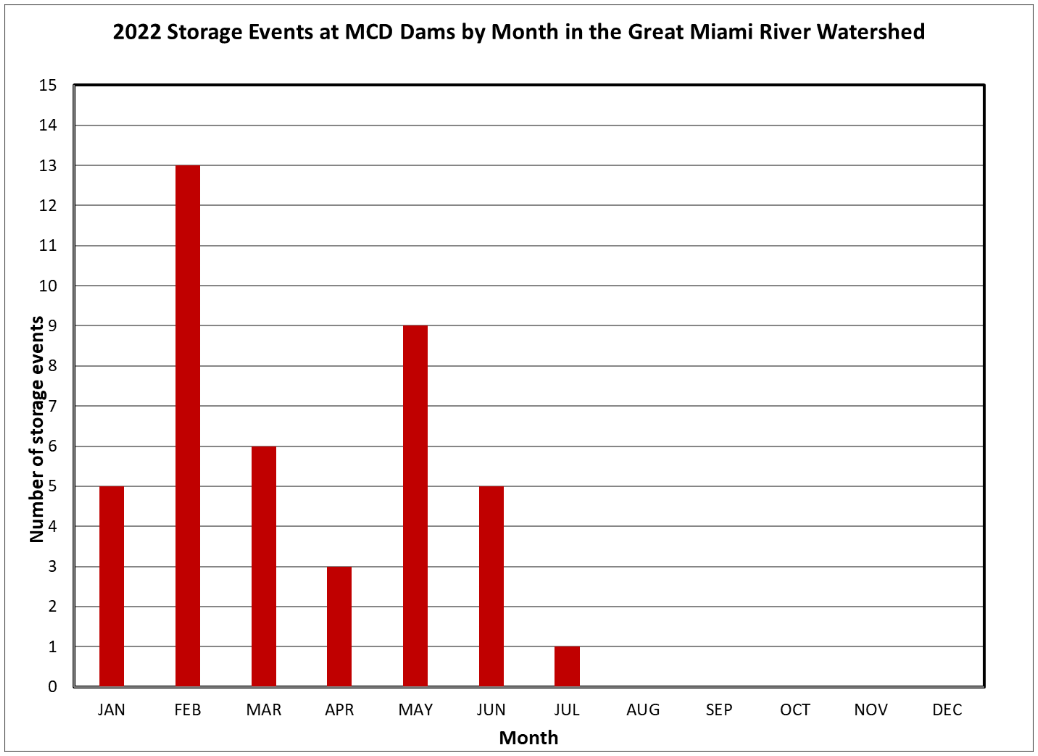


Figure 12 - Number of storage events by month in 2022.

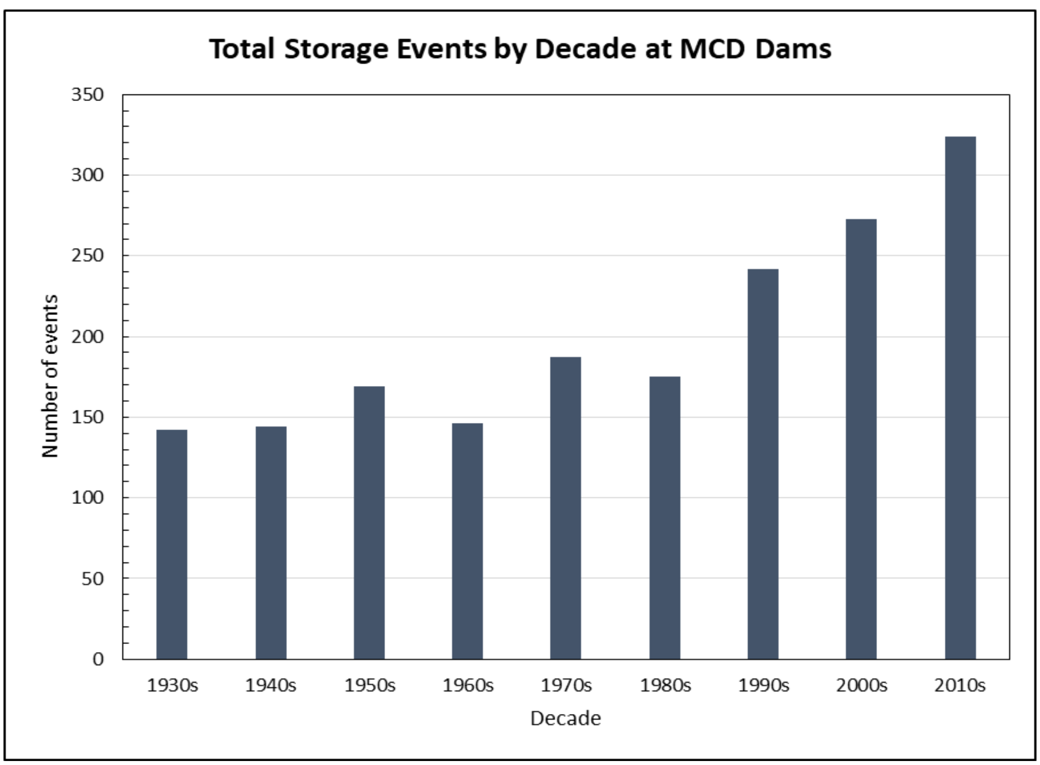


Figure 13 - Number of storage events recorded by MCD for each decade.

GROUNDWATER LEVELS IN THE BURIED VALLEY AQUIFER SYSTEM

MCD selected eight observation wells (6 MCD and 2 ODNR) 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 a well installed in a representative portion 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.

Table 3 displays the depths of each of the index wells. All the index wells are equipped with loggers and telemetry. The loggers measure the depth-to-water below ground surface every hour and transmit the data to NWIS allowing the data to be accessed in near real-time.

Groundwater levels measured at the eight index wells in 2022 ended the year at slightly lower levels than at the beginning of the year (see Figure 15). The lowest groundwater levels (greatest depths to groundwater) at all but one index well occurred in December. Highest groundwater levels occurred in March or May.

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).

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

MCD 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 maintains a network of observation wells in the Great Miami River Watershed system which includes 26 wells.

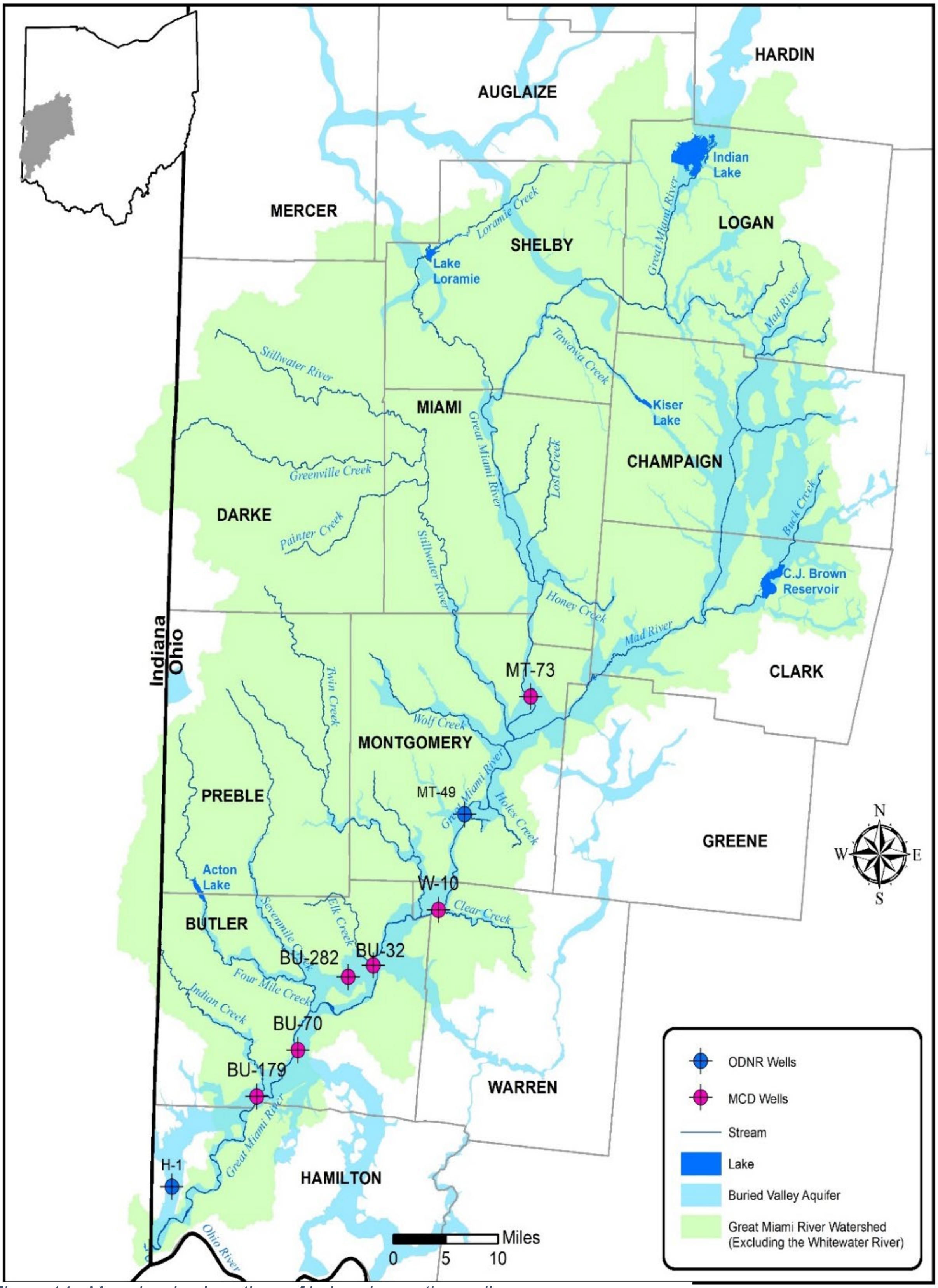


Figure 14 - Map showing Locations of index observation wells

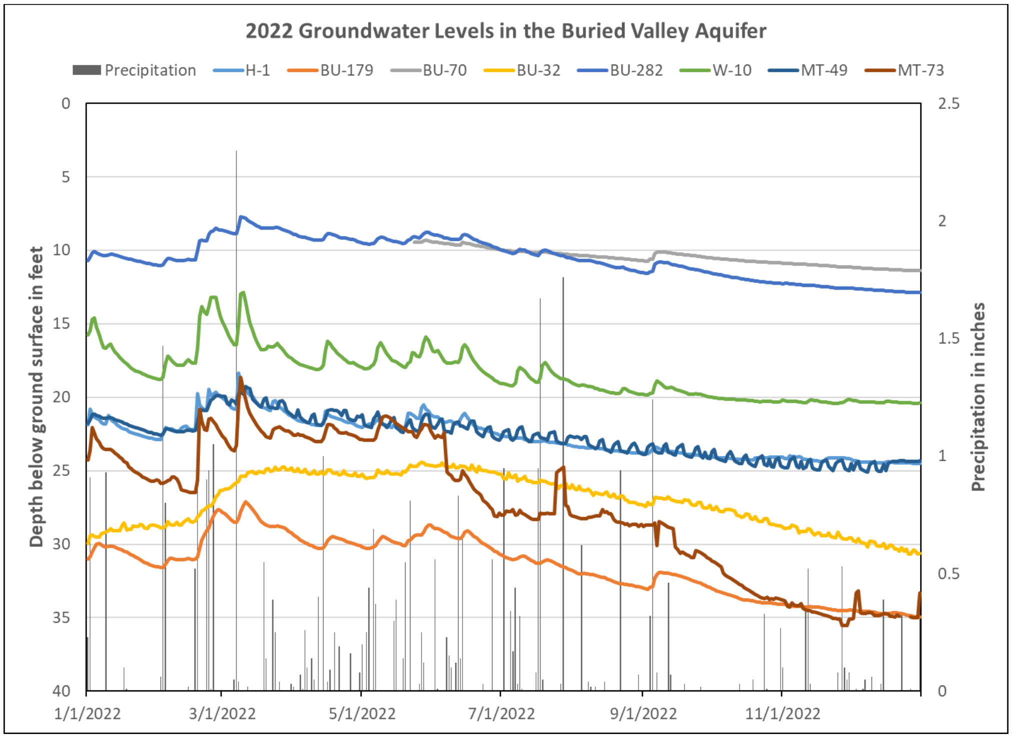


Figure 15 - Depth below ground surface measured at eight buried valley aquifer observation wells in 2022.

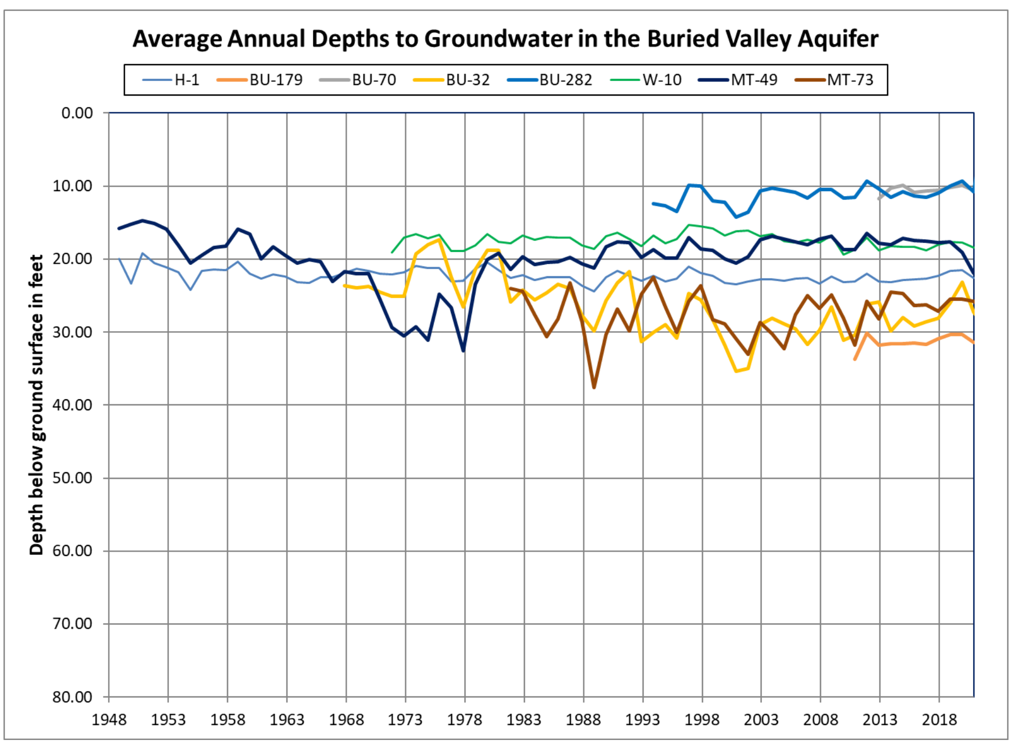


Figure 16 - Average annual depths to groundwater at eight buried valley aquifer observation wells.

WATER USE IN THE GREAT MIAMI RIVER WATERSHED

Through its water withdrawal facilities registration program, the ODNR records water usage that occurs in the Great Miami River Watershed. The program requires all water users who have the capacity to withdraw more than 100,000 gallons of water daily to register their facility. Water use information for 2022 was not available at the time of this report and so 2021 water use information is reported instead. Given recent water use trends it's likely the differences between 2021 and 2022 water use data are negligible.

In 2021, surface water withdrawals in the Great Miami River Watershed average 23 million gallons of water per day. Groundwater withdrawals averaged 259 million gallons of water per day. Groundwater withdrawals comprise 92 percent of total water use in the Great Miami River Watershed. Total groundwater withdrawn during 2021 was 94 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 comprised about 75 percent of total groundwater use (see Figure 17). The remaining groundwater withdrawals were by 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 a little over 300 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 23 million gallons of water per day in 2020. Most of this decrease occurred because of the closure of two power-generating stations which used surface water for cooling. Groundwater withdrawals peaked in 2002 at 330 million gallons of water per day. In 2021, groundwater use was down to 259 million gallons of water per day.

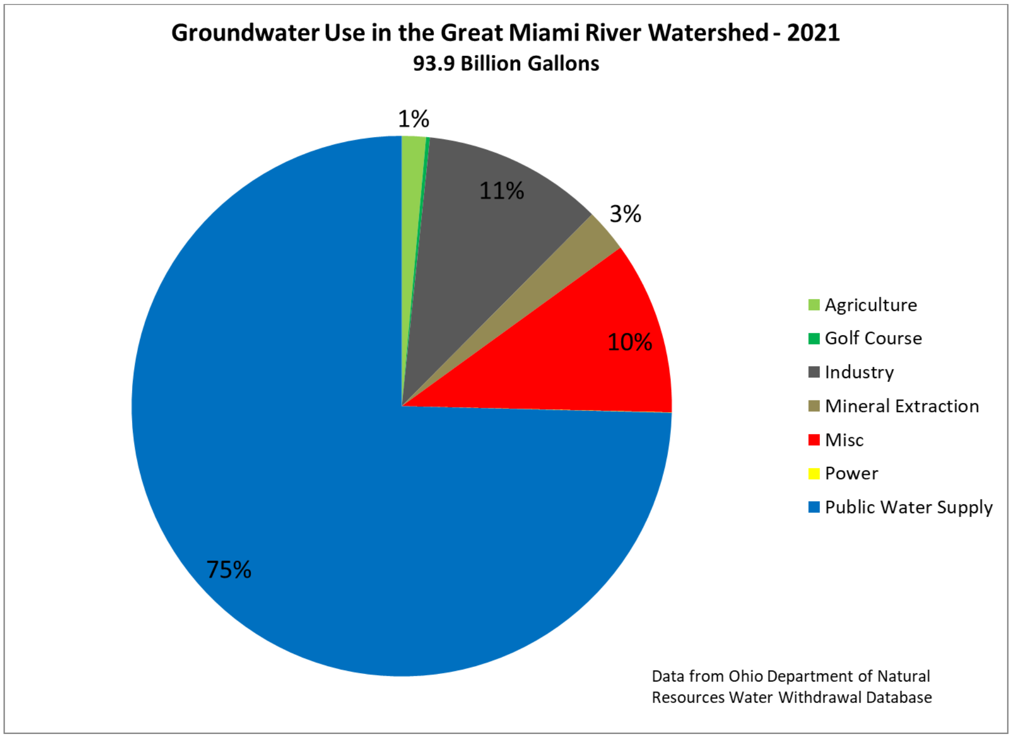


Figure 17 - Groundwater use in the Great Miami River Watershed during the year 2021.

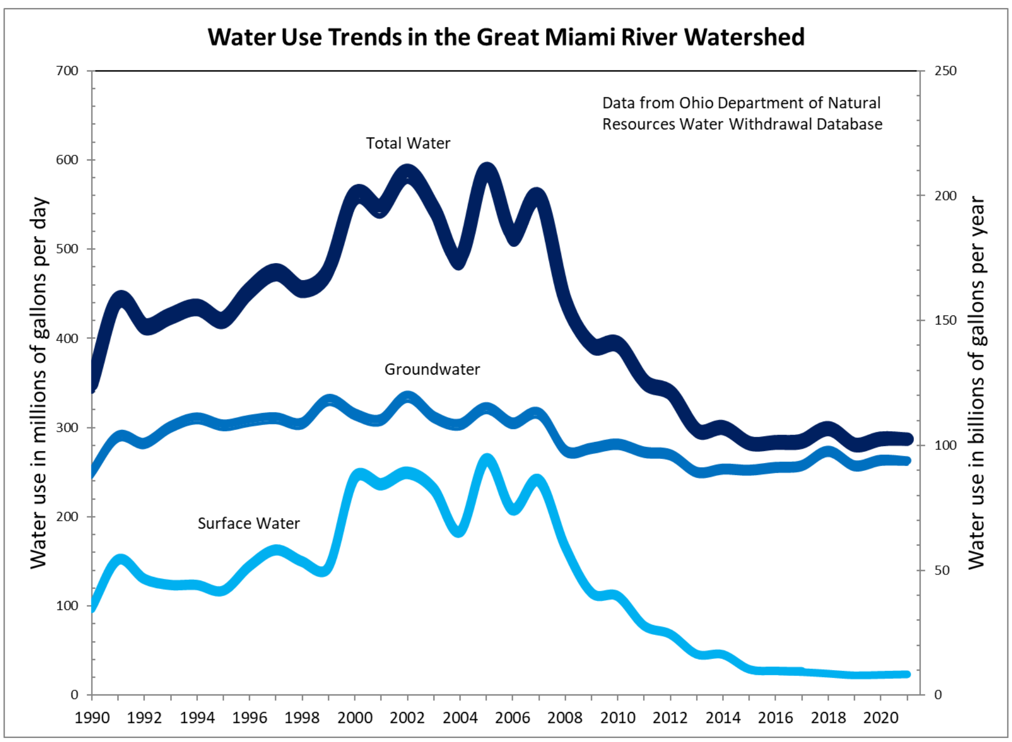


Figure 18 - Total water, surface water, and groundwater withdrawals in the Great Miami River Watershed between 1990 and 2021. Table 2—Retention Basin Operation (Storage Events) during 2022.

SUMMARY

Precipitation delivered to the Great Miami River Watershed in 2022 fell below the 30-year average, while runoff was above the 30-year average. The MCD flood protection system recorded 42 separate storage events during the year. Groundwater levels in the buried valley aquifer system tended to reach their highest levels in March and dropped to their lowest levels during the month of 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 MCD flood protection dams.

Groundwater levels in the buried valley aquifer system are generally 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 MCD data along with information supplied by:

Streamflow and runoff data:
U.S. Geological Survey, Water Resources Division

Groundwater Level and Water Use Data:
Ohio Department of Natural Resources, Division of Water Resources

MIAMI CONSERVANCY DISTRICT

38 E. Monument Avenue

Dayton, Ohio 45402

Phone: (937) 223-1271

Fax: (937) 223-4730

www.MCDWater.org