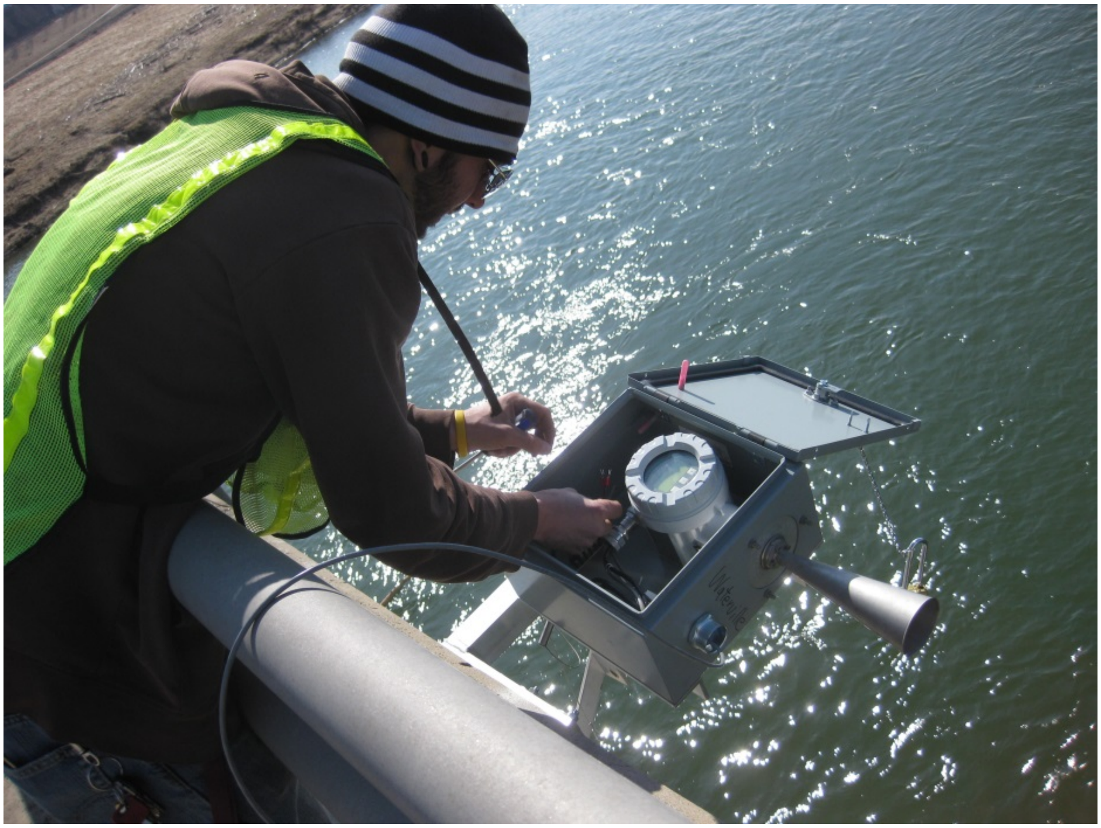
MCD Report 2015-24

MIAMI CONSERVANCY DISTRICT

2015 Water Data Report
Great Miami River Watershed, Ohio



MCD staff collecting data about the Great Miami River

Abstract

Water in the rivers, streams, and aquifers of the Great Miami River Watershed is used by people in many ways including drinking and personal care, agriculture, recreation, industrial process water, commercial, food production, and thermoelectric power generation. Tracking the trends of water quality and quantity helps communities better understand water availability and water health issues. To collect water data in 2015, MCD and its partners operated an extensive hydrologic monitoring system and tracked annual and long-term trends in precipitation, runoff, and groundwater levels. Long-term trends in precipitation, runoff, and streamflow are increasing and likely reflect climatic variability coupled with declining water use. Groundwater levels are staying steady. MCD also measured water quality data to track nutrients and other contaminants in rivers, streams, and groundwater. Water quality in rivers and streams reflects continued nutrient enrichment. A small study of groundwater quality indicated the presences of naturally occurring nuisance contaminants as well as human caused impacts to the aquifer.

For more information on the current programs of MCD, visit www.MCDWater.org.

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BACKGROUND

The Miami Conservancy District (MCD) is a conservancy district, which is a political subdivision of the State of Ohio. MCD works as a regional government agency throughout the 15-county Great Miami River Watershed. Formed in 1915, MCD provides flood protection, water resource monitoring and information, and recreational opportunities. MCD operates automated and observer precipitation stations and an extensive stream gaging network to record stream stage and calculate streamflow. 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.

For more information on MCD's current programs, visit www.MCDWater.org.

Water in the Great Miami River Watershed

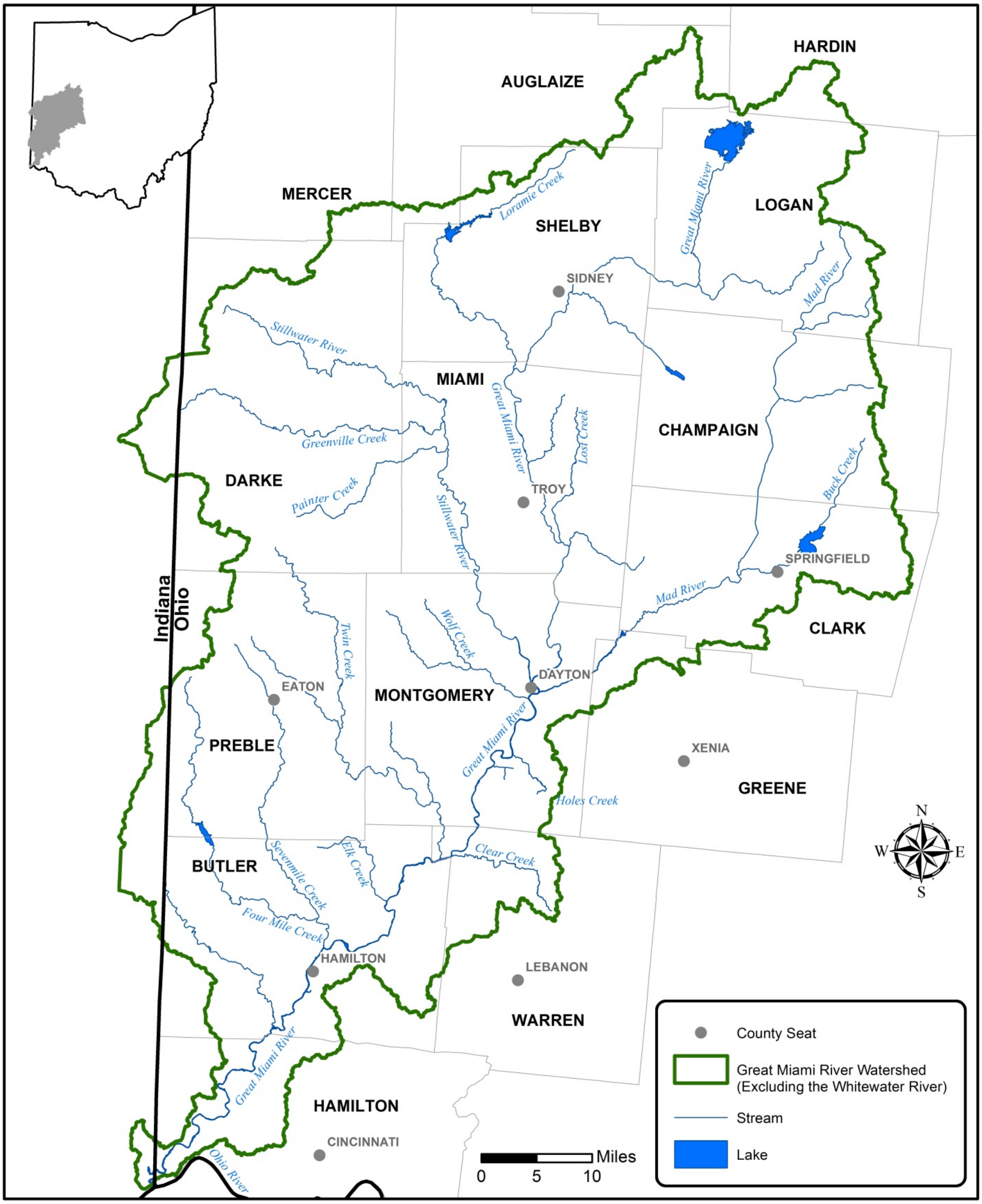
Water in the rivers, streams, and aquifers of the Great Miami River Watershed provides for drinking water, wastewater assimilation, thermoelectric power generation, irrigation, industrial process water, and aquatic recreation activities. According to the most recent Ohio Department of Natural Resources (ODNR) statistics, 2014 water use in the Great Miami River Watershed was approximately 295 million gallons of water per day. Groundwater from regional aquifers comprised about 84 percent of this water use. The buried valley aquifer is the most productive and important of these aquifers.

Rivers and Streams

With headwaters near Indian Lake, the Great Miami River flows 170 miles southwest to its confluence with the Ohio River west of Cincinnati. The Great Miami River Watershed drains all or parts of 15 counties and also includes the Stillwater and Mad rivers; and the Twin, Wolf and Sevenmile creeks (Figure 1). The total drainage area of the Great Miami River Watershed in Ohio is 3,946 square miles. The entire watershed, including the Whitewater River in Indiana, drains 5,371 square miles.

The Great Miami River Watershed boasts some of the highest quality fish and macroinvertebrate populations in Ohio. Stretches of the Stillwater River, Greenville Creek, Twin Creek and Great Miami River meet exceptional warm-water habitat criteria (Ohio Environmental Protection Agency, 2001). The exceptional warm-water habitat designation is reserved for those streams in Ohio that support "unusual and exceptional" assemblages of aquatic organisms. Many of the rivers and streams in the Great Miami River Watershed are designated "warm-water habitat," meaning the streams and rivers support the "typical" warm-water assemblage of aquatic organisms that are expected to be found given the regional climate, hydrology, and land use. However, nearly 30 percent of rivers and streams in the Great Miami River do not meet the standards for their assigned designation.

Figure 1 – Great Miami River Watershed



Buried Valley Aquifer

The buried valley aquifer system is the most utilized aquifer in southwestern Ohio because of its abundant supply of high-quality groundwater. This system consists of highly permeable sand and gravel deposits as thick as 200 feet that can store a great deal of groundwater. The system underlies the river and streambeds, allowing plenty of opportunity for groundwater recharge. This essentially makes the aquifer a renewable resource. The buried valley aquifer is a valuable natural resource. Managing it wisely will ensure the aquifer continues to support and enhance the region's economy and quality of life. Highlights include:

- Total aquifer storage of approximately 1.5 trillion gallons of groundwater.
- Principal drinking water source for an estimated 2.3 million people.
- Yields in excess of 2,000 gallons of water per minute are possible in wells near large streams.
- Much of the groundwater maintains a constant temperature of 56 degrees Fahrenheit.

The United States Environmental Protection Agency (U.S. EPA) designated the buried valley aquifer as a sole source aquifer in 1988. Sole source aquifers serve as the sole or principal source of drinking water for an area. Contamination of the aquifer would create a significant hazard to public health. As a result of this designation, all federally funded projects constructed near the aquifer, and its principal recharge zone, are subject to U.S. EPA review. This ensures that projects are designed and built in a way that doesn't create a hazard to public health.

Hydrogeologic Setting

The types of geologic deposits and their distribution are important in determining how water and the amount and types of dissolved minerals in the water are transported through a watershed. (Debrewer et al., 2000). The climate and geology of the region influence many physical properties of the landscape such as soil type, topography, runoff, and the quality of surface water and groundwater.

The Great Miami River Watershed lies almost entirely within the Till Plains section of the Central Lowland physiographic province (Fenneman, 1938). With the exception of a few areas near the Ohio River, the entire watershed was affected by Pleistocene glaciations. Multiple advances and retreats of Pleistocene glaciers left behind a landscape characterized by a flat to gently rolling land surface that is cut by steep-walled river valleys of low to moderate relief. Land-surface altitudes range from 1,550 feet above mean sea level in the northern parts of the watershed to 450 feet at the confluence of the Great Miami River with the Ohio River in Hamilton County, Ohio.

The Great Miami River Watershed has a temperate continental climate characterized by well-defined seasons and large annual temperature variations from summer to winter. Tropical air masses from the Gulf of Mexico and the Western Atlantic Ocean are the main source of moisture to the region. Frequent thunderstorms occur in the watershed as tropical air masses from the Gulf of Mexico move northeast and collide with arctic air masses moving south (Indiana Department of Natural Resources, 1988; U.S. Geological Survey, 1991).

The geology of the Great Miami River Watershed consists of unconsolidated Pleistocene glacial deposits, predominantly Wisconsinan and Illinoian in age, overlying a thick sequence of older limestones and shales of Devonian, Silurian, and Ordovician age (Klaer & Thompson, 1948; Norris & Spieker, 1966). The thickness of glacial deposits generally decreases from northern portions of the watershed to the south. In southwestern Ohio, the Till Plains section consists of broad areas of ground moraine interspersed with small curvilinear ridgelines called end moraines that mark former glacial margins. The major river valleys tend to be partially filled in with thick sequences of sand and gravel mixed with layers of silt and clay.

The Cincinnati Arch is the dominant bedrock structural feature in southwestern Ohio. The axis of the Cincinnati Arch runs southeast to northwest through extreme southern portions of the Great Miami River Watershed. Bedrock to the north of the axis has a slight north-northwest dip of 5 to 10 ft/mi (feet per mile). The Cincinnati Arch is thought to be an area of emergent land near the end of the Paleozoic Era that was subjected to erosion and dissection by streams. This period of erosion removed many of the younger rock units from the center of the arch leaving older rock units exposed at the surface.

The present-day course of the Great Miami River generally follows one of the ancient tributary valleys to the Teays River. The Teays River Valley is a significant geologic feature of southwestern Ohio. It consists of a series of buried valleys that reflect ancient drainage networks carved out by the Teays River and its tributaries prior to the glaciations of the Pleistocene. The Teays River originated in North Carolina and entered Ohio near Portsmouth where it flowed north and then northwest across Clark, Champaign, Logan, Shelby, and Mercer counties before entering Indiana and Illinois.

Aquifers

The buried valley aquifer system (Figure 2), which is associated with the Great Miami River and its principal tributaries, is the most productive groundwater resource in Ohio (Ohio Department of Natural Resources, 1999). It provides potable water for many communities within the Great Miami River Watershed. The buried valley aquifer system consists of highly permeable sand and gravel deposits that fill, or partially fill, preglacial river valleys. Major aquifer systems within and surrounding the Great Miami River Watershed include sand and gravel buried valley aquifers; carbonate bedrock aquifers; and water-bearing sand and gravel lenses within overlying glacial till later referred to as upland glacial sediment aquifers.

Land Use

Most of the Great Miami River Watershed lies within the Eastern Corn Belt Plains Ecoregion, which is characterized by rolling till plains with local moraines; rich soils; and extensive corn, soybean, and livestock production. Extreme southern portions of the watershed in Hamilton County lie within the Northern Bluegrass Ecoregion characterized by more rugged and deeply dissected terrain featuring woodlands and hay, grain, cattle, hog, and poultry farming. Much of the land in the Great Miami River Watershed was once covered with beech forests, elm/ash swamp forests, and some oak/sugar-maple forests.

According to the most recent information, the 2011 National Land Cover Database, (see Table 1), agriculture is the dominant land use of the Great Miami River Watershed, comprising about 68 percent of the land. Most of the remaining land is either developed (17.8 percent) or forested (11.5 percent) (see Figure 3). A comparison between 2001 and 2011 shows a 0.5-percent increase in developed land and a similar magnitude decrease in agricultural land.

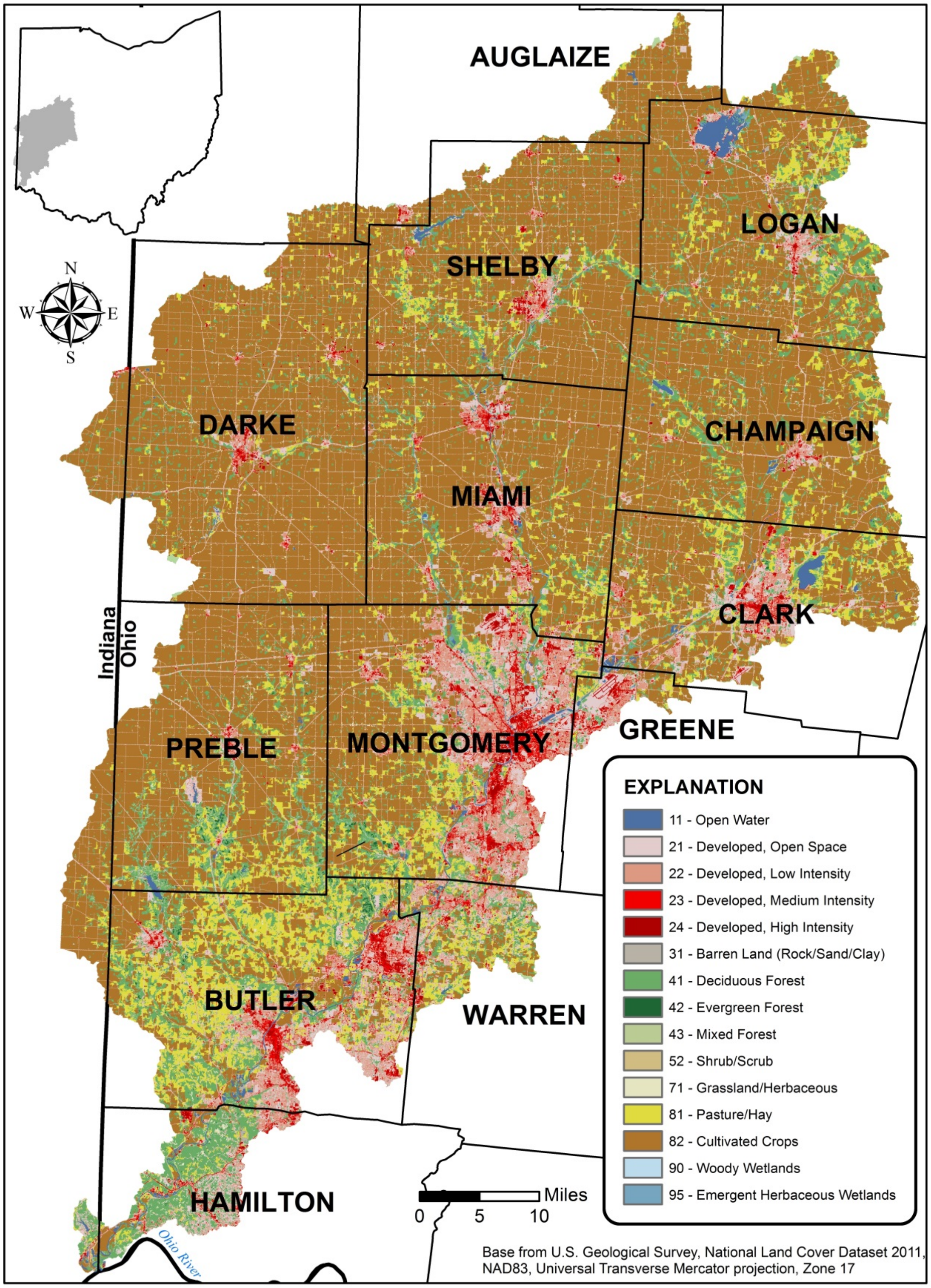
Table 1 Comparison of land cover between 2001 and 2011 National Land Cover Database

Land Cover	2001	2011
Open Water	0.98%	1.01%
Developed	17.32%	17.82%
Forested	11.55%	11.54%
Agricultural (Crops, Pasture, and Hay)	68.57%	68.04%
Wetlands	0.27%	0.26%
Other	1.31%	1.33%

The estimated population of the Great Miami River Watershed is 1.4 million people based on 2010 census data. Major urban areas include Springfield, Dayton, Middletown, Hamilton, and Fairfield. Also, the extreme western edge of Cincinnati extends into the Great Miami River Watershed in Hamilton County.

Figure 2 –Buried Valley Aquifer

Figure 3 – Land cover



WATER QUANTITY

The Water Cycle

A cooperative partnership between USGS and MCD has allowed for long-term tracking of changes in water availability including precipitation, runoff and groundwater levels. The data collected is used to estimate water inflows, outflows, and changes in water storage for the Great Miami River Watershed upstream of the Hamilton stream gaging station, an area of some 3,630 square miles. These records are useful for comparing current hydrologic measurements with historical measurements, and analyzing trends of water entering and leaving the watershed as well as trends in aquifer levels. The information can be used for planning related to water supply, flood protection, construction, agriculture, commerce, and industry.

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. Some of the precipitation infiltrates the ground and percolates through the soil until it reaches the water table. This water provides recharge to the aquifers and helps sustain the groundwater resources in the Great Miami River Watershed. Water in the aquifer either remains underground and in storage for a long period of time 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 are able to sustain flow, even during periods of prolonged drought, because the underlying buried valley aquifer provides base flow to the streams and rivers.

Measuring Precipitation

MCD measures precipitation throughout the Great Miami River Watershed. The data is provided to the National Weather Service to assist with climatic assessments and flood forecasting. The data is also analyzed in conjunction with groundwater level data to better understand how precipitation affects the water stored in the buried valley aquifer.

To collect this data, MCD operates two precipitation networks--manual observers and automated tipping bucket rain gages. The manual observer network is staffed by MCD staff and citizens who record daily rainfall at 42 stations within the Great Miami River Watershed. This data is also used by NOAA to help develop the rainfall frequency atlas for the Midwest, and monthly Climatological Data reports for Ohio. Twenty-eight of MCD's manual observer stations data have at least 75 years of record. The station in Urbana has the longest period of recorded data — 134 years. These long records are important for understanding environmental trends and for use in resource planning.

The second precipitation network consists of 15 tipping bucket rain gages that automatically record and transmit accumulated rainfall data. These gages are co-located with stream gages and equipped with Geostationary Orbiting Environmental Satellite (GOES) telemetry (see Figure 4).

2015 Precipitation in the Great Miami River Watershed

Annual precipitation in 2015 was above normal. An average of 45.26 inches of precipitation fell across the Great Miami River Watershed, 4.97 inches above a 30-year average of annual precipitation for all MCD observer stations. Normal annual precipitation for the 30-year average is currently calculated at 40.30 inches (see Appendix A, Precipitation Data).

In 2015, MCD began to use a 30-year interval to calculate the average for each station. This average is the norm for each station. The use of a 30-year interval is consistent with World Meteorological Organization (WMO) standards for determining climatic norms. By using a 30-year interval, MCD can also compare the 30-year average with other federal datasets. Currently, most federal agencies that collect climatic data are using the time interval of 1981-2010 for establishing precipitation and other climatic norms. This time interval is shifted forward every ten years. For example, the next time interval for establishing climatic norms will be the interval of 1991-2020. In 2021, MCD will recalculate 30-year averages for precipitation, runoff, and groundwater recharge for the Great Miami River Watershed to include the years 1991 through 2020.

The monthly precipitation pattern for 2015 was characterized by near normal winter and spring precipitation followed by above-normal summer precipitation. The year 2015 ended with near normal precipitation during the fall. Figure 5 illustrates the monthly precipitation and accumulated monthly precipitation for the Great Miami River Watershed during 2015 as compared to the long-term mean.

Monthly precipitation totals for April, June, July, and December 2015 were significantly above normal. Monthly precipitation totals for February, May, and September 2015, were below normal. June was the wettest month averaging 8.16 inches of precipitation across the watershed. February was the driest month and averaged just 1.27 inches of precipitation. No monthly precipitation record highs or lows were set for the Great Miami River Watershed in 2015 (see Figure 6).

Annual precipitation totals for the Great Miami River Watershed going back to 1915 are shown in Figure 7. Annual precipitation exceeded the 30-year average for the Great Miami River Watershed in 16 of the 26 years from 1990 to 2015. The two highest annual precipitation totals ever recorded for the watershed occurred during this time interval in 1990 and 2011. The decade of the 2000s has the highest average annual precipitation for the Great Miami River Watershed compared to other decades since recording of annual precipitation in the watershed began (see Figure 8).

Further evidence that precipitation is trending upward in recent decades is shown in Figure 9, which shows how the annual precipitation 30-year average for the Great Miami River Watershed has increased in recent decades. There is an upward trend in the 30-year average annual precipitation beginning in the late 1980s. In 1988, the 30-year average annual precipitation was 37.27 inches. In 2015, the 30-year average annual precipitation stood at 41.18 inches, an increase of nearly 4 inches over 27 years.

Figure 4 – Location of MCD's precipitation gages

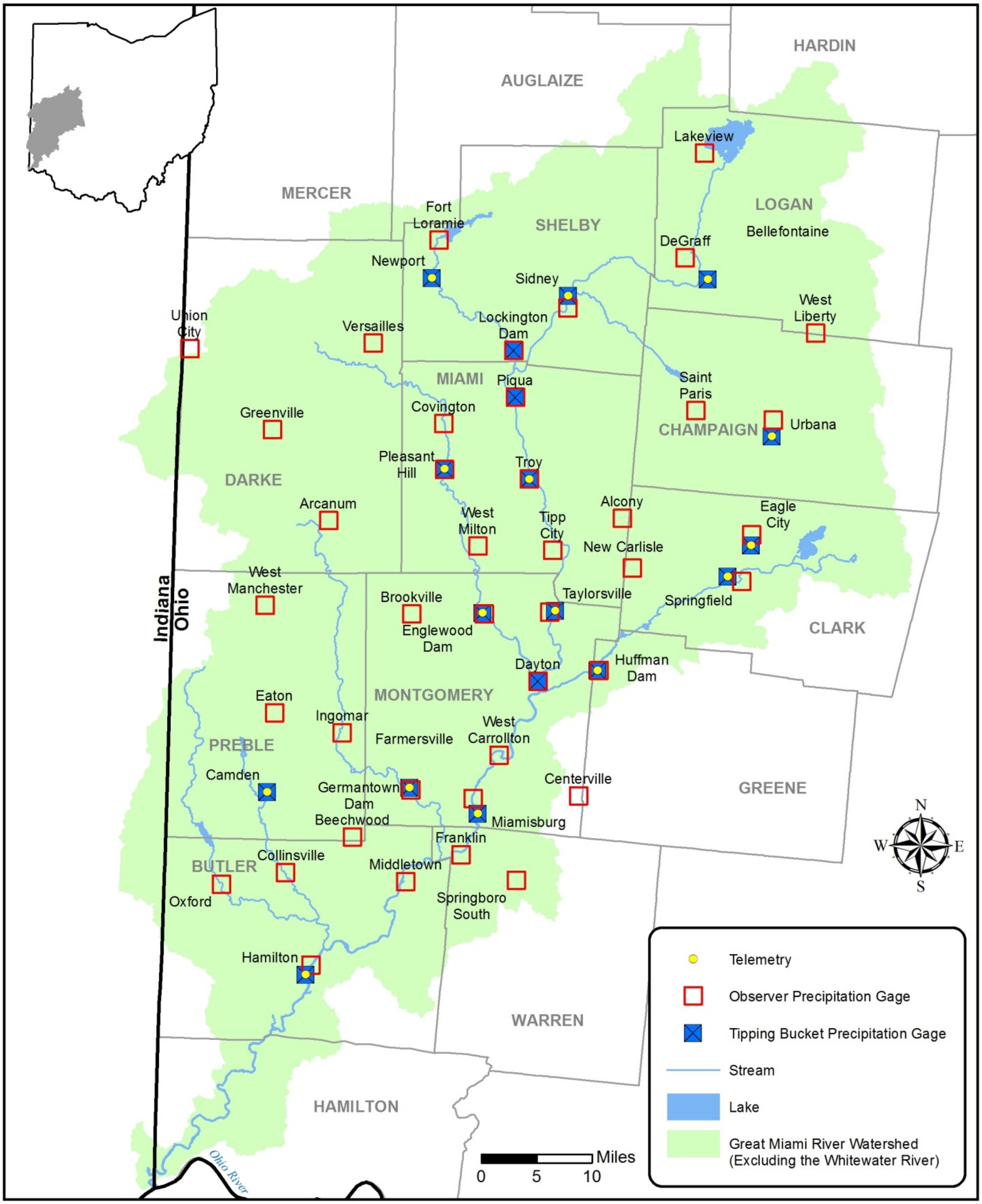


Figure 5 – 2015 monthly precipitation and accumulated monthly precipitation

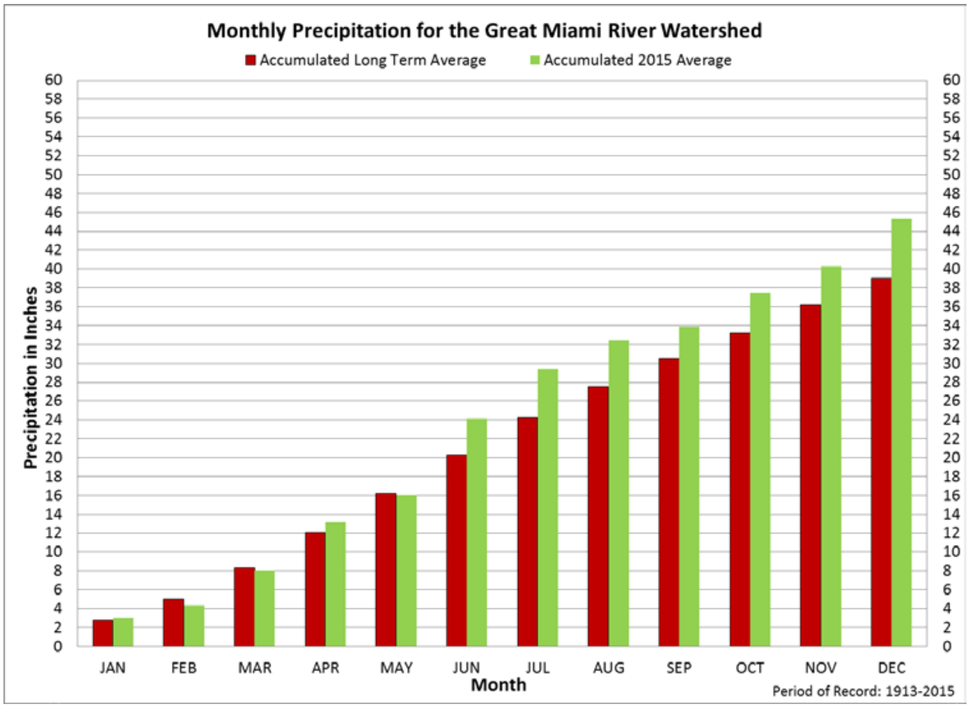


Figure 6 – 2015 monthly precipitation totals compared with monthly means, record highs, and record lows

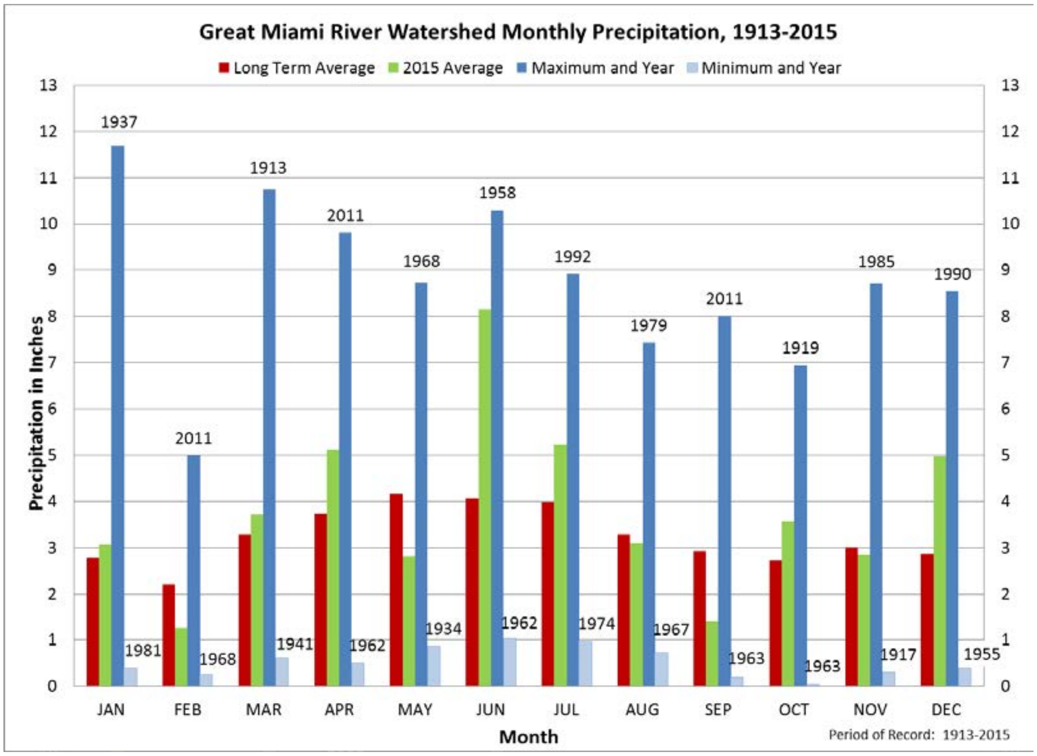


Figure 7 – Average annual precipitation

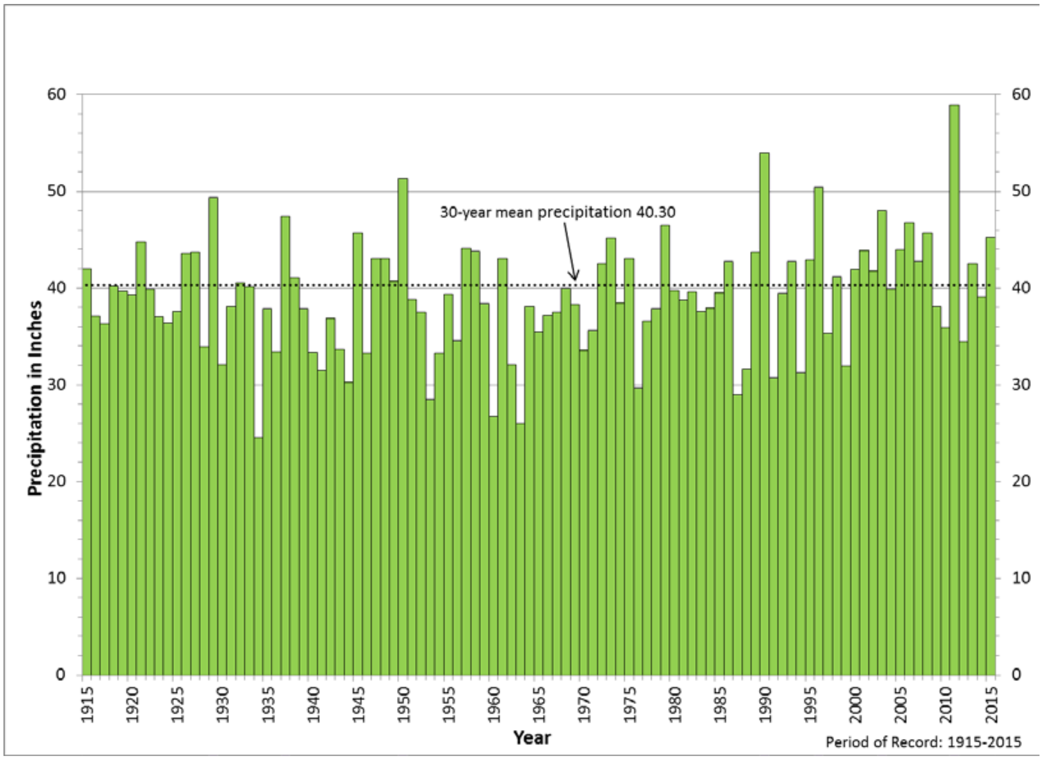


Figure 8 – Mean annual precipitation by decade

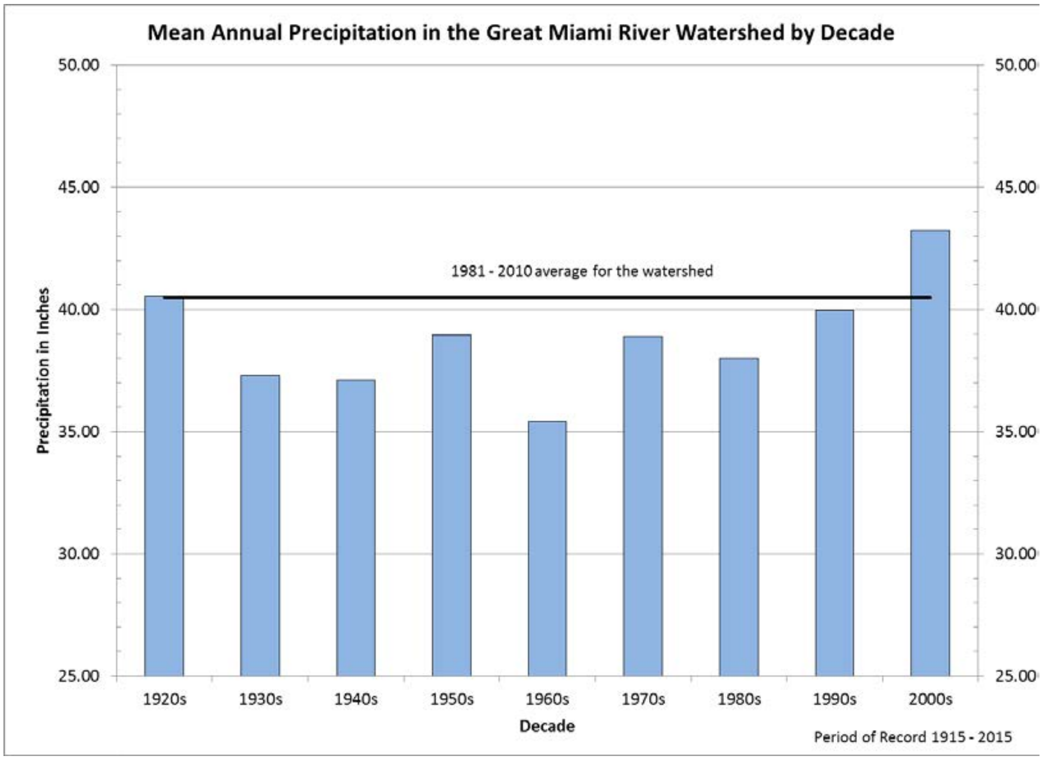
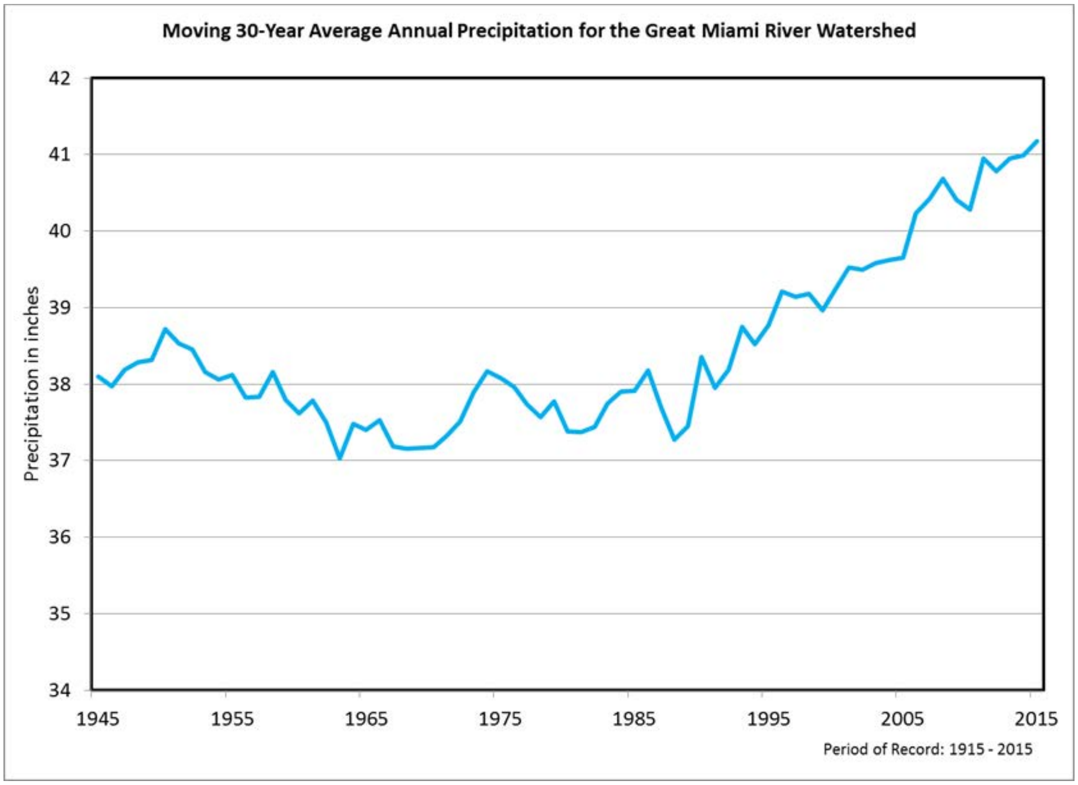


Figure 9 – Moving 30-year average annual precipitation for the Great Miami River Watershed

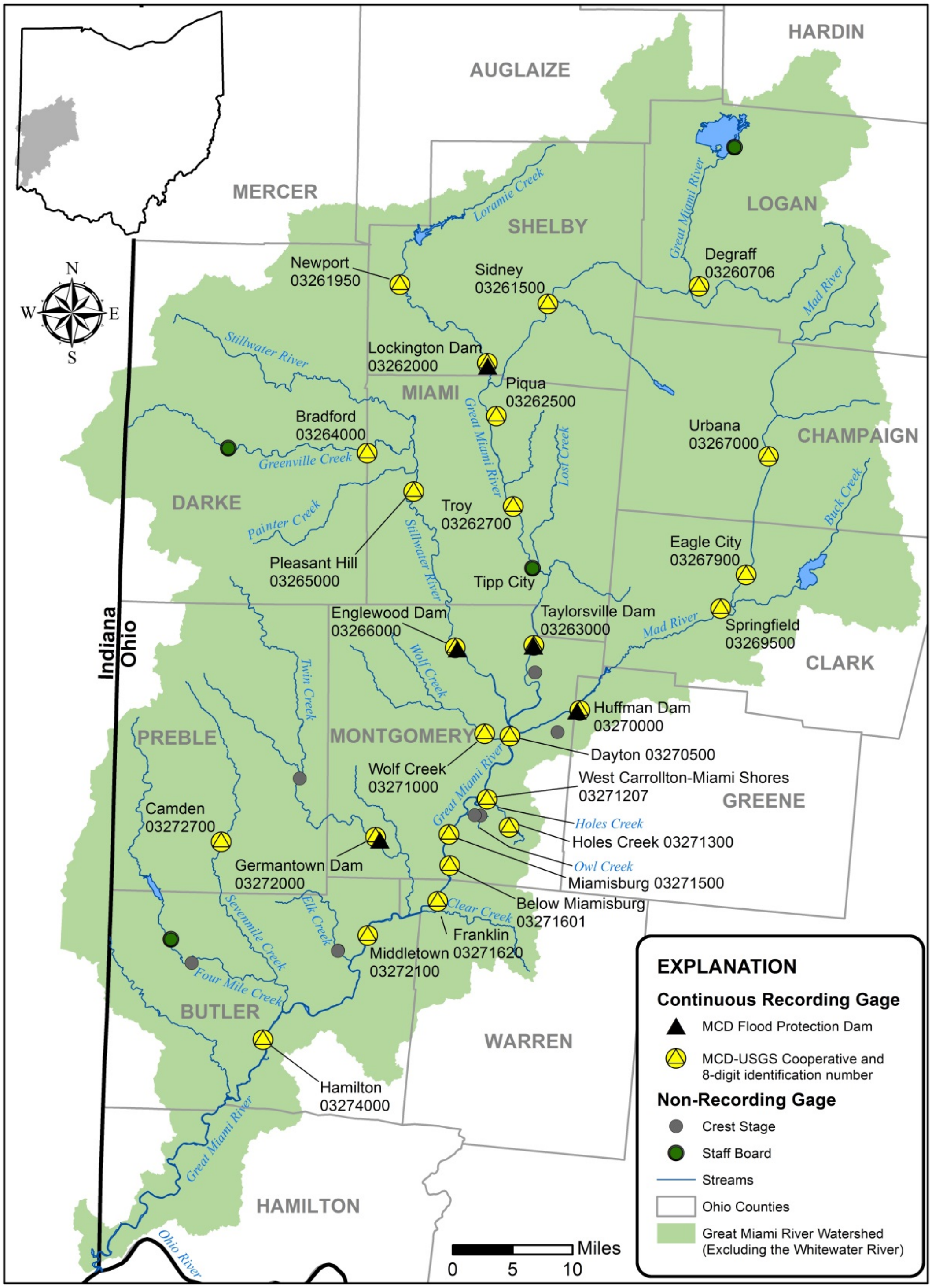


Measuring Runoff, Streamflow, and Groundwater Recharge

MCD operates an extensive stream gaging network throughout the Great Miami River Watershed to record stream stage and calculate streamflow (see Figure 10). The stream gaging network provides data that is used to determine streamflow, calculate runoff, and estimate average groundwater recharge. Most of the gages have been recording streamflows for more than 30 years.

The network consists of 25 automated stream gages maintained through a cooperative partnership with USGS. All 25 stream gages are equipped with telemetry systems that allow MCD, USGS, and the National Weather Service to receive real-time stream stage, discharge, and precipitation data. Daily monitoring of stream gages by MCD staff ensures gage reliability and accuracy during significant storm events USGS processes the data from the gages, prepares rating curves and tables, and computes records for publication in state and federal reports. These public records provide surface water levels and streamflow data (discharge) to any interested party via the National Water Information System (NWIS) website at http://waterdata.usgs.gov/nwis. In addition to USGS, the U.S. Army Corps of Engineers and the National Weather Service are cooperative partners on one or more of the 25 gages. MCD maintains automated gages on the downstream side of the five MCD flood protection dams on Loramie and Twin creeks and the Great Miami, Stillwater, and Mad rivers. Crest stage, wire weight, and staff gages are also used to measure water surface elevations during storm events. The National Weather Service's Ohio River Forecast Center uses the stream gaging network to forecast peak streamflows and provide flood warnings to communities during large runoff events.

Figure 10 – Location of stream gaging stations



2015 Runoff in the Great Miami River Watershed

Overall, 2015 annual runoff was above normal at 12 of the 13 gaging stations (see Figure 10). The gaging station on Holes Creek near Kettering recorded the highest 2015 runoff total in the Great Miami River Watershed at 22.62 inches while the stream gage on the Mad River near Urbana recorded the lowest runoff total at 14.54 inches (see Appendix B, Summary of Precipitation, Runoff, & Base Flow Data).

The Hamilton station is the furthest downstream station managed by MCD and is the closest stream gaging station to the mouth of the Great Miami River. Using this gage, MCD estimated annual runoff for the Great Miami River Watershed at 18.30 inches, which is 3.74 inches above normal.

How runoff is computed

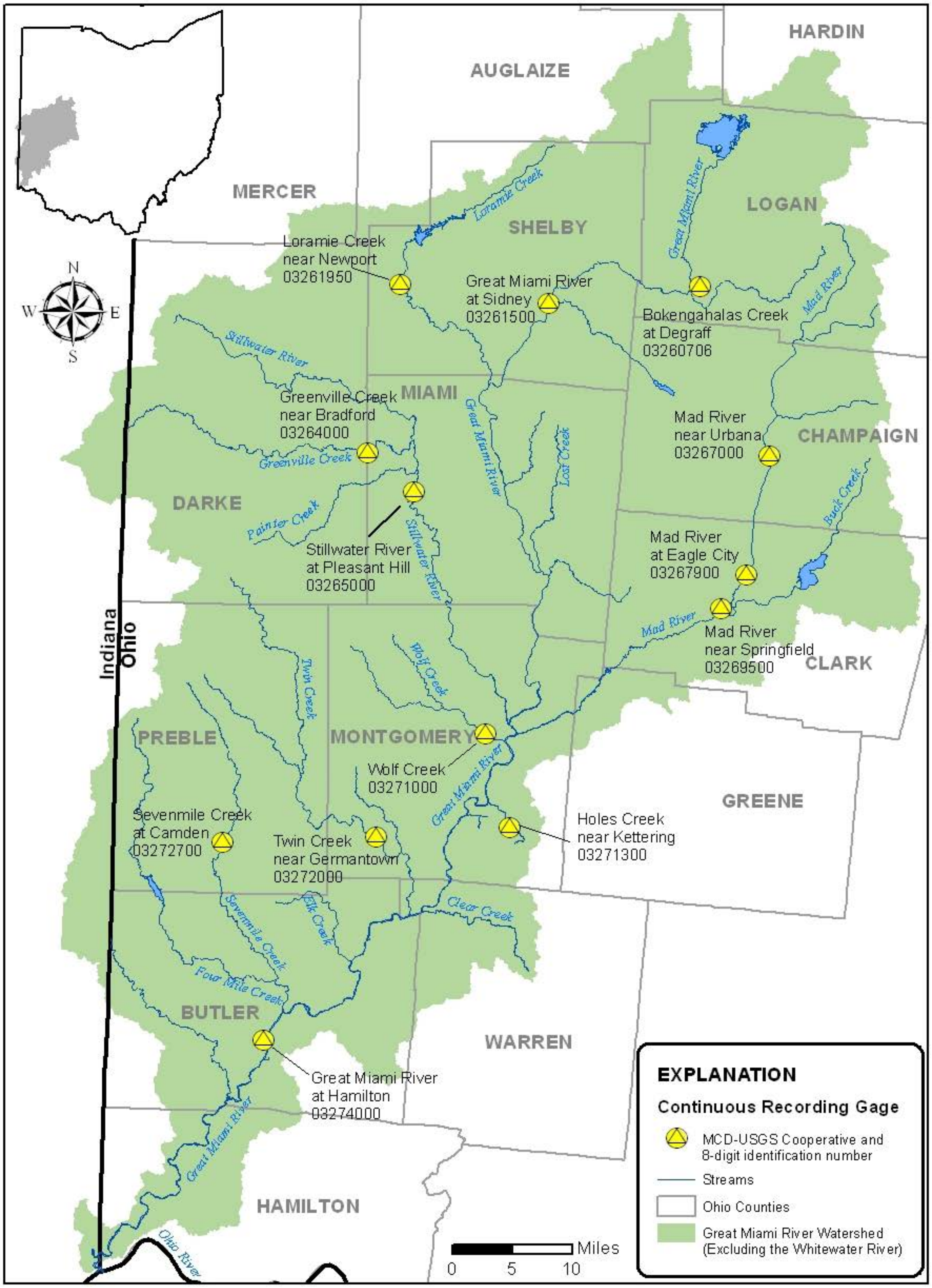
Runoff is defined as the portion of precipitation which flows downhill and enters streams, rivers, lakes or ponds. Runoff is composed of two components, surface runoff and base flow or groundwater runoff. Surface runoff consists of water from rainfall that flows directly across the land and into a stream, river, or lake. Base flow runoff consists of water from rainfall which seeps into the ground, enters into an aquifer, and then flows out into a stream, river, lake, or pond.

MCD staff use a USGS software program called PART to compute total runoff, surface runoff, and base flow from the streamflow records of the 13 gaging stations in the Great Miami River Watershed network listed in Appendix B. PART uses streamflow partitioning to estimate a daily record of base flow from the streamflow record (Rutledge, 1998). The software scans the period of record for days that fit a requirement of antecedent recession, designates groundwater discharge to be equal to streamflow on these days, and linearly interpolates the groundwater discharge on days that do not fit the requirement of antecedent recession.

This method of analysis is appropriate if all or most of the groundwater in a watershed discharges to a stream, and if a stream gaging station at the downstream end of the watershed measures all or most outflow. Regulation and diversion of streamflow should be negligible and the watershed should be characterized by diffuse recharge events that are roughly concurrent with peaks in streamflow. These conditions are likely met for 13 of the 25 stream gaging stations in the Great Miami River Watershed with drainage areas of between 1 and 500 square miles.

Because the drainage area for the Great Miami River at the Hamilton gaging station greatly exceeds 500 square miles, there is a concern as to whether or not the runoff analysis by PART is appropriate for computing base flow at this gage. MCD staff compared surface and base flow runoff computations from PART for the Hamilton gage with a weighted average of surface and base flow runoff for eight gaging stations upstream of the Hamilton gage that met the requirements for PART analysis. The weighted averages for surface and baseflow runoff are based upon the area of the watershed upstream of each stream gaging station.

Figure 10 – Location of stream gaging stations used to compute runoff



2015 Surface Runoff

Surface runoff was above normal at all gaging stations in 2015 (see Appendix B, Summary of Precipitation, Runoff, & Base Flow Data). The Loramie Creek gage near Newport recorded the highest surface runoff (17.98 inches) of the gaging stations in 2015. The gaging station on the Mad River near Urbana recorded the lowest surface runoff at 2.82 inches.

The watershed upstream of the Loramie Creek near Newport gaging station is characterized by agricultural land use and contains a high percentage of silt and clay-rich soils. Much of the watershed is drained by agricultural tiles. With low permeability soils and extensive tile drains, precipitation tends to be routed into streams as surface runoff. In contrast, the Mad River Watershed upstream of the Urbana gaging station is characterized highly permeable soils which formed on top of buried valley aquifers. Precipitation tends to infiltrate the soil, move downward, and enter the saturated zone in the aquifer. This process reduces surface runoff.

To estimate surface runoff for the entire Great Miami River Watershed upstream of the Hamilton gaging station, MCD staff compared the PART surface runoff estimate for the Hamilton gaging station streamflow record with an average of PART surface runoff estimates for the streamflow record at eight upstream gaging stations (see Figure 11). The eight upstream gaging stations all have drainage areas of less than 550 mi^2 and meet the remaining criteria for analysis by PART.

PART analysis of the streamflow record for the Hamilton gaging station yielded a total runoff estimate of 18.30 inches and a base flow runoff estimate of 7.70 inches. MCD estimated surface runoff by subtracting base flow runoff from total runoff. The result was an estimate of 10.60 inches for surface runoff in 2015.

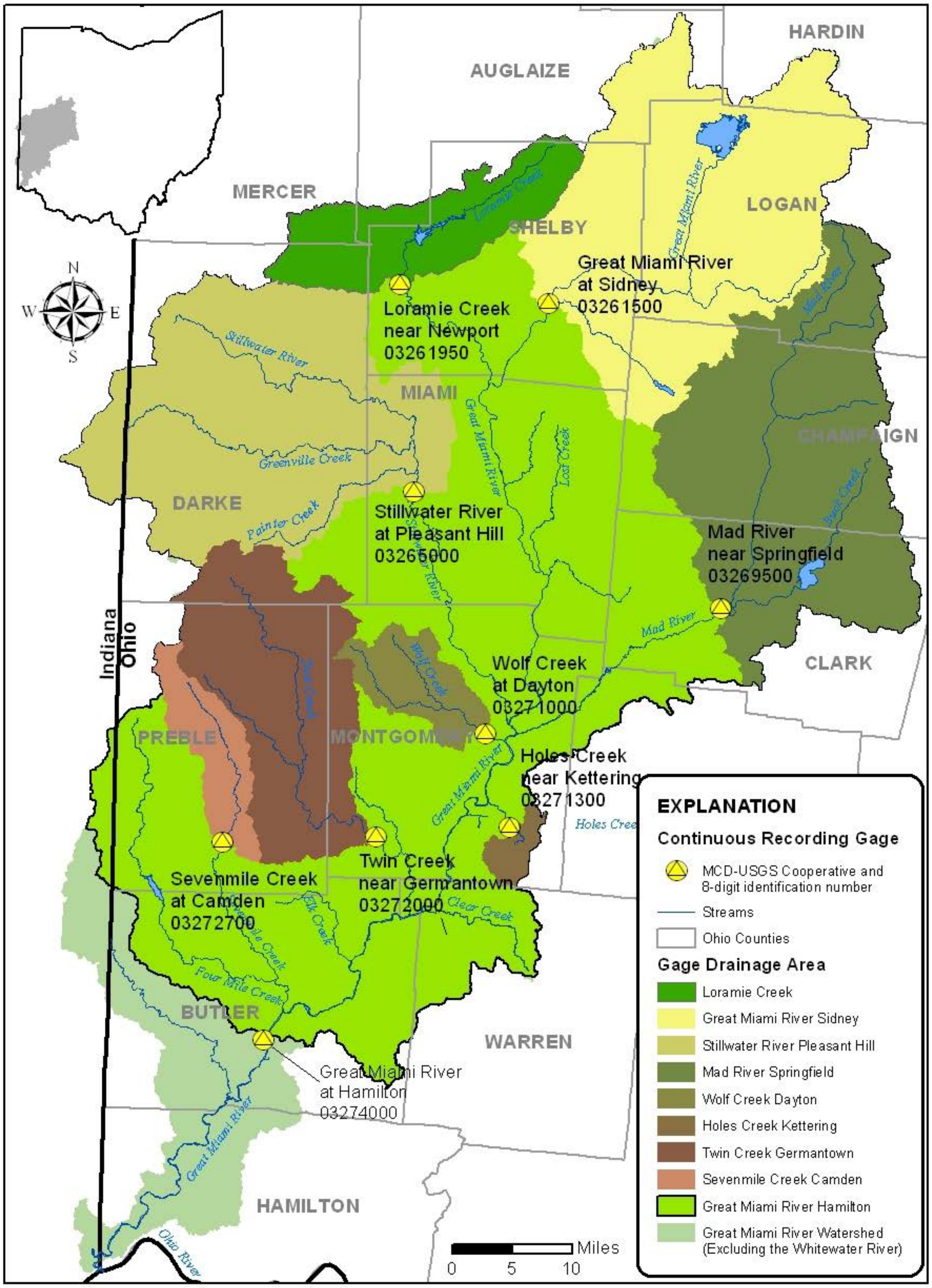
For analysis of surface runoff of the upstream gage streamflow records, MCD repeated the same process. Surface runoff was estimated by subtracting base flow runoff from total runoff for each gage. MCD staff then estimated surface runoff for the entire drainage area upstream of Hamilton by computing an average 2015 surface runoff of the eight upstream gages weighted by the drainage area of each gage. The result yielded an estimate of 10.65 inches for surface runoff in 2015.

A comparison of the two calculations shows very good agreement, so the analysis of the Hamilton streamflow record using PART appears valid. For the purpose of this report, a surface runoff of 10.60 inches is used, which is 3.60 inches above normal surface runoff (7.00) inches) for the Hamilton gage. Surface runoff contributed about 58 percent of the total runoff measured at the Great Miami River at Hamilton gage in 2015.

2015 Base Flow Runoff

Annual base flows were above normal at eight of the 13 stream gaging stations in 2015 (see Appendix B, Summary of Precipitation, Runoff, & Base Flow Data). Base flow is the portion of streamflow derived from groundwater inflows and wastewater discharges from industrial and municipal wastewater treatment plants. The Mad River gaging station at Urbana recorded the highest 2015 base flow (11.72 inches). The Loramie Creek gaging station near Newport recorded the lowest 2015 base flow (3.24 inches).

Figure 11 – Drainage areas of stream gaging stations used to compute runoff



PART analysis of the Hamilton gage streamflow record resulted in a base flow runoff estimate of 7.70 inches for 2015. A weighted average of PART base flow estimates for the eight upstream gages yielded a base flow estimate of 7.32 inches. Comparison of the two estimates shows reasonable agreement, so PART analysis of the Hamilton gage streamflow record appears valid. For the purpose of this report, a 2015 base flow runoff of 7.70 inches is used for the drainage area upstream of the Hamilton gage. This estimate for base flow runoff is 0.14 inches above the normal annual base flow (7.56) for the Hamilton gage. Base flow contributed about 42 percent of the total runoff measured at Hamilton in 2015.

A base flow index was computed for each of the stream gages listed in Appendix B. The base flow index is computed by dividing mean annual base flow runoff by mean annual total runoff. The Mad River gaging stations at Springfield, Eagle City and Urbana and the Bokengahalas Creek gaging station at De Graff have significantly higher base flow indices than other stations. Higher base flow indices for the Mad River and Bokengahalas Creek gaging stations are the result of the inflow of groundwater from the buried valley aquifer into the river or stream channel. Base flow indices in other areas of the Great Miami River Watershed vary widely (see Figure 12).

Trends in Annual Runoff

The normal annual runoff at the Hamilton gaging station from 1981-2010 is calculated at 14.56 inches. Annual runoff at Hamilton exceeded normal seven out of 10 years from 2000-2009 (see Figure 13). A Mann-Kendall trend analysis was performed on the annual runoff data (Helsel, 1992). The results suggest there is an increasing trend in annual runoff for the Great Miami River between 1928 and 2015. Further evidence for a rising trend in runoff is present in computations for the 30-year annual mean runoff for the Great Miami River Watershed upstream of the Hamilton gaging station (see Figure 14). The 30-year mean annual runoff at Hamilton has increased from 11.76 inches in 1960 to 15.36 inches in 2015, an increase of 3.60 inches over 55 years. That is an increase of nearly 31 percent, a significant increase.

2015 Flow in the Great Miami River at Hamilton

The highest mean daily flow recorded at the Hamilton stream gaging station in 2015 was 43,900 cubic feet per second (cfs) on December 29. The lowest 2015 mean daily flow at Hamilton was 620 cfs on October 17. The mean daily flow for Hamilton in 2015 was 4,894 cfs. Normal daily flow (Mean daily flow for 1981 – 2010) for the Great Miami River at Hamilton is 3,893 cfs.

The Hamilton stream gaging station has a sufficient period of record to look at trends in five-year-interval mean daily steam flows going back to 1931. The data show an increasing trend in mean daily flow over the 85-year span from 1931 to 2015 (see Figure 15). The 2011-2015 interval has the highest five-year-interval mean daily flow (4,904 cfs) of any five-year interval going back to 1931. The 2001-2005 interval has the second highest five-year mean daily flow (4,657 cfs). In fact, the three five-year intervals from 2001-2015 have the three highest mean daily flows for the entire time period.

Figure 12 – Base flow index of stream gage drainage areas used to estimate base flow runoff

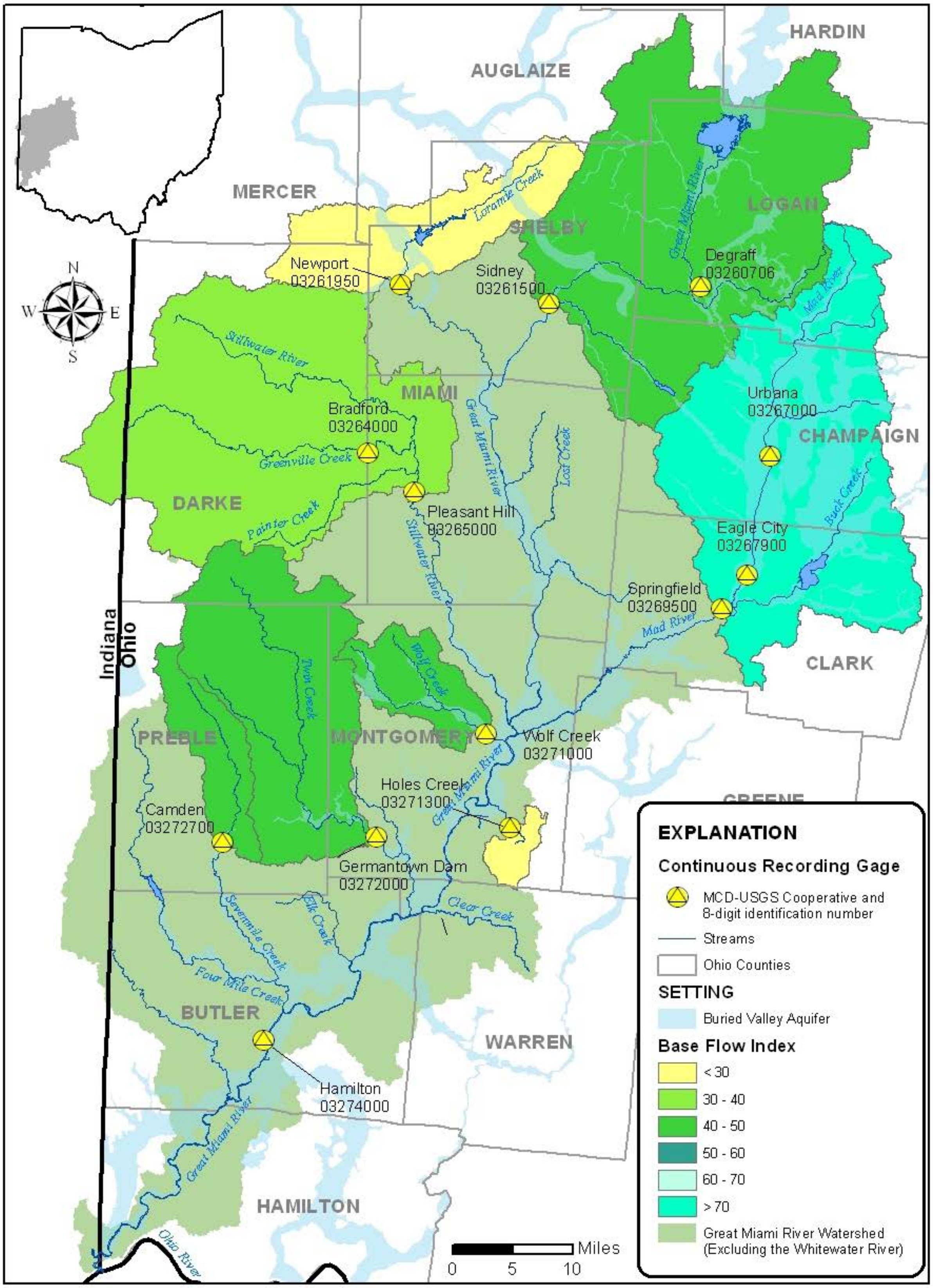


Figure 13 – Annual runoff for the Great Miami River at Hamilton

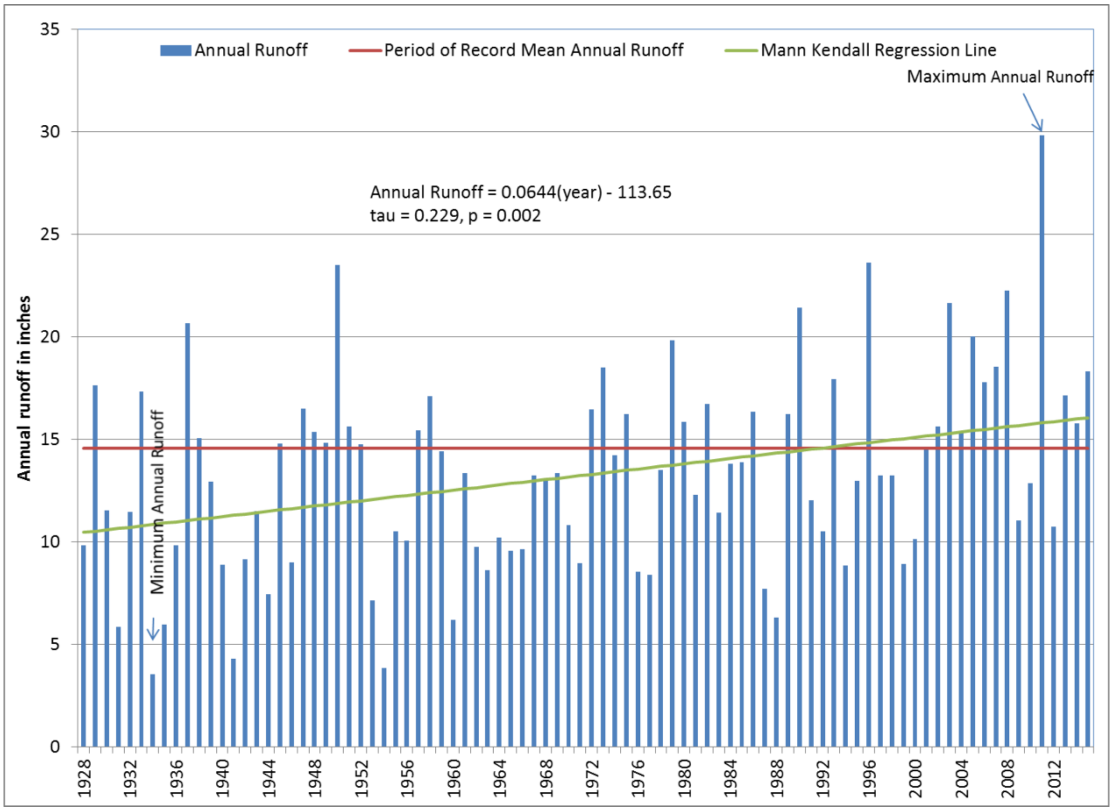


Figure 14 – Moving 30-year average mean runoff for the Great Miami River Watershed

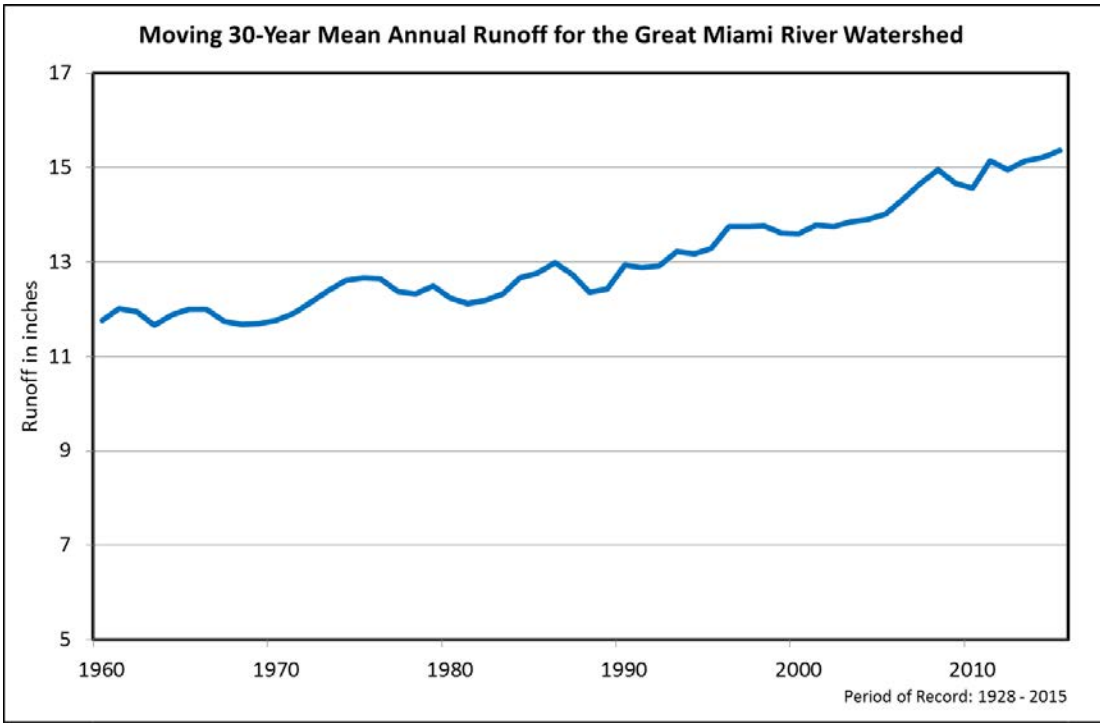


Figure 15 – Mean Daily Flow by 5-year Intervals for the Great Miami River at Hamilton

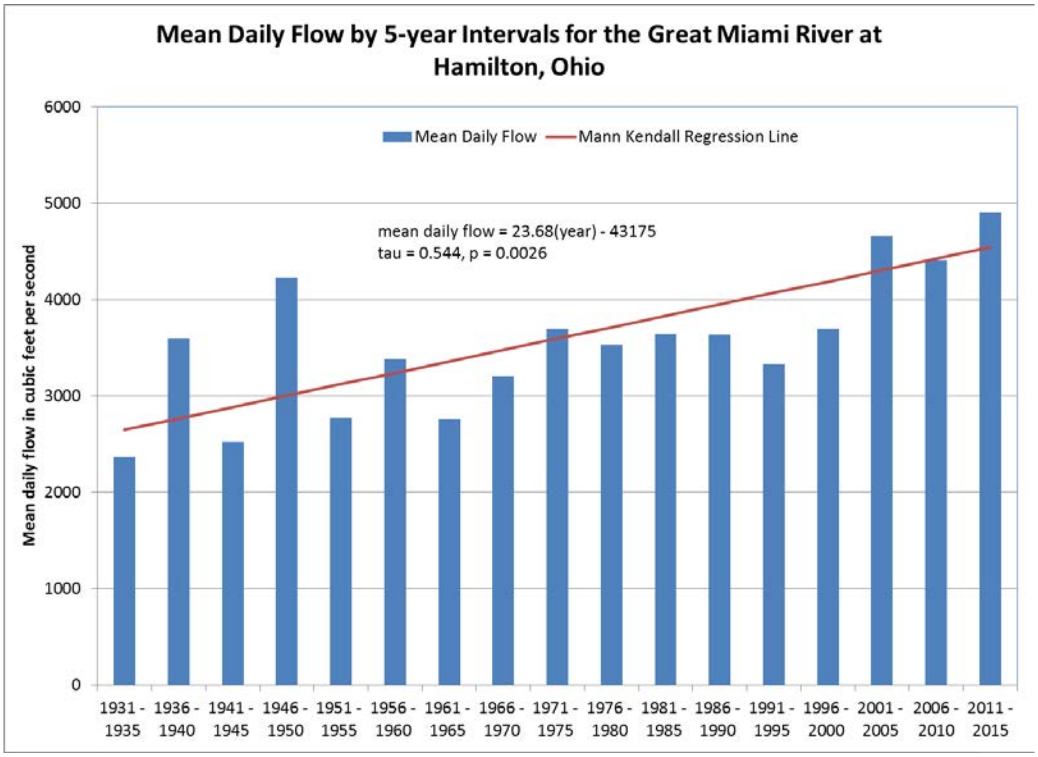
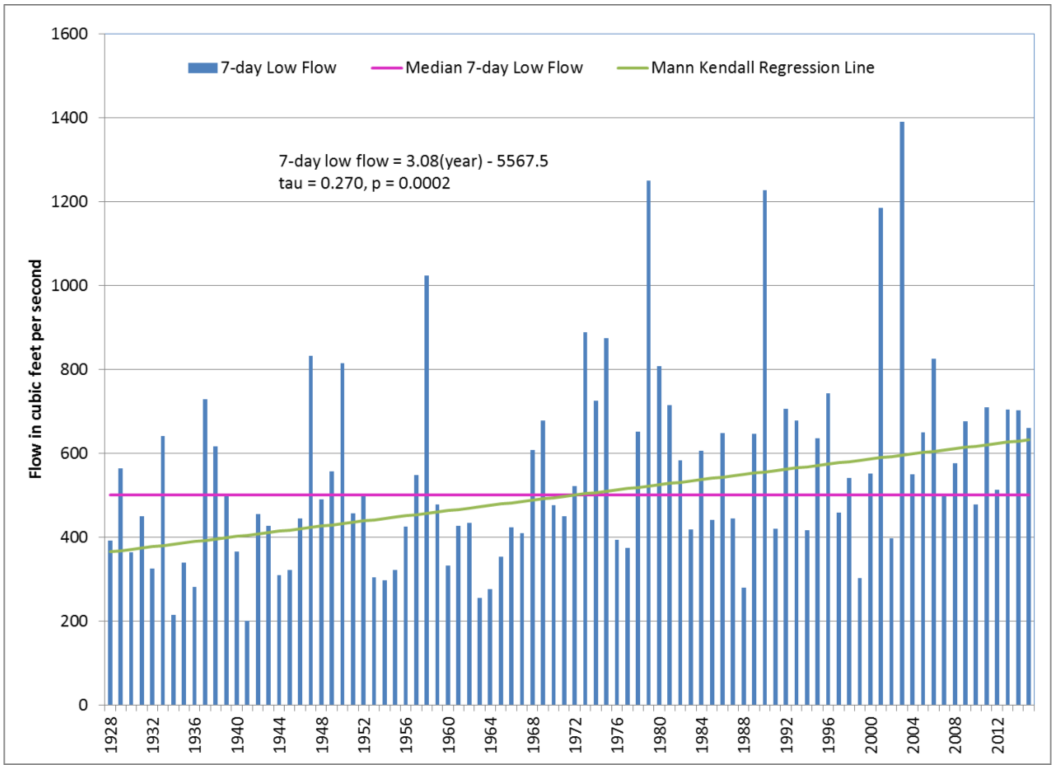


Figure 16 – Annual 7-day Low Flows on the Great Miami River at Hamilton



A Mann-Kendall trend analysis was performed on the five-year-interval mean daily flow data (Helsel, 1992). The results suggest there is an increasing trend in five-year interval mean daily flows for the Great Miami River during the time period of 1931-2015.

The annual seven-day low flow is the lowest mean value for any seven-consecutive-day period in a year. The 2015 seven-day low flow measured on the Great Miami River at Hamilton was 660 cfs. Normal seven-day low flow is 623 cfs. MCD staff performed a Mann-Kendall test on the seven-day low flow data for the entire period of record. The results indicate an increasing trend in the seven-day low flow for the period analyzed (1928-2015) (see Figure 16).

Streamflow data collected at the stream gaging station on the Great Miami River at Hamilton indicates increasing trends in the mean daily flow and the seven-day low flow since 1928. These trends, coupled with above normal precipitation in 18 of the 26 years from 1990 to 2015, suggest a tendency towards wetter climate conditions over the past couple of decades.

2015 Groundwater Recharge in the Great Miami River Watershed

Annual groundwater recharge in 2015 fell below normal at seven of the 12 stream gaging stations analyzed (see Appendix C, RORA Calculated Groundwater Recharge Data). Groundwater recharge in the Great Miami River Watershed originates from precipitation that infiltrates through the soil or fractures in bedrock and eventually reaches the aquifer. Once precipitation enters the aquifer system, it flows toward nearby streams and rivers entering the stream or river channel as base flow. The time span from when precipitation falls on the ground, infiltrates into the aquifer, flows through the aquifer, and finally enters a river or stream typically ranges from less than a year to several decades or more (Rowe, Shapiro, & Schlosser, 1999).

Groundwater recharge ranged from a high of 12.74 inches for the Mad River Watershed upstream of the Urbana station to a low of 5.76 inches for the Twin Creek Watershed upstream of the Germantown station. The mean 2015 groundwater recharge, weighted by drainage area for the 12 stream gaging stations, is 8.56 inches.

Normal annual groundwater recharge for the Great Miami River Watershed is 8.75 inches; therefore 2015 annual groundwater recharge is estimated to be 0.19 inches below normal.

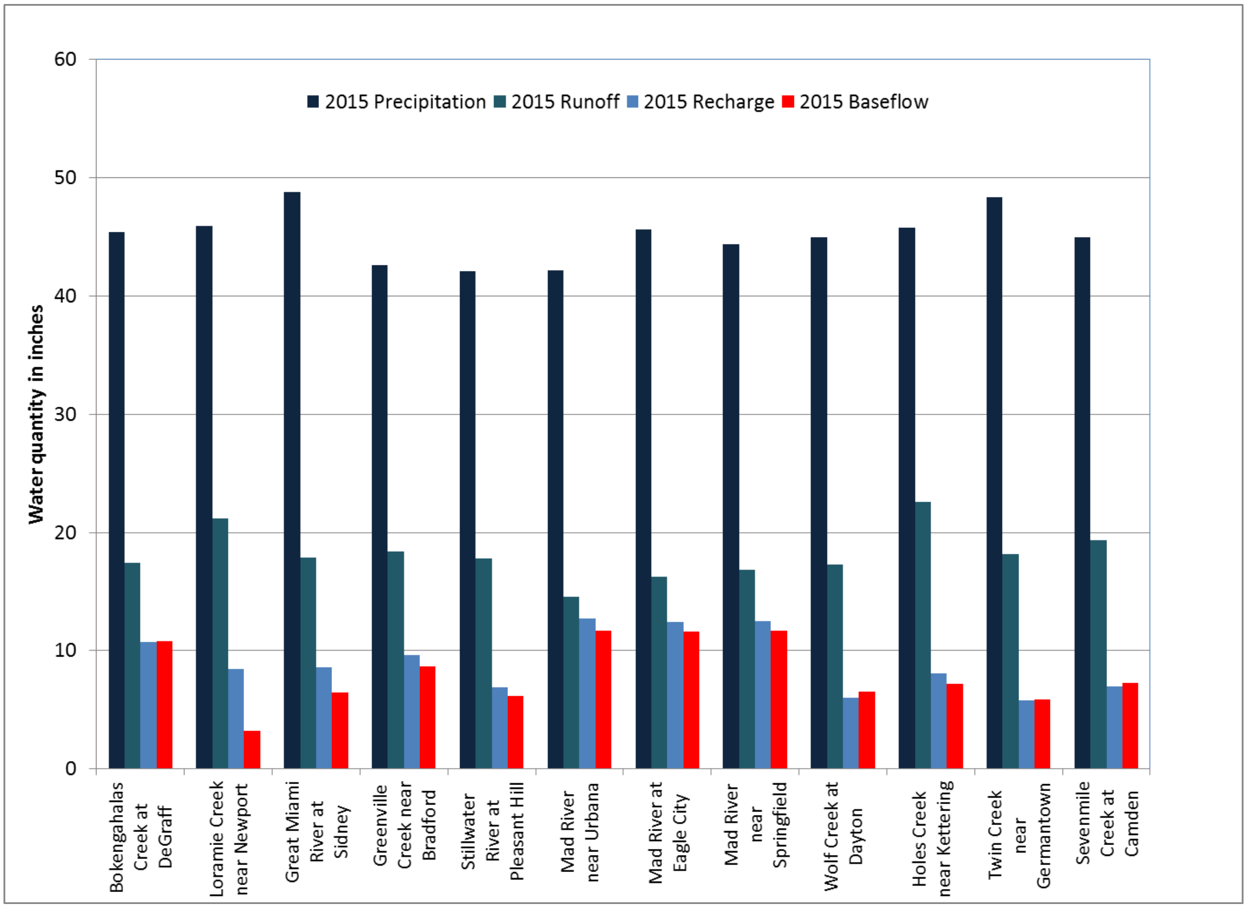
Estimates of annual groundwater recharge and annual base flow are significantly higher at the Mad River and Bokengahalas Creek gaging stations than other stations (see Figure 17). Groundwater recharge values are highly dependent upon the characteristics of the watershed upstream of the stream gaging station, and reflect the local geology of the river and aquifer system. For example, the Mad River Watershed is characterized by an extensive buried valley aquifer system beneath and alongside the present day Mad River channel. The buried valley aquifer system is overlain by relatively permeable soils that developed in sand and gravel deposits. Precipitation can easily infiltrate through the soil and reach the water table below providing recharge to the buried valley aquifer system. Thus, annual groundwater recharge for the Mad River stream gaging stations near Springfield, Eagle City, and Urbana are significantly higher than stream gaging stations with drainage areas that don't possess these hydrologic characteristics (see Appendix C, RORA Calculated Groundwater Recharge Data). The Bokengahalas Creek Watershed has a much smaller drainage area than the Mad River

Watershed, but it too possesses buried valley aquifer sands and gravels along the course of Bokengahalas Creek which are easily recharged by precipitation.

How Groundwater Recharge is Estimated

MCD uses the USGS software programs RECESS and RORA to estimate the groundwater recharge to aquifers in watersheds upstream of each of the 12 stream gaging stations in the Great Miami River Watershed. The programs utilize streamflow records to define a master recession curve for the watershed of interest and then estimate groundwater recharge using the recession-curve-displacement method (Rutledge, 1998; Rutledge, 2000). This technique is appropriate for watersheds characterized by diffuse areal recharge to the aquifer and all or most of the groundwater discharges to a stream. Regulation and diversion of streamflow should be negligible, and the stream gaging station at the downstream end of the watershed should measure all or most of the flow leaving the watershed. These conditions were met for the watersheds analyzed in this report.

Figure 17 – 2015 Groundwater Recharge to Aquifers



2015 Groundwater Levels

The groundwater level data collected in 2015 illustrates that groundwater in shallow observation wells near rivers often fluctuate and mimic trends in river flows. Groundwater levels rise when the river flows increase during runoff events, and fall when the river flows recede. This reflects the interaction between surface water and groundwater in the Great Miami River Watershed.

Ninety-two wells were observed to analyze groundwater levels and changes in groundwater storage (see Figure 18). Of those wells, 60 are installed in buried valley sand and gravel deposits, and 32 are screened in upland glacial sediment aquifers surrounding the buried valley system.

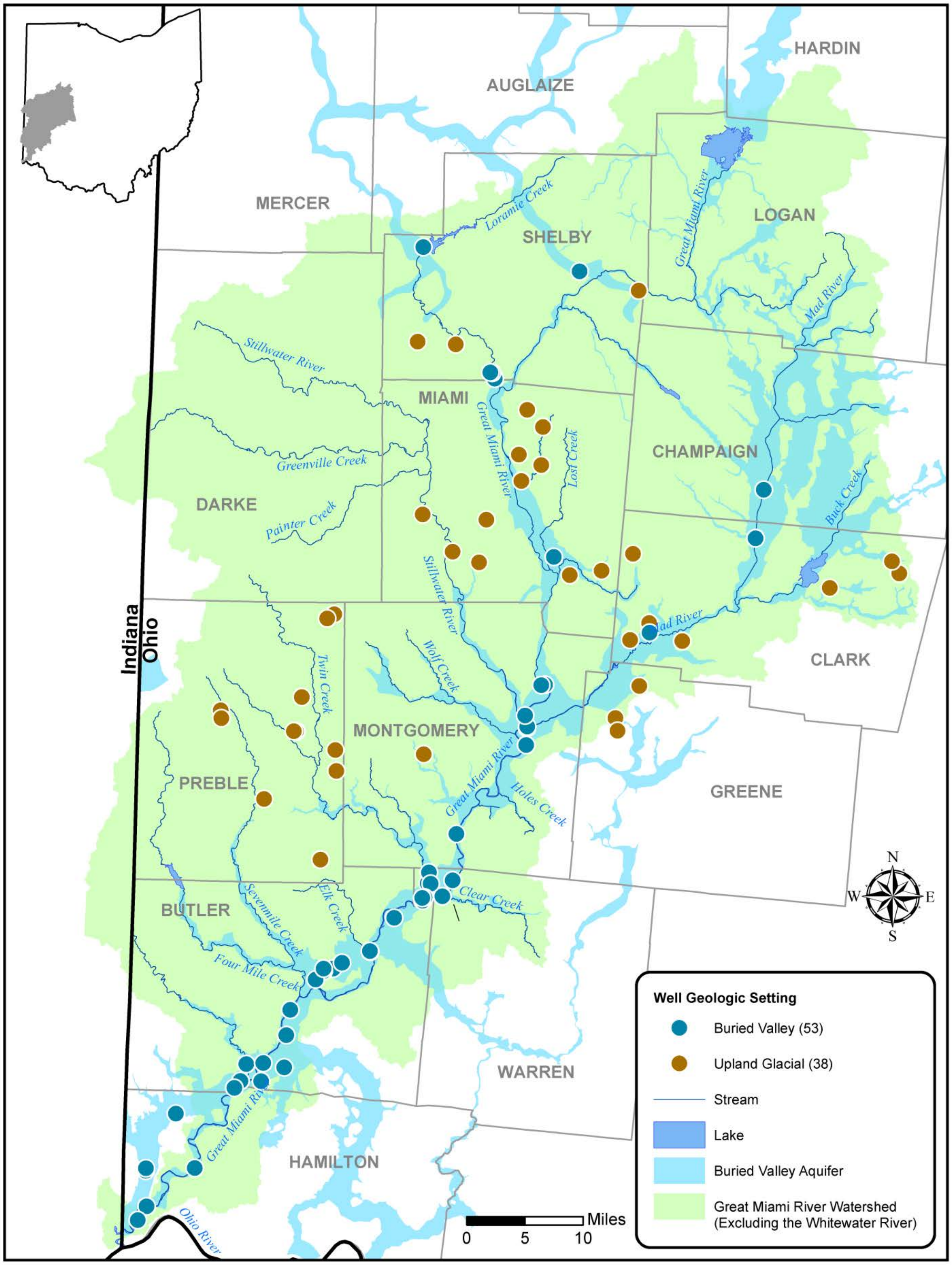
Groundwater levels at 30 selected observation well sites are shown in Appendix D, Groundwater Observation Well Hydrographs. The hydrographs in Appendix D are representative of 2015 groundwater levels in the buried valley aquifer. The wells were selected because they are installed in the buried valley aquifer, have loggers with complete or near complete records for 2015, and are located near stream gages which allows for comparisons between groundwater levels and river flows. Many of the hydrographs also show river discharge at the nearest gaging station. Hydrographs for observation wells near rivers show peak 2015 groundwater levels closely associated with higher flow events in the river. For example, a number of high flow events occurred from March through July, and groundwater levels for wells near the river tend to show groundwater level peaks coinciding with these high flow events.

In contrast, groundwater levels at Wells MT-6, MT-426, and MON00007 in downtown Dayton show peak groundwater levels occurring in March and April followed by a steady decline until September. These three wells are influenced by seasonal pumping for geothermal cooling systems or the Riverscape MetroPark fountains which also use groundwater. Furthermore, wells MT-426 and MON00007 are installed at greater depths than most of the other observation wells and groundwater levels measured in these wells do not respond to changes in river flow to the same extent as many of the other observation wells. The combination of heavy spring and summer pumping and greater well depths for two of the three wells gives rise to a different seasonal pattern of groundwater level fluctuations than other wells in the network.

In a typical year, groundwater levels tend to rise from December through May. By June groundwater levels at most observation wells begin to decline, reaching their lowest levels in November or December. The seasonal groundwater level pattern for 2015 was a little different due to above-normal precipitation occurring in June and July.

Statistical plots are also shown in Appendix D for 13 selected observation wells with 10 or more years of record. The wells were selected because they represent general groundwater conditions in the buried valley aquifer. The plots show how 2015 groundwater levels compare with period of record percentile ranges for each well. In general, groundwater levels started 2015 at below to slightly below normal levels and finished the year at much higher than normal levels. Groundwater levels at most observation wells were also much higher than normal during the months of June and July due to the large amount of precipitation which occurred during those months. A large precipitation event near the end of December resulted in rapid rises in groundwater levels at most of the 13 observation wells at the end of 2015. Prior to that precipitation event, groundwater levels at most of the 13 observation wells measured in the slightly below-normal to normal range.

Figure 18 – Locations of wells used for the analysis of 2015 groundwater levels



2015 Groundwater Storage

In 2015, there was a small net gain in groundwater stored in aquifers in the Great Miami River Watershed from the beginning to the end of the year. The change in groundwater storage (ΔS_g) in 2015 was estimated for each observation well by multiplying the change in groundwater level (ΔH) from the beginning to the end of the year by a storage coefficient (S) as stated in the following equation:

$$\Delta S_g = \Delta H(S)$$

In this report, ΔH is defined as the difference between the first January and the last December groundwater level measurement at a particular observation well in 2015. ΔH is highly variable among observation wells (see figure 19). Most of the 92 observation wells recorded groundwater level rises of 1 to 3 feet in 2015. However, there were some locations that had small (≤ 2ft) declines for ΔH in 2015. Some of these sites are located near pumping wells and may reflect changes in pumping conditions.

For this report, values of 0.10 and 0.0006 are used as estimates of the storage coefficient for unconfined and confined sand and gravel aquifers based upon values reported in Joseph & Eberts (1994) and Spieker (1968).

Appendix E shows computations of ΔS for each of the 92 observation wells used to estimate mean groundwater storage for the watershed. The observation wells were divided into two categories, buried valley aquifer or upland glacial sediment aquifer, based upon the aquifer the well was screened in. The mean 2015 groundwater ΔH for the buried valley aquifer wells is 2.3 ft. The mean 2015 groundwater ΔH for wells installed in upland glacial aquifers is 1.2 ft. The positive values reflect an increase in groundwater levels in both aquifer systems from the beginning to the end of 2015. Differences in groundwater mean ΔH between the two aquifer systems are largely due to the following factors:

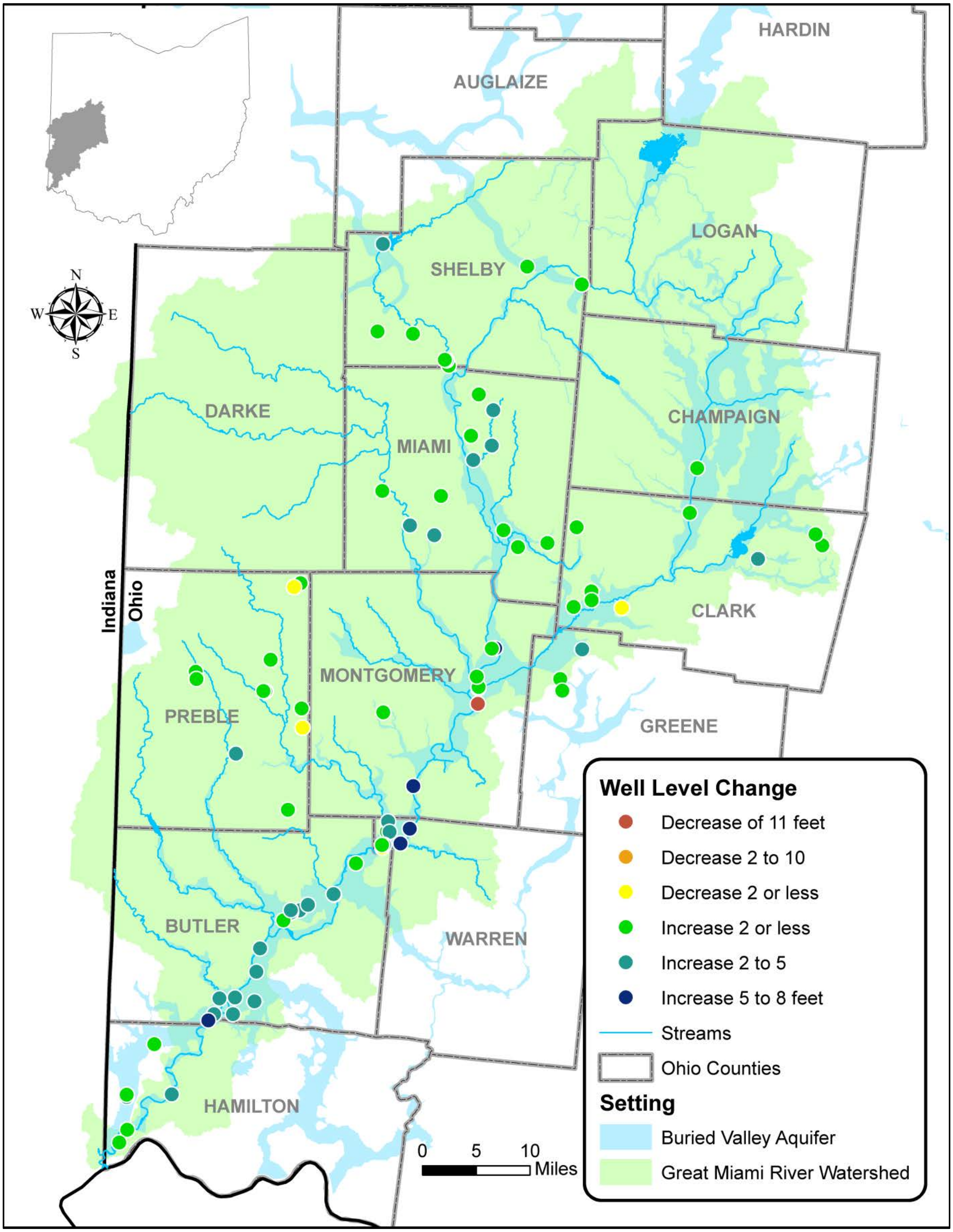
1. Buried valley aquifers tend to be thicker and more aerially extensive than upland glacial sediment aquifers.

2. The buried valley aquifer system occurs at lower elevations and is a focal point for surface runoff from surrounding upland areas.

3. Buried valley aquifers are often hydraulically connected with the Great Miami River and tributary streams which serve as important recharge boundaries near municipal wellfields.

4. Much of the buried valley aquifer system is unconfined and has a larger storage coefficient and greater ability to store water.

Figure 19 – Net change in groundwater levels from beginning to the end of 2015



Confined or unconfined aquifer determinations for each well are based upon analysis of well logs, groundwater level and temperature records, and regional aquifer studies. The mean change in groundwater storage for the Great Miami River Watershed is estimated by computing a weighted average of ΔS_g for the buried valley and upland glacial aquifer observation wells. The weighted average is based upon the land surface area of the buried valley aquifer system (350 mi^2) versus the land surface area of the upland glacial aquifer system (3542 mi^2). Mean ΔS_g for buried valley and upland glacial aquifers is estimated at 2.6 and 0.3 in respectively. The estimated 2015 mean groundwater ΔS_g for the entire Great Miami River Watershed is 0.5 in.

2015 Water Budget for the Great Miami River Watershed

A water budget is a quantitative statement of the balance between water gains and losses over a period of time. The water budget for the Great Miami River Watershed can be expressed using the following equations,

$$\text{Inflows} = \text{Outflows} \pm \Delta\text{Storage}$$

or

$$P = R + C + U \pm \Delta S_s \pm \Delta S_g + ET \qquad (1)$$

Where:

P = precipitation
R = runoff from surface water and groundwater
C = consumptive water losses from human activity
U = subsurface underflow of groundwater
ΔS_s = change in soil moisture
ΔS_g = change in groundwater storage
ET = evapotranspiration

In 2015, the total water inflow into the Great Miami River Watershed from precipitation (P) was 45.26 inches.

Outflows for the watershed included surface runoff estimated at 10.60 inches and base flow runoff estimated at 7.70 inches for a total runoff (R) of 18.30 inches based upon streamflow data collected at the Hamilton gaging station.

At the time this report was finalized, consumptive losses (C) from water use in 2015 were not available from ODNR's Division of Soil and Water Resources. However, water use estimates obtained for years 2008-2014 suggest consumptive losses are only a minor component of the water budget and account for on average 21,449 million gallons of water outflow per year (see Appendix F). This equates to about 0.34 inches of outflow per year on average. Consumptive loss coefficients in Appendix F were obtained from Shaffer & Runkle (2007). Consumptive losses in the Great Miami River Watershed are minimized because most of the water withdrawn is returned to the watershed as wastewater return flow.

MCD estimated subsurface underflow (U) of groundwater at the Hamilton gaging station by using the formula,

$$U = T \cdot I \cdot L \qquad (2)$$

Where:

T = buried valley aquifer transmissivity
I = the hydraulic groundwater gradient
L = width of the buried valley aquifer

Aquifer pump tests by USGS near the Hamilton North wellfield determined a transmissivity (T) of 50,000 ft^2/day for the semi confined portion of the buried valley aquifer system (Sheets & Bossenbroek, 2005). This value agrees with previous estimates for aquifer transmissivity by Spieker (1968). The hydraulic gradient of the buried valley aquifer system at the Hamilton gaging station is estimated from potentiometric surface maps produced by MCD in 2007. The hydraulic gradient is estimated at 0.0017. The width of the buried valley aquifer system at the Hamilton gaging stations was obtained from GIS overlays of the buried valley aquifer and determined to be approximately 8,625 feet.

Substituting values for T, I, and L into equation (2) yields a value of 733,125 ft^3/day for U. Converting U to inches of water over the entire watershed per year yields a value of 0.03 inches which is negligible when compared to other outflows. U is assumed to be fairly constant from year to year.

Soil moisture and changes in soil moisture (ΔS_s) are difficult to measure from month to month. The water budget in this report is calculated on an annual basis with the start and end of the water budget year occurring in early winter when soil moisture tends to be at field capacity or fully saturated. Since the water budget cycle begins and ends when soils are saturated ΔS_s is assumed to be near zero.

Changes in groundwater storage (ΔS_g) during 2015 were discussed previously. ΔS_g for 2015 is estimated to be 0.5 inches.

Evapotranspiration (ET) losses for 2015 were not directly measured. However, by rearranging equation (1) to solve for ET, an estimate can be made,

$$ET = P - (R + C + U \pm \Delta S_s \pm \Delta S_g) \qquad (3)$$

Substituting known values rounded to the nearest tenth and assuming that C and U are negligible when compared to other outflows and ΔS_s is zero, equation 3 simplifies to

$$ET = 45.3 - (18.3 + 0.3 + 0.5)$$
$$ET = 26.2 \text{ inches}$$

The estimated 2015 water budget for the Great Miami River Watershed indicates that outflows from evapotranspiration, runoff, and consumptive use were slightly less than inflows from precipitation resulting in a net water storage gain for aquifers (see Table 2).

Table 2 – 2015 water budget summary

Inflow	**Watershed Area (mi²)**	**Inches**	**Acre-feet**	**Gallons**
Precipitation (P)	3630	45.3	8,770,080	2,857,743,096,673
Outflows	**Watershed Area (mi²)**	**Inches**	**Acre-feet**	**Gallons**
Evapotranspiration (ET)	3630	26.2	5,064,576	1,650,299,324,701
Total Runoff (R)	3630	18.3	3,542,880	1,154,452,509,252
a. Surface Runoff	3630	10.6	1,535,248	500,262,754,009
b. Base Flow Runoff	3630	7.7	1,490,720	485,753,241,598
Consumptive Use (C)	3630	0.3	65,824	21,448,844,434
Total Outflow	3630	44.8	8,673,280	2,826,200,678,388
Groundwater Storage	**Watershed Area (mi²)**	**Inches**	**Acre-feet**	**Gallons**
Groundwater Storage (ΔS_g)	3630	0.5	96,800	31,542,418,286

Summary of 2015 Water Quantity Data

In general, water budget inflows and outflows were above average in 2015. Of the 45.26 inches of precipitation received in the Great Miami River Watershed, an estimated 18.30 inches flowed out of the Great Miami River Watershed as surface and base flow runoff. The average groundwater recharge in the Great Miami River Watershed is estimated at 8.56 inches. In general, the buried valley aquifer received most of its recharge in 2015 between the months of March and July with a final recharge event at the end of December to close out the year. The total amount of recharge received by the buried valley aquifer was close to normal, and groundwater levels ended 2015 at much higher than normal levels.

The year 2015 can probably best be described as a wetter than normal year in terms of hydrologic conditions. Recent trends in hydrologic data for the Great Miami River Watershed indicate a tendency toward wetter than normal conditions. Above normal precipitation occurred in seven out of the 10 years from 2000-2009. Increasing trends are present in annual runoff, mean daily flows, and seven-day low flows for the Great Miami River Watershed. Climate variability and changes in water use may be contributing to these trends.

WATER QUALITY

Groundwater and surface water in the Great Miami River Watershed are connected. Water is continuously exchanged among rivers, streams, and the underlying aquifers. Degradation of water quality in streams can threaten aquifers and vice versa. MCD strives to increase regional understanding of water quality conditions in surface water and groundwater resources and has managed a surface water quality monitoring program focused on nutrients in the Great Miami River Watershed since 2006.

The interaction between groundwater and surface water can increase the transport of nutrients as well as other contaminants by creating contaminant fluxes from groundwater to surface water and vice versa. For example, groundwater comprises much of the flow in the Great Miami River at certain times of the year when low flow conditions are present. Under these conditions, nutrients transported by groundwater may comprise a significant part of the nutrient loads carried by the river or stream. Conversely, during times of the year when flows are high, most of the nutrient load originates as runoff from land. At that time, the river or stream may act as a temporary source of nutrients into the groundwater.

Municipal drinking water wells that are installed in the buried valley aquifers along the Great Miami River floodplain often induce recharge from the river into the groundwater. For example, the City of Dayton utilizes recharge lagoons which enhances infiltration of surface water from the Great Miami and Mad rivers into the buried valley aquifer system. Induced aquifer recharge and recharge lagoons are potential pathways for contaminants in local rivers to be transported into the aquifer system and into drinking water wells. Monitoring nutrients and other contaminants in rivers and streams is a key component to understanding groundwater health and potential pollution concerns.

Nutrient Monitoring in Surface Water

MCD operates and maintains four nutrient monitoring stations in the Great Miami, Stillwater, and Mad rivers (see Table 3). In 2015, samples for nitrogen and phosphorus analysis were collected at all four locations (see Figure 20).

- Stillwater River at Englewood provides data for the Stillwater River Watershed upstream of Englewood Dam.
- Great Miami River at Huber Heights provides data for the Upper Great Miami River Watershed.
- Mad River near Dayton provides data for the Mad River Watershed.
- Great Miami River near Fairfield provides data for the entire Great Miami River Watershed upstream of the gaging station at Hamilton, Ohio.

Also funded by MCD, a fifth nutrient monitoring station in the Great Miami River Watershed is operated and maintained by Heidelberg University. It is located on the Great Miami River at Miamisburg. This station is part of Heidelberg's Ohio Tributary Monitoring Program and has been in operation since 1996. Data collection on the Great Miami River at Miamisburg station followed the procedures outlined in the chemical monitoring sections of a U.S. EPA-approved Quality Assurance Project Plan (QAPP) (Baker, 2009).

Data collection at the four MCD monitoring stations is conducted according to an Ohio EPA-approved Level 3 Project Study Plan and Quality Assurance Project Plan (QAPP) under the Ohio Credible Data Program. MCD staff retrieves water samples from the automated samplers weekly and then delivers select samples to a laboratory for chemical analysis. The laboratory analyzes the water for ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total phosphorus, orthophosphate, and total suspended solids.

Ohio's Water Quality Standards

The OEPA conducts biological and water quality studies on select rivers and streams in the Great Miami River Watershed to determine whether or not they meet state water quality standards. OEPA does not monitor each river annually.

OEPA divides the Great Miami River Watershed into eight different study areas. The mainstem of the Great Miami River is divided into three study areas: upper, middle, and lower. The study area of the Upper Great Miami River extends from the headwaters of Indian Lake downstream to Quincy. OEPA most recently studied the Upper Great Miami River in 2008 and previously in 1996.

The study area of the Middle Great Miami River extends from Quincy downstream to the confluence of the Mad River in Dayton. OEPA most recently studied the Middle Great Miami River in 2009 and previously in 1995.

The study area of the Lower Great Miami River extends from Dayton downstream to the Ohio River. OEPA studied the Lower Great Miami River in 2010 and previously in 1995.

The OEPA uses biological use designations—Exceptional Warmwater, Warmwater, Modified Warmwater and Coldwater—to set statewide water quality standards for rivers and streams. The use designations are defined in Ohio Administrative Code (OAC) 3745-1-07 as follows:

> *Exceptional Warmwater* – waters capable of supporting and maintaining exceptional or unusual communities of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the seventy-fifth percentile of the identified reference sites on a statewide basis.
>
> *Warmwater* – waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within each of the ecoregions in Ohio.
>
> *Modified Warmwater* – waters that have been the subject of a use attainability analysis and have been found to be incapable of supporting and maintaining a balanced,

integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat.

Coldwater – waters which support trout stocking and management under the auspices of ODNR's Division of Wildlife, excluding waters in lake run stocking programs, lake or reservoir stocking programs, experimental or trial stocking programs, and put and take programs on waters without or without the potential restoration of natural coldwater attributes of temperature and flow.

The 2008 OEPA study of the Upper Great Miami River concluded that the Great Miami River attained or partially attained Warmwater habitat standards. When impairments were identified, they tended to be on tributary streams and upstream of impounded areas of the river, such as upstream of lowhead dams (OEPA, 2011).

The 2009 OEPA study on the Middle Great Miami River concluded that a majority of the river miles of the mainstem of the Great Miami River between Quincy and Dayton met exceptional warmwater habitat standards (OEPA, 2011 and 2013a). OEPA concluded that high quality stream channel, and riparian corridor habitat and influx of groundwater as baseflow combine to give much of the Middle Great Miami River a high assimilative capacity for nutrients. When impairments occur on the Great Miami River upstream of Dayton, they tend to be associated with poor habitat conditions, the presence of lowhead dams, or acute localized impacts from wastewater discharges.

The 2010 OEPA study of the Lower Great Miami River concluded that most of the Lower Great Miami River met warmwater biological use standards, but significant impacts associated with nutrient enrichment were noted (OEPA, 2012). The Qualitative Habitat Evaluation Index (QHEI) scores for many of the sampling sites on this section met exceptional warmwater habitat criteria. Yet, biological index scores were not high enough for exceptional warmwater habitat designation by OEPA. Nutrient enrichment was determined by OEPA to be the primary reason for the underperformance of fish and macroinvertebrate communities.

Elevated levels of nutrients (nitrogen and phosphorus) are widespread in the surface water and groundwater of the Great Miami River Watershed. Nutrients enter water from numerous sources including discharges from municipal wastewater treatment plants, runoff from urban and agricultural land, discharges from drainage tiles in agricultural fields, and infiltration of nutrients into groundwater from agriculture and failing septic systems.

Nutrient enrichment occurs when excessive amounts of nitrogen and phosphorus are present in the water column of lakes, rivers, and streams. Excessive nutrients in natural water systems can over stimulate the growth of phytoplankton and periphyton such as algae and cyanobacteria. When phytoplankton and periphyton growth is overstimulated, it can disrupt aquatic ecosystems and cause biological impairment. The OEPA reports that nutrient concentrations in the water column of the Great Miami River and its tributaries frequently indicated enrichment. According to OEPA, when nutrient enrichment co-occurs with aquatic habitat degradation, it is a leading cause of impairment.

Ohio's Nutrient Standards

Currently, there are no statewide standards for in-stream nutrient concentrations in Ohio but there is language in the administrative code that states phosphorus should be limited to the extent necessary to prevent nuisance growths of algae and weeds (Administrative Code, 3745-1-04, Part E).

Research conducted by OEPA suggests significant correlations exist between phosphorus and the health of aquatic ecosystems (Miltner and Rankin, 1998). Biological community performance is highest when phosphorus concentrations are lowest in headwater and wadeable streams (Miltner and Rankin, 1998). Furthermore, the lowest phosphorus concentrations are often associated with the highest quality habitats.

In the study of the association among nutrients, habitat, and biota in rivers and stream, OEPA researchers propose a tiered or multi-criteria approach for evaluating impacts of nutrients on attainment of water quality standards (Ohio Environmental Protection Agency, 1999). Table 3 lists the recommended statewide nutrient target concentrations (Ohio Environmental Protection Agency, 2013b).

More recently, the OEPA's Nutrient Reduction Strategy (Ohio Environmental Protection Agency, 2013b) proposes pairing nutrient concentration data with biological data to determine attainment of water quality standards. Exceedances of statewide nutrient target concentrations alone would not necessarily trigger a violation of water quality standards.

Table 3 – Proposed statewide nutrient target concentrations for rivers and streams in Ohio

Stream Type	Drainage Area (mi^2)	EWH* TP* (mg/L)	WWH* TP* (mg/L)	EWH* Nitrate + Nitrite (mg/L)	WWH* Nitrate + Nitrite (mg/L)
Headwaters	< 20	0.05	0.08	0.50	1.0
Wadable	20 - < 200	0.05	0.10	0.50	1.0
Small River	200 - < 1000	0.10	0.17	1.0	1.5
Large Rivers	> 1000	0.15	0.30	1.5	2.0

*EWH – rivers and streams that are designated as exceptional warmwater habitat
*WWH – rivers and streams that are designated as warmwater habitat
*TP – total phosphorus
Nutrient target concentrations obtained from Tables 1 and 2 of Ohio Environmental Protection Agency, 1999.

Figure 20 – Locations of MCD and Heidelberg nutrient monitoring stations

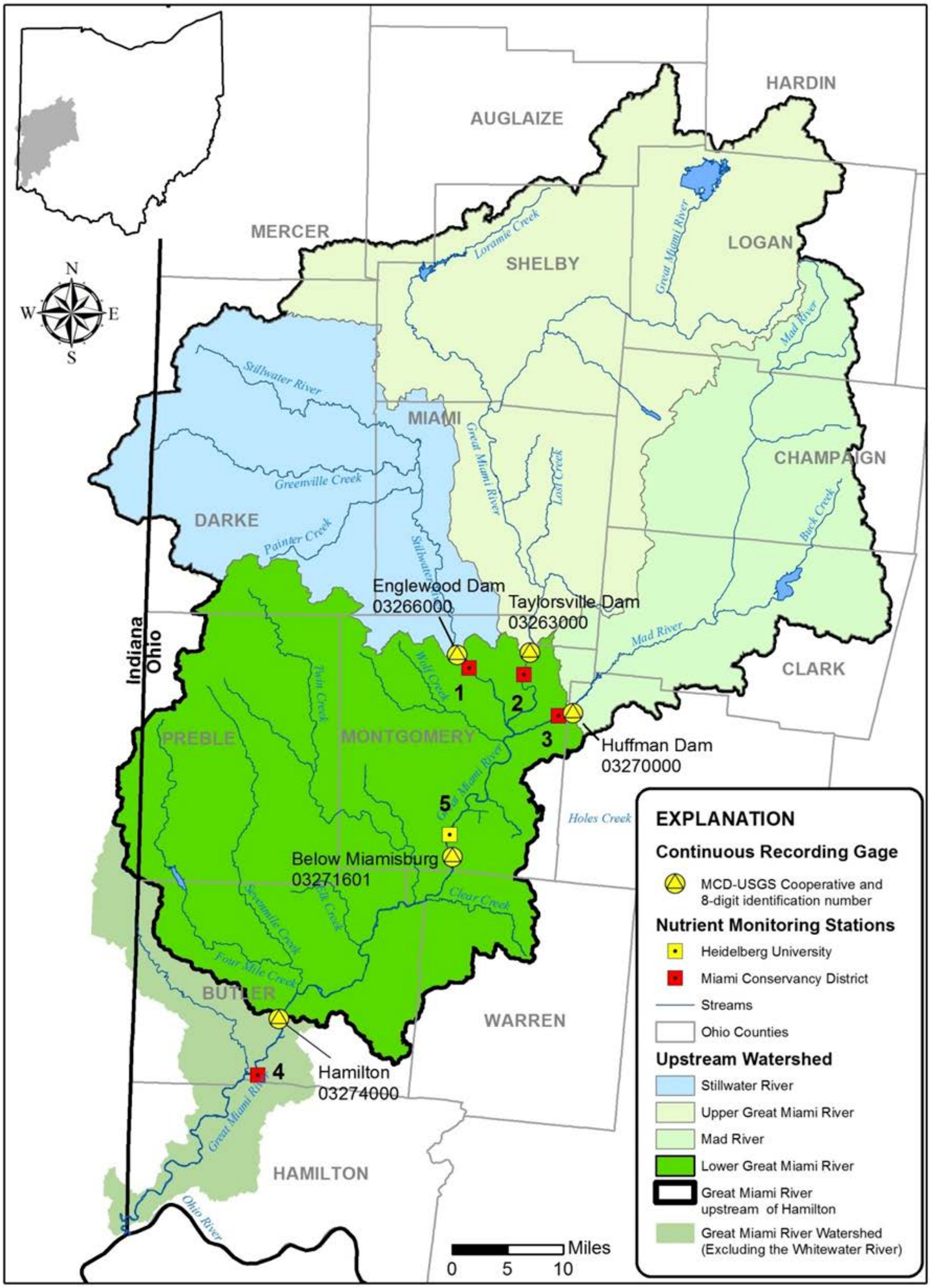


Table 4 – Attribute data for nutrient monitoring stations

Location Map Number	Monitoring Station Name	Nearest USGS Stream Gage	USGS Gage ID	Drainage Area (mi^2)
1	Stillwater River at Englewood	Stillwater River at Englewood	03266000	650
2	Great Miami River at Huber Heights	Great Miami River at Taylorsville	03263000	1,149
3	Mad River near Dayton	Mad River near Dayton	03270000	635
4	Great Miami River near Fairfield	Great Miami River at Hamilton	03274000	3,630
5	Great Miami River at Miamisburg	Great Miami River below Miamisburg	03271601	2,715

2015 Nutrient Concentrations

In 2015, median and mean concentrations of nitrate + nitrite exceeded the Ohio Environmental Protection Agency (OEPA) proposed nutrient target concentrations at all sampling stations (see Appendix G). The highest observed concentration for nitrate + nitrite in 2015 was 15.20 mg/L in a sample collected from the Great Miami River at Huber Heights, Ohio. As reference, this concentration also exceeded the drinking water primary maximum contaminant level (MCL) of 10 mg/L.

Total nitrogen concentration and river discharge plots for each of the sampling stations are shown in Appendix H. The plots illustrate how total nitrogen concentrations tend to rise quickly during a runoff event. As the runoff event ends, total nitrogen concentrations quickly decrease back to normal levels. The highest total nitrogen concentrations measured in 2015 tended to occur during spring and early summer runoff events, but high concentrations associated with runoff can occur at any time of the year.

Median concentrations of total phosphorus samples collected in 2015 were below the OEPA-recommended nutrient target concentration at the Mad River near Dayton, Great Miami River at Miamisburg, and at the Great Miami River near Fairfield stations. However, mean total phosphorus concentrations exceeded OEPA-recommended target concentrations at every station except the Great Miami River near Fairfield station. The highest total phosphorus concentration measured was 1.24 mg/L in a sample collected from the Great Miami River at Huber Heights station.

Total phosphorus concentrations and river discharge plots are illustrated in Appendix H. The levels of total phosphorus also tend to rise sharply with runoff events throughout the year at all five nutrient monitoring stations. When the runoff events end, total phosphorus concentrations tend to quickly decline.

Total phosphorus concentrations also tend to rise during prolonged periods of lower flows in rivers which typically occur during the summer and early fall. This trend is particularly pronounced in the data collected from the Great Miami River at Miamisburg, and Great Miami River near Fairfield stations. Increases in total phosphorus during lower river flows are most likely due to discharges from wastewater treatment plants. Generally, the observed rise in total phosphorus concentrations during low flows is not as great in magnitude as during large runoff events.

2015 Annual Nutrient Loads

For the purpose of this report, nutrient load is defined as the quantity of nutrients flowing out of a particular watershed in a given period of time (usually one year). Nutrient loads are useful for quantifying the net export of nutrients to receiving waterbodies downstream of a watershed. Nutrient loads for the Great Miami River Watershed and its principal tributary watersheds are tabulated in Appendix J.

Total nitrogen and dissolved inorganic nitrogen loads measured in 2015 for the Stillwater River, Upper Great Miami River, and Mad River watersheds were below average for the period between 2006 and 2015. However total and dissolved inorganic load estimates for the Lower Great Miami River Watershed were above average. Overall, total and dissolved inorganic nitrogen load estimates for the entire Great Miami River Watershed upstream of Hamilton were slightly above period of record averages (see Appendix J).

Estimated total phosphorus loads for the Stillwater and Lower Great Miami River watersheds were below average while total phosphorus loads for the Upper Great Miami River and Mad River watersheds were slightly above average. Overall, the total phosphorus load estimate for the entire Great Miami River Watershed upstream of Hamilton was slightly below the period of record average.

The estimated 2015 annual loads for the entire Great Miami River Watershed upstream of Hamilton are: 22,161 metric tons of total nitrogen, 14,820 metric tons of dissolved inorganic nitrogen and 1,730 metric tons of total phosphorus. Estimated 2015 annual loads for the Great Miami River Watershed upstream of Hamilton were very close to average for the time period of 2007 – 2015 for which the Great Miami River near Fairfield station has been in operation. Nutrient load data for the Great Miami River Watershed upstream of Hamilton does not suggest the presence of any strong upward or downward trends in nutrient loading.

How Annual Loads are calculated

The annual load for a pollutant in a river or stream is defined as the total mass of that pollutant transported by the river or stream in a given year. Calculation of a pollutant load requires information on the streamflow, pollutant concentration, and time window for which the streamflow and pollutant concentration data is to be applied. The pollutant loads are calculated using a numeric integration approach (Richards, 1998). Mathematically, an annual load for nutrients is estimated by using the equation:

$$\text{Load} = k\sum^{n} c_i q_i t_i$$

$i=1$

Where k is a constant used to convert units to metric tons per year, c_i is the ith observation of concentration, q_i is the corresponding observation of flow, and t_i is the time interval represented by the ith sample.

The total nitrogen concentrations were estimated for this report by adding sample concentrations of ammonia, nitrite, nitrate, and total Kjeldahl nitrogen. Dissolved inorganic nitrogen concentrations were estimated by adding sample concentrations of ammonia, nitrite, and nitrate. Total phosphorus concentrations were measured directly from water samples. Lower Great Miami River Watershed loads were estimated by subtracting measured total nitrogen and phosphorus loads at the Stillwater River at Englewood, Great Miami River near Huber Heights, and Mad River near Dayton stations from the Great Miami River near Fairfield station.

2015 Annual Nutrient Yields

Nutrient yield is defined as the quantity of nutrients flowing out of a particular watershed per unit area of the watershed. The size of a watershed can overshadow the effects that land use and the physiography have on loads because large watersheds contribute large loads due to their high volume of runoff (Reutter, 2003). In other words, a big watershed is likely to have a larger pollutant load than a small watershed regardless of land use differences between the two watersheds. The impacts of land use and physiography on nutrient loads in various watersheds are often better observed when yields as opposed to loads are compared. Annual yields for the Great Miami River Watershed and its principal tributary watersheds are tabulated in Appendix K.

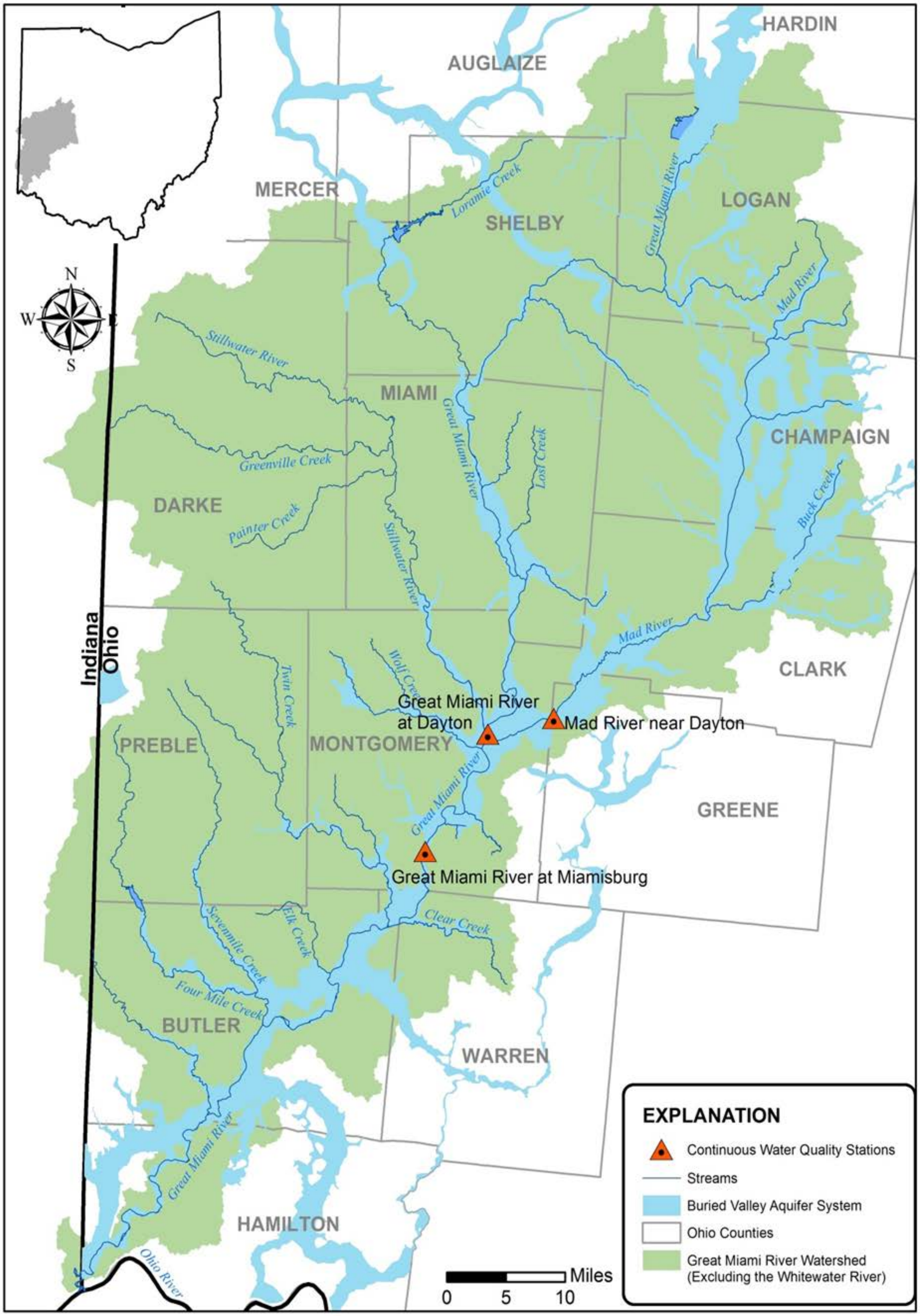
Total nitrogen, dissolved inorganic nitrogen, and total phosphorus yields for the Great Miami River Watershed upstream of Hamilton were estimated at 2,357, 1,576, and 184 kg/km^2 respectively. For 2015, the Lower Great Miami River Watershed had the highest total nitrogen, dissolved inorganic nitrogen, and total phosphorus yields in comparison to the other subwatersheds that make up the Great Miami River Watershed upstream of Hamilton. The Mad River Watershed had the lowest total nitrogen (1,723 kg/km^2) and dissolved inorganic nitrogen (1,126 kg/km^2) yields while the Stillwater River Watershed had the lowest total phosphorus yield (81 kg/ km^2).

How Annual Yields are calculated

The yield of a watershed is computed by dividing the pollutant load by the watershed area. Total nitrogen, dissolved inorganic nitrogen, and total phosphorus yields were computed for all five nutrient monitoring stations, and used to determine subwatershed yields

2015 Temperature, pH, Dissolved Oxygen, and Chlorophyll

MCD partners with YSI Inc., a Xylem brand, to access data collected by multi-parameter sensors (sondes) deployed at the Mad River near Dayton monitoring station and the Great Miami River at Miamisburg monitoring station. YSI also installed monitoring equipment in the Great Miami River at Dayton near Helena Street (see Figure 21). All three sondes are in impounded areas behind lowhead dams. The sondes measure water temperature, specific conductance, pH, chlorophyll, dissolved oxygen, and turbidity at hourly intervals. The data helps track changes in water chemistry that result from changes in the algal biomass in the water column (sestonic) and on the river bottom (benthic). Time-series plots of water temperature, dissolved oxygen levels, pH, and chlorophyll measured at the three sites from June 1 to October 30 can be found in Appendix L.


HARDIN
AUGLAIZE
MERCER
SHELBY
LOGAN
Loramie Creek
Great Miami River
Mad River
Stillwater River
MIAMI
CHAMPAIGN
Greenville Creek
Lost Creek
DARKE
Painter Creek
Buck Creek
Stillwater River
Mad River
Indiana
Ohio
Twin Creek
Wolf Creek
CLARK
Great Miami River at Dayton
Mad River near Dayton
PREBLE
MONTGOMERY
GREENE
Great Miami River
Great Miami River at Miamisburg
Sevenmile Creek
Elk Creek
Clear Creek
Four Mile Creek
BUTLER
WARREN
Great Miami River
HAMILTON
Ohio River
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W
E
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Miles
0
5
10
EXPLANATION
Continuous Water Quality Stations
Streams
Buried Valley Aquifer System
Ohio Counties
Great Miami River Watershed (Excluding the Whitewater River)

Daily variations in dissolved oxygen and pH are caused by daily variations in water temperature and by algal photosynthesis and aerobic respiration. As water temperature rises, the solubility of oxygen decreases. As sunlight warms water during the day dissolved oxygen concentrations in the water decrease. As water temperatures cool overnight, dissolved oxygen concentrations increase.

Daily variations in dissolved oxygen due to photosynthesis and respiration are timed differently than daily variations due to daytime and nighttime temperature changes. Photosynthesis by algae and aquatic plants occurs in sunlight. Photosynthesis consumes carbon dioxide and releases oxygen into the water column causing an increase in the dissolved oxygen during the day. At night, the process of photosynthesis shuts down and algae and aquatic plants begin to consume oxygen through the process of respiration. Respiration consumes oxygen and releases carbon dioxide into the water column causing dissolved oxygen to decrease and carbon dioxide to increase. As carbon dioxide in the water increases the water becomes more acidic. This causes pH to decrease.

As the algal biomass in the river increases, daily variations in dissolved oxygen tend to increase and overwhelm the influence of daily temperature swings. According to OEPA daily variations in dissolved oxygen should remain less than 6 mg/L (OEPA, 2013c). Daily variations in dissolved oxygen greater than 6 mg/L are indicative of eutrophic conditions. Increases in sestonic algae result in higher concentrations of chlorophyll in the water column. The sondes measure chorophyll in the water column. This data documents how the river ecology responds to elevated nutrient levels. The data is recorded and delivered to the YSI EcoNet website remotely. Realtime data is accessed at:
www.ysieconet.com/public/WebUI/Default.aspx?hidCustomerID=73.

The sondes deployed at the Great Miami River at Miamisburg and the Mad River near Dayton monitoring stations were operational throughout the entire five month period. However, dissolved oxygen measurements were not collected at Miamisburg from June 1 to July 10, and chlorophyll measurements were not collected at the Mad River near Dayton from June 1 to July 10. The sonde deployed at the Great Miami River at Dayton was not operational from July 18 to August 13 due to equipment malfunction.

The data illustrates a striking difference in algal biomass indicators between the Mad River near Dayton monitoring station and at the two Great Miami River monitoring stations. The concentrations of chlorophyll were significantly higher in the Great Miami River, which suggests greater algal biomass. The nutrient data collected in 2015 also illustrates that total phosphorus and total nitrogen concentrations tend to be higher in the Great Miami River than in the Mad River. Higher nutrient concentrations in the water column combined with warmer water temperatures may give rise to greater algal biomass leading to eutrophic conditions.

Chlorophyll

The plots in Appendix L show sestonic chlorophyll concentrations exceeded 100 µg/L in the Great Miami River at Dayton and Miamisburg monitoring stations on multiple occasions during the summer and early fall. The highest sestonic chlorophyll concentration measured in the Great Miami River at Dayton monitoring station was 175 µg/L on September 20. The highest sestonic chlorophyll concentration measured on the Great Miami River at Miamisburg monitoring station was 381 µg/L on August 5. In contrast, sestonic chlorophyll concentrations measured at the Mad River near Dayton monitoring station were significantly lower.. The highest sestonic chlorophyll concentration measured at the Mad River near Dayton station was 28 µg/L on October 28.

For a watershed the size of the Great Miami River with total phosphorus concentrations averaging 0.2 to 0,3 mg/L, a typical range for mean sestonic chlorophyll levels is 20 to 60 µg/L (Van Niewenhuyse & Jones, 1996). Mean chlorophyll concentrations measured in the Great Miami River at the Dayton and Miamisburg monitoring stations were both computed at 34 µg/L and fell within this typical range. The mean sestonic chlorophyll concentration for the Mad River near Dayton monitoring station in 2015 was computed at 4 µg/L, which is significantly lower than the typical range (Van Niewenhuyse & Jones, 1996).

Dissolved Oxygen

The water quality standard for dissolved oxygen set by OEPA for warmwater habitat streams is a minimum of 4 mg/L. Summer and fall dissolved oxygen concentrations measured at the Mad River near Dayton monitoring station typically remained between 6 and 12 mg/L. The highest dissolved oxygen concentration measured in the summer of 2015 was 12.2 mg/L. Overall, dissolved oxygen levels met state water quality standards for warmwater habitat. Daily dissolved oxygen variations did not exceed 6 mg/L and were not indicative of eutrophic conditions for the Mad River near Dayton monitoring stations.

Summer and fall dissolved oxygen concentrations measured at the Great Miami River at Dayton monitoring station ranged between 6 and 26 mg/L. Maximum daily dissolved oxygen level variations exceeded 15 mg/L near the end of September. These large diurnal variations in dissolved oxygen corresponded with the highest chlorophyll concentrations. This suggests that sestonic algal biomass was a significant factor in controlling dissolved oxygen levels in the water. Minimum dissolved oxygen levels did not fall below 4 mg/L meeting state quality standards for warmwater habitat. Overall, daily dissolved oxygen variations for the Great Miami River at Dayton were indicative of eutrophic conditions.

Summer and fall dissolved oxygen concentrations measured in the Great Miami River at Miamisburg monitoring station ranged from 6 to 18 mg/L. Maximum daily dissolved oxygen level variations exceeded 10 mg/L near the end of September. The highest dissolved oxygen and chlorophyll concentrations occurred between August and late October. Daily dissolved oxygen variations for the Great Miami River at Miamisburg were indicative of eutrophic conditions.

Larger variations in dissolved oxygen concentrations were measured at the two Great Miami River monitoring stations which correlate well with increased chlorophyll concentrations. This is indicative of increased algal biomass in the river. The algal biomass at all three sites could be impacted by the presence of lowhead dams located downstream of the monitoring stations which create pools and slow water velocities potentially enhancing the growth of phytoplankton (Zhang, et al., 2015).

pH

The mean pH value measured at the Mad River near Dayton monitoring station was 8.27 standard units (s.u.) with a maximum value of 8.81 s.u. and a minimum value of 7.73 s.u. Mean pH measured at the Great Miami River at the Dayton monitoring station was recorded at 8.60 s.u. with a maximum of 9.83 s.u. and a minimum of 7.99 s.u. Mean pH for the Great Miami River at Miamisburg was 8.05 s.u. with a maximum of 8.74 s.u. and a minimum of 7.77 s.u. The Mad River station recorded the lowest variability in pH of the three monitoring stations. In general, the highest daily variations in pH tended to correspond with higher chlorophyll concentrations. This suggests photosynthesis by sestonic algae was a significant factor in controlling the pH of the water.

Temperature

The mean water temperature measured at the Mad River near Dayton monitoring station was 19.34 °C with a maximum value of 24.94 °C and a minimum value of 9.66 °C. The mean water temperature measured at the Great Miami River at Dayton monitoring station was 20.60 °C with a maximum value of 27.15 °C and a minimum value of 10.80 °C. The mean water temperature measured at the Great Miami River at Miamisburg monitoring station was 21.50 °C with a maximum value of 27.71 °C and a minimum value of 11.63 °C. Overall, the water temperatures measured at the Mad River monitoring station were lower than those measured at the two Great Miami River monitoring stations. Higher base flows in the Mad River from groundwater likely keep water temperatures significantly cooler than water temperatures in the Great Miami River. Cooler water temperatures may help in minimize daily dissolved oxygen variations and prevent dissolved oxygen levels from falling below state water quality standards.

Groundwater Quality Study

To evaluate groundwater quality in the buried valley aquifer, samples were collected from eight wells (see Figure 22). The wells selected for the study are installed in unconfined sand and gravel aquifers with permeable soils at the surface. Six of the eight wells were installed at shallow (< 50 feet) depths. Monitoring well depths and screened intervals are summarized in Table 5. All of the wells are surrounded by land use that has the potential to release contaminants into the aquifer. The goal of the study is to provide a better understanding of human impacts on groundwater quality across the buried valley aquifer.

Each well was equipped with a bladder pump installed within the screened interval of the well. The bladder pumps allow low-flow purging techniques to be used (Puls and Barcelona,1996).

Samples were collected on two occasions in 2015; once between May 28 and June 3 (spring 2015) and once between October 1 and 8 (fall 2015). The wells were sampled for a range of compounds including major ions, metals, pesticides, radionuclides, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). To evaluate laboratory precision, duplicate samples were collected at one location during each sampling event

.

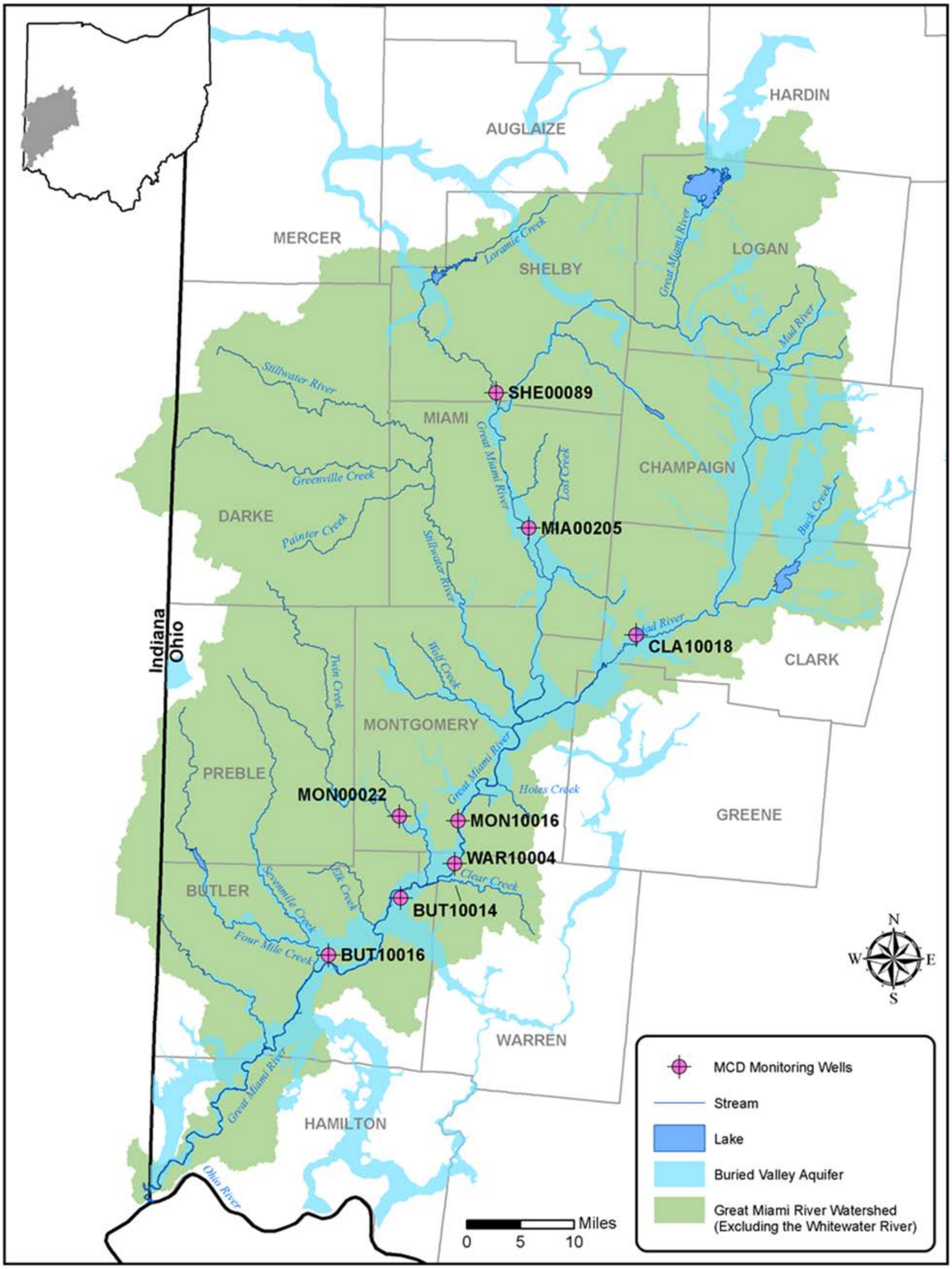
Table 5 – Construction details for groundwater quality monitoring wells

Monitoring Well ID	Casing Diameter (in)	Well Depth (ft)	Screened Interval (ft)	Aquifer Screened
BUT10014	2	40	35 - 40	Sand and Gravel
BUT10016	2	65	60 - 65	Sand and Gravel
CLA10018	2	16	11 - 16	Sand and Gravel
MIA00205	2	24	19 - 24	Sand and Gravel
MON00022	2	15	10 - 15	Sand and Gravel
MON10016	2	108	88 - 108	Sand and Gravel
SHE00089	2	43	38 - 43	Sand and Gravel
WAR10004	2	32.5	27.5 – 32.5	Sand and Gravel

Because Ohio does not have statewide standards for groundwater quality, as a benchmark MCD compared the results of this study to state drinking water standards. Drinking water standards are generally more stringent than other standards, so groundwater that meets drinking water standards should be suitable for other uses.

National Primary Drinking Water Regulations for parameters are legally enforceable standards by the USEPA that apply to public water systems. Primary standards set maximum contaminant levels (MCLs) that help protect public health by limiting the contaminant levels in drinking water. National Secondary Drinking Water Standards are advisable guidelines addressing secondary maximum contaminant levels (SMCLs) that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. The USEPA recommends, but does not require, that water systems incorporate secondary standards. The USEPA Office of Water also publishes non enforceable health-based screening levels (HBSLs) for some constituents which may pose potential human-health concerns but do not yet have an enforceable standard. HBSLs are used as a supplement for evaluating contaminants in drinking water in a human-health context.

Figure 22 – Locations of groundwater quality monitoring well sites



2015 Groundwater Quality Study Results

Complete analytical results can be found in Appendix M, Ground Water Quality Data. In summary, the results of the groundwater quality study show that samples collected from six of the eight monitoring wells met all human health-based drinking water standards including MCLs and HBSLs. Samples collected from monitoring well BUT10014 exceeded the MCL for Trichloroethene, and samples collected from monitoring well BUT10016 exceeded the HBSL for Manganese. Trichloroethene and manganese were the only constituents detected at concentrations exceeding human-health-based drinking water standards. Samples collected from five of the eight monitoring wells exceeded an SMCL for at least one constituent (see Table 6). Contaminants present at concentrations exceeding SMCLs included iron, manganese, and total dissolved solids. There were also detections of contaminants in at least one sample at concentrations that did not exceed any regulatory standards. These contaminants included the compounds Bis(2-ethylehexyl)phthalate, 2,4-D, Dalapon, Dinoseb, and dibenz(a,h)anthracene. All of these compounds are manufactured and their presence in groundwater likely reflects human activities on land over the buried valley aquifer.

VOCs

Trichloroethene is a volatile organic compound (VOC) used primarily to remove grease from fabricated metal parts. The MCL for trichloroethene is 5 µg/L. The compound trichloroethene was detected in well BUT10014 at concentrations of 23.6 and 22.4 µg/L. Well BUT10014 is located at Smith Park in Middletown close to the former Aeronca Air Products site, a site which underwent environmental cleanup activities (Robinson and Richter, 2012).

Nutrients

All of the samples were within the drinking water maximum contaminant level (MCL) for nitrate, although concentrations in groundwater samples from well CLA10018 approached the MCL of 10 mg/L. Common sources of nitrates in groundwater include fertilizers, sewage and septic tanks, and animal waste. It should be noted nitrate concentrations in samples from well CLA10018 exceeded the MCL in previous years.

Nuisance Contaminants

Iron, manganese, and total dissolved solids are generally considered to be “nuisance” contaminants. Their presence does not typically pose a health threat. They can, however, have adverse aesthetic impacts causing water to appear cloudy or colored. They can also adversely impact plumbing fixtures, stain laundry, and cause taste and odor issues. The SMCL for Iron is 0.3 mg/L. Groundwater samples collected from wells BUT10016, MON10016, and SHE00089 exceeded this standard once in 2015. The SMCL for manganese is 0.05 mg/L. Manganese concentrations in groundwater samples collected from wells BUT10016, MIA00205, MON10016, and SHE00089 exceeded this standard. Manganese also has a HBSL of 0.3 mg/L. Manganese concentrations in groundwater samples collected from well BUT10016 exceeded this standard. The SMCL for total dissolved solids is 500 mg/L. Groundwater samples collected from wells BUT10014 and MON00022 had concentrations which exceeded this standard.

Table 6 – Summary of significant detections of constituents in groundwater

Fall 2015		**Benchmark**		**Sample Sites**							
Parameter	**Units**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Nitrogen, Nitrate-Nitrite	mg/L	MCL	10			9.07					
Iron	mg/L	SMCL	0.3		**1.72**				**0.310**		
Manganese	mg/L	HBSL, SMCL	0.3, 0.05		**0.400**		**0.103**		**0.0798**	**0.287**	
Total Dissolved Solids	mg/L	SMCL	500	**542**				**755**			
2,4-D	ug/L	MCL	70							0.135	
Dalapon	ug/L	MCL	200				1.06			0.670	
Radon	pCi/L	MCL	4,000								
Bis(2-ethylhexyl)phthalate	ug/L	MCL	6				1.01	1.42			
Dibenz(a,h)anthracene	ug/L	—	—								0.240
Trichloroethene	ug/L	MCL	5	**22.4**							

Spring 2015		**Benchmark**		**Sample Sites**							
Parameter	**Units**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Nitrogen, Nitrate-Nitrite	mg/L	MCL	10			9.46					
Iron	mg/L	SMCL	0.3		**1.85**				**0.367**	**0.334**	
Manganese	mg/L	HBSL, SMCL	0.3, 0.05		**0.424**		**0.143**		**0.0863**	**0.268**	
Total Dissolved Solids	mg/L	SMCL	500	**657**				**657**			
2,4-D	ug/L	MCL	70				0.225	0.559		0.375	0.220
Dinoseb	ug/L	MCL	7				0.680	0.576		0.647	0.652
Radon	pCi/L	MCL	4,000				234	382		272	509
Bis(2-ethylhexyl)phthalate	ug/L	MCL	6								1.06
Trichloroethene	ug/L	MCL	5	**23.6**							

MCL - Maximum Contaminant Level set by USEPA
SMCL - Secondary Maximum Contaminant Level set by USEPA
AMCL - Alternative Maximum Contaminant Level set by USEPA

HBSL - Non enforceable Health Based Screening Level based on (1) latest USEPA Office of Water policies for establishing drinking water benchmarks and (2) most recent USEPA peer reviewed toxicity information
NA - Not analyzed
Numbers in bold exceed a benchmark

Herbicides, SVOCs, and PAHs

The compounds 2, 4-D, dalapon, and dinoseb are herbicides used to control weeds. The compounds 2,4-D and dinoseb were detected in groundwater samples from wells MIA00205, MON00022, SHE00089,and WAR10004 during the spring sampling event. The compound 2,4-D was detected in the groundwater sample from well SHE00089 during the fall sampling event. Dalapon was detected in groundwater samples from wells MIA00205 and SHE00089 during the fall sampling event. All measured concentrations of herbicides were below the compound MCLs (see Table 6).

Bis(2-ethylhexyl) phthalate is an organic compound used as a plasticizer for polyvinylchloride (PVC) and other polymers including rubber, cellulose and styrene. The MCL for bis(2-ethylhexyl) phthalate is 6 µg/L. This compound was detected in well WAR10004 during the spring sampling event and in wells MIA00205 and MON00022 during the fall event. All measured concentrations of bis(2-ethylhexyl)phthalate were below the MCL (see Table 6).

Dibenz(a,h)anthracene is a polycyclic aromatic hydrocarbon (PAH) compound. Common sources of PAHs in groundwater include combustion of hydrocarbons such as coal and gasoline, leaking fuel storage tanks, and stormwater runoff from asphalt surfaces. There are no human health-based benchmarks established for dibenz(a,h)anthracene in drinking water. Dibenz(a,h)anthracene was detected in the groundwater sample from well WAR10004 during the fall sampling event.

While the sample set of this study was small and the results cannot be used to generalize about the health of the entire buried valley aquifer, the results can be used to better understand which contaminants are likely to be the most significant in terms of impacting regional groundwater quality in the buried valley aquifer system. Furthermore, when the results of this study are placed in context with previous studies a clearer picture of groundwater quality in the aquifer begins to emerge. Overall, the results of this MCD groundwater quality study and previous studies show anthropogenic contaminants such as nitrate, pesticides, and VOCs are more prevalent in groundwater samples from sensitive aquifer settings such as shallow unconfined sand and gravel aquifers (Ohio Environmental Protection Agency, 2015), (Rowe et al, 2004), and (Stuck, 2016). These findings underscore the importance of managing land use over the buried valley aquifer in order to preserve the quality of the water resource. Proactive source water protection programs are a must for communities in the region that hope to sustain the quality of their groundwater resources.

CONCLUSIONS

2015 Water Quantity

The year 2015 was a wet year throughout the Great Miami River Watershed. Annual precipitation and runoff levels were both above normal. Groundwater recharge was near average. Groundwater levels at most MCD observation wells in the buried valley aquifer began 2015 at below normal levels and ended the year at above normal levels. The water budget totals show a small net gain in groundwater storage by the end of the year.

Long-term trends in precipitation, runoff, and streamflow are increasing and likely reflect climatic variability coupled with declining water use.

2015 Water Quality

The results of data collected to monitor the trends of water quality in rivers and streams continue to indicate nutrient enrichment. When compared with previous data, nutrient loads in 2015 were mostly near station period of record averages. Higher than average total nitrogen and dissolved inorganic nitrogen loading did occur in the Lower Great Miami River Watershed. Seasonal variations in total nitrogen, total phosphorus, and orthophosphate were driven by runoff processes and low flow conditions. Total nitrogen concentrations tend to be highest at higher flows. Total phosphorus and orthophosphate concentrations tend to increase during both high and low flows.

The results of data collected to study groundwater quality of the buried valley aquifer show that anthropogenic contaminants such as nitrate, pesticides, and VOCs can be found in buried valley aquifer zones with a high degree of intrinsic vulnerability. The results of the study are consistent with previous studies and further underscore the need for better management of land use activities over aquifers.

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Appendix A - Precipitation Data

STATION	YEARS OF RECORD*	MEAN OF RECORD**	2015 TOTAL	DEPARTURE
Alcony	35	39.22	41.85	2.63
Arcanum	56	41.25	40.75	-0.50
Beechwood	43	40.22	49.53	9.31
Bellefontaine	43	40.29	45.55	5.26
Brookville	45	39.89	45.65	5.76
Centerville	52	42.99	51.94	8.95
Collinsville	45	40.69	49.56	8.87
Covington	59	39.92	42.62	2.70
Dayton	133	40.50	44.94	4.44
De Graff	54	38.82	45.41	6.59
Eaton	96	40.90	45.01	4.11
Englewood Dam	89	40.73	42.11	1.38
Ft. Loramie	95	37.59	45.94	8.35
Franklin	86	40.55	51.58	11.03
Germantown Dam	94	40.83	48.33	7.50
Greenville	111	38.77	43.43	4.66
Hamilton	98	40.52	47.09	6.57
Huffman Dam	84	40.70	48.83	8.13
Ingomar	81	42.76	46.15	3.39
Lakeview	90	39.24	44.05	4.81
Lockington Dam	95	38.81	47.11	8.30
Miamisburg	91	41.76	50.31	8.55
Middletown	92	40.33	46.95	6.62
New Carlisle	91	40.73	41.48	0.75
Oxford	85	40.93	48.32	7.39
Piqua	101	41.82	46.10	4.28
Pleasant Hill	95	39.22	42.09	2.87
St. Paris	79	40.93	41.25	0.32
Sidney	117	39.69	48.83	9.14
Springboro, South	38	40.93	50.26	9.33
Springfield North	50	41.36	45.66	4.30
Springfield, WPC	105	41.58	44.36	2.78
Taylorsville Dam	90	42.14	46.11	3.97
Tipp City	92	39.89	38.17	-1.72
Troy	84	39.41	42.18	2.77
Union City	47	37.84	43.82	5.98
Urbana	134	40.19	42.14	1.95
Versailles	97	38.11	41.75	3.64
West Carrollton	52	40.85	45.80	4.95
West Liberty	53	40.29	44.72	4.43
West Manchester	87	40.24	45.54	5.30
West Milton	79	38.83	36.79	-2.04
Average for Watershed		**40.29**	**45.26**	**4.97**

* The years of record values include only years with full uninterrupted monthly records.
** The 30-year average represents the average annual precipitation at each stationfor the time period of 1981-2010. The 30-year average will be recalculated every 10 years to account for climatic trends and variability.

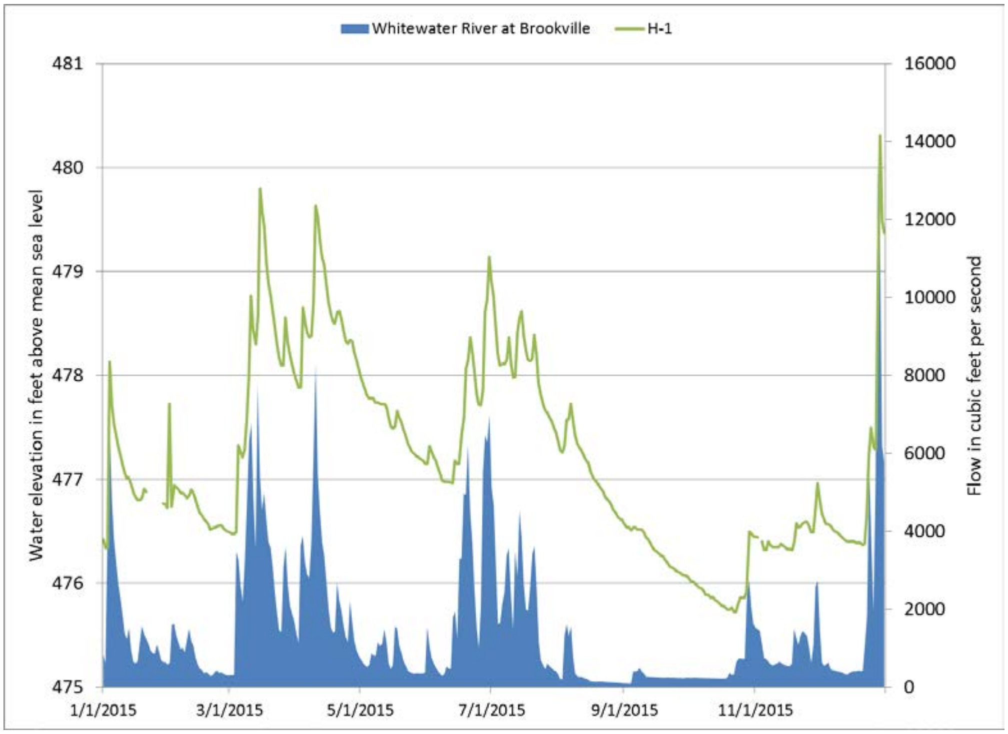
Appendix B - Summary of Precipitation, Runoff, & Base Flow Data

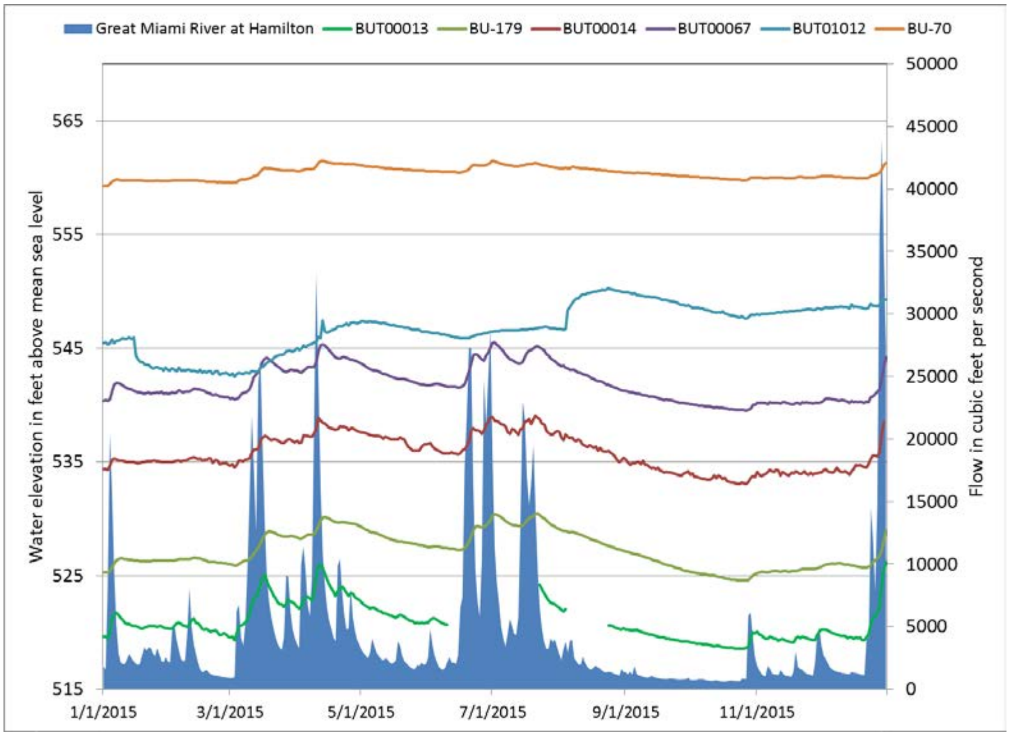
Station Name	USGS ID	Drainage Area (mi^2)	Time Period	2015 Precipitation at Nearest Observer (in)	2015 Runoff (in)	2015 Surface Runoff (in)	2015 Baseflow (in)	Normal Runoff (in)	Normal Surface Runoff (in)	Normal Baseflow (in)	Baseflow Index
Bokengahalas Creek at DeGraff	3260706	40.4	1981 - 2010	45.41	17.41	6.60	10.81	16.41	5.23	11.18	68%
Loramie Creek near Newport	3261950	152.0	1981 - 2010	45.94	21.22	17.98	3.24	13.52	10.11	3.41	25%
Great Miami River at Sidney	3261500	541.0	1981 - 2010	48.83	17.87	11.41	6.46	14.28	7.87	6.41	45%
Greenville Creek near Bradford	3264000	193.0	1981 - 2010	42.62	18.37	9.69	8.68	14.75	6.88	7.87	53%
Stillwater River at Pleasant Hill	3265000	503.0	1981 - 2010	42.09	17.79	11.66	6.13	13.71	8.27	5.44	40%
Mad River near Urbana	3267000	162.0	1981 - 2010	42.14	14.54	2.82	11.72	15.29	2.62	12.67	83%
Mad River at Eagle City	3267900	310.0	1981 - 2010	45.66	16.23	4.64	11.59	14.96	3.53	11.43	76%
Mad River near Springfield	3269500	490	1981 - 2010	44.36	16.87	5.19	11.68	15.40	3.79	11.61	75%
Wolf Creek at Dayton	3271000	68.7	1981 - 2010	44.94	17.25	10.74	6.51	15.31	8.62	6.69	44%
Holes Creek near Kettering	3271300	18.7	1981 - 2010	45.80	22.62	15.44	7.18	19.62	13.79	5.83	30%
Twin Creek near Germantown	3272000	275.0	1981 - 2010	48.33	18.14	12.24	5.90	15.24	9.16	6.08	40%
Sevenmile Creek at Camden	3272700	69.0	1981 - 2010	45.01	19.35	12.08	7.27	15.14	8.25	6.89	46%
Great Miami River at Hamilton	3274000	3630.0	1981 - 2010	47.09	18.30	10.60	7.70	14.56	7.00	7.56	52%

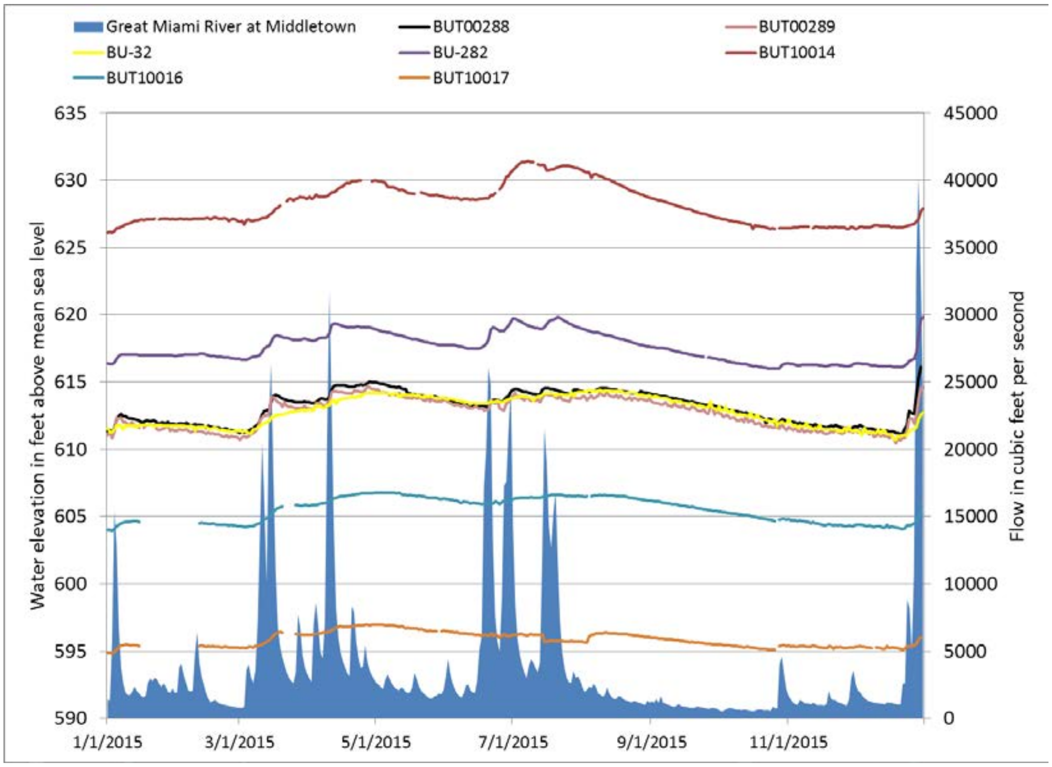
Appendix C - RORA Calculated Groundwater Recharge Data

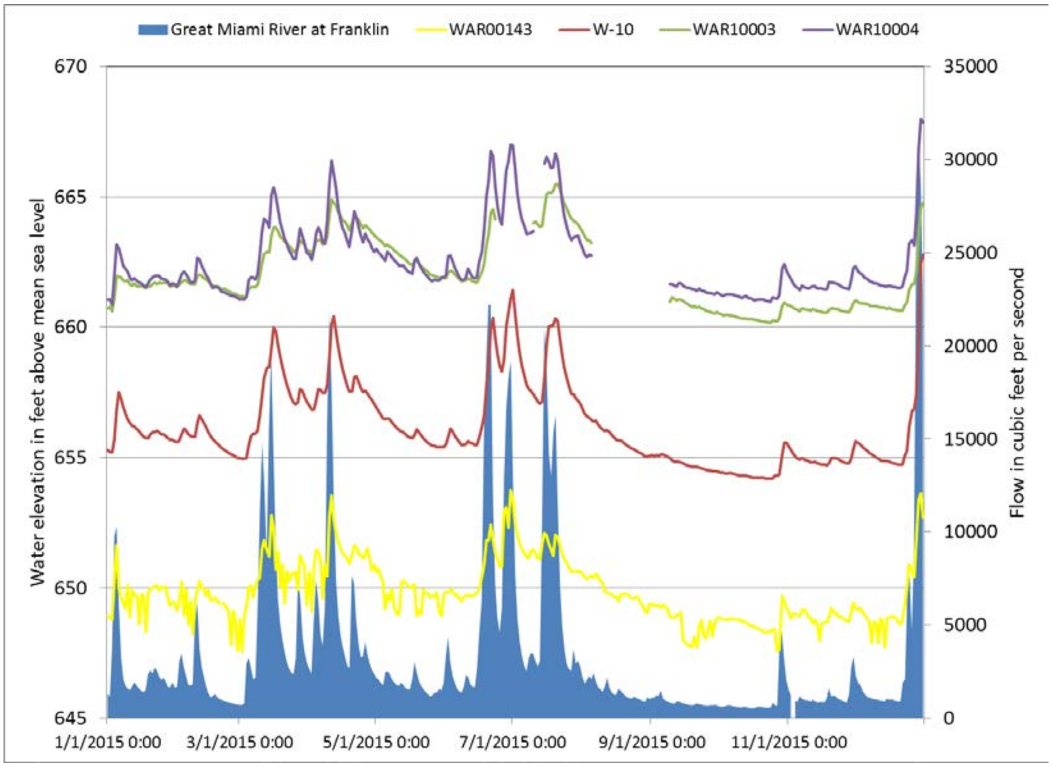
Station Name	USGS ID	Drainage Area (mi^2)	Time Period	2015 GW Recharge (in)	Normal GW Recharge (in)	Amount Above/Below Mean (in)
Bokengahalas Creek at DeGraff	3260706	40.4	1981 - 2010	10.71	11.96	-1.25
Loramie Creek near Newport	3261950	152.0	1981 - 2010	8.42	7.34	1.08
Great Miami River at Sidney	3261500	541.0	1981 - 2010	8.56	8.46	0.10
Greenville Creek near Bradford	3264000	193.0	1981 - 2010	9.59	9.21	0.38
Stillwater River at Pleasant Hill	3265000	503.0	1981 - 2010	6.91	6.84	0.07
Mad River near Urbana	3267000	162.0	1981 - 2010	12.74	13.84	-1.10
Mad River at Eagle City	3267900	310.0	1981 - 2010	12.45	12.69	-0.24
Mad River near Springfield	3269500	490.0	1981 - 2010	12.47	12.87	-0.40
Wolf Creek at Dayton	3271000	68.7	1981 - 2010	6.03	7.33	-1.30
Holes Creek near Kettering	3271300	18.7	1981 - 2010	8.05	6.99	1.06
Twin Creek near Germantown	3272000	275.0	1981 - 2010	5.76	6.89	-1.13
Sevenmile Creek at Camden	3272700	69.0	1981 - 2010	6.94	8.23	-1.29

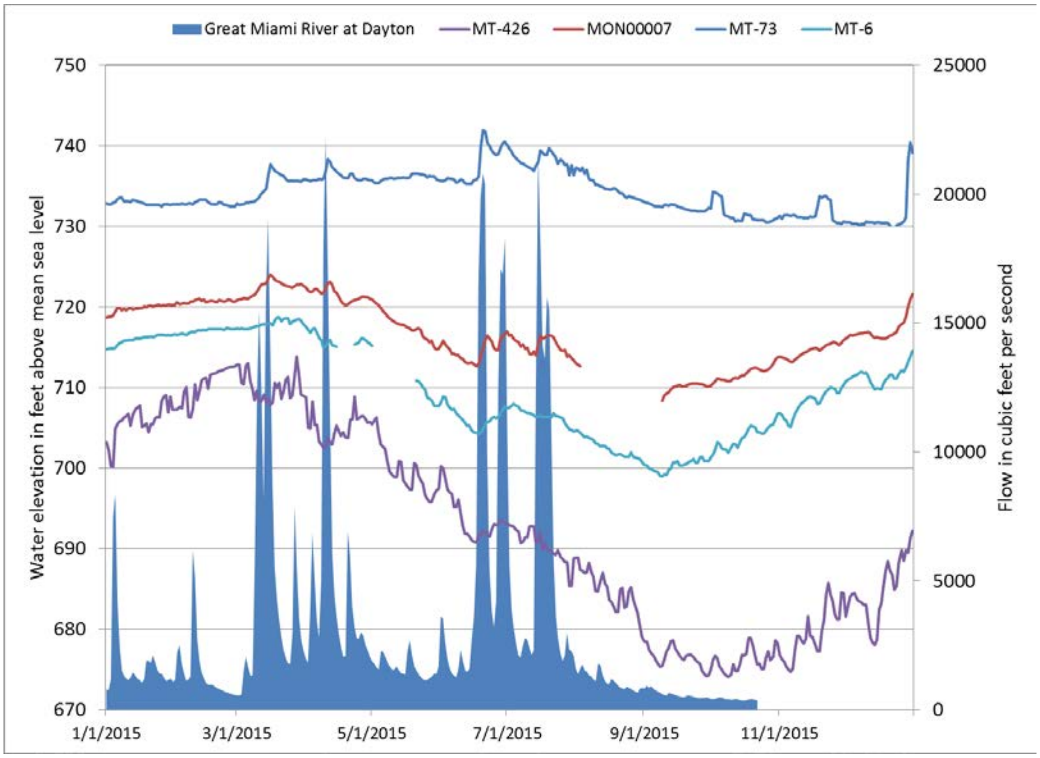
Appendix D - Groundwater Observation Well Hydrographs

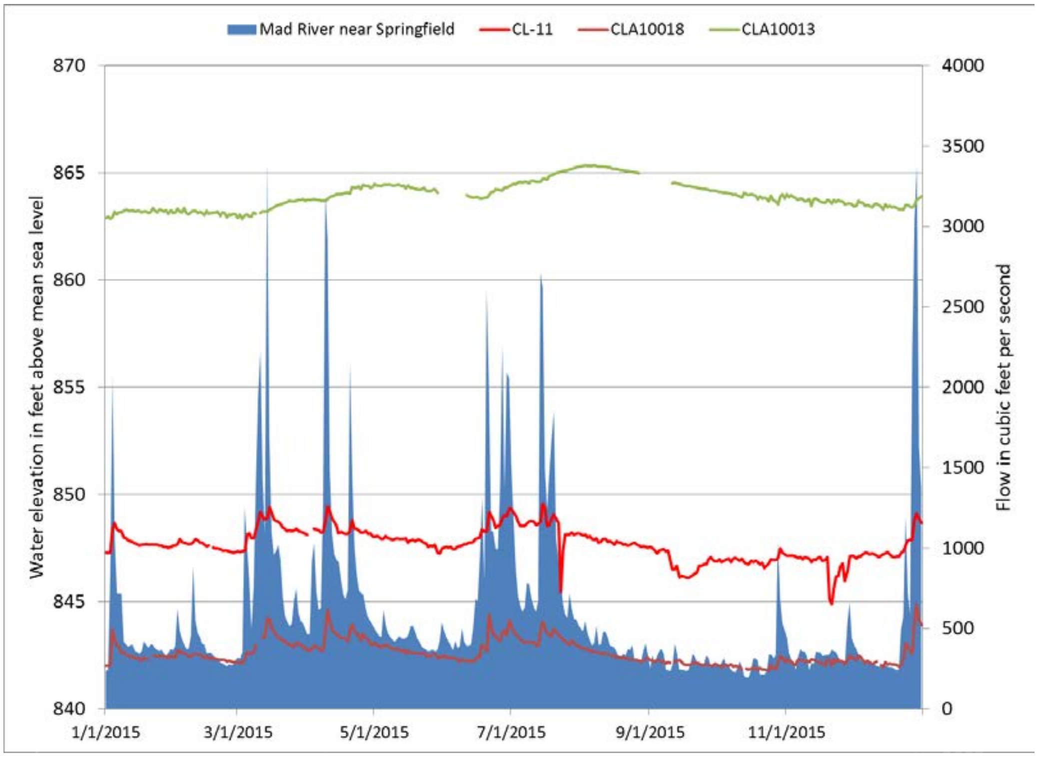


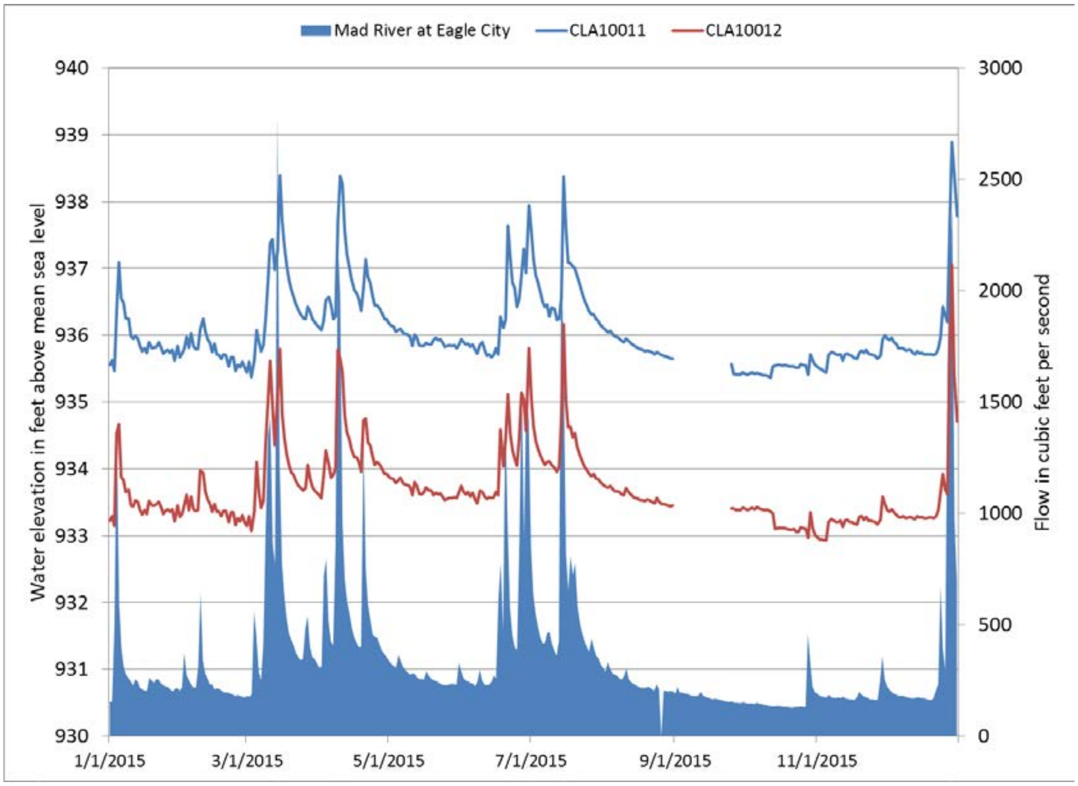


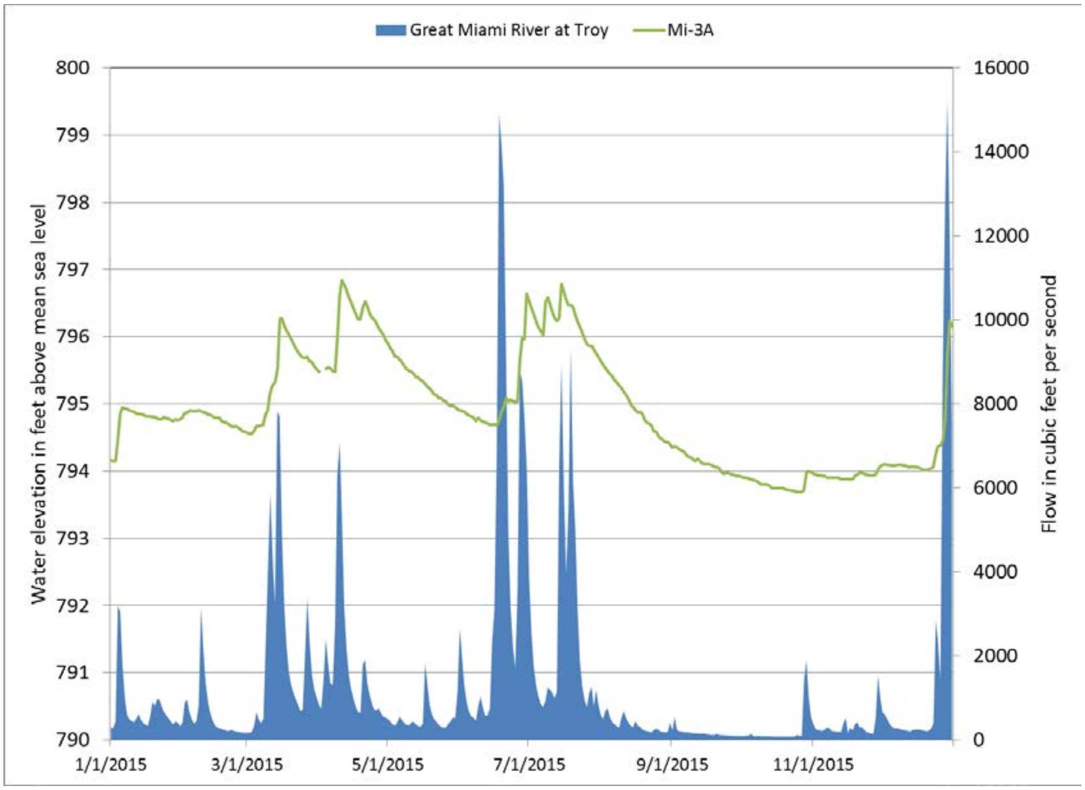

Great Miami River at Middletown
BUT00288
BUT00289
BU-32
BU-282
BUT10014
BUT10016
BUT10017
Water elevation in feet above mean sea level
Flow in cubic feet per second
635
630
625
620
615
610
605
600
595
590
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

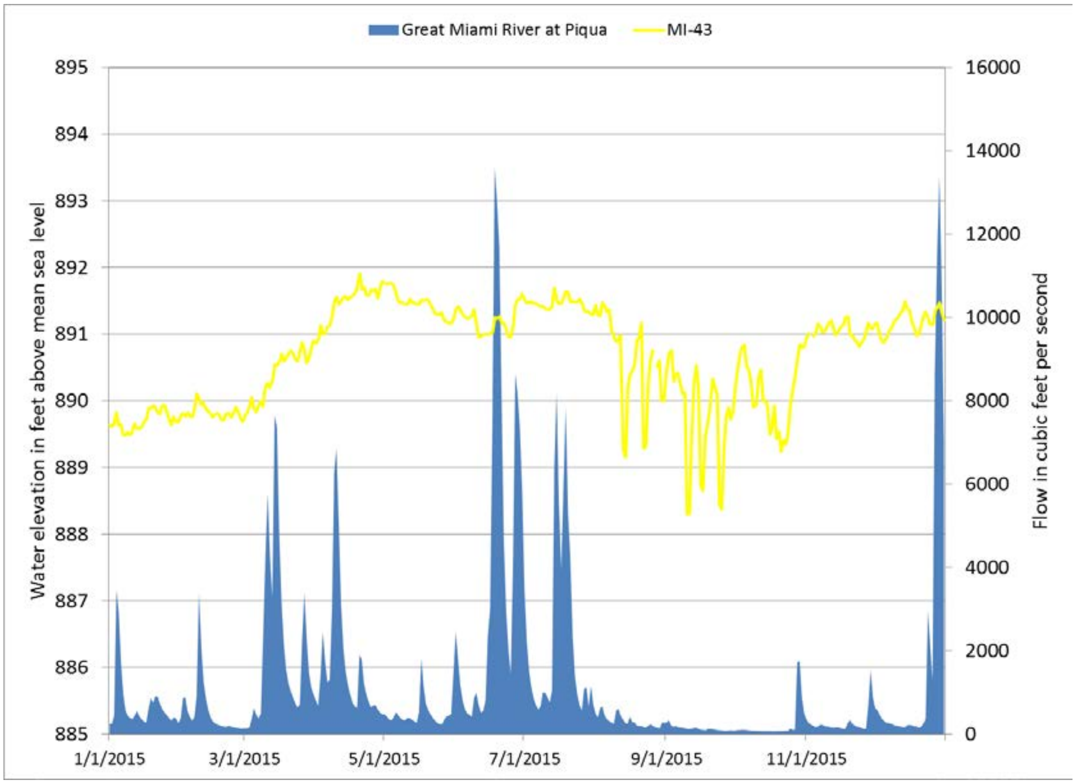

Great Miami River at Franklin
WAR00143
W-10
WAR10003
WAR10004
Water elevation in feet above mean sea level
Flow in cubic feet per second
670
665
660
655
650
645
35000
30000
25000
20000
15000
10000
5000
0
1/1/2015 0:00
3/1/2015 0:00
5/1/2015 0:00
7/1/2015 0:00
9/1/2015 0:00
11/1/2015 0:00

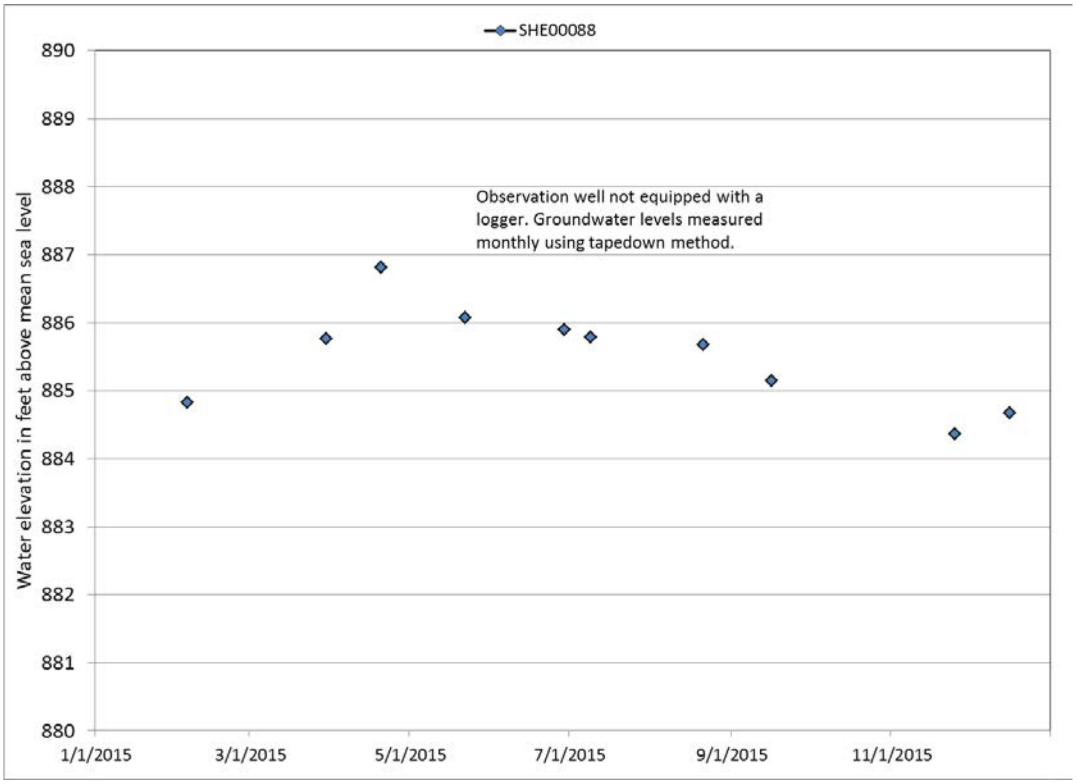

Great Miami River at Dayton
MT-426
MON00007
MT-73
MT-6
Water elevation in feet above mean sea level
Flow in cubic feet per second
750
740
730
720
710
700
690
680
670
25000
20000
15000
10000
5000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

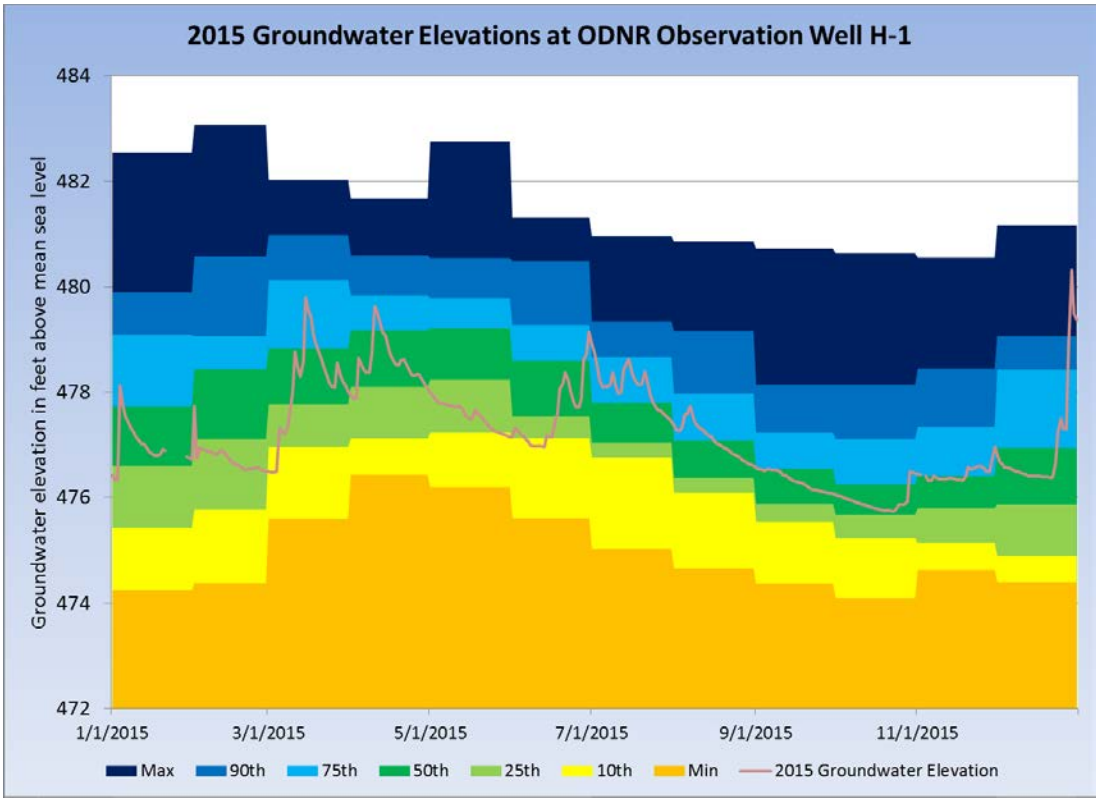

Mad River near Springfield
CL-11
CLA10018
CLA10013
Water elevation in feet above mean sea level
Flow in cubic feet per second
870
865
860
855
850
845
840
4000
3500
3000
2500
2000
1500
1000
500
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

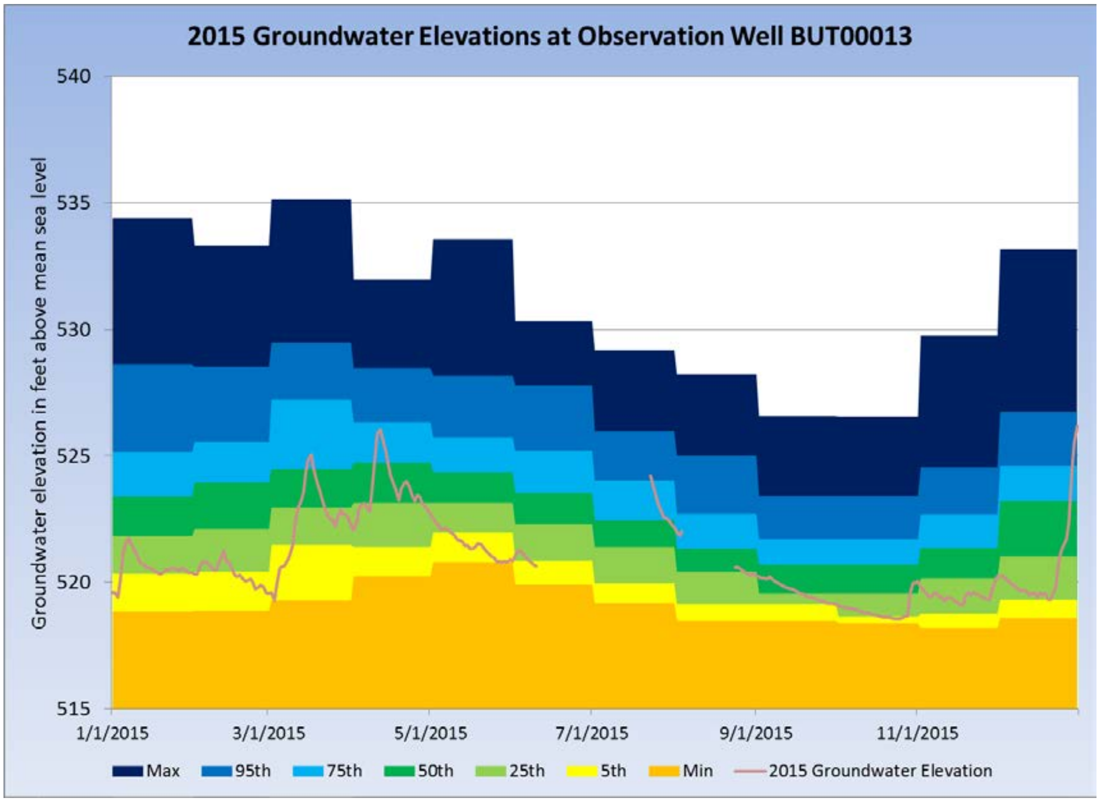

Mad River at Eagle City
CLA10011
CLA10012
Water elevation in feet above mean sea level
Flow in cubic feet per second
940
939
938
937
936
935
934
933
932
931
930
3000
2500
2000
1500
1000
500
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

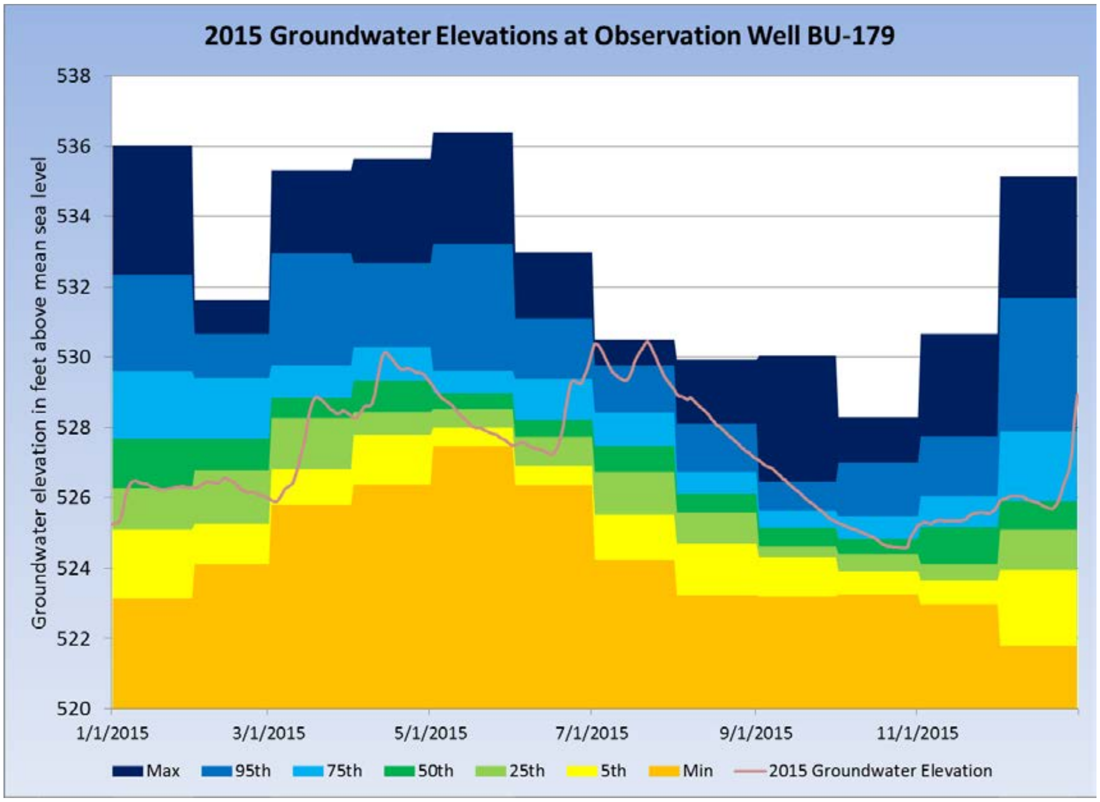

Great Miami River at Troy
Mi-3A
Water elevation in feet above mean sea level
Flow in cubic feet per second
800
799
798
797
796
795
794
793
792
791
790
16000
14000
12000
10000
8000
6000
4000
2000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

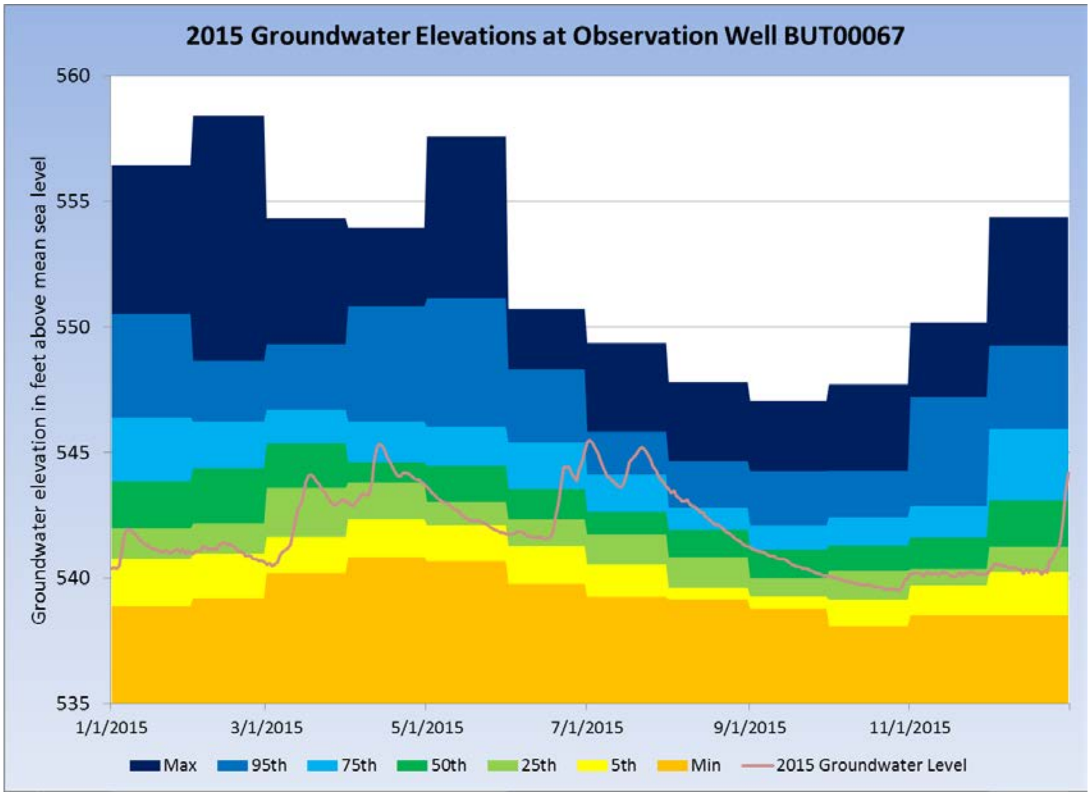

Great Miami River at Piqua
MI-43
Water elevation in feet above mean sea level
Flow in cubic feet per second
895
894
893
892
891
890
889
888
887
886
885
16000
14000
12000
10000
8000
6000
4000
2000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

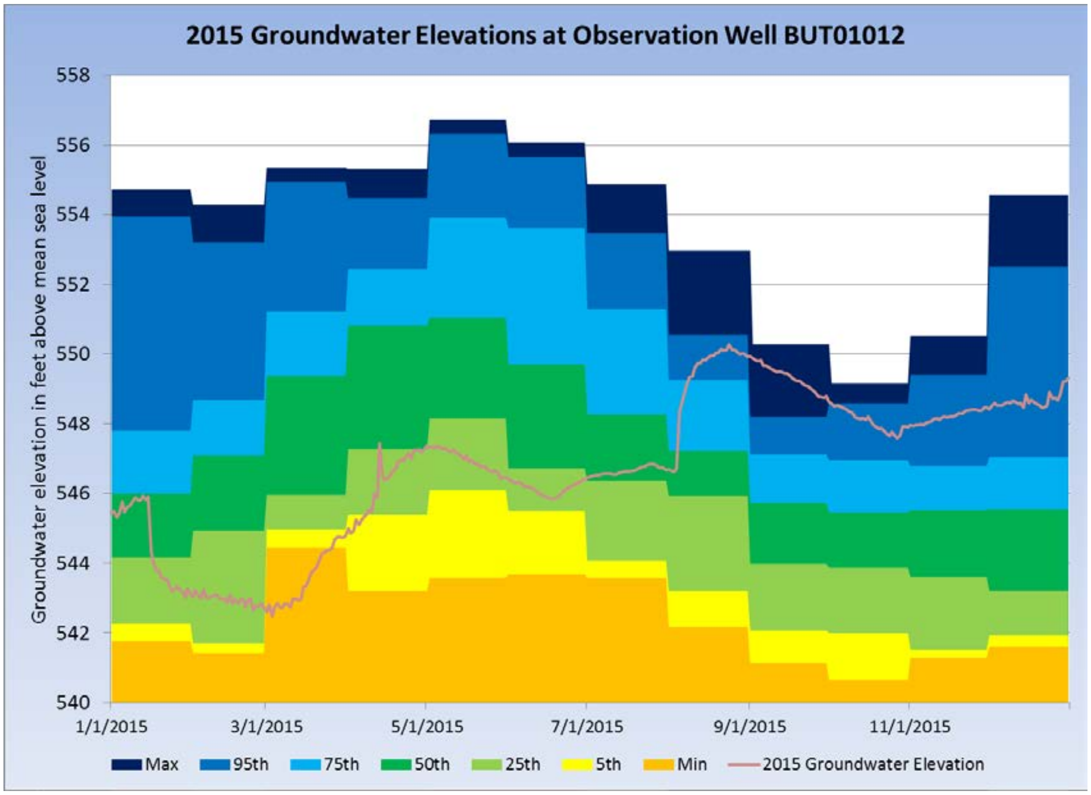

SHE00088
Water elevation in feet above mean sea level
Observation well not equipped with a logger. Groundwater levels measured monthly using tapedown method.
890
889
888
887
886
885
884
883
882
881
880
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

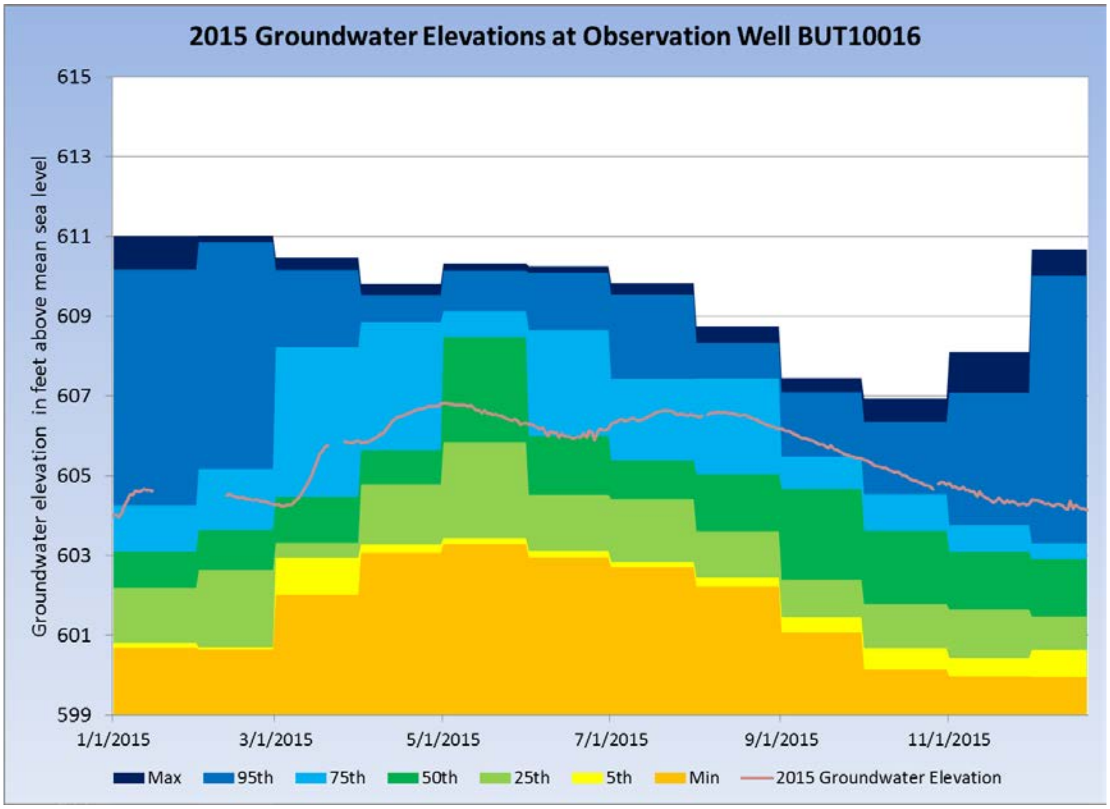

2015 Groundwater Elevations at ODNR Observation Well H-1
Groundwater elevation in feet above mean sea level
484
482
480
478
476
474
472
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
90th
75th
50th
25th
10th
Min
2015 Groundwater Elevation

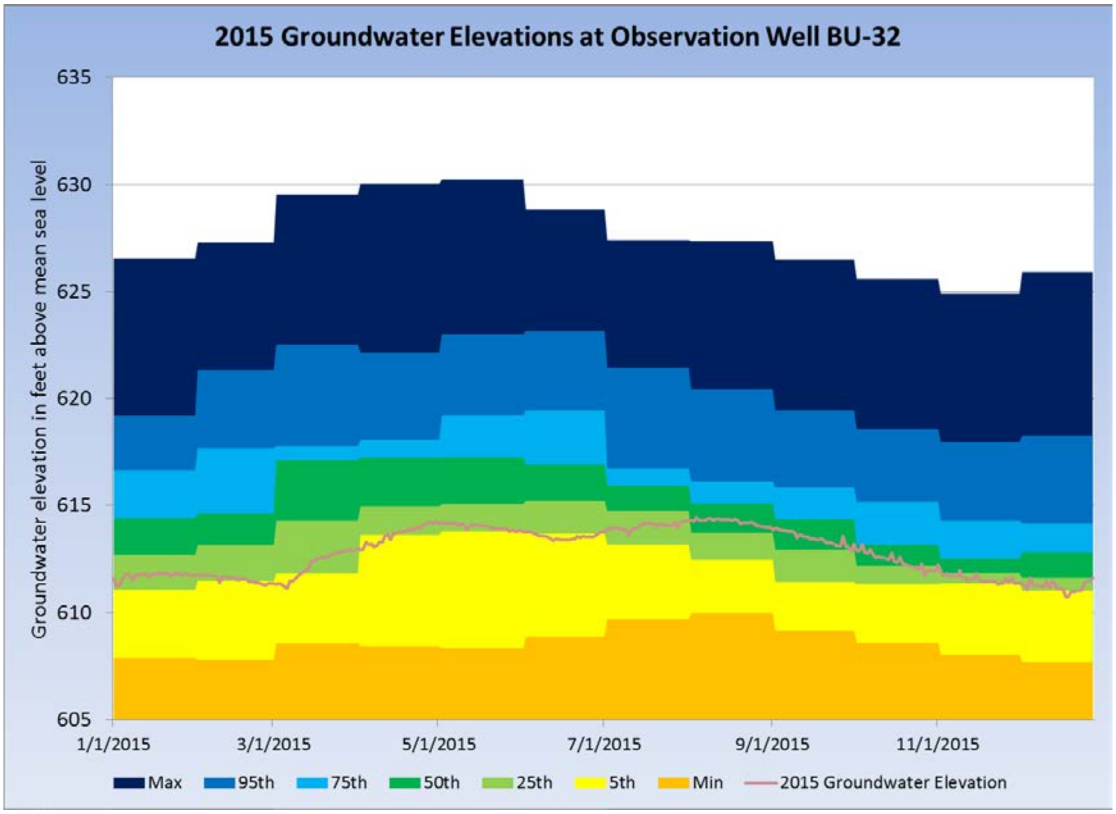

2015 Groundwater Elevations at Observation Well BUT00013
Groundwater elevation in feet above mean sea level
540
535
530
525
520
515
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation

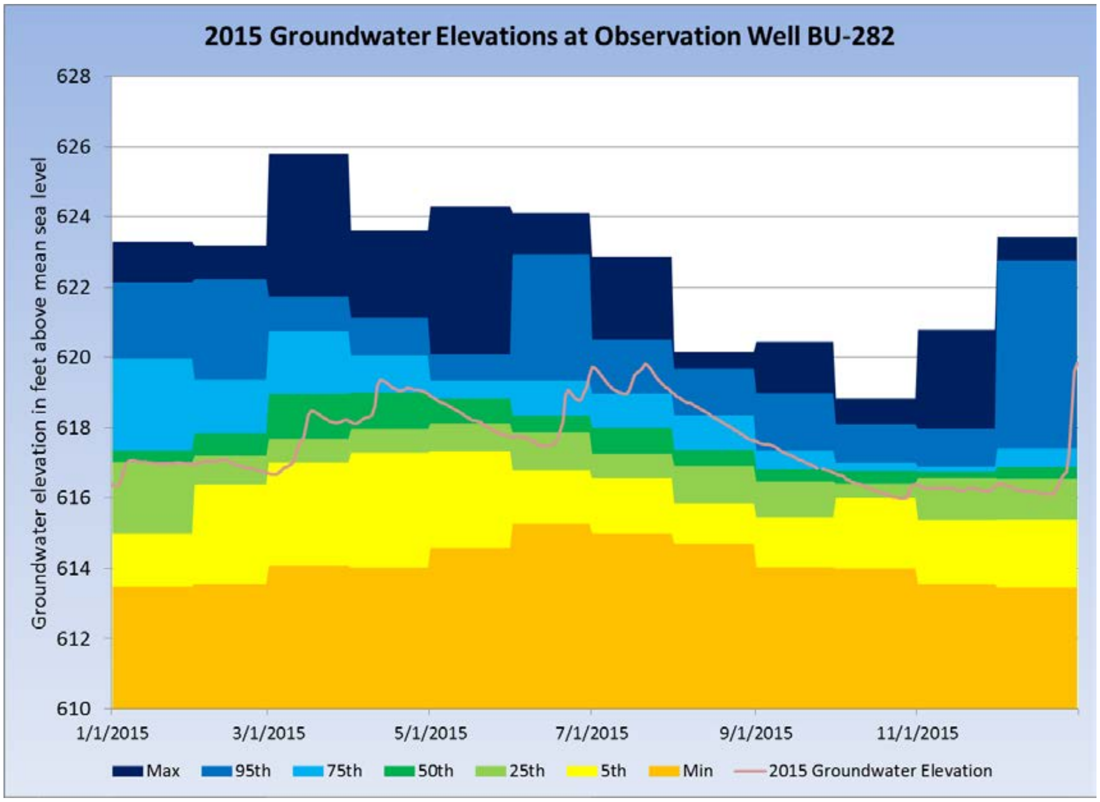

2015 Groundwater Elevations at Observation Well BU-179
Groundwater elevation in feet above mean sea level
538
536
534
532
530
528
526
524
522
520
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation

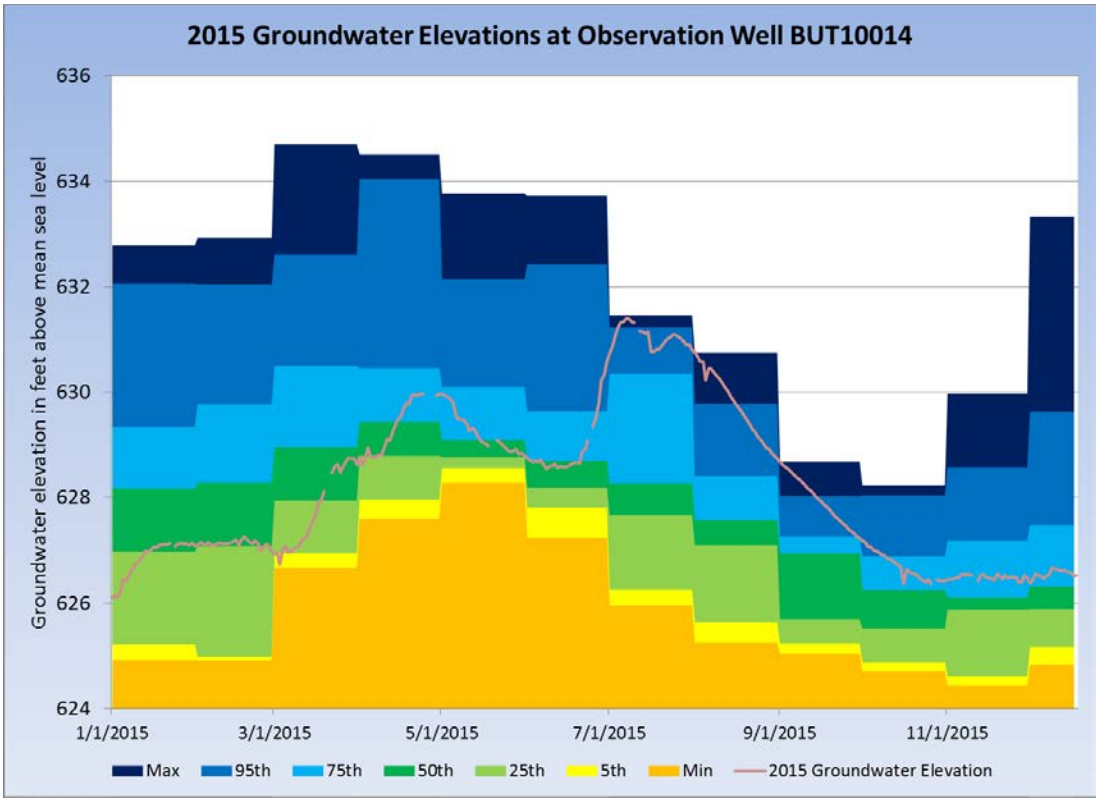

2015 Groundwater Elevations at Observation Well BUT00067
Groundwater elevation in feet above mean sea level
560
555
550
545
540
535
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Level

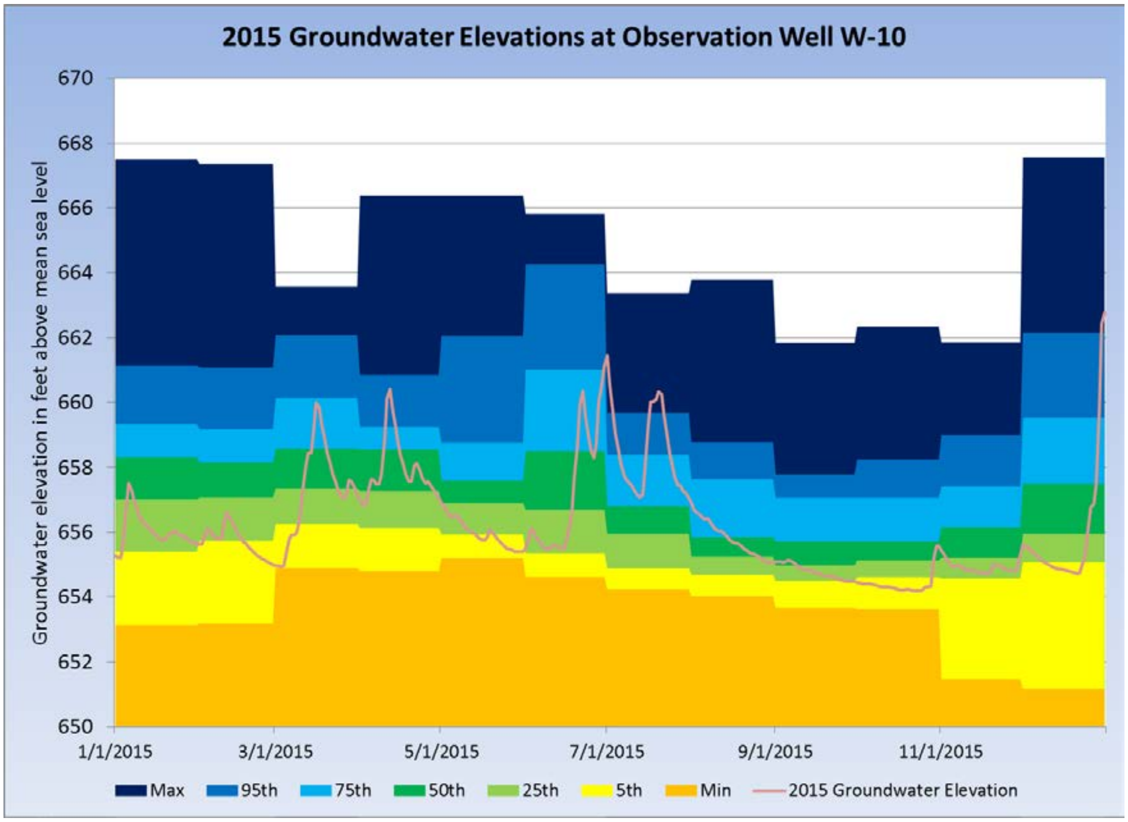

2015 Groundwater Elevations at Observation Well BUT01012
Groundwater elevation in feet above mean sea level
558
556
554
552
550
548
546
544
542
540
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation

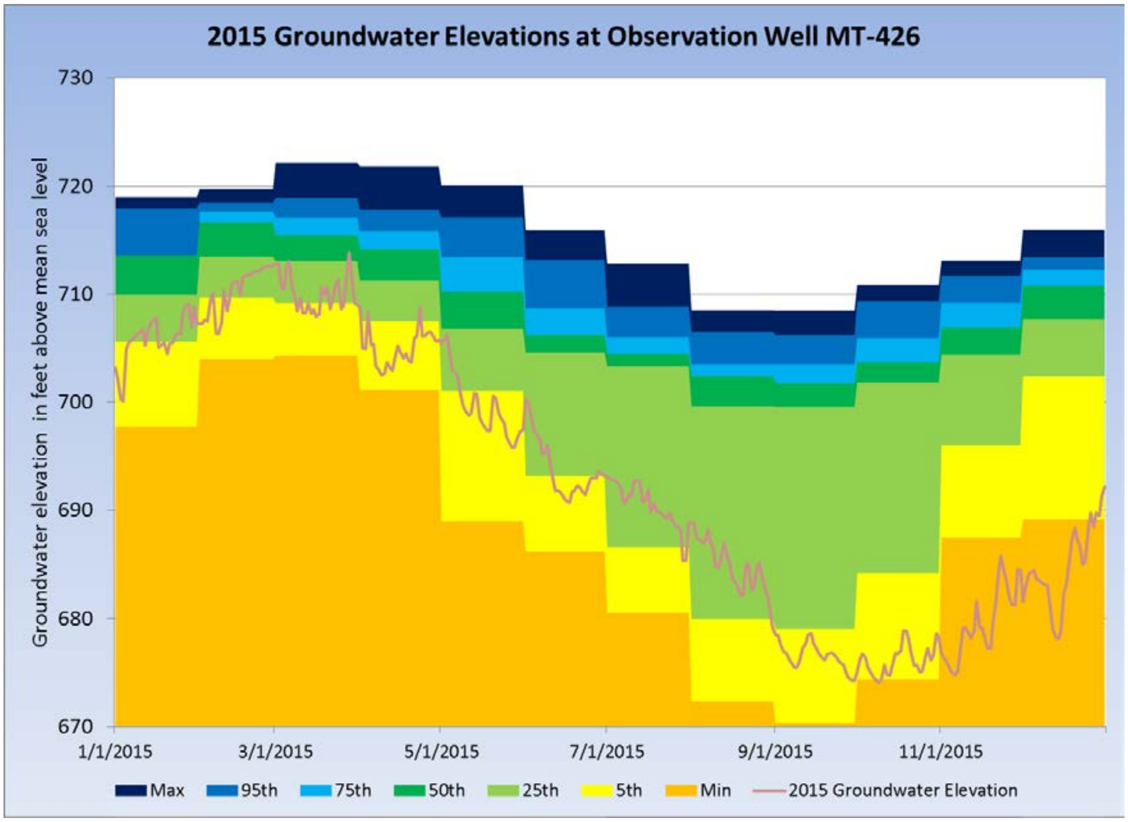

2015 Groundwater Elevations at Observation Well BUT10016
Groundwater elevation in feet above mean sea level
615
613
611
609
607
605
603
601
599
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation

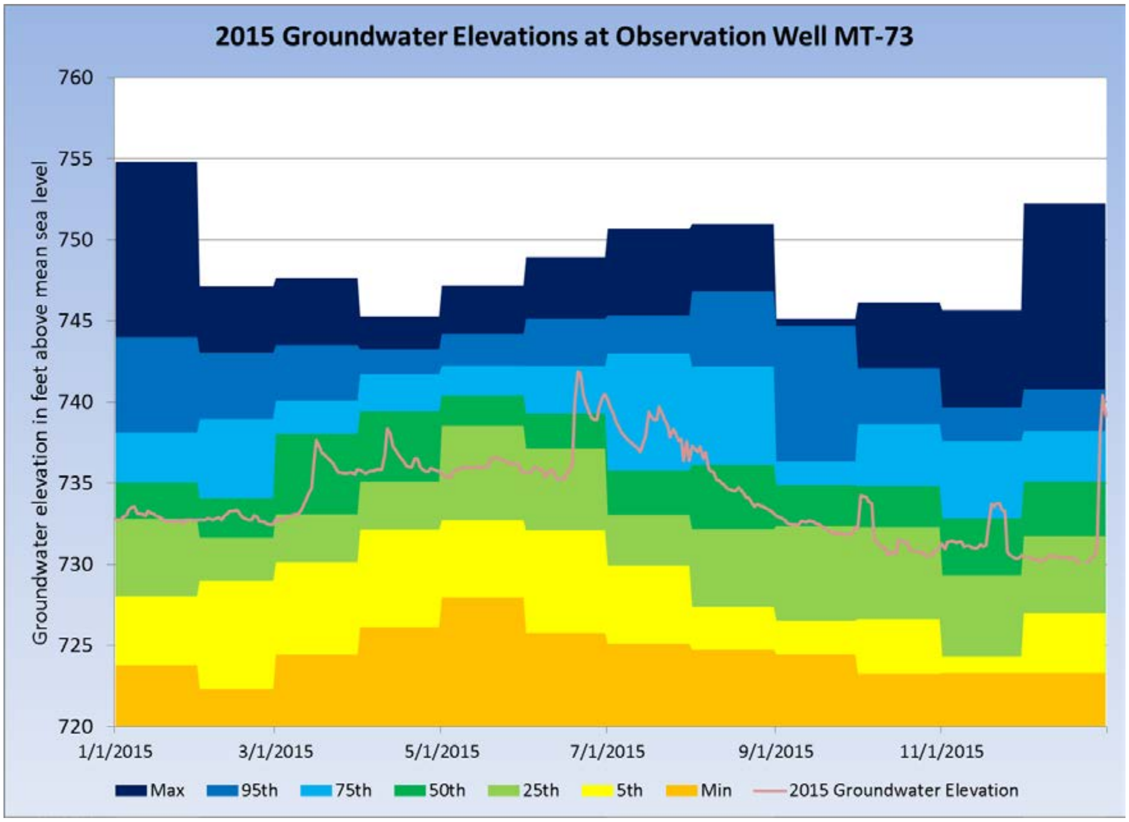

2015 Groundwater Elevations at Observation Well BU-32
Groundwater elevation in feet above mean sea level
635
630
625
620
615
610
605
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation

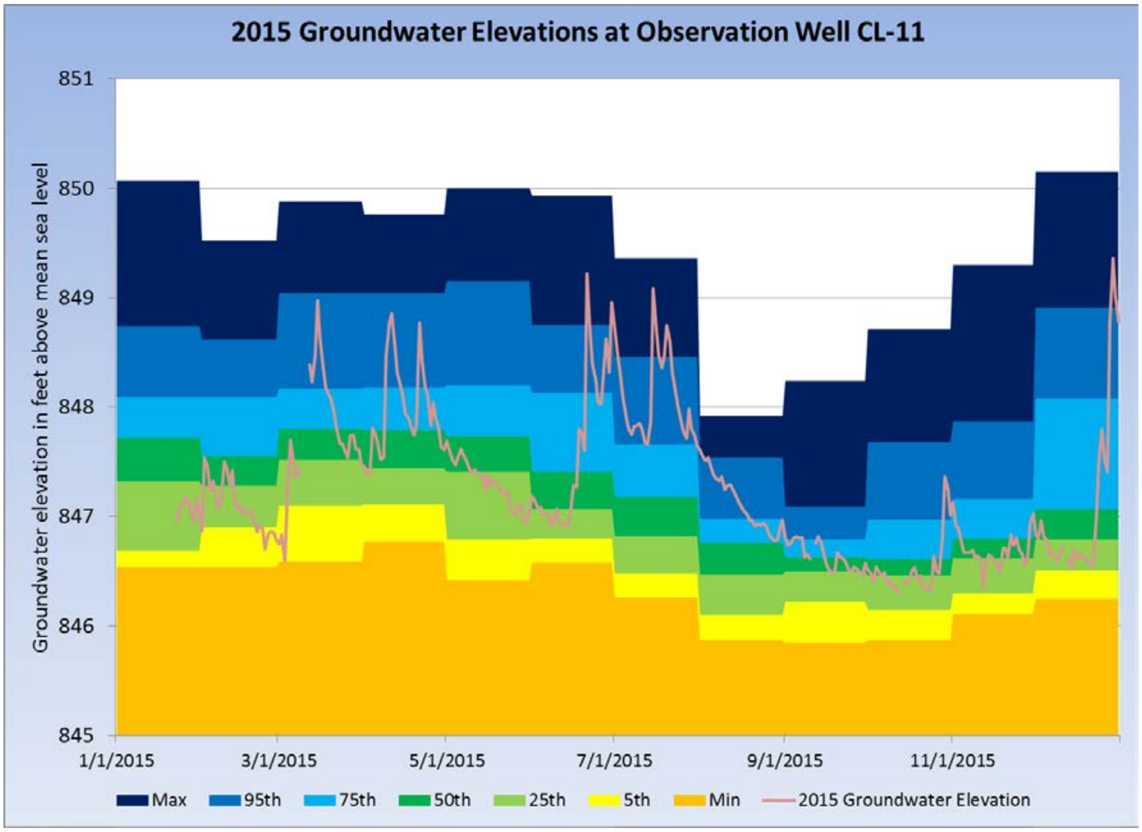

2015 Groundwater Elevations at Observation Well BU-282
Groundwater elevation in feet above mean sea level
628
626
624
622
620
618
616
614
612
610
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation


2015 Groundwater Elevations at Observation Well BUT10014
Groundwater elevation in feet above mean sea level
636
634
632
630
628
626
624
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation


2015 Groundwater Elevations at Observation Well W-10
Groundwater elevation in feet above mean sea level
670
668
666
664
662
660
658
656
654
652
650
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation


2015 Groundwater Elevations at Observation Well MT-426
Groundwater elevation in feet above mean sea level
730
720
710
700
690
680
670
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation


2015 Groundwater Elevations at Observation Well MT-73
Groundwater elevation in feet above mean sea level
760
755
750
745
740
735
730
725
720
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation


2015 Groundwater Elevations at Observation Well CL-11
Groundwater elevation in feet above mean sea level
851
850
849
848
847
846
845
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
Max
95th
75th
50th
25th
5th
Min
2015 Groundwater Elevation

Appendix E - ΔS Computations for Observation Wells

Observation Well	Well Depth	Aquifer	Aquifer Type	Estimated Storage Coefficient	H_1 (ft)	H_2 (ft)	ΔH (ft)	ΔS_{2015} (in)
BU-179	43	buried valley	unconfined	0.1	525.25	528.92	3.67	4.40
BU-282	74	buried valley	unconfined	0.1	616.37	619.85	3.48	4.18
BU-32	234	buried valley	unconfined	0.1	611.58	612.74	1.16	1.39
BU-70	54	buried valley	confined	0.0006	559.25	561.30	2.05	0.01
BUT00013	154	buried valley	unconfined	0.1	519.61	526.22	6.61	7.93
BUT00014	107	buried valley	unconfined	0.1	534.38	538.25	3.87	4.64
BUT00019	66	buried valley	unconfined	0.1	565.60	567.60	2.00	2.40
BUT00020	40	buried valley	unconfined	0.1	565.05	567.20	2.15	2.58
BUT00033	51	buried valley	unconfined	0.1	614.40	616.46	2.06	2.47
BUT00067	60	buried valley	unconfined	0.1	540.39	544.47	4.08	4.90
BUT00283	155	buried valley	unconfined	0.1	617.23	618.88	1.65	1.98
BUT00288	43	buried valley	unconfined	0.1	611.31	615.51	4.20	5.04
BUT00289	75	buried valley	unconfined	0.1	611.07	614.80	3.73	4.48
BUT01007	40	buried valley	unconfined	0.1	602.53	604.64	2.11	2.53
BUT01008	42	buried valley	unconfined	0.1	608.48	611.29	2.81	3.37
BUT01012	65	buried valley	unconfined	0.1	545.43	549.44	4.01	4.81
BUT10013	30	buried valley	unconfined	0.1	542.10	544.23	2.13	2.56
BUT10014	40	buried valley	unconfined	0.1	626.10	628.08	1.98	2.38
BUT10016	68	buried valley	unconfined	0.1	604.00	605.72	1.72	2.06
BUT10017	39	buried valley	unconfined	0.1	594.85	596.31	1.46	1.75
CHA10010	43	buried valley	unconfined	0.1	956.27	957.69	1.42	1.70
CLA00010	37	buried valley	unconfined	0.1	1008.76	1010.09	1.33	1.60
CLA00018	50	buried valley	unconfined	0.1	835.35	837.07	1.72	2.06
CLA10011	60	buried valley	unconfined	0.1	935.56	937.48	1.92	2.30
CLA10012	29	buried valley	unconfined	0.1	933.23	934.45	1.22	1.46
CLA10013	44	buried valley	confined	0.0006	1035.70	1035.57	-0.13	0.00
CLA10017	180	buried valley	confined	0.0006	847.08	848.71	1.63	0.01
CLA10018	17.5	buried valley	unconfined	0.1	842.02	843.82	1.80	2.16
H1	124	buried valley	unconfined	0.1	476.42	479.37	2.95	3.54
HAM00001	60	buried valley	unconfined	0.1	493.09	494.35	1.26	1.51
HAM00003	94	buried valley	unconfined	0.1	462.58	464.57	1.99	2.39
HAM00005	105	buried valley	unconfined	0.1	487.45	489.83	2.38	2.86
HAM00006	55	buried valley	unconfined	0.1	504.29	506.25	1.96	2.35
HAM00007	60	buried valley	unconfined	0.1	521.64	522.60	0.96	1.15
MI-3A	130	buried valley	unconfined	0.1	794.16	796.16	2.00	2.40
MIA00002	95	buried valley	confined	0.0006	860.51	863.51	3.00	0.02
MIA00003	81	buried valley	unconfined	0.1	826.21	828.34	2.13	2.56
MON00006	207	buried valley	unconfined	0.1	718.10	720.98	2.88	3.46
MON00007	210	buried valley	unconfined	0.1	718.73	721.83	3.10	3.72
MON00009	210	buried valley	unconfined	0.1	720.06	721.27	1.21	1.45
MON00261	26	buried valley	unconfined	0.1	731.16	732.58	1.42	1.70
MON00293	83	buried valley	unconfined	0.1	738.95	740.57	1.62	1.94

Observation Well	Well Depth	Aquifer	Aquifer Type	Estimated Storage Coefficient	H_1 (ft)	H_2 (ft)	ΔH (ft)	ΔS_{2015} (in)
MON10016	108	buried valley	unconfined	0.1	679.94	686.74	6.80	8.16
MT-426	194	buried valley	confined	0.0006	706.01	695.05	-10.96	-0.08
MT-73	95	buried valley	unconfined	0.1	732.81	739.17	6.36	7.63
SHE00024	108	buried valley	confined	0.0006	991.74	992.14	0.40	0.00
SHE00028	90	buried valley	confined	0.0006	989.98	990.37	0.39	0.00
SHE00039	80	buried valley	confined	0.0006	930.58	932.67	2.09	0.02
SHE00045	87	buried valley	confined	0.0006	884.36	886.22	1.86	0.01
SHE00054	104	buried valley	confined	0.0006	904.26	907.77	3.51	0.03
SHE00088	90	buried valley	confined	0.0006	884.25	885.98	1.73	0.01
W-10	51	buried valley	unconfined	0.1	655.29	662.78	7.49	8.99
WAR00008	81	buried valley	unconfined	0.1	650.56	650.52	-0.04	-0.05
WAR00011	37	buried valley	unconfined	0.1	663.87	665.80	1.93	2.32
WAR00013	51	buried valley	unconfined	0.1	660.15	662.55	2.40	2.88
WAR00015	Unknown	buried valley	confined	0.0006	671.72	673.80	2.08	0.01
WAR00143	30	buried valley	unconfined	0.1	648.92	652.17	3.25	3.90
WAR00145	40	buried valley	unconfined	0.1	651.39	652.12	0.73	0.88
WAR10003	67	buried valley	unconfined	0.1	660.72	664.77	4.05	4.86
WAR10004	33	buried valley	unconfined	0.1	661.06	667.43	6.37	7.64
CLA00001	72	upland glacial	confined	0.0006	987.75	991.38	3.63	0.03
CLA00002	93	upland glacial	confined	0.0006	1180.49	1181.45	0.96	0.01
CLA00014	197	upland glacial	confined	0.0006	1133.42	1134.57	1.15	0.01
CLA00015	58	upland glacial	unconfined	0.1	831.38	832.13	0.75	0.90
GRE00013	Unknown	upland glacial	unconfined	0.1	828.27	831.79	3.52	4.22
GRE00014	Unknown	upland glacial	unconfined	0.1	828.01	828.73	0.72	0.86
GRE00015	159	upland glacial	confined	0.0006	867.39	867.68	0.29	0.00
MIA00004	140	upland glacial	confined	0.0006	878.19	880.69	2.50	0.02
MIA00006	199	upland glacial	confined	0.0006	910.77	912.88	2.11	0.02
MIA00007	59	upland glacial	unconfined	0.1	816.30	818.05	1.75	2.10
MIA00008	86	upland glacial	confined	0.0006	903.57	904.26	0.69	0.00
MIA00014	38	upland glacial	unconfined	0.1	904.59	905.10	0.51	0.61
MIA00015	154	upland glacial	confined	0.0006	905.29	906.40	1.11	0.01
MIA00018	92	upland glacial	confined	0.0006	844.30	844.85	0.55	0.00
MIA00020	119	upland glacial	confined	0.0006	864.81	865.15	0.34	0.00
MIA00041	Unknown	upland glacial	confined	0.0006	844.10	846.90	2.80	0.02
MIA00042	Unknown	upland glacial	confined	0.0006	844.10	846.90	2.80	0.02
MON00001	31	upland glacial	unconfined	0.1	820.94	821.24	0.30	0.36
PRE00001	60	upland glacial	confined	0.0006	956.52	957.68	1.16	0.01
PRE00003	105	upland glacial	confined	0.0006	849.96	850.31	0.35	0.00
PRE00004	143	upland glacial	confined	0.0006	879.67	880.21	0.54	0.00
PRE00005	60	upland glacial	confined	0.0006	975.39	974.84	-0.55	0.00
PRE00007	55	upland glacial	confined	0.0006	1073.72	1075.26	1.54	0.01
PRE00010	45	upland glacial	confined	0.0006	906.28	908.72	2.44	0.02
PRE00011	37	upland glacial	confined	0.0006	1080.52	1081.20	0.68	0.00
PRE00012	71	upland glacial	confined	0.0006	1020.64	1020.97	0.33	0.00
PRE00022	Unknown	upland glacial	confined	0.0006	983.14	981.83	-1.31	-0.01

Observation Well	Well Depth	Aquifer	Aquifer Type	Estimated Storage Coefficient	H_1 (ft)	H_2 (ft)	ΔH (ft)	ΔS_{2015} (in)
PRE00064	Unknown	upland glacial	confined	0.0006	919.37	921.38	2.01	0.01
PRE00065	Unknown	upland glacial	confined	0.0006	918.57	920.19	1.62	0.01
PRE00066	83	upland glacial	confined	0.0006	916.72	918.03	1.31	0.01
SHE00037	50	upland glacial	confined	0.0006	950.20	951.01	0.81	0.01
SHE00046	126	upland glacial	confined	0.0006	917.65	918.40	0.75	0.01

Appendix F- Recent Water Withdrawals

ODNR Division of Water Reported 2008 Annual Water Withrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	44,026	8,172	1,949	934	3,920	467	569	60,039
Groundwater	606	21,842	71,489	1,705	11,330	354	8,669	115,993
Total Use	44,632	30,014	73,438	2,639	15,250	821	9,238	176,032
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Total Consumptive Loss	893	7,682	11,016	2,639	2,135	821	924	26,110

* All water use numbers are reported in millions of gallons

** Southwestern Ohio Water Company transferred an average of 14.25 mgd of groundwater to the Mill Creek Watershed for industrial use

ODNR Division of Water Reported 2009 Annual Water Withdrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	29,112	4,749	1,942	774	4,318	380	245	41,519
Groundwater	551	18,564	69,226	1,544	2,073	296	9,081	101,335
Total Use	29,664	23,313	71,168	2,318	6,391	675	9,326	142,854
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Total Consumptive Loss	593	7,012	10,675	2,318	895	675	933	23,101

* All water use numbers are reported in millions of gallons

** Southwestern Ohio Water Company transferred an average of 14.25 mgd of groundwater to the Mill Creek Watershed for industrial use

ODNR Division of Water Reported 2010 Annual Water Withdrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	28,772	3,294	1,940	1,129	3,980	534	419	40,068
Groundwater	577	18,404	79,682	2,012	1,991	390	8,692	111,747
Total Use	29,349	21,697	81,622	3,141	5,971	925	9,111	151,814
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Consumptive Loss	587	6,959	12,243	3,141	836	925	911	25,601

* All water use numbers are reported in millions of gallons

** Southwestern Ohio Water Company transferred 14.57 mgd of groundwater to the Mill Creek Watershed for industrial use

ODNR Division of Water Reported 2011 Annual Water Withdrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	16,825	3,184	1,925	856	4,626	404	295	28,116
Groundwater	394	16,657	68,844	1,705	2,431	311	8,893	99,235
Total Use	17,219	19,841	70,769	2,562	7,057	716	9,187	127,351
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Total Consumptive Loss	344	6,447	10,615	2,562	988	716	919	22,591

* All water use numbers are reported in millions of gallons

** Southwestern Ohio Water Company transferred an average of 13.59 mgd of groundwater to the Mill Creek Watershed for industrial use

ODNR Division of Water Reported 2012 Annual Water Withdrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	14,269	2,382	1,996	1,335	4,145	481	179	24,787
Groundwater	328	15,641	68,444	2,026	2,096	454	10,023	99,011
Total Use	14,597	18,022	70,440	3,361	6,241	935	10,202	123,797
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Total Consumptive Loss	292	6,186	10,566	3,361	874	935	1,020	23,233

* All water use numbers are reported in millions of gallons

** Southwestern Ohio Water Company transferred an average of 13.35 mgd of groundwater to the Mill Creek Watershed for industrial use

ODNR Division of Water Reported 2013 Annual Water Withdrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	6,459	2,365	1,648	1,089	4,160	376	451	16,547
Groundwater	394	11,168	65,123	1,902	1,909	273	9,262	90,030
Total Use	6,852	13,533	66,771	2,991	6,069	649	9,712	106,577
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Total Consumptive Loss	137	4,862	10,016	2,991	850	649	971	20,475

* All water use numbers are reported in millions of gallons

** Southwestern Ohio Water Company transferred 9.61 mgd of groundwater to the Mill Creek Watershed for industrial use

ODNR Division of Water Reported 2014 Annual Water Withdrawals in the Great Miami River Watershed								
	Power	Industry	Public Water Supply	Agriculture	Mineral Extraction	Golf Course	Miscellaneous	Annual Total
Surface Water	6,055	2,280	1,865	1,179	4,559	323	194	16,455
Groundwater	109	10,795	66,186	1,722	2,769	275	9,198	91,054
Total Use	6,165	13,075	68,051	2,900	7,328	597	9,392	107,509
Consumptive Use Coefficient (%)	2	10	15	100	14	100	10	
Total Consumptive Loss	123	4,776	10,208	2,900	1,026	597	939	20,570

* All water use numbers are reported in millions of gallons

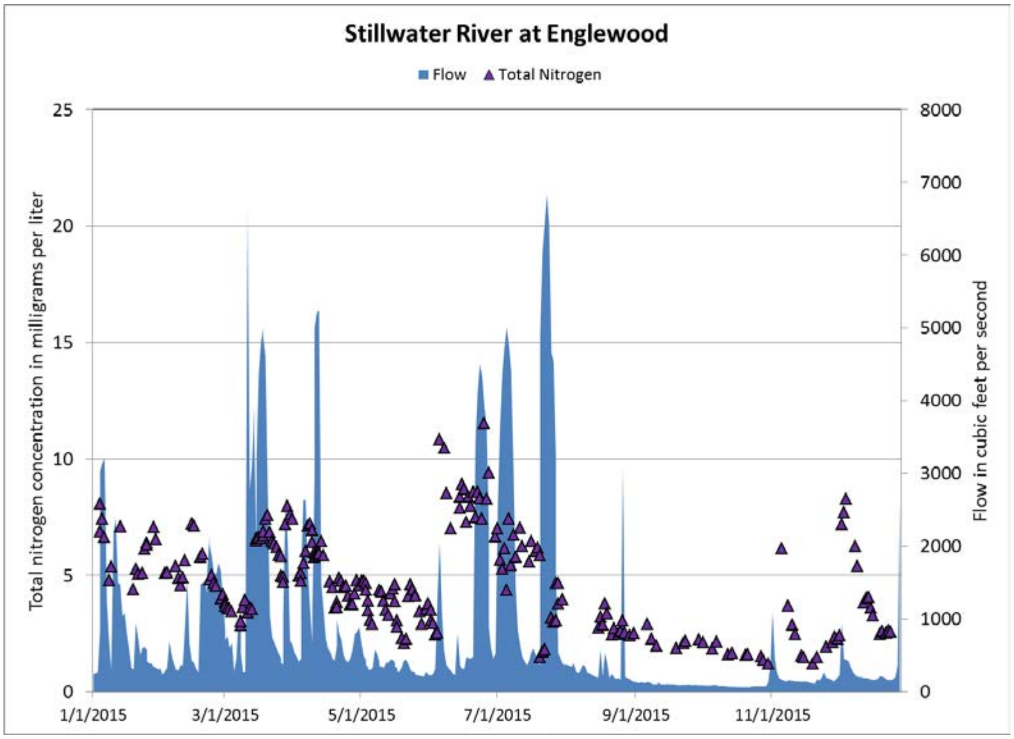
** Southwestern Ohio Water Company transferred an average of 9.50 mgd of groundwater to the Mill Creek Watershed for industrial use

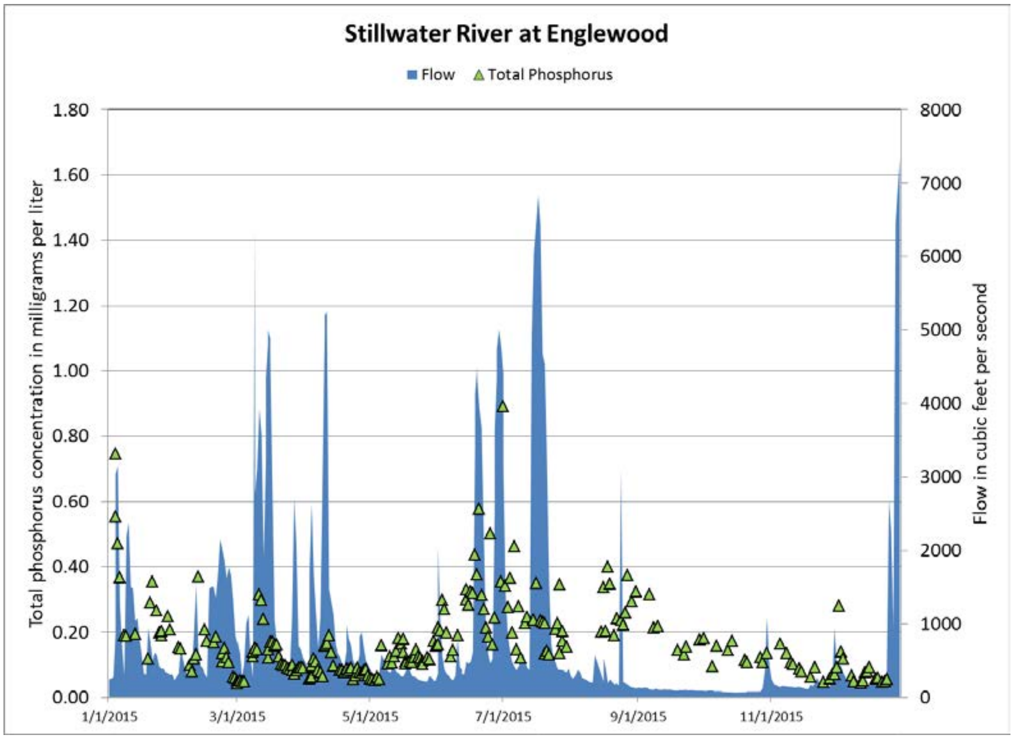
Appendix G - Nutrient Concentration Statistics

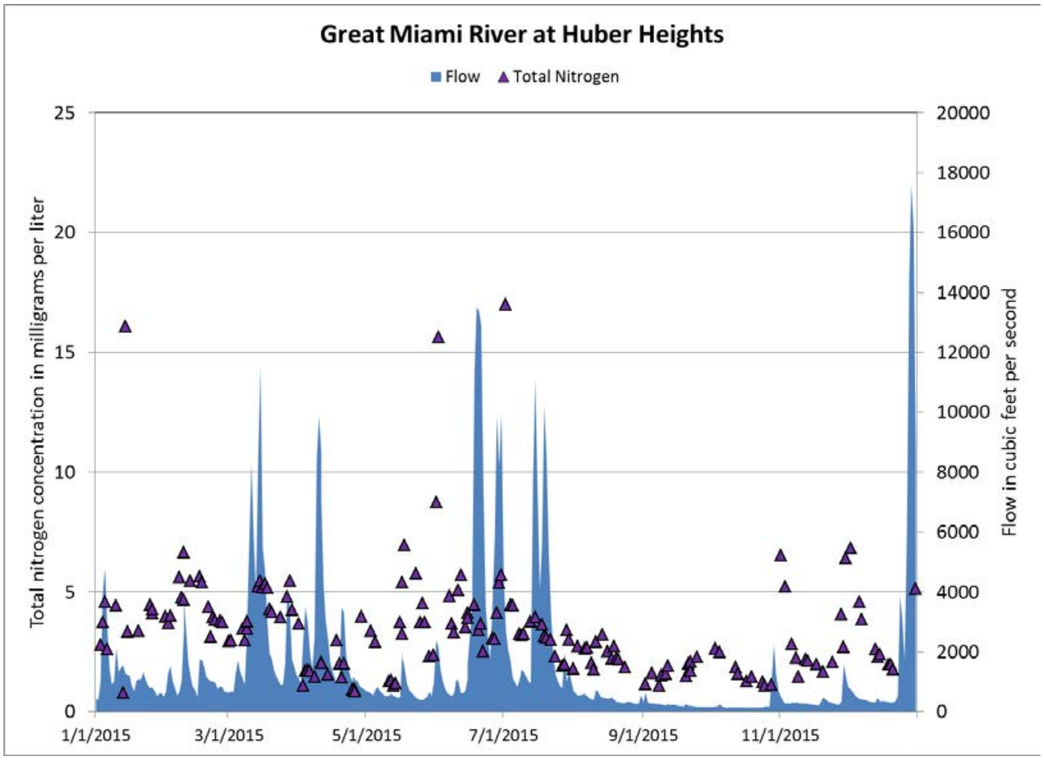
Stillwater River at Englewood									
Parameter	**Number of Samples**	**Number of Detections Above Reporting Limit**	**Minimum (mg/l)**	**25th Percentile (mg/l)**	**Median (mg/l)**	**Mean (mg/l)**	**75th Percentile (mg/l)**	**Maximum (mg/l)**	**OEPA Target (mg/l)**
Ammonia	239	163	0.04	0.10	0.16	0.15	0.20	0.49	
Nitrite	239	28	0.02	0.10	0.10	0.10	0.10	0.92	
Nitrate + Nitrite	239	239	0.07	2.15	3.62	3.70	4.96	9.86	1.00
Total Kjeldahl Nitrogen	239	220	0.17	0.50	0.71	0.91	1.20	3.22	
Dissolved Inorganic Nitrogen	239	239	0.15	2.33	3.81	3.85	5.08	10.06	
Total Nitrogen	239	239	1.21	3.08	4.59	4.76	6.28	11.55	
Orthophosphate as P	239	141	0.02	0.05	0.10	0.09	0.10	0.52	
Total Phosphorus	239	239	0.04	0.09	0.14	0.17	0.21	0.89	0.10
Great Miami River at Huber Heights									
Parameter	**Number of Samples**	**Number of Detections Above Reporting Limit**	**Minimum (mg/l)**	**25th Percentile (mg/l)**	**Median (mg/l)**	**Mean (mg/l)**	**75th Percentile (mg/l)**	**Maximum (mg/l)**	**OEPA Target (mg/l)**
Ammonia	175	175	0.02	0.05	0.05	0.08	0.08	0.89	
Nitrite	NA	NA	NA	NA	NA	NA	NA	NA	
Nitrate + Nitrite	172	172	0.45	1.28	2.16	2.45	3.25	15.20	1.00
Total Kjeldahl Nitrogen	175	175	0.24	0.60	0.79	0.89	1.04	12.08	
Dissolved Inorganic Nitrogen	172	172	0.48	1.38	2.21	2.53	3.32	15.30	
Total Nitrogen	172	172	0.80	2.01	3.11	3.44	4.18	16.99	
Orthophosphate as P	175	175	0.05	0.15	0.17	0.17	0.20	0.43	
Total Phosphorus	175	175	0.11	0.17	0.22	0.26	0.29	1.24	0.15
Mad River near Dayton									
Parameter	**Number of Samples**	**Number of Detections Above Reporting Limit**	**Minimum (mg/l)**	**25th Percentile (mg/l)**	**Median (mg/l)**	**Mean (mg/l)**	**75th Percentile (mg/l)**	**Maximum (mg/l)**	**OEPA Target (mg/l)**
Ammonia	241	167	0.05	0.09	0.14	0.15	0.20	0.39	
Nitrite	241	241	0.02	0.10	0.10	0.09	0.10	0.10	
Nitrate + Nitrite	241	241	1.06	2.07	2.41	2.43	2.76	4.22	1.50
Total Kjeldahl Nitrogen	241	231	0.23	0.56	0.76	1.02	1.07	5.78	
Dissolved Inorganic Nitrogen	241	241	1.17	2.25	2.52	2.58	2.92	4.31	
Total Nitrogen	241	241	2.12	3.07	3.42	3.59	3.83	8.83	
Orthophosphate as P	241	240	0.02	0.04	0.08	0.09	0.10	0.57	
Total Phosphorus	241	241	0.08	0.13	0.16	0.22	0.22	1.21	0.17

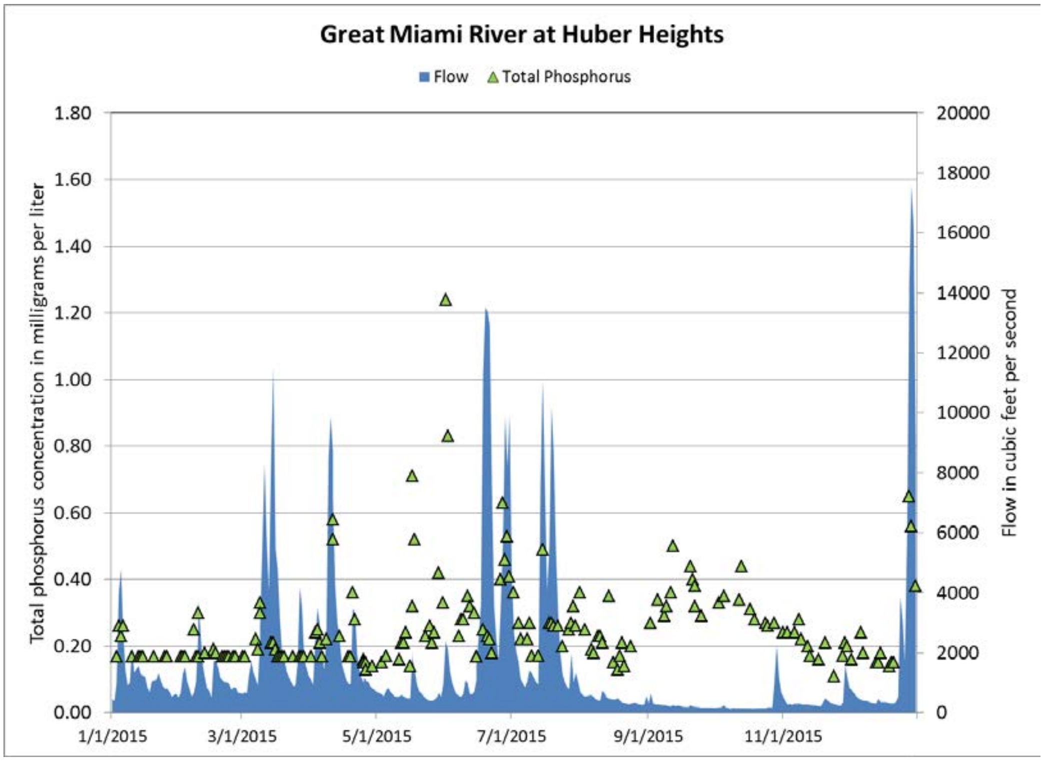
Great Miami River at Miamisburg									
Parameter	**Number of Samples**	**Number of Detections Above Reporting Limit**	**Minimum (mg/l)**	**25th Percentile (mg/l)**	**Median (mg/l)**	**Mean (mg/l)**	**75th Percentile (mg/l)**	**Maximum (mg/l)**	**OEPA Target (mg/l)**
Ammonia	432	425	0.002	0.02	0.04	0.06	0.07	0.82	
Nitrite	456	456	0.010	0.01	0.01	0.03	0.02	0.95	
Nitrate + Nitrite	478	478	0.89	2.01	2.61	2.89	3.44	11.80	2.00
Total Kjeldahl Nitrogen	478	478	0.27	0.65	0.83	1.24	1.05	38.15	
Dissolved Inorganic Nitrogen	478	478	0.90	2.07	2.64	2.95	3.50	12.01	
Total Nitrogen	478	478	1.52	2.96	3.47	4.19	4.69	40.25	
Orthophosphate as P	477	477	0.018	0.11	0.16	0.18	0.23	0.50	
Total Phosphorus	477	477	0.12	0.22	0.28	0.36	0.41	6.51	0.30
Great Miami River near Fairfield									
Parameter	**Number of Samples**	**Number of Detections Above Reporting Limit**	**Minimum (mg/l)**	**25th Percentile (mg/l)**	**Median (mg/l)**	**Mean (mg/l)**	**75th Percentile (mg/l)**	**Maximum (mg/l)**	**OEPA Target (mg/l)**
Ammonia	240	168	0.04	0.11	0.16	0.16	0.20	0.29	
Nitrite	240	20	0.02	0.10	0.10	0.10	0.10	0.14	
Nitrate + Nitrite	240	240	0.86	2.06	2.96	2.97	3.63	9.12	2.00
Total Kjeldahl Nitrogen	240	240	0.26	0.72	1.23	1.33	1.71	4.07	
Dissolved Inorganic Nitrogen	240	240	1.02	2.21	3.09	3.12	3.81	9.22	
Total Nitrogen	240	240	2.41	3.55	4.24	4.45	5.03	10.25	
Orthophosphate as P	240	208	0.02	0.07	0.10	0.12	0.15	0.46	
Total Phosphorus	240	240	0.11	0.18	0.25	0.30	0.38	0.86	0.30

Appendix H - Nutrient Concentrations and Discharge for Samples Collected in 2015






Great Miami River at Huber Heights
Flow
Total Nitrogen
Total nitrogen concentration in milligrams per liter
Flow in cubic feet per second
25
20
15
10
5
0
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015


Great Miami River at Huber Heights
Flow
Total Phosphorus
Total phosphorus concentration in milligrams per liter
Flow in cubic feet per second
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1/1/2015
3/1/2015
5/1/2015
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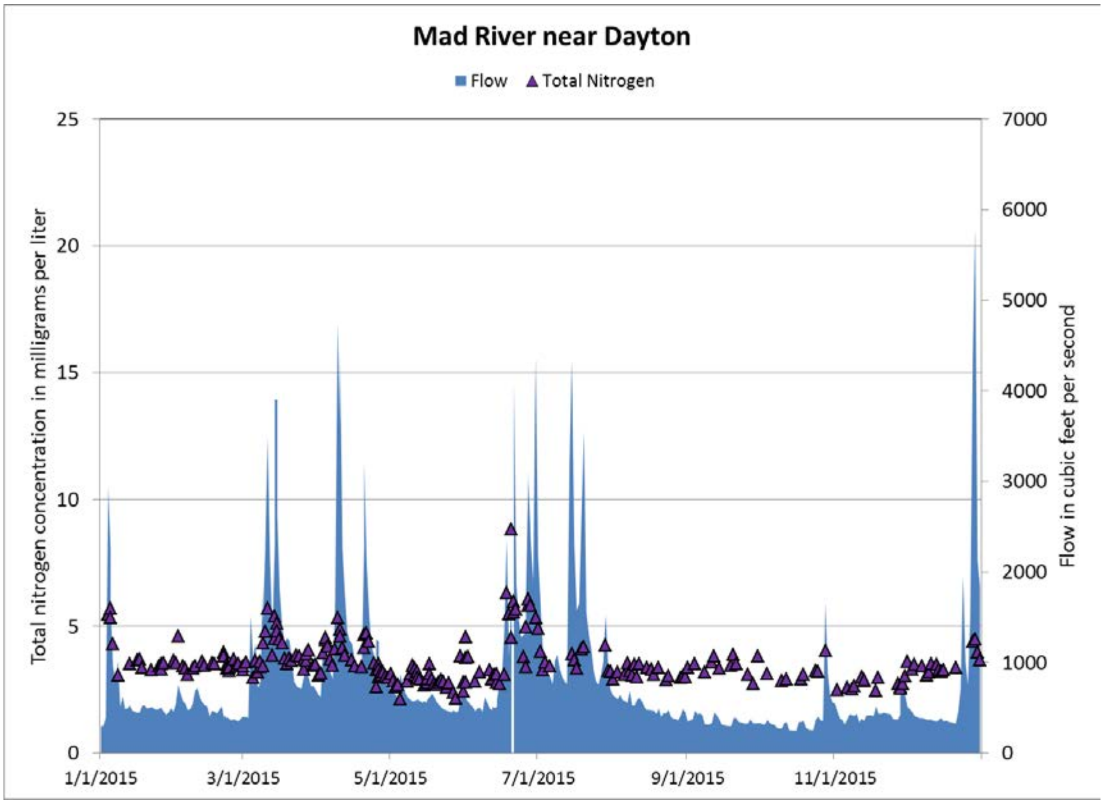
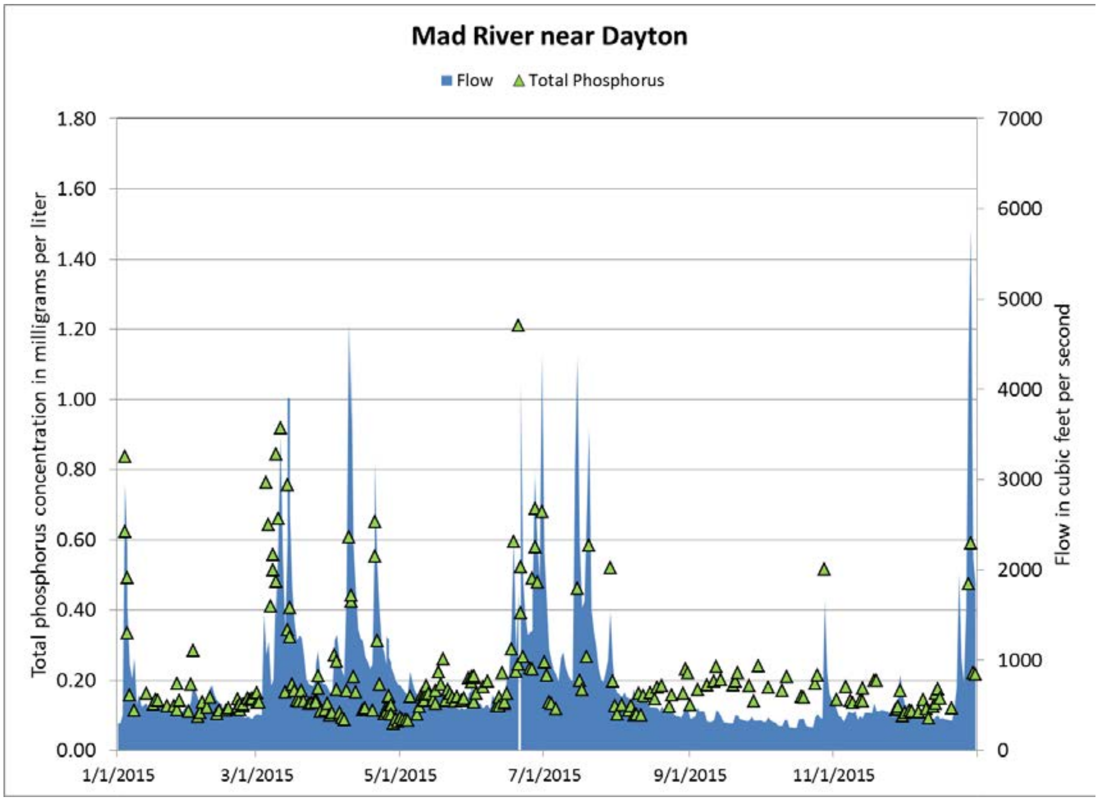
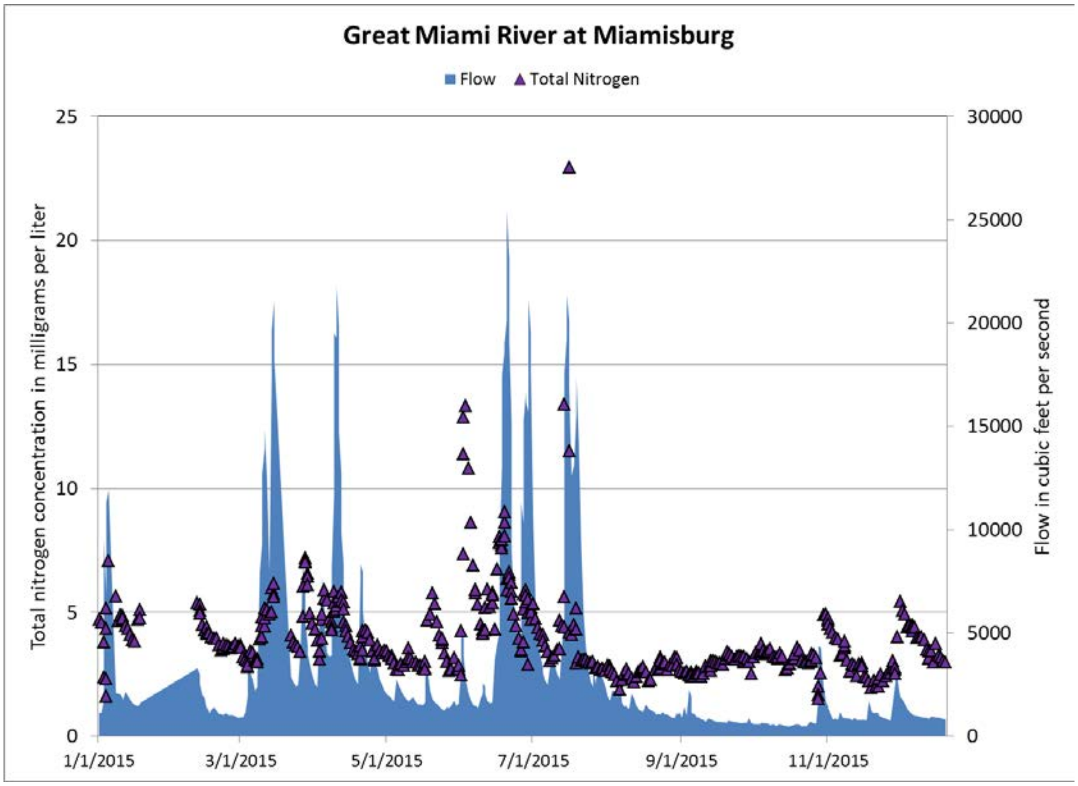
9/1/2015
11/1/2015


Mad River near Dayton
Flow
Total Nitrogen
Total nitrogen concentration in milligrams per liter
Flow in cubic feet per second
0
5
10
15
20
25
0
1000
2000
3000
4000
5000
6000
7000
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015


Mad River near Dayton
Flow
Total Phosphorus
Total phosphorus concentration in milligrams per liter
Flow in cubic feet per second
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
0
1000
2000
3000
4000
5000
6000
7000
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015


Great Miami River at Miamisburg
Flow
Total Nitrogen
Total nitrogen concentration in milligrams per liter
Flow in cubic feet per second
25
20
15
10
5
0
30000
25000
20000
15000
10000
5000
0
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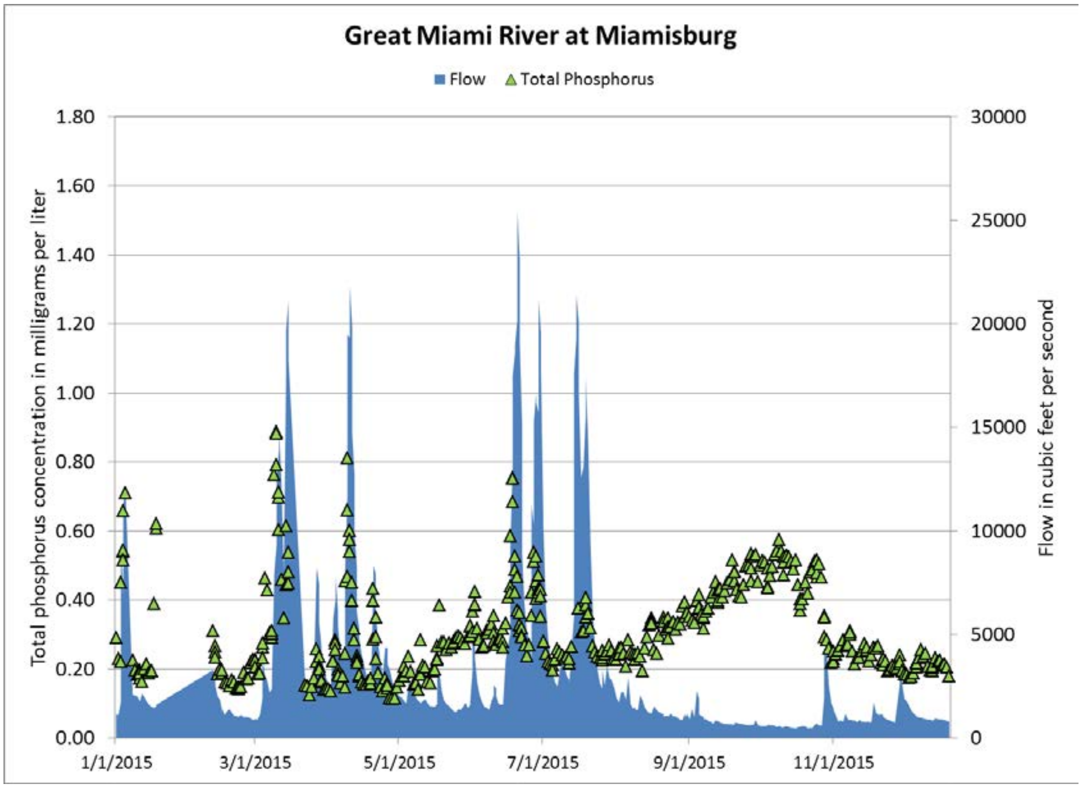
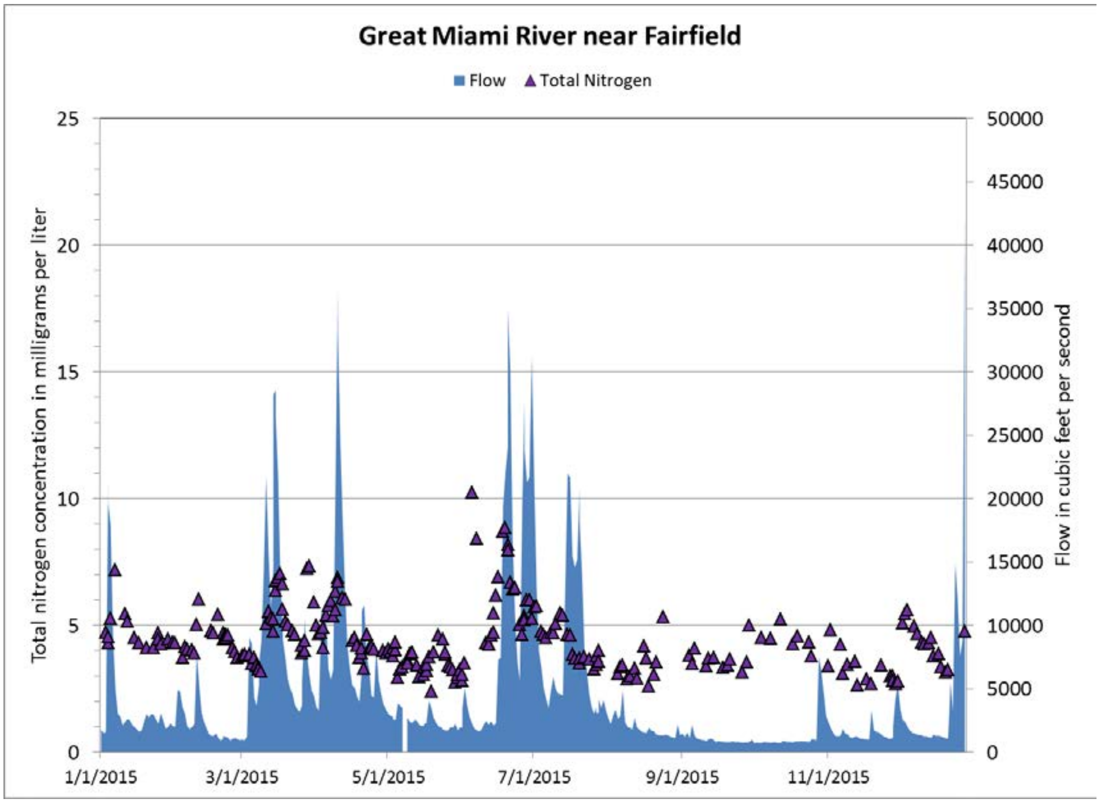
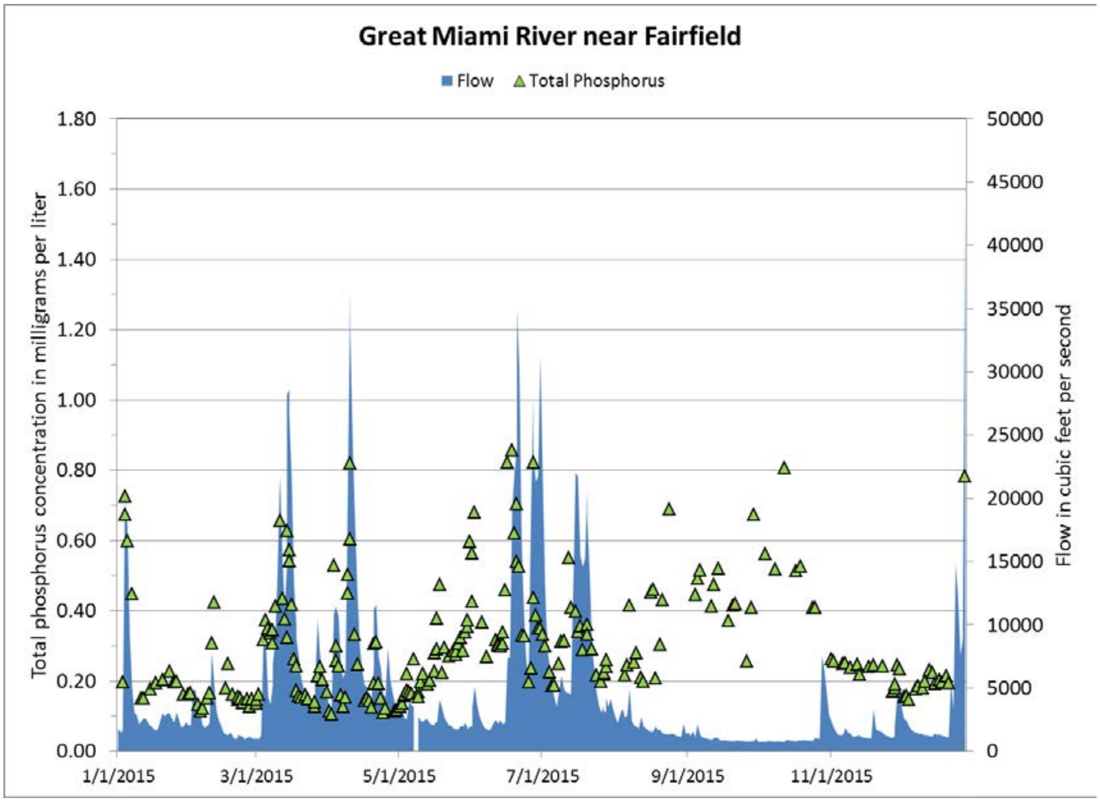
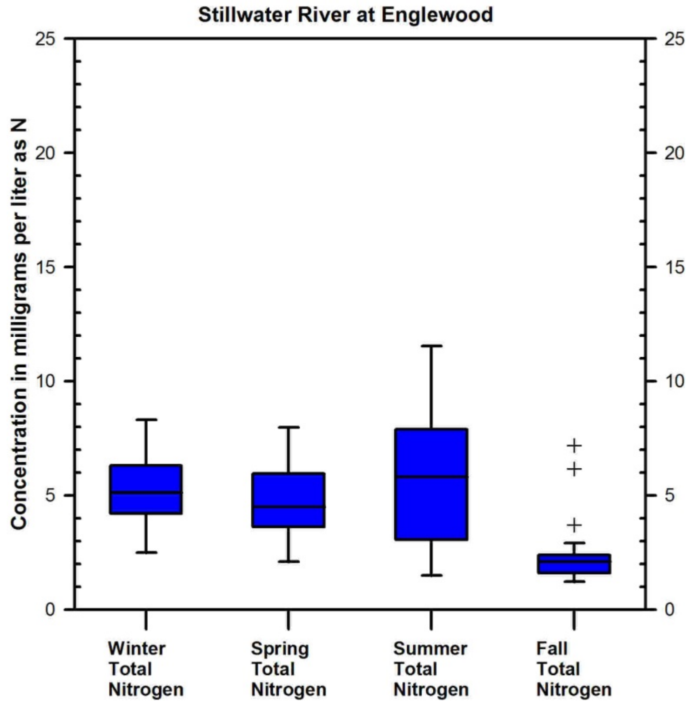
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

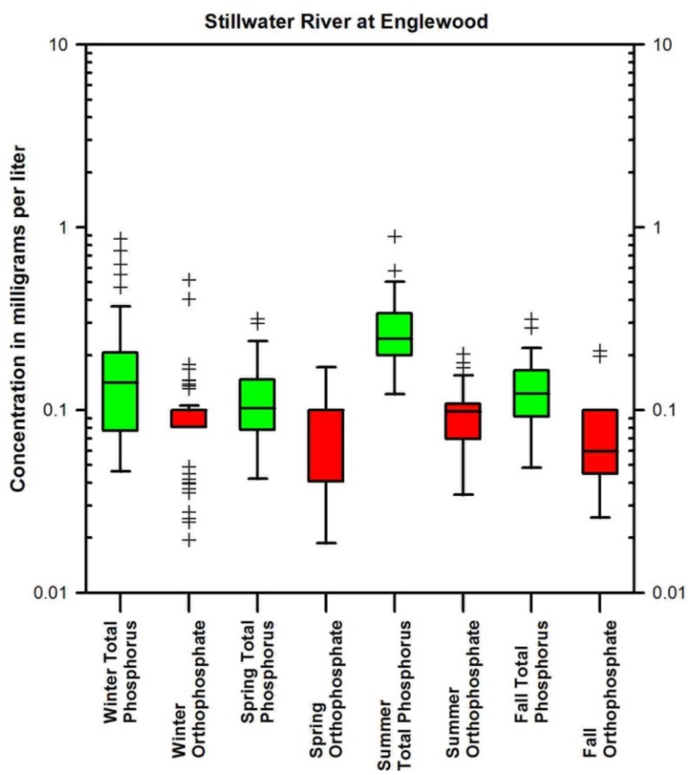

Great Miami River at Miamisburg
Flow
Total Phosphorus
Total phosphorus concentration in milligrams per liter
Flow in cubic feet per second
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
30000
25000
20000
15000
10000
5000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

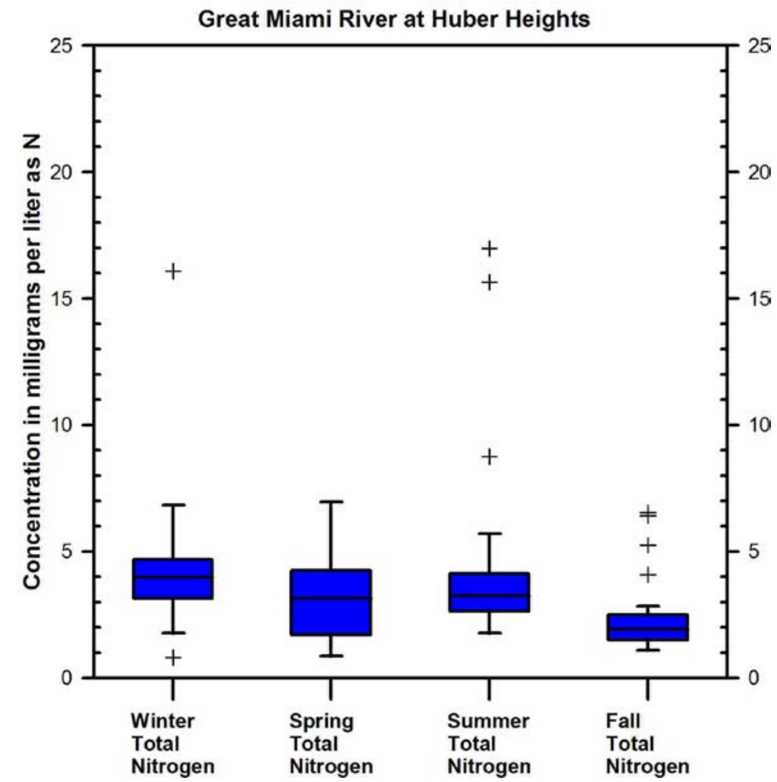

Great Miami River near Fairfield
Flow
Total Nitrogen
Total nitrogen concentration in milligrams per liter
Flow in cubic feet per second
25
20
15
10
5
0
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

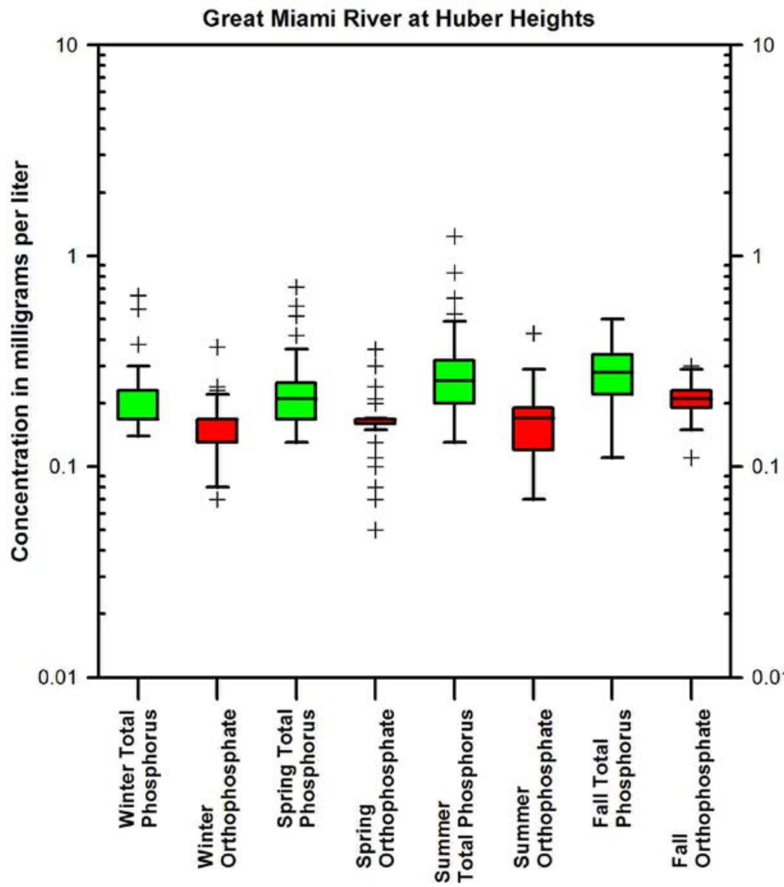

Great Miami River near Fairfield
Flow
Total Phosphorus
Total phosphorus concentration in milligrams per liter
Flow in cubic feet per second
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015

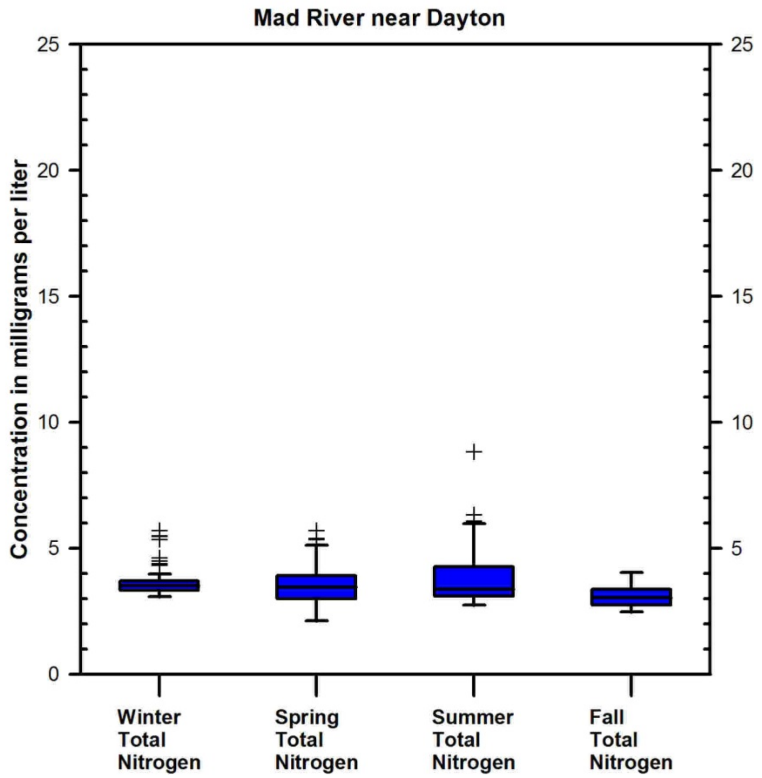
Appendix I - Seasonal Variations in Nutrient Concentrations for Samples Collected in 2015

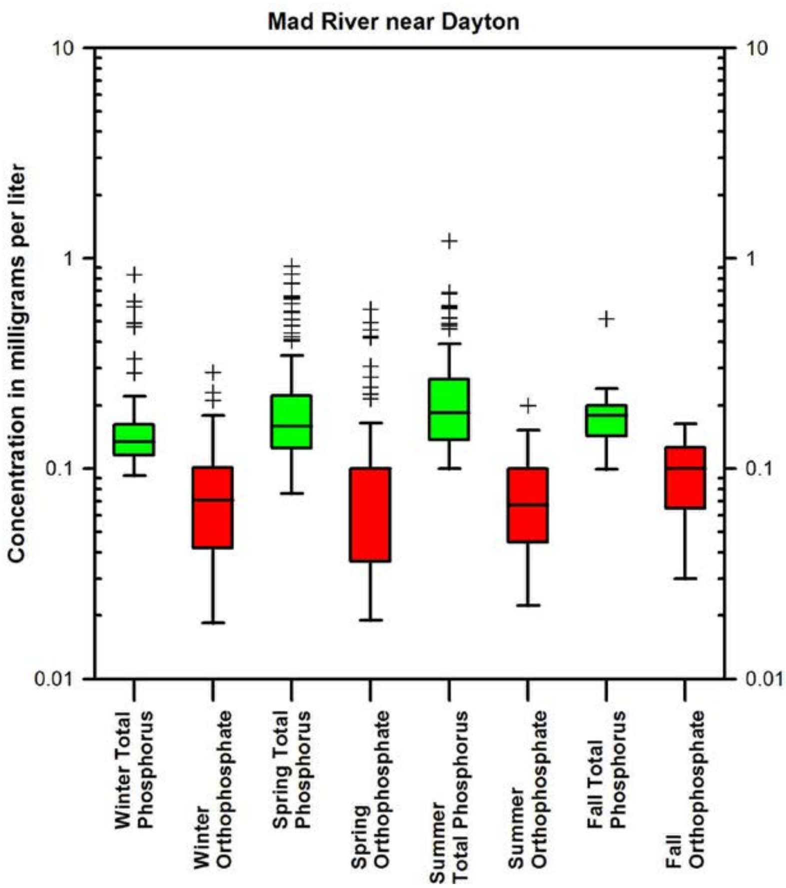


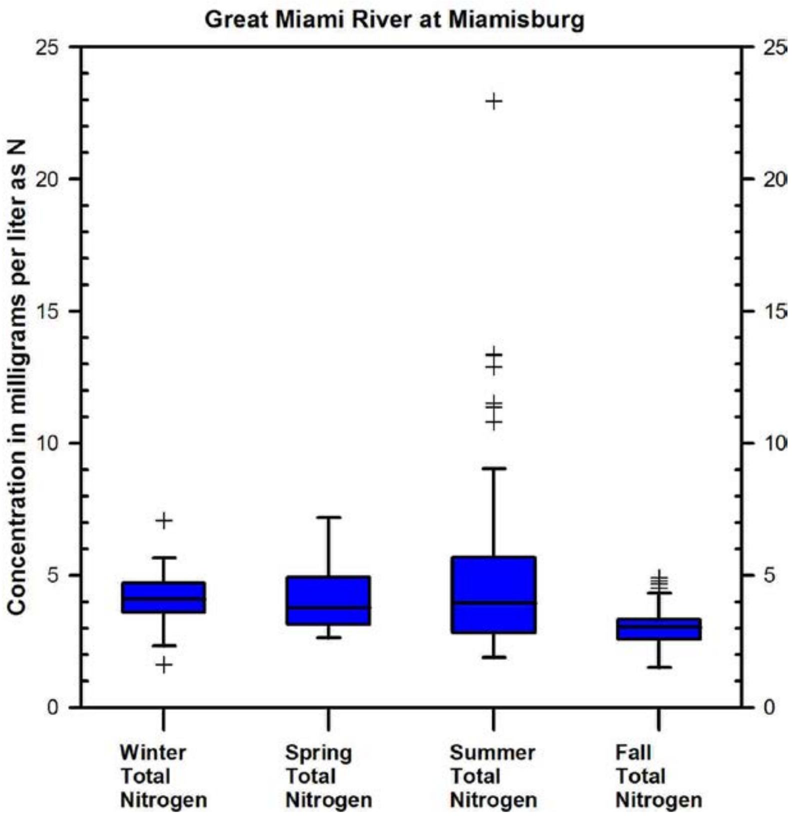


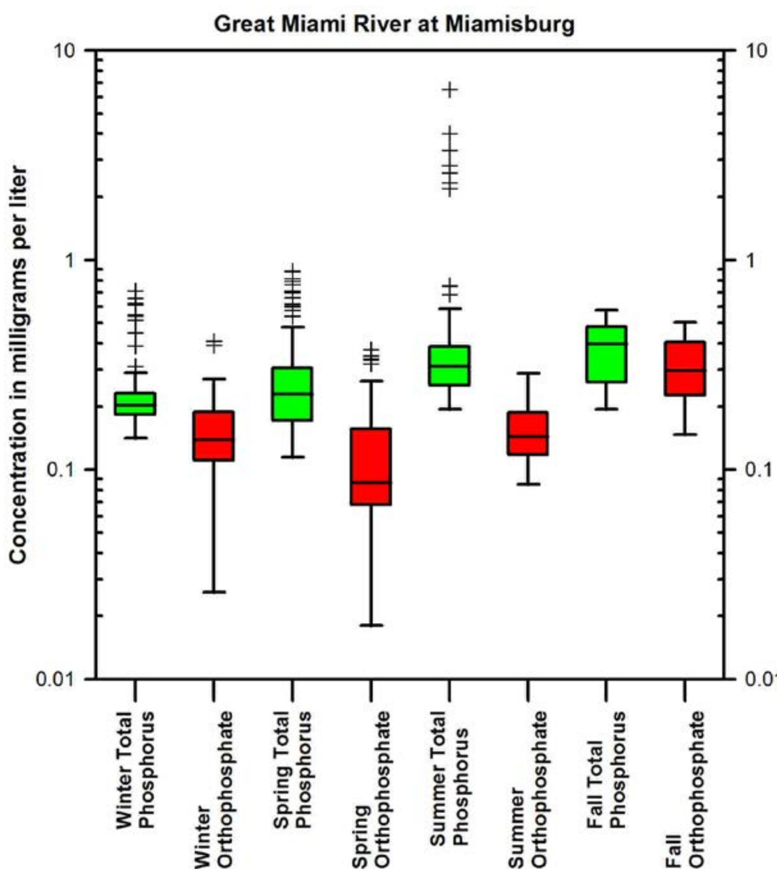

Great Miami River at Huber Heights
Concentration in milligrams per liter as N
0
5
10
15
20
25
Winter Total Nitrogen
Spring Total Nitrogen
Summer Total Nitrogen
Fall Total Nitrogen

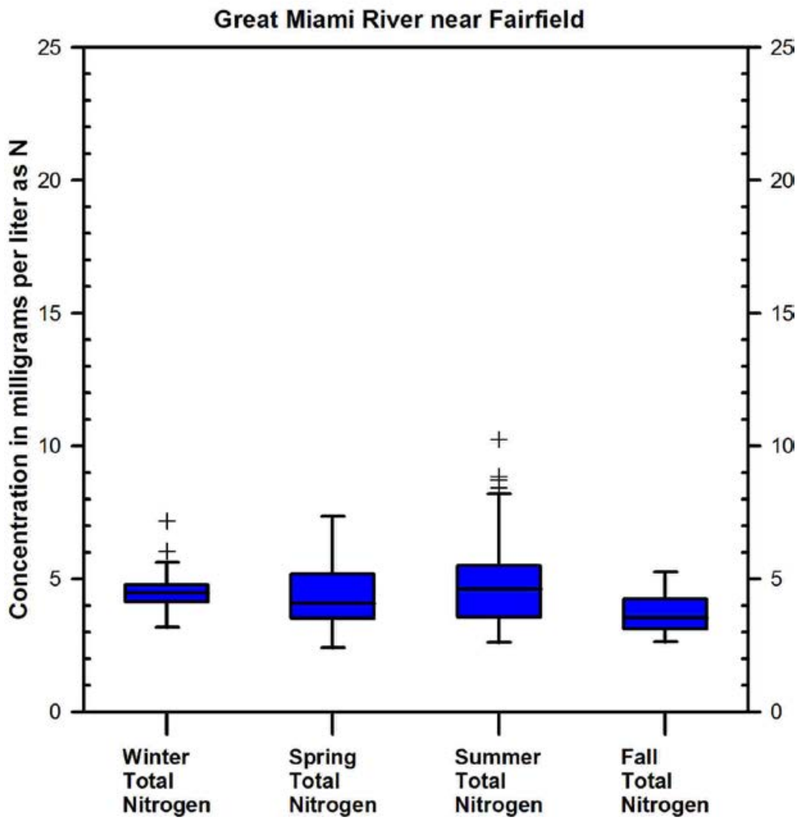

Great Miami River at Huber Heights
Concentration in milligrams per liter
0.01
0.1
1
10
Winter Total Phosphorus
Winter Orthophosphate
Spring Total Phosphorus
Spring Orthophosphate
Summer Total Phosphorus
Summer Orthophosphate
Fall Total Phosphorus
Fall Orthophosphate

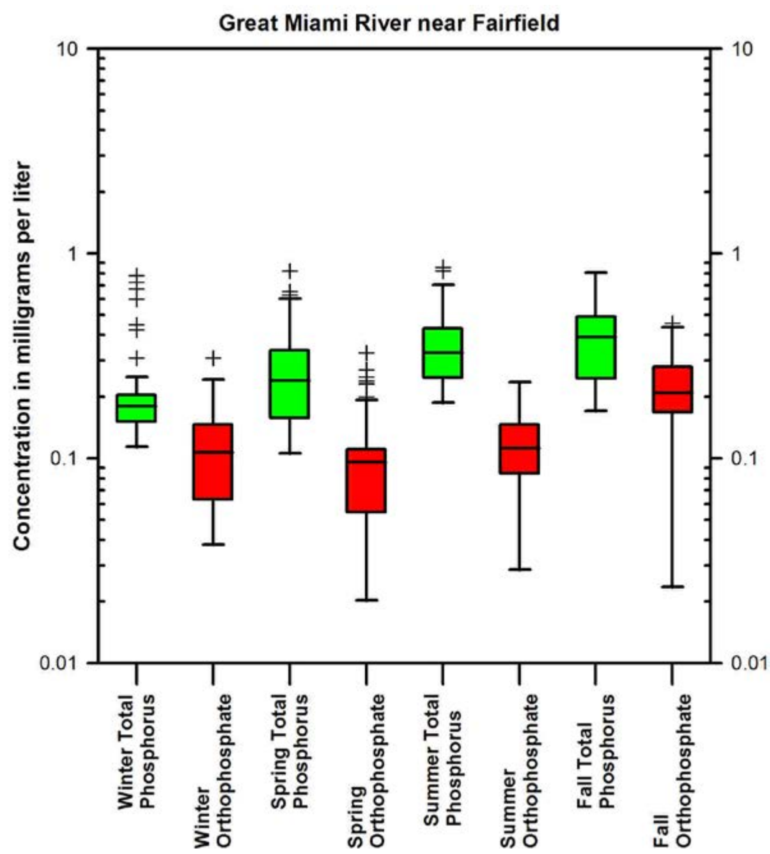

Mad River near Dayton
Concentration in milligrams per liter
0
5
10
15
20
25
Winter Total Nitrogen
Spring Total Nitrogen
Summer Total Nitrogen
Fall Total Nitrogen


Mad River near Dayton
Concentration in milligrams per liter
0.01
0.1
1
10
Winter Total Phosphorus
Winter Orthophosphate
Spring Total Phosphorus
Spring Orthophosphate
Summer Total Phosphorus
Summer Orthophosphate
Fall Total Phosphorus
Fall Orthophosphate


Great Miami River at Miamisburg
Concentration in milligrams per liter as N
25
20
15
10
5
0
Winter Total Nitrogen
Spring Total Nitrogen
Summer Total Nitrogen
Fall Total Nitrogen


Great Miami River at Miamisburg
Concentration in milligrams per liter
10
1
0.1
0.01
Winter Total Phosphorus
Winter Orthophosphate
Spring Total Phosphorus
Spring Orthophosphate
Summer Total Phosphorus
Summer Orthophosphate
Fall Total Phosphorus
Fall Orthophosphate


Great Miami River near Fairfield
Concentration in milligrams per liter as N
25
20
15
10
5
0
Winter Total Nitrogen
Spring Total Nitrogen
Summer Total Nitrogen
Fall Total Nitrogen


Great Miami River near Fairfield
Concentration in milligrams per liter
10
1
0.1
0.01
Winter Total Phosphorus
Winter Orthophosphate
Spring Total Phosphorus
Spring Orthophosphate
Summer Total Phosphorus
Summer Orthophosphate
Fall Total Phosphorus
Fall Orthophosphate

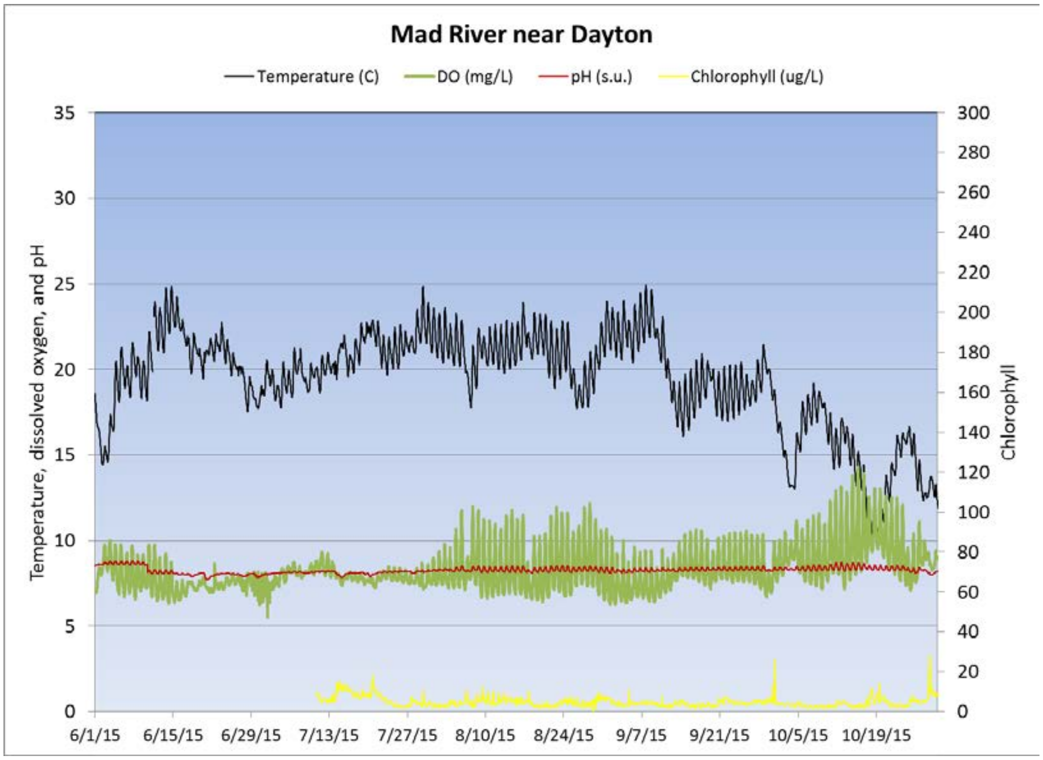
Appendix J – Nutrient Load Summary

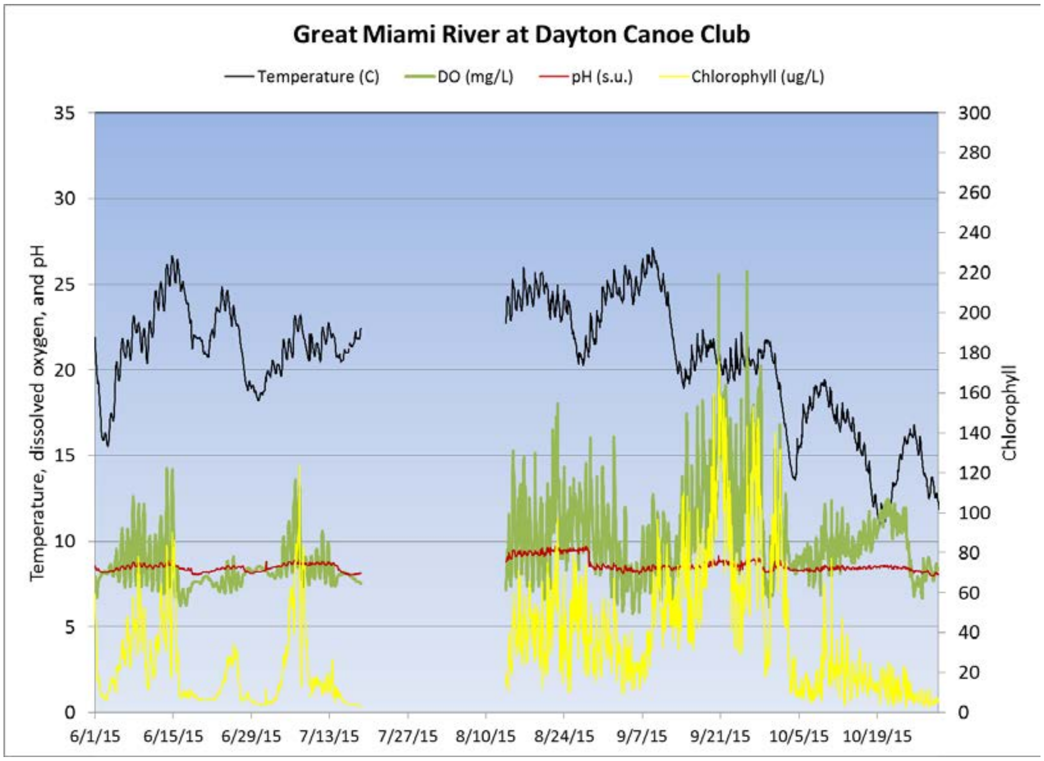
Stillwater River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (metric tons)	5,550	4,464	6,148	3,417	4,642	6,056	2,089	5,135	3,667	3,959	4,513
Dissolved Inorganic Nitrogen (metric tons)	4,120	3,019	4,292	2,778	3,565	4,697	1,583	4,063	2,704	3,120	3,394
Total Phosphorus (metric tons)	165	365	519	118	175	322	75	294	161	175	237
Total Flow (acre-feet)	614,696	663,828	754,258	377,304	474,368	862,054	252,317	554,173	469,327	624,371	564,669
Upper Great Miami River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (metric tons)	NA	NA	9,601	3,914	4,434	8,937	2,918	7,301	5,282	5,264	5,956
Dissolved Inorganic Nitrogen (metric tons)	NA	NA	6,552	3,111	3,497	6,732	2,125	5,522	4,206	3,804	4,443
Total Phosphorus (metric tons)	NA	NA	688	174	314	780	160	583	242	459	425
Total Flow (acre-feet)	NA	NA	1,478,988	528,798	669,138	1,758,911	611,289	1,088,697	921,734	1,200,042	1,032,200
Mad River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (metric tons)	NA	3,242	3,493	NA	NA	4,144	1,887	2,951	2,762	2,833	3,045
Dissolved Inorganic Nitrogen (metric tons)	NA	2,174	2,447	NA	NA	2,996	1,335	2,118	1,844	1,852	2,109
Total Phosphorus (metric tons)	NA	206	239	NA	NA	288	110	199	181	208	204
Total Flow (acre-feet)	NA	697,275	742,710	NA	NA	983,754	437,523	606,212	555,328	588,033	658,691
Lower Great Miami River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (metric tons)	NA	NA	7,630	NA	NA	9,794	3,512	5,992	9,551	10,105	7,764
Dissolved Inorganic Nitrogen (metric tons)	NA	NA	4,143	NA	NA	8,748	2,334	3,012	3,834	6,044	4,686
Total Phosphorus (metric tons)	NA	NA	1,007	NA	NA	1,448	327	928	1,491	888	1,015
Total Flow (acre-feet)	NA	NA	1,164,511	NA	NA	2,291,745	770,624	1,059,953	1,103,992	1,208,001	1,266,471
Great Miami River Watershed (upstream of Miamisburg)											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (metric tons)	15,435	14,275	18,890	10,359	11,818	21,491	7,566	15,000	12,583	15,857	14,327
Dissolved Inorganic Nitrogen (metric tons)	11,979	10,117	13,443	7,339	8,816	15,058	5,791	11,191	8,528	9,703	10,197
Total Phosphorus (metric tons)	1,174	1,546	1,802	756	840	1,790	597	1,115	945	1,321	1,189
Total Flow (acre-feet)	2,606,463	2,869,209	3,209,564	1,548,744	1,793,817	3,996,440	1,509,559	2,441,995	2,137,750	2,526,657	2,464,020
Great Miami River Watershed (upstream of Hamilton)											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (metric tons)	NA	18,619	26,879	NA	NA	28,666	10,406	21,378	21,263	22,161	21,339
Dissolved Inorganic Nitrogen (metric tons)	NA	11,879	17,438	NA	NA	22,967	7,377	14,715	12,588	14,820	14,541
Total Phosphorus (metric tons)	NA	1,513	2,455	NA	NA	2,822	672	2,004	2,076	1,730	1,896
Total Flow (acre-feet)	NA	3,471,558	4,141,823	NA	NA	5,826,493	2,071,753	3,309,034	3,050,381	3,620,446	3,641,641

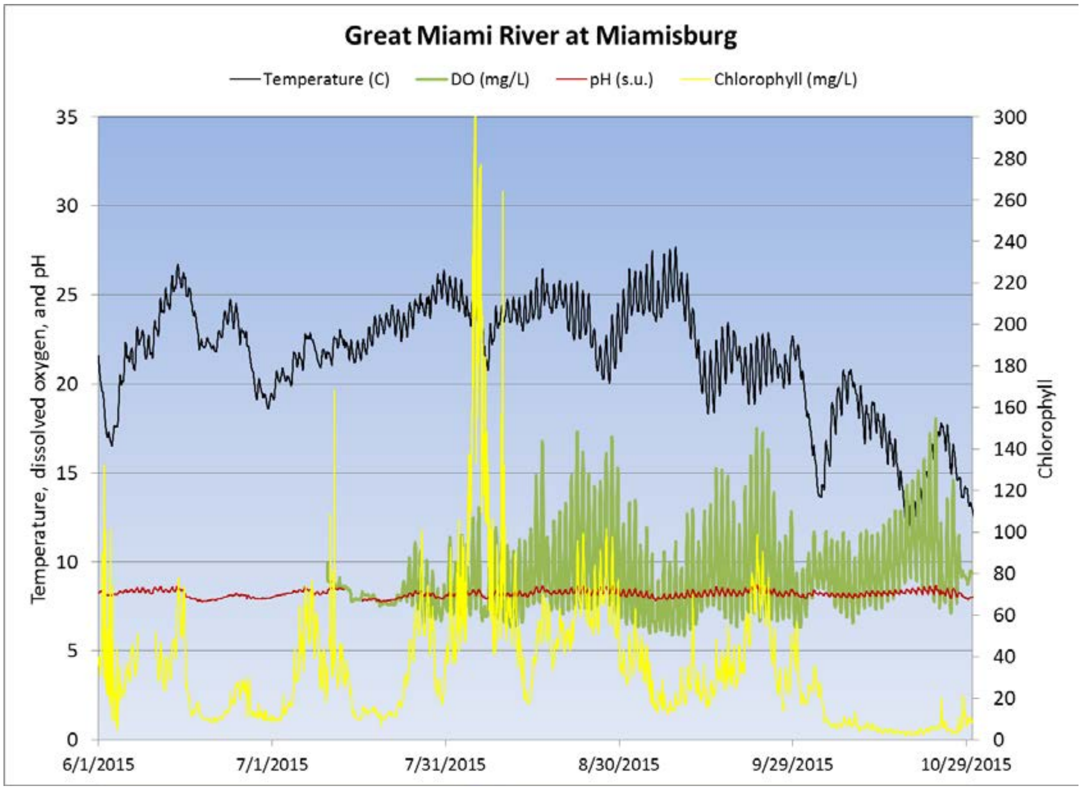
Appendix K – Nutrient Yield Summary

Stillwater River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (kg/km^2)	3,297	2,652	3,652	2,030	2,758	3,597	1,241	3,050	2,178	2,173	2,663
Dissolved Inorganic Nitrogen (kg/km^2)	2,447	1,794	2,549	1,650	2,118	2,790	941	2,414	1,606	1,741	2,005
Total Phosphorus (kg/km^2)	98	217	308	70	104	191	45	175	96	81	139
Total Flow (acre-feet)	614,696	663,828	754,258	377,304	474,368	862,054	252,317	554,173	469,327	585,590	560,791
Upper Great Miami River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (kg/km^2)	NA	NA	3,226	1,315	1,490	3,003	981	2,453	1,775	1,769	2,002
Dissolved Inorganic Nitrogen (kg/km^2)	NA	NA	2,202	1,045	1,175	2,262	714	1,855	1,413	1,278	1,493
Total Phosphorus (kg/km^2)	NA	NA	231	58	105	262	54	196	81	154	143
Total Flow (acre-feet)	NA	NA	1,478,988	528,798	669,138	1,758,911	611,289	1,088,697	921,734	1,200,042	1,032,200
Mad River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (kg/km^2)	NA	1,971	2,124	NA	NA	2,520	1,147	1,794	1,680	1,723	1,851
Dissolved Inorganic Nitrogen (kg/km^2)	NA	1,322	1,488	NA	NA	1,822	812	1,288	1,121	1,126	1,283
Total Phosphorus (kg/km^2)	NA	125	146	NA	NA	175	67	121	110	127	124
Total Flow (acre-feet)	NA	697,275	742,710	NA	NA	983,754	437,523	606,212	555,328	588,033	658,691
Lower Great Miami River Watershed											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (kg/km^2)	NA	NA	2,463	NA	NA	3,162	1,134	1,934	3,083	3,359	2,523
Dissolved Inorganic Nitrogen (kg/km^2)	NA	NA	1,337	NA	NA	2,824	753	994	1,238	2,012	1,526
Total Phosphorus (kg/km^2)	NA	NA	325	NA	NA	468	106	299	481	299	330
Total Flow (acre-feet)	NA	NA	1,164,511	NA	NA	2,291,745	770,624	1,059,953	1,103,992	1,246,782	1,272,934
Great Miami River Watershed (upstream of Miamisburg)											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (kg/km^2)	2,195	2,030	2,686	1,473	1,681	3,056	1,076	2,133	1,789	2,255	2,038
Dissolved Inorganic Nitrogen (kg/km^2)	1,704	1,439	1,912	1,044	1,254	2,141	824	1,592	1,213	1,380	1,450
Total Phosphorus (kg/km^2)	167	220	256	108	119	254	85	159	134	188	169
Total Flow (acre-feet)	2,606,463	2,869,209	3,209,564	1,548,744	1,793,817	3,996,440	1,509,559	2,441,995	2,137,750	2,526,657	2,464,020
Great Miami River Watershed (upstream of Hamilton)											
Constituent	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Mean**
Total Nitrogen (kg/km^2)	NA	1,980	2,859	NA	NA	3,049	1,107	2,274	2,262	2,357	2,270
Dissolved Inorganic Nitrogen (kg/km^2)	NA	1,264	1,855	NA	NA	2,443	785	1,565	1,339	1,576	1,547
Total Phosphorus (kg/km^2)	NA	161	261	NA	NA	300	71	213	221	184	202
Total Flow (acre-feet)	NA	3,471,558	4,141,823	NA	NA	5,826,493	2,071,753	3,309,034	3,050,381	3,620,446	3,641,641

Appendix L – Continuous Water Quality Data






Great Miami River at Miamisburg
Temperature (C)
DO (mg/L)
pH (s.u.)
Chlorophyll (mg/L)
Temperature, dissolved oxygen, and pH
Chlorophyll
35
30
25
20
15
10
5
0
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
6/1/2015
7/1/2015
7/31/2015
8/30/2015
9/29/2015
10/29/2015

Appendix M - Groundwater Quality Data

Spring 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Dissolved Oxygen	mg/L	YSI sonde			—	—	3.57	0.14	5.89	0.13	0.61	0.35	0.10	4.65
pH	S.U.	YSI sonde			SMCL	6.5 - 8.5	6.88	7.35	7.07	7.01	6.75	7.12	7.07	7.23
Specific Conductance	mS/cm	YSI sonde			—	—	1013	495	569	689	1431	1090	654	593
Temperature	°C	YSI sonde			—	—	13.12	12.73	10.83	10.48	10.95	12.53	11.24	13.35
Ammonia	mg/L	EPA 350.1	0.200	0.0732	—	—	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200
Chloride	mg/L	SM 4500-CL-E	2.00	0.806	SMCL	250	91.2	12.9	14.5	14.0	11.7	64.1	7.57	38.1
Fluoride	mg/L	SM 4500 F-C	0.200	0.0174	MCL	4	0.200	0.270	0.261	0.200	< 0.200	< 0.200	0.530	0.250
Nitrite Nitrogen as NO2-N	mg/L	SM 4500 NO3-F	0.100	0.0210	MCL	1	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Nitrogen, Nitrate-Nitrite	mg/L	SM 4500 NO3-F	0.100	0.0157	MCL	10	1.28	< 0.100	9.46	1.93	0.118	< 0.100	< 0.100	0.387
Nitrogen, Total Kjeldahl	mg/L	EPA 351.2	0.500	0.165	—	—	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
Phosphorus	mg/L	SW 6010B	0.100	0.00452	—	—	< 0.100	0.121	< 0.100	7.28	8.71	49.9	15.9	22.8
Sulfate	mg/L	EPA 375.4 Modified	10.0	3.80	SMCL	250	33.5	58.9	11.6	32.9	382	58.6	44.0	30.0
Total Hardness	mg/L	EPA 200.7	0.662	0.0850	—	—	404	303	341	352	572	323	322	241
Total Orthophosphate, as P	mg/L	SM 4500 P-F	0.100	0.0218	—	—	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Aluminum	mg/L	SW 6010B	0.100	0.00561	MCL	0.2	< 0.100	0.428	< 0.100	< 0.100	< 0.100	< 0.100	0.138	< 0.100
Antimony	mg/L	SW 7041	0.00300	0.00110	MCL	0.006	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300
Arsenic	mg/L	SW 7060A	0.00300	0.000763	MCL	0.01	< 0.00300	0.00458	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300
Barium	mg/L	SW 6010B	0.00500	0.000747	MCL	2	0.263	0.266	0.0830	0.131	0.115	0.115	0.167	0.0663
Beryllium	mg/L	SW 6010B	0.000500	0.0000236	MCL	0.004	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500
Boron	mg/L	SW 6010B	0.100	0.00328	HBSL	6000	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Cadmium	mg/L	SW 7131A	0.000200	0.0000702	MCL	0.005	< 0.00300	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200
Calcium	mg/L	SW 6010B	0.100	0.0174	—	—	110	75.9	78.6	95.0	156	82.5	76.4	53.7
Chromium, Hexavalent	mg/L	SM 3500 Cr B	0.0100	0.00480	MCL	0.1	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Cobalt	mg/L	SW 6010B	0.00500	0.000815	—	—	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Copper	mg/L	SW 6010B	0.00500	0.000566	SMCL	1	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Iron	mg/L	SW 6010B	0.0500	0.00534	SMCL	0.3	0.0940	**1.85**	< 0.0500	< 0.0500	< 0.0500	**0.367**	**0.334**	< 0.0500
Lead	mg/L	SW 7421	0.00200	0.000738	MCL	0.015	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200
Lithium	mg/L	SW 6010B	0.00500	0.0000315	—	—	< 0.00500	< 0.00500	< 0.00500	< 0.00500	0.0108	< 0.00500	0.00571	< 0.00500
Magnesium	mg/L	SW 6010B	0.100	0.0101	—	—	31.7	27.6	35.0	27.9	44.4	28.3	31.8	26.1
Manganese	mg/L	SW 6010B	0.00500	0.00153	HBSL, SMCL	0.3, 0.05	< 0.00500	**0.424**	< 0.00500	**0.143**	< 0.00500	**0.0863**	**0.268**	< 0.00500

Spring 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Molybdenum	mg/L	SW 6010B	0.0100	0.00207	HBSL	0.04	< 0.0100	0.0249	0.0218	0.0134	< 0.0100	0.0142	< 0.0100	< 0.0100
Nickel	mg/L	SW 6010B	0.00500	0.00118	HBSL	0.1	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Potassium	mg/L	SW 6010B	1.00	0.0397	—	—	3.88	1.33	1.48	1.08	2.94	2.42	1.32	1.95
Silver	mg/L	SW 6010B	0.00200	0.000384	HBSL	0.1	< 0.00200	0.00239	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200
Sodium	mg/L	SW 6010B	1.00	0.0631	—	—	47.4	6.39	7.50	7.28	8.71	49.9	15.9	22.8
Strontium	mg/L	SW 6010B	0.00500	0.000527	HBSL	4	0.793	0.456	2.31	0.384	0.498	0.421	0.834	0.425
Thallium	mg/L	SW 7841/EPA 279.2	0.00100	0.000407	MCL	0.002	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100
Vanadium	mg/L	SW 6010B	0.00500	0.000517	—	—	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Zinc	mg/L	SW 6010B	0.0100	0.00138	HBSL	2	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Alkalinity, Total (As CaCO3)	mg/L	SM 2320B	25.0	25.0	—	—	348	248	298	318	378	298	308	219
Biochemical Oxygen Demand	mg/L	SM 5210B	2.00	2.00	—	—	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00
Carbonaceous Biological Oxygen Demand	mg/L	EPA 405.1/SM 5210	2.00	2.00	—	—	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00
Chemical Oxygen Demand	mg/L	HACH 8000	5.00	4.68	—	—	7.00	< 5.00	< 5.00	5.00	7.00	< 5.00	< 5.00	< 5.00
Cyanide, Total	mg/L	EPA 335.4	0.0100	0.00195	MCL	0.2	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Phenolics, Total Recoverable	mg/L	EPA 420.4	0.0100	0.00336	—	—	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Total Dissolved Solids (Residue, Filterable)	mg/L	SM 2540C	5.00	1.67	SMCL	500	**657**	340	344	380	**657**	458	338	280
Total Organic Carbon	mg/L	SM 5310C	1.00	0.142	—	—	< 1.00	< 1.00	< 1.00	< 1.00	1.21	< 1.00	1.03	< 1.00
E. coli	MPN/100 mL	Colilert	1.00		MCL	0	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
2,4,5-T	ug/L	SW 8151	0.118	0.0477	HBSL	70				< 0.118	< 0.118		< 0.118	< 0.118
2,4,5-TP (Silvex)	ug/L	SW 8151	0.119	0.0249	—	—				< 0.119	< 0.119		< 0.119	< 0.119
2,4-D	ug/L	SW 8151	0.125	0.0439	MCL	70				**0.225**	**0.559**		**0.375**	**0.220**
2,4-DB	ug/L	SW 8151	0.118	0.0417	HHBP	210				< 0.118	< 0.118		< 0.118	< 0.118
4,4´-DDD	ug/L	SW 8081	0.0500	0.0153	HBSL	1				< 0.0500	< 0.0500		< 0.0500	< 0.0500
4,4´-DDE	ug/L	SW 8081	0.0500	0.0168	HBSL	0.1				< 0.0500	< 0.0500		< 0.0500	< 0.0500
4,4´-DDT	ug/L	SW 8081	0.0500	0.0217	HBSL	0.0000072				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Aldrin	ug/L	SW 8081	0.0500	0.0168	HBSL	0.002				< 0.0500	< 0.0500		< 0.0500	< 0.0500
alpha-BHC	ug/L	SW 8081	0.0500	0.0217	HBSL	0.006				< 0.0500	< 0.0500		< 0.0500	< 0.0500
alpha-Chlordane	ug/L	SW 8081	0.0500	0.0153	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
beta-BHC	ug/L	SW 8081	0.0500	0.0238	HBSL	0.02				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Chlordane	ug/L	SW 8081	0.500	0.211	MCL	2				< 0.500	< 0.500		< 0.500	< 0.500
Dalapon	ug/L	SW 8151	0.228	0.0445	MCL	200				< 0.228	< 0.228		< 0.228	< 0.228
delta-BHC	ug/L	SW 8081	0.0500	0.0217	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500

Spring 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Dicamba	ug/L	SW 8151	0.118	0.0427	HBSL	3000				< 0.118	< 0.118		< 0.118	< 0.118
Dichloroprop	ug/L	SW 8151	0.118	0.0361	HBSL	300				< 0.118	< 0.118		< 0.118	< 0.118
Dieldrin	ug/L	SW 8081	0.0500	0.0153	HBSL	0.002				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Dinoseb	ug/L	SW 8151	0.118	0.0563	MCL	7				**0.680**	**0.576**		**0.647**	**0.652**
Endosulfan I	ug/L	SW 8081	0.0500	0.0119	HHBP	42				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endosulfan II	ug/L	SW 8081	0.0500	0.0181	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endosulfan sulfate	ug/L	SW 8081	0.0500	0.0238	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endrin	ug/L	SW 8081	0.0500	0.0153	MCL	2				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endrin aldehyde	ug/L	SW 8081	0.0500	0.0168	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endrin ketone	ug/L	SW 8081	0.0500	0.0247	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
gamma-BHC	ug/L	SW 8081	0.0500	0.0168	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
gamma-Chlordane	ug/L	SW 8081	0.0500	0.0217	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Heptachlor	ug/L	SW 8081	0.0500	0.0181	MCL	0.4				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Heptachlor epoxide	ug/L	SW 8081	0.0500	0.0217	MCL	0.2				< 0.0500	< 0.0500		< 0.0500	< 0.0500
MCPA	ug/L	SW 8151	23.4	8.15	HBSL	140				< 23.4	< 23.4		< 23.4	< 23.4
MCPP	ug/L	SW 8151	23.5	5.24	—	—				< 23.5	< 23.5		< 23.5	< 23.5
Methoxychlor	ug/L	SW 8081	0.0500	0.0247	MCL	40				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Toxaphene	ug/L	SW 8081	0.500	0.210	MCL	3				< 0.500	< 0.500		< 0.500	< 0.500
Radon	pCi/L	SM 7500-Rn-B	100	NR	MCL	300				234	**382**		272	**509**
Uranium, Total	µg/L	EPA 200.8	0.001	NR	MCL	30				0.00254	0.00236		0.00102	<0.001
1,2,4,5-Tetrachlorobenzene	ug/L	SW 8270C	5.00	0.411	—	—				< 5.00	< 5.00		< 5.00	< 5.00
1,2,4-Trichlorobenzene	ug/L	SW 8270C	5.00	0.312	MCL	70				< 5.00	< 5.00		< 5.00	< 5.00
1,2-Dichlorobenzene	ug/L	SW 8270C	5.00	0.388	MCL	600				< 5.00	< 5.00		< 5.00	< 5.00
1,2-Diphenylhydrazine	ug/L	SW 8270C	5.00	0.386	HBSL	0.04				< 5.00	< 5.00		< 5.00	< 5.00
1,3,5-Trinitrobenzene	ug/L	SW 8270C	5.00	0.878	—	—				< 5.00	< 5.00		< 5.00	< 5.00
1,3-Dichlorobenzene	ug/L	SW 8270C	5.00	0.319	HBSL	600				< 5.00	< 5.00		< 5.00	< 5.00
1,4-Dichlorobenzene	ug/L	SW 8270C	5.00	0.341	MCL	75				< 5.00	< 5.00		< 5.00	< 5.00
1-Methylnaphthalene	ug/L	SW 8270C	5.00	0.382	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2,3,4,6-Tetrachlorophenol	ug/L	SW 8270C	10.0	0.269	—	—				< 10.0	< 10.0		< 10.0	< 10.0
2,4,5-Trichlorophenol	ug/L	SW 8270C	5.00	0.717	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2,4,6-Trichlorophenol	ug/L	SW 8270C	5.00	0.445	HBSL	2				< 5.00	< 5.00		< 5.00	< 5.00
2,4-Dichlorophenol	ug/L	SW 8270C	5.00	0.448	HBSL	20				< 5.00	< 5.00		< 5.00	< 5.00
2,4-Dimethylphenol	ug/L	SW 8270C	5.00	0.402	HBSL	100				< 5.00	< 5.00		< 5.00	< 5.00

Spring 2015					**Benchmark**		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
2,4-Dinitrophenol	ug/L	SW 8270C	10.0	0.956	HBSL	10				< 10.0	< 10.0		< 10.0	< 10.0
2,4-Dinitrotoluene	ug/L	SW 8270C	5.00	0.521	HBSL	0.05				< 5.00	< 5.00		< 5.00	< 5.00
2,6-Dichlorophenol	ug/L	SW 8270C	5.00	0.319	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2,6-Dinitrotoluene	ug/L	SW 8270C	5.00	0.501	HBSL	0.05				< 5.00	< 5.00		< 5.00	< 5.00
2-Chloronaphthalene	ug/L	SW 8270C	5.00	0.427	HBSL	600				< 5.00	< 5.00		< 5.00	< 5.00
2-Chlorophenol	ug/L	SW 8270C	5.00	0.226	HBSL	40				< 5.00	< 5.00		< 5.00	< 5.00
2-Methylnaphthalene	ug/L	SW 8270C	5.00	0.0625	HBSL	30				< 5.00	< 5.00		< 5.00	< 5.00
2-Methylphenol	ug/L	SW 8270C	5.00	0.871	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2-Nitrophenol	ug/L	SW 8270C	5.00	0.385	—	—				< 5.00	< 5.00		< 5.00	< 5.00
3 & 4-Methylphenol	ug/L	SW 8270C	5.00	0.727	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4,6-Dinitro-2-methylphenol	ug/L	SW 8270C	10.0	0.435	—	—				< 10.0	< 10.0		< 10.0	< 10.0
4-Bromophenyl phenyl ether	ug/L	SW 8270C	5.00	0.279	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4-Chloro-3-methylphenol	ug/L	SW 8270C	5.00	0.293	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4-Chlorophenyl phenyl ether	ug/L	SW 8270C	5.00	0.476	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4-Nitrophenol	ug/L	SW 8270C	5.00	0.470	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Acenaphthene	ug/L	SW 8270C	5.00	0.0350	HBSL	400				< 5.00	< 5.00		< 5.00	< 5.00
Acenaphthylene	ug/L	SW 8270C	5.00	0.0696	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Acetophenone	ug/L	SW 8270C	5.00	0.273	HBSL	700				< 5.00	< 5.00		< 5.00	< 5.00
Aniline	ug/L	SW 8270C	5.00	0.396	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Anthracene	ug/L	SW 8270C	5.00	0.0504	HBSL	2000				< 5.00	< 5.00		< 5.00	< 5.00
Benz(a)anthracene	ug/L	SW 8270C	0.260	0.0840	—	—				< 0.260	< 0.260		< 0.260	< 0.260
Benzidine	ug/L	SW 8270C	5.00	0.662	HBSL	0.0002				< 5.00	< 5.00		< 5.00	< 5.00
Benzo(a)pyrene	ug/L	SW 8270C	0.200	0.0820	MCL	0.2				< 0.200	< 0.200		< 0.200	< 0.200
Benzo(b)fluoranthene	ug/L	SW 8270C	0.170	0.0527	—	—				< 0.170	< 0.170		< 0.170	< 0.170
Benzo(g,h,i)perylene	ug/L	SW 8270C	5.00	0.0923	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Benzo(k)fluoranthene	ug/L	SW 8270C	1.70	0.0574	—	—				< 1.70	< 1.70		< 1.70	< 1.70
Benzyl Alcohol	ug/L	SW 8270C	5.00	0.384	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Bis(2-chloroethoxy)methane	ug/L	SW 8270C	5.00	0.450	—	—				< 5.00	< 5.00		< 5.00	< 5.00
bis-(2-Chloroethyl)ether	ug/L	SW 8270C	5.00	0.428	HBSL	0.03				< 5.00	< 5.00		< 5.00	< 5.00
Bis(2-chloroisopropyl)ether	ug/L	SW 8270C	5.00	0.495	HBSL	300				< 5.00	< 5.00		< 5.00	< 5.00
Bis(2-ethylhexyl)phthalate	ug/L	SW 8270C	1.00	0.334	MCL	6				< 1.00	< 1.00		< 1.00	**1.06**
Butyl benzyl phthalate	ug/L	SW 8270C	5.00	0.247	HBSL	1000				< 5.00	< 5.00		< 5.00	< 5.00
Chrysene	ug/L	SW 8270C	5.00	0.0625	—	—				< 5.00	< 5.00		< 5.00	< 5.00

Spring 2015					Benchmark		Samples Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Dibenz(a,h)anthracene	ug/L	SW 8270C	0.200	0.0742	—	—				< 0.200	< 0.200		< 0.200	< 0.200
Dibenzofuran	ug/L	SW 8270C	5.00	0.254	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Diethyl phthalate	ug/L	SW 8270C	5.00	0.374	HBSL	6000				< 5.00	< 5.00		< 5.00	< 5.00
Dimethyl phthalate	ug/L	SW 8270C	5.00	0.462	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Di-n-butyl phthalate	ug/L	SW 8270C	5.00	0.415	HBSL	700				< 5.00	< 5.00		< 5.00	< 5.00
Di-n-octyl phthalate	ug/L	SW 8270C	5.00	0.342	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Fluoranthene	ug/L	SW 8270C	5.00	0.0540	HBSL	300				< 5.00	< 5.00		< 5.00	< 5.00
Fluorene	ug/L	SW 8270C	5.00	0.0598	HBSL	300				< 5.00	< 5.00		< 5.00	< 5.00
Hexachlorobenzene	ug/L	SW 8270C	5.00	0.276	MCL	1				< 5.00	< 5.00		< 5.00	< 5.00
Hexachlorobutadiene	ug/L	SW 8270C	5.00	0.463	HBSL	0.9				< 5.00	< 5.00		< 5.00	< 5.00
Hexachlorocyclopentadiene	ug/L	SW 8270C	5.00	0.337	MCL	50				< 5.00	< 5.00		< 5.00	< 5.00
Hexachloroethane	ug/L	SW 8270C	5.00	0.359	HBSL	0.9				< 5.00	< 5.00		< 5.00	< 5.00
Hexachloropropene	ug/L	SW 8270C	5.00	0.501	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Indeno(1,2,3-cd)pyrene	ug/L	SW 8270C	0.220	0.0566	—	—				< 0.220	< 0.220		< 0.220	< 0.220
Isophorone	ug/L	SW 8270C	5.00	0.214	HBSL	60				< 5.00	< 5.00		< 5.00	< 5.00
m-Dinitrobenzene	ug/L	SW 8270C	5.00	0.262	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Naphthalene	ug/L	SW 8270C	5.00	0.0651	HBSL	100				< 5.00	< 5.00		< 5.00	< 5.00
Nitrobenzene	ug/L	SW 8270C	5.00	0.314	HBSL	10				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitrosodimethylamine	ug/L	SW 8270C	5.00	0.376	—	—				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitroso-di-n-butylamine	ug/L	SW 8270C	5.00	0.384	—	—				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitrosodi-n-propylamine	ug/L	SW 8270C	5.00	0.346	HBSL	0.005				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitrosodiphenylamine	ug/L	SW 8270C	5.00	0.602	HBSL	7				< 5.00	< 5.00		< 5.00	< 5.00
Pentachlorobenzene	ug/L	SW 8270C	5.00	0.289	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Pentachloronitrobenzene	ug/L	SW 8270C	5.00	0.582	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Pentachlorophenol	ug/L	SW 8270C	1.00	0.429	MCL	1				< 1.00	< 1.00		< 1.00	< 1.00
Phenanthrene	ug/L	SW 8270C	5.00	0.0745	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Phenol	ug/L	SW 8270C	5.00	0.263	HBSL	2000				< 5.00	< 5.00		< 5.00	< 5.00
Pyrene	ug/L	SW 8270C	5.00	0.0613	HBSL	200				< 5.00	< 5.00		< 5.00	< 5.00
Pyridine	ug/L	SW 8270C	5.00	0.454	—	—				< 5.00	< 5.00		< 5.00	< 5.00
1,1,1,2-Tetrachloroethane	ug/L	SW 8260B	1.00	0.220	HBSL	1	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1,1-Trichloroethane	ug/L	SW 8260B	1.00	0.283	MCL	200	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1,2,2-Tetrachloroethane	ug/L	SW 8260B	1.00	0.230	HBSL	1	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1,2-Trichloroethane	ug/L	SW 8260B	1.00	0.337	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00

Spring 2015					Benchmark		Sample Sites							
Parameter	Units	Method	PQL	MDL	Type	Value	BUT10014	BUT10016	CLA10018	MIA00205	MON00022	MON10016	SHE00089	WAR10004
1,1-Dichloroethane	ug/L	SW 8260B	1.00	0.274	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1-Dichloroethene	ug/L	SW 8260B	1.00	0.224	MCL	7	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1-Dichloropropene	ug/L	SW 8260B	1.00	0.213	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,3-Trichlorobenzene	ug/L	SW 8260B	1.00	0.228	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,3-Trichloropropane	ug/L	SW 8260B	1.00	0.271	HBSL	30	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,4-Trichlorobenzene	ug/L	SW 8260B	1.00	0.214	MCL	70	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,4-Trimethylbenzene	ug/L	SW 8260B	1.00	0.194	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dibromo-3-chloropropane	ug/L	SW 8260B	5.00	0.869	MCL	0.2	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
1,2-Dibromoethane	ug/L	SW 8260B	1.00	0.192	MCL	0.05	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dichlorobenzene	ug/L	SW 8260B	1.00	0.570	MCL	600	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dichloroethane	ug/L	SW 8260B	1.00	0.300	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dichloropropane	ug/L	SW 8260B	1.00	0.230	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,3,5-Trimethylbenzene	ug/L	SW 8260B	1.00	0.199	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,3-Dichlorobenzene	ug/L	SW 8260B	1.00	0.197	HBSL	600	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,3-Dichloropropane	ug/L	SW 8260B	1.00	0.237	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,4-Dichlorobenzene	ug/L	SW 8260B	1.00	0.214	MCL	75	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
2,2-Dichloropropane	ug/L	SW 8260B	1.00	0.262	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
2-Butanone	ug/L	SW 8260B	10.0	2.75	—	—	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
2-Chlorotoluene	ug/L	SW 8260B	1.00	0.217	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
2-Hexanone	ug/L	SW 8260B	10.0	0.0779	HBSL	40	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
4-Chlorotoluene	ug/L	SW 8260B	1.00	0.241	HBSL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
4-Isopropyltoluene	ug/L	SW 8260B	1.00	0.182	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
4-Methyl-2-pentanone	ug/L	SW 8260B	10.0	1.91	—	—	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Acetone	ug/L	SW 8260B	20.0	3.76	HBSL	6000	< 20.0			< 20.0	< 20.0		< 20.0	< 20.0
Acetonitrile	ug/L	SW 8260B	20.0	2.41	—	—	< 20.0			< 20.0	< 20.0		< 20.0	< 20.0
Acrolein	ug/L	SW 8260B	10.0	1.49	HBSL	4	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Acrylonitrile	ug/L	SW 8260B	10.0	0.388	HBSL	0.06	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Allyl chloride	ug/L	SW 8260B	1.00	0.250	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Benzene	ug/L	SW 8260B	1.00	0.269	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromobenzene	ug/L	SW 8260B	1.00	0.221	HBSL	60	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromochloromethane	ug/L	SW 8260B	1.00	0.293	HBSL	90	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromodichloromethane	ug/L	SW 8260B	1.00	0.232	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromoform	ug/L	SW 8260B	1.00	0.231	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00

Spring 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Bromomethane	ug/L	SW 8260B	1.00	0.494	HHBP	140	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Carbon Disulfide	ug/L	SW 8260B	10.0	0.242	HBSL	700	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Carbon Tetrachloride	ug/L	SW 8260B	1.00	0.241	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chlorobenzene	ug/L	SW 8260B	1.00	0.265	MCL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chloroethane	ug/L	SW 8260B	1.00	0.261	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chloroform	ug/L	SW 8260B	1.00	0.269	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chloromethane	ug/L	SW 8260B	1.00	0.318	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
cis-1,2-Dichloroethene	ug/L	SW 8260B	1.00	0.296	MCL	70	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
cis-1,3-Dichloropropene	ug/L	SW 8260B	1.00	0.234	HBSL	0.3	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Dibromochloromethane	ug/L	SW 8260B	1.00	0.645	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Dibromomethane	ug/L	SW 8260B	1.00	0.299	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Dichlorodifluoromethane	ug/L	SW 8260B	1.00	0.242	HBSL	1000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Ethylbenzene	ug/L	SW 8260B	1.00	0.168	MCL	700	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Hexachlorobutadiene	ug/L	SW 8260B	1.00	0.277	HBSL	0.9	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Iodomethane	ug/L	SW 8260B	10.0	1.10	—	—	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Isopropylbenzene	ug/L	SW 8260B	1.00	0.204	HBSL	700	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
m,p-Xylene	ug/L	SW 8260B	5.00	0.410	MCL	10000	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
Methyl tert-Butyl Ether	ug/L	SW 8260B	5.00	0.239	—	—	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
Methylene Chloride	ug/L	SW 8260B	1.00	0.164	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Naphthalene	ug/L	SW 8260B	5.00	0.212	HBSL	100	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
n-Butylbenzene	ug/L	SW 8260B	1.00	0.167	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
n-Hexane	ug/L	SW 8260B	5.00	0.225	—	—	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
n-Propylbenzene	ug/L	SW 8260B	1.00	0.204	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
o-Xylene	ug/L	SW 8260B	1.00	0.220	MCL	10000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
sec-Butylbenzene	ug/L	SW 8260B	1.00	0.193	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Styrene	ug/L	SW 8260B	1.00	0.210	MCL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
tert_Butylbenzene	ug/L	SW 8260B	1.00	0.193	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Tetrachloroethene	ug/L	SW 8260B	1.00	0.230	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Toluene	ug/L	SW 8260B	1.00	0.231	MCL	1000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
trans-1,2-Dichloroethene	ug/L	SW 8260B	1.00	0.225	MCL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
trans-1,3-Dichloropropene	ug/L	SW 8260B	1.00	0.203	HBSL	0.3	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Trichloroethene	ug/L	SW 8260B	1.00	0.295	MCL	5	**23.6**			< 1.00	< 1.00		< 1.00	< 1.00
Trichlorofluoromethane	ug/L	SW 8260B	1.00	0.250	HBSL	2000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00

Spring 2015					Benchmark		Sample Sitees							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Vinyl acetate	ug/L	SW 8260B	1.00	0.282	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Vinyl Chloride	ug/L	SW 8260B	1.00	0.224	MCL	2	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00

MCL - Maximum Contaminant Level set by USEPA
SMCL - Secondary Maximum Contaminant Level set by USEPA
AMCL - Alternative Maximum Contaminant Level set by USEPA
HBSL - Non enforceable Health Based Screening Level based on (1) latest USEPA Office of Water policies for establishing drinking water benchmarks and (2) most recent USEPA peer reviewed toxicity information
HHBP - Human Health Benchmark for Pesticides set by USEPA
— No drinking water benchmark set for the compound
Numbers in bold exceed a benchmark

Fall 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Dissolved Oxygen	mg/L	YSI sonde			—	—	3.61	0.74	2.88	1.37	1.48	0.85	1.04	2.00
pH	S.U.	YSI sonde			SMCL	6.5 - 8.5	6.50	7.03	6.95	6.75	6.54	7.03	6.89	7.22
Specific Conductance	mS/cm	YSI sonde			—	—	955	570	709	665	1094	784	623	582
Temperature	°C	YSI sonde			—	—	15.28	12.83	15.74	14.95	16.84	13.00	11.96	14.23
Ammonia	mg/L	EPA 350.1	0.200	0.0732	—	—	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	< 0.200	0.204	< 0.200
Chloride	mg/L	SM 4500-CL-E	2.00	0.806	SMCL	250	84.7	12.7	19.1	14.6	12.4	76.8	8.80	40.6
Fluoride	mg/L	SM 4500 F-C	0.200	0.0174	MCL	4	< 0.200	0.268	0.230	< 0.200	< 0.200	< 0.200	0.470	0.238
Nitrite Nitrogen as NO2-N	mg/L	SM 4500 NO3-F	0.100	0.0210	MCL	1	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Nitrogen, Nitrate-Nitrite	mg/L	SM 4500 NO3-F	0.100	0.0157	MCL	10	1.45	< 0.100	9.07	< 0.100	< 0.100	< 0.100	< 0.100	0.117
Nitrogen, Total Kjeldahl	mg/L	EPA 351.2	0.500	0.165	—	—	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500
Phosphorus	mg/L	SW 6010B	0.100	0.00452	—	—	< 0.100	0.111	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Silica	mg/L	EPA 200.7/SW 6010	0.107	0.00296	—	—				10.0	8.06	9.27	10.3	7.29
Sulfate	mg/L	EPA 375.4 Modified	10.0	3.80	SMCL	250	33.6	49.9	13.1	30.6	33.4	29.5	30.4	31.6
Total Hardness	mg/L	EPA 200.7	0.662	0.0850	—	—	362	284	324	342	585	292	318	242
Total Orthophosphate, as P	mg/L	SM 4500 P-F	0.100	0.0218	—	—	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Aluminum	mg/L	SW 6010B	0.100	0.00561	MCL	0.2	< 0.100	0.331	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Antimony	mg/L	SW 7041	0.00300	0.00110	MCL	0.006	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300
Arsenic	mg/L	SW 7060A	0.00300	0.000763	MCL	0.01	< 0.00300	0.00529	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300	< 0.00300
Barium	mg/L	SW 6010B	0.00500	0.000747	MCL	2	0.241	0.235	0.0774	0.126	0.118	0.0976	0.152	0.0612
Beryllium	mg/L	SW 6010B	0.000500	0.0000236	MCL	0.004	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500	< 0.000500
Boron	mg/L	SW 6010B	0.100	0.00328	HBSL	6000	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	0.101	< 0.100	< 0.100
Cadmium	mg/L	SW 7131A	0.000200	0.0000702	MCL	0.005	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200	< 0.000200
Calcium	mg/L	SW 6010B	0.100	0.0174	—	—	96.6	70.2	74.5	91.8	155	73.8	74.2	52.5
Chromium, Hexavalent	mg/L	SM 3500 Cr B	0.0100	0.00480	MCL	0.1	< 0.00400	< 0.00400	< 0.00400	< 0.00400	< 0.00400	< 0.00400	< 0.00400	< 0.00400
Cobalt	mg/L	SW 6010B	0.00500	0.000815	—	—	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Copper	mg/L	SW 6010B	0.00500	0.000566	SMCL	1	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Iron	mg/L	SW 6010B	0.0500	0.00534	SMCL	0.3	< 0.0500	**1.72**	< 0.0500	< 0.0500	< 0.0500	**0.310**	0.140	< 0.0500
Lead	mg/L	SW 7421	0.00200	0.000738	MCL	0.015	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200
Lithium	mg/L	SW 6010B	0.00500	0.0000315	—	—	< 0.00500	< 0.00500	< 0.00500	< 0.00500	0.0110	< 0.00500	< 0.00500	< 0.00500
Magnesium	mg/L	SW 6010B	0.100	0.0101	—	—	29.4	26.3	33.6	27.4	47.8	26.1	32.1	26.9

Fall 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Manganese	mg/L	SW 6010B	0.00500	0.00153	HBSL, SMCL	0.3, 0.05	< 0.00500	**0.400**	< 0.00500	**0.103**	0.0265	**0.0798**	**0.287**	< 0.00500
Molybdenum	mg/L	SW 6010B	0.0100	0.00207	HBSL	0.04	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	0.0133	< 0.0100	< 0.0100
Nickel	mg/L	SW 6010B	0.00500	0.00118	HBSL	0.1	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Potassium	mg/L	SW 6010B	1.00	0.0397	—	—	4.09	1.43	1.10	1.34	4.14	2.45	1.37	2.26
Silver	mg/L	SW 6010B	0.00200	0.000384	HBSL	0.1	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200	< 0.00200
Sodium	mg/L	SW 6010B	1.00	0.0631	—	—	49.4	6.04	7.81	7.71	9.09	44.1	13.0	23.4
Strontium	mg/L	SW 6010B	0.00500	0.000527	HBSL	4	0.691	0.421	2.32	0.385	0.555	0.396	0.768	0.428
Thallium	mg/L	SW 7841/EPA 279.2	0.00100	0.000407	MCL	0.002	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100	< 0.00100
Vanadium	mg/L	SW 6010B	0.00500	0.000517	—	—	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500	< 0.00500
Zinc	mg/L	SW 6010B	0.0100	0.00138	HBSL	2	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	0.0586	< 0.0100	< 0.0100
Alkalinity, Total (As CaCO3)	mg/L	SM 2320B	25.0	25.0	—	—	358	248	298	333	407	268	313	229
Biochemical Oxygen Demand	mg/L	SM 5210B	2.00	2.00	—	—	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00
Carbonaceous Biological Oxygen Demand	mg/L	EPA 405.1/SM 5210	2.00	2.00	—	—	< 2.00	< 2.00	< 2.00	16.6	< 2.00	10.9	< 2.00	37.7
Chemical Oxygen Demand	mg/L	HACH 8000	5.00	4.68	—	—	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
Cyanide, Total	mg/L	EPA 335.4	0.0100	0.00195	MCL	0.2	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Phenolics, Total Recoverable	mg/L	EPA 420.4	0.0100	0.00336	—	—	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Total Dissolved Solids (Residue, Filterable)	mg/L	SM 2540C	5.00	1.67	SMCL	500	**542**	324	374	383	**755**	424	354	300
Total Organic Carbon	mg/L	SM 5310C	1.00	0.142	—	—	< 1.00	< 1.00	< 1.00	< 1.00	1.09	< 1.00	< 1.00	< 1.00
E. coli	MPN/100 mL	Colilert	1.00		MCL	0	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
2,4,5-T	ug/L	SW 8151	0.118	0.0477	HBSL	70				< 0.118	< 0.118		< 0.118	< 0.118
2,4,5-TP (Silvex)	ug/L	SW 8151	0.119	0.0249	—	—				< 0.119	< 0.119		< 0.119	< 0.119
2,4-D	ug/L	SW 8151	0.125	0.0439	MCL	70				< 0.118	< 0.118		0.135	< 0.118
2,4-DB	ug/L	SW 8151	0.118	0.0417	HHBP	210				< 0.118	< 0.118		< 0.118	< 0.118
4,4´-DDD	ug/L	SW 8081	0.0500	0.0153	HBSL	1				< 0.0500	< 0.0500		< 0.0500	< 0.0500
4,4´-DDE	ug/L	SW 8081	0.0500	0.0168	HBSL	0.1				< 0.0500	< 0.0500		< 0.0500	< 0.0500
4,4´-DDT	ug/L	SW 8081	0.0500	0.0217	HBSL	0.0000 072				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Aldrin	ug/L	SW 8081	0.0500	0.0168	HBSL	0.002				< 0.0500	< 0.0500		< 0.0500	< 0.0500
alpha-BHC	ug/L	SW 8081	0.0500	0.0217	HBSL	0.006				< 0.0500	< 0.0500		< 0.0500	< 0.0500
alpha-Chlordane	ug/L	SW 8081	0.0500	0.0153	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Aroclor 1016	ug/L	SW 8082	0.500	0.238	HBSL	0.5				< 0.500	< 0.500		< 0.500	< 0.500
Aroclor 1221	ug/L	SW 8082	0.500	0.124	—	—				< 0.500	< 0.500		< 0.500	< 0.500
Aroclor 1232	ug/L	SW 8082	0.500	0.232	—	—				< 0.500	< 0.500		< 0.500	< 0.500

Fall 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Aroclor 1242	ug/L	SW 8082	0.500	0.233	—	—				< 0.500	< 0.500		< 0.500	< 0.500
Aroclor 1248	ug/L	SW 8082	0.500	0.147	—	—				< 0.500	< 0.500		< 0.500	< 0.500
Aroclor 1254	ug/L	SW 8082	0.500	0.196	HBSL	0.1				< 0.500	< 0.500		< 0.500	< 0.500
Aroclor 1260	ug/L	SW 8082	0.500	0.249	—	—				< 0.500	< 0.500		< 0.500	< 0.500
beta-BHC	ug/L	SW 8081	0.0500	0.0238	HBSL	0.02				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Chlordane	ug/L	SW 8081	0.500	0.211	MCL	2				< 0.500	< 0.500		< 0.500	< 0.500
Dalapon	ug/L	SW 8151	0.228	0.0445	MCL	200				1.06	< 0.228		0.670	< 0.228
delta-BHC	ug/L	SW 8081	0.0500	0.0217	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Dicamba	ug/L	SW 8151	0.118	0.0427	HBSL	3000				< 0.118	< 0.118		< 0.118	< 0.118
Dichloroprop	ug/L	SW 8151	0.118	0.0361	HBSL	300				< 0.118	< 0.118		< 0.118	< 0.118
Dieldrin	ug/L	SW 8081	0.0500	0.0153	HBSL	0.002				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Dinoseb	ug/L	SW 8151	0.118	0.0563	MCL	7				< 0.118	< 0.118		< 0.118	< 0.118
Endosulfan I	ug/L	SW 8081	0.0500	0.0119	HHBP	42				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endosulfan II	ug/L	SW 8081	0.0500	0.0181	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endosulfan sulfate	ug/L	SW 8081	0.0500	0.0238	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endrin	ug/L	SW 8081	0.0500	0.0153	MCL	2				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endrin aldehyde	ug/L	SW 8081	0.0500	0.0168	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Endrin ketone	ug/L	SW 8081	0.0500	0.0247	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
gamma-BHC	ug/L	SW 8081	0.0500	0.0168	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
gamma-Chlordane	ug/L	SW 8081	0.0500	0.0217	—	—				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Heptachlor	ug/L	SW 8081	0.0500	0.0181	MCL	0.4				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Heptachlor epoxide	ug/L	SW 8081	0.0500	0.0217	MCL	0.2				< 0.0500	< 0.0500		< 0.0500	< 0.0500
MCPA	ug/L	SW 8151	23.4	8.15	HBSL	140				< 23.4	< 23.4		< 23.4	< 23.4
MCPP	ug/L	SW 8151	23.5	5.24	—	—				< 23.5	< 23.5		< 23.5	< 23.5
Methoxychlor	ug/L	SW 8081	0.0500	0.0247	MCL	40				< 0.0500	< 0.0500		< 0.0500	< 0.0500
Toxaphene	ug/L	SW 8081	0.500	0.210	MCL	3				< 0.500	< 0.500		< 0.500	< 0.500
Radon	pCi/L	SM 7500-Rn-B	100	NR	MCL	300				309	456		447	564
Uranium, Total	µg/L	EPA 200.8	0.001	NR	MCL	30				1.8	1.4		0.80	0.37
1,2,4,5-Tetrachlorobenzene	ug/L	SW 8270C	5.00	0.411	—	—				< 5.00	< 5.00		< 5.00	< 5.00
1,2,4-Trichlorobenzene	ug/L	SW 8270C	5.00	0.312	MCL	70				< 5.00	< 5.00		< 5.00	< 5.00
1,2-Dichlorobenzene	ug/L	SW 8270C	5.00	0.388	MCL	600				< 5.00	< 5.00		< 5.00	< 5.00
1,2-Diphenylhydrazine	ug/L	SW 8270C	5.00	0.386	HBSL	0.04				< 5.00	< 5.00		< 5.00	< 5.00
1,3,5-Trinitrobenzene	ug/L	SW 8270C	5.00	0.878	—	—				< 5.00	< 5.00		< 5.00	< 5.00

Fall 2015					Benchmark		Sample Sites							
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
1,3-Dichlorobenzene	ug/L	SW 8270C	5.00	0.319	HBSL	600				< 5.00	< 5.00		< 5.00	< 5.00
1,4-Dichlorobenzene	ug/L	SW 8270C	5.00	0.341	MCL	75				< 5.00	< 5.00		< 5.00	< 5.00
1-Methylnaphthalene	ug/L	SW 8270C	5.00	0.382	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2,3,4,6-Tetrachlorophenol	ug/L	SW 8270C	10.0	0.269	—	—				< 10.0	< 10.0		< 10.0	< 10.0
2,4,5-Trichlorophenol	ug/L	SW 8270C	5.00	0.717	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2,4,6-Trichlorophenol	ug/L	SW 8270C	5.00	0.445	HBSL	2				< 5.00	< 5.00		< 5.00	< 5.00
2,4-Dichlorophenol	ug/L	SW 8270C	5.00	0.448	HBSL	20				< 5.00	< 5.00		< 5.00	< 5.00
2,4-Dimethylphenol	ug/L	SW 8270C	5.00	0.402	HBSL	100				< 5.00	< 5.00		< 5.00	< 5.00
2,4-Dinitrophenol	ug/L	SW 8270C	10.0	0.956	HBSL	10				< 10.0	< 10.0		< 10.0	< 10.0
2,4-Dinitrotoluene	ug/L	SW 8270C	5.00	0.521	HBSL	0.05				< 5.00	< 5.00		< 5.00	< 5.00
2,6-Dichlorophenol	ug/L	SW 8270C	5.00	0.319	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2,6-Dinitrotoluene	ug/L	SW 8270C	5.00	0.501	HBSL	0.05				< 5.00	< 5.00		< 5.00	< 5.00
2-Chloronaphthalene	ug/L	SW 8270C	5.00	0.427	HBSL	600				< 5.00	< 5.00		< 5.00	< 5.00
2-Chlorophenol	ug/L	SW 8270C	5.00	0.226	HBSL	40				< 5.00	< 5.00		< 5.00	< 5.00
2-Methylnaphthalene	ug/L	SW 8270C	5.00	0.0625	HBSL	30				< 5.00	< 5.00		< 5.00	< 5.00
2-Methylphenol	ug/L	SW 8270C	5.00	0.871	—	—				< 5.00	< 5.00		< 5.00	< 5.00
2-Nitrophenol	ug/L	SW 8270C	5.00	0.385	—	—				< 5.00	< 5.00		< 5.00	< 5.00
3 & 4-Methylphenol	ug/L	SW 8270C	5.00	0.727	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4,6-Dinitro-2-methylphenol	ug/L	SW 8270C	10.0	0.435	—	—				< 10.0	< 10.0		< 10.0	< 10.0
4-Bromophenyl phenyl ether	ug/L	SW 8270C	5.00	0.279	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4-Chloro-3-methylphenol	ug/L	SW 8270C	5.00	0.293	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4-Chlorophenyl phenyl ether	ug/L	SW 8270C	5.00	0.476	—	—				< 5.00	< 5.00		< 5.00	< 5.00
4-Nitrophenol	ug/L	SW 8270C	5.00	0.470	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Acenaphthene	ug/L	SW 8270C	5.00	0.0350	HBSL	400				< 5.00	< 5.00		< 5.00	< 5.00
Acenaphthylene	ug/L	SW 8270C	5.00	0.0696	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Acetophenone	ug/L	SW 8270C	5.00	0.273	HBSL	700				< 5.00	< 5.00		< 5.00	< 5.00
Aniline	ug/L	SW 8270C	5.00	0.396	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Anthracene	ug/L	SW 8270C	5.00	0.0504	HBSL	2000				< 5.00	< 5.00		< 5.00	< 5.00
Benz(a)anthracene	ug/L	SW 8270C	0.260	0.0840	—	—				< 0.260	< 0.260		< 0.260	< 0.260
Benzidine	ug/L	SW 8270C	5.00	0.662	HBSL	0.0002				< 5.00	< 5.00		< 5.00	< 5.00
Benzo(a)pyrene	ug/L	SW 8270C	0.200	0.0820	MCL	0.2				< 0.200	< 0.200		< 0.200	< 0.200
Benzo(b)fluoranthene	ug/L	SW 8270C	0.170	0.0527	—	—				< 0.170	< 0.170		< 0.170	< 0.170
Benzo(g,h,i)perylene	ug/L	SW 8270C	5.00	0.0923	—	—				< 5.00	< 5.00		< 5.00	< 5.00

Fall 2015					Benchmark	Sample Sites								
Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Benzo(k)fluoranthene	ug/L	SW 8270C	1.70	0.0574	—	—				< 1.70	< 1.70		< 1.70	< 1.70
Benzyl Alcohol	ug/L	SW 8270C	5.00	0.384	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Bis(2-chloroethoxy)methane	ug/L	SW 8270C	5.00	0.450	—	—				< 5.00	< 5.00		< 5.00	< 5.00
bis-(2-Chloroethyl)ether	ug/L	SW 8270C	5.00	0.428	HBSL	0.03				< 5.00	< 5.00		< 5.00	< 5.00
Bis(2-chloroisopropyl)ether	ug/L	SW 8270C	5.00	0.495	HBSL	300				< 5.00	< 5.00		< 5.00	< 5.00
Bis(2-ethylhexyl)phthalate	ug/L	SW 8270C	1.00	0.334	MCL	6				**1.01**	**1.42**		< 1.00	< 1.00
Butyl benzyl phthalate	ug/L	SW 8270C	5.00	0.247	HBSL	1000				< 5.00	< 5.00		< 5.00	< 5.00
Chrysene	ug/L	SW 8270C	5.00	0.0625	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Dibenz(a,h)anthracene	ug/L	SW 8270C	0.200	0.0742	—	—				< 0.200	< 0.200		< 0.200	**0.240**
Dibenzofuran	ug/L	SW 8270C	5.00	0.254	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Diethyl phthalate	ug/L	SW 8270C	5.00	0.374	HBSL	6000				< 5.00	< 5.00		< 5.00	< 5.00
Dimethyl phthalate	ug/L	SW 8270C	5.00	0.462	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Di-n-butyl phthalate	ug/L	SW 8270C	5.00	0.415	HBSL	700				< 5.00	< 5.00		< 5.00	< 5.00
Di-n-octyl phthalate	ug/L	SW 8270C	5.00	0.342	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Fluoranthene	ug/L	SW 8270C	5.00	0.0540	HBSL	300				< 5.00	< 5.00		< 5.00	< 5.00
Fluorene	ug/L	SW 8270C	5.00	0.0598	HBSL	300				< 5.00	< 5.00		< 5.00	< 5.00
Hexachlorobenzene	ug/L	SW 8270C	5.00	0.276	MCL	1				< 5.00	< 5.00		< 5.00	< 5.00
Hexachlorobutadiene	ug/L	SW 8270C	5.00	0.463	HBSL	0.9				< 5.00	< 5.00		< 5.00	< 5.00
Hexachlorocyclopentadiene	ug/L	SW 8270C	5.00	0.337	MCL	50				< 5.00	< 5.00		< 5.00	< 5.00
Hexachloroethane	ug/L	SW 8270C	5.00	0.359	HBSL	0.9				< 5.00	< 5.00		< 5.00	< 5.00
Hexachloropropene	ug/L	SW 8270C	5.00	0.501	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Indeno(1,2,3-cd)pyrene	ug/L	SW 8270C	0.220	0.0566	—	—				< 0.220	< 0.220		< 0.220	< 0.220
Isophorone	ug/L	SW 8270C	5.00	0.214	HBSL	60				< 5.00	< 5.00		< 5.00	< 5.00
m-Dinitrobenzene	ug/L	SW 8270C	5.00	0.262	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Naphthalene	ug/L	SW 8270C	5.00	0.0651	HBSL	100				< 5.00	< 5.00		< 5.00	< 5.00
Nitrobenzene	ug/L	SW 8270C	5.00	0.314	HBSL	10				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitrosodimethylamine	ug/L	SW 8270C	5.00	0.376	—	—				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitroso-di-n-butylamine	ug/L	SW 8270C	5.00	0.384	—	—				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitrosodi-n-propylamine	ug/L	SW 8270C	5.00	0.346	HBSL	0.005				< 5.00	< 5.00		< 5.00	< 5.00
N-Nitrosodiphenylamine	ug/L	SW 8270C	5.00	0.602	HBSL	7				< 5.00	< 5.00		< 5.00	< 5.00
Pentachlorobenzene	ug/L	SW 8270C	5.00	0.289	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Pentachloronitrobenzene	ug/L	SW 8270C	5.00	0.582	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Pentachlorophenol	ug/L	SW 8270C	1.00	0.429	MCL	1				< 1.00	< 1.00		< 1.00	< 1.00

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Phenanthrene	ug/L	SW 8270C	5.00	0.0745	—	—				< 5.00	< 5.00		< 5.00	< 5.00
Phenol	ug/L	SW 8270C	5.00	0.263	HBSL	2000				< 5.00	< 5.00		< 5.00	< 5.00
Pyrene	ug/L	SW 8270C	5.00	0.0613	HBSL	200				< 5.00	< 5.00		< 5.00	< 5.00
Pyridine	ug/L	SW 8270C	5.00	0.454	—	—				< 5.00	< 5.00		< 5.00	< 5.00
1,1,1,2-Tetrachloroethane	ug/L	SW 8260B	1.00	0.220	HBSL	1	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1,1-Trichloroethane	ug/L	SW 8260B	1.00	0.283	MCL	200	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1,2,2-Tetrachloroethane	ug/L	SW 8260B	1.00	0.230	HBSL	1	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1,2-Trichloroethane	ug/L	SW 8260B	1.00	0.337	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1-Dichloroethane	ug/L	SW 8260B	1.00	0.274	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1-Dichloroethene	ug/L	SW 8260B	1.00	0.224	MCL	7	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,1-Dichloropropene	ug/L	SW 8260B	1.00	0.213	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,3-Trichlorobenzene	ug/L	SW 8260B	1.00	0.228	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,3-Trichloropropane	ug/L	SW 8260B	1.00	0.271	HBSL	30	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,4-Trichlorobenzene	ug/L	SW 8260B	1.00	0.214	MCL	70	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2,4-Trimethylbenzene	ug/L	SW 8260B	1.00	0.194	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dibromo-3-chloropropane	ug/L	SW 8260B	5.00	0.869	MCL	0.2	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
1,2-Dibromoethane	ug/L	SW 8260B	1.00	0.192	MCL	0.05	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dichlorobenzene	ug/L	SW 8260B	1.00	0.570	MCL	600	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dichloroethane	ug/L	SW 8260B	1.00	0.300	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,2-Dichloropropane	ug/L	SW 8260B	1.00	0.230	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,3,5-Trimethylbenzene	ug/L	SW 8260B	1.00	0.199	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,3-Dichlorobenzene	ug/L	SW 8260B	1.00	0.197	HBSL	600	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,3-Dichloropropane	ug/L	SW 8260B	1.00	0.237	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
1,4-Dichlorobenzene	ug/L	SW 8260B	1.00	0.214	MCL	75	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
2,2-Dichloropropane	ug/L	SW 8260B	1.00	0.262	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
2-Butanone	ug/L	SW 8260B	10.0	2.75	—	—	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
2-Chlorotoluene	ug/L	SW 8260B	1.00	0.217	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
2-Hexanone	ug/L	SW 8260B	10.0	0.0779	HBSL	40	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
4-Chlorotoluene	ug/L	SW 8260B	1.00	0.241	HBSL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
4-Isopropyltoluene	ug/L	SW 8260B	1.00	0.182	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
4-Methyl-2-pentanone	ug/L	SW 8260B	10.0	1.91	—	—	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Acetone	ug/L	SW 8260B	20.0	3.76	HBSL	6000	< 20.0			< 20.0	< 20.0		< 20.0	< 20.0
Acetonitrile	ug/L	SW 8260B	20.0	2.41	—	—	< 20.0			< 20.0	< 20.0		< 20.0	< 20.0

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Parameter	**Units**	**Method**	**PQL**	**MDL**	**Type**	**Value**	**BUT10014**	**BUT10016**	**CLA10018**	**MIA00205**	**MON00022**	**MON10016**	**SHE00089**	**WAR10004**
Acrolein	ug/L	SW 8260B	10.0	1.49	HBSL	4	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Acrylonitrile	ug/L	SW 8260B	10.0	0.388	HBSL	0.06	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Allyl chloride	ug/L	SW 8260B	1.00	0.250	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Benzene	ug/L	SW 8260B	1.00	0.269	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromobenzene	ug/L	SW 8260B	1.00	0.221	HBSL	60	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromochloromethane	ug/L	SW 8260B	1.00	0.293	HBSL	90	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromodichloromethane	ug/L	SW 8260B	1.00	0.232	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromoform	ug/L	SW 8260B	1.00	0.231	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Bromomethane	ug/L	SW 8260B	1.00	0.494	HHBP	140	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Carbon Disulfide	ug/L	SW 8260B	10.0	0.242	HBSL	700	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Carbon Tetrachloride	ug/L	SW 8260B	1.00	0.241	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chlorobenzene	ug/L	SW 8260B	1.00	0.265	MCL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chloroethane	ug/L	SW 8260B	1.00	0.261	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chloroform	ug/L	SW 8260B	1.00	0.269	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Chloromethane	ug/L	SW 8260B	1.00	0.318	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
cis-1,2-Dichloroethene	ug/L	SW 8260B	1.00	0.296	MCL	70	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
cis-1,3-Dichloropropene	ug/L	SW 8260B	1.00	0.234	HBSL	0.3	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Dibromochloromethane	ug/L	SW 8260B	1.00	0.645	MCL	80	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Dibromomethane	ug/L	SW 8260B	1.00	0.299	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Dichlorodifluoromethane	ug/L	SW 8260B	1.00	0.242	HBSL	1000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Ethylbenzene	ug/L	SW 8260B	1.00	0.168	MCL	700	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Hexachlorobutadiene	ug/L	SW 8260B	1.00	0.277	HBSL	0.9	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Iodomethane	ug/L	SW 8260B	10.0	1.10	—	—	< 10.0			< 10.0	< 10.0		< 10.0	< 10.0
Isopropylbenzene	ug/L	SW 8260B	1.00	0.204	HBSL	700	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
m,p-Xylene	ug/L	SW 8260B	5.00	0.410	MCL	10000	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
Methyl tert-Butyl Ether	ug/L	SW 8260B	5.00	0.239	—	—	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
Methylene Chloride	ug/L	SW 8260B	1.00	0.164	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Naphthalene	ug/L	SW 8260B	5.00	0.212	HBSL	100	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
n-Butylbenzene	ug/L	SW 8260B	1.00	0.167	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
n-Hexane	ug/L	SW 8260B	5.00	0.225	—	—	< 5.00			< 5.00	< 5.00		< 5.00	< 5.00
n-Propylbenzene	ug/L	SW 8260B	1.00	0.204	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
o-Xylene	ug/L	SW 8260B	1.00	0.220	MCL	10000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
sec-Butylbenzene	ug/L	SW 8260B	1.00	0.193	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00

Fall 2015					Benchmark		Sample Sites							
Parameter	Units	Method	PQL	MDL	Type	Value	BUT10014	BUT10016	CLA10018	MIA00205	MON00022	MON10016	SHE00089	WAR10004
Styrene	ug/L	SW 8260B	1.00	0.210	MCL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
tert_Butylbenzene	ug/L	SW 8260B	1.00	0.193	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Tetrachloroethene	ug/L	SW 8260B	1.00	0.230	MCL	5	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Toluene	ug/L	SW 8260B	1.00	0.231	MCL	1000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
trans-1,2-Dichloroethene	ug/L	SW 8260B	1.00	0.225	MCL	100	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
trans-1,3-Dichloropropene	ug/L	SW 8260B	1.00	0.203	HBSL	0.3	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Trichloroethene	ug/L	SW 8260B	1.00	0.295	MCL	5	**22.4**			< 1.00	< 1.00		< 1.00	< 1.00
Trichlorofluoromethane	ug/L	SW 8260B	1.00	0.250	HBSL	2000	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Vinyl acetate	ug/L	SW 8260B	1.00	0.282	—	—	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00
Vinyl Chloride	ug/L	SW 8260B	1.00	0.224	MCL	2	< 1.00			< 1.00	< 1.00		< 1.00	< 1.00

MCL – Maximum Contaminant Level set by USEPA
SMCL - Secondary Maximum Contaminant Level set by USEPA
AMCL - Alternative Maximum Contaminant Level set by USEPA
HBSL - Non enforceable Health Based Screening Level based on (1) latest USEPA Office of Water policies for establishing drinking water benchmarks and (2) most recent USEPA peer reviewed toxicity information
HHBP - Human Health Benchmark for Pesticides set by USEPA
— No drinking water benchmark set for the compound
Numbers in bold exceed a benchmark

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