2.15 FUTURE POTENTIAL AREAS OF RISK

There are several potential areas of risk which will impact the natural hazards of the state, but are not easily categorized within any of the existing natural hazards located within the HIRA. The following potential areas of risk will be addressed in this section:

- Future growth
- Harmful algal bloom
- Hydraulic fracturing
- Climate change

FUTURE GROWTH

The Ohio Development Services Agency, Office of Research publishes individual county statistics evaluating the 2010 Census and the current American Community Survey (ACS) data. The county profiles cover an array of characteristics ranging from demographics to taxable land value. These county profiles and the underlying Census projections for population change were used to determine the possible future population changes for all of the counties in the state. Overall between 2010 and 2016, the State of Ohio has seen very little change in population, showing an estimated 0.67 percent increase. This increase can be attributed to the significant increases in southwest and central Ohio, which include counties from Regions 1 and 2.

The projection shows significant population changes in central (Columbus Metropolitan Area) and southwest Ohio (Cincinnati Metropolitan Area). Specifically, the greatest changes in central Ohio took place in Delaware County (12.8 percent) and Franklin County (8.7 percent) (Table 2.15.a), and the greatest in southwest Ohio was Warren (6.7 percent) County.

COUNTY	Region	Census Pop (2010)	Current Population (2016 ACS)	% Change 2010-16
Delaware	**2**	**174,189**	**196,463**	**12.8%**
Franklin	**2**	**1,163,529**	**1,264,518**	**8.7%**
Warren	**2**	**212,868**	**227,063**	**6.7%**
Union	**2**	**52,267**	**55,457**	**6.1%**
Fairfield	**2**	**146,177**	**152,597**	**4.4%**

The dataset projections for 2020, 2030, and 2040 show the significant growth will continue to be focused in and around central Ohio. Four counties (Delaware, Union, Fairfield, and Licking) are projected to lead in the percentage of growth for each 10 year period between 2010 and 2040. Delaware County is projected to see the greatest increase every decade.

COUNTY	Region	Census Pop (2010)	Projection (2020)	2010-2020 Projection %
Delaware	**2**	174,189	210,630	**20.92%**
Union	**2**	52,267	59,760	**14.34%**

Fairfield	**2**	146,177	165,850	**13.46%**
Licking	**2**	166,492	180,860	**8.63%**
Morrow	**2**	34,827	37,380	**7.33%**

Morrow County is projected to see the fifth greatest increase from 2010 to 2020, but then Knox County will overtake it in the following years.

COUNTY	Region	Projection (2020)	Projection (2030)	2020-2030 Projection %
Delaware	**2**	210,630	246,000	**16.79%**
Union	**2**	59,760	68,230	**14.17%**
Fairfield	**2**	165,850	187,820	**13.25%**
Licking	**2**	180,860	196,570	**8.69%**
Knox	**2**	64,960	69,810	**7.47%**

By 2040, Delaware County is project to have a population of 282,160, an increase of 43% over the 2016 population.

COUNTY	Region	Projection (2030)	Projection (2040)	2030-2040 Projection %
Delaware	**2**	246,000	282,160	**14.70%**
Union	**2**	68,230	77,360	**13.38%**
Fairfield	**2**	187,820	210,910	**12.29%**
Licking	**2**	196,570	212,370	**8.04%**
Knox	**2**	69,810	74,850	**7.22%**

Knowing this increase in population will be an impact on the hazards in the Delaware County, the county's 2014 multi-jurisdictional mitigation plan clearly describes the difficulties associated with double digit increases in population and the associated growth of the built environment. Per the 2014 Delaware County LHMP, the great recession influenced development trends in the county and the changes of development patterns have done little to affect the vulnerability of any jurisdiction from previous to current plans. Delaware County is still the fastest growing county in Ohio.

Still large sections of farmland have been and are being developed into residential housing, retail commercial facilities and office parks with the necessary infrastructure to support them. Increased runoff and shorter time available for natural attenuation has resulted in greater water levels and flows near existing neighborhoods.

Delaware County has a clear understanding of the problems, their implications and is working to address them through mitigation planning and educational outreach. Part of the difficulty in addressing the situation is that the growth areas are creating high-value real estate for Ohio, while the impacted areas range from manufactured home parks to older, residential structures built in or near the floodplain. Over time the size of the regulatory floodplain can be expected to increase due to development. Two other central Ohio counties, Franklin and Union, experienced moderate growth; however, no adverse impacts were observed for different reasons. Union County did not sustain enough growth to cause any sizable impacts, and Franklin County's growth was driven heavily by the increase of multi-family structures acting as in-fill or redevelopment of existing developed areas.

Considering the rapid growth in southwest Ohio and the impacts on Warren County, the Warren County Regional Planning Commission has planned for structured growth, which has resulted in minimal adverse impact. The Warren County multi-jurisdictional mitigation plan outlines the program objectives to:

- Discourage small, isolated subdivisions where soil conditions and lot size are not conducive to on-site wastewater disposal systems, where applicable;
- Encourage a logical pattern of residential development where future growth would occur in proximity to existing residential areas, within the designated Urban Service Areas of the township;
- Build multi-family housing at a scale that can accommodate the need, combined with prudent use of the Planned Unit Development process, to accomplish quality development, mitigating the impact of county utilities and other public services;
- Develop adequate, well designed and affordable housing for the elderly population, the handicapped and families with children;
- Give a stronger emphasis to establishing open space/green belt areas, separating developing residential areas from incompatible uses;
- Establish a system to encourage housing maintenance through a coordinated, ongoing inspection program by county and local officials;
- Encourage the repair or removal of dilapidated/substandard structures;
- Identify, document and protect older homes or residential areas of historical and/or architectural significance from unwanted, incompatible land uses; and
- Explore the establishment of an historical zoning district to protect individual structures or neighborhoods of historical and/or architectural significance.

Mitigation planning and associated strategies have been adequately developed at the local level to minimize adverse effects from the significant growth experienced in central and southwest Ohio and aid in community resilience.

OHIO BALANCED GROWTH STRATEGY

One of the primary strategies that the State of Ohio adopted to address future growth throughout state is the Ohio Balanced Growth Strategy (http://balancedgrowth.ohio.gov). This strategy is a voluntary, incentive based program that provides local governments with a regional planning framework based upon watersheds and water resource protection. The fundamental principle to

guide the action of state agencies is that if local governments within a watershed can agree upon areas where development is to be encouraged and which are to be conserved, Ohio will align state programs to support these locally based decisions and conversely will not utilize state programs to violate them.

The Ohio Water Resources Committee (OWRC) has implemented this initiative statewide based upon a previous program developed by the Ohio Lake Erie Commission (OLEC). The program has many elements that encourage balanced growth throughout the state, specifically:

- Focusing on land use and development planning in Ohio's watersheds. The goal is to link land use planning to the health of watersheds and major bodies of water.
- Creation of Watershed Planning Partnerships to encourage regional cooperation on the issues of land use planning and development.
- Production of Watershed Balanced Growth Plans, which will guide how growth and conservation would be promoted by both local and state policies.
- The development of model regulations to promote local land use practices that minimize development impacts on water quality.
- Align state policies, incentives and other resources to support Watershed Balanced Growth planning and implementation.

WATERSHED BALANCED GROWTH PLANS

One of the primary aspects of the Ohio Balanced Growth Strategy is the creation and adoption of a Watershed Balanced Growth Plan. These plans are intended to provide a framework for regional decision-making on growth, conservation, stormwater issues and water quality. Each of these plans is based upon the 10 guiding principles for sustainable Ohio watersheds, the guiding principles are:

- Maximize investment in existing core urban areas, transportation, and infrastructure networks to enhance the economic vitality of existing communities.
- Minimize the conversion of green space and the loss of critical habitat areas, farmland, forest, and open spaces.
- Limit any net increase in the loading of pollutants or transfer of pollution loading from one medium to another.
- To the extent feasible, protect and restore the natural hydrology of the watershed and flow characteristics of its streams, tributaries, and wetlands.
- Restore the physical habitat and chemical water quality of the watershed to protect and restore diverse and thriving plant communities and preserve rare and endangered species.
- Encourage the inclusion of all economic and environmental factors into cost / benefit accounting in land use and development decisions.
- Avoid development decisions that shift economic benefits or environmental burdens from one location within a region to another.
- Establish and maintain a safe, efficient, and accessible transportation system that integrates highway, rail, air, transit, water, and pedestrian networks to foster economic

growth and personal travel.

- Encourage all new development and redevelopment initiatives to address the need to protect and preserve access to historic, cultural, and scenic resources.
- Promote public access to and enjoyment of our natural resources for all Ohioans.

These Watershed Balanced Growth plans are not intended to supersede either local comprehensive plans or local hazard mitigation plans, but to harmonize with them. Each Watershed Balanced Growth Plan must identify or include the following:

- Priority Conservation Areas (PCA), which are critical areas to protect within the watershed. This includes areas which provide flood control, are susceptible to significant natural hazards and offer areas for ecological / open space restoration in urban areas.
- Priority Development Areas (PDA), which are areas where development should be encouraged. This includes areas which will maximize development potential and efficient use of infrastructure.
- The related documentation for justifying the designation of any PCAs or PDAs.
- Plans for the implementation of any developed strategies and a description of the governance structure.
- A specific statement noting how the plan will meet the 10 guiding principles for sustainable Ohio watersheds.

STATE INCENTIVES

One of the challenges of the Balance Growth Program is that the State of Ohio is a home rule State. Therefore all land use, zoning, and planning decisions are made solely at the local level. State agencies do, however, influence the location of development in many ways through infrastructure investments, economic development incentives, tax policies and other policies and programs. In order to encourage local watershed groups to undertake the Balanced Growth Program process, the state created an incentive package that is available to Watershed Planning Partners and their participating local jurisdictions with an endorsed plan. These are the 26 state programs that include special consideration for Balanced Growth participating communities these programs are offered by various state agencies including the OEPA, ODNR, ODSA, ODOT and several other State agencies. More information about the specific state sponsored incentives is available at http://balancedgrowth.ohio.gov/BalancedGrowthStrategy.aspx

BEST LOCAL LAND USE PRACTICES

In addition to providing incentives for the adoption of Balance Growth Plans, the State has created several best local land use practices that address the following subject matters:

- Stream, Floodplain, and Wetland Protection
- Storm Water Management/Erosion and Sediment Control
- Comprehensive Planning
- Compact Development
- Conservation Development

- Natural Areas Establishment and Management
- Source Water Protection

These best local land use practices are available for download at:
http://balancedgrowth.ohio.gov/BestLocalLandUsePractices/BestLocalLandUseP ractices2012.aspx

LOCAL ADOPTION OF WATERSHED BALANCED GROWTH PLANS

Since 2008, 12 local State endorsed Watershed Balanced Growth Plans have been adopted throughout the State of Ohio and over half of those plans were adopted in the past three years. The plans must be adopted at the local level with support from local governments that represent at least 75% of the geographic land area of a watershed, and 75% of the local governments in the watershed and 75% of the population in the watershed. Once local support requirements are met, the state conducts a final review prior to endorsing the plan to ensure compliance with the criteria of the program.

The following Watershed Balanced Growth Plans have been adopted at the local level and endorsed by the State of Ohio:

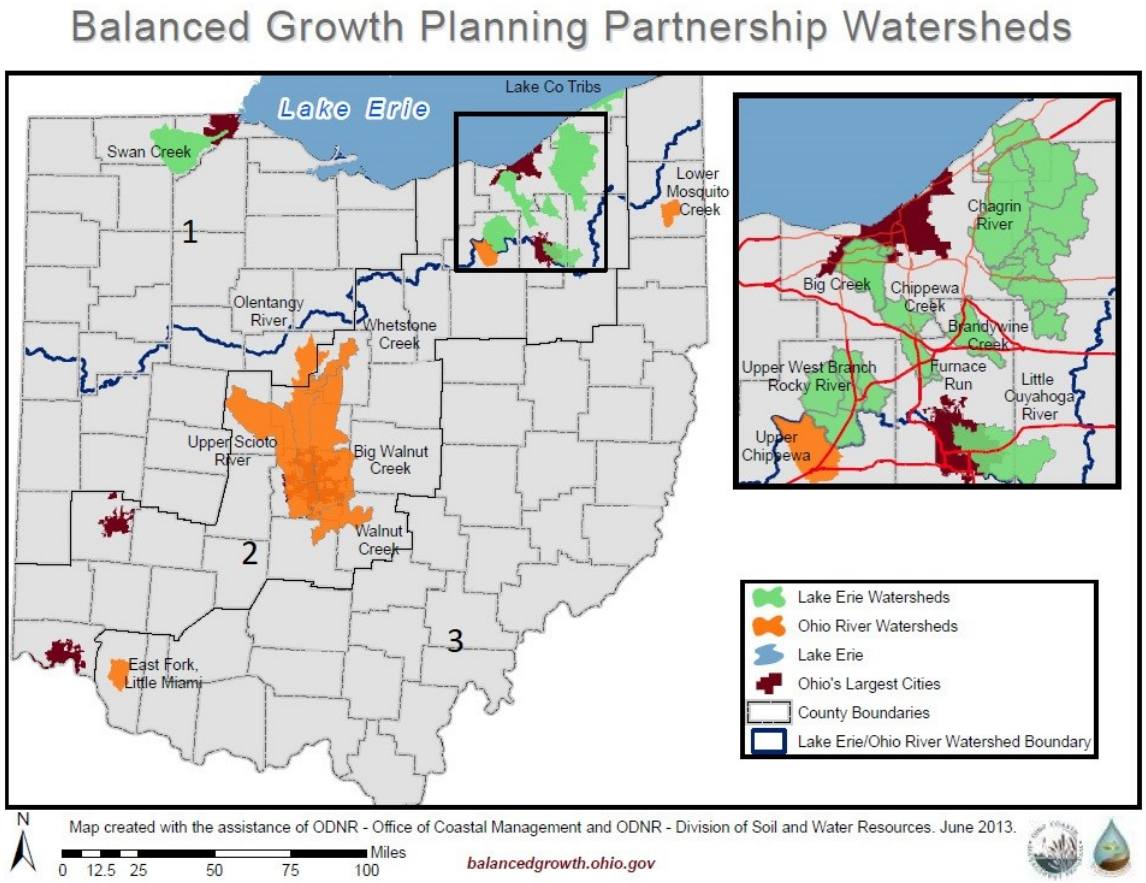
- Chippewa Creek Watershed (December 2008)
- Upper West Branch Rocky River Watershed (June 2009)
- Chagrin River Watershed (September 2009)
- Swan Creek Watershed (September 2009)
- Big Creek Watershed (June 2011)
- Furnace Run (December 2011)
- Eastern Lake County Coastal Tributaries (December 2011)
- Middle East Fork (February 2012)
- Lower Mosquito Creek (February 2012)
- Upper Chippewa Creek (April 2012)
- Olentangy River (April 2012)
- Walnut Creek (February 2013)
- Brandywine Creek (March 2014)

These 13 endorsed Watershed Balanced Growth Plans are spread across 18 different counties throughout the State. The following counties have at least one State Endorsed Watershed Balanced Growth Plan within their borders:

- Clermont
- Cuyahoga
- Delaware
- Fairfield
- Franklin
- Fulton
- Geauga
- Lake
- Licking
- Lucas
- Marion
- Medina
- Morrow
- Pickaway
- Portage
- Summit
- Trumbull
- Union

The majority of the endorsed plans in the State are primarily located within central and north eastern parts of the State. Of these 18 counties, two counties (Franklin, Medina), have specifically incorporated the State Endorsed Watershed Balanced Growth Plan into their Local Hazard Mitigation Plan and nine of counties have references to local watershed and storm water

management plans throughout their Local Hazard Mitigation Plans. The continued adoption of the Watershed Balanced Growth Plans throughout the State will encourage sound planning and land use development Statewide. These activities will promote linkages between Balanced Growth Plans and local hazard mitigation plans which will minimize adverse effects of future growth and contribute to more resilient communities.



HARMFUL ALGAL BLOOMS

The Ohio Sea Grant Program states Harmful Algal Blooms (HAB) are caused by a combination of warm water temperatures (above 60 degrees Fahrenheit) and high concentrations of phosphorus in the water. Typically, a high concentration of phosphorus and nitrogen in cold weather will produce a bloom of diatoms, in cool weather we would expect a bloom of green algae, and in warm weather we often see blue-green algae.

One of the main focuses on reducing the number of HABs is to reduce the amount of phosphorus, which is one of the three major components in most fertilizers, followed by nitrogen and potassium. Phosphorus entering natural water ways is a major issues in the state. In Lake Erie, more than 65% of the phosphorus that causes HABs comes from agricultural fertilizer and manure runoff. Some phosphorus also comes from sewage treatment plants, combined sewer overflows, water treatment plants, cleaning products, faulty septic tanks and residential lawn fertilizers. The largest phosphorus load, about 80-90%, happens during heavy rain storms when fertilizer and other phosphorus sources are quickly washed into rivers and streams that flow into Lake Erie.

HABs can produce toxins that are capable of causing illness and sometimes even death. Microcystin is the most concerning toxin as it causes skin rashes, GI problems and varying degrees of nervous system, liver and kidney damage. While most healthy adults recover from contact with the toxin, it can be more problematic to children, the elderly and people with pre-existing conditions that weaken their systems. Exposure has also killed people in other parts of the world. The toxin can also be fatal to pets that drink or come in contact with contaminated water.

LAKE ERIE

Lake Erie is the southernmost, shallowest and warmest of the Great Lakes. Its watershed has the least forest, the most agricultural land and the second-most urban/suburban land. Therefore, Lake Erie gets more sediment and nutrients (fertilizer runoff, sewage, etc.) than the other lakes, while also having environmental conditions that favor algal blooms. HABs typically occur first in Maumee Bay at the mouth of the Maumee River and in Sandusky Bay at the mouth of the Sandusky River because blue-green algae prefer warm water and high concentrations of phosphorus. Both bays are very warm and shallow, and the watersheds of both rivers have very high percentages of farm land (the Maumee is the largest tributary to the Great Lakes and drains 4.2 million acres of agricultural land). As a result, both streams contain very high concentrations of phosphorus that eventually feeds into Lake Erie.

CLIMATE CHANGE

Climate change will bring more rain and snow, higher average temperatures and flooding to the Great Lakes region. More rain and snowfall increases runoff of the nutrients that fuel harmful algal blooms into the lake. The cyanobacteria that cause HABs also prefer the warmer water that comes with the higher air temperature caused by climate change. When combined, these changing conditions can increase the severity of harmful algal blooms.

OHIO'S DOMESTIC ACTION PLAN (DAP)

https://lakeerie.ohio.gov/LakeEriePlanning/OhioDomesticActionPlan2018.aspx

Ohio's Domestic Action Plan (DAP) will advance efforts toward the proposed 40 percent nutrient reduction target put forth in the Great Lakes Water Quality Agreement of 2012 (GLWQA). Ohio's DAP will expand on the collaborative implementation initiatives and will also include the Central Basin as well as the Western Basin of Lake Erie. The DAP was developed with input through meetings and conversations with various stakeholder groups and state agencies.

While the focus of the DAP is to achieve nutrient reductions from the base year of 2008, we also need to consider the potential impact of new sources of phosphorus coming into in the watershed, the increased frequency and severity of rainfall events, and how these changes pose challenges to the over-all net reduction of nutrients as we work towards the established goals.

The Goals of the Ohio Domestic Action Plan

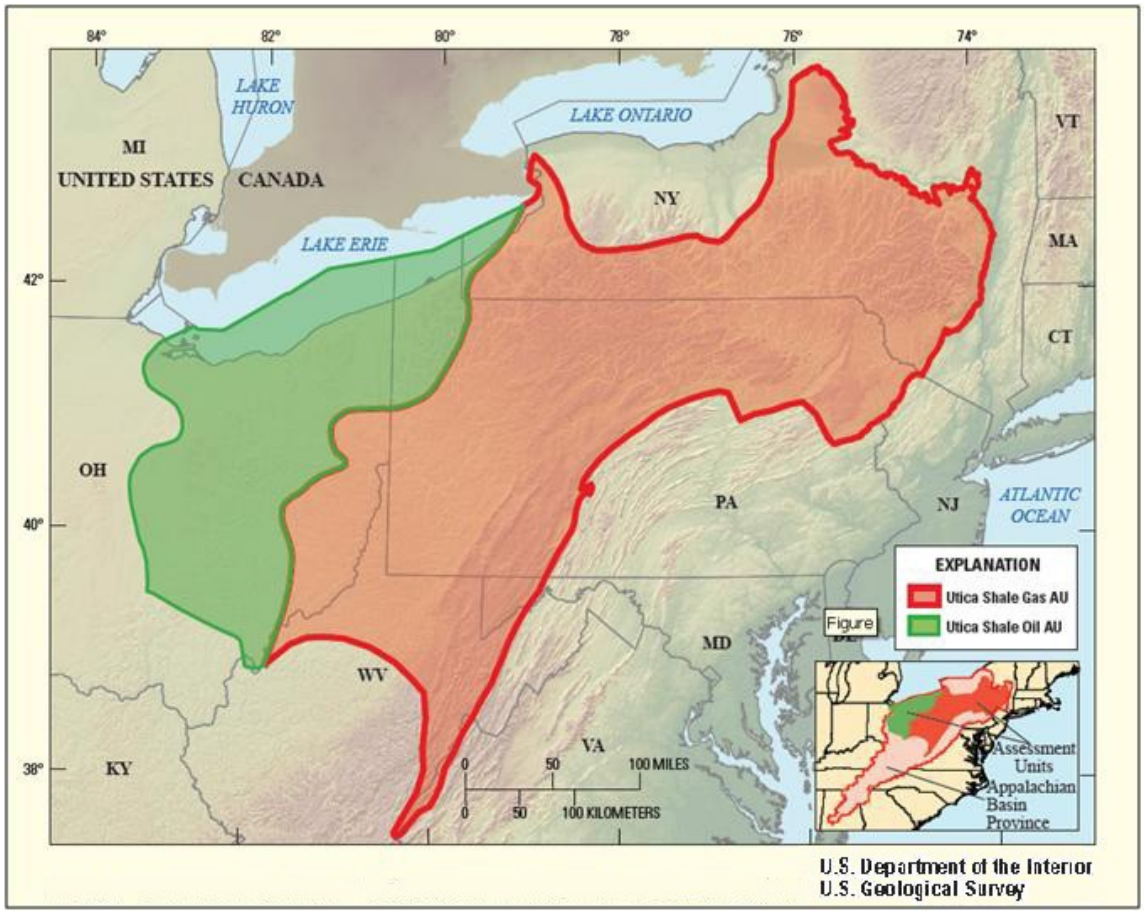
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus entering Lake Erie's western basin by the year 2025 with an aspirational goal of a 20 percent reduction by 2020.
- Achieve a 40 percent total annual load reduction in the amount of total phosphorus entering Lake Erie's central basin by the year 2025 with an aspirational goal of a 20 percent reduction by 2020.

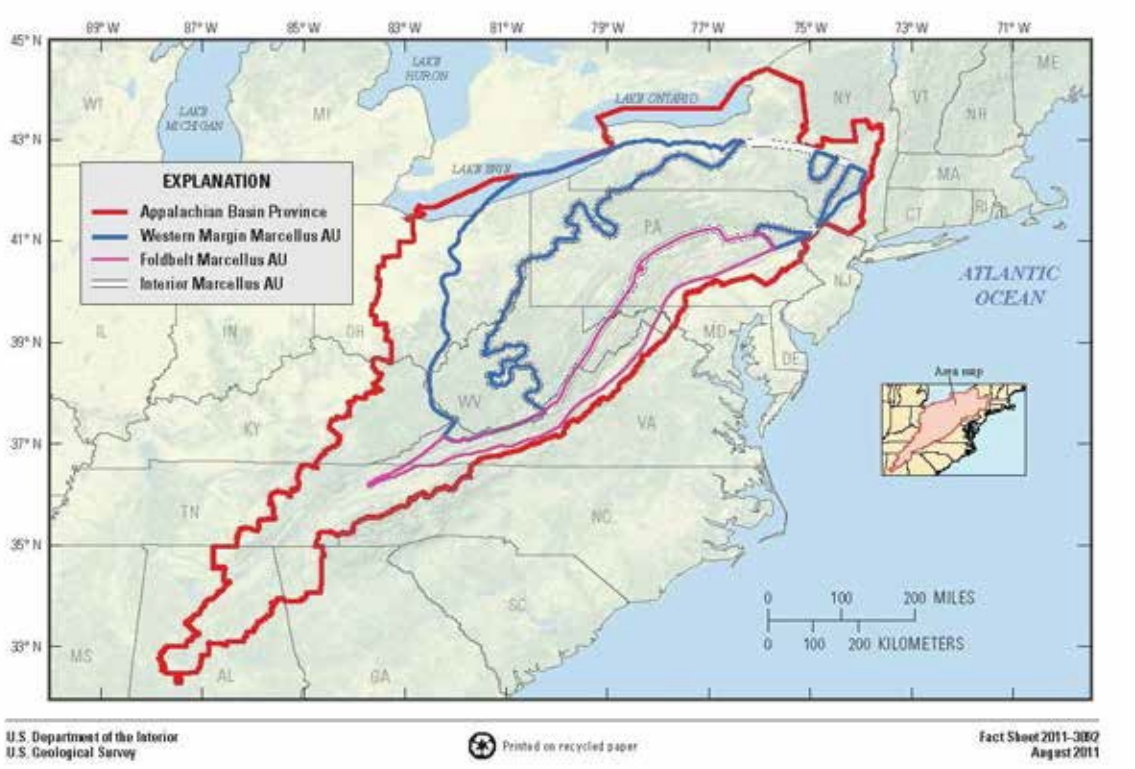
The Domestic Action Plan is based on the following guiding principles:

- Implementation of point and nonpoint nutrient reduction practices.
- Verification of targeted practice implementation and effectiveness.
- Documentation of water quality changes resulting through the implementation of nutrient reduction practices.
- Adaptability to allow for the modification of programs, practices and policy as new information is obtained and changes occur.
- Accountability to ensure compliance with rules and laws, establish clear areas of responsibilities, and that the commitment is made and kept toward achieving the goals.

HYDRAULIC FRACTURING

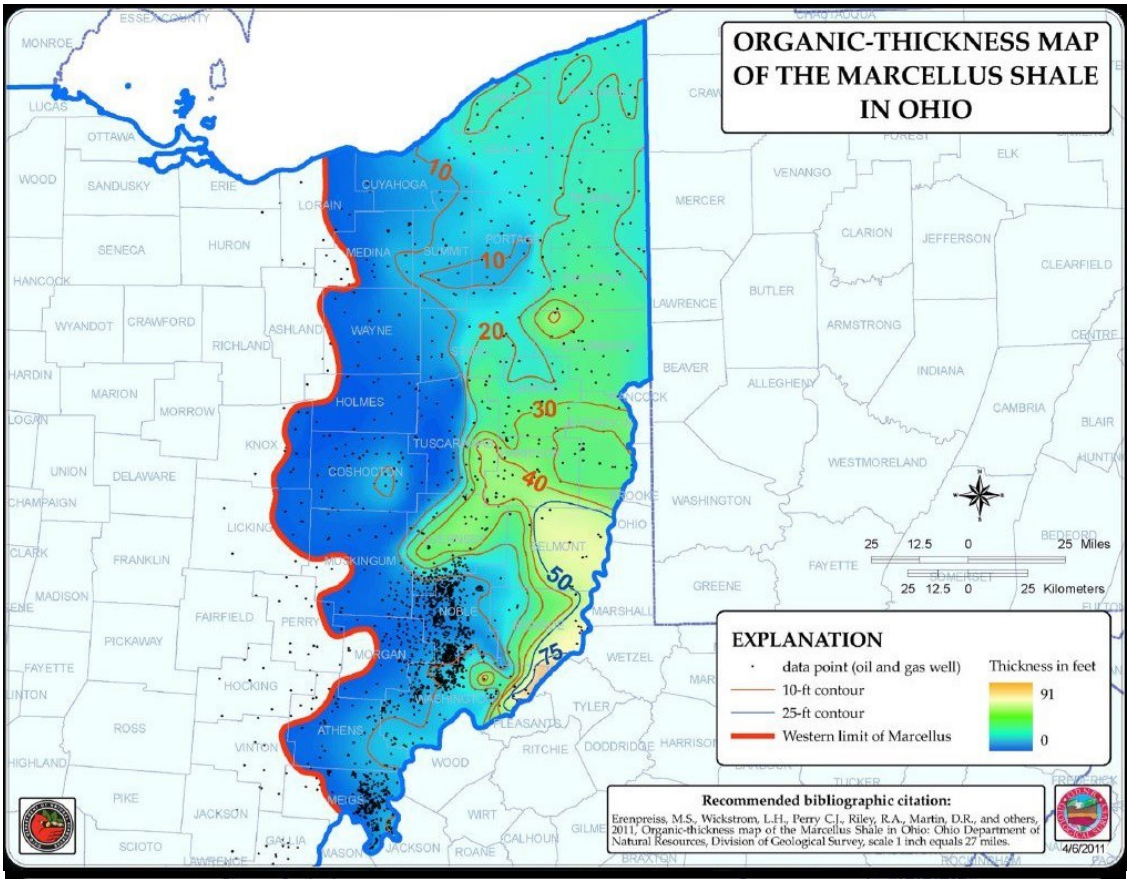
Together, the Marcellus and Utica Shale regions extend across New York, Pennsylvania, Maryland, West Virginia, Ohio and portions of Kentucky and these deposits sit between 7,000 and 12,000 feet below ground. Both the Marcellus and the Utica shale regions are important geologic formations because they hold large reserves of natural gas. Researchers estimate the Marcellus Shale alone could contain as much as 363 trillion cubic feet of natural gas. Ohio is experiencing far less Marcellus Shale drilling than several of the neighboring states because the Marcellus Shale is much thinner on its western edge.

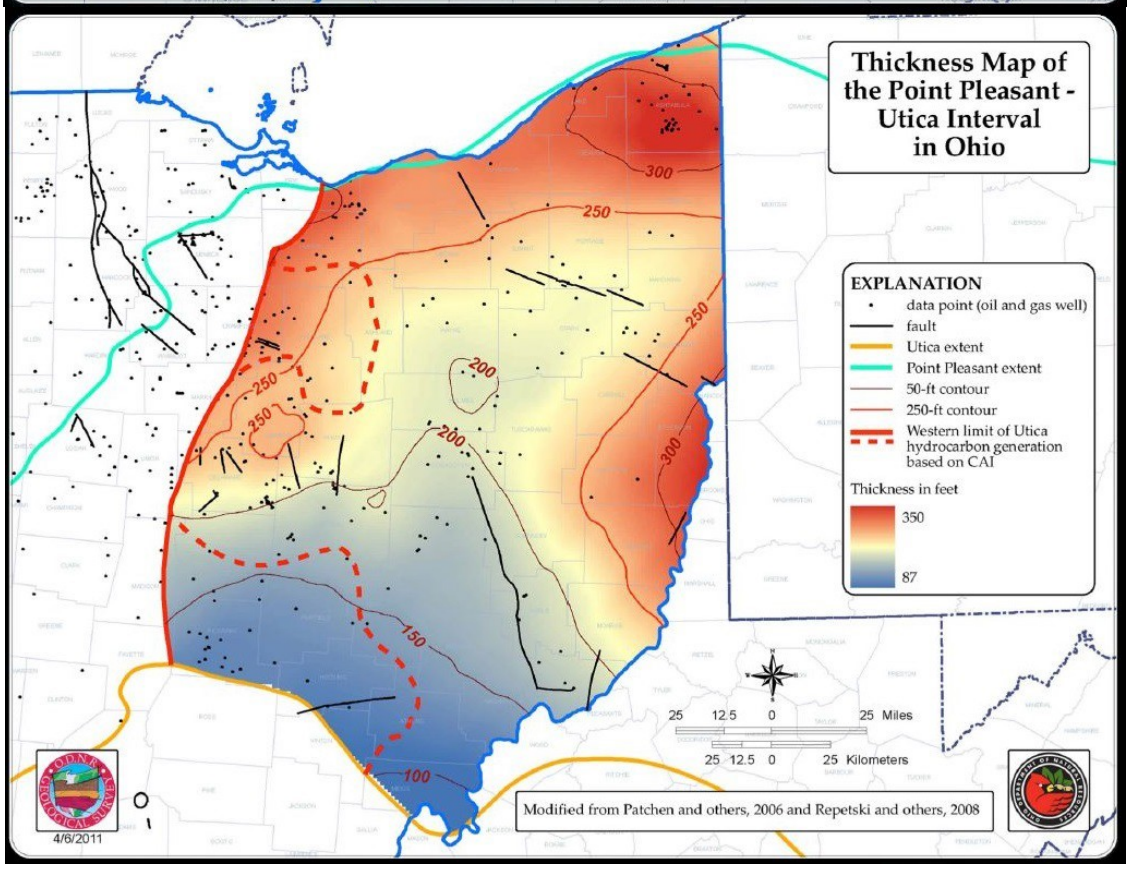




However, Ohio has and will continue to see a significant increase in drilling as much of the state sits over the Utica Shale Formation. The extraction of natural gas from the shale is a two-step process of horizontal drilling and hydraulic fracturing. The process starts with a production well, which is drilled thousands of feet downward and then gradually angled out horizontally through the shale deposit. After the well is drilled, a mixture of water, sand and chemical additives is injected at very high pressure to fracture the shale. This part of the process called hydraulic fracturing or fracing, is a technique used in the oil and gas industry since the 1950's.

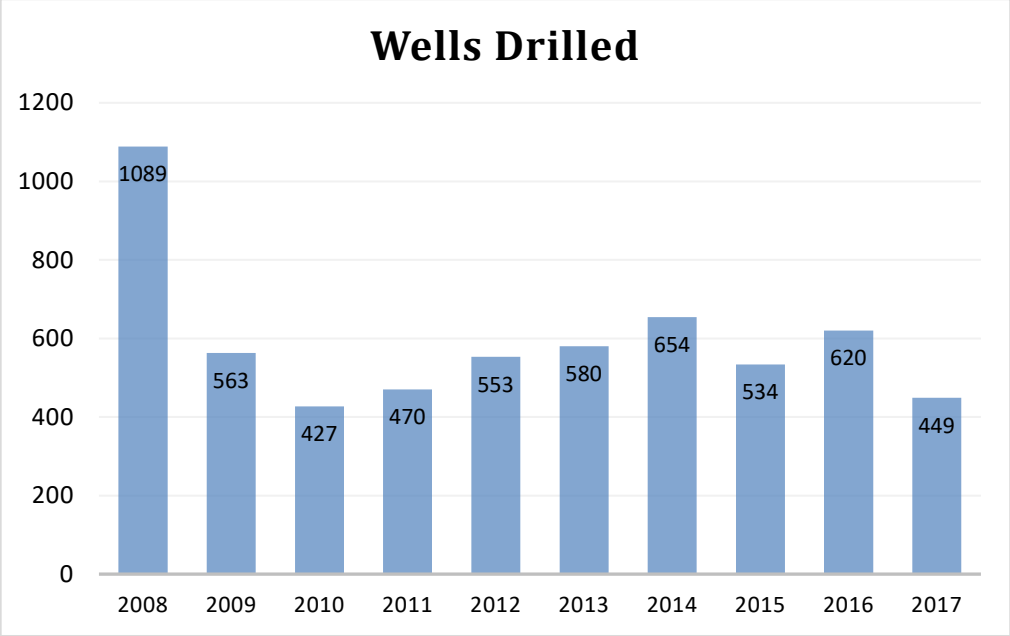
Per the ONDR Division of Geological Survey, resource estimates indicate the Devonian-age Marcellus Shale is the largest exploration play in the eastern United States. Recently, the application of horizontal drilling combined with multi-staged hydraulic fracturing to create permeable flow paths from wellbores into shale units has resulted in a drilling boom for the Marcellus in the Appalachian Basin states of Pennsylvania, West Virginia, southern New York, and eastern Ohio. Fracturing technology also may have application in other shale units, such as the Ordovician-age Utica Shale, which extends across much of the Appalachian Basin region. While limited production has occurred in the Utica up to this point, thickness and widespread geographical extent indicate it may also have great oil-and-gas potential.


ORGANIC-THICKNESS MAP OF THE MARCELLUS SHALE IN OHIO
EXPLANATION
data point (oil and gas well)
10-ft contour
25-ft contour
Western limit of Marcellus
Thickness in feet
91
0
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Recommended bibliographic citation:
Erenpreiss, M.S., Wickstrom, L.H., Perry C.J., Riley, R.A., Martin, D.R., and others, 2011, Organic-thickness map of the Marcellus Shale in Ohio: Ohio Department of Natural Resources, Division of Geological Survey, scale 1 inch equals 27 miles.
4/6/2011


Thickness Map of the Point Pleasant - Utica Interval in Ohio
EXPLANATION
data point (oil and gas well)
fault
Utica extent
Point Pleasant extent
50-ft contour
250-ft contour
Western limit of Utica hydrocarbon generation based on CAI
Thickness in feet
350
87
25 12.5 0 25 Miles
25 12.5 0 25 Kilometers
Modified from Patchen and others, 2006 and Repetski and others, 2008
4/6/2011

CURRENT STATE OF NATURAL GAS AND OIL DRILLING IN OHIO

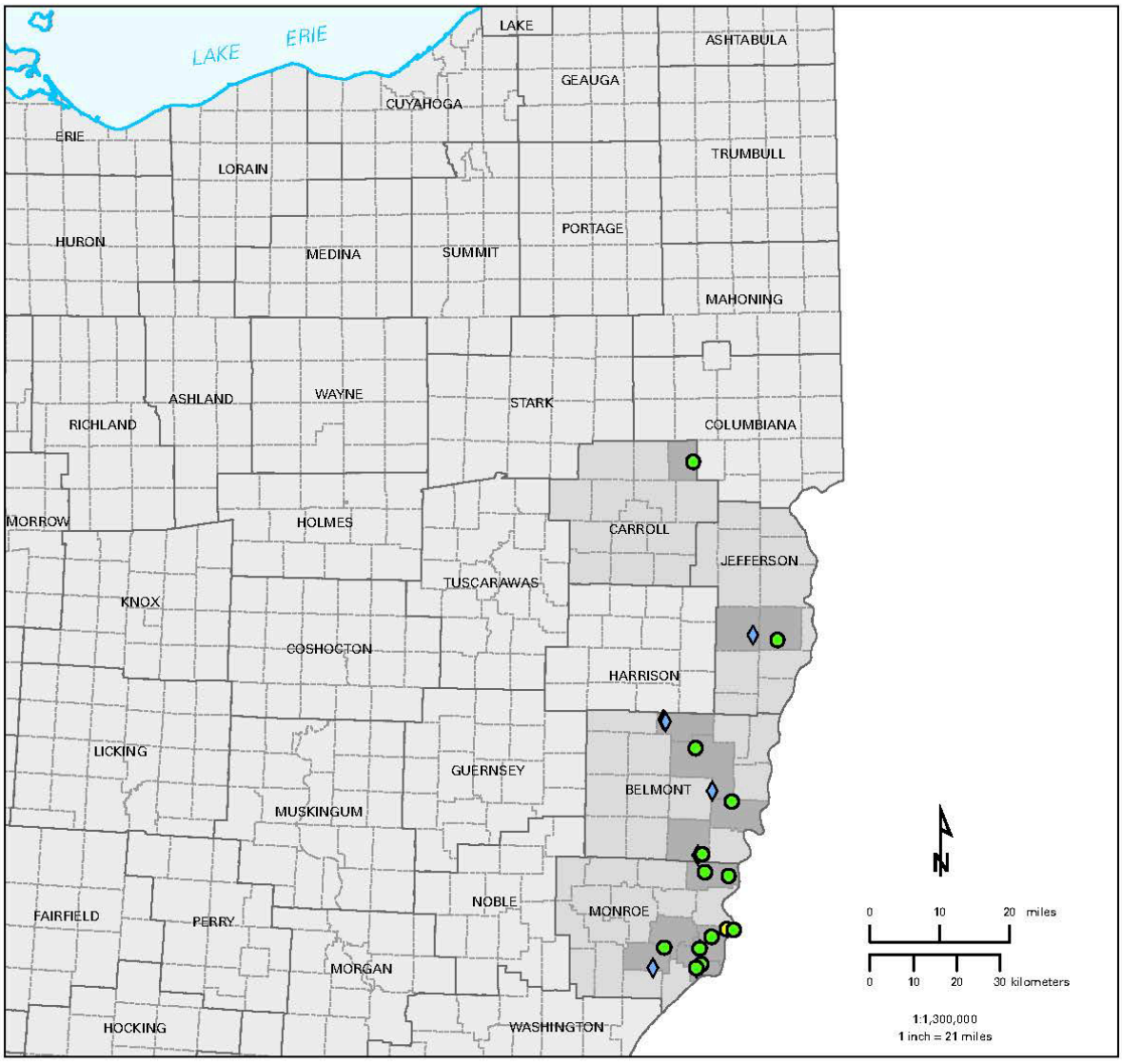
The Ohio Oil & Gas Summary issued each year reflects the most up to date information and trends effecting Ohio's oil and gas industries. The 48th edition of this Summary noted that 449 oil and gas wells were drilled in the state is 2017 and this is down from a peak of 1089 new wells drilled in 2008. The spike of wells drilled from 2005-2008 was related to the exploration of the Devonian Shale.



The ONDR Division of Oil and Gas Resources Management indicates the activity of horizontal well drilling in the Marcellus and Utica-Point Pleasant Shale in the State. As this map indicates the current and future activity will occur in the eastern and southeastern portions of the State.

OHIO DEPARTMENT OF NATURAL RESOURCES

HORIZONTAL MARCELLUS WELL ACTIVITY IN OHIO



EXPLANATION

Horizontal well status as of 12/1/2018

- PERMITTED-(Permitted; Not Drilled; Canceled) (24)
- DRILLED-(Drilling; Well Drilled) (12)
- PRODUCING-(Producing; Plugged Back) (23)
- INACTIVE-(Drilled Inactive; Shut in) (1)

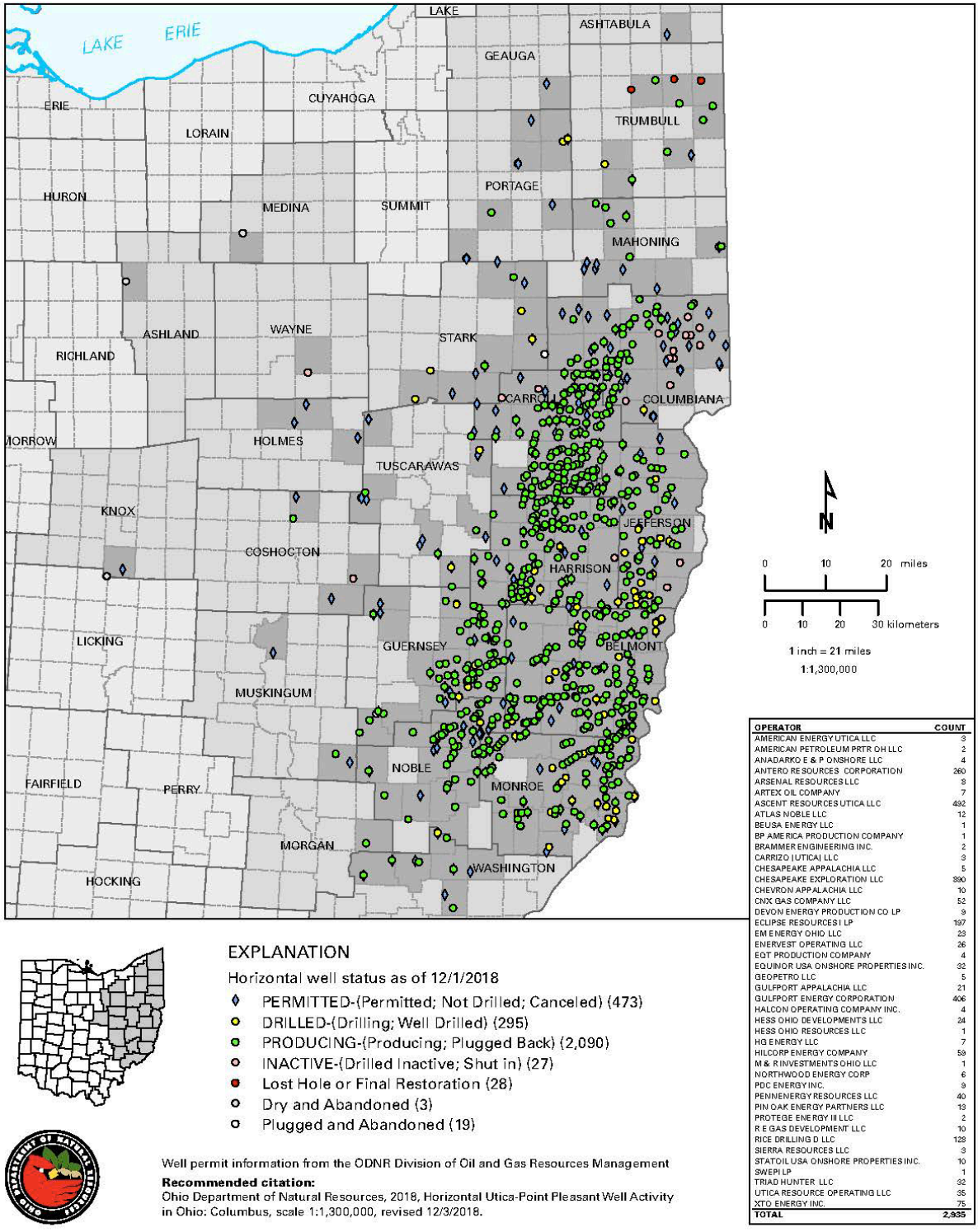
OPERATOR	COUNT
ALLIANCE PETROLEUM CORPORATION	1
ASCENT RESOURCES UTICA LLC	3
CHESAPEAKE EXPLORATION LLC	1
CNX GAS COMPANY LLC	1
ECLIPSE RESOURCES I LP	13
EM ENERGY OHIO LLC	1
EQUINOR USA ONSHORE PROPERTIES INC.	15
HESS OHIO RESOURCES LLC	3
PHILLIPS EXPLORATION INC	1
PROTEGE ENERGY II LLC	1
TRIAD HUNTER LLC	17
XTO ENERGY INC.	3
TOTAL	**60**

Well permit information from the ODNR Division of Oil and Gas Resources Management

Recommended citation:
Ohio Department of Natural Resources, 2018, Horizontal Marcellus Well Activity in Ohio: Columbus, scale 1:1,300,000, revised 12/3/2018.

OHIO DEPARTMENT OF NATURAL RESOURCES

HORIZONTAL UTICA - PT PLEASANT WELL ACTIVITY IN OHIO



OPERATOR	COUNT
AMERICAN ENERGY UTICA LLC	3
AMERICAN PETROLEUM PRTR OH LLC	2
ANADARKO E & P ONSHORE LLC	4
ANTERO RESOURCES CORPORATION	260
ARSENAL RESOURCES LLC	8
ARTEX OIL COMPANY	7
ASCENT RESOURCES UTICA LLC	492
ATLAS NOBLE LLC	12
BEUSA ENERGY LLC	1
BP AMERICA PRODUCTION COMPANY	1
BRAMMER ENGINEERING INC.	2
CARRIZO (UTICA) LLC	3
CHESAPEAKE APPALACHIA LLC	5
CHESAPEAKE EXPLORATION LLC	390
CHEVRON APPALACHIA LLC	10
CNX GAS COMPANY LLC	52
DEVON ENERGY PRODUCTION CO LP	9
ECLIPSE RESOURCES I LP	197
EM ENERGY OHIO LLC	23
ENERVEST OPERATING LLC	26
EQT PRODUCTION COMPANY	4
EQUINOR USA ONSHORE PROPERTIES INC.	32
GEOPETRO LLC	5
GULFPORT APPALACHIA LLC	21
GULFPORT ENERGY CORPORATION	406
HALCON OPERATING COMPANY INC.	4
HESS OHIO DEVELOPMENTS LLC	24
HESS OHIO RESOURCES LLC	1
HG ENERGY LLC	7
HILCORP ENERGY COMPANY	59
M & R INVESTMENTS OHIO LLC	1
NORTHWOOD ENERGY CORP	6
PDC ENERGY INC.	9
PENNENERGY RESOURCES LLC	40
PIN OAK ENERGY PARTNERS LLC	13
PROTEGE ENERGY III LLC	2
R E GAS DEVELOPMENT LLC	10
RICE DRILLING D LLC	128
SIERRA RESOURCES LLC	3
STATOIL USA ONSHORE PROPERTIES INC.	10
SWEPI LP	1
TRIAD HUNTER LLC	32
UTICA RESOURCE OPERATING LLC	35
XTO ENERGY INC.	75
TOTAL	2,935

EXPLANATION

Horizontal well status as of 12/1/2018

- PERMITTED-(Permitted; Not Drilled; Canceled) (473)
- DRILLED-(Drilling; Well Drilled) (295)
- PRODUCING-(Producing; Plugged Back) (2,090)
- INACTIVE-(Drilled Inactive; Shut in) (27)
- Lost Hole or Final Restoration (28)
- Dry and Abandoned (3)
- Plugged and Abandoned (19)

Well permit information from the ODNR Division of Oil and Gas Resources Management

Recommended citation:
Ohio Department of Natural Resources, 2018, Horizontal Utica-Point Pleasant Well Activity in Ohio: Columbus, scale 1:1,300,000, revised 12/3/2018.

ENVIRONMENTAL CONCERNS

Some citizens and local governments are becoming aware and concerned about the potential environmental and societal impacts of drilling activity in their communities. The primary concerns noted in "Drilling for Natural Gas in the Marcellus and Utica Shales: Environmental Regulatory Basics" by ODNR & OEPA dated January 2014 are:

- The possible impacts of brine or flowback water on ground water resources
- The hydraulic fracturing fluid compositions and there possible health effects
- Increased road traffic and higher road maintenance costs
- Method of disposal for the brine, hydraulic fracturing fluid and other substances related to the drilling
- Possible increase in seismic activity from injection wells
- Possible increase in air pollution from the drilling related activities

REGULATION OF NATURAL GAS DRILLING IN THE MARCELLUS AND UTICA SHALE

The regulation of Natural Gas Drilling in the Marcellus and Utica Shale lies with primarily two bodies in the State of Ohio: the Ohio Department of Natural Resources (ODNR) and the Ohio Environmental Protection Agency (OEPA). The table below is a summary of ODNR and OEPA regulatory authorities over oil/gas drilling and production activities.

Summary of ODNR and Ohio EPA regulatory authority over oil/gas drilling and production activities

	Ohio Department of Natural Resources	Ohio Environmental Protection Agency
Drilling in the shale deposits	✓ Issues permits for drilling oil/gas wells in Ohio. ✓ Sets requirements for proper location, design and construction requirements for wells. ✓ Inspects and oversees drilling activity. ✓ Requires controls and procedures to prevent discharges and releases. ✓ Requires that wells no longer used for production are properly plugged. ✓ Requires registration for facility owners with the capacity to withdraw water at a quantity greater than 100,000 gallons per day.	✓ Requires drillers obtain authorization for construction activity where there is an impact to a wetland, stream, river or other water of the state. ✓ Requires drillers obtain an air permit to install and operate (PTIO) for units or activities that have emissions of air pollutants.
Wastewater and drill cutting management at drill sites	✓ Sets design requirements for on-site pits/lagoons used to store drill cuttings and brine/flowback water. ✓ Requires proper closure of on-site pits/lagoons after drilling is completed. ✓ Sets standards for managing drill cuttings and sediments left on-site.	✓ Requires proper management of solid wastes shipped off-site for disposal.
Brine/flowback water disposal	✓ Regulates the disposal of brine and oversees operation of Class II wells used to inject oil/gas-related waste fluids. ✓ Reviews specifications and issues permits for Class II wells. ✓ Sets design/construction requirements for Class II underground injection wells. ✓ Responds to questions/concerns from citizens regard safety of drinking water from private wells from oil/natural gas drilling.	
Brine/flowback water hauling	✓ Registers transporters hauling brine and oil/gas drilling-related wastewater in Ohio.	
Pumping water to the drill site from a public water supply system		✓ Requires proper containment devices at the point of connection to protect the public water system.

The ODNR Division of Oil and Gas summarizes below the impacts and effects of the two primary legislative acts that created the current framework for have regulating the oil and gas industry in the State of Ohio.

SENATE BILL 165

On March 31, 2010 Governor Ted Strickland signed Substitute SB 165, the first major revision to Ohio oil and gas law in twenty-five years. Many significant changes were implemented as a result of passage of this new legislation which became effective on June 30, 2010. The bill provided for enhanced permitting authority in urban areas, strengthened funding for operations and orphan well plugging, added additional notification requirements by the industry and expanded enforcement provisions.

SENATE BILL 315

On June 11, 2012, Governor John Kasich signed landmark oil and gas regulatory legislation, which established one of the nation's toughest regulatory frameworks for overseeing the new technologies that allow for the exploration of natural gas in deep shale rock formations. Among other things, SB 315 creates the nation's first combined well construction and hydraulic fracturing chemical disclosure requirement, requires the sharing of all chemical information with doctors, allows appeals to the Ohio Oil & Gas Commission for certain permitting concerns prior to pursuing court action, and requires operators to take pre-drilling water samples and to disclose the proposed source of water used in wet drilling and hydraulic fracturing.

LOCAL LAND USE, ZONING REGULATION, AND HOME RULE

In the state, municipal corporations (cities and villages) have certain powers granted to them in Article XVIII of the state Constitution that exist outside their authority found in the Revised Code. Because these powers originate in the Constitution, laws passed by the General Assembly that interfere with them are invalid as applied to municipal corporations unless those laws otherwise are sanctioned by the Constitution. These constitutionally granted powers, known as "home rule" power include the power of local self-government, the exercise of certain police powers, and the ownership and operation of public utilities. "Police power" has been defined as the authority to make regulations for the public health, safety, and morals and the general welfare of society. Keep in mind any Municipal laws for the exercise of municipal police powers cannot be in conflict with general laws. Included in these "Police power" regulations are local land use and zoning regulation. http://www.lsc.state.oh.us/membersonly/128municipalhomerule.pdf

Per the American Bar Association, on February 17, 2015, the Ohio Supreme Court ruled that a city ordinance aimed at limiting fracing operations cannot be used to circumvent the state's authority over oil and gas drilling. Specifically, the court held in State ex rel. Morrison v. Beck Energy Corp., No. 2015-Ohio-485, that because the state had granted a permit to a drilling company under a state regulatory scheme governing oil and gas operations, the municipality could not pass ordinances setting forth additional restrictions.

The case arises out of a dispute over a permit that Beck Energy Corp. obtained from the state of Ohio to drill an oil and gas well within the Munroe Falls city limits. Beck Energy obtained its permit pursuant to an Ohio statute that (1) provided uniform statewide regulation of oil and gas production; (2) gave a state agency the sole and exclusive authority to regulate the permitting, location, and spacing of oil and gas wells; and (3) required parties seeking to drill a new well to obtain a state permit.

Soon after Beck Energy began drilling, however, Munroe Falls filed a lawsuit seeking an injunction to prohibit the drilling. The city argued that Beck Energy violated city ordinances requiring the company to meet certain conditions before it began drilling. The trial court granted the city's request for injunctive relief and prohibited Beck Energy from drilling until it complied with the

city's ordinances. The court of appeals reversed, holding that the state statute governing drilling operations prohibited the city from enforcing its ordinances. Munroe Falls sought relief from the Ohio Supreme Court.

The main issue before the Ohio Supreme Court was whether the state's Home Rule Amendment allowed Munroe Falls to enforce its own permitting scheme on top of the state's permitting system. The Ohio constitution's Home Rule Amendment gives local municipalities the broadest possible powers of self-government in connection with all matters that are strictly local and do not infringe on matters that are of a statewide nature. But the amendment provides that a municipal ordinance must yield to a state law if (1) the municipality's ordinance represents an exercise of police power, rather than of local self-government; (2) the statute is a general law; and (3) the ordinance conflicts with the state statute.

After analyzing these three factors, the Ohio Supreme Court concluded that Munroe Falls' ordinances had to yield to the state statute. The city did not dispute—and the court agreed—that its ordinances amounted to an exercise of police power. Likewise, the court determined that the Ohio statute constituted a general law, as the law operated uniformly throughout the state.

THE NORTHSTAR 1 CLASS II INJECTION WELL AND SEISMIC EVENTS IN YOUNGSTOWN

A preliminary report was released by ODNR in March 2012 on the Northstar 1 Class II Injection Well and the Seismic Events in the Youngstown, Ohio Area. The reports show that since March 2011, the Youngstown area has experienced 12 low-magnitude seismic events along a previously unknown fault line. These events ranged from 2.1- to 4.0-magnitude and were recorded by the ODNR Ohio Seismic Network (OhioSeis). The OhioSeis network works closely with the U.S. Geological Survey to monitor and study all seismic activity within the state. Prior to the network's establishment in 1999, monitoring earthquakes in Ohio was sporadic at best. In fact, before the network was operational, the Ohio Geological Survey was unable to accurately determine any seismic events below an approximate magnitude of 3.1. A station at Youngstown State University joined the network in 2003.

Before 2011, OhioSeis had not recorded earthquake activity with epicenters located in the Youngstown area. Also, no fault line had been previously mapped within the boundaries of Youngstown or Mahoning County. However, the broad geographical area does have a history of seismic activity, and Mahoning Valley residents have felt earthquakes from nearby faults. In fact, the area has experienced at least three prior earthquakes in the past 25 years.

The 2011 earthquakes are distinct from previous seismic activity in the region because of their proximity to a Class II deep injection well, known as the Northstar 1 well. In fact, all of the events were clustered less than a mile around the well. Northstar 1 is one of 177 operational Class II deep injection wells primarily used for oil and gas fluid waste disposal (Ohio Disposal Wells). The well is drilled 200' into the rock formation known as the Precambrian layer at a depth of 9,184' and began injection in December 2010.

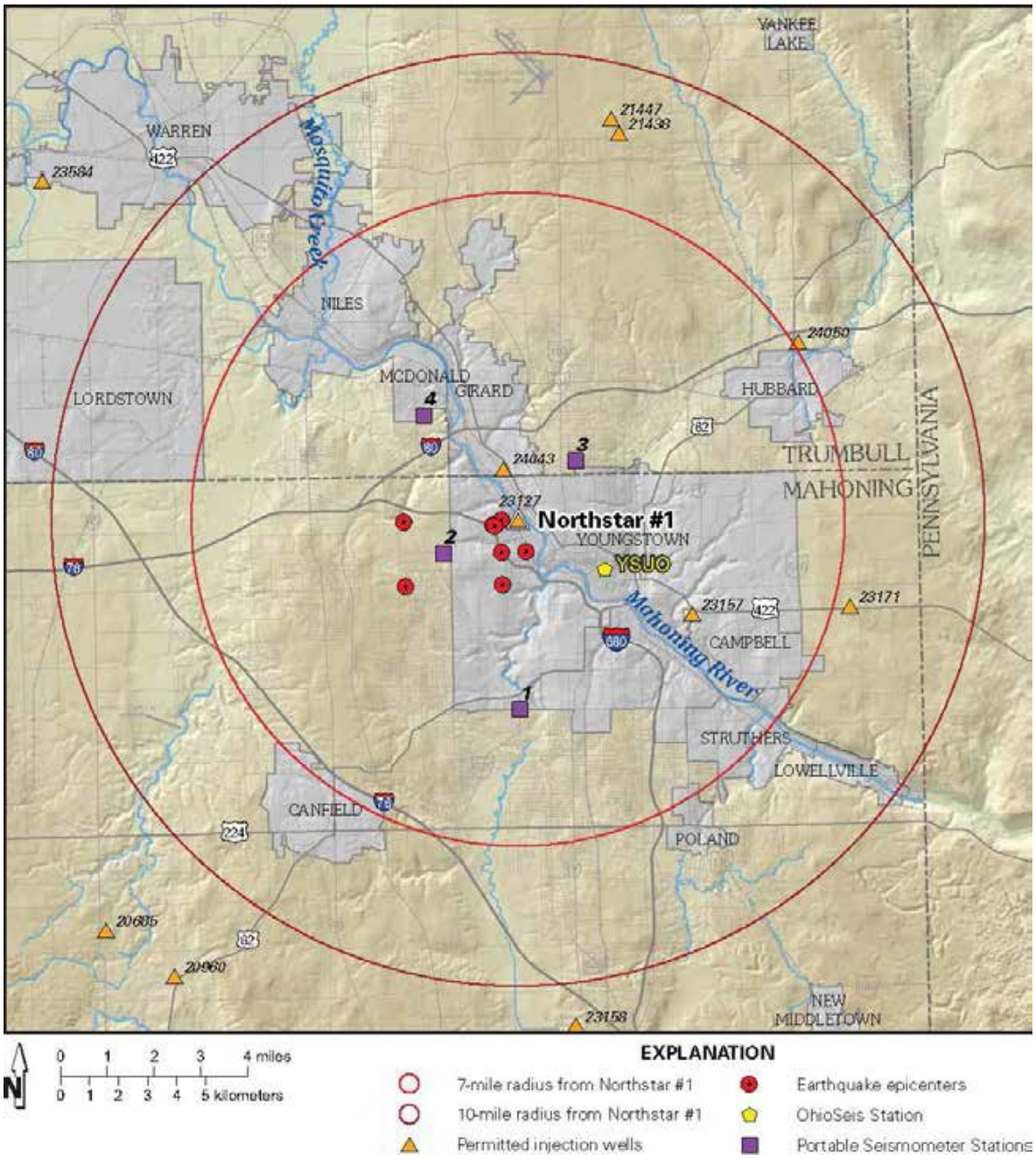
The below table, provide by the US EPA, describes the six categories or "classes" of injection wells, along with the estimated national inventory for each class. The six classes are based on similarity in the fluids injected, activities, construction, injection depth, design, and operating techniques.

This categorization ensures that wells with common design and operating techniques are required to meet appropriate performance criteria for protecting underground sources of drinking water.

Classes	Use	Inventory
Class I	Inject hazardous wastes, industrial non-hazardous liquids, or municipal wastewater beneath the lowermost Underground Sources of Drinking Water (USDW).	680 wells
Class II	Inject brines and other fluids associated with oil and gas production, and hydrocarbons for storage.	172, 068 wells
Class III	Inject fluids associated with solution mining of minerals beneath the lowermost USDW.	22,131 wells
Class IV	Inject hazardous or radioactive wastes into or above USDWs. These wells are banned unless authorized under a federal or state ground water remediation project.	33 sites
Class V	All injection wells not included in Classes I-IV. In general, Class V wells inject non-hazardous fluids into or above USDWs and are typically shallow, on-site disposal systems. However, there are some deep Class V wells that inject below USDWs.	400,000 to 650,000 wells Note: an inventory range is presented because a complete inventory is not available.
Class VI	Inject Carbon Dioxide (CO2) for long term storage, also known as Geologic Sequestration of CO2.	6-10 commercial wells expected to come online by 2016. (Interagency Task Force on Carbon Capture and Storage)

Ohio runs its Class II deep injection program on behalf of the U.S. EPA. As a result, the state meets and in many instances far exceeds U.S. EPA standards and regulations for the program. Since the program's inception in 1983, more than 202 million barrels of oilfield fluids have been disposed of, with no reports of subsurface ground water contamination incidents. In addition, no seismic event had been previously linked to operations at any of the state's Class II wells.

The earthquakes and their potential link to the Northstar 1 deep injection well were closely scrutinized by state geologists and regulators, who performed 35 separate inspections of the well from April 26 to Dec. 15, 2011. Each inspection indicated the well was operating within its permitted injection pressure and volume. In addition, ODNR regulators conducted additional testing of the well to determine if injection fluids were entering permitted injection zones. Tracer tests showed injections were reaching appropriate zones and were within permitted injection intervals. However, the tests proved inconclusive with regard to the volume of fluid entering the Precambrian layer. As a result, state regulators requested the well owner plug the Precambrian section of the Northstar 1 borehole, and the well operator voluntarily agreed to the procedure, albeit on a delayed timetable. With only one seismometer deployed in the Youngstown area, state geologists lacked the necessary data on the earthquakes' depth and exact location to draw a direct correlation between the seismic events and the deep injection well.



LAMONT-DOHERTY EARTH OBSERVATORY AT COLUMBIA UNIVERSITY

In November 2011, the ODNR Director ordered the Ohio Geological Survey to seek an outside research partner and deploy the needed portable seismometers around the Youngstown area. The Lamont-Doherty Earth Observatory at Columbia University had the available equipment and was willing to assist the state. The seismometers were deployed on Dec. 1, 2011. On Dec. 24, the newly deployed equipment recorded a 2.7-magnitude earthquake in the area. Data from the portable seismometers was downloaded and analyzed by experts at Lamont- Doherty. On Dec. 29, Lamont-Doherty presented ODNR with their preliminary findings, which indicated the seismic event depth was 2,454' below the injection well.

Based on the Lamont-Doherty data, ODNR regulators ordered the immediate halt of injections at

Northstar 1, either voluntarily by the operator or by agency order. The next day, the Youngstown area experienced a 4.0-magnitude seismic event. Gov. John Kasich immediately placed an indefinite moratorium on three drilled deep injection wells and one well with a permit pending in the vicinity of the Northstar 1 well.

INDUCED SEISMICITY

Geologists believe it is very difficult for all conditions to be met to induce seismic events. In fact, all the evidence indicates that properly located Class II injection wells will not cause earthquakes. To induce an earthquake a number of circumstances must be met:

- A fault must already exist within the crystalline basement rock and that fault must already be in a near-failure state of stress.
- An injection well must be drilled deep enough and near enough to the fault and have a path of communication to the fault.
- The injection well must inject a sufficient quantity of fluids at a high enough pressure and for an adequate period of time to cause failure, or movement, along that fault (or system of faults).

A number of coincidental circumstances appear to make a compelling argument for the recent Youngstown-area seismic events to have been induced:

- The Northstar 1 well began injection operations in December 2010. Roughly three months later, the first seismic events were noted and were fairly close to the well.
- Subsequent seismic events were clustered around the vicinity of the wellbore.
- Evidence of permeability zones within the Precambrian basement rock is interpreted in some of the geophysical logs obtained from within the Northstar 1 well; and (Logs A, B, C, and D).
- Once sufficient monitoring equipment was in place, the focal depths of events were found to be about 4,000' laterally and 2,500' vertically from the wellbore terminus.

It appears there are observed permeability zones within the Precambrian basement rock in the drill coring logs recorded by the Battelle Memorial Institute during the drilling of Northstar 1. These logs were not available to inform regulators of possible issues in geological formations prior to well operation. Instead, Battelle produced and made the logs available to provide geologists with additional information on the region's geological formations. In the future, ODNR will require the Class II well owner to provide a suite of geophysical logs germane to the respective injection well.

To establish a better understanding of what may have happened, further analysis and detailed modeling of all factors must be completed on the Northstar 1 well and the surrounding geology. This work is already underway through ODNR and cooperating agencies and institutions.

FUTURE EVENTS

As the number of oil, gas, and injection wells in the state increases, so does the potential for environmental impacts. The state is mitigating this risk by enhancing regulatory and monitoring programs for well drilling and waste disposal operations. Additional information on these efforts can be found at the ODNR Division of Oil and Gas website: http://oilandgas.ohiodnr.gov/. The state's direction will be to continue to take steps to ensure that oil and natural gas development benefits the citizens of the state and does not adversely impact human health and the environment.

CLIMATE CHANGE

The Intergovernmental Panel on Climate Change defines climate change as "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use." The National Oceanic Atmospheric Administration defines climate change as "a non-random change in climate that is measured over several decades or longer. The change may be due to natural or human-induced causes."

The Ohio State University's climate outreach notes that, "Climate change, two words that are already synonymous with changes in weather patterns across the world, from global warming to increased rainfall and severe storms. But climate change affects different areas in different ways – while some regions will see increased precipitation in the form of snow or rain, others will dry out because of reduced rainfall. And while overall temperatures across the globe are likely to increase, climate change can also be related to an increase in freezing temperatures and severe winter storms. Ohio is likely to be affected by a number of these phenomena, and adapting to different weather conditions will be important to maintain quality of life in the area."

Climate change acts as an amplifier of existing natural hazards. The fact that climate change is occurring is not disputed and over the past several decades there has been a marked increase in the frequency and severity of weather-related disasters, both nationally and in the state. This trend is being driven in part by changing global and regional climate conditions. The preponderance of available scientific evidence for anthropogenic forcing of climate change is overwhelming, or simply stated climate change is, in part, being caused by human actions, rather than natural factors alone. It is important that all levels of government and all sectors of society have at least a basic understanding of the potential impacts of climate change. The best available scientific data and modeling suggest that climate change has and will continue to impact natural hazards in the state. While the impacts of climate change may vary by regions and jurisdictions throughout the state, it is clear that the potential consequences of climate change will have significant impacts on all the citizens of the state.

OHIO EMERGENCY MANAGEMENT AGENCY SUMMARY ANALYSIS

The scientific studies and data referenced within this section come to one cohesive conclusion, climate change will have an impact on the natural hazards in the state through 2100. The greatest impact to the natural hazards in the state from climate change will be from the changes in precipitation rate and variability. To put it simply, these changes will lead to increased flooding in the spring and fall and increased periods of drought in the summer. Another impact on the state from the effects of climate change is a warming trend that will enhance the possibility of extended and increased extreme heat wave events. This climate change related warming trend will likely lead to an increased evaporation /transpiration feedback cycle, which will lead to reduced availability of water resources.

Since many of the anticipated effects of climate change exacerbate or accelerate existing natural hazards, many of the possible mitigation and adaptation strategies already exist. Based upon the best available scientific data and studies, Ohio EMA would make the following general mitigation and adaption strategy recommendations:

1. Develop greater built environment resilience
2. Improve stormwater infrastructure

3. Increase water quality and resource protection
4. Enhance essential utility resilience

These recommendations will be useful and positive actions regardless of the long term impacts of the climate change on the state. Each of these recommendations will be addressed in greater detail later in this section.

LITERATURE AND STUDIES REVIEW

While there is a considerable amount of climate change data and related studies available, there are still challenges in synthesizing the data from the available scientific sources into both the state and local hazard mitigation plans, due to the spatial context of the data in the Midwest. The majority of these studies use a spatial resolution of the entire United States or a regional approach such as focusing on the Great Lakes or Midwest Regions. There is a limited amount of data available that specifically address the impacts and effects of climate change at the state, watershed or local level for Ohio.

The fact that climate change is occurring is not disputed. The current scientific data and modeling suggest that climate change has and will impact the state. The challenges in determining the probability and severity of future impacts can make it difficult to determine with an absolute degree of certainty the full degree of impact climate change may have on the state. This is also further complicated by the fact that information gathered is continually evolving. Therefore, this section will not attempt to estimate potential losses. This section will only provide information on the potential impacts climate change may have on some of our already existing hazards profiled within the SOHMP.

This section incorporates basic scientific findings and the most current projections for global climate change as they have the potential to impact the state and the Great Lakes Region. This section will not address any one specific jurisdiction or region in an attempt to determine risk as has been completed for natural hazards within this plan update. In some instances, examples of potential impacts to specific areas are incorporated. It is important to note that in such instances, the analysis has been conducted by scientists and subject matter experts as referenced, and not by Ohio EMA Staff. As climate science evolves and improves, future updates to this plan will incorporate any new or improved relevant climate change data.

Several new or updated climate resiliency or related studies have been completed since the 2014 SOHMP, but the underlying issues with the availability of downscaled climate change data continues to be a challenge. The new or updated studies include:

- Ohio River Basin - Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance
- NOAA National Centers for Environmental Information State Summary for Ohio
- Climate Resilience in Ohio, A Public Health Approach to Preparedness and Planning – Ohio Public Health Association
- Fourth National Climate Assessment
- Smart Growth Fixes for Climate Adaptation and Resilience – EPA
- ODOT Infrastructure Resiliency Plan
- Climate Change, Extreme Precipitation and Flooding: The Latest Science - Union of Concerned Scientist

- Local Jurisdiction Climate, Sustainability or Resiliency Plans

OHIO RIVER BASIN– Formulating Climate Change Mitigation/Adaptation Strategies through Regional Collaboration with the ORB Alliance

https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/5108/

The Huntington District of the USACE, in collaboration with the Ohio River Basin Alliance, the Institute for Water Resources, the Great Lakes and Ohio River Division, and numerous other Federal agencies, non-governmental organizations, research & academic institutions, prepared the Ohio River Basin Climate Change Pilot Report.

The report provides downscaled climate modeling information for the entire basin with forecasts of future precipitation and temperature changes as well as forecasts of future streamflow at numerous gaging points throughout the basin. These forecasts are presented at the Hydrologic Unit Code-4 sub-basin level through three 30-year time periods between 2011 and 2099 developed as part of the response to climate change pilot study of the Ohio River basin.

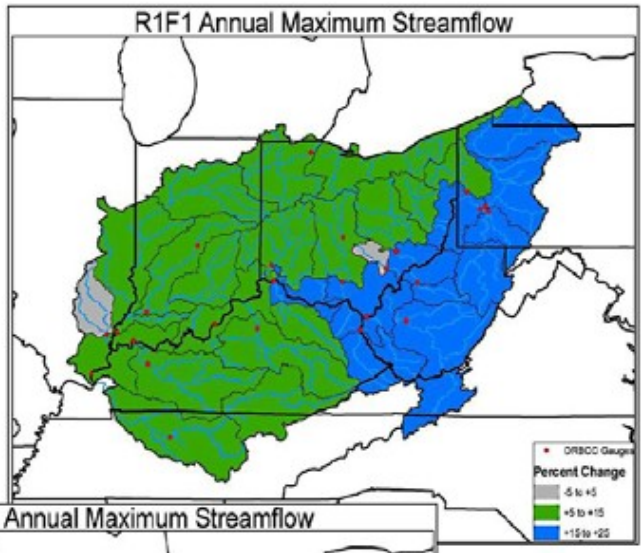
This pilot study was one of the first studies that has developed a downscaled model using current climate change data. This model was developed using archived CMIP3 and CMIP5 Climate and Hydrology Projections, which were in turn downscaled to the river basin level. The downscaled modeling results included both observed data for the 1951-2001(R1) and three 30 year forecast periods; 2011-2040(F1), 2041- 2070(F2) and 2071-2099(F3). The pilot study produced stream flow outputs for the following nine measures:

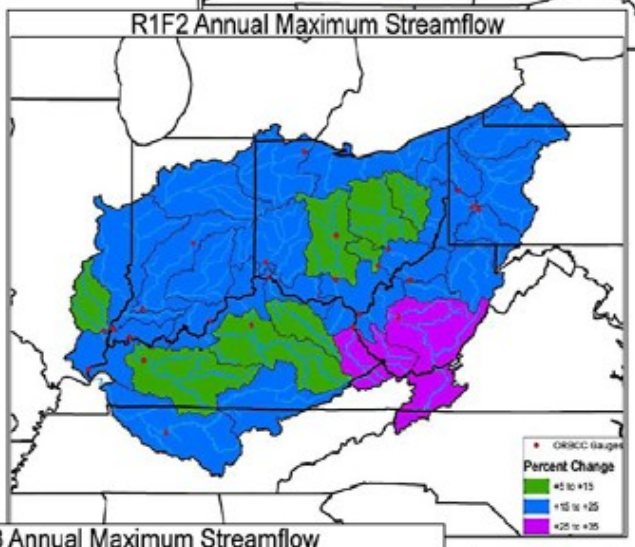
1. Annual % change mean flow
2. Annual % change maximum flow
3. Annual % change minimum flow
4. March % change mean flow
5. March % change maximum flow
6. March % change minimum flow
7. October % change mean flow
8. October % change maximum flow
9. October % change minimum flow

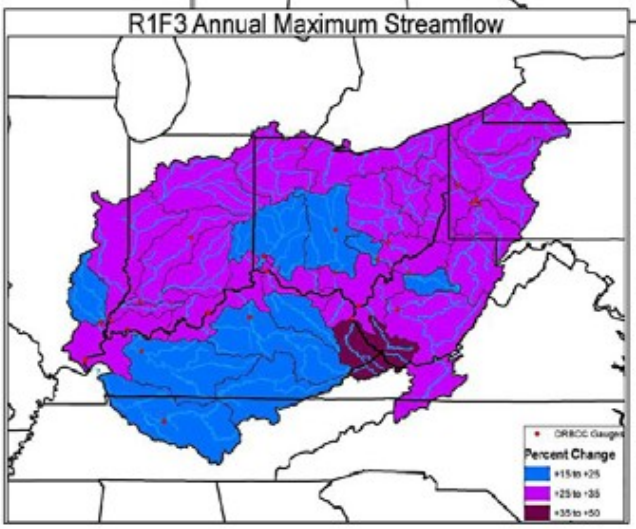
Thematic basin maps have been created to represent the above noted data, these maps highlight the percent changes for the three 30-year periods which are referenced in the maps below as F1 (2011-2040), F2 (2041-2070) and F3 (2071- 2099). The thematic basin maps for the percent change in annual maximum stream flow and percent change in October maximum stream flow have been included for reference. The remainder of the thematic basin maps are available in the draft study.

The downscaling of these ensemble climate models suggest the overall mean, maximum and minimum flows will generally be within range of recent history through the year 2040. After the year 2040, the increases occur in the mean and maximum flows in the 10% to 40% range. There are some watersheds in northern and eastern Ohio that appear to experience greater than 40% increases in mean and maximum flows. This appears to occur primarily from later summer until early winter. The autumn increases in maximum flows may enhance early cool season flood events in late autumn and early winter. These increases could lead to worsening spring flooding beyond 2040. The models suggest that droughts could lengthen or shift more between spring, summer and autumn beyond 2040. The models also suggest that the overall variability is also likely to increase with time as well.

Percent Change in Annual Maximum Stream Flow: In terms of the annual % change in the annual max flows; F1 shows an increase in the max flows across portions of PA and WV within the basin. In F2, this higher max discharge trend continues, but spreads into OH and IN and the Cumberland River watershed.

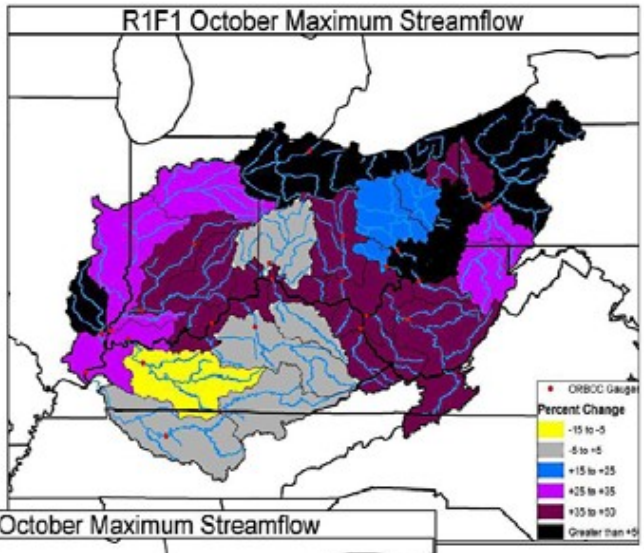


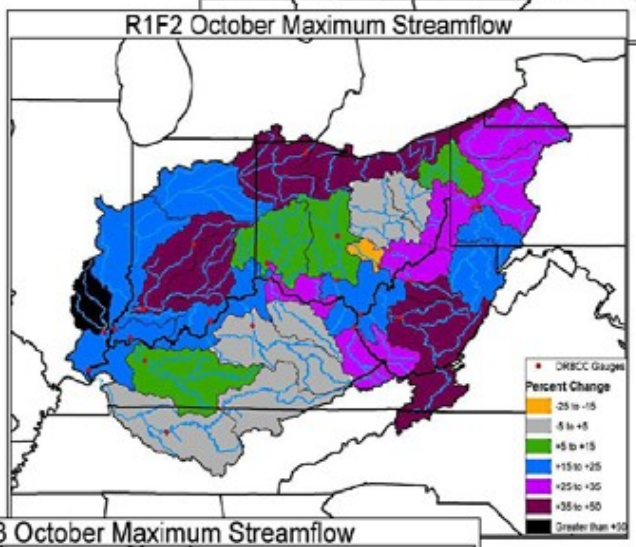


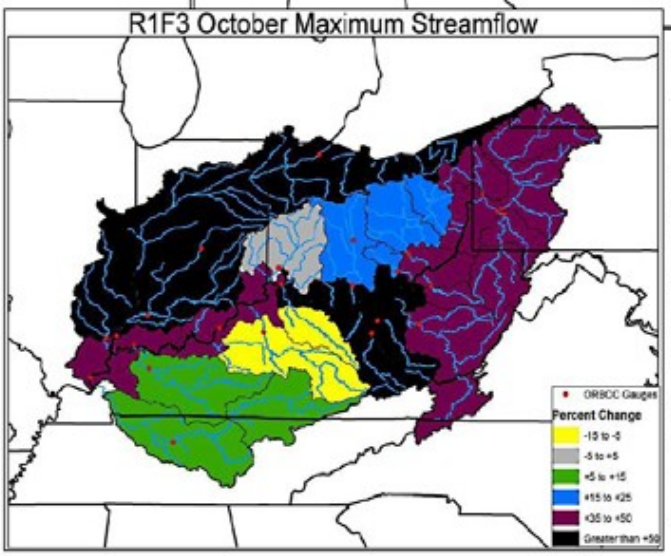


The % change in max flow increases markedly in the Kanawha and Big Sandy River sub-basins. In F3, the annual % change in max flows increases substantially across PA, WV, OH, IN and IL. The increase in annual % change in max flows appears significant in the Big Sandy River watershed during this third period. The progression of these flow changes is shown below in the three figures.

Percent Change in October Maximum Stream Flow: Period F1 shows increases in % change of max flow over much of the basin and substantially higher October flows in the Allegheny River and Little Wabash River watersheds and significant increases in the Kanawha, Scioto, Big Sandy and White River watersheds over the base condition.







Period F2 shows some relaxing of the wetter October conditions but the Kanawha, White River and Little Wabash remain higher than the base condition flows. Period F3 shows a return to higher October flows across the basin with the exception of central OH and KY. Substantial increases during this period are seen in the Big Sandy River, White River and Wabash River watersheds.

The report also included the results of preliminary investigations into the various impacts that forecasted climate change may have on ecosystems and infrastructure, and recommends mitigation and adaptation strategies. The mitigation and adaptation strategies in the pilot study can be deployed at all levels of government, private or corporate ownership to address the anticipated climate change impacts identified in the report and other effects cited in the research literature. Strategies for addressing unavoidable, residual impacts of climate change were also developed, along with objective assessments of the likelihood of success. These strategies include:

- Restoring Wetlands
- Reconnecting Floodplains
- Reducing Consumptive Uses of Water
- Harvesting Precipitation and Flood Flows
- Drought Contingency Planning
- Increasing Nutrient and Abandoned Mine Drainage Management
- Modifying Thermoelectric Power Plant Cooling Systems
- Reducing Flood Damages Through Nonstructural Measures
- Increasing Water Quality and Flow Discharge Monitoring
- Promoting Wise Land Use Management
- Modifying Reservoir Operations, Policies and Structures
- Managing Ecosystem Stress
- Temporal Staging

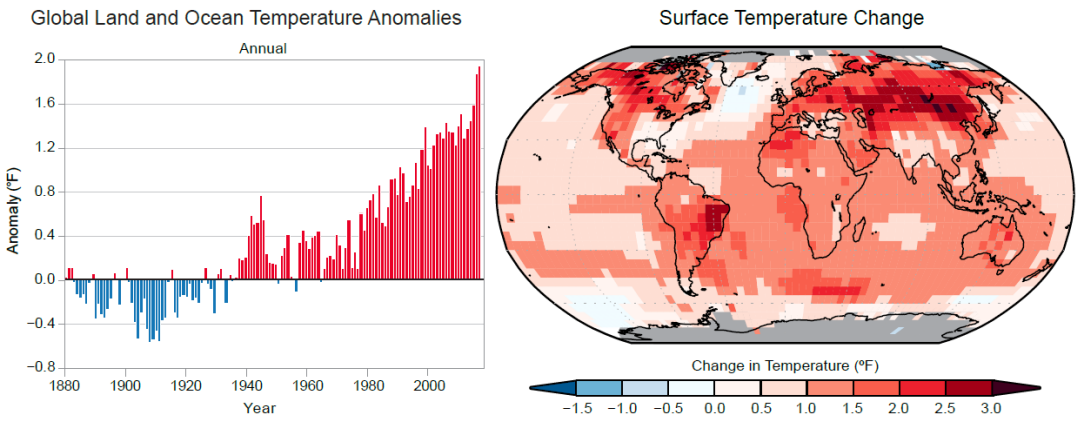
The report then recommends “next-steps”, which include filling in numerous data gaps identified during the study process. Many gaps in knowledge, understanding, and modeling need to be filled and much more investment will be required to assure ourselves that (1) the downscaled modeling results displayed in this pilot study are updated on a regular basis (at least decadal), (2) the mitigation and adaptation measures identified remain current based on new strategies and the documented successes or failures of applied strategies by others, and (3) the USACE accept an Army Strong role in leading basin water managers toward a comprehensive plan for basin water planning that can offset the potential effects of climate change on infrastructure and the ecosystems that are dependent upon operation of those facilities.

FOURTH NATIONAL CLIMATE ASSESSMENT VOLUME 1 & 2

Fourth National Climate Assessment | Volume 1

The National Climate Assessment is the authoritative assessment of the science of climate change, with a focus on the United States, and serves as the foundation for efforts to assess climate-related risks and inform decision-making. The climate of the United States is strongly connected to the changing global climate and this assessment highlights past, current, and projected climate changes for the United States and the globe.

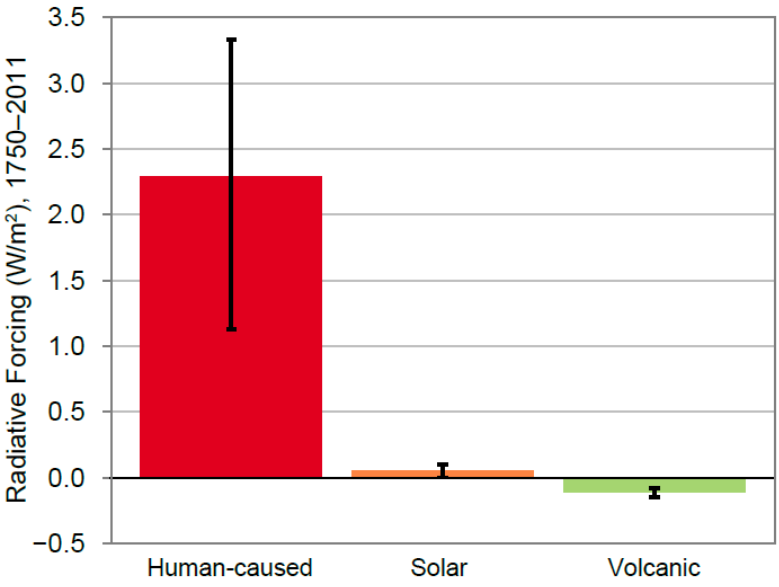
Global annually averaged surface air temperature has increased by about 1.8°F (1.0°C) over the last 115 years (1901–2016). This period is now the warmest in the history of modern civilization, with the last three years being the warmest years on record for the globe. These trends are expected to continue over climate timescales.



This assessment concludes, based on extensive evidence, that it is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence.

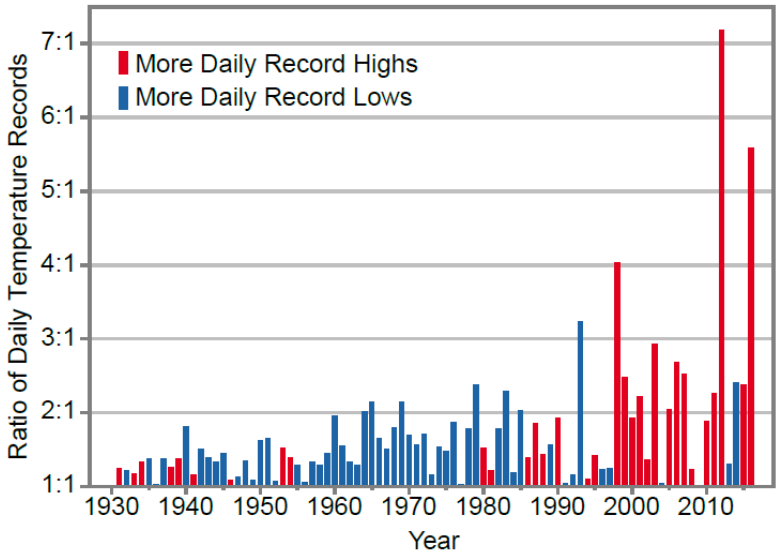
In addition to warming, many other aspects of global climate are changing, primarily in response to human activities. Thousands of studies conducted by researchers around the world have documented changes in surface, atmospheric, and oceanic temperatures; melting glaciers; diminishing snow cover; shrinking sea ice; rising sea levels; ocean acidification; and increasing atmospheric water vapor.

Changes in the characteristics of extreme events are particularly important for human safety, infrastructure, agriculture, water quality and quantity, and natural ecosystems. Heavy rainfall is increasing in intensity and frequency across the United States and globally, and is expected to continue to increase.



Additionally, heatwaves have become more frequent in the United States since the 1960s, while extreme cold temperatures and cold waves are less frequent. Recent record-setting hot years are projected to become common in the near future for the United States, as annual average temperatures continue to rise. Annual average temperature over the contiguous United States has increased by 1.8°F (1.0°C) for the period 1901–2016; over the next few decades (2021–2050), annual average temperatures are expected to rise by about 2.5°F

for the United States, relative to the recent past (average from 1976–2005), under all plausible future climate scenarios.



The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse gases (especially carbon dioxide) emitted globally. Without major reductions in emissions, the increase in annual average global temperature relative to preindustrial times could reach 9°F (5°C) or more by the end of this century. With significant reductions in emissions, the increase in annual average global temperature could be limited to 3.6°F (2°C) or less.

The global atmospheric carbon dioxide (CO2) concentration has now passed 400 parts per million (ppm), a level that last occurred about 3 million years ago, when both global average temperature and sea level were significantly higher than today. Continued growth in CO2 emissions over this century and beyond would lead to an atmospheric concentration not experienced in tens to hundreds of millions of years. There is broad consensus that the further and the faster the Earth system is pushed towards warming, the greater the risk of unanticipated changes and impacts, some of which are potentially large and irreversible.

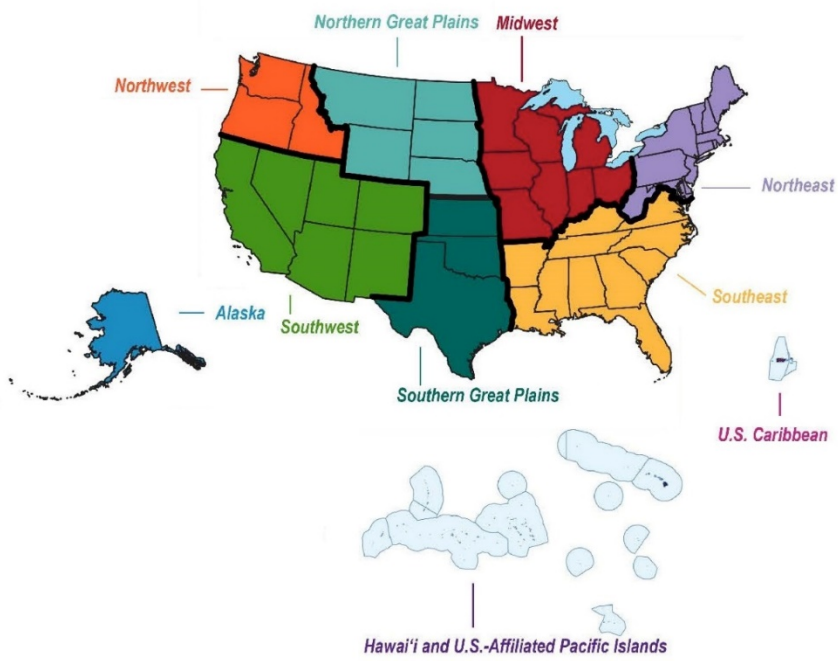
Fourth National Climate Assessment | Volume 2- Summary Findings

Volume 2 of the Fourth National Climate Assessment (NCA4) focused on consolidating the findings into twelve broad Key Messages:

1. Communities
2. Economy
3. Interconnected Impacts
4. Actions to Reduce Risks
5. Water
6. Health
7. Indigenous Peoples
8. Ecosystems and Ecosystem Services
9. Agriculture and Food
10. Infrastructure
11. Oceans and Coasts
12. Tourism and Recreation

These Key Messages broadly apply across the nation and generally echo other climate change studies in stating that climate change will like have broad impacts in many sectors of American life. For communities across the country, climate change creates new risks and exacerbates existing vulnerabilities, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.

Volume 2 of the Fourth National Climate Assessment further delineates the impacts of climate change by breaking down the nations into 10 Regions. The State of Ohio is located within the Midwest region, so that is the region we will focus on.



Midwest Chapter

NCA4 identifies 6 key messages in the Midwest Chapter: Agriculture, Forestry, Biodiversity & Ecosystems, Human Health, Transportation & Infrastructure, and Vulnerability & Adaptation. Biodiversity & Ecosystems and Vulnerability & Adaptation are newly introduced key messages for this report. A summary of the overall findings in each key message area of the NCA4 report follows:

Agriculture

The Midwest is a major producer of a wide range of food and animal feed for national consumption and international trade. Increases in warm-season absolute humidity and precipitation have eroded soils, created favorable conditions for pests and pathogens, and degraded the quality of stored grain. Projected changes in precipitation, coupled with rising extreme temperatures before mid-century, will reduce Midwest agricultural productivity to levels of the 1980s without major technological advances.

Forestry

Midwest forests provide numerous economic and ecological benefits, yet threats from a changing climate are interacting with existing stressors such as invasive species and pests to increase tree mortality and reduce forest productivity. Without adaptive actions, these interactions will result in the loss of economically and culturally important tree species, such as paper birch and black ash, and are expected to lead to the conversion of some forests to other forest types or even to non-forested ecosystems by the end of the century. Land managers are beginning to manage risk in forests by increasing diversity and selecting for tree species adapted to a range of projected conditions.

Biodiversity and Ecosystems

The ecosystems of the Midwest support a diverse array of native species and provide people with essential services such as water purification, flood control, resource provision, crop pollination, and recreational opportunities. Species and ecosystems, including the important freshwater resources of the Great Lakes, are typically most at risk when climate stressors, like temperature increases, interact with land-use change, habitat loss, pollution, nutrient inputs, and nonnative invasive species. Restoration of natural systems, increases in the use of green infrastructure, and targeted conservation efforts, especially of wetland systems, can help protect people and nature from climate change impacts.

Human Health

Climate change is expected to worsen existing health conditions and introduce new health threats by increasing the frequency and intensity of poor air quality days, extreme high temperature events, and heavy rainfalls, extending pollen seasons, and modifying the distribution of disease-carrying pests and insects. By mid-century, the region is projected to experience substantial, yet avoidable, loss of life, worsened health conditions, and economic impacts estimated in the billions of dollars as a result of these changes. Improved basic health services and increased public health measures—including surveillance and monitoring—can prevent or reduce these impacts.

Transportation and Infrastructure

Storm water management systems, transportation networks, and other critical infrastructure are already experiencing impacts from changing precipitation patterns and elevated flood risks. Green infrastructure is reducing some of the negative impacts by using plants and open space to absorb storm water. The annual cost of adapting urban storm water systems to more frequent and severe storms is projected to exceed $500 million for the Midwest by the end of the century.

Community Vulnerability and Adaptation

At-risk communities in the Midwest are becoming more vulnerable to climate change impacts such as flooding, drought, and increases in urban heat islands. Integrating climate adaptation into planning processes offers an opportunity to better manage climate risks now. Developing knowledge for decision-making in cooperation with vulnerable communities will help to build adaptive capacity and increase resilience.

Adaption actions could have a positive impact on the effects of climate change in the Midwest. The Community Vulnerability and Adaptation Key Messages of NCA4 follow:

- Expanding the use of green infrastructure and locating it properly may mitigate the negative impact of heat islands in urban settings.

- Documented implementation of climate change planning and action in Midwest cities and rural communities remains low.
- In-depth interviews with local decision-makers on water management across scales have suggested that a lack of political and financial support at the state and federal levels is a barrier to adaptation action in cities and counties.
- While initiatives are underway in the Midwest to mainstream adaptation action (such as the Great Lakes Climate Adaptation Network), there are few examples in published literature that document failure or success.

Factors that shape or contribute to the successful adoption and implementation of adaptation by public-sector organizations include:

- Plans written by a professional staff and approved by elected officials;
- Community engagement, including the participatory development of plans; the formation of action teams or regional collaborations across jurisdictions, sectors, and scales; and public- and private-sector leaders who champion and support the process;
- Adaptation actions that address multiple community goals, not just climate change;
- Well-structured implementation, including the identification of parties responsible for each step, explicit timelines, explicit and measurable goals, and explicit provisions and timelines for monitoring and updating the plan; and
- Adequate funding for the adaptation actions and for sustained community outreach and deliberation.

ODOT INFRASTRUCTURE RESILIENCY PLAN

The plan's executive summary states that the key objective of the study was to identify the vulnerability of the Ohio Department of Transportation's (ODOT's) infrastructure to climate change effects and extreme weather events. The analysis includes a discussion and analysis of the type of transportation assets vulnerable, the degree of exposure, sensitivity, adaptive capacity, and the potential approaches to adapt to these changes. The study includes:

- Understanding the vulnerability of ODOT's overall transportation system to climate change;
- Determining potential consequences from a broad range of potential climate impacts;
- Identifying facilities at risk to climate change impacts within Ohio by type;
- Identify range of adaptation and/or sustainability options (activities) that ODOT should consider in detail in future adaptation studies
- Providing the foundation for ODOT to integrate the results of this vulnerability assessment into future decision making processes and future adaptation/resiliency studies.

Utilizing ODOT's existing GIS systems, the project team developed additional GIS mapping and analytics to evaluate the vulnerability of ODOT's infrastructure to climate change effects. This effort determined that the primary climate change effect of concern is the increased incidence of heavy precipitation events, which will impair the functioning of core assets -- highways, bridges, and culverts.

A summary of this study's recommendations are below:

- Identify a lead office within ODOT- Office of Planning.
- Completion of Annual Tasks by the Resiliency Lead
- Ongoing refinement of VAST model for the 3 asset types (highways, bridges, culverts):

- Interagency Coordination

THE IMPACT OF CLIMATE CHANGE AND POPULATION GROWTH ON THE NFIP THROUGH 2100
http://www.aecom.com/deployedfiles/Internet/News/Sustainability/FEMA%20Climate%20Change%20Report/Climate_Change_Report_AECOM_2013-06-11.pdf

This study was funded by FEMA at the request of the Government Accountability Office. The goal of the study is to gain a better understanding of the potential impacts of climate change on the National Flood Insurance Program. This study focused on both riverine and coastal flooding throughout the U.S. with estimates at 20-year intervals through the year 2100. The study relied on existing data, studies, reports, and research. Although no new climate modeling was performed for this study, the methods used to evaluate the data were innovative. The study found that in riverine environments the typical 1% annual change of floodplain nationwide is projected to grow by about 45%, with areas in the northwest and the Great Lakes region experiencing growth that may exceed 100%. Nationally, 30% of that 45% increase in floodplain is due solely to population growth and would occur without the effects of climate change. The study suggests that 70% of that 45% increase in floodplain riverine areas is due solely to climate change and would occur even if there was no population growth. For reference, the below maps indicate the projected increases in both the percent change in 1% annual flood discharge through 2100 and the median projected percent change in special flood hazard areas through 2100. These results reflect national averages only and are not intended to be interpreted locally.

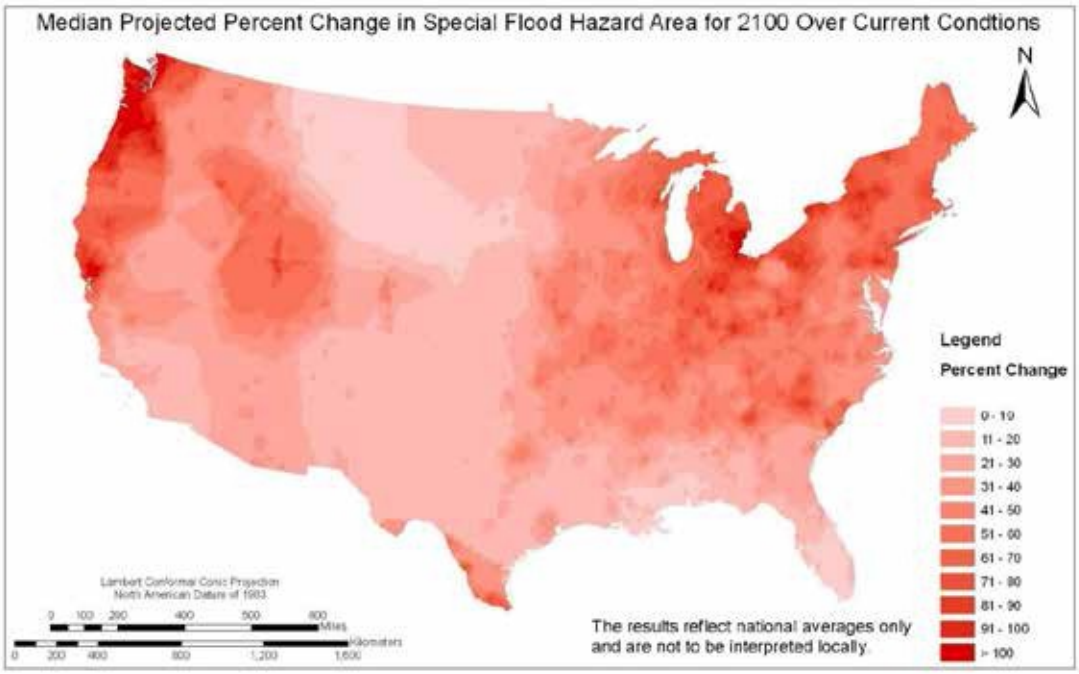


Figure 4-10. The median (50th percentile) relative change of the SFHA at epoch 5 (2100). Changes are with respect to current conditions.

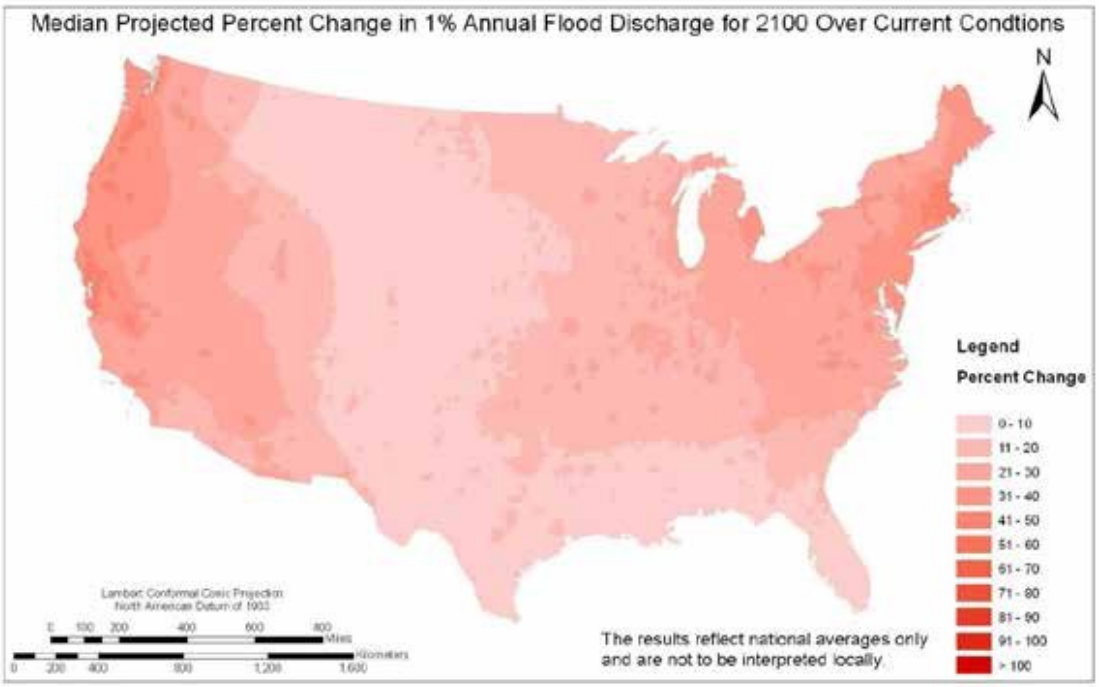


Figure 4-5. The median (50th percentile) relative change of the 1%-annual flood discharge at epoch 5 (2100). Changes are with respect to current conditions.

CLIMATE CHANGE, EXTREME PRECIPITATION AND FLOODING: THE LATEST SCIENCE – UNION OF CONCERNED SCIENTISTS

https://www.ucsusa.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf

This report is a synopsis by Union of Concerned Scientist of the latest scientific findings on how and why precipitation and flooding patterns have changed in the United States, a summary of the possible future scenarios, and recommendations. While coastal flooding and sea level rise are important parts of the complete picture of flood risk, this synopsis focuses on flooding of inland areas.

According to the 2017 Climate Science Special Report, flooding across the United States is changing, though not uniformly across the country. The data shows that flood frequency has increased in the Mississippi Valley and the Midwest over the last century, including an increase in moderate and major flood frequency in the Midwest. Across the country, increasingly frequent heavy rain is one of the most obvious weather changes. The regions experiencing increases in extreme precipitation generally align well with those experiencing increases in flood frequency. Increases in extreme precipitation frequency and intensity are projected to continue across much of the United States over the 21st century, particularly in the northern and Midwestern regions.

The reports cites several current Federal flood risk reductions programs that may help to mitigate future flood risk such as the Hazard Mitigation Assistance suite of grant programs, HUD CDBG Disaster Recovery grants, and several others. The report also recommends several possible reforms to the NFIP that would establish risk-based insurance rates, fund mapping that factors for future conditions and provide incentives for investment in flood risk reduction measures. Additionally the report suggests several policies that could be implemented at all levels of government, not just at the federal level. The possible policies include:

- Plan, design, build, retrofit and maintain infrastructure to withstand the reality of climate change.

- Incentivize regional flood risk planning to help consolidate funding and resources and implement flood resilience measures on a larger scale.
- Design and implement policies that incentivize good behavior.
- Ensure targeted funding and resources for disadvantaged populations.

The report concludes by stating our current climate no longer replicates many past patterns. Our future climate will only stray farther from what we have come to expect and have developed our societies to withstand. To adapt, we must understand these unfolding precipitation and flooding trends, prepare for changes, and learn to be more resilient amidst them. But, vitally, we are only adaptable to a point, beyond which the damages, costs, and strain will create deep harm. We must recognize the climate risks to the U.S. landscape that we simply cannot cope with, and we must strive to reduce changes to our climate and thus slow, and where we can, outright avoid these dangerous risks.

CLIMATE CHANGE IN THE MIDWEST: IMPACTS, RISKS, VULNERABILITY, AND ADAPTATION

S.C. Pryor, Provost's Professor of Atmospheric Science at Indiana University Bloomington and editor of the Journal of Geophysical Research Atmospheres edited and released Climate Change in the Midwest: Impacts, Risks, Vulnerability, and Adaptation in 2013. This book presents research that focuses on identifying and quantifying the major vulnerabilities to climate change in the Midwest. The book addresses the key sectors that may have vulnerabilities amplified by the effects of climate change, including agriculture, human health, water, energy and infrastructure.

The climate vulnerability assessment performed in the book came to the following conclusions for the Midwest:

1. The average temperature may increase 1 to 3 degrees Celsius over the next several decades. Projected change in the climate models indicate a clear tendency towards increased frequency of heat waves. Further cold- air outbreaks and other extreme cold spells will still occur but with reduced likelihood.
2. That rainfall will increase variably across the Midwest over the next several decades. The rainfall potential will increase 20-30% in the spring and winter months and there will be a significant increase in variability of precipitation events in the summer and fall months. There is evidence to suggest a split in future rainfall events, leading to a greater likelihood of droughts in the summer months and floods in the fall months.
3. Some other affects include the likelihood of warmer nights and possibly warmer days leading to an increased susceptibly to pests. The warming will likely cause a reduction in crop yields and the evaporation / transpiration feedback will lead to less available water resources.
4. The projected soil loss through erosion is expected to be significant and greater than anything that has occurred in the previous century.
5. The most direct impact of climate on human health is heat-related morbidity and mortality. The climate models indicate an increase in heat stress across all models over the course of the 21st century.
6. Using the concepts of stream flow elasticity, projected increases in precipitation over much of the Midwest are estimated to increase by 16- 20%

DROUGHT, EXTREME SUMMER WEATHER AND INVASIVE SPECIES

The studies and reports referenced above indicate that a warming trend will increase over the next several decades up to the extent of the studies/reports which is 2100. This warming trend will increase the possibility of extended and increased extreme heat wave events. The average temperature may increase 1 to 3 degrees Celsius over the next several decades throughout the Midwest. The projected change in the climate models indicate a clear tendency towards increased frequency of heat waves. Further cold-air outbreaks and other extreme cold spells will still occur, but with reduced likelihood. The studies suggest that a warming trend combined with increased variability of rainfall events in the summer months will lead to increasing periods of drought in the state and the Great Lakes region. The models suggest that droughts could lengthen or shift more between spring, summer and autumn beyond 2040. The warming trend will likely cause a reduction in crop yields and the evaporation / transpiration feedback will lead to less available water resources for human consumption, recreation and agricultural purposes. The changes in precipitation, drought and heat patterns will also create more heat related stress on crops and livestock. The changing weather patterns may also lead to a greater amount of crop pests and pathogens ranging farther northward.

FLOODING, SEVERE THUNDERSTORMS, SEVERE WINTER/ICE STORMS

The studies and reports referenced above indicate that one of the primary impacts on the state from climate change will be the changes in precipitation rates and variability. The studies also indicated that rainfall will increase variably across the Midwest over the next several decades. The increased variability of precipitation events will mostly occur in the summer and fall months. There is evidence to suggest a split in future rainfall events, leading to a greater likelihood of droughts in the summer months and floods in the fall months.

The studies also indicated that after the year 2040, the increases occurring in the mean and maximum stream flows will be in the 10% to 40% range with the north and northeast parts of that state experiencing greater than 40% increases. These increases appear to occur primarily from later summer until early winter, with the autumn increases in maximum stream flows enhancing early cool season flood events in late autumn/early winter. These increases also indicated the possibility of worsening spring flooding beyond 2040.

MITIGATION AND ADAPTION STRATEGIES

As the climate change data specific to the state becomes more readily available, mitigation and adaptation will be one of the focuses of dealing with the impacts of climate change. Ohio EMA has recommended four mitigation and adaption strategies that will help alleviate the future impacts of climate change on the natural hazards within the state. These strategies are recommended because they will have positive impacts regardless of climate change and its predicted long term impacts.

DEVELOP GREATER BUILT ENVIRONMENT RESILIENCE

The built environment refers to the any buildings or structures which are manmade as opposed to the natural environment. Developing resilience in the built environment is an important mitigation action, especially when you factor for the probability of increasing precipitation rates and variability. Examples of actions that increase resilience of the built environment include:

- Reduce the number of pre-FIRM flood prone, repetitive loss and severe repetitive loss structures through FEMA mitigation grant programs.

- Adopting building, zoning and floodplain regulations that include higher standards than the minimum regulatory requirements.
- Encourage resilient local land use regulation through the Ohio Balanced Growth Initiative.

IMPROVE STORMWATER INFRASTRUCTURE

Stormwater infrastructure is normally designed to convey or capture flows associated with a designed storm event; the scale of which is based on a probability distribution of observed rainfall events. One of the underlying assumptions of the atypical design approach is that the rainfall probability distribution is static. The best available climate change models indicate that future larger precipitation events will occur with an increasing frequency. The existing stormwater infrastructure, which was designed with current storm approach, cannot be expected to provide the intended level of protection throughout its lifetime service. Examples of actions that improve stormwater infrastructure are:

- Encourage increased green infrastructure and the use of low impact development strategies to reduce stormwater.
- Seek to minimize impervious surfaces such as parking lots, roads, and rooftops in sensitive areas.
- Encourage riparian buffers along streams, rivers, and waterways to maintain natural floodplains.
- Protect and reestablish wetlands to hold runoff and recharge groundwater.
- Implement the separation of combined storm and sanitary sewer overflows to reduce pollution from sewage, bacteria, and E. Coli entering waters during storm event

INCREASE WATER QUALITY AND RESOURCE PROTECTION

The current climate change models indicate that its effects will have a variety of impacts on ground water resources and water quality. The higher water and air temperatures and changes in the timing, intensity, and duration of precipitation will impact water quality and ground water resources. Examples of actions that can be pursued to increase water quality and provide ground and surface water resources protection include:

- Encourage effective water-conservation strategies during summer months, and consider year-round water-conservation strategies for water-intensive users.
- Implement the separation of combined storm and sanitary sewer overflows to reduce pollution from sewage, bacteria, and E. Coli entering waters during storm events.
- Recommend sewer and septic systems be upgraded to reduce non-point source pollution from urban areas, farmland, and other sources.
- Ensure that water extractions and diversions are appropriately planned and factor the future impacts of climate change.

ENHANCE UTILITY AND ENERGY RESILIENCE

Water, electricity, and wastewater treatment are three utility services that are essential for modern daily life. These three utilities support business, industry, recreation, housing, hospitals and schools in communities across the state. These essential utility services have been traditionally planned, designed and operated with an assumption that the future environment is mostly static and predictable. The scientific climate change models show that increasingly

variable and extreme precipitation patterns and temperature increases crises will intensify the risks faced by these essential utility services. With these risks in mind, essential utilities need to be working to strengthen their resilience to extreme climate events, also seeking ways to mitigate the impacts of climate change. Examples of actions that can be pursued to assist utilities services in increasing their resiliency include:

- Engage and educate stakeholders, having their active engagement will help to build shared a understanding and support for utility initiatives
- Strengthen existing utility transmission generation networks so they are able to cope with the future demand resulting from climate change.
- Encourage the development and construction of green infrastructure to help lessen the impact of the increasing extreme climate events.
- Support the upgrade of neglected infrastructure networks to provide an efficient supply of utilities.

LOCAL CLIMATE CHANGE ADAPTATION AND MITIGATON PLANS

Ohio's largest 6 cities (Columbus, Cleveland, Cincinnati, Toledo, Akron and Dayton) and the City of Athens have all, in varying levels, identified potential climate change impacts for the city and either acknowledge the need for future adaptation planning (Toledo, Dayton) or have already created adaptation/action plans (Athens, Columbus, Cleveland, Cincinnati, Akron).

Commonly identified impacts by the cities include:

- Health implications from deteriorated air quality and increased temperatures, and;
- Increased heavy precipitation and storm events.

Among cities with adaptation plans:

- Energy efficiency, transportation, and water and food supply are commonly reoccurring themes.
- The cities of Akron, Cincinnati and Cleveland have all identified quantitative, city-wide greenhouse gas reduction goals.
- The cities of Columbus, Cincinnati and Cleveland cite lack of federal and/or state level action on climate change as a driver for its city level adaptation and mitigation planning.

Actions/Recommendations:

- Athens has 10 key recommendations (pertaining to sustainability more generally).
- Columbus has 43 recommendations grouped into 8 thematic areas.
- Cincinnati has 80 recommendations (several recommendation per each objective).
- Cleveland has several actions per each of the 28 objectives.
- Akron has "strategies" for consideration but no finalized recommendations or actions.

The subsequent pages summarize the following documents:

- The Greenprint for Akron (2012)
- The Athens Sustainability Action Plan (2017)
- The Green Cincinnati Plan (2018)
- The Cleveland Climate Action Plan (2018)
- Columbus Climate Action Plan (2018)
- The Potential Impacts of Climate Change on Dayton, Ohio (2013)

- The University of Michigan Climate Center's City Fact Sheet: Toledo Ohio (2016)

Akron

The City of Akron has recognized likely impacts of climate change on the city and has laid out 7 guiding principles as part of its sustainability plan for the city. The city has completed a study to identify baseline levels and sources of emissions in order to achieve tangible Green House Gas (GHG) reductions. The City of Akron's Climate Action Plan was completed using the International Council for Local Environmental Initiatives (ICLEI)'s Climate and Air Pollution Planning Assistance software and is intended to identify where policymakers will need to target emissions reduction activities if they are to make significant progress toward adopted targets.

Athens

The Athens Sustainability Action Plan explores 8 topic areas (energy, economy, solid waste, food, housing and development, transportation, water, air and greenhouse gas emissions) and the current status in Athens for each topic as well as an action plan for each. Based on community concerns and additional research, the City of Athens Environment and Sustainability Commission has identified 10 key recommendations as the most important to put the city on a sustainable path and to reduce greenhouse gas emissions.

Columbus

The Columbus Climate Adaptation Plan (CCAP) recommends 43 actions to be taken by the City that fall under 8 thematic chapters (Extreme Heat, Air quality and Energy, Flooding, Water Quality, Water Use, Ecosystems, Emergency Preparedness and Vulnerable Populations). The list of recommended actions are prioritized into necessary and aspirational actions. Necessary actions are considered the most impactful and easiest to implement based on expertise, cost and will. The Plan recommends that various city departments should assume leadership roles in project planning, assigning duties and executing actions. The City could allocate funds related to climate adaption to departments to utilize and the annual sustainability report should include documentation of progress toward completion of each action item.

Cincinnati

Following Cincinnati's 2017 commitment to reach 100% renewable energy in the city by 2035, the 2018 Green Cincinnati Plan outlines 80 high-impact recommendations to reduce carbon emissions by 80% by 2050. The recommendations have been grouped into eight themes: built environment, education & outreach, energy, food, natural systems, resilience, transportation, and waste. It also identifies 26 measureable goals that will be used to measure progress toward a sustainable, equitable and resilient Cincinnati. The report identifies that adoption of autonomous vehicles, encouraging electric vehicle use and infrastructure, and industrial energy efficiency as the top three recommendations in terms of potential impact towards the 2050 GHG goal.

Cleveland

The 2013 Cleveland Climate Action Plan (updated in 2018) established an overarching GHG reduction goal of 80% below 2010 emissions by 2050, with interim goals of 16% reduction by 2020 and 40% reduction by 2030. The plan identified 28 objectives across five focus areas (energy efficiency and green building, clean energy, sustainable transportation, clean water and vibrant green space, more local food, less waste) and cross-cutting priorities as well as goals through numeric targets and time frames for achieving targets. Additionally, it identifies actions, which are specific strategies that will be implemented to meet the goals and objectives.

Dayton

The City of Dayton does not have a designated climate or sustainability plan. The city has, however, identified and analyzed the potential impacts of climate change on the city. It has acknowledged that the next step is deciding which strategies make the most sense for the city's climate efforts. Strategies focus on increasing the amount of green infrastructure, encouraging the use of pervious surfaces, on-site stormwater management through rain gardens and bio-swales, urban forestry, green and white roofs, energy efficiency, renewable energy, land-use planning, updated zoning policies, the use of reflective pavement, strategies to increase adaptive capacity of residents and businesses, and enhancing community engagement and empowerment.

Toledo

The City of Toledo (with the University of Michigan) has created a Climate Fact Sheet on the city. The city recognizes deteriorating water infrastructure as a major issue as the city is built over a wetland area and ground saturation and stormwater overflow pose major threats to health. The city of Toledo is partnering with General Motors and Teledyne to increase green infrastructure in flood-prone neighborhoods.

CLIMATE CHANGE ADAPTATION LITERATURE AND STUDIES REVIEW

There are several current studies that suggest various climate change adaption strategies for the Great Lakes or Midwestern region. Many of these studies do not provide enough downscaled data or go into sufficient detail to warrant full inclusion within this current iteration of the plan update. As climate science evolves and improves, future updates to this plan will incorporate any new or improved relevant climate change adaption strategies.

CLIMATE CHANGE RESEARCH AT THE OHIO STATE UNIVERSITY

http://esn.osu.edu/climate-change

The Ohio State University has long been a leader in global climate change research, from physical drivers to impacts to adaptation and mitigation. Research teams across the university are investigating many aspects of global change, including:

- Glaciers, climate change and sea level, atmospheric sciences, contemporary and paleo climate.
- Ecosystem and biodiversity impacts, greenhouse gas monitoring and mitigation, freshwater quantity and quality, economic modeling, coastal community adaptation and mitigation.
- Changes in ecosystem services, risk and decision science, education and community engagement, agricultural impacts and strategies.

THE OHIO STATE CLIMATE CHANGE OUTREACH TEAM

http://changingclimate.osu.edu/

The Ohio State University Climate Change Outreach Team is a partnership among multiple departments within Ohio State University; the team's goal is to help localize the climate change issue by bringing related research and resources to residents of Ohio and the Great Lakes region. The team is comprised of leading academics from Ohio State Extension, the Department of Agricultural, Environmental, & Development Economics, Byrd Polar Research Center, School

of Environment and Natural Resources (SENR), Department of Geography, Department of Evolution, Ecology & Organismal Biology, Ohio Agricultural Research and Development Center (OARDC) and the Ohio Sea Grant College Program & Stone Laboratory.

CLIMATE CHANGE ADAPTATION IN GREAT LAKE CITIES STUDY

http://deepblue.lib.umich.edu/handle/2027.42/97435

This study looks at the anticipated impacts of climate change and how those impacts affected different communities throughout the state. Researchers have identified a variety of resources, assets, and governance structures that increase the ability and likelihood of successful adaptation, even in the face of significant uncertainty. In order to anticipate and successfully respond to these impacts, cities in the state need to better understand the opportunities and constraints within their own organizations.

To evaluate this capacity, an Integrated Assessment was conducted for four cities in the state (Toledo, Dayton, Elyria, and Avon Lake). The study takes a broad view of the political, social, and ecological causes, consequences, and potential solutions to climate vulnerability and impact reduction. The results of the study describe the capacities and constraints each city possesses, as well as identifies best practices cities can implement to take advantage of these capacities and overcome constraints. Each city had specific capacities and constraints based on the analysis, several overarching themes emerged. Decision-makers in each city expressed interest in adapting to climate change. Leaders within city governments are working to connect issues of sustainability and adaptation to the core mission of their departments, as well as forming policy networks across the city. Overall, leadership and the quality of current city employees emerged as key capacities throughout the study, but there are significant constraints to adaptation as well. Two broad trends identified are scarce financial resources and limited access to scientific knowledge. The lessons learned in this study could be applied to future plan updates as additional appropriate climate change data become available statewide.

ADAPTING TO CLIMATE CHANGE: A PLANNING GUIDE FOR STATE COASTAL MANAGER'S – A GREAT LAKES SUPPLEMENT

https://coast.noaa.gov/czm/media/adaptationgreatlakes.pdf

This report for the Great Lakes region is intended to provide additional detail and supplement the Adapting to Climate Change: A Planning Guide for State Coastal Managers, which the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean and Coastal Resources released in 2010. The report included information on climate change and steps to help set up a planning process, assess vulnerability, devise a strategy, and implement a plan to minimize climate change impacts on the Great Lake's coasts. The planning guide also provides an extensive list of resources to help throughout the planning and implementation process.

The report provides updated data and information on the potential climate change impacts and effects for Great Lakes coastal areas. It highlights case examples of adaptive actions taking place in the Great Lakes region today, many of which are still in the planning and policy development stages.

NOAA – NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION STATE SUMMARY OF OHIO

https://statesummaries.ncics.org/oh

The State Climate Summaries were produced to meet a demand for state-level information in the wake of the Third U.S. National Climate Assessment, released in 2014. The summaries cover assessment topics directly related to NOAA's mission, specifically historical climate variations and trends, future climate model projections of climate conditions during the 21st century, and past and future conditions of sea level and coastal flooding.

The three key takeaways from the Ohio Summary are:

- Historically unprecedented warming is projected by the end of the 21st century and increases in extreme heat are of particular concern for Cincinnati, Columbus and other urban areas where urban heat island effect raises summer temperatures.
- Winter and spring precipitation are projected in increase. Extreme precipitation is projected to increase, potentially causing more frequent and intense floods.
- The intensity of future droughts is projected in increase. Future summer droughts are likely to be more intense.

SMART GROWTH FIXES FOR CLIMATE ADAPTATION AND RESILIENCE- EPA
https://www.epa.gov/smartgrowth/smart-growth-fixes-climate-adaptation-and-resilience

The Environmental Protection Agency's (EPA) Smart Growth Fixes for Climate Adaptation and Resilience: Changing Land Use and Building Codes and Policies to Prepare for Climate Change (2017) is intended to help local jurisdictions develop strategies to prepare for climate change impacts through land use, zoning and building code policies. The policy options described in this publication bring multiple short- and long-term environmental, economic, health, and societal benefits that can not only prepare a community and its residents and businesses for the impacts of climate change, but also improve everyday life.

The strategies can be worked into a local community's regular processes, for example, through scheduled updates to zoning and building codes. This approach allows incremental change, which might be easier for some communities because it costs little or nothing extra compared to "business as usual", and gives communities the opportunity to adjust codes based on the most up-to-date climate observations and projections. To help communities determine which policy and code changes might be best for them, the options in each chapter are categorized as modest adjustments, major modifications, and wholesale changes.

The options can address one, some or all of the following hazards: flooding and precipitation, sea level rise, extreme heat, drought, and wildfire. Examples of the options include, but are not limited to:

- Use regional climate change, population demographics, transportation demand, and related projections to understand where community assets could be vulnerable.
- Evaluate development incentives to see if they encourage development in particularly vulnerable areas.
- Design open space in flood plains for multiple amenities.
- Adopt a site plan requirement that requires all new development to retain all stormwater on-site.
- Establish a task force to review building codes, development patterns, and other relevant issues.

CLIMATE RESILIENCE IN OHIO, A PUBLIC HEALTH APPROACH TO PREPAREDNESS AND PLANNING
https://ohiopha.org/download/climate-resiliency-in-ohio/

In 2016, the Ohio Public Health Association (OPHA) formed the Ohio Public Health Resiliency Coalition (OPHCRC) to develop a document for use by local public health professionals in their efforts to address the public health impacts of climate change and climate-related weather events in their jurisdictions.

The result of the OPHCRC's work is the paper titled Climate Resilience in Ohio, a public health approach to preparedness and planning that focuses on the risks and adverse outcomes that the communities served by Ohio's local health departments (LHDs) are likely to face due to climate change effects. It was the Coalition's decision to focus first on adaptation and resilience from a public health perspective and then to build upon this work and address mitigation efforts. In the context of climate change, the term "adaptation" refers to activities, programs and efforts that seek to allow societies to continue functioning in the face of continued temperature increases and fluctuations in local weather patterns.

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

As downscaled climate change data becomes more readily available the state will assess its vulnerability in terms of population, structures and critical facilities at risk. The state will also encourage the inclusion of such data in local hazard mitigation plans once the data is granular enough to support the analysis.