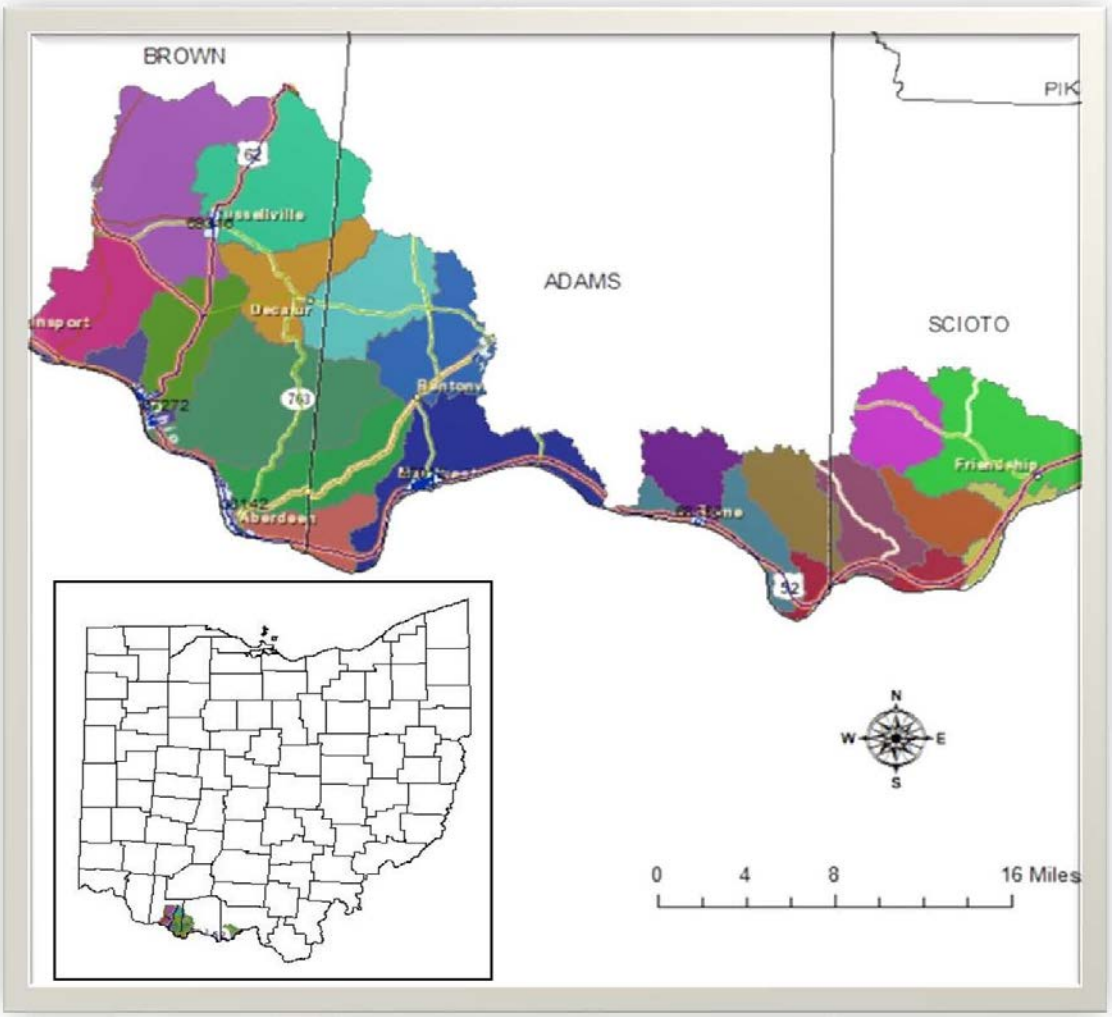
Study Plan
for the
Biological and Water Quality Study of the Southwest Ohio River Tributaries - 2016

(Turkey, Straight, and Eagle Creeks)

Adams, Brown, and Scioto Counties



Division of Surface Water
Ecological Assessment Section
June 6, 2016

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Biological and Water Quality Study of the Southwest Ohio River Tributaries
(Turkey, Straight, and Eagle Creeks)

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Prepared by
State of Ohio Environmental Protection Agency

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Introduction

As part of the Total Maximum Daily Load (TMDL) process and in support of the basin approach for National Pollutant Discharge Elimination System (NPDES) permitting, an intensive ambient assessment will be conducted during the 2016 field sampling season within the southwest Ohio River tributaries (SWORT), including Turkey, Straight, and Eagle Creeks (Table 3). The study area is composed of all or portions of 22 HUC12 watershed assessment units (WAUs). Data from a total of 46 sampling stations will be collected in the SWORT study area. Ambient biology, macrohabitat quality, water column chemistry, and bacteriological data will be collected from most of these sites. Diel water quality (DO, pH, conductivity, and temperature), sediment chemistry (metals, organics, and particle size), nutrients, and fish tissue will be evaluated at selected sampling locations (Tables 2 and 3).

Sampling Objectives

1. Systematically sample and assess the principal drainage networks of selected Southwest Ohio River tributaries in support of the TMDL process; including Turkey, Straight, and Eagle creeks,
2. Gather ambient environmental information (biological, chemical, and physical) from designated water bodies, to assess current beneficial uses (e.g., aquatic life, recreational, water supply), Table 2,
3. Collect fish tissue samples for human health consumption advisories at selected stations as listed under sample types in Table 2,
4. Verify the appropriateness of existing, unverified beneficial use designations,
5. Establish baseline ambient biological conditions at selected reference stations to evaluate the effectiveness of future pollution abatement efforts, and
6. Document any changes in biological, chemical, and physical conditions of the study areas where historical information exists, thus expanding the Ohio EPA database for statewide trends analysis (e.g., 305[b]).

Total Maximum Daily Load

Information collected as part of this survey will support TMDL development for this study area. The objectives of the TMDL process are to estimate pollutant loads from various sources within the basin, define or characterize allowable loads to support the various beneficial uses, and to allocate pollutant loads among different pollutant sources through appropriate controls (e.g., NPDES permitting, storm water management, 319 proposals, non-point source pollution controls or other abatement strategies).

The components of the TMDL process supported by this survey are primarily the identification of impaired waters, verification (and re-designation if necessary) of beneficial use designations, and sources of use impairment. These data are necessary precursors to the development of effective control or abatement strategies.

Aquatic Life Use Designations (ALU)

Many of the streams contained within the study area are designated Exceptional Warmwater Habitat (EWH) or Warmwater Habitat (WWH). For some of the streams, this will be the first time that they will be sampled and assessed. Ohio EPA is obligated to review, evaluate, or recommend (where appropriate) beneficial uses prior to basing any permitting actions on existing, unverified designations, or entirely unclassified water bodies. Much of the sampling effort for this survey is allocated to fulfill this obligation.

Town Run Sampling (50902011003)

In 2006, Ohio EPA conducted an intensive biological and water quality study of the White Oak Creek watershed and part of the sampling efforts included Town Run. An excerpt from the report states the following: "Biological sampling in Town Run (RM 0.9 in 2008) found a marginally good community of macroinvertebrates and a reproducing population of the cold water indicator two-lined salamander upstream from the Georgetown WWTP discharge (RM 0.80). Downstream from the WWTP discharge (RM 0.7 in 2008) the macroinvertebrate community was very poor and there was no observed reproduction of the two-lined salamander. High concentrations of ammonia-N (median of 3.24 mg/L), phosphorus-T (median of 3.04 mg/L), and nitrate-nitrite-N (median of 6.39 mg/L) were recorded downstream from the WWTP discharge in 2006."

http://www.epa.ohio.gov/portals/35/documents/WhiteOakCreekTSD2006.pdf

As a result of observed stream impacts, Ohio EPA included Town Run on the 303(D) list, which is the state's prioritized list of impaired waters. Since the impairment in Town Run could be directly attributed to high nitrogen-ammonia concentrations from a point-source discharge (Village of Georgetown WWTP), Ohio EPA prepared a Category 4B alternative in lieu of a TMDL:

http://www.epa.ohio.gov/portals/35/tmdl/WhiteoakCreekTMDL_final_dec09_appH.pdf.

In an effort to address aging treatment plant infrastructure and also to provide treatment technologies to address receiving stream issues, the Village completed improvements to the WWTP in 2014. As a result, nitrogen-ammonia levels in the treated effluent have dramatically improved. During the period of January 2015 – May 2016, the facility discharged treated effluent with nitrogen-ammonia concentrations of 0.3 mg/l (summer- 50th percentile) and 0.635 mg/l (summer – 95th percentile).

Now that improvements to the WWTP have been in place for over one year, Ohio EPA will be conducting follow-up monitoring of Town Run in 2016. The main objective of the monitoring is to measure progress toward aquatic life use attainment in Town Run.

SAMPLING ACTIVITIES

Chemical/Physical Water and Sediment

Chemical sampling locations within the study area are listed in Table 2. Conventional chemical and physical water quality samples will be collected five times at each designated location. Sediment samples will be collected at five locations. A total of 19 sondes will be deployed at designated locations, five of which will overlap with sentinel sites. Chemical parameters to be tested are listed in Table 4. Surface water sampling will occur across a variety of flow conditions, from lower flows to moderate and higher flows.

Bacteriological Sampling

Water samples will be collected at 20 sites for bacteriological analyses to determine the attainment status of the Primary Contact Recreational use of streams in the study area. Testing will include *Escherichia coli* (*E. coli*) bacteria. Each site will be sampled at least 5 times, while sentinel sites may have 5-10 bacteriological samples.

Chlorophyll

Benthic and sestonic chlorophyll-*a* samples are to be collected at 19 designated wadeable and headwater sonde sites noted in Tables 2 and 3. Benthic chlorophyll samples are to be collected at least once, and should be timed to coincide with deployment of sonde automated data loggers during stable, baseflow conditions (typically the second deployment).

Biological Assemblage and Physical Habitat

Fish and macroinvertebrate assemblage samples will be collected as listed in Tables 2 and 3. Qualitative Habitat Evaluation Index (QHEI) scores will be calculated by evaluating habitat at all fish sampling locations.

Fish Tissue

Fish tissue samples will be collected from five potential locations as part of the Ohio Fish Tissue Consumption Monitoring Program. Sampling locations may vary based on the availability of sport fish collected at each location. Fillet samples of edible-size sport fish will be tested for organochlorinated pesticides, PCBs, mercury, lead, cadmium, arsenic, and selenium. Results will be used in the Ohio Sport Fish Consumption Advisory Program.

QUALITY ASSURANCE/SAMPLING METHODS

Ohio EPA Manuals

All biological, chemical, data processing, and data analysis methods and procedures adhere to those specified in the Surface Water Field Sampling Manual for water column chemistry, bacteria and flows (Ohio EPA 2015a), Biological Criteria for the Protection of Aquatic Life, Volumes II - III (Ohio EPA 1987, 1989a, 2015b), 2015 Updates to the Biological Criteria for the Protection of Aquatic Life, Volume II (Ohio EPA 2015c), The Qualitative Habitat Evaluation Index (QHEI) - Rationale, Methods, and Application (Ohio EPA 1989b, 2006) for habitat assessment, Surface Water Field Sampling Manual – Appendix III for sediment sampling (Ohio EPA 2015a), and Ohio EPA Fish Tissue Collection Guidance Manual (Ohio EPA 2012) for fish tissue sampling.

Use Attainment

The attainment status of aquatic life uses will be determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. Numerical biological criteria are based on multi-metric

biological indices including the Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb), indices measuring the response of the fish community; and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes et al. 1986, Omernik 1987). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is full if all three indices (or those available) meet the applicable criteria; partial if at least one of the indices did not attain, and performance did not fall below the fair category; and non if all indices either fail to attain or any index indicates poor or very poor performance. The results will be compared to WWH biocriteria for the Western Allegheny Plateau (WAP), Interior Plateau (IP), and Eastern Corn Belt Plains ecoregions.

Recreational use attainment will be determined using *E. coli* bacteria, which are indicator organisms for the potential presence of pathogens in surface water. *E. coli* can originate from untreated human or animal wastes, and they are the basis for recreational use water quality criteria in Rule 3745-1-07 of the OAC.

Stream Habitat Evaluation

Physical habitat is evaluated using the (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Ohio EPA 1989b). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable and diverse aquatic faunas. Evaluations of the type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to evaluate the characteristics of a stream segment. Individual sites may have much poorer physical habitat due to a localized disturbance, yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values higher than 60 were generally conducive to the establishment of warmwater faunas while those which scored in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

Biological Community Assessment

Quantitative macroinvertebrate sample will be collected from artificial substrates, and qualitative samples from natural stream habitats. Artificial substrate collections will be collected at all sites with greater than 20 mi^2 drainage areas, or at reference site locations. This sample provides quantitative data and consists of a composite sample of five modified Hester-Dendy multiple-plate artificial substrate samplers which are allowed to colonize for six weeks. Qualitative sampling will be conducted at all sampling locations. This sampling effort consists of an inventory of all observed macroinvertebrate taxa from the natural stream habitats at each site with no attempt to quantify populations, other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, and margin). Detailed macroinvertebrate assemblage sampling protocols are documented in Ohio EPA (2015b).

Fish will be sampled at each sampling location using pulsed DC headwater, wading, or boat electrofishing methods depending on watershed size at each sampling location. Sites with drainage areas greater than 20 mi^2, and at reference site locations, will be sampled twice during the sampling index period. Fish are processed in the field, which includes identifying each individual to species, counting individuals at all sites, weighing individuals at wading and boat sites, and recording any external abnormalities. Detailed fish assemblage sampling protocols are documented in Ohio EPA (2015b).

Sediment

Fine-grained multi-incremental sediment samples will be collected in the upper 4 inches of bottom material using either decontaminated stainless steel scoops or Ekman dredges. Collected sediment will be placed into appropriate containers, placed on ice (to maintain 4°C) and shipped to the Ohio EPA Division of Environmental Services (DES) lab. Sampling and decontamination protocols will follow those listed in Ohio EPA (2015a Appendix III).

Chlorophyll

Benthic and sestonic chlorophyll-*a* samples will be collected and preserved using appropriate methods, as outlined in Ohio EPA (2015a Volume II), and delivered to the Ohio EPA DES lab for analysis. Alkalinity must be requested as a routine water quality parameter at all study sites along with the routine field parameters, especially temperature and pH.

Surface Water Chemistry

Surface water grab samples will be collected and preserved using appropriate methods, as outlined in Ohio EPA (2015a), and delivered to the Ohio EPA Division of Environmental Services lab for analyses. Field measurements of dissolved oxygen, pH, temperature, and conductivity will be made using multiparameter field meters along with all grab samples for surface water chemistry. Datasonde® continuous recorders will be placed at select locations to evaluate diel measurements of dissolved oxygen, pH, temperature, and conductivity.

Bacteria

Water samples will be collected into appropriate containers, cooled to 4°C, and transported to Pace Analytical Services in Englewood, Ohio within 6 hours of sample collection. All samples will be analyzed for *E. coli* bacteria using U.S.EPA approved methods (STORET Parameter Code 31648).

Fish Tissue

Tissue fillet samples will be collected from fish of edible size, and species preferred for analysis may include spotted bass, largemouth bass, smallmouth bass, flathead catfish, walleye, saugeye, white bass, common carp, freshwater drum, buffalo, and channel catfish. When possible, composite samples (by species) will be collected using a minimum of three fish and a minimum of 150 grams of material. At each sampling location, an attempt will be made to collect five fish species for fillet tissue analysis. Fish will be collected via electrofishing samplers. Sampling locations are listed in Tables 2 and 3. Fish used for tissue analysis will be filleted in the field using decontaminated stainless steel fillet knives. Filleted samples will be wrapped in aluminum foil, placed in a sealed plastic bag, and placed on wet or dry ice. Sampling and decontamination protocols will follow those listed in the *Ohio EPA Fish Collection Guidance Manual* (2012). Fish tissue samples will be stored in chest freezers at the Ohio EPA Groveport Field Facility prior to delivery to DES.

Field Quality Control Samples

Ten percent of the sediment, water, and bacteria samples will be submitted to the lab as field duplicates and field blanks; approximately 5% will be duplicates and 5 % will be blanks. One sonde recorder site will have two instruments placed in the river as field duplicates. Field blanks will occur at a minimum of 5 percent of the water samples. Field instruments will be calibrated daily, using manufacturer guidelines and requirements noted in Ohio EPA (2015a). Matrix spike duplicates will be collected for organic water samples at a minimum of 5 percent of the samples.

Lake Sampling

Turkey Creek Lake

Location and Description

Turkey Creek Lake is the largest (50 acres) of five small impoundments built by the Civilian Conservation Corps (CCC) during the 1930's to serve as water supplies for the six CCC camps working in Shawnee State Forest in Scioto County (http://forestry.ohiodnr.gov/shawnee#tabc3a). This section of Turkey Creek headwaters feeding Turkey Creek Lake is approximately 98 percent forested and drains 8.7 mi^2. Presently, it is used for small boat recreation in Shawnee State Park (electric, paddle and pedal) and has a swimming beach. Turkey Creek Lake is no longer used as a drinking water supply.

Sampling Locations

A total of five sampling events per season will occur approximately once per month from May through September in 2016 and 2017. Grab samples for chemical analysis will be collected at 0.5 m below the surface and 0.5 m above the bottom at the deepest area of the lake, marked as L-1 in Figure 1 below. Because sediment sampling has not occurred within 10 years, samples will also be collected at L-1.

Figure 1. Turkey Creek Lake with the sampling location noted as L-1.

Monitoring and Sampling

During each month, field meter measurements for temperature, dissolved oxygen, pH and conductivity will be done in the water column at the L-1 location at roughly 0.5-meter depth intervals. A continuous log of temperature throughout the water column will be performed to help identify the presence of thermal stratification.

Water samples will be collected each monitoring month of both years for nutrients, low-level total phosphorous, low-level orthophosphate, chemistry (turbidity, nitrite, total dissolved solids, etc.), nutrients, metals, and chlorophyll-*a*.

Because the Ohio Department of Natural Resources regularly collects bacteria samples at the swimming beach (see figure above), *E. coli* sampling will only be performed at the L-1 location during each month of the study period.

During May, July and September of each year, phytoplankton and zooplankton sampling will be collected and submitted for analysis. Sample collection for analysis of cyanotoxins and saxitoxin will also be performed during these three months each year.

Sediment samples will be collected for analysis of percent solids, total organic carbon, metals, base/neutral/acid extractible compounds, pesticides and polychlorinated biphenyls. If results are low or not detected, it may be determined that sediment sampling in 2017 is not necessary.

Lake Waynoka, Waynoka Upground Reservoir, and Sycamore Run Reservoir

Description

Lake Waynoka is a private gated community located approximately 5 miles south of the village of Sardinia in Brown County. It features an approximately 300-acre recreational lake created in 1970 by a Tennessee realty company who bought the farm land and obtained permission to dam the headwaters of Straight Creek. The lake has a drainage area of approximately 6.3 square miles.

In addition to the recreational lake, there are two waterbodies associated with the public water supply system serving the lake community that will be part of the study plan. Sycamore Run Reservoir is an approximately 11 acre impoundment of Sycamore Run Creek and has a drainage area of approximately one square mile. Water from this reservoir is pumped to a man-made upground reservoir from which the water treatment plant withdraws water.

There is also a treated sanitary wastewater storage lagoon that discharges to Straight Creek downstream of the dam in coordination with controlled releases from the lake, but this lagoon is not part of this study plan.

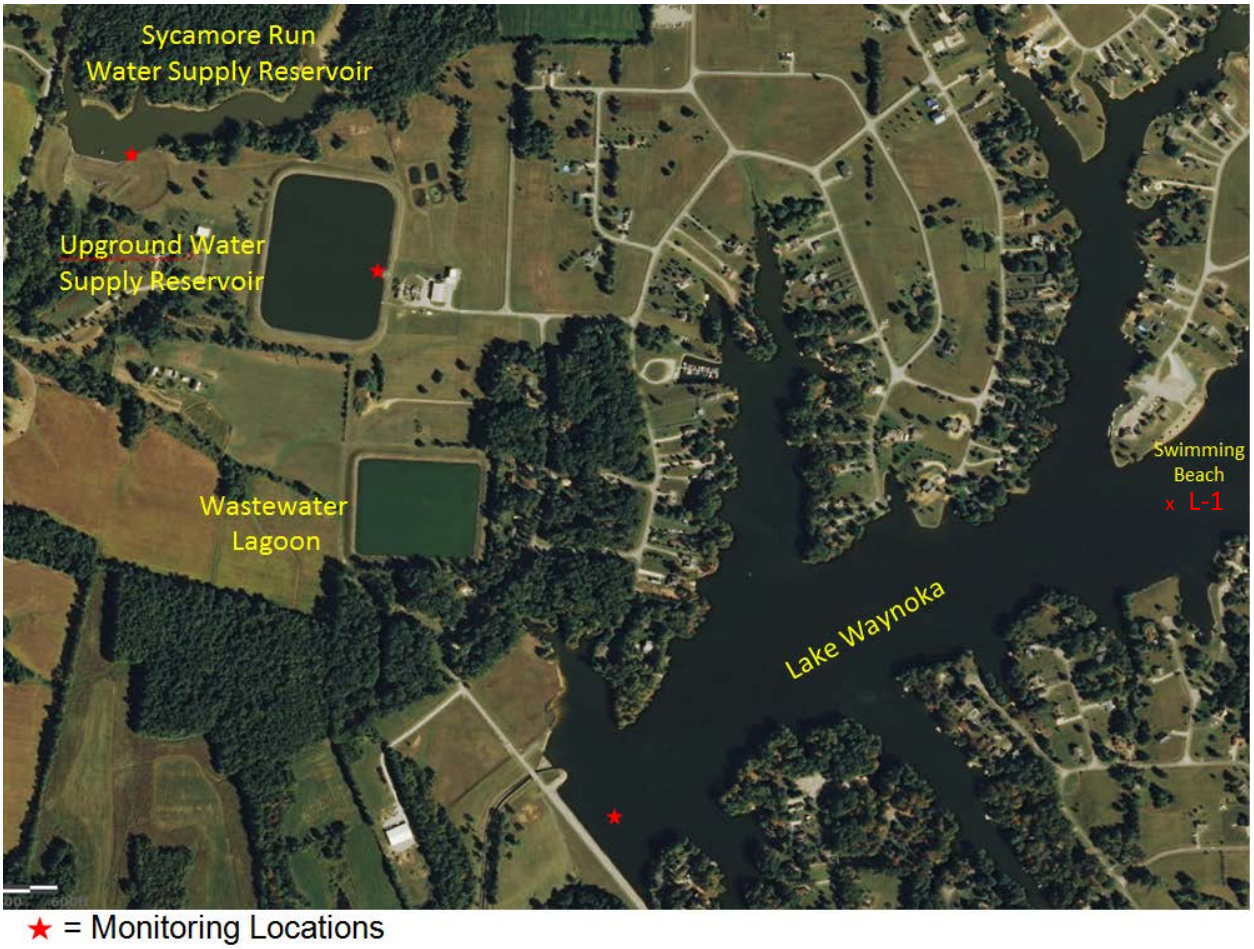

Figure 2. Location of waterbodies and monitoring locations at Lake Waynoka.

Sampling Plan

A total of ten sampling events at each of the three waterbodies identified by this plan will be sampled five times approximately once per month from May through September over two field seasons (2015 & 2016). The following monitoring will occur at each waterbody:

Lake Waynoka - During each monitoring month, grab samples for chemical analysis will be collected at 0.5 meter below the surface and 0.5 meter above the bottom at the deepest area of the lake located near the dam. Water samples will be collected for nutrients, low-level total phosphorous, low-level orthophosphate, chemistry (turbidity, nitrite, total dissolved solids, total suspended solids, total volatile suspended solids, alkalinity, carbonate/bicarbonate, chloride, sulfate, metals, and chlorophyll-*a*.

In 2015, a sediment sample will be collected at the same location for analysis of percent solids, total organic carbon, metals, base/neutral/acid extractible compounds and pesticides. If results are low, it may be determined that sediment sampling in 2017 is not necessary.

During May, July and September of each year, phytoplankton and zooplankton samples will be collected and submitted for analysis. Sample collection for analysis of cyanotoxin and saxitoxin will also be performed during these three months each year.

During each monitoring month, measurements for temperature, dissolved oxygen, pH and conductivity will be collected in the water column at the location of chemistry grab samples at 0.5-meter depth intervals. A continuous log of temperature throughout the water column will be performed to identify the presence of thermal stratification.

Because Lake Waynoka is a recreational lake with a swimming beach, *E. coli* samples will be collected from the water surface at the water chemistry location and at the perimeter of the swimming area.

Upground Water Supply Reservoir - Because access out onto the water is not practicable, a water sample will be collected near the intake structure using a tube sampler extended as far as possible from the shore. Instead of using a churn splitter, the contents of the tube sampler will be mixed by inverting it twice and then immediately dispensing into sample containers.

During each monitoring month, samples will be collected for nutrients, cyanotoxin, saxitoxin, and atrazine. During May, July and September of each year, phytoplankton samples will also be collected and submitted for analysis.

Sycamore Run Water Supply Reservoir - Because access out onto the water is not practicable, a water sample will be collected between the dam and the intake structure using a tube sampler extended as far as possible from the shore. Instead of using a churn splitter, the contents of the tube sampler will be mixed by inverting it twice and then immediately dispensing into sample containers.

During each monitoring month, samples will be collected for nutrients, cyanotoxin, saxitoxin, and atrazine. During May, July and September of each year, phytoplankton samples will also be collected and submitted for analysis.

In 2016, a sample will be collected 0.5 meters from the bottom of the reservoir using a Van Dorn sampler deployed from the end of the intake structure for molecular identification of toxin-forming bacteria residue using the qualitative polymerase chain reaction(qPCR) method. If a means for getting out onto the water can be found, an alternate location and collection method may be selected.

Monitoring and Sampling

Except where described, all field practices will follow guidelines in the 2015 *Surface Water Field Sampling Manual* and *Inland Lakes Sampling Procedure Manual*. Data will be used to assess use designations previewed in the *Ohio 2012 Integrated Water Quality Monitoring and Assessment Report*. The uses, criteria and assessment methods described in the report are considered draft until they are adopted into the Ohio Water Quality Standards. The strategy of the report generally focuses on water quality conditions in the epilimnion of lakes, although the entire water column is examined when the lake is un-stratified.

Field Quality Control Samples

Five percent of the water samples will be submitted to the lab as field duplicates. Field blanks will occur at a minimum of 5 percent of the water samples. Field instruments will be calibrated daily, using manufacturer guidelines and requirements noted in the “Surface Water Field Sampling Manual, 2015” (Ohio EPA). Matrix spike duplicates will be collected for organic water samples at a minimum of 5 percent.

Field Staff and Other Contacts

Ohio EPA

DSW Central Office

EAS

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Modeling

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Standards

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DSW Southwest District Office

Laura Marshall: (937) 285-6031-Water Quality
Joshua "Joby" Jackson: (937) 285-6029 (Supervisor)

Contact Ben Rich regarding study plan.

Hospitals

(see attached maps)

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Southwest Regional Medical Center
425 Home Street
Georgetown, OH 45121
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Fax: 937-378-7808
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Ohio DNR

District 5:
1076 Old Springfield Pike
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Wildlife Officers

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***Brown**: Eric Lamb*
(937) 372-5639x5220

***Scioto:** Hollie Fluharty*
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County Sheriffs

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Scioto County
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Table 1. Active NPDES facilities in the study area and receiving waters.

OEPA Permit Number	Facility Name	Design Discharge (MGD)[2]	Wastewater Type, Treatment System, Cont. or Batch Discharge	Stream & RM at Discharge	County
050902010201	Headwaters Turkey Creek				
0PP00029	ODNR - Shawnee State Park Lodge & Cabins	0.04	Extended aeration package plant	Turkey Creek (11.83)	Scioto
0PP00035	Shawnee State Park Campground WWTP	0.025	Extended aeration package plant	Turkey Creek (10.28)	Scioto
050902010601	Crooked Creek-Ohio River				
0IB00022	Dayton Power & Light Co Killen Electric Generating	15	Sediment ponds with neutralization, aerobic digestion package plant, carbon adsorption groundwater treatment system	Ohio River (389.40)	Adams
0IY00002	Adams County Water Co Inc.		Sand filters to treat backwash from iron/manganese removal system, Batch	Ohio River (589.28)	Adams
0PB00024	Manchester WWTP	0.3	activated sludge/contact stabilization	Ohio River (583.71)	Adams
050902010605	- Lawrence Creek-Ohio River				
0IB00049	DP&L JM Stuart Generating Station	20.8	Bottom Ash and Fly Ash Disposal settling ponds, rapid sand filtration, coagulation and neutralization, extended aeration	Buzzards Roost Creek Little, Threemile Creek and Ohio River (576.37)	Adams
1PB00100	Aberdeen WWTP	0.385	Activated sludge, extended aeration	Ohio River (572.57)	Brown
050902010701	Headwaters West Fork Eagle Creek				

OEPA Permit Number	Facility Name	Design Discharge (MGD)[2]	Wastewater Type, Treatment System, Cont. or Batch Discharge	Stream & RM at Discharge	County
1PA00104	Russellville WWTP		Controlled Discharge	Honey Creek (0.82)	Brown
050902010801	Redoak Creek				
1PB00103	Ripley STP	0.4	Oxidation ditch	Ohio River (564.3)	Brown
050902010802	Headwaters Straight Creek				
1PS00013	Waynoka Regional W & SD		Oxidation ditch with clarification, Controlled Discharge	Straight Creek (18.45)	Brown
050902010804	- Lee Creek-Ohio River				
1IN00293	US Shoe Site aka former US Shoe Facility	0.072	Industrial	Ohio River (565.1)	Brown
0509020101003	Big Run-Whiteoak Creek				
1PB00101	Georgetown WWTP	1.1	Aerobic digestion, polymer addition, volute dewatering process	Town Run (6.95)	Brown

Proposed Sampling Locations

Table 2. Summary of the 2016 Southwest Ohio River tributaries survey.

Code	Sample Type	Count
F	Fish - 1 Pass	30
F2	Fish - 2 Pass	10
T	Fish Tissue	5
MQ	Macro - Quantitative	10
Mq	Macro - Qualitative	30
C	Chemistry	46
N	Chemistry w/ nutrients	19
Sn	Sentinel	5
Sd	Sediment	5
B	Bacteria	20
D	Datasonde®	19

Table 3. Sampling locations for the 2016 Southwest Ohio River tributaries survey. Map # corresponds to sampling locations in Figure 3.

Map #	River Code	RM	Station ID	Location	Latitude	Longitude	HUC12	Drain.	Sampling
1	10-508-000	10.70	303609	Turkey Creek Dst. Turkey Creek Lake	38.731854	-83.189219	50902010201	8.72	F, Mq, C, N, D, B
2	10-508-000	12.90	303610	Turkey Creek Dst. Wolfden Run, Adj. SR 125	38.749415	-83.220097	50902010201	1.58	F, Mq, C
3	10-508-000	9.58	X04P03	Turkey Creek Dst. Roosevelt Lake @ Mackletree Rd	38.725147	-83.173966	50902010202	16.50	F, Mq, C, N, D
4	10-508-000	4.10	X04P02	Turkey Creek at Friendship dst. US 52	38.696178	-83.099324	50902010202	39.00	F2, MQ, C, Sn, N, D, O, Sd, B

Map #	River Code	RM	Station ID	Location	Latitude	Longitude	HUC12	Drain.	Sampling
5	10-508-000	6.70	200744	Turkey Creek Upst. Pond Lick Run @ SR 125	38.708600	-83.135000	50902010202	26.40	F2, MQ, C
6	10-099-000	4.64	303613	Pond Run off SF Rd 1 (Pond Run Rd.) at backpack trail	38.662341	-83.197250	50902010203	3.19	F, Mq, C
7	10-099-000	0.38	303602	Pond Run @ US 52	38.660088	-83.129213	50902010203	11.35	F, Mq, C, N, D, B
8	10-507-000	0.43	303601	Nace Run @ Shawnee SP Marina dst dam	38.676773	-83.113329	50902010204	1.45	F, Mq, C, B
9	10-089-000	0.10	303597	E Fk Upper Twin Cr @ Upper Twin Creek-Rocky Rd (C-96)	38.660109	-83.225298	50902010205	3.89	F, Mq, C
10	10-085-000	2.60	X04P01	Upper Twin Ck @ US 52 At McGaw	38.638056	-83.224777	50902010205	12.80	F, Mq, C, Sn, N, D, O, Sd, B
11	10-082-000	5.20	3003600	Lower Twin Creek (RM 5.2) Adj. Lower Twin Creek Rd.	38.678669	-83.310233	50902010206	6.10	F, Mq, C
12	10-082-000	1.65	X99Q02	Lower Twin Creek Adj. Upper Twin Creek-Rocky Fork Rd.	38.642564	-83.272146	50902010206	15.10	F, Mq, C, Sn, N, D, O, Sd, B
13	10-096-000	0.66	303603	McAtee Run @ US 52	38.628184	-83.159422	50902010207	1.59	F, Mq, C, B
14	10-081-000	1.80	303604	Rock Run in Shawnee S.F. Off Tram Rd.	38.629135	-83.278377	50902010207	0.78	F, Mq, C
15	10-069-000	0.10	303605	Russell Fk @ Point Cemetery Rd	38.674202	-83.382597	50902010209	5.10	F, Mq, C
16	10-067-000	1.40	200741	Stout Run N of Rome,, Adj. Blue Creek Rd., Dst. Russell Fork	38.691775	-83.379309	50902010209	12.90	F, Mq, C, N, D, B
17	10-075-000	1.23	303599	Long Lick Run @ Ford Dst. Owl Hollow	38.667041	-83.346994	50902010210	2.80	F, Mq, C
18	10-077-000	0.35	303608	Sulphur Creek @ Sulphur Cr Rd.	38.639349	-83.323008	50902010210	2.40	F, Mq, C, B

Map #	River Code	RM	Station ID	Location	Latitude	Longitude	HUC12	Drain.	Sampling
19	10-060-000	0.45	303595	Donaldson Creek @ US 52	38.707650	-83.520090	50902010601	2.80	F, Mq, C
20	10-056-000	1.43	303612	Isaacs Creek @ Broadway St., Manchester	38.691877	-83.614455	50902010601	4.90	F, Mq, C, B
21	10-057-000	1.10	303598	Island Creek @ Island Creek Rd.	38.702200	-83.582200	50902010601	6.80	F, Mq, C
22	10-049-000	1.70	X03W13	Fishing Gut Ck Nr Old SR 249 E of Aberdeen	38.659738	-83.746875	50902010605	1.90	F, Mq, C
23	10-050-000	1.30	X99Q01	Little Threemile Creek E Of Maysville @ US 52	38.642057	-83.685438	50902010605	4.70	F, Mq, C, B
24	10-120-002	0.10	X99Q04	Honey Creek E of Russellville @ Mouth (Trib to NW Fk @ RM 2.32)	38.871598	-83.768439	50902010701	0.90	F, Mq, C
25	10-120-001	1.80	X03W07	Northwest Fk (Trib to W Fk Eagle Ck (7.05)) at Russellville-Winchester Rd	38.865870	-83.759923	50902010701	7.20	F, Mq, C, N, D
26	10-120-002	0.72	303606	Russellville WWTP outfall to Honey Creek	38.870700	-83.779900	50902010701	--	*C,B*
27	10-110-000	10.95	303607	E Fk Eagle Ck S of W Union @ Farm Ford	38.777330	-83.580486	50902010702	9.87	F, Mq, C
28	10-110-000	7.90	X03S03	E Fk Eagle Ck W of West Union @ Twp Rd. 231	38.780300	-83.613600	50902010702	15.10	F, Mq, C, N, D, B
29	10-110-002	0.10	303611	Trib to E Fk Eagle Cr @ RM 6.92 Adj Eagle Cr Rd. @ driveway	38.778832	-83.626439	50902010702	5.10	F, Mq, C
30	10-110-000	0.82	X03W04	E Fk Eagle Ck @ End of East Fork Rd	38.784772	-83.698020	50902010703	48.00	F2, T, MQ, C, N, D
31	10-110-000	4.30	200691	E. Fk. Eagle Creek S of Fairview @ Brier Ridge Rd.	38.795500	-83.653900	50902010703	36.00	F2, MQ, C

Map #	River Code	RM	Station ID	Location	Latitude	Longitude	HUC12	Drain.	Sampling
32	10-120-000	7.38	X03W05	W Fk Eagle Ck @ SR 125 SW of Russellville	38.852880	-83.748375	50902010704	28.00	F2, MQ, C, N, D
33	10-120-000	3.30	200693	W. Fk. Eagle Creek SW of Decatur Upst. SR 353	38.813300	-83.740600	50902010704	54.00	F2, T, MQ, C, N, D, B
34	10-113-000	0.70	302949	Adas Run Dst SR 125	38.806963	-83.665453	50902010705	3.30	*Chemistry only*
35	10-100-000	14.43	303537	Eagle Cr Dst Confl. W Fk and E Fk Eagle Cr	38.786345	-83.713091	50902010705	108.00	F2, T, MQ, C, Sn, N, D, O, Sd, B
36	10-100-000	6.20	200689	Eagle Creek E of Ripley @North Pole Rd. (covered Bridge)	38.750064	-83.773079	50902010705	129.00	F2, T, MQ, C, N, D
37	10-117-000	0.30	302954	Hannah Run @ McClanahan Rd. (T-110)	38.788066	-83.602033	50902010705	2.10	*Chemistry only*
38	10-115-000	0.95	302952	Lick Run @ Old Cincinnati Pike (Rd 21)	38.806421	-83.623173	50902010705	0.70	*Chemistry only*
39	10-300-000	16.75	X03W09	Straight Creek at Arnheim @ Brownstown-Arnheim Rd.	38.931900	-83.829200	50902010802	12.50	F, Mq, C, N, D
40	10-300-000	9.45	X03W11	Straight Creek WSW of Russellville @ Day Hill Arnheim Rd (old SR 125)	38.856100	-83.850000	50902010802	34.00	F2, MQ, C, N, D, B
41	10-316-000	0.05	302968	Sycamore Run Nr. Fite-Hauck Rd. and Ash Ridge Arnheim Rd.	38.930639	-83.813406	50902010802	1.60	F, C
42	10-314-000	1.25	302966	W Fk Straight Cr @ W Fk Rd.	38.911198	-83.858616	50902010802	4.30	*Chemistry only*
43	10-300-000	2.78	X03W12	Straight Creek at Centerpoint @ Old US 68	38.798600	-83.888900	50902010803	57.00	F2, T, MQ, C, Sn, N, D, O, Sd, B
44	10-407-000	0.80	X02S03	Georgetown WWTP outfall to Town Run	38.852200	-83.910300	50902011003	--	C, B

Map #	River Code	RM	Station ID	Location	Latitude	Longitude	HUC12	Drain.	Sampling
45	10-407-000	0.63	X02W04	Town Run Dst Georgetown WWTP	38.851400	-83.912500	50902011003	1.40	F, Mq, C, N, D, B
46	10-407-000	0.81	X02S05	Town Run Just Upst. Georgetown WWTP	38.852200	-83.910000	50902011003	1.40	F, Mq, C, N, D, B

Code	Sample Type	Code	Sample Type	Code	Sample Type	Code	Sample Type	Code	Sample Type
F	Fish - 1 Pass	MQ	Macro - Quantitative	N	Chemistry w/ nutrients	Sd	Sediment		
F2	Fish - 2 Pass	Mq	Macro - Qualitative	Sn	Sentinel	B	Bacteria		
T	Fish Tissue	C	Chemistry	R	Reference	D	Datasonde®		

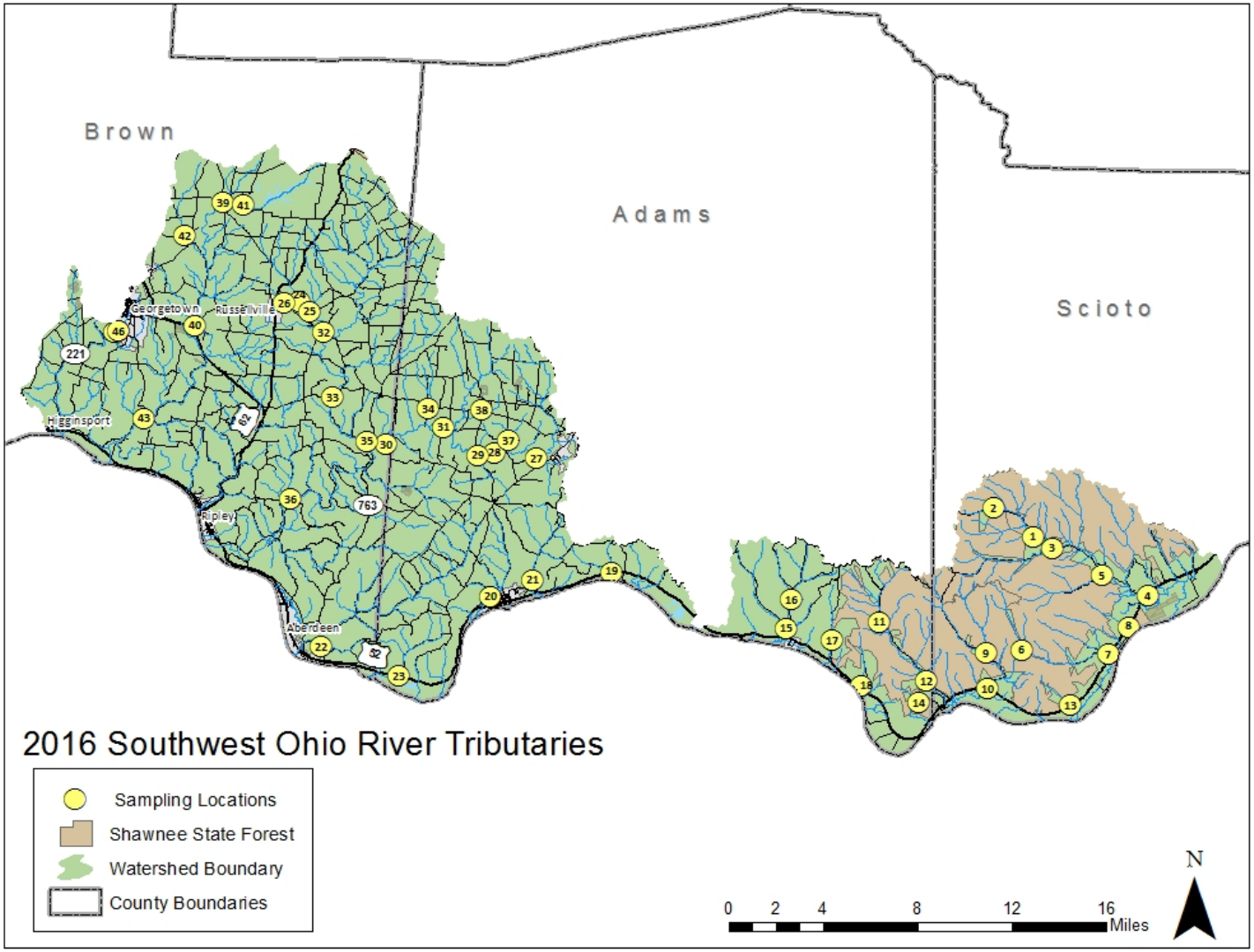

Figure 3. Sampling locations in the SWORT study area, 2016. Numbers on sampling locations correspond to those listed in Table 3.

Table 4. List of chemical and water quality parameters to be analyzed/measured in surface water, sediment, and fish tissue samples from the SWORT basin sampling locations. The method detection limit or an "X" is placed in the column where samples will be collected. Not all sites will be sampled for all parameters.

Parameter	Method	Stream	Lake	Sediment	Fish Tissue
Oxygen Demand					
BOD, 5-day	SM 5210B	2 mg/L			
cBOD, 20-day	OEPA 310.2	2 mg/L			
Chemical Oxygen Demand	SM 5220D	20 mg/L			
Physical Properties					
Alkalinity	USEPA 310.1	5 mg/L	5 mg/L		
Hardness	USEPA 200.7	10 mg/L	10 mg/L		
Specific Conductance	Field Meter / SM 2510B	X/1 µS/cm	X/1 µS/cm		
Total Dissolved Solids	SM 2540C	10 mg/L	10 mg/L		
Total Suspended Solids	SM 2540D	5 mg/L	5 mg/L		
Volatile Suspended Solids	SM 2540 D/E		5 mg/L		
Turbidity	OEPA 180.1	2 NTU	2 NTU		
% Solids	SM 2540G			0 %	
% Lipids	OEPA 581.5				0 %
pH	Field Meter	X	X	X	
Dissolved Oxygen (mg/L and % sat)	Field Meter	X	X		
Temperature	Field Meter	X	X		
Nutrients					
Ammonia	USEPA 350.1	0.05 mg/L	0.05 mg/L	X	
Nitrate-Nitrite	USEPA 350.1	0.5 mg/L	0.5 mg/L		
Nitrite	USEPA 353.2	0.02 mg/L	0.02 mg/L		
Total Kjeldahl Nitrogen	USEPA 351.2	0.2 mg/L	0.2 mg/L		
Total Phosphorus	USEPA 365.4	0.01 mg/L	0.01 mg/L	50 mg/kg	
Orthophosphate	USEPA 365.4	0.01 mg/L	0.01 mg/L		
Total Organic Carbon	SM 5310B	2 mg/L	2 mg/L	0.1 %	X
Anions					
Carbonate/Bicarbonate	SM 2320B	5 mg/L	5 mg/L		
Chloride	USEPA 325.1	5 mg/L	5 mg/L		
Sulfate	USEPA 375.2	10 mg/L	10 mg/L		
Cations					
Aluminum	USEPA 200.7	200 µg/L	200 µg/L	X	
Barium	USEPA 200.7	15 µg/L	15 µg/L	X	
Calcium	USEPA 200.7	2 mg/L	2 mg/L	X	
Iron	USEPA 200.7	50 µg/L	50 µg/L	X	
Magnesium	USEPA 200.7	1 mg/L	1 mg/L	X	
Manganese	USEPA 200.7	10 µg/L	10 µg/L	X	
Potassium	USEPA 200.7	2 mg/L	2 mg/L	X	
Sodium	USEPA 200.7	5 mg/L	5 mg/L	X	
Strontium	USEPA 200.7	30 µg/L	30 µg/L	X	
Toxic Metals					
Zinc	USEPA 200.7	10 µg/L	10 µg/L	8 mg/kg	
Hardness	USEPA 200.7	10 mg/L	10 mg/L		

Table 4. Continued

Parameter	Method	Stream	Lake	Sediment	Fish Tissue
Arsenic	USEPA 200.8/SM 3113B	2 µg/L	2 µg/L	0.8 mg/kg	0.05 mg/kg
Cadmium	USEPA 200.8/SM 3113B	0.2 µg/L	0.2 µg/L	0.8 mg/kg	0.004 mg/kg
Chromium	USEPA 200.8	2 µg/L	2 µg/L	0.8 mg/kg	
Copper	USEPA 200.8	2 µg/L	2 µg/L	0.8 mg/kg	
Lead	USEPA 200.8/SM 3113B	2 µg/L	2 µg/L	0.8 mg/kg	0.04 mg/kg
Nickel	USEPA 200.8	2 µg/L	2 µg/L	0.8 mg/kg	
Selenium	USEPA 200.8/SM 3113B	2 µg/L	2 µg/L	0.8 mg/kg	0.05 mg/kg
Silver	USEPA 200.8			0.8 mg/kg	
Mercury	USEPA 245.1/SM 3113B			0.02 mg/kg	0.02 mg/kg
Bacteria					
Escherichia coli	USEPA 1603	2 CFU	2 CFU		
Algal Biomass/Toxins					
Chlorophyll-*a*	USEPA 445.0	0.3 µg/L	0.3 µg/L		
Microcystins	OEPA 701.0		0.3 µg/L		
Saxitoxin	OEPA 702.0		0.022 µg/L		
Cylindrospermopsin	OEPA 703.0		0.05 µg/L		
Organic Compounds					
Atrazine	OEPA 704.0		0.2 µg/L		
Glyphosate	USEPA 547	X			
Herbicides	USEPA 525.2	X	X		
Acid Herbicides	USEPA 515.1	X			
Semi-volatile organics	USEPA 8270C			.4-2 mg/kg	
PCBs/Pesticides/Chlordane	USEPA 8082A/OEPA 590.1/608	X		4 µg/kg	10 µg/kg

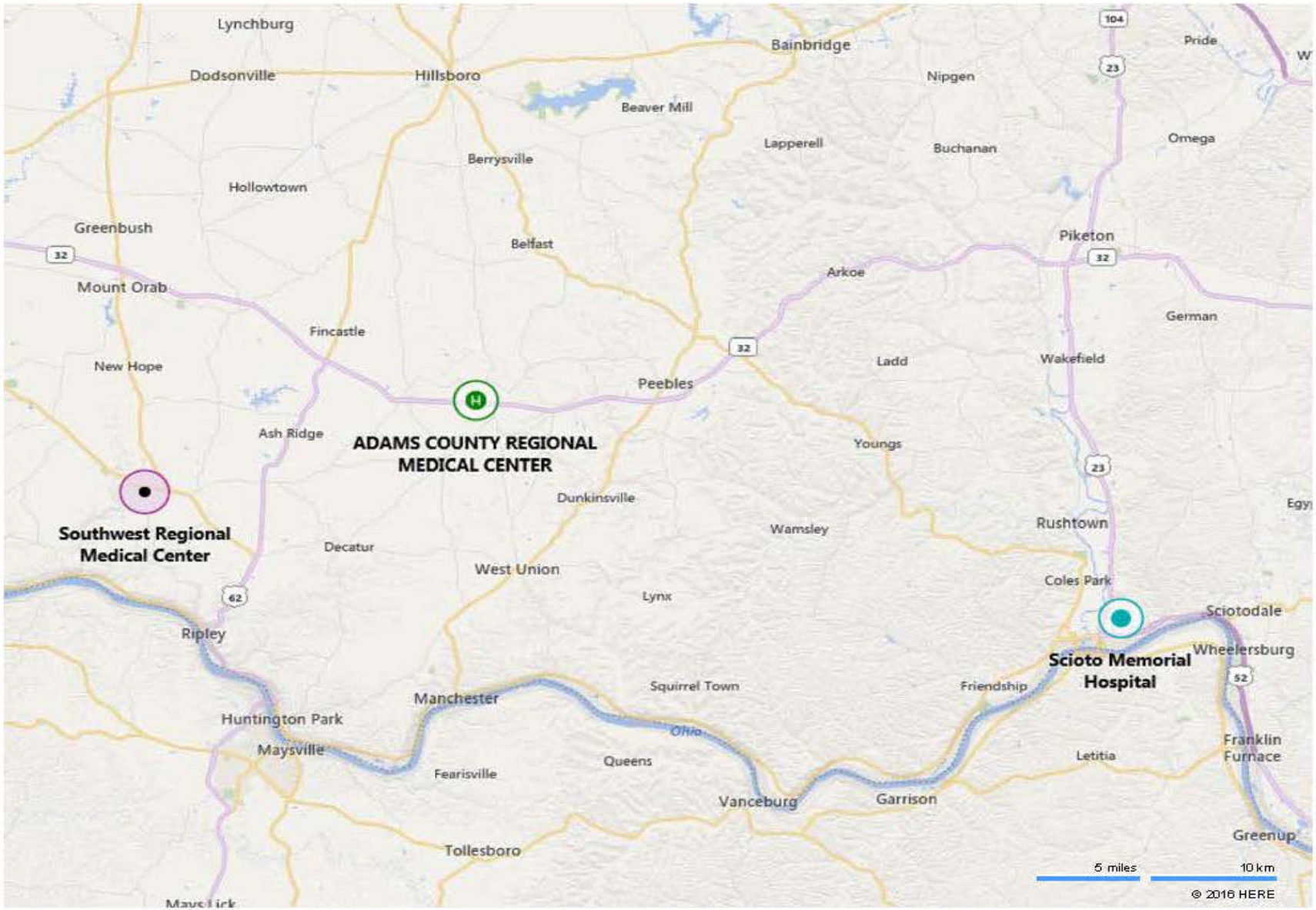

Figure 4. Overview map of medical center and hospital locations within the study area (Bing maps, 2016).

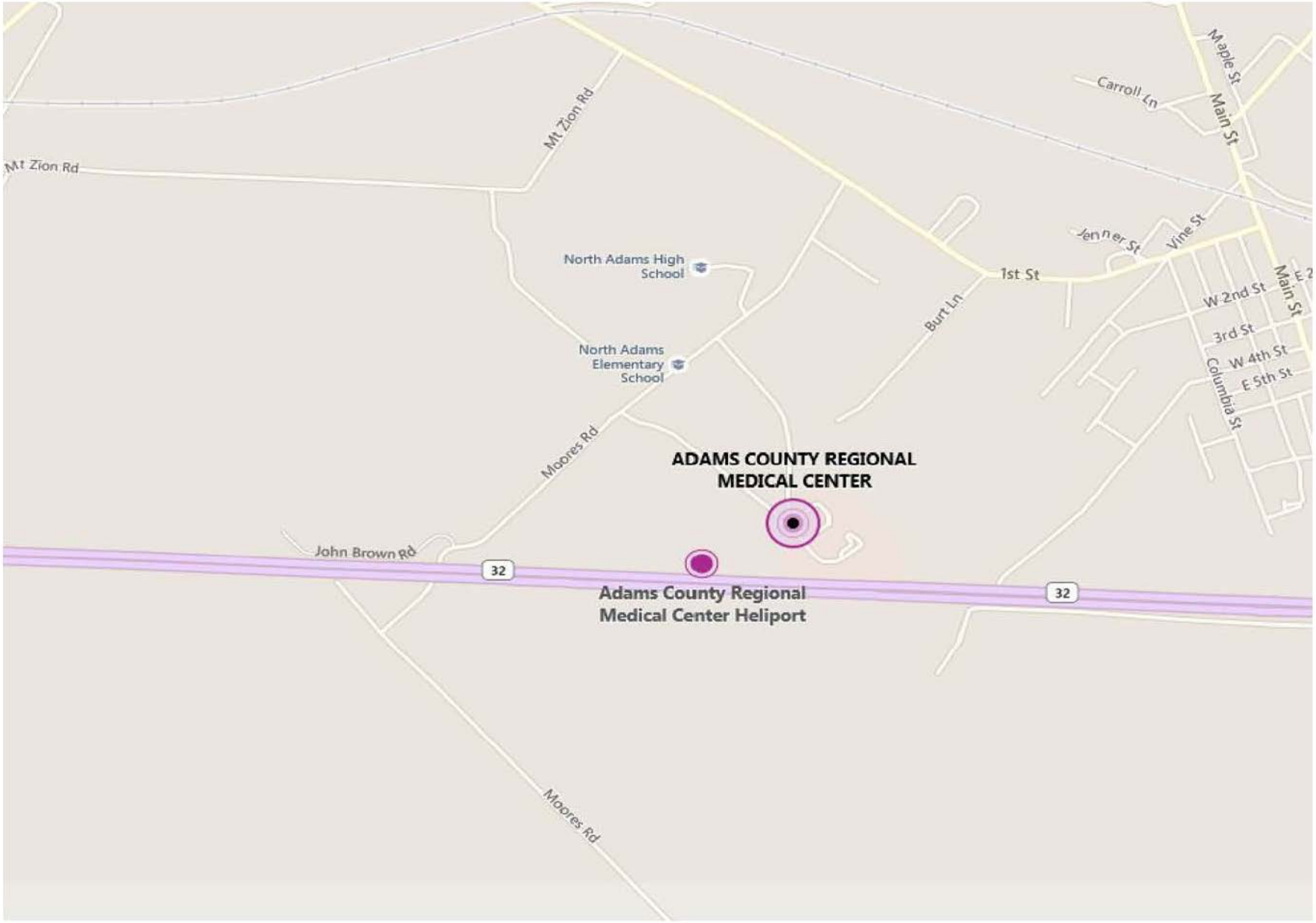

Figure 5. Adams County Regional Medical Center local roads map (Bing maps, 2016).

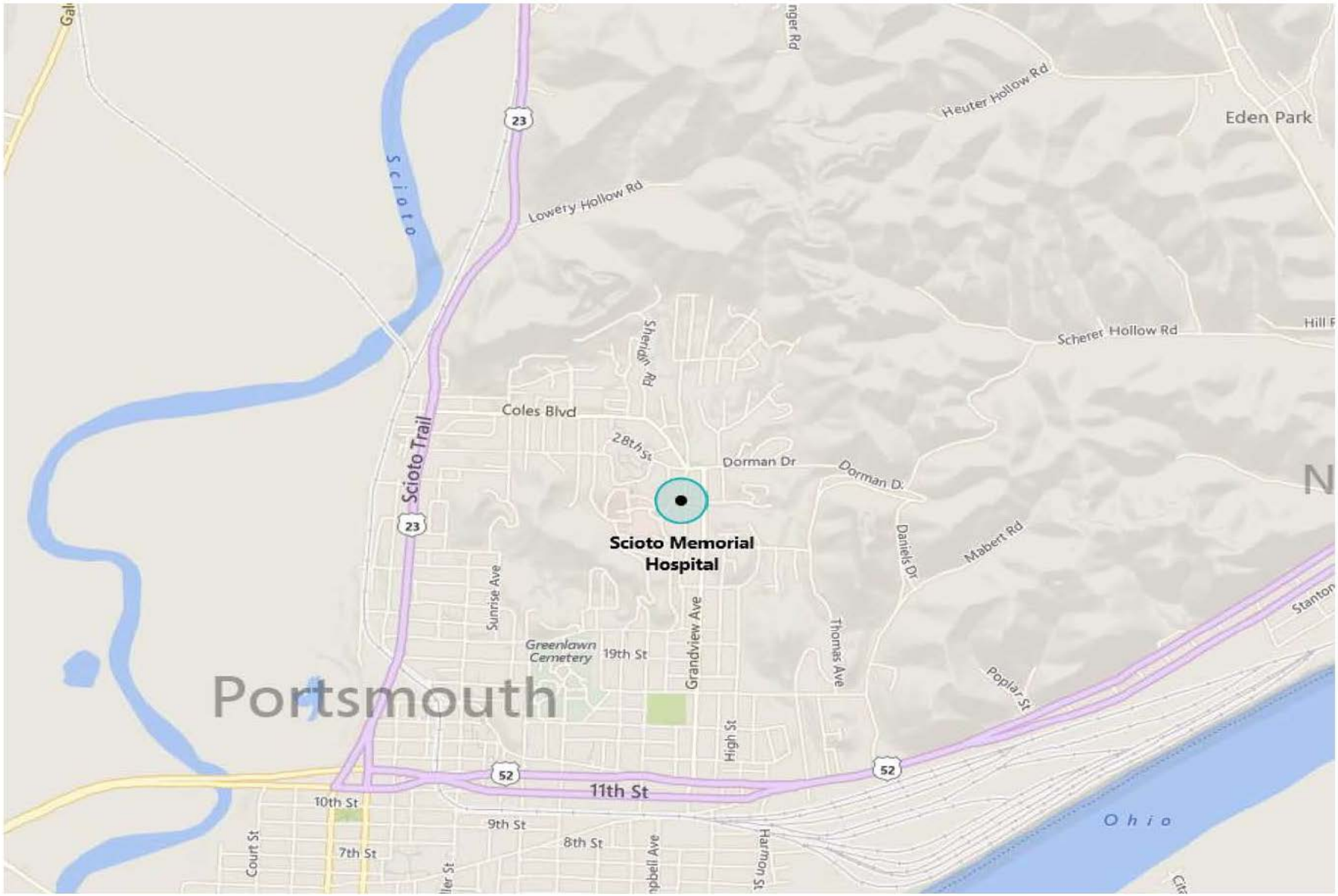

Figure 6. Scioto Memorial Hospital local roads map (Bing maps, 2016).

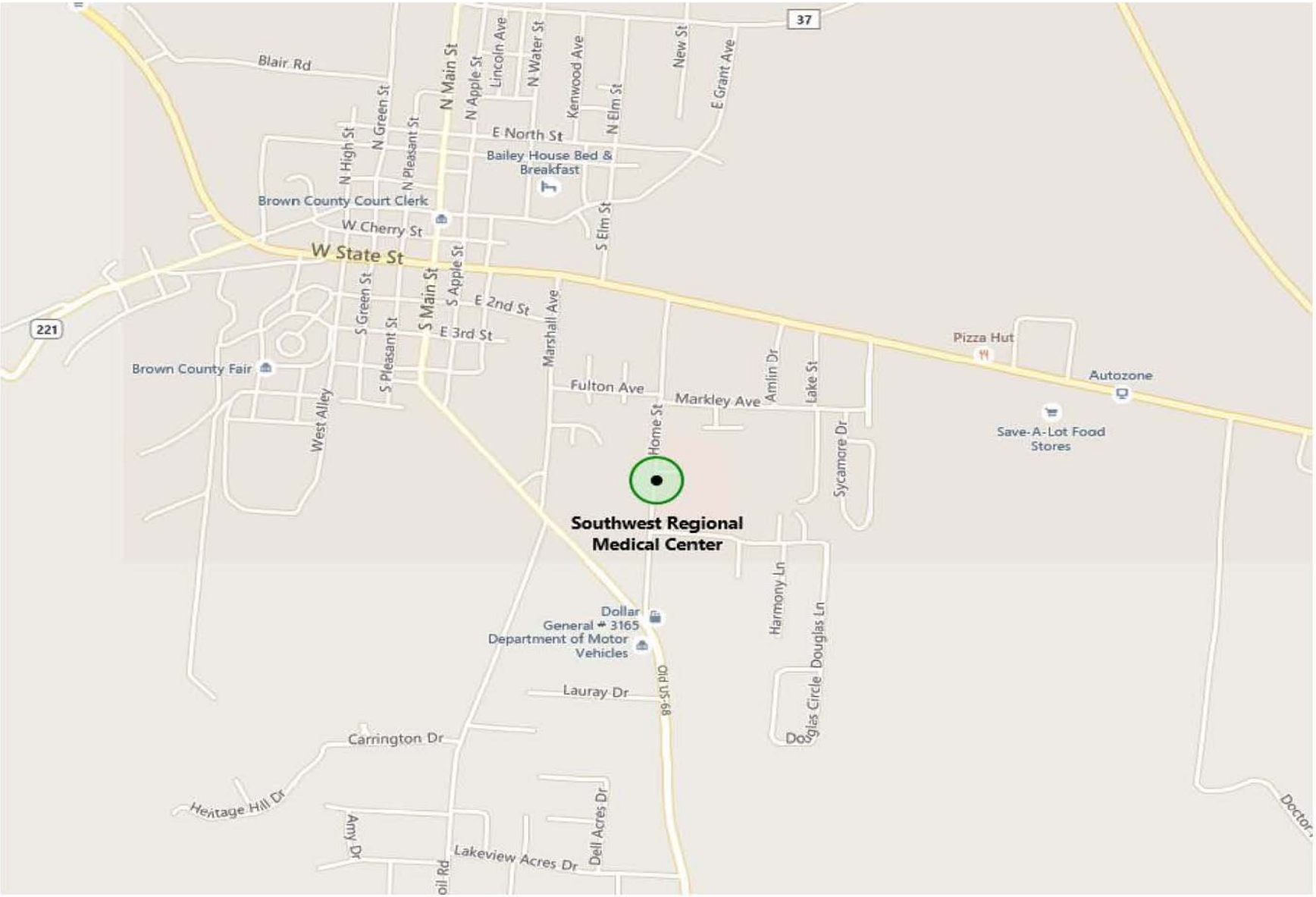

Figure 7. Southwest Regional Medical Center local roads map (Bing maps, 2016).

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