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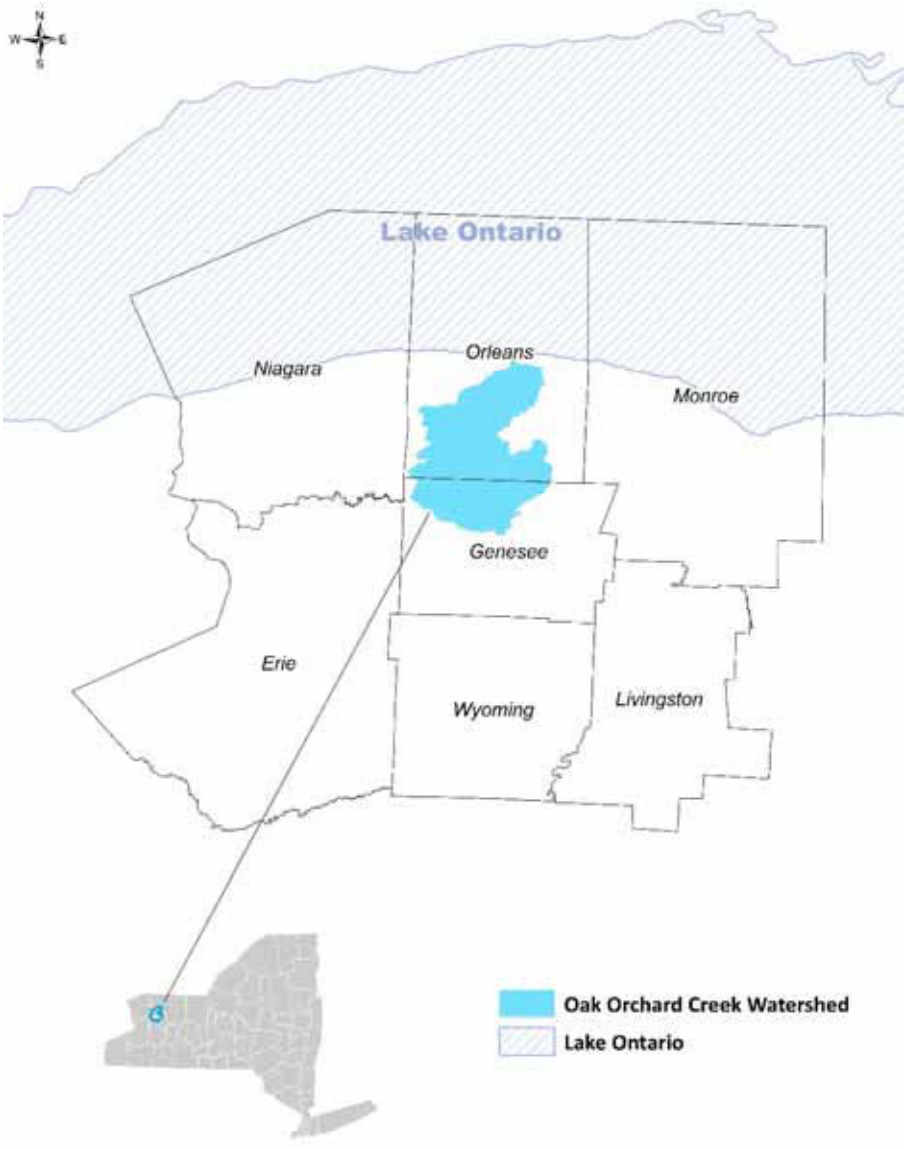
OAK ORCHARD CREEK

Biological Stream Assessment

July 1, 2017



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BIOLOGICAL STREAM ASSESSMENT

Oak Orchard Creek
Orleans and Genesee Counties, New York
Lake Ontario Drainage Basin

Survey date: July 28-29, 2015
Report date: July 1, 2017

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Stream: Oak Orchard Creek
River Basin: Lake Ontario
Reach: East Oakfield to Lake Ontario, NY

Background

The Stream Biomonitoring Unit (SBU) conducted a biological assessment of water quality at twelve locations in the Oak Orchard Creek watershed including six main-stem and six tributary sites, July 28-29, 2015. The survey was conducted to update water quality assessment information for the watershed in the NYSDEC's Waterbody Inventory Report, and provide biological and water chemical data for water quality modeling purposes in the watershed.

To characterize water quality and assess any impacts to aquatic life, benthic macroinvertebrate communities were collected via traveling kick samples from riffle areas at each of nine locations and modified Hester-Dendy Multiplates at three locations. Four replicate macroinvertebrate samples were collected from each location. Methods used are described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC, 2014) and summarized in the appendices of this document. The contents of each sample were field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of 100-specimen subsamples (kick samples) and 250-specimen subsamples (multiplate samples) from each site. Biological assessment of water quality was conducted through calculation of benthic macroinvertebrate community metrics including the Biological Assessment Profile (BAP) score. Expected variability in the results of benthic macroinvertebrate community samples is presented in Smith and Bode (2004).

Nutrient criteria were evaluated through collection of water column chemistry samples at each location on the same day as biological sampling. Samples were collected using a depth-integrated DH-81 water column sampler from ten equidistant points across a single stream width transect. Samples were shipped overnight to ALS Environmental, in Rochester, NY for analysis of a full nutrient suite of parameters including: ammonia, nitrate-nitrite, total kjeldahl nitrogen, orthophosphate, total phosphorus, chlorophyll-a, total suspended solids, and chloride.

Results and Conclusions

1. The results of the biological and water chemical survey of the Oak Orchard Creek watershed in 2015 suggest significant areas of water quality impairment. This includes both impacts on aquatic life, elevated concentrations of nutrients and dense algal growth.
2. Aquatic life is not supported at 6 of the twelve locations surveyed. This includes both main-stem Oak Orchard Creek locations as well as tributaries (Figure 2). Based on results of the Biological Assessment Profile (BAP) score the worst impacts to aquatic life exist in the upper portions of the watershed (Figure 1 and 2).
3. Phosphorus data at all sites surveyed suggest elevated levels ≥30µg/L TP. At many of these sites where phosphorus was elevated, BAP scores also indicated significant impacts to biological communities.
4. Like phosphorus, in the upper portions of the watershed, nitrate-nitrite concentrations were elevated to the extent they also have an impact on aquatic life.
5. Landuse inference and load estimates suggest the source of phosphorus in the watershed is primarily from agricultural based non-point source run-off. The exceptions were two upper watershed sub-basins in which specific point sources may be contributing factors.

Discussion

Oak Orchard Creek is an approximately 275 mi^2 watershed draining mostly agricultural land that enters Lake Ontario west of Rochester near Albion, New York. Prior to updates to the NYSDEC's Waterbody Inventory/Priority Waterbodies List in October of 2017, of the 12 individual segments in Oak Orchard Creek's watershed, 6 were listed as unassessed, 5 with minor impacts, and 1 impaired (Otter Creek, Segment Number 0301-0037). All segment listings as impacted or impaired were documented as the result of nutrients with general agricultural practices as the suspected source. Because of these documented water quality impacts, in 2015 the NYSDEC's Bureau of Water Resource Management (BWRM), in the Division of Water, requested the SBU conduct a water quality survey to: 1) update water quality assessment information for the watershed in the NYSDEC's Waterbody Inventory Report, 2) provide biological and water chemical data for water quality modeling purposes in the watershed, and 3) evaluate the implementation of proposed numeric nutrient criteria. BWRM staff were concerned with elevated nutrient concentrations throughout the watershed, the potential for excessive algal growth, and consequential impacts on recreation and aquatic life (Steven Gladding, NYSDEC BWRM, Personal Communication, June 2015). This report document's NYSDEC's efforts in fulfilling these project objectives and documenting the severity, extent, and potential sources of elevated nutrients in the watershed. The Waterbody Inventory/Priority Waterbodies List was updated to reflect the findings of this more recent survey of the Oak Orchard Creek watershed.

To characterize water quality and assess any impacts to aquatic life the SBU collected benthic macroinvertebrates at each of twelve locations in the Oak Orchard Creek watershed including six main-stem and six tributary sites, July 28-29, 2015 (Figure 1). Samples were collected using either a traveling kick sample from wadeable riffle areas at each of nine locations or modified Hester-Dendy Multiplates at three non-wadeable locations. Replicate macroinvertebrate samples (4/site) were collected to accurately assess natural variability in biological results for greater confidence in assessment conclusions (NYSDEC, 2014). 100-specimen subsamples (kick samples) and 250-specimen subsamples (multiplate samples) were processed from each site. Resulting macroinvertebrate community data were used to assess water quality through calculation of benthic macroinvertebrate community metrics including the Biological Assessment Profile (BAP) score. Stream substrate composition and physical habitat condition was estimated using a pebble count and habitat assessment form respectively, to provide indication of areas of potential geomorphological impacts to aquatic life. Water column chemistry samples were collected using a depth-integrated DH-81 water column sampler from ten equidistant points across a single stream width transect. These samples were then analyzed by ALS Environmental, in Rochester, NY for a full nutrient suite of parameters including: ammonia, nitrate-nitrite, total kjeldahl nitrogen, orthophosphate, total phosphorus, chlorophyll-a, total suspended solids, and chloride.

The results of the biological assessment survey suggest aquatic life is not fully supported (BAP $\leq$ 5.0) in many areas of Oak Orchard Creek. Of the twelve locations surveyed, 5 are moderately impacted, and 1 is severely impacted (Figures 1 and 3). In these locations water quality is not of sufficient quality for the propagation and survival of the natural communities of aquatic life expected in this type of stream. These degraded reaches include both the main-stem Oak Orchard Creek and tributaries (Figure 1). BAP scores indicate the worst impacts to aquatic life exist in the upper portions of the watershed, stations ORCH-36.2, ORCE-2.2, ORCH-21.6, and ORCO-2.1 respectively) (Figures 1 and 2). BAP scores from the furthest downstream station (ORCH-0.2) and the tributary site on Marsh Creek (MARO-1.9) were slightly less degraded but still indicate impairment of aquatic life (Figures 1 and 2). Dominant macroinvertebrate taxa at these and other locations reflect tolerance to both general pollution as well as high nutrient concentrations. For example, abundance of the freshwater scud *Gammarus* sp., and worms in the genus *Nais*, reflect abundant organic enrichment of detritus and biofilms on which they feed

(Table 5). The abundance of the midges *Glyptotendipes* sp., and *Dicrotendipes* sp., and the caddisflies *Ceratopsyche slossonae* and *Hydropsyche betteni,* because of their filtering mode of feeding, reflect abundant fine particulate organic material in the water column such as suspended algae (Table 5).

Evaluation of stream substrates at all sites suggests there are no major physical limitations to support a diverse community of benthic macroinvertebrates. Often, substrates with a high percentage of fine sediment or loose unstable gravel result in diminished macroinvertebrate communities. In Oak Orchard Creek, pebble count data suggest a diversity of stable substrate, dominated at most sites by rubble and course gravel (Figure 4 and Table 3). Therefore, substrates are conducive for sustaining diverse populations of macroinvertebrates. There are however, some areas in which assessment of instream and riparian habitat indicated alteration from the natural condition (Figure 5 and Table 4). These alterations to habitat condition may negatively impact the survival of sensitive benthic macroinvertebrate taxa and other aquatic life.

Water column chemistry sampling results indicate nutrient levels in Oak Orchard Creek are elevated and likely a significant cause of impacts to aquatic life throughout the watershed. These results are supported by the dominance of nutrient tolerant benthic macroinvertebrates throughout the samples (Table 5). The water chemistry sampling data suggest phosphorus concentration at all sites surveyed exceeds the concentration (approximately 30µg/L TP) documented to cause impacts to aquatic life (Smith et al. 2007; Smith and Tran 2010; Smith et al. 2013; Smith et al. 2015) (Figure 6). Several locations exceeded this phosphorus threshold for protection of aquatic life by more than six times (≥190µg/L TP) (Figure 6). In addition to impacts on aquatic life the phosphorus concentrations observed in Oak Orchard Creek likely degrade recreational ability both in and on the water (Smith et al. 2015). Like phosphorus, in the upper portions of the watershed, nitrate-nitrite concentrations were elevated to the extent they also likely have an impact on aquatic life.

Estimating Phosphorus Loads and Sources

NYSDEC created a simple spreadsheet-based approach to quickly assess sources of pollutants (such as phosphorus), analyze their potential pollutant load, and estimate potential reductions in a watershed. This simple yet effective model can be used to screen waterbodies for more detailed analysis, data needs, and evaluate the most appropriate planning action (e.g., total maximum daily load (TMDL) plan, watershed plan, or permit modification). The tool focuses on the sources of nutrients (nitrogen and phosphorus) within a watershed. In the current investigation of the Oak Orchard Creek watershed, the tool provides useful planning information to help identify nutrient sources and potential areas for reduction strategies when combined with the ambient nutrient monitoring data. Details on the tool can be found in the "Vision Approach to Implement Clean Water Act 303(d) Program and Clean Water Planning" (NYDEC 2015).

Results of applying the tool to Oak Orchard Creek watershed suggests approximately 60% of the 275 mi^2 watershed is agricultural land (pasture/hay and cultivated crops) and 33% is combination of forest, grasslands and wetlands. Therefore, the majority of nutrient reduction strategies should focus on implementing agricultural, non-point source, best management practices (BMPs).

Estimated phosphorus loads were calculated for nonpoint sources based on land use, annual runoff volume and pollutant concentration; onsite septic systems within 250 ft of a waterbody; and point sources (based on Discharge Monitoring Reports (DMR) and permit information). The results suggest the major source of the estimated phosphorus load within the Oak Orchard Creek watershed is agricultural land (row crops and hay/pasture). In most sub-basins, greater than 80% of the phosphorus load likely comes from agriculture (Table 6). However, the results also point to two of the smaller sub-basins (ORCE2.2 and ORCH2.1)

receiving excess phosphorus from point sources, 43% and 38% of their phosphorus load respectively (Table 6). Therefore, in these two instances where sub-basin nutrient loads appear to also be influenced by point sources a strategy which reviews phosphorus permit limitations may be warranted.

Based on the results of analyzing potential nutrient sources and loads we suggest the following recommendations to reduce nutrient loads and improve water quality in the Oak Orchard Creek watershed:

1. Verify that the National Land Cover Dataset (NLCD) 2011 is representative of the land uses within the watershed. The NLCD is collected at the national level and may not be accurate to a finer scale (local level) analysis. It is possible that agricultural load/land use is over estimated.
2. Communicate results to the County Soil and Water Conservation (SWCD) staff to better understand the current implementation/priorities of conservation activities within the watershed. The current estimation assumes no BMPs installed on the landscape. Work with Bureau of Water Resource Management Nonpoint Source Program and SWCDs to identify the most appropriate BMPs to help reduce the amount of phosphorus reaching Oak Orchard Creek and tributaries.
3. Work with Bureau of Water Assessment and Monitoring Procurement, Communication and Partnership Section to identify implementation activities within the watershed that could be included in the Finger Lakes Lake Ontario Watershed Protection Alliance (FL-LOWPA) County work plans.
4. Check with Bureau of Water Permits to review wastewater treatment plant permits within the watershed and determine, if any, actions that may be taken.

Literature Cited

NYSDEC, 2014. Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State. NYSDEC SOP #208-14. Division of Water, NewYork State Department of Environmental Conservation, 625 Broadway, Albany, New York, 171 pages.

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Smith A. J., Thomas, R. L., Nolan, J. K., Velinsky, D. J., Klein, S., Duffy B. D. 2013. Regional nutrient thresholds in wadeable streams of New York State protective of aquatic life. Ecological Indicators 29:455-467

Smith, A.J., B.T. Duffy, and M.A. Novak. 2015. Observer Rating of Recreational Use in Wadeable Streams of New York State, USA: Implications for Nutrient Criteria Development. Water Research 69:195-209

Figure 1. Overview map, Oak Orchard Creek watershed and 2015 sampling locations.

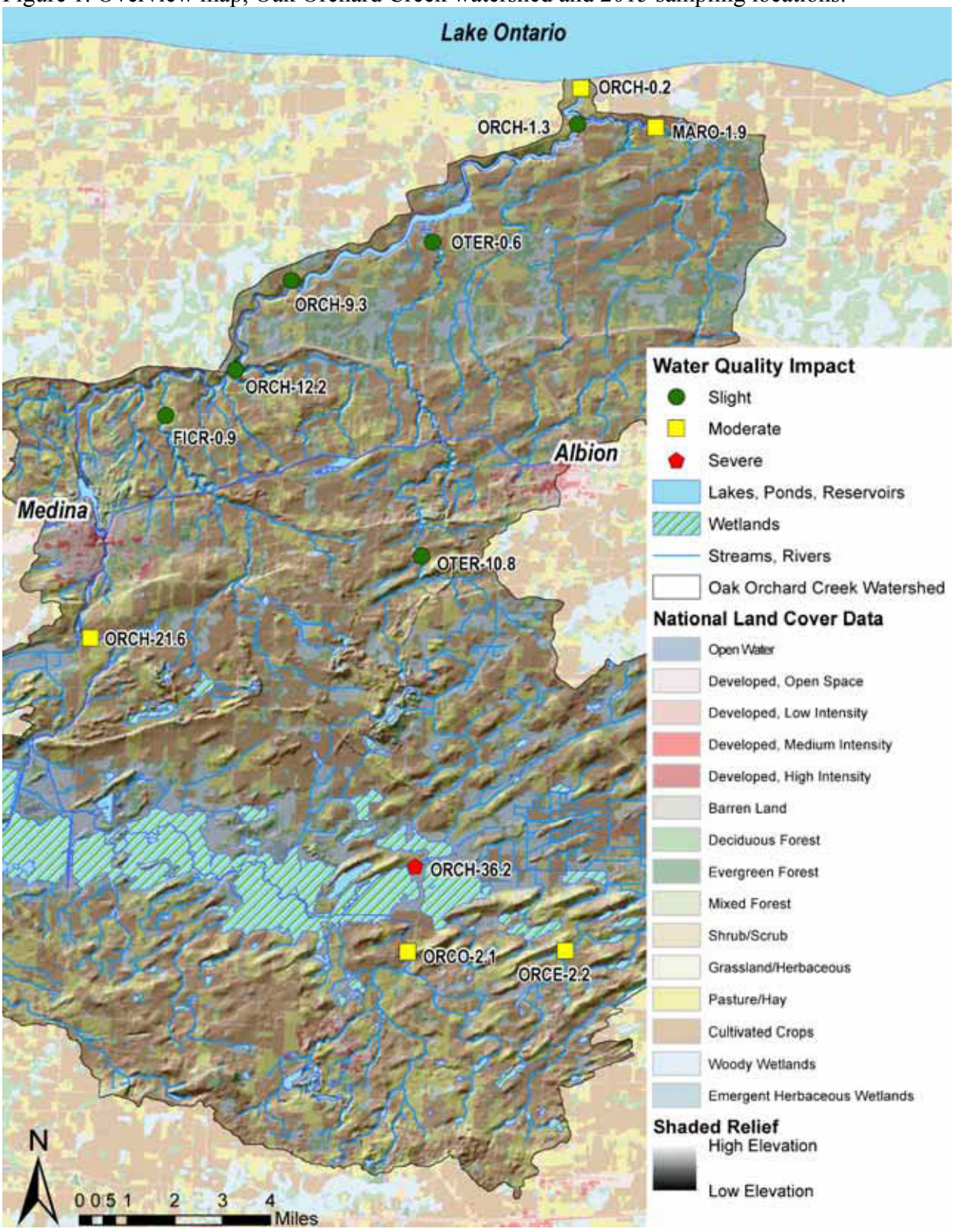

Figure 2. Site location map, tributary to Oak Orchard Creek, Station ORCE-2.2.

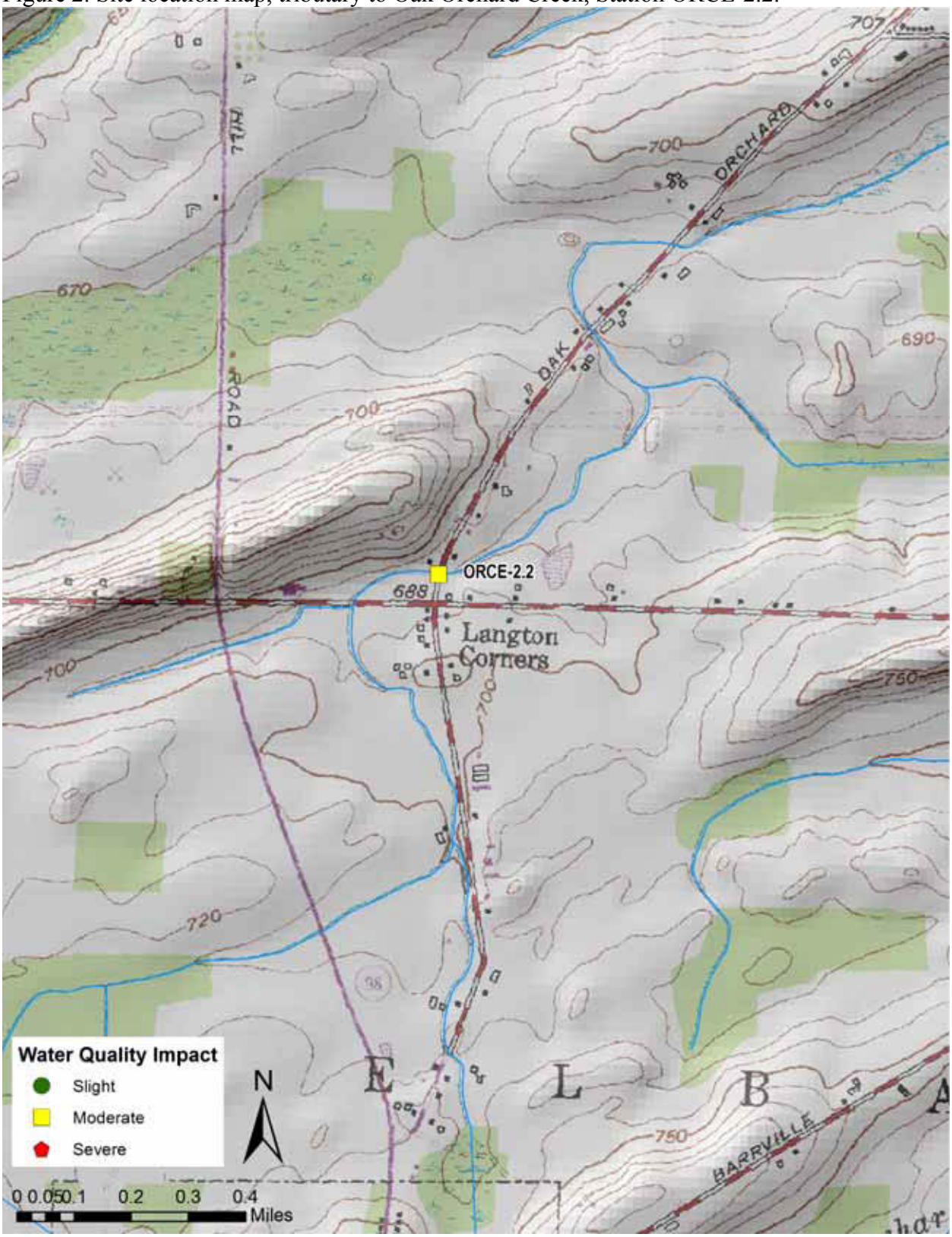

Figure 2a. Site location map, tributary to Oak Orchard Creek, Station ORCO-2.1.

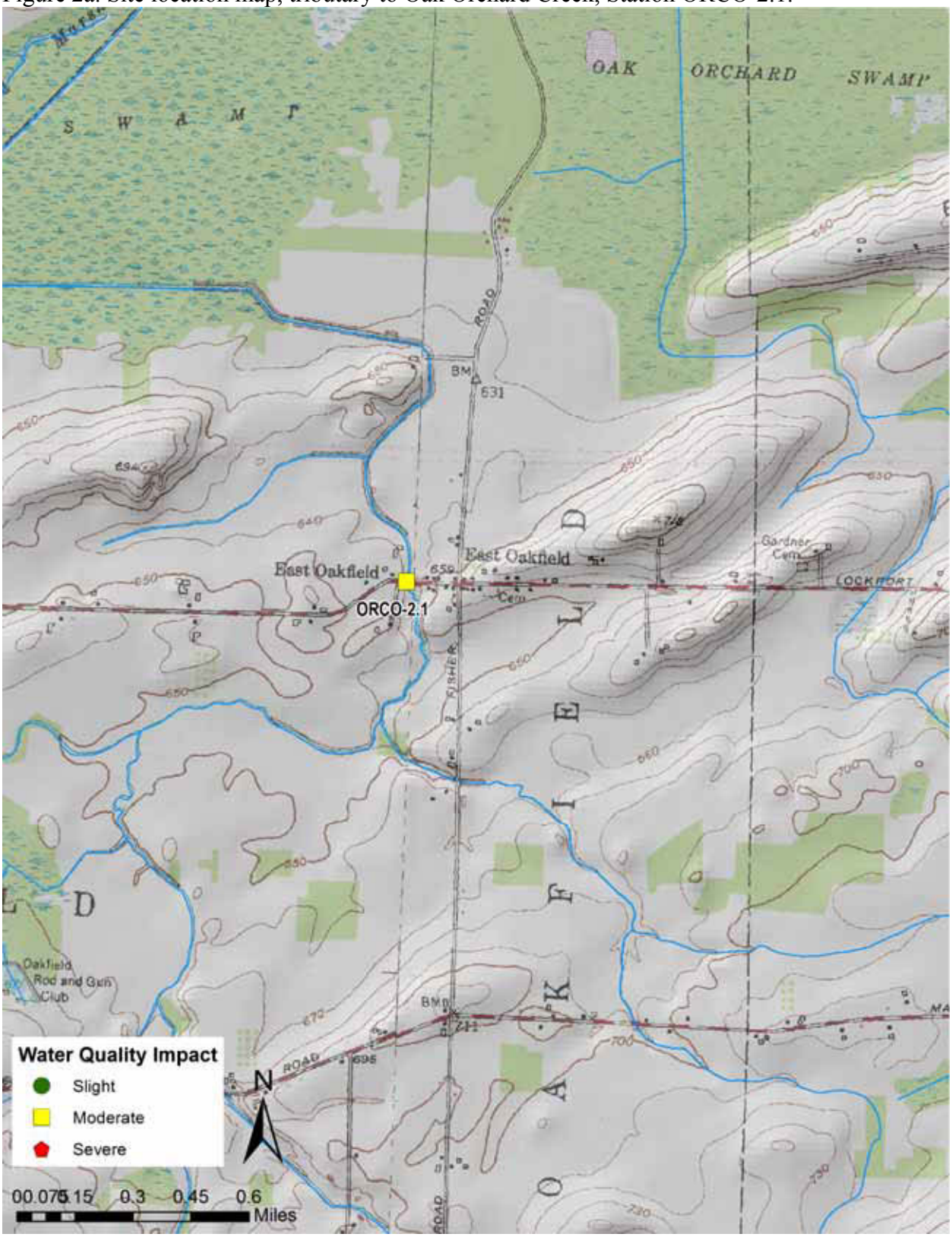

Figure 2b. Site location map, Oak Orchard Creek, Station ORCH-36.2.

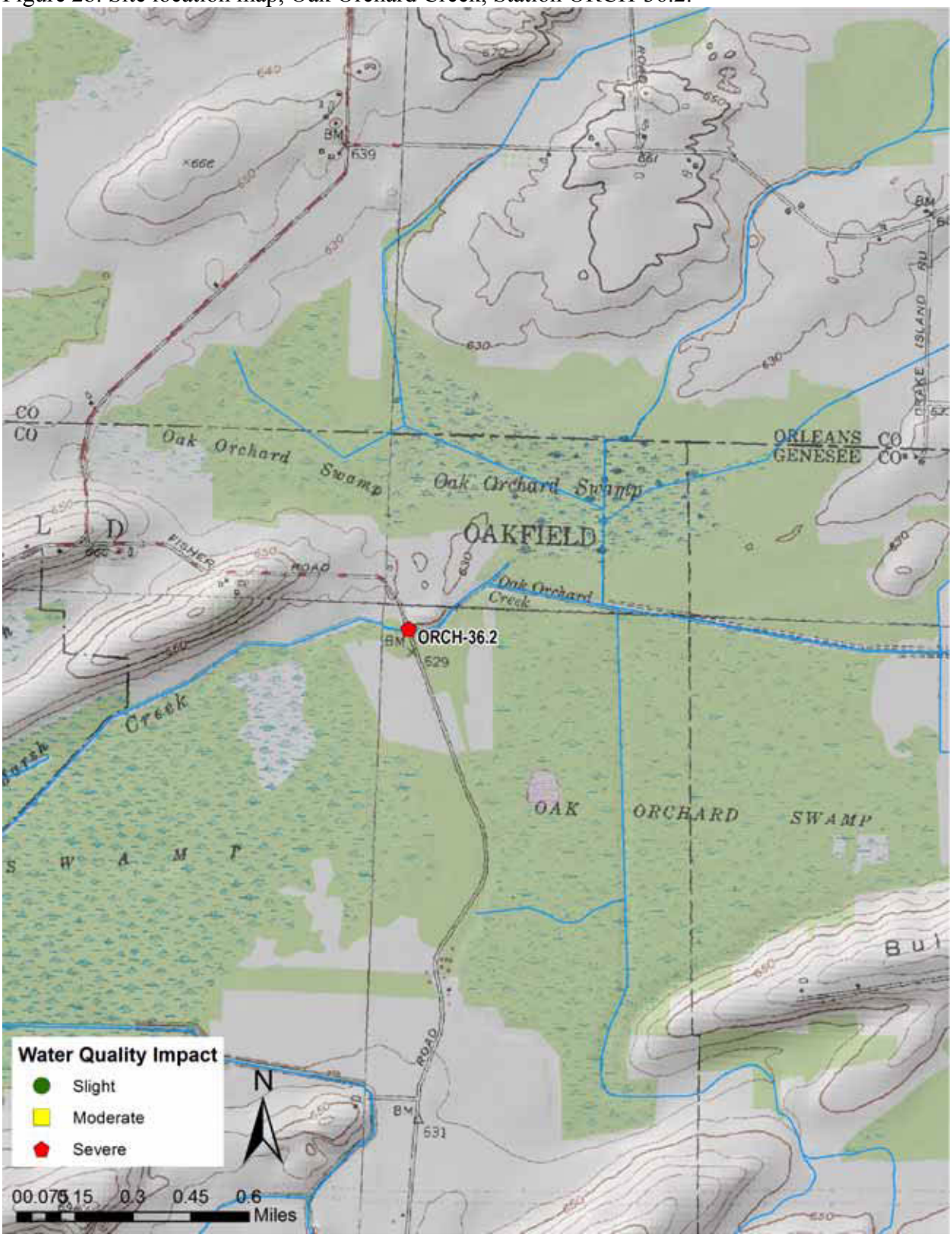

Figure 2c. Site location map, Oak Orchard Creek, Station ORCH-21.6.

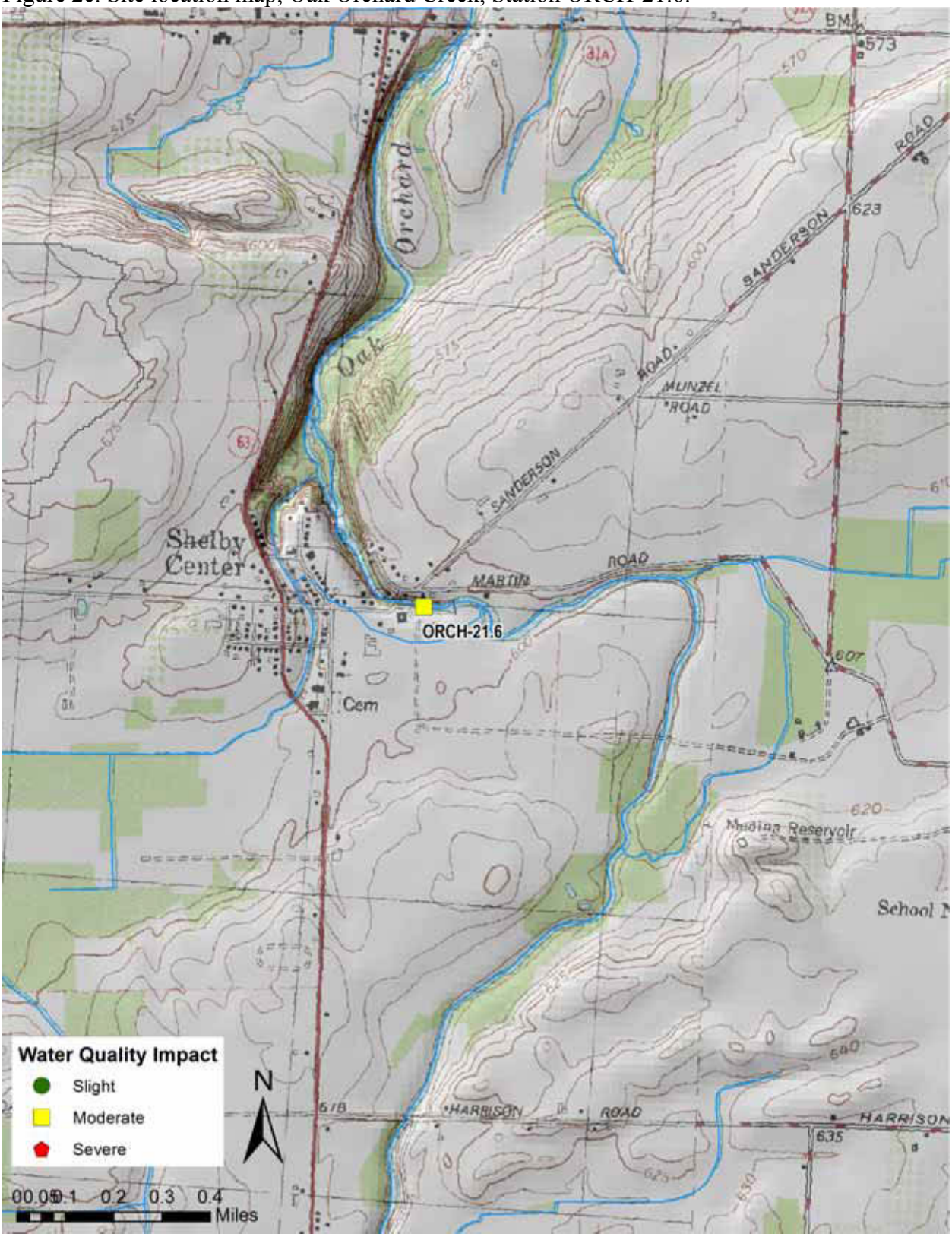

Figure 2d. Site location map, Otter Creek tributary to Oak Orchard Creek, Station OTER-10.8.

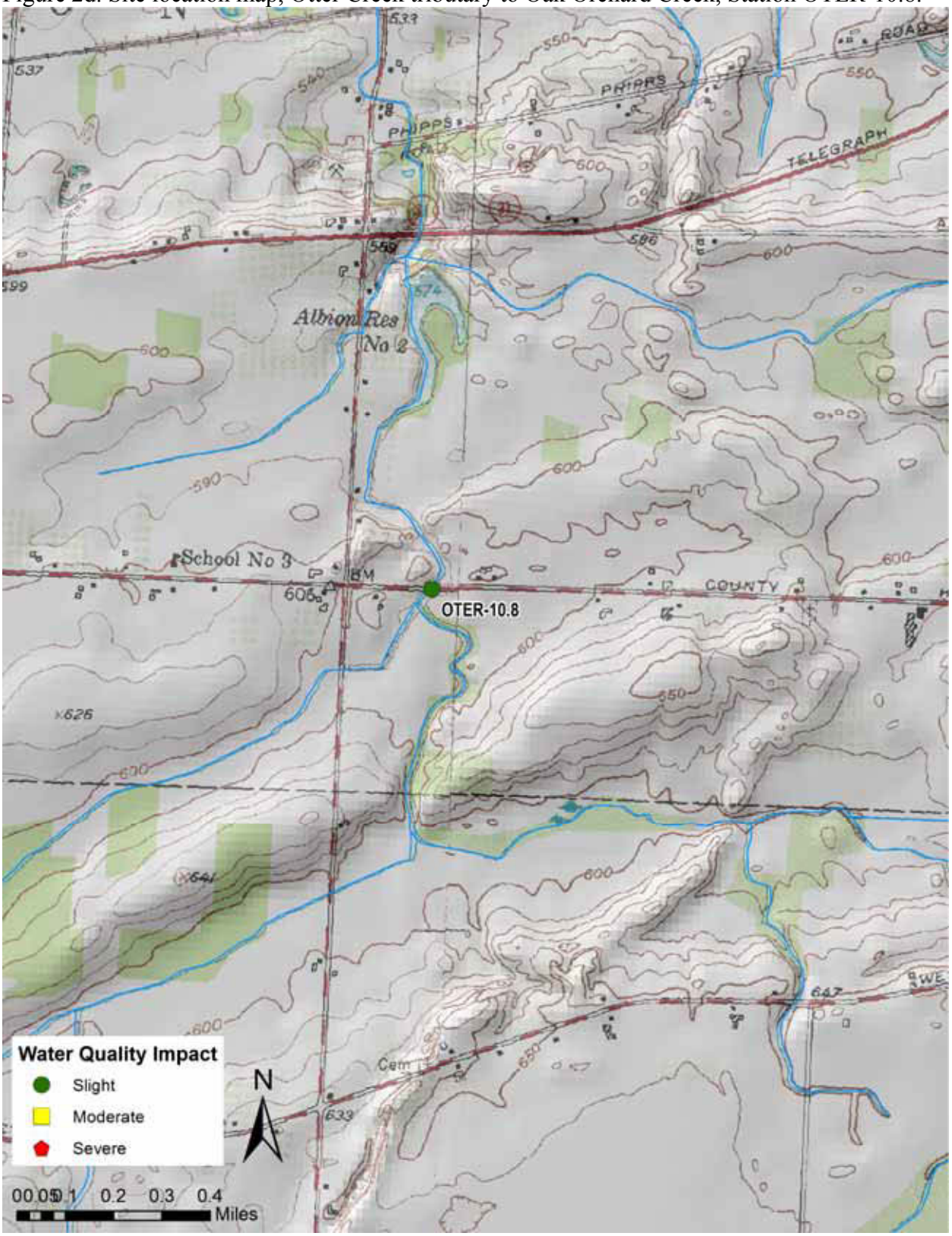

Figure 2e. Site location map, Fish Creek tributary to Oak Orchard Creek, Station FICR-0.9 and Oak Orchard Creek, Station ORCH-12.2.

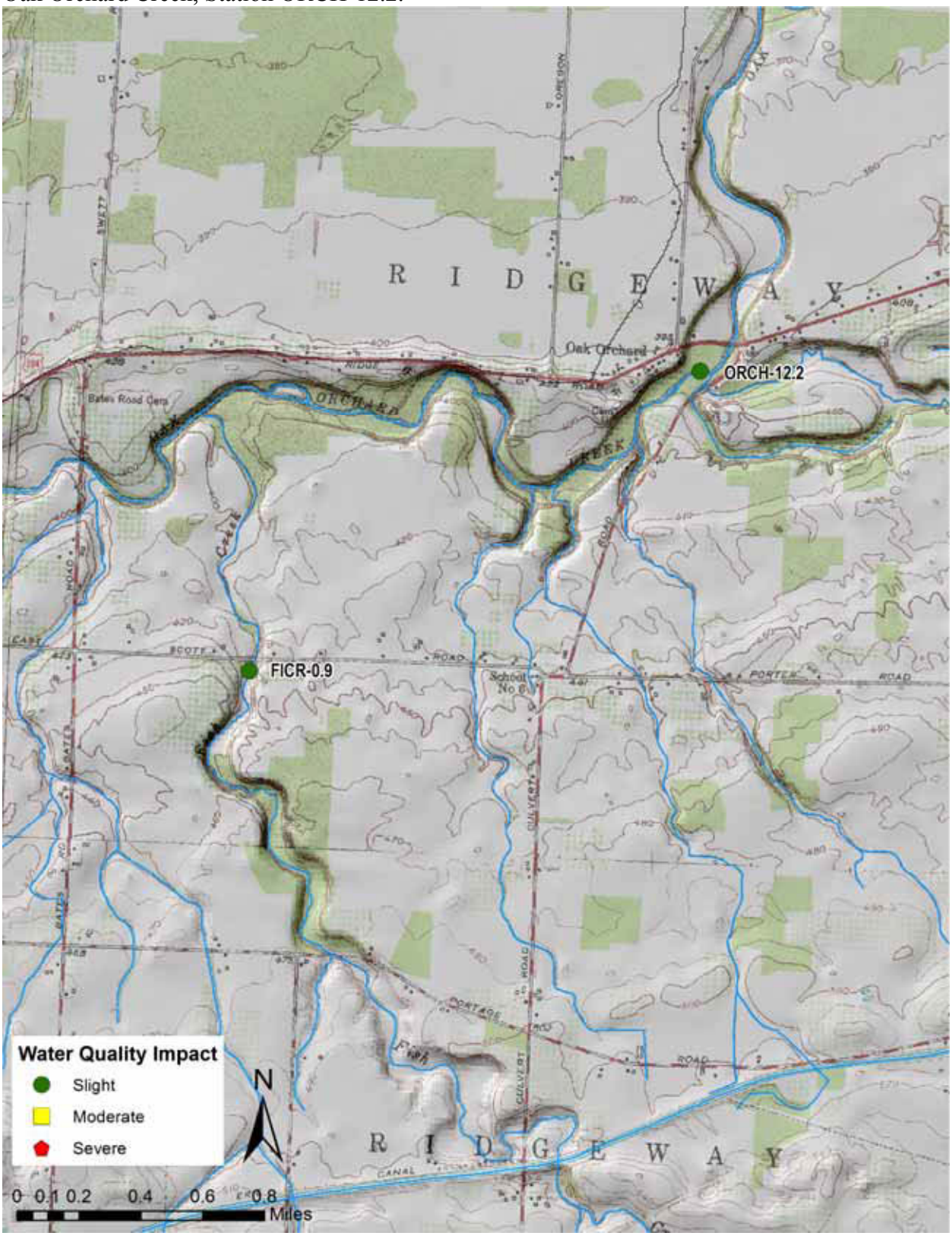

Figure 2f. Site location map, Oak Orchard Creek, Station ORCH-9.3.

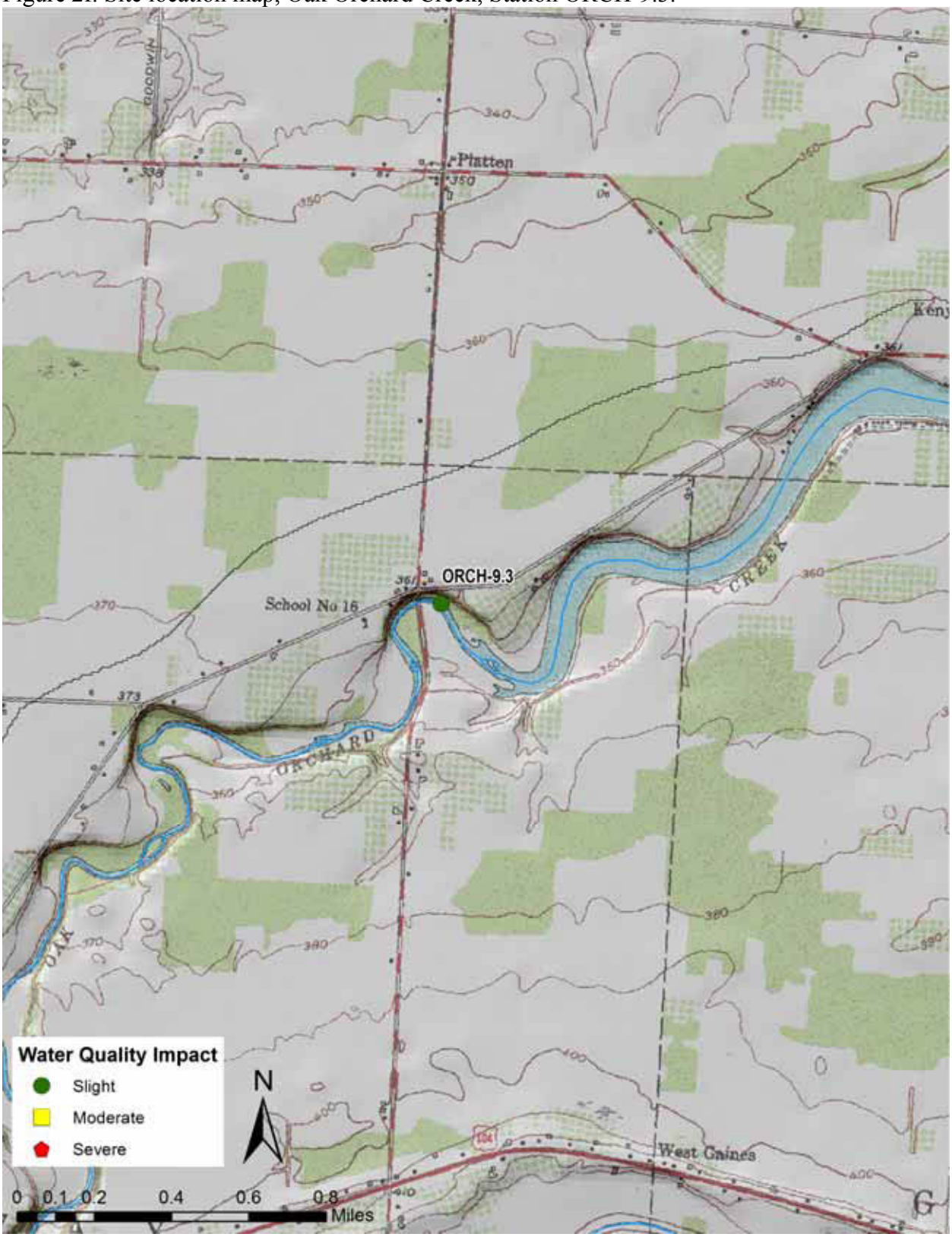

Figure 2g. Site location map, Otter Creek tributary to Oak Orchard Creek, Station OTER-0.6.

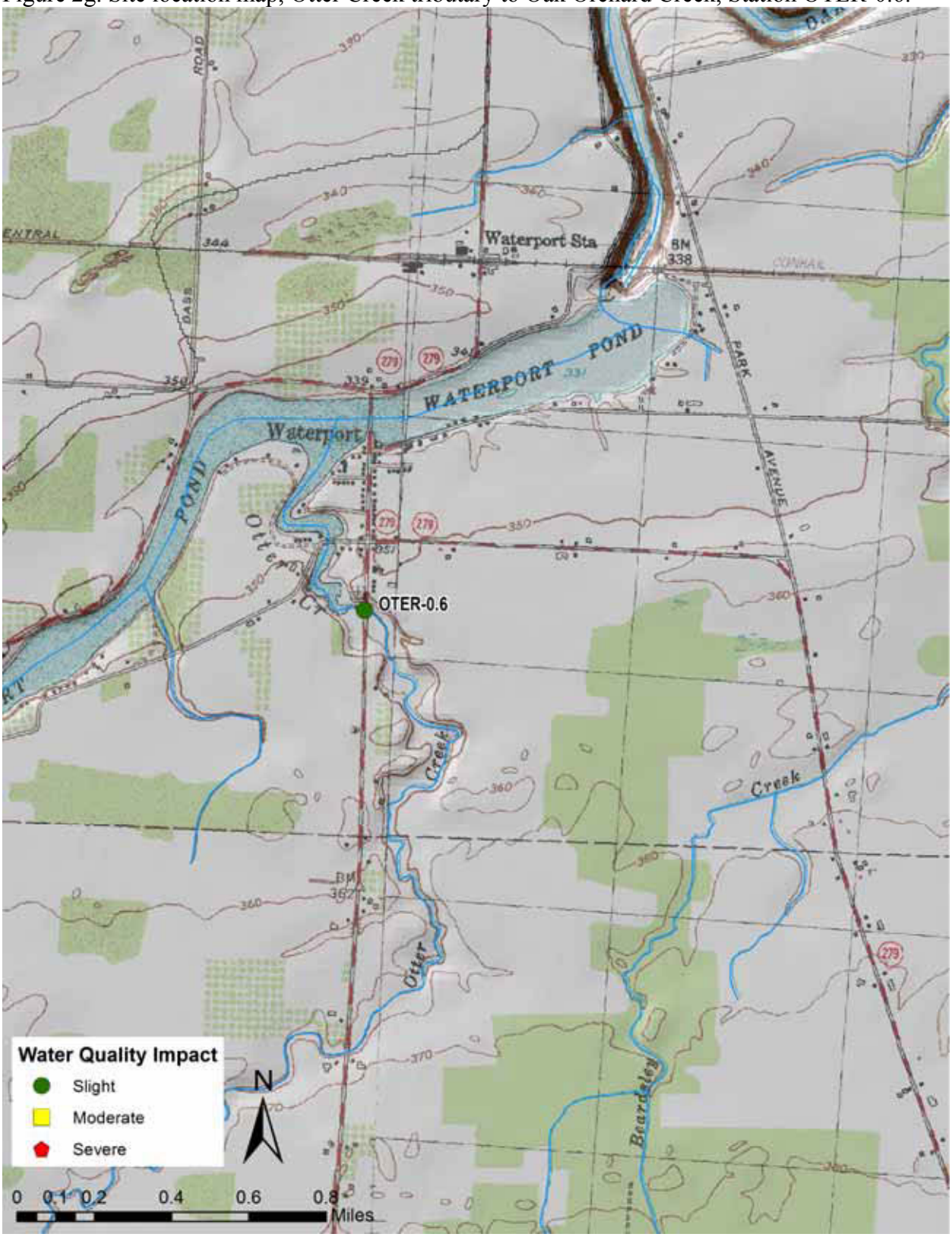

Figure 2h. Site location map, Marsh Creek tributary to Oak Orchard Creek, Station MARO-1.9.

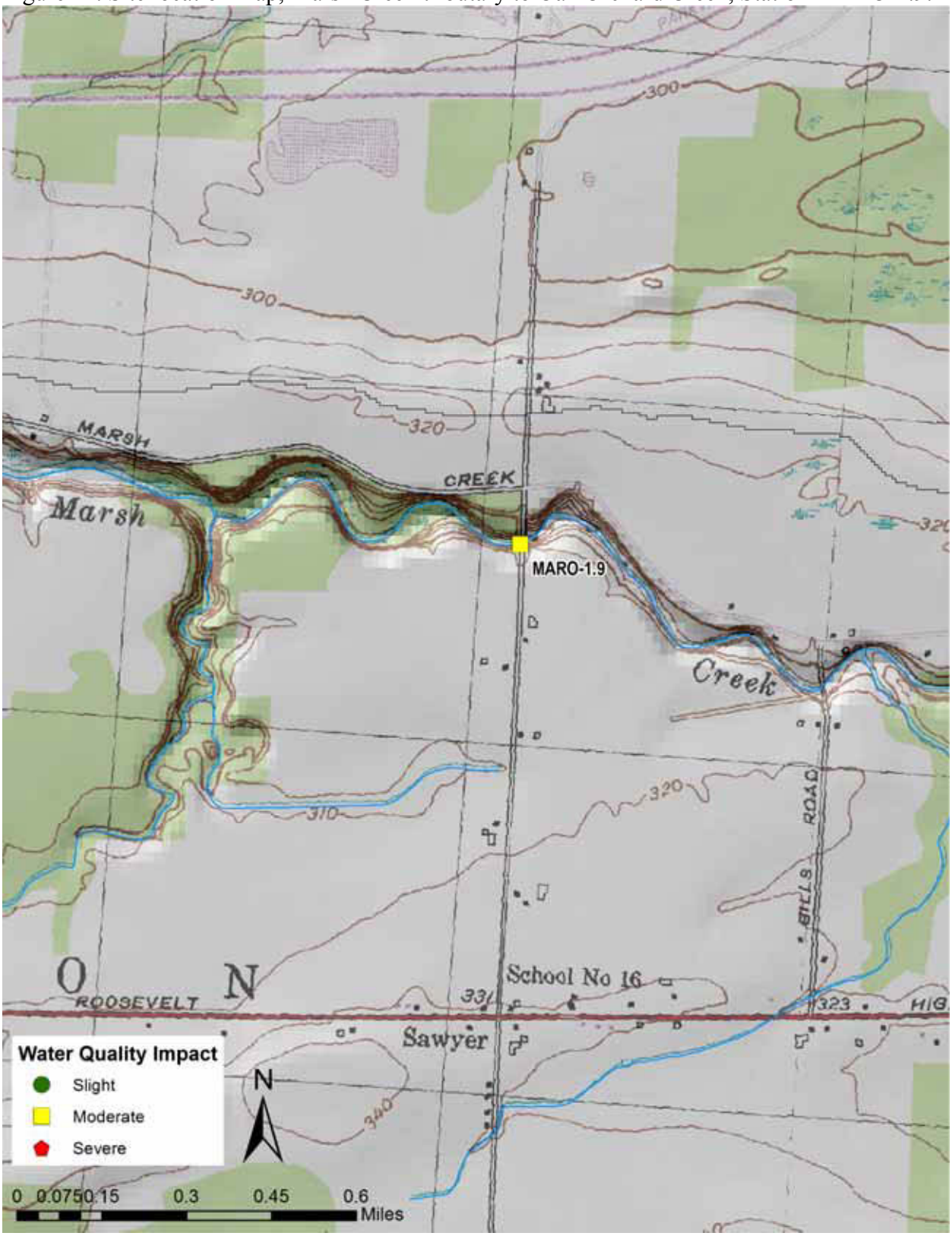

Figure 2i. Site location map, Oak Orchard Creek, Stations ORCH-1.3 and ORCH-0.2.

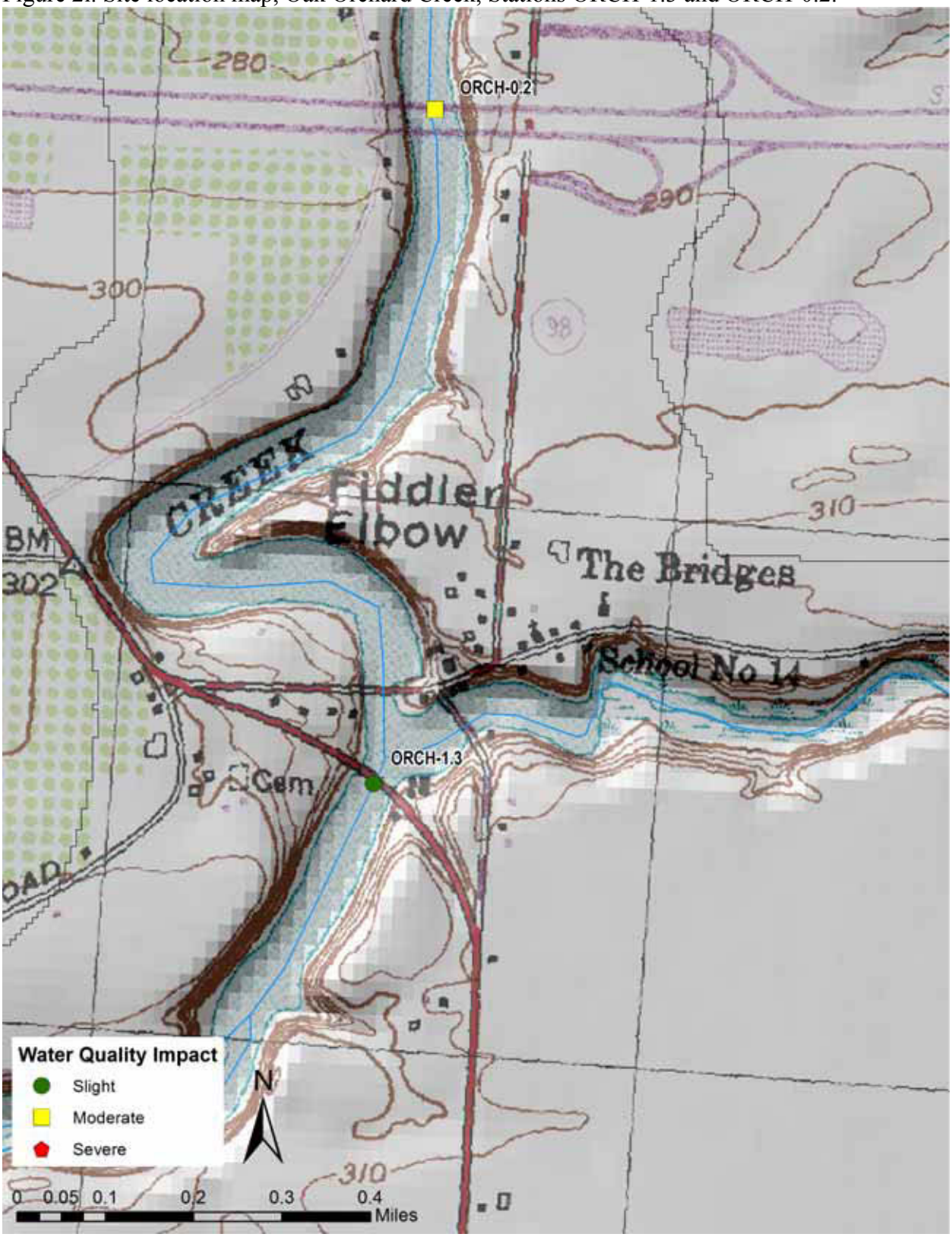

Table 1. Survey locations on Oak Orchard Creek, 2015.

ORCE-2.2	Elba, NY Oak Orchard Rd, Below Elba WWTP Latitude: 43.100278 Longitude: -78.184944	
ORCO-2.1	Oakfield, NY Lockport Rd, Below Oakfield WWTP Latitude: 43.098139 Longitude: -78.250111	
ORCH-36.2	Oakfield, NY Fisher Rd Latitude: 43.124167 Longitude: -78.248417	
ORCH-21.6	Shelby, NY Upstream of Martin Rd bridge Latitude: 43.18979 Longitude: -78.38674	

Table 1 Cont'd. Survey locations on Oak Orchard Creek.

OTER-10.8	Albion, NY County Route 74 bridge Latitude: 43.218592 Longitude: -78.250814	
FICR-0.9	Oak Orchard on the Ridge, NY Upstream of East Scott Rd bridge Latitude: 43.25829 Longitude: -78.35928	
ORCH-12.2	Oak Orchard on the Ridge, NY Upstream of Rte 104 bridge Latitude: 43.27317 Longitude: -78.33118	
ORCH-9.3	Ridgeway, NY Downstream of Town Line Rd bridge Latitude: 43.27317 Longitude: -78.33118	

Table 1 Cont'd. Survey locations on Oak Orchard Creek.

OTER-0.6	Albion, NY Eagle Harbor Waterport Rd Latitude: 43.314528 Longitude: -78.251333	
MARO-1.9	Kent, NY Sawyer Rd Latitude: 43.351806 Longitude: -78.1605	
ORCH-1.3	Waterport, NY Roosevelt Highway Latitude: 43.351806 Longitude: -78.192917	
ORCH-0.2	Waterport, NY Lake Ontario State Parkway Latitude: 43.362889 Longitude: -78.192111	

Figure 3. Biological Assessment Profile (BAP) of index values, Oak Orchard Creek Watershed, 2015. The BAP represents the mean of individual community metric values for each site. The red horizontal reference line represents the threshold for impairment of aquatic life. Sites with BAP scores below this threshold are considered not supporting of aquatic life.

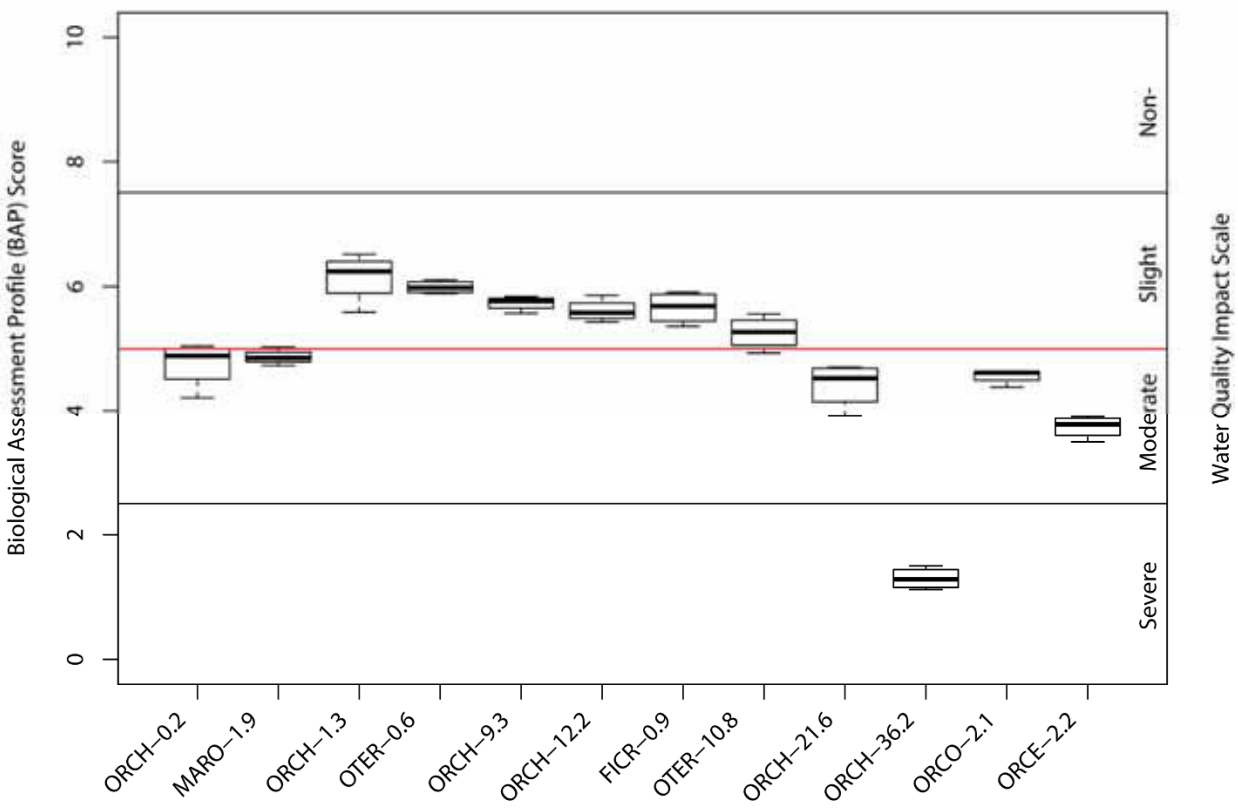

Table 2. Summary of field measured physical and chemical attributes from each sampling location in Oak Orchard Creek watershed, 2015.

Station	Depth (m)	Width (m)	Current (cm/sec)	Embed. (%)	Temp. (°C)	Conduct. (µmhos)	pH	DO (mg/L)	DO Sat. (%)
ORCH-0.2	Multiplate no data recorded				21.9	615	7.7	6.5	75
MARO-1.9	0.1	10	70	25	26	560	8.5	9.33	115
ORCH-1.3	Multiplate no data recorded				22.1	621	7.7	6.7	76
OTER-0.6	0.1	2.5	50	35	23.4	523	8.2	9.8	115
ORCH-9.3	0.2	50	66	40	24.5	670	8.2	9.3	112
ORCH-12.2	0.3	13	100	60	23.3	671	7.9	7.1	83
FICR-0.9	0.1	1	25	25	24.7	734	8.3	7.6	91
OTER-10.8	0.1	3	30	50	25.5	803	8.2	7	86
ORCH-21.6	0.3	10	75	50	27.8	1683	8.5	8.9	114
ORCH-36.2	Multiplate no data recorded				20.7	1173	7.7	7.7	54
ORCO-2.1	0.2	12	62	50	18.1	2530	8.2	10.6	112
ORCE-2.2	0.1	2	20	50	24.1	2180	8.1	10.7	128

Figure 4. Pebble count analysis from Oak Orchard Creek watershed, 2015.

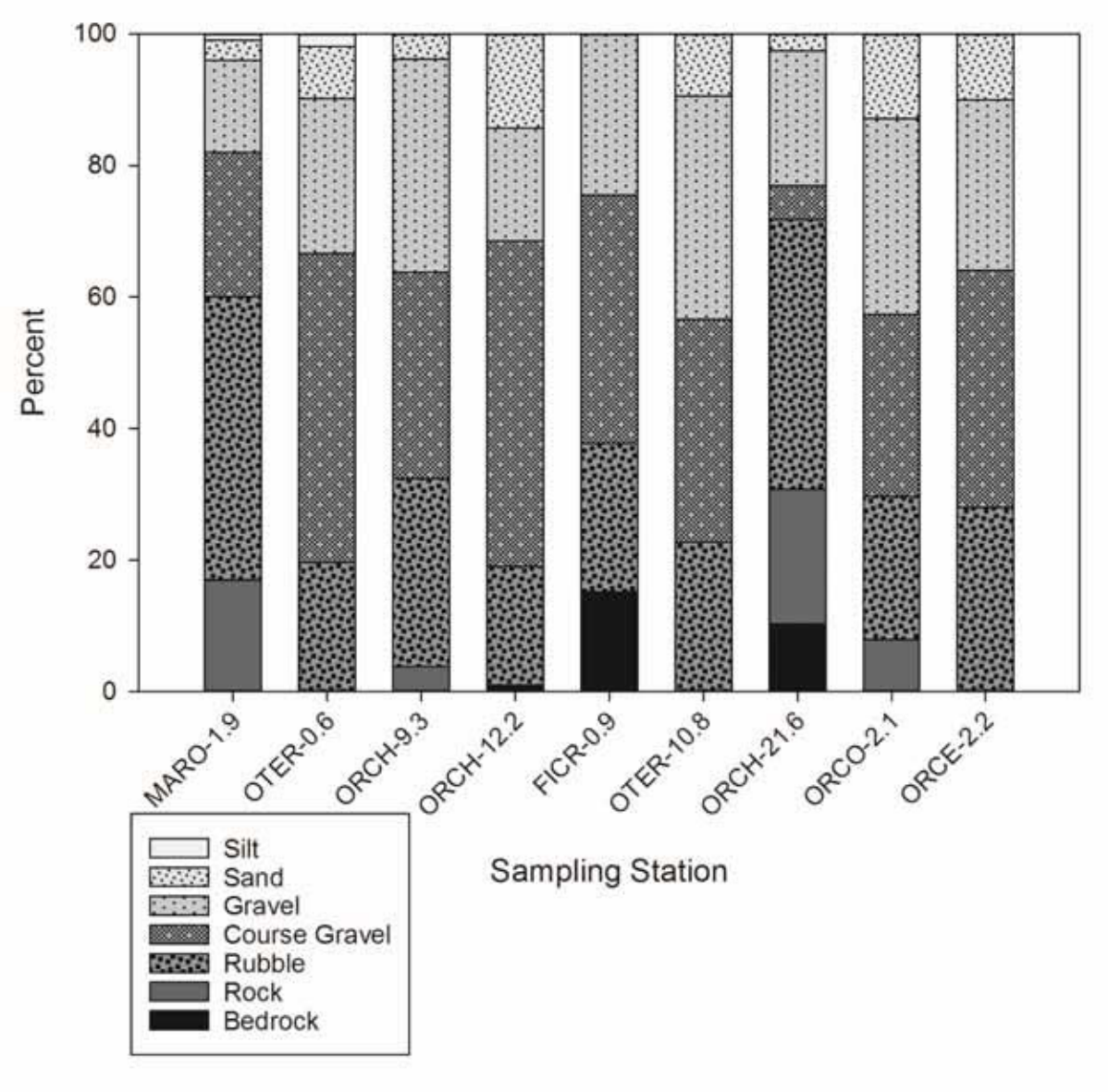

Table 3. Summary of substrate particle sizes recorded from pebble counts in Oak Orchard Creek watershed, 2015. Values are calculated as a proportion of the total from a random count of 50-100 pebbles, depending on stream size, in the stream reach. Coarse Gravel is abbreviated as C. Gravel. Wadeable stream sites only.

Station	Silt	Sand	Gravel	C. Gravel	Rubble	Rock	Bedrock
MARO-1.9	0.01	0.03	0.14	0.22	0.43	0.17	0.00
OTER-0.6*	0.02	0.08	0.24	0.47	0.20	0.00	0.00
ORCH-9.3	0.00	0.04	0.32	0.31	0.29	0.04	0.00
ORCH-12.2	0.00	0.14	0.17	0.50	0.18	0.00	0.01
FICR-0.9*	0.00	0.00	0.25	0.38	0.23	0.00	0.15
OTER-10.8*	0.00	0.09	0.34	0.34	0.23	0.00	0.00
ORCH-21.6*	0.00	0.03	0.21	0.05	0.41	0.21	0.10
ORCO-2.1	0.00	0.13	0.30	0.28	0.22	0.08	0.00
ORCE-2.2*	0.00	0.10	0.26	0.36	0.28	0.00	0.00

Figure 5. Habitat assessment scores for each sampling location in Oak Orchard Creek watershed, 2015. Only wadeable stream locations are presented.

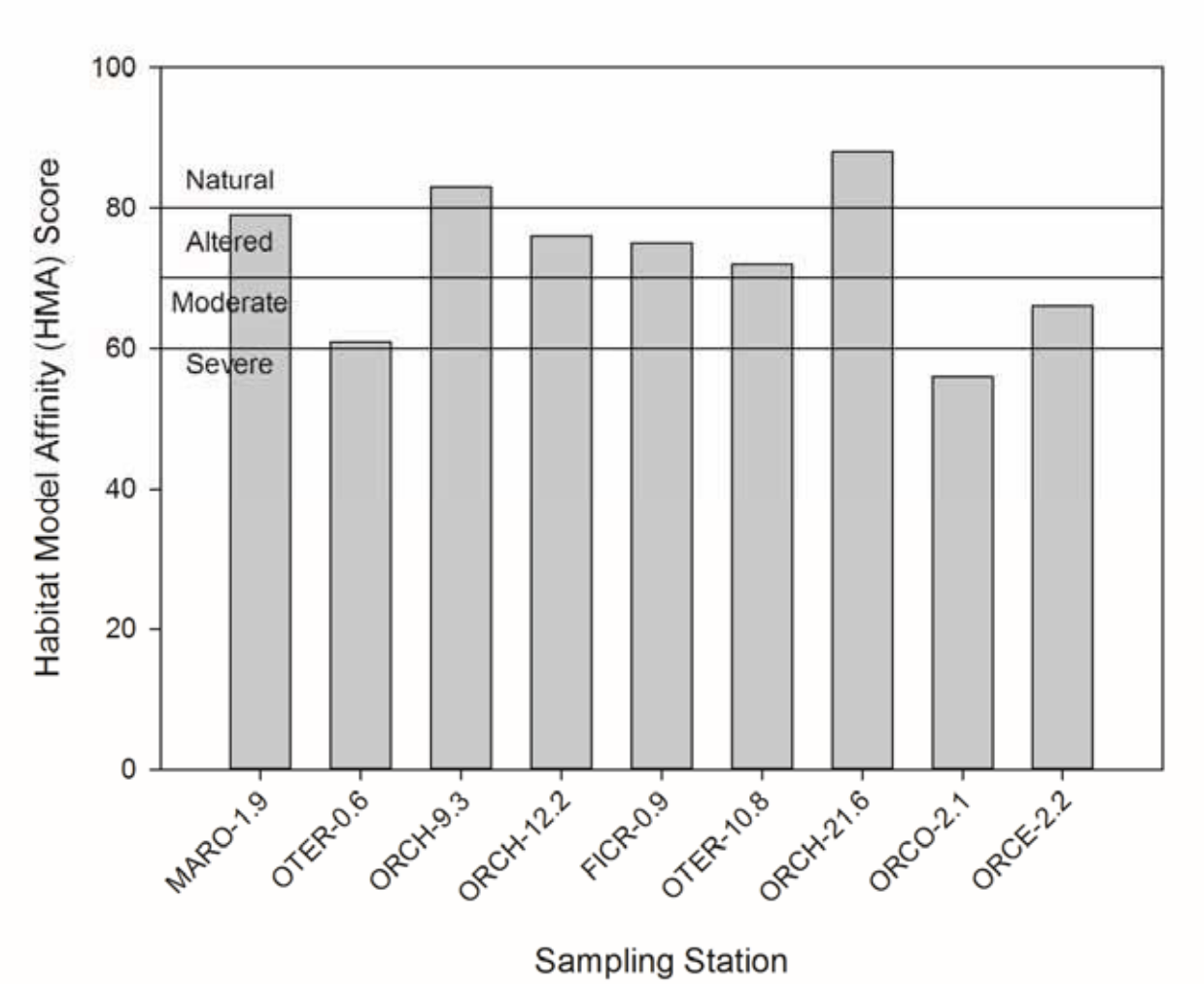

Table 4. Summary of physical habitat attribute scores* used in calculating the Habitat Model Affinity (Figure 4) at locations in Oak Orchard Creek watershed, 2015. Wadeable stream sites only.

Station	Epi. Cover	Embed.	Vel/Dep Reg.	Sed. Dep.	Flow Satus	Chan. Alt.	Rif. Freq.	Bank Stab.	Bank Veg.	Rip. Width
MARO-1.9	11	16	15	14	17	13	10	16	13	20
OTER-0.6	14	14	10	9	12	15	9	15	12	0
ORCH-9.3	12	12	15	14	18	17	18	15	17	13
ORCH-12.2	18	8	20	7	17	18	17	10	14	10
FICR-0.9	18	10	18	15	19	16	17	19	18	11
OTER-10.8	15	9	11	11	17	18	8	15	17	10
ORCH-21.6	10	16	13	13	8	18	13	12	15	17
ORCO-2.1	6	10	12	5	20	7	14	14	12	2
ORCE-2.2	13	10	14	12	19	17	11	9	14	1

* The following attributes are ranked on a scale from 0 (poor) - 20 (optimal). Epi. Cover = Epifaunal substrate cover, Embed. = Embeddedness, Vel/Dep Reg. = Velocity Depth Regime, Sed. Dep. = Sediment Deposition, Flow Status = Channel Flow Status, Chan. Alt. = Channel Alteration, Rif. Freq. = Riffle Frequency, Bank Stab. = Bank Stability, Bank Veg. = Bank Vegetative Cover, Rip. Width = Riparian Corridor Width. Values of 10 or below are highlighted to identify those parameters ranked as marginal or poor.

Figure 6. Total phosphorus and nitrate-nitrite concentrations from Oak Orchard Creek watershed, 2015.

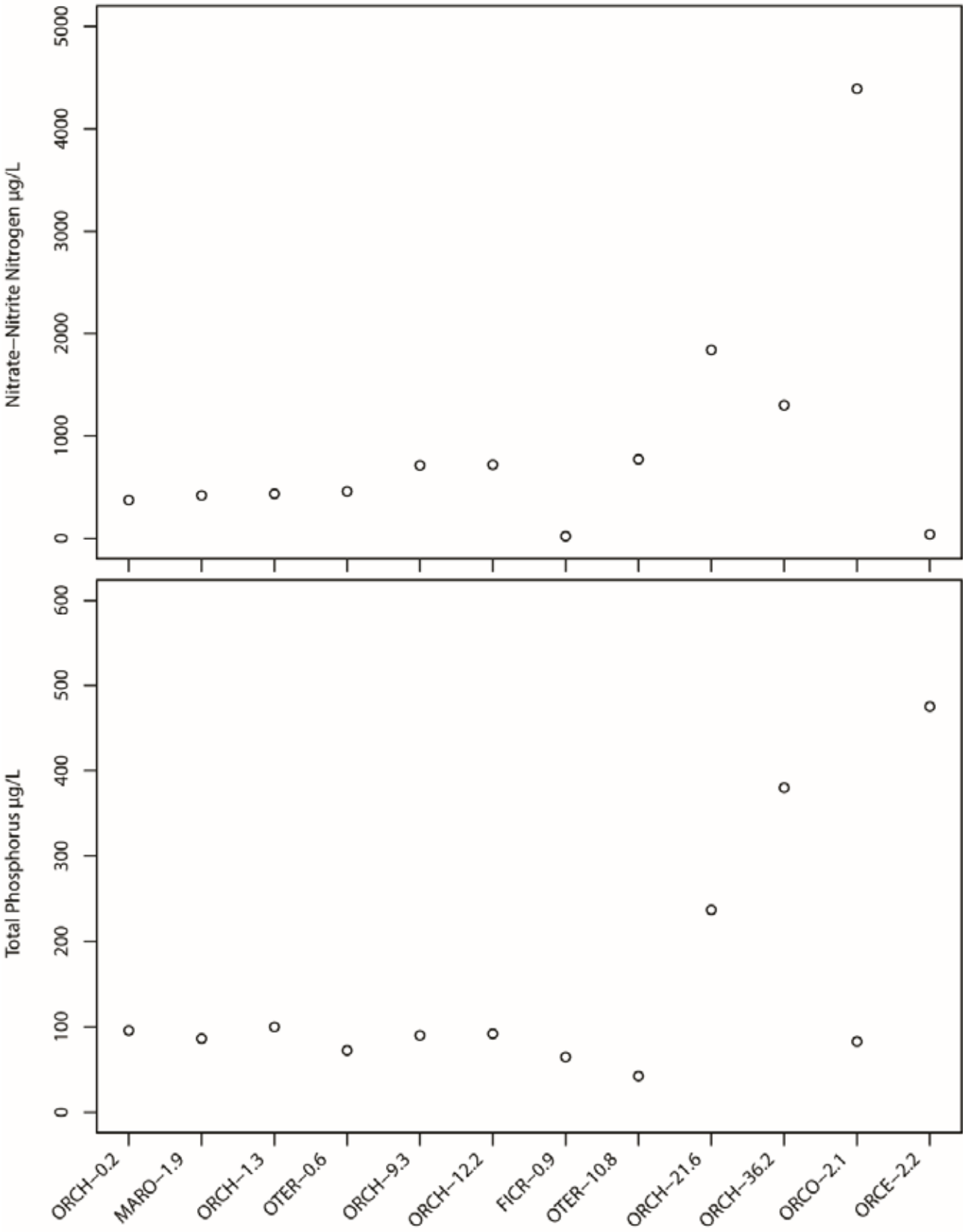

Table 5. Macroinvertebrate species collected in Oak Orchard Creek watershed, 2015. Species information is categorized by: Site ID – River Mile, Replicate Number. Values represent the number of individuals in each sample for the respective taxon.

Genus species	Location-Station, Replicate																							
	FICR-0.9, 1	FICR-0.9, 2	FICR-0.9, 3	FICR-0.9, 4	MARO-1.9, 1	MARO-1.9, 2	MARO-1.9, 3	MARO-1.9, 4	ORCE-2.2, 1	ORCE-2.2, 2	ORCE-2.2, 3	ORCE-2.2, 4	ORCO-2.1, 1	ORCO-2.1, 2	ORCO-2.1, 3	ORCO-2.1, 4	OTER-0.6, 1	OTER-0.6, 2	OTER-0.6, 3	OTER-0.6, 4	OTER-10.8, 1	OTER-10.8, 2	OTER-10.8, 3	OTER-10.8, 4
Antocha sp.	1	1	2	2									2	3	4	3								
Atherix sp.					1																			
Baetis flavistriga	5	5	5	4	3	7	5	3									8	8	5	13	5	9	1	11
Baetis intercalaris																					4	4		
Baetis pluto	1							1									4	2	2	2			13	
Boyeria sp.									1	1														
Caecidotea sp.	2	1	1	7	3	1	1													2		1	5	5
Caenis latipennis		2	1																					
Cardiocladius obscurus		1																	1					
Ceratopsyche bronta	1				5	8	5	6						2	3	2	2	1						
Ceratopsyche slossonae					2			2					10	6	5	7	1	2		2				
Ceratopsyche sparna	18	5	14	6	14	8	11	14									5	6	9	5			3	2
Cheumatopsyche sp.	16	16	10	13	7	3	10	9	7	3		5	1	5	5	2	3	4	6	5	6	8	9	6
Chimarra obscura		2	2	10																				
Cladotanytarsus sp.													2											
Corydalus cornutus																		1	1	1				
Cricotopus bicinctus	3	3	2										7	3	6	6	3	4	1	6			4	2
Cricotopus tremulus gr.																								1
Cricotopus trifascia gr.	1					1	1										3			4				
Cryptochironomus sp.												1			1									
Diamesa sp.											1		3	2		2					3			
Dicranota sp.																					1			

Genus species	Location-Station, Replicate																							
	FICR-0.9, 1	FICR-0.9, 2	FICR-0.9, 3	FICR-0.9, 4	MARO-1.9, 1	MARO-1.9, 2	MARO-1.9, 3	MARO-1.9, 4	ORCE-2.2, 1	ORCE-2.2, 2	ORCE-2.2, 3	ORCE-2.2, 4	ORCO-2.1, 1	ORCO-2.1, 2	ORCO-2.1, 3	ORCO-2.1, 4	OTER-0.6, 1	OTER-0.6, 2	OTER-0.6, 3	OTER-0.6, 4	OTER-10.8, 1	OTER-10.8, 2	OTER-10.8, 3	OTER-10.8, 4
Dicrotendipes modestus					1																			
Dolophilodes sp.																								1
Dubiraphia sp.									1		1	1												
Dubiraphia vittata																			1	1				
Dugesia sp.	5	5	6		8	5	10	12												1				
Eukiefferiella coerulescens gr.														2										
Eukiefferiella devonica gr.						3							2	1	1					3				
Ferrissia sp.					1	1		2																
Gammarus sp.				2	10	11	7	14	17	11	7	20	35	28	41	32	6	9	6	5	4	5	9	11
Glyptotendipes sp.																1								
Goniobasis livescens						1																		
Helicopsyche borealis		1	1	2													1							
Hemerodromia sp.									1						1			1						
Heptagenia sp.	1	2		4				1											1	1				
Hetaerina sp.										2	1													
Heterocloeon sp.				2													1	1	1	1				
Hydropsyche betteni	1	2	5			1	1		4	6	7	10	3	7	6	3	1				15	9	4	1
Hydropsyche sp.													1								1			
Hydroptila sp.		1			1	1											1	2						1
Isonychia sp.																			1					
Limnodrilus hoffmeisteri																						1		
Maccaffertium sp.							1																	
Maccaffertium terminatum																			1					

Genus species	Location-Station, Replicate																							
	FICR-0.9, 1	FICR-0.9, 2	FICR-0.9, 3	FICR-0.9, 4	MARO-1.9, 1	MARO-1.9, 2	MARO-1.9, 3	MARO-1.9, 4	ORCE-2.2, 1	ORCE-2.2, 2	ORCE-2.2, 3	ORCE-2.2, 4	ORCO-2.1, 1	ORCO-2.1, 2	ORCO-2.1, 3	ORCO-2.1, 4	OTER-0.6, 1	OTER-0.6, 2	OTER-0.6, 3	OTER-0.6, 4	OTER-10.8, 1	OTER-10.8, 2	OTER-10.8, 3	OTER-10.8, 4
Macronychus sp.																							1	
Micropsectra dives gr.	1												3	4	2	5								
Micropsectra sp.																							1	
Microtendipes pedellus gr.	2										1	3									1	1	2	
Nais bretscheri						1																		
Nais sp.																3								
Nilotanypus sp.			1	2																				
Oecetis sp.	1						1																	
Optioservus fastiditus	1	2	2	1										1		1					2			3
Optioservus ovalis													1											
Optioservus sp.					1								8	5	1	6					11	4	7	10
Orconectes rusticus																			1				1	1
Orthocladius dubitatus	1												6	7	3	11								
Parametriocnemus sp.		2	3	2		2	1	4		1	1			1	3	2	1	3	1	1	6	6	2	2
Paratanytarsus sp.									1															
Paratendipes sp.					1																			
Physella sp.					1	2	1											1						
Pisidium sp.			1		1								1					2	1	2				
Polypedilum fallax gr.																					1	4		1
Polypedilum flavum	20	28	21	18	22	21	20	3	18	24	19	14					12	9	11	9	2	2	6	10
Polypedilum illinoense																							3	
Polypedilum laetum				1						1		1				5								
Polypedilum scalaenum gr.													1											

Genus species	Location-Station, Replicate																							
	FICR-0.9, 1	FICR-0.9, 2	FICR-0.9, 3	FICR-0.9, 4	MARO-1.9, 1	MARO-1.9, 2	MARO-1.9, 3	MARO-1.9, 4	ORCE-2.2, 1	ORCE-2.2, 2	ORCE-2.2, 3	ORCE-2.2, 4	ORCO-2.1, 1	ORCO-2.1, 2	ORCO-2.1, 3	ORCO-2.1, 4	OTER-0.6, 1	OTER-0.6, 2	OTER-0.6, 3	OTER-0.6, 4	OTER-10.8, 1	OTER-10.8, 2	OTER-10.8, 3	OTER-10.8, 4
Potthastia gaedii gr.													4	14	10	4								
Pristinella sp.									1								1	1		2				
Prodiamesa sp.															1									
Psephenus herricki		1		1													2	1	2	4				
Pycnopsyche sp.																						1		
Rheotanytarsus exiguus gr.	3	1				1	4			1							1			1				
Simulium sp.					1	4	3	3			2		1	1	1		2		2	4	2	3	2	3
Sphaerium sp.																	1							
Stempellinella sp.																		1						
Stenelmis crenata	6	6	6	5			1			2	3	4		2	1		8	4	9	3	9	6	6	
Stenelmis sandersoni															3									
Stenelmis sp.	1	2	3	6	2	2	2	1	9	9	12	18	4	4		2	18	19	15	11	9	18	5	8
Stictochironomus sp.					2			6																
Sublettea coffmani																							1	1
Tabanus sp.										1														
Tanytarsus glabrescens gr.																								1
Tanytarsus guerlus gr.			1																					
Thienemanniella sp.																		1						
Thienemanniella xena														1										
Thienemannimyia gr. spp.	3	5	3	7	5	3	6	4	4		1						3	7	7	3		1		
Tipula sp.	1	3	1	1	2	1	2	4	1		2	5					1			1	1		1	2
Tvetenia bavarica gr.	3		1										3	1					1		3	1	1	1
Tvetenia vitracies	2	2	8		4	11	3	8							1	2	7	3	8	4				

Genus species	Location-Station, Replicate																						
	FICR-0.9, 1	FICR-0.9, 2	FICR-0.9, 3	FICR-0.9, 4	MARO-1.9, 1	MARO-1.9, 2	MARO-1.9, 3	MARO-1.9, 4	ORCE-2.2, 1	ORCE-2.2, 2	ORCE-2.2, 3	ORCE-2.2, 4	ORCO-2.1, 1	ORCO-2.1, 2	ORCO-2.1, 3	ORCO-2.1, 4	OTER-0.6, 1	OTER-0.6, 2	OTER-0.6, 3	OTER-0.6, 4	OTER-10.8, 1	OTER-10.8, 2	OTER-10.8, 3	OTER-10.8, 4
Undet. Tubificidae w/o cap. setae									4	1	9	1	2				1	1				4	3	2
Undetermined Branchiobdellidae				1																				
Undetermined Ceratopogonidae											1													
Undetermined Enchytraeidae							1		1						1									
Undetermined Heptageniidae		1		3																				
Undetermined Hirudinea							1	1																
Undetermined Naididae									1	6	2	3						1	2	3				
Undetermined Pisidiidae											2	1												
Undetermined Planorbidae											1													
Undetermined Tabanidae												1												
Undetermined Turbellaria									28	31	27	12				1	3	5	4		14	12	10	5
Xenochironomus xenolabis					2	1	2	1																
Zavreliella sp.								1																

Genus species	Location-Station, Replicate																						
	ORCH-0.2, 1	ORCH-0.2, 2	ORCH-0.2, 3	ORCH-0.2, 4	ORCH-1.3, 1	ORCH-1.3, 2	ORCH-1.3, 3	ORCH-1.3, 4	ORCH-12.2, 1	ORCH-12.2, 2	ORCH-12.2, 3	ORCH-12.2, 4	ORCH-21.6, 1	ORCH-21.6, 2	ORCH-21.6, 3	ORCH-21.6, 4	ORCH-36.2, 1	ORCH-36.2, 2	ORCH-36.2, 3	ORCH-36.2, 4	ORCH-9.3, 1	ORCH-9.3, 2	ORCH-9.3, 3	ORCH-9.3, 4
Ablabesmyia sp.			4			4	12																	
Amnicola sp.			4	4																				
Ancyronyx variegatus																			2					
Argia sp.					8																			
Baetis flavistriga									8	8	13	16	3	6	5	11					5	2		5
Baetis pluto																							1	
Bezzia sp.			4																					
Caecidotea sp.													5	3	1	4							1	
Caenis sp.	12		4															2						
Cardiocladius obscurus																							2	
Ceratopsyche sparna									14	14	10	14	21	24	12	19					28	19	11	16
Cheumatopsyche sp.									1	3	2	2	8	8	9	4						3	8	3
Chimarra obscura														2							1	1	2	
Chironomus sp.																	8	4		18				
Cricotopus bicinctus							4									1							2	2
Cricotopus sp.					8	12																		
Cricotopus trifascia gr.										1	4	1		1		1					2	5		
Cryptochironomus sp.																			4					
Cyrnellus sp.					12																			
Dicrotendipes modestus	28	12	8	28	8	8	12	12																
Dicrotendipes neomodestus	36	68	16	48	28	16	12	20																
Dicrotendipes simpsoni		12	12			4	4										118	84	54	80				

Genus species	Location-Station, Replicate																							
	ORCH-0.2, 1	ORCH-0.2, 2	ORCH-0.2, 3	ORCH-0.2, 4	ORCH-1.3, 1	ORCH-1.3, 2	ORCH-1.3, 3	ORCH-1.3, 4	ORCH-12.2, 1	ORCH-12.2, 2	ORCH-12.2, 3	ORCH-12.2, 4	ORCH-21.6, 1	ORCH-21.6, 2	ORCH-21.6, 3	ORCH-21.6, 4	ORCH-36.2, 1	ORCH-36.2, 2	ORCH-36.2, 3	ORCH-36.2, 4	ORCH-9.3, 1	ORCH-9.3, 2	ORCH-9.3, 3	ORCH-9.3, 4
Dreissena polymorpha	2588	1968	2216	1280	2240	1584	1072	1048									2	10	8	6				
Dugesia sp.	12	8		4		16	20	16			1		2	1										
Einfeldia sp.	4	4	4	4	4																			
Enallagma sp.	12		4				8										6	14	14	20				
Eukiefferiella devonica gr.																1								
Ferrissia sp.							4	4																
Fossaria sp.									1							1								
Gammarus fasciatus		8																						
Gammarus sp.			4	8					7	9	11	7	3	2	10	4					5	8	7	8
Glyptotendipes sp.	356	256	388	240	28	164	44	36	2	3		1					372	478	396	618	1			
Goniobasis sp.										2												1	2	
Haliplus sp.								16																
Helisoma sp.		12		4		60	48											2	8					
Hemerodromia sp.									1			1												
Heptagenia sp.																						2		
Heterocloeon sp.									2	1														
Hydropsyche betteni										1		1		1	1	1								
Hydroptila sp.						4		12	4	6	4	4		1							3	2		3
Ischnura sp.		4																						
Maccaffertium terminatum									4		1													
Micropsectra sp.					4																			
Microtendipes pedellus gr.							4		2	2					1									2
Nais bretscheri		8																						

Genus species	Location-Station, Replicate																							
	ORCH-0.2, 1	ORCH-0.2, 2	ORCH-0.2, 3	ORCH-0.2, 4	ORCH-1.3, 1	ORCH-1.3, 2	ORCH-1.3, 3	ORCH-1.3, 4	ORCH-12.2, 1	ORCH-12.2, 2	ORCH-12.2, 3	ORCH-12.2, 4	ORCH-21.6, 1	ORCH-21.6, 2	ORCH-21.6, 3	ORCH-21.6, 4	ORCH-36.2, 1	ORCH-36.2, 2	ORCH-36.2, 3	ORCH-36.2, 4	ORCH-9.3, 1	ORCH-9.3, 2	ORCH-9.3, 3	ORCH-9.3, 4
Nais sp.	16	32	16	20	12	4	4	12									8		8	8				
Nais variabilis	152	28	80	28	52	28	24	32									8	20	8	16				
Nanocladius sp.	4		4		4		4	8																
Neureclipsis sp.		56	32	100		12	108	64									2	4	6	12				
Nyctiophylax sp.	4																							
Oecetis sp.		4				4	4		2		1	1												
Optioservus sp.										1														
Orthotrichia sp.		8	16	12	12	4		4																
Parachironomus frequens													1											
Parachironomus sp.	4	4	12	4	8	8	12	4																
Paragnetina media										1				1							1			
Paratanytarsus sp.	8	20	20	4	24	24	16	20									4							
Paratendipes sp.																			4	6				
Physella sp.			4					4																
Pisidium sp.										2	2		4	5	1	2					1	2	3	
Plauditus sp.																					4	7	6	13
Polypedilum flavum	8				12	12	16	4	11	14	8	10	20	21	30	24					11	13	16	8
Polypedilum illinoense						4														12				
Polypedilum laetum	4			4																			1	
Polypedilum sp.				4																				
Polypedilum tritum				4																				
Pristinella sp.												1				1								
Psephenus herricki									1	1						1					3	1	1	1

Genus species	Location-Station, Replicate																						
	ORCH-0.2, 1	ORCH-0.2, 2	ORCH-0.2, 3	ORCH-0.2, 4	ORCH-1.3, 1	ORCH-1.3, 2	ORCH-1.3, 3	ORCH-1.3, 4	ORCH-12.2, 1	ORCH-12.2, 2	ORCH-12.2, 3	ORCH-12.2, 4	ORCH-21.6, 1	ORCH-21.6, 2	ORCH-21.6, 3	ORCH-21.6, 4	ORCH-36.2, 1	ORCH-36.2, 2	ORCH-36.2, 3	ORCH-36.2, 4	ORCH-9.3, 1	ORCH-9.3, 2	ORCH-9.3, 3	ORCH-9.3, 4
Pseudochironomus sp.	4						4																
Rheotanytarsus exiguus gr.	8	8		4	60	60	28	16											4				
Simulium sp.									15	14	24	20	12	7	6	9					14	16	17	12
Sphaerium sp.									4	3	1	4	13	11	6	8					2			6
Stenacron interpunctatum					4																			
Stenelmis crenata									1	1	5	2	2		1	2					3	4	5	4
Stenelmis sp.									9	6	4	5	6	4	7	4					6	6	5	5
Stenochironomus sp.		16	4	28	8	8	44	20																
Stenonema femoratum		4	4		4	16	16	8																
Stylaria lacustris	8	4	12		36	32	16	12																
Tanytarsus guerlus gr.	4	4	8	16	4		4																	
Tanytarsus sp.							12																	
Thienemanniella lobapodema					4		4																	
Thienemanniella sp.				4	4			4																
Thienemannimyia gr. spp.						12	8	4	3	1	2	1			1						1	1	2	2
Tipula sp.															1									
Tribelos/Endochironomus/Phaenops ectra Co	28	52	44	20	4	24	28	4																
Tricorythodes sp.					44	32	12	24		1	1	1									2	1	5	
Tvetenia vitracies									5	4	5	4				1					4	3		3
Undet. Tubificidae w/o cap. setae									1	1	1	3			1							1		1
Undetermined Baetidae									1															
Undetermined Branchiobdellidae																								1
Undetermined Cambaridae																					1			1

Genus species	Location-Station, Replicate																							
	ORCH-0.2, 1	ORCH-0.2, 2	ORCH-0.2, 3	ORCH-0.2, 4	ORCH-1.3, 1	ORCH-1.3, 2	ORCH-1.3, 3	ORCH-1.3, 4	ORCH-12.2, 1	ORCH-12.2, 2	ORCH-12.2, 3	ORCH-12.2, 4	ORCH-21.6, 1	ORCH-21.6, 2	ORCH-21.6, 3	ORCH-21.6, 4	ORCH-36.2, 1	ORCH-36.2, 2	ORCH-36.2, 3	ORCH-36.2, 4	ORCH-9.3, 1	ORCH-9.3, 2	ORCH-9.3, 3	ORCH-9.3, 4
Undetermined Coenagrionidae					4																			
Undetermined Heptageniidae	4																						2	1
Undetermined Hirudinea					6	4	4	12							1				2					
Undetermined Naididae				8													6	2		10				
Undetermined Simuliidae														2	2									
Undetermined Turbellaria					16							1			4	1					2	2	1	3
Viviparus georgianus									1															
Xenochironomus xenolabis						4																		

Table 6. Estimated percentage of phosphorus loads from potential sources in Oak Orchard Creek watershed within the sample station sub-basins. Data derived from TMDL-Lite analysis.

Sample Stations	Sub-basin size (sq miles)	Developed land (%)	Forest (%)	Agriculture (%)	Onsite septic (%)	Point source (%)
ORCH0.2	270	3	4	83	1	9
FICR0.9	18.4	2	3	94	1	0
ORCE2.2	3	3	2	51	1	43
MARO1.9	26.7	7	4	88	1	0
ORCH1.3	231	3	4	82	1	10
ORCH12.2	191.5	3	4	80	1	12
ORCH21.6	148	3	5	82	1	10
ORCH36.2	62	3	4	88	1	4
ORCH9.3	201	3	4	81	1	11
ORCH2.1	18.8	3	1	57	<1	38
OTER0.6	21	3	4	92	2	0
OTER10.8	10.4	2	5	92	1	0