State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of the Grand River Basin

Hydrologic Units 04110004 010, 04110004 020, 04110004 030, and 04110004 040,

Ashtabula, Geauga, Portage and Trumbull Counties

June 4, 2009

Ted Strickland, Governor, State of Ohio
Chris Korleski, Director

Biological and Water Quality Study of the Upper Grand River Watershed 2007

Ashtabula, Geauga, Portage and Trumbull Counties
Counties

June 4, 2009

OHIO EPA Technical Report EAS/2009-6-5

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NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio’s surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents, the following new publications by the Ohio EPA have become available. These publications should also be consulted as they represent the latest information and analyses used by the Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

These documents and this report may be obtained by writing to:

Ohio EPA, Division of Surface Water
Ecological Assessment Section
4675 Homer Ohio Lane
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ACKNOWLEDGMENTS

Study Area Description – Bob Miltner
Pollutant Loadings – Scott Winkler
Chemical Water Quality – Scott Winkler, Bob Miltner
Sediment Quality – Paul Anderson, Bob Miltner
Physical Habitat – Bob Miltner
Biological Assessment:
    Macroinvertebrate community – Ed Moore, Jack Freda
    Fish community – Bob Miltner
Data Management - Dennis Mishne
Reviewers – Marc Smith, Jeff DeShon, Mike Galloway

Water chemistry analysis was provided by the Ohio EPA division of Environmental Services. Numerous college interns and district office staff assisted in the collection of field samples. Landowners who granted permission for site access are duly appreciated.

Copies of this report are located on the Ohio EPA internet web page (www.epa.state.oh.us/dsw/document_index/psdindx.html) or may be available on CD from:

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FOREWORD

What is a Biological and Water Quality Survey?

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 4-5 watersheds study areas with an aggregate total of 250-300 sampling sites.

The Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by Ohio EPA (*e.g.,* NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]), and are eventually incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators (Figure i). The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or

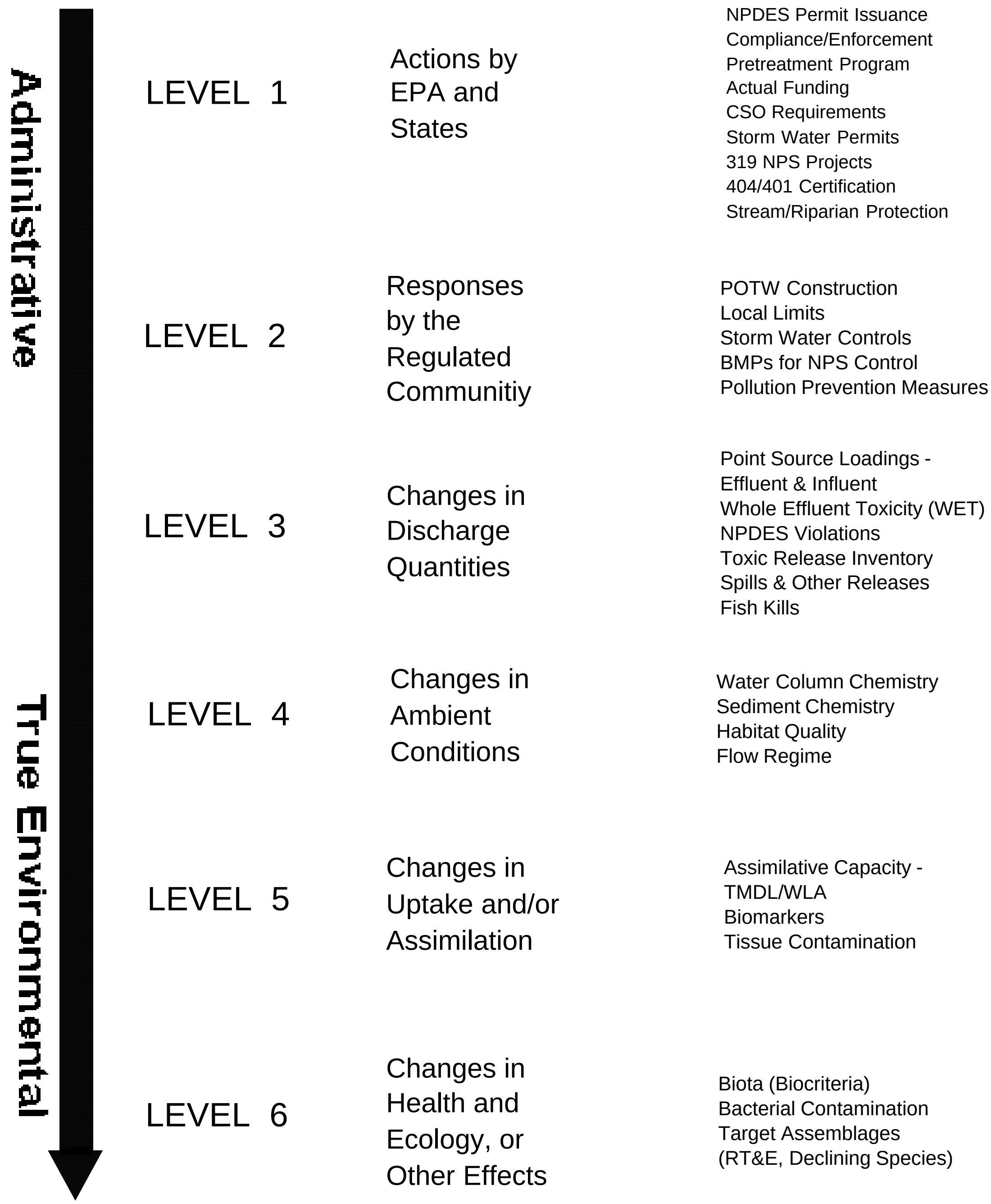

Figure i. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition. Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreation uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Use

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.*

3) *Coldwater Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi^2 drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.,* true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a "tiered" approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use can be having a water depth of at least one meter over an area of at least 100 square feet or, lacking this, where frequent human contact is a reasonable expectation. If a water body does not meet either criterion, the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliform, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Attainment of recreation uses are evaluated based on monitored bacteria levels. The Ohio Water Quality Standards state that all waters should be free from any public health nuisance associated with raw or poorly treated sewage (Administrative Code 3745-1-04, Part F). Additional criteria (Administrative Code 3745-1-07) apply to waters that are designated as suitable for full body contact such as swimming (PCR- primary contact recreation) or for partial body contact such as wading (SCR- secondary contact recreation). These standards were developed to protect human health, because even though fecal coliform bacteria are relatively harmless in most cases, their presence indicates that the water has been contaminated with fecal matter.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The AWS and IWS use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health.

Introduction

A biological and water quality survey of the Upper Grand River watershed was conducted in 2007. The geographic scope of the survey included the drainage basin upstream from the confluence with Mill Creek (Ashtabula County), and comprised four hydrologic units (see **Study Area** for a description of the hydrologic units). Objectives of the survey were to determine the status of aquatic life uses, assign causes and sources of impairment where appropriate (Table 1), assess performance of National Pollution Discharge Elimination System (NPDES) permitted dischargers, and support development of Total Maximum Daily Loads for stream segments identified as impaired or threatened. Recommended changes and additions to aquatic life uses are summarized in Table 1.

The following publicly owned wastewater treatment plants were bracketed with biological and water quality samples:

Facility	Receiving Stream
The Village of Orwell	Grand River via unnamed tributary at RM 62.6
The Village of Rock Creek	Rock Creek
The Village of Parkman	Grand River

The findings of this evaluation factor into regulatory actions taken by the Ohio EPA (e.g., NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]) and are incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

Executive Summary

CAUSES AND SOURCES - The condition of biological communities in the upper Grand River basin is governed principally by post-glacial physiography. Briefly, the upper Grand River valley was carved by a glacier, and became a lake in the immediate wake of glacial retreat. The dominant feature of the catchment now is the glacial lake-plain and lacustrine deposits that fill the valley. This has essentially resulted in three classes of streams: lowland streams, upland headwaters, and the non-wadeable Grand River mainstem. The lowland streams flank the eastern and southern edges of the valley. The upland headwaters drain from the west, but become lowland streams in character as they flow through the lacustrine deposits of the valley floor. Because the lowland streams are sluggish and have fine-grained substrates, they cannot, in all cases, be reasonably expected to support biological communities typical of the ecoregion. This is especially the case where substrates are composed primarily of muck, silt and clay. At the other extreme, some of the headwaters drain areas where bedrock is very close to the surface, and consequently, flow is not sustained through the summer because the shallow soil horizon does not store water. Apart from these natural limitations, some of the sites evaluated in the upper watershed were convincingly impacted by pollution or loss of habitat (Table 1; Figure 1). Of the nine sites with defined impairments, three were due to habitat alterations, three were starved of flow by impoundments, two were impaired by organic enrichment from on-site sewerage, and one from a combination of high TDS and organic enrichment.

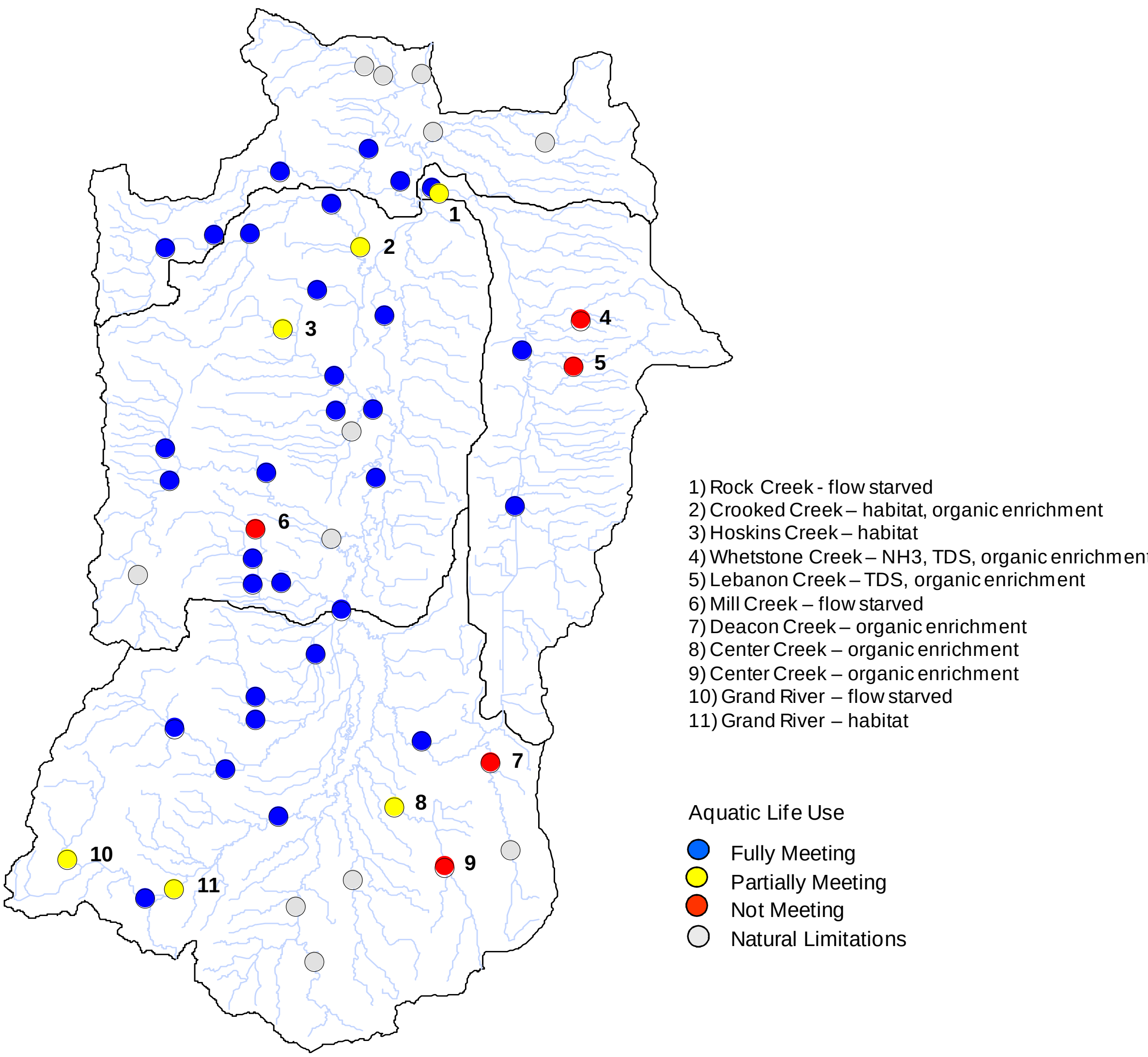

Figure 1. Attainment status of aquatic life use for sites assessed during the 2007 biological and water quality survey of the upper Grand River basin. The legend lists specific locations where the aquatic life use was not met and the given primary cause of non-attainment was unambiguously linked to anthropogenic sources.

Table 1. Aquatic life use attainment status of sites sampled during 2007 biological and water quality survey of upper Grand River basin, relative to the existing or recommended use (noted as by the table header ALU). Where the aquatic life use in not met, the cause(s) for impairment is listed. Scoring criteria are for the Erie-Ontario Lake Plain. Acronyms are: QHEI, Qualitative Habitat Evaluation Index; ICI, Invertebrate Community Index; IBI Index of Biotic Integrity; MIWb, Modified Index of Well-being; ALU, aquatic life use (existing/recommended). Numeric scores failing criterion are noted with an asterisk. Narrative[b] scores for the ICI are based on qualitative samples and are abbreviated as E, exceptional; VG, very good; G, good; F, fair; P, poor; and VP, very poor. Fair scores fail the WWH criterion, good scores fail the EWH criterion.

RM	STORET	Drainage Area	QHEI	Coldwater Bugs	ICI	IBI	MIWb[a]	ALU Existing/Proposed	Status	CAUSES/Notes[c]
04110004010										
03-001	Grand River									
98.95	200631	6.8	75.0	11	E	28[†]	NA	WWH/CWH	Partial	Habitat - Dams
95.38	G01S07	14.1	80.5	2	E	56	NA	EWH	Full	
94.27	G01K09	15.2	58.0	1	E	40*	NA	EWH	Partial	Habitat - Bridge Construction
88.50	G01K20	32.1	71.0	0	54	50	8.0	WWH	Full	
03-022	Baughman Creek									
3.30	G02S06	15.5	67.5	3	58	46	NA	WWH	Full	
03-023	Center Creek									
6.25	300174	6.4	43.5	0	F	30*	NA	WWH	Non	NH3, TKN, TDS - Unsewered
3.03	G01K13	11.6	56.0	0	G	28*	NA	WWH	Partial	Wetlands, Residual impact from upstream
03-024	Mud Run									
4.05	300172	8.5	53.0	0	F	22*	NA	WWH	Non	Natural - Wetlands

Table 1. Continued.

RM	STORET	Drainage Area	QHEI	Coldwater Bugs	ICI	IBI	IWB2	ALU Existing/Proposed	STATUS	CAUSES/Notes
03-025	Dead Branch									
7.86	300170	4.8	0.0	0	P		NA	WWH	-	Natural - Wetlands
4.10	300169	12.7	0.0	0	LF		NA	WWH	-	Natural - Wetlands
03-046	Deacon Creek									
5.31	300176	5.2	0.0	0	P		NA	WWH	-	Natural - Wetlands
1.38	300175	9.3	53.0	0	P	26*	NA	WWH	Non	Low flow, Organic Enrichment
03-160	Swine Creek									
10.40	300178	6.5	71.0	7	E	54	NA	CWH	Full	
8.18	G01K16	11.8	72.5	5	E	52	NA	CWH	Full	
1.72	200628	18.0	54.5	0	G	44	NA	WWH	Full	
03-162	Andrews Creek									
3.62	300179	6.0	68.0	1	G	38	NA	WWH	Full	
03-163	Plum Creek									
1.48	300180	1.3	53.0	6	F†	40	NA	CWH	Full	Natural - Low Flow

Table 1. Continued.

RM	STORET	Drainage Area	QHEI	Coldwater Bugs	ICI	IBI	IWB2	ALU Existing/Proposed	STATUS	CAUSES/Notes
04110004020										
03-001	Grand River									
75.58	300209	126.2	58.0	0	MG	46	8.4	WWH	Full	
65.88	G01W06	212.0	60.0	0	40	45	8.8	WWH	Full	
60.80	G01K07	232.0	0.0	0	40		NA	WWH	(Full)	
55.62	G01K08	251.0	59.0	0	36	49	8.4	WWH	Full	
03-017	Crooked Creek									
6.70	300182	3.2	80.0	1	G	38	NA	CWH	Full	
3.51	300181	6.9	82.5	9	E	58	NA	EWH/CWH	Full	
1.62	G01K01	9.3	55.0	0	G	32	NA	WWH	Partial	Channelization, Habitat
03-018	Mud Creek									
3.78	300188	1.7	0.0	4	G		NA	WWH	-	
03-019	Mill Creek									
4.94	300186	2.8	69.0	0	P	26*	NA	PHWH or WWH?	Non	Flow starved - dst impoundment
2.30	300185	8.9	68.5	4	VG	44	NA	EWH/CWH	Full	
03-020	Garden Creek									
2.31	300183	1.0	62.0	2	G	38	NA	WWH	Full	
03-048	Trib to Mill @ RM 3.79									
0.13	300191	3.5	0.0	2	G		NA	WWH	-	

Table 1. Continued.

RM	STORET	Drainage Area	QHEI	Coldwater Bugs	ICI	IBI	IWB2	ALU Existing/Proposed	STATUS	CAUSES/Notes
03-049	Trib to Crooked @ RM 6.50									
0.29	300194	1.9	0.0	3	F		NA	PHWH		
03-140	Hoskins Creek									
4.88	300184	5.7	63.5	4	G	32†	NA	EWH/CWH	Partial	Channelization along US 6
2.01	G01K19	13.5	62.0	5	E	46	NA	EWH/CWH	Full	
03-141	Indian Creek									
1.30	200624	1.8	79.5	8	E	58	NA	EWH/CWH	Full	
03-143	Trib to Hoskins @ RM 0.4									
1.40	300196	7.2	0.0	0	F		NA	WWH	-	Natural - Wetlands
03-144	Trib to Hoskins @ RM 2.45									
1.15	300197	2.0	0.0	4	MG		NA	PHWH/CWH		
03-150	Phelps Creek									
4.90	300190	23.5	73.5	3	E	36†	7.4†	EWH/CWH	Partial/Full	Redesignated to CWH
1.23	G01K06	25.8	65.0	2	60	45	7.7	EWH/WWH	Partial/Full	Segment previously unsampled, meets WWH
03-151	North Branch Phelps Creek									
1.10	300189	6.3	66.5	2	E	38	NA	WWH	Full	Needs follow up monitoring, pond construction
03-152	South Branch Phelps Creek									
5.20	300193	4.7	69.5	0	-	34*	NA	WWH	Partial	Natural - Low Flow
0.58	300192	11.8	73.5	1	G	44	NA	WWH	Full	

Table 1. Continued.

RM	STORET	Drainage Area	QHEI	Coldwater Bugs	ICI	IBI	IWB2	ALU Existing/Proposed	STATUS	CAUSES/Notes
04110004030										
03-130	Rock Creek									
9.64	G01W02	52.0	61.5	0	E	45	7.4	WWH	Full	
1.23	G01K03	70.0	50.5	0	44	41	7.2*	WWH	Partial	Flow starved, Nutrients
0.95	G01W05	70.0	68.5	0	44	40	8.2	WWH	Full	
03-133	Whetstone Creek									
2.00	300200	5.9	51.5	0	F	30	NA	WWH	Non	TDS, NH3/source unknown
03-134	Lebanon Creek									
1.93	300198	4.0	50.5	2	F	28	NA	WWH	Non	TDS, Nutrients/source unknown
03-138	Snyder Ditch									
0.60	300199	29.0	50.0	0	46	34	6.4	MWH	Full	

Table 1. Continued.

RM	STORET	Drainage Area	QHEI	Coldwater Bugs	ICI	IBI	IWB2	ALU Existing/Proposed	STATUS	CAUSES/Notes
04110004040										
03-001	Grand River									
49.45	G02K54	323.0	64.5	0	52	56	9.2	WWH	Full	
45.90	G02W16	417.0	59.0	0	48	46	8.6*	EWH	Partial	Natural - Wetlands
03-012	Bronson Creek									
1.52	300201	5.2	60.0	1	F	38	NA	WWH	Partial	Natural - Low Flow
0.82	G02K50	7.5	77.5	5	F	52	NA	WWH	Partial	Natural - Low Flow
03-013	Trumbull Creek									
9.03	300205	2.7		0	P		NA	PHWH		Natural - Low Flow
6.23	300204	13.1	69.0	5	E	40†	NA	EWH/CWH	Full	
2.05	G02K51	19.6	70.5	1	48	44	NA	WWH	Full	
03-014	Spring Creek									
5.02	300202	1.9	76.0	3	VG	48	NA	WWH	Full	Has coldwater potential if restored
2.76	300207	6.5	61.5	0	G	36	NA	WWH	Full	Has coldwater potential if restored
03-015	Three Brothers Creek									
6.68	300203	5.8	66.5	1	F	44	NA	WWH	Partial	Natural - Low Flow/Salamander present
1.99	300208	8.4	72.5	1	F	44	NA	WWH	Partial	Natural - Low Flow

Table 1. Continued.

	IBI		MIWb		ICI	
	WWH	EWH	WWH	EWH	WWH	EWH
Headwaters	40	50	NA	NA	34	46
Wadeable	38	50	7.9	9.4	34	46
Boat	40	50	8.7	9.6	34	46

a- MIwb is not applicable to headwater streams with drainage areas < 20 mi2.
b- A qualitative narrative evaluation based on community composition, EPT taxa richness, and QCTV scores.
c- Causes and Sources listed are considered to be a primary influence on water quality, but may not be the only issue leading to impairment. See text for discussion of additional causes that cumulatively have led to impairment.
* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb uits).
ns - Nonsignificant departure from biocriteria (<4 IBI or ICI units, or <0.5 MIwb units).
† - Coldwater Aquatic Life Use (existing or proposed) - biological criteria do not apply. Attainment status is qualitatively based on narrative assessment of the number of coldwater macroinvertebrate and/or fish taxa, their relative abundance, and the presence of salamanders.

Recommendations - Hydrologic Unit 04110004 010

Status of Non-aquatic Life Uses

All non-aquatic life uses should remain as presently designated in the Ohio Water Quality Standards for all of the waters surveyed within the hydrologic unit. For those not presently designated, industrial water supply, agricultural water supply, and primary contact recreational use are appropriate designations.

03-001 GRAND RIVER

Status of Aquatic Life Uses

Within the 010 hydrologic unit, the Grand River transitions rapidly from a small, upland, coldwater stream to a large, lowland swamp stream. As such, three aquatic life uses are appropriate. Upstream from the north crossing of US 422 (RM 98.95), the stream supports 11 coldwater macroinvertebrates, clearly demonstrating the CWH use. However, the fish community was intractably limited because the reach is bracketed by two impoundments, isolating the fish community and leaving the reach flow starved by the impoundment at SR 168. Downstream from the Village of Parkman, the stream transitions to an upland stream that supports an exceptional community. The habitat at Hobart Road (RM 94.3) appeared to have been destabilized by bridge construction, and the fish community narrowly missed the EWH criterion. In the absence of new or continuing stress, the habitat and community should recover in this reach.

As the stream approaches West Farmington, it transitions to a lowland, warmwater stream. The reach near West Farmington supports two rare fish species, the sand darter and northern brook lamprey. Near the hydrologic unit boundary, at County Line Donley Road, the river begins to support a fauna typical of larger streams and rivers including redhorse suckers and walleye. In supporting a native population of walleye, sand darters and northern brook lamprey, the river is exceptional indeed, if not in the ability to achieve biological index scores meeting the EWH criteria.

Other Recommendations and Future Monitoring Concerns

The site at Hobart Road should be revisited in several years to ascertain whether the habitat and fish community have passively recovered. The presence of rare species and a native population of walleye suggests that the reach through and downstream from West Farmington should be considered for the Superior High Quality Water antidegradation tier.

03-022 BAUGHMAN CREEK

Status of Aquatic Life Uses

Baughman Creek is designated WWH. The fish and macroinvertebrate communities sampled at Fenton Road met respective criterion for WWH. Upstream from Fenton Road, a lens of sandy loam soil provides sustained baseflow, thus enabling a high quality biological community to exist in the stream despite habitat rendered marginal via historic and recent channelization.

Other Recommendations and Future Monitoring Concerns

In the absence of chemical pollutants, streams with baseflow sustained by groundwater tend to do well and are resilient to occasional habitat perturbations. However, channelization should be discouraged, and sustainable channel designs encouraged, given the presence of northern brook lamprey and several declining species. Baughman Creek is listed as a Superior High Quality Water for antidegradation.

03-023 CENTER CREEK

Status of Aquatic Life Uses

Center Creek has an unverified WWH designation. Although habitat quality has been degraded by historic channelization, substrates and soils in the surrounding sub-catchment are gravelly, and consequently, the creek should be able to support a WWH assemblage. Apart from poor habitat, the fish and macroinvertebrate communities sampled at Corey Hunt Road (RM 3.03) and SR 45 (RM 6.25) were limited due to organic enrichment, possibly from Paradise Lake mobile home park and unsewered homes along Housel Craft Road, Corey Hunt Road, and SR 45.

Other Recommendations and Future Monitoring Concerns

The feasibility of sanitary sewers for Bristol Township should be investigated.

03-024 MUD RUN

Status of Aquatic Life Uses

Mud Run has an unverified WWH designation. Although the reach sampled had not been extensively modified for drainage, natural limitations imposed by clay substrates, low gradient, and lack of sustained flow during the summer effectively imparted modified characteristics to the stream, which appears to preclude biological communities that are consistent with expectations for a typical warmwater stream.

Other Recommendations and Future Monitoring Concerns

Development of scoring expectations for swamp/wetland streams would help to objectively place this stream along the bio-condition gradient.

03-025 DEAD BRANCH

Status of Aquatic Life Uses

Dead Branch has an unverified WWH use. The stream is a swamp stream that has natural limitations imposed by clay substrates and low gradient.

Other Recommendations and Future Monitoring Concerns

Development of scoring expectations for swamp/wetland streams would help to objectively place this stream along the bio-condition gradient.

03-046 DEACON CREEK

Status of Aquatic Life Uses

Deacon Creek is presently undesignated in Chapter 3745-1-10 of the Ohio Administrative Code. The site located at Shaffer Road (RM 5.31) was a wetland. At Hyde Oakfield Road (RM 1.38), the creek was not flowing at the time the fish sample was collected. Also, the potential for the stream to support biological communities typical of the ecoregion was naturally limited by hardpan and silt substrates of lacustrine origin. That said, both the fish and macroinvertebrate indicators scored in the poor range, coincident with high concentrations of the ammonia nitrogen and total Kjeldahl nitrogen, suggesting organic enrichment may have been an additional stress.

Other Recommendations and Future Monitoring Concerns
Development of scoring expectations for swamp/wetland streams would help to objectively place this stream along the bio-condition gradient. The issue of whether organic enrichment is an addition source of stress to Deacon Creek should be investigated.

03-160 SWINE CREEK
Status of Aquatic Life Uses
Swine Creek has a verified WWH designation based on samples collected in the lowland reach (downstream from Girdle Road, RM 7.1). Samples collected in the upland reach at Swine Creek Park Picnic Area (RM 10.4) and at Curtis Middlefield Road (RM 8.2) demonstrate that a CWH use is appropriate given the presence of five or more coldwater macroinvertebrate taxa and mottled sculpin at both sites.

Other Recommendations and Future Monitoring Concerns
The coldwater character of Swine Creek could be enhanced with riparian restoration in the reach along Swine Creek Road, especially between RM 10.3 and 11.2, and with aggressive stormwater management for the developed area centered near SR 528.

03-162 ANDREWS CREEK
Status of Aquatic Life Uses
Andrews Creek holds an unverified WWH designation. That use is appropriate based on the results of fish and macroinvertebrate samples collected at Girdle Road (RM 3.6).

03-163 PLUM CREEK
Status of Aquatic Life Uses
Plumb Creek has an unverified WWH designation. Results of samples collected at Girdle Road demonstrate that the Plum Creek is a cold water habitat stream, as six coldwater macroinvertebrate taxa and one coldwater fish species, the central mudminnow, were collected.

Recommendations - Hydrologic Unit 04110004020
03-001 GRAND RIVER
Status of Aquatic Life Uses
The entire reach of the Grand River mainstem through the 020 hydrologic unit has a verified WWH designation. That use was fully met at the four locations sampled within the reach.

Other Recommendations and Future Monitoring Concerns
The Grand River is one of the few streams in Ohio that supports self-sustaining, native populations of walleye and muskellunge, both highly valued sport fish. As such, this reach should be considered for the SHQW antidegradation tier.

03-017 Crooked Creek

Status of Aquatic Life Uses
Crooked Creek has a verified EWH use based on a fish sample collected at Windsor Mechanicsville Road. Samples collected in 2007 demonstrate by the presence of nine coldwater macroinvertebrate taxa and mottled sculpin indicate that upstream from Windsor Mechanicsville Road (RM 2.5), a CWH use is appropriate, and downstream, where the creek flows through the lacustrine lowlands, a WWH use is appropriate.

Other Recommendations and Future Monitoring Concerns
The site at Callahan Road (RM 6.7) underperformed its potential, given the high quality of physical habitat present. Logging in the watershed upstream from Callahan Road may have been responsible.

03-018 Mud Creek

Status of Aquatic Life Uses
Mud Creek has an unverified WWH designation. Field observations and results of a macroinvertebrate sample collected at Higley Road (RM 3.78), where the drainage area was 1.7 square miles, suggest that the reach sampled was primary headwaters, and should be reassessed for Primary Headwater Habitat status.

03-019 Mill Creek (Windsor Township)

Status of Aquatic Life Uses
Mill Creek has a verified EWH use based on one fish sample collected at SR 534. Results from fish and macroinvertebrate samples collected in 2007 indicate that a CWH use is appropriate for the reach upstream from SR 534 (RM 1.7) to RM 3.5. The stream at Wiswell Road (RM 4.9) may have been flow starved by an impoundment at Cox Road. The drainage area, however, was 2.8 mi^2. Downstream from SR 534, where the creek enters the lacustrine lowlands, a WWH use is appropriate.

Other Recommendations and Future Monitoring Concerns
The effect the impoundment at Cox Road has on stream flow should be examined to better define the boundary between primary headwaters and CWH.

03-020 Garden Creek

Status of Aquatic Life Uses
Garden Creek has an unverified WWH designation. Based on fish and macroinvertebrate samples collected at Girdle Road (RM 2.3), the WWH use is a good fit.

03-048 TRIBUTARY TO MILL @ RM 3.79

Status of Aquatic Life Uses

This stream is not listed in Chapter 3745-1-10 of the Ohio Administrative Code. The site at Girdle Road (RM 0.1), based a macroinvertebrate sample, was transitional between primary headwater habitat and warmwater habitat, as such, the reach should be reassessed for Primary Headwater Habitat status.

03-049 TRIB TO CROOKED @ RM 6.50

Status of Aquatic Life Uses

The macroinvertebrate sample collected at Callender Road indicated that this stream should be considered primary headwaters and re-evaluated for PHWH status.

03-140 HOSKINS CREEK

Status of Aquatic Life Uses

Hoskins Creek has a verified EWH designation base on one fish sample collected at Windsor Mechanicsville Road (RM 1.7). Fish and macroinvertebrate samples collected at two locations in 2007 demonstrate that a CWH use is a better fit given that four or more coldwater macroinvertebrate taxa were collected at both sites, along with mottled sculpin. The fish sample collected upstream from SR 534 and downstream US 6 underperformed relative to the available habitat. The stream is channelized upstream from US 6 and lacks riparian cover.

Other Recommendations and Future Monitoring Concerns

The feasibility of riparian restoration for the reach running alongside US 6 should be explored.

03-141 INDIAN CREEK

Status of Aquatic Life Uses

Indian Creek is designated EWH based on one fish sample collected at Noble Road (RM 1.4). Results of fish and macroinvertebrate samples collected downstream from Noble Road at RM 1.3 in 2007 demonstrate that a CWH use is more appropriate given the presence of 8 coldwater macroinvertebrate taxa, and redside dace and mottled sculpin.

Other Recommendations and Future Monitoring Concerns

As high-quality coldwater streams are rare in Ohio, periodic monitoring and careful stewardship of the catchment is warranted.

03-143 TRIBUTARY TO HOSKINS @ RM 0.4

Status of Aquatic Life Uses

This stream is undesignated in Chapter 3745-1-10 of the Ohio Administrative Code. Insufficient information exists on which to assign an aquatic life use as the drainage area for the location sampled was greater than 5 mi^2, and the fish community was not evaluated.

Other Recommendations and Future Monitoring Concerns
Sampling at Noble Road is recommended to determine the proper use.

03-144 TRIB TO HOSKINS @ RM 2.45
Status of Aquatic Life Uses
The macroinvertebrate sample and field observations from the site at SR 534 (RM 1.15) determine that this stream is primary headwaters supporting four coldwater macroinvertebrate taxa. As such, it should be revaluated as Primary Headwater Habitat (PHWH).

03-150 PHELPS CREEK
Status of Aquatic Life Uses
Phelps Creek is presently designated EWH based on a single fish sample collected at Wiswell Road (RM 4.9). Fish and macroinvertebrate samples collected in 2007 from Wiswell Road and Windsor Road Extension (T-525; RM 1.23) indicate that a CWH use is appropriate for the reach upstream from SR 534 (RM 2.1) given the combination of 3 coldwater macroinvertebrate taxa, plus redside dace and mottled sculpin. Downstream from SR 534, where the creek enters the lacustrine lowlands, a WWH use is more apt.

Other Recommendations and Future Monitoring Concerns
The effects of land development along US 322 on the creek should be monitored.

03-151 NORTH BRANCH PHELPS CREEK
Status of Aquatic Life Uses
The North Branch of Phelps Creek has a default WWH aquatic life use. Results of fish and macroinvertebrate samples collected at Huntely Road confirm this use.

Other Recommendations and Future Monitoring Concerns
Follow-up monitoring is needed to assess any potential impact to the stream from a pond constructed during the field survey immediately upstream Huntely Road.

03-152 SOUTH BRANCH PHELPS CREEK
Status of Aquatic Life Uses
The South Branch of Phelps Creek has a default WWH aquatic life use. Results of fish and macroinvertebrate samples collected adjacent to US 322 (RM 0.58) confirm this use. The reach sampled at Peters Road (RM 5.2) is transitional to primary headwater habitat.

Recommendations - Hydrologic Unit 04110004030
03-130 ROCK CREEK
Status of Aquatic Life Uses
Rock Creek has a verified WWH use. Biological samples collected adjacent to Footville Richmond Road (RM 0.95), and Dodgeville Road (RM 9.64) met WWH criteria. Samples

collected at SR 46 (RM 1.23), however, narrowly missed the standard for WWH because the stream was flow starved by Lake Roaming Rock. Additionally, nuisance levels of algae were present.

Other Recommendations and Future Monitoring Concerns
The feasibility of managing releases from Lake Roaming Rock should be investigated.

03-133 WHETSTONE CREEK
Status of Aquatic Life Uses
Whetstone Creek has an unverified WWH designation. Results of fish and macroinvertebrate samples collected near SR 46 (RM 2.00) documented that the WWH use was not being met. Habitat quality, though marginal, was sufficient to support a WWH fish assemblage. Water chemistry samples revealed high ammonia nitrogen and high total dissolved solid concentrations, suggesting that pollution was the cause of non-attainment.

Other Recommendations and Future Monitoring Concerns
Follow-up water chemistry monitoring in 2008 detected neither high ammonia nor high TDS concentrations. The source of the impairment remains unknown.

03-134 LEBANON CREEK
Status of Aquatic Life Uses
Lebanon Creek has an unverified WWH designation. Results of fish and macroinvertebrate samples collected at Institute Road (RM 1.93) documented that the WWH use was not being met despite marginally sufficient habitat. Water chemistry samples revealed high concentrations of total dissolved solids and nutrients, and supersaturating concentrations of dissolved oxygen.

Other Recommendations and Future Monitoring Concerns
The source of elevated nutrients and dissolved solids to Lebanon Creek was not identified.

03-138 SNYDER DITCH
Status of Aquatic Life Uses
Snyder Ditch is undesignated in Chapter 3745-1-10 of the Ohio Administrative Code. Poor habitat quality resulting from active channel maintenance, and the results of biological samples collected at Moore Road (RM 0.6) demonstrated that the aquatic life use should be Modified Warmwater Habitat (MWH).

Recommendations - Hydrologic Unit 04110004040
03-001 GRAND RIVER
Status of Aquatic Life Uses
The Grand River mainstem within hydrologic unit 040 is bounded on the south by the confluence with Rock Creek (RM 50.59) and to the north by Mill Creek (RM 41.28). The river transitions from a verified WWH use to a verified EWH use at Fobes Road (RM 44.7). Fish and

macroinvertebrate samples collected at Footville Richmond Road (RM 48.2), and a macroinvertebrate sample collected downstream from Riverdale Road at RM 45.9 fully supported the WWH use. A fish sample collected at Schweitzer Road (RM 42.4) partially met the EWH use. The partial attainment of the EWH was not related to pollution, it was due to natural limitations.

Other Recommendations and Future Monitoring Concerns
The Grand River is unique in having populations of walleye, northern pike and muskellunge inhabiting the same reach. The reason these species co-occur is because the habitat is largely intact, and the water unpolluted.

03-012 Bronson Creek

Status of Aquatic Life Uses
Bronson Creek has an unverified WWH use. Fish samples collected at Schweitzer Road (RM 0.82) and Windsor-Mechanicsville Road (RM 1.52) fully supported the WWH use. Qualitative macroinvertebrate samples collected at the same locations narrowly missed the WWH attainment due to interstitial flow. A WWH use for this stream is appropriate.

Other Recommendations and Future Monitoring Concerns
Because Bronson Creek is a bedrock stream and experiences critically low flows during the summer, it is especially sensitive to disturbance and pollution. Watershed protection, agricultural best management practices, and riparian restoration should be advanced.

03-013 Trumbull Creek

Status of Aquatic Life Uses
Trumbull Creek has a verified EWH use based on one fish sample collected at Windsor-Mechanicsville Road (RM 3.5). Results of biological samples and habitat assessments from three locations in 2007 demonstrate that a WWH use is best for the lowland reach downstream from Windsor-Mechanicsville Road, and a CWH use is appropriate from Windsor-Mechanicsville Road to the confluence with Spring Creek (RM 7.38). Upstream from Spring Creek, the creek transitions to primary headwater habitat.

Other Recommendations and Future Monitoring Concerns
Considerable potential exists to augment the coldwater character of Trumbull Creek, predicated on habitat protection and restoration, and riparian restoration in the primary headwaters.

03-014 Spring Creek

Status of Aquatic Life Uses
Spring Creek, despite its namesake, has a default WWH use. Fish and macroinvertebrate samples collected at Callahan Road (RM 2.76) and Legget Road (RM 5.02) demonstrate a CWH use at Legget Road, and WWH use at Callahan Road. The creek probably transitions back to a coldwater stream at some point before joining Trumbull Creek.

Other Recommendations and Future Monitoring Concerns
An impoundment on Spring Creek immediately upstream from Murphy Road (RM 4.1) is why the site at Callahan met criteria for a WWH use and not a CWH use. Further monitoring is needed to pin-down where the coldwater and warmwater segments begin and end.

03-015 THREE BROTHERS CREEK
Status of Aquatic Life Uses
Three Brothers Creek has an unverified WWH use. Results of fish and macroinvertebrate samples collected at Camp Beaumont (RM 1.99) and Stumpville Road (RM 6.68) suggest that a WWH use is suitable. Based on a WWH use, the fish community met at both sampling locations, but the macroinvertebrate community was rated as fair owing to intermittent flows.

03-015 Three Brothers Creek
Other Recommendations and Future Monitoring Concerns
Subregional scoring expectations for small, bedrock streams subject to low or intermittent flows in the summer need to be derived.

Table 2. Use designations for water bodies in the upper Grand River basin updated based on the results of the 2007 survey. Asterisks denote existing uses unverified by intensive surveys. Unverified existing uses confirmed by the present survey are noted by */+. Use changes recommended based on the results of the 2007 survey are noted by a delta (Δ) symbol

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Marsh creek		*							*	*		*		
Mentor creek and Mentor marsh	*	*							*	*		*		
Black brook		*							*	*		*		
Heisley creek		*							*	*		*		
Grand river - headwaters to RM 98.5 (dst US 442 upper crossing)		*				Δ			*	*		*		Impoundment ust Parkman defines boundary
RM 98.5 to st. rte. 608 (RM 91.8)			+						+	+		+		
- st. rte. 608 to Fobes rd. (RM 44.7)		+							+	+		+		
- at RM 89.12		+						o	+	+		+		PWS intake - West Farmington
- Fobes rd. to Harpersfield dam (RM 30.9)			+						+	+		+		
- Harpersfield dam to st. rte. 2 (RM 5.5)			+		o				+	+		+		
- st. rte. 2 to the mouth		*			o				*	*		*		
Pebble branch		*							*	*		*		
Red creek		*			o				*	*		*		
Big creek - headwaters to Girdled rd. (RM 7.1)		+							+	+		+		
- Girdled road to the mouth		+			o				+	+		+		
Kellogg creek		+			o				+	+		+		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Ellison creek		+			o				+	+		+		
Gordon (Jordan) creek						+			+	+		+		
East creek						+			+	+		+		
Aylworth creek						+			+	+		+		
Jenks creek						+			+	+		+		
Cutts creek						+			+	+		+		
Paine creek - headwaters to Paine falls (RM 2.9)		+							+	+		+		
- Paine falls to the mouth			+		o				+	+		+		
Bates creek		*							+	+		+		
Phelps creek			+			+			+	+		+		
Unnamed tributary (Paine creek RM 7.2)			+			+			+	+		+		
Talcott creek						+			+	+		+		
Griswold creek		*							*	*		*		
Mill creek - headwaters to Doty rd. (RM 1.5)					o	+			+	+		+		
- Doty rd. to the mouth		+			o				+	+		+		
Unnamed tributary (Mill creek RM 4.3)						+			+	+		+		
Coffee creek		+							+	+		+		
Center creek		*							*	*		*		
Mill creek		+							+	+		+		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Cemetery creek		+							+	+		+		
Griggs creek		*							*	*		*		
Askue run		+							+	+		+		
Peters creek		+							+	+		+		
Bronson creek		*/+							*/+	*/+		*/+		
Trumbull creek – Trask Road (RM 7.8) to Windsor Mechanicsville Road (RM 3.4)			+			Δ			*/+	*/+		*/+		
Trumbull creek – Windsor Mechanicsville Road (RM 3.4) to the confluence with the Grand River		Δ												
Spring creek		*/+							*/+	*/+		*/+		
Three Brothers creek		*/+							*/+	*/+		*/+		
Badger run		*							*	*		*		
Rock creek		+							+	+		+		
Plum creek		*							*	*		*		
Sugar creek		*							*	*		*		
Whetstone creek		*/+							*/+	*/+		*/+		
Lebanon creek		*/+							*/+	*/+		*/+		
Snyder Ditch		*		Δ					*/+	*/+		*		
Crooked creek – headwaters to Windsor Mechanicsville Road (RM 2.5)			+			Δ			*/+	*/+		*/+		
Windsor Mechanicsville to confluence with Mud Creek		Δ												

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Mud creek		*							*	*		*		
Hoskins creek – US 6 (RM 5.7) to Hurlburt Road (RM 2.0)			+			Δ			*/+	*/+		*/+		
Indian creek			+			Δ			*/+	*/+		*/+		
Montville ditch		*							*	*		*		
Phelps creek – confluence of the N. and S. Branch (RM 8.0) to SR 534 (RM 2.1)			+			Δ			+	+		+		
- SR 534 to the confluence with the Grand River		Δ												
North branch		*/+							*/+	*/+		*/+		
South branch		*/+							*/+	*/+		*/+		
Mill creek – South Windsor Road (RM 4.5) to SR 534 (RM 1.8)			+			Δ			*/+	*/+		*/+		
Garden creek		*/+							*/+	*/+		*/+		
Swine creek – headwaters to Girdle Road (RM 7.0)						Δ			+	+		+		
- Girdle Road to confluence with the Grand River		+												
Grapevine creek		*							*	*		*		
Andrews creek		*/+							*/+	*/+		*/+		
Plum creek		*				Δ			*/+	*/+		*/+		
Coffee creek		*							*	*		*		
Baughman creek		+							+	+		+		
Center creek		*/+							*/+	*/+		*/+		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Mud run		*/+							*/+	*/+		*/+		
Dead branch		*							*	*		*		
McKinley creek		*							*	*		*		
Big creek		*							*	*		*		

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = coldwater habitat; LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water; PCR = primary contact recreation; SCR = secondary contact recreation.

Study Area

The upper Grand River basin drains the southwestern quarter of Ashtabula County, the northeastern corner of Geauga County and the northwestern quarter of Trumbull County (Figure 2). The basin was formed by a glacial lobe, and the valley was occupied by a post glacial lake. As a result, surficial substrates in the valley are fine-grained, being derived from lacustrine sediments. Wetlands and swamps flanking the Grand River mainstem are remnants of the glacial lake. Forested lands and wetlands make up half the land use in the basin, with wetlands contributing 8.7% to the total, a high percentage for Ohio. Agriculture comprises 36.2% of the land use, with crop acreage split between forage and grains at an approximate ratio of 1 to 3. Dairy and beef cattle make up most of the livestock production. Ashtabula County is tenth in terms of dairy production for Ohio. According to the 2002 Census of Agriculture, five farms in Ashtabula County held 500 or more cattle (Table x). Fortunately, concentrated animal feeding operations (CAFOs) are not a prominent fixture in the basin, most farms holding cattle (beef or dairy) are small-scale operations (Table 3). Similarly, most hog farms are small scale. No large poultry operations are located in the county. Anecdotally, logging and lumber mills are common in Amish areas, especially the southwestern quarter of the basin. Land developed for municipal, industrial, transportation, and residential uses accounts for 6.2% of land uses; however, only 0.1% of developed land is classed as high or medium intensity (i.e., dense aggregations of impervious surfaces). In the northwestern quarter of the basin, large-lot, single family homes are being carved into woodlots, often adjacent to high quality, cold headwaters.

Given that the basin is largely rural, most of the homes in the basin are not served by centralized sewer collection systems. The relative density of unsewered homes in the area, compared to statewide figures, is relatively low, with 16 of the 19 census blocks comprising the basin falling below the median. Densities in the other 3 blocks are less than the 75th percentile. However, local aggregations of unsewered homes are found along SR 45 in Bristol Township.

Table 3. Distribution of farms in Ashtabula County by head of livestock.

Number of Poultry	Farms	Number of Hogs	Farms	Number of Cattle	Farms
1 - 49	96	1 - 24	71	1 -9	220
50 - 99	15	25 - 49	2	10 - 19	98
100 - 399	2	50 - 99	4	20 - 49	94
400 - 3199		100 - 199		50 - 99	58
3200 - 9999		200 - 499	1	100 - 199	21
10000 - 19999		500 - 999	1	200 - 499	13
20000 or more*		1000 or more		500 or more	5

*Note that mega-farm poultry operations run into the millions.

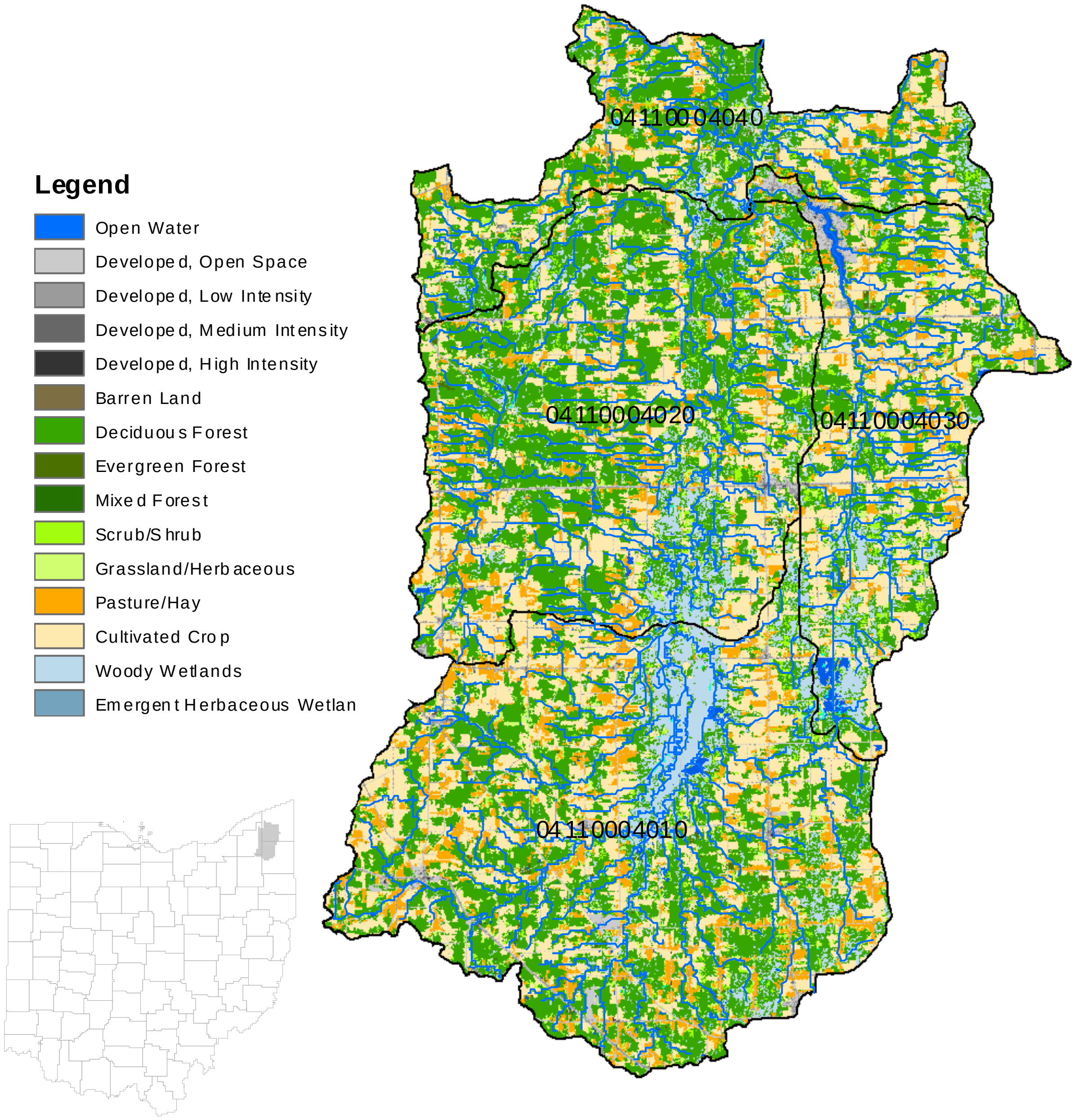

Figure 2. Land uses circa 2001 for the upper Grand River basin as determined by Landsat imagery.

Pollutant Loadings

Rock Creek – Village of Rock Creek WWTP (3PA00029)

The Village of Rock Creek WWTP was originally constructed in 1990. The current design flow is 0.07 mgd. Effluent flow averaged approximately 0.044 mgd during 2007 and 0.049 mgd in 2008. Current treatment processes consist of flow equalization, extended aeration activated sludge, secondary clarification, surface sand filtration, chlorination, and dechlorination.
The facility experiences recurring permit violations for dissolved oxygen, residual chlorine, and pH (Table 3). Effluent ammonia concentrations were consistently low between 2001 and 2007 (Figure 3); however, four violations were reported during 2008.

Table 4. Effluent statistics for the Village of Rock Creek WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration
$cBOD_5$	30 Day average	1	25 mg/l	25.4175 mg/l
$cBOD_5$	30 Day Maximum	1	6.6 mg/l	6.9266 mg/l
$cBOD_5$	7 day average	2	15 mg/l	21.3 mg/l
Chlorine Residual	Maximum Conc.	5	0.038 mg/l	1.622 mg/l
DO Summer	Minimum[1]	194	7.0 mg/l	6.03 mg/l
Fecal Coliform	30 Day average	3	1,000 cfu/100 ml	2708 cfu/100 ml
Fecal Coliform	7 Day average	4	2,000 cfu/100 ml	4725 cfu/100 ml
NH_3-N	7 Day average	26	2.3 mg/l	10.6597 mg/l

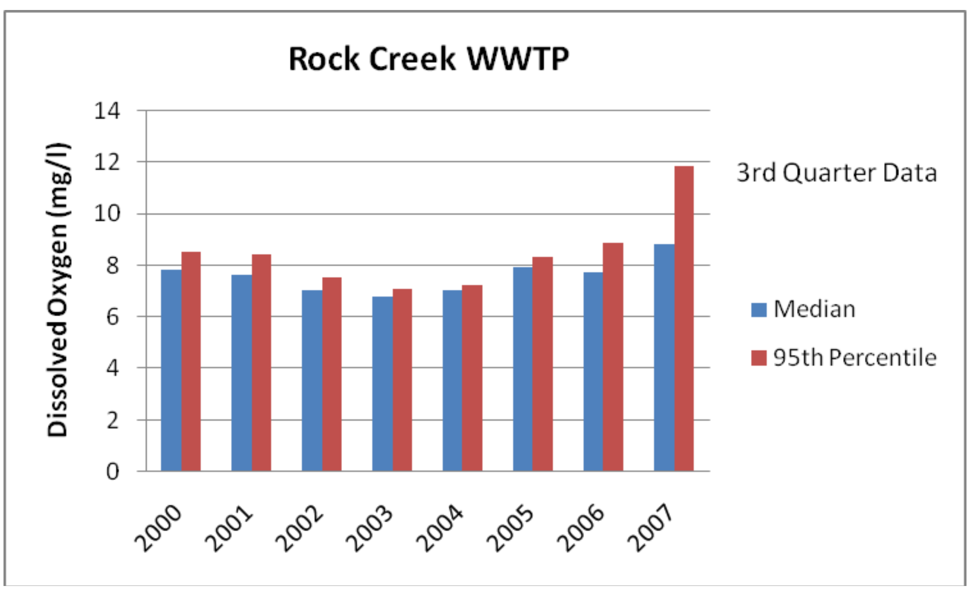

Figure 3. Third quarter (July, August, September) median and 95th percentile effluent concentrations for dissolved oxygen reported by the Rock Creek WWTP, 2000-2007.

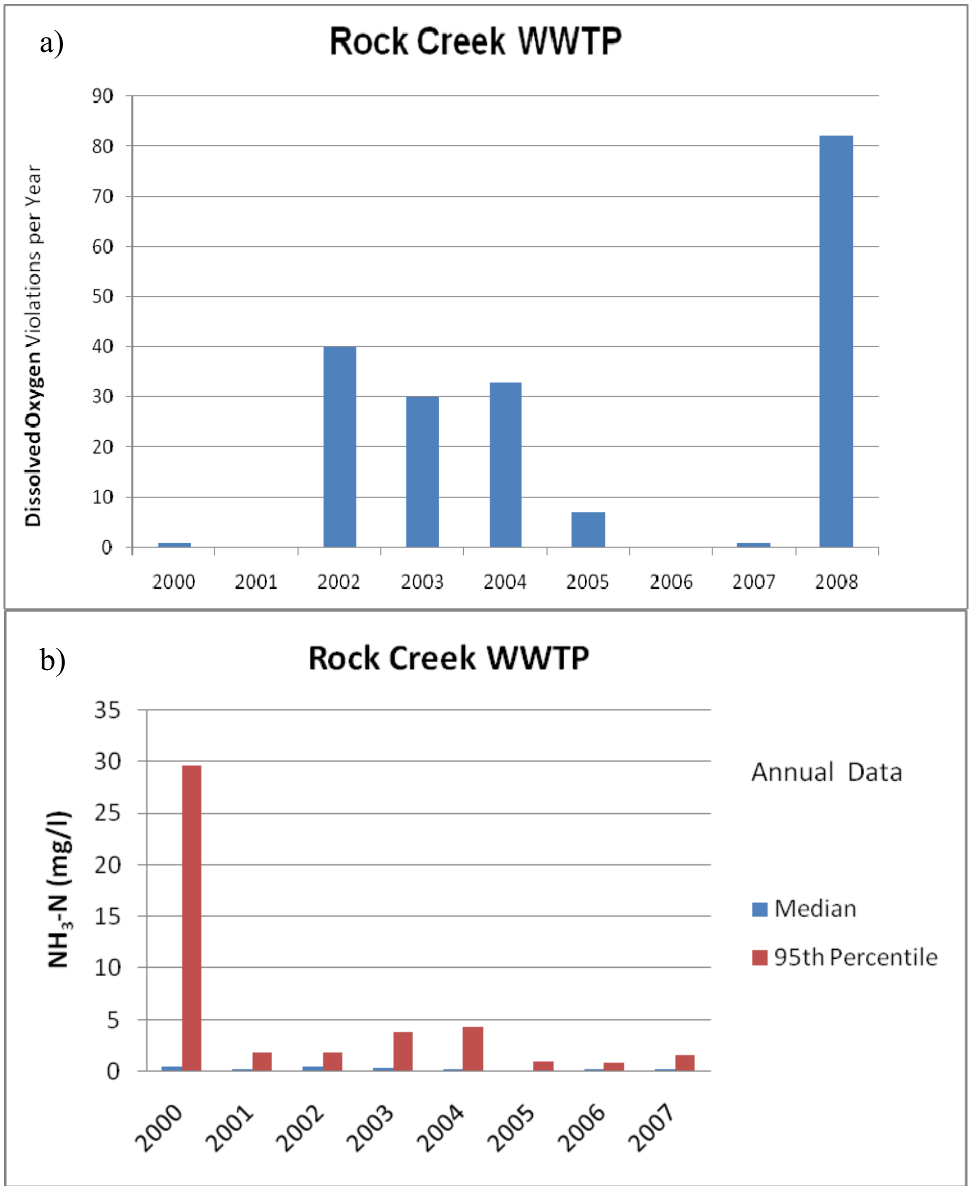

Figure 4. (a) Frequency of dissolved oxygen permit exceedences by the Rock Creek WWTP, 2000-2007. (b) Annual median and 95th percentile effluent concentrations for ammonia nitrogen reported by the Rock Creek WWTP, 2000-2007.

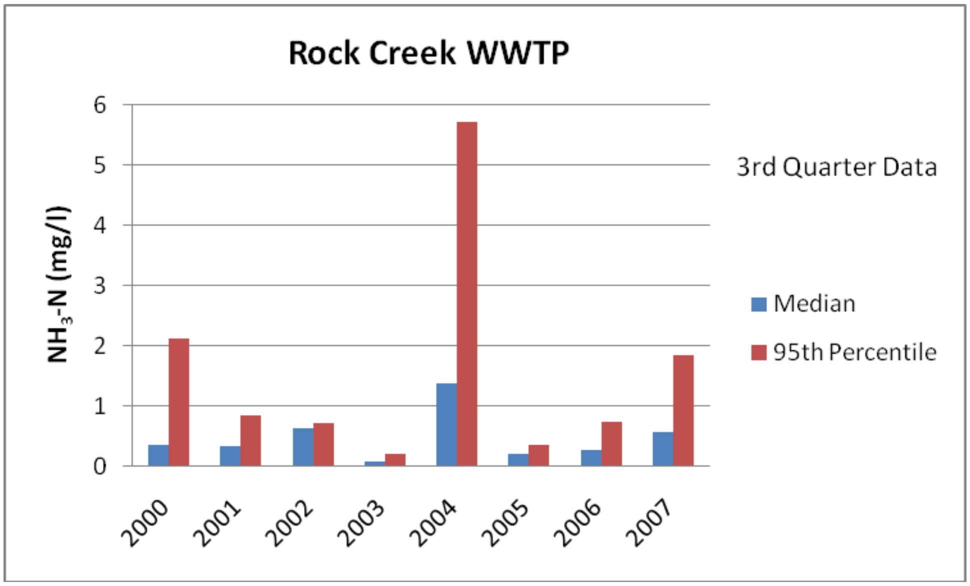

Figure 5. Third quarter (July, August, September) median and 95th percentile effluent concentrations for ammonia nitrogen reported by the Rock Creek WWTP, 2000-2007.

Rock Creek – Roaming Shores WWTP (3PB00068)

The Roaming Shores WWTP was originally constructed in 1968 and expanded in 2002. The current design flow is 0.160 mgd. Effluent flow averaged approximately 0.141 mgd during 2007 and 0.157 mgd during 2008. The plant processes consist of a sewage grinder with a bar screen, aerated flow equalization, extended aeration activated sludge, secondary clarification, rapid sand filtration, and UV disinfection. The facility had 10 violations of CBOD in 2008 and 8 violations of CBOD in 2007. All of the other violations occurred prior to April 27, 2005. During the period of 2000 to 2008 there were 108 violations - 83 of those occurred in 2000 and 2001.

Table 5. Effluent statistics for the Roaming Shores WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration (mg/l)
$CBOD_1$	30 Day average	7	7.5 mg/l	9.97 mg/l
$CBOD_1$	30 Day average Load	3	4.5 kg/d	5.4 kg/d
$CBOD_1$	7 Day average	12	9.0 mg/d	17.25 mg/d
$CBOD_1$	7 Day average Load	16	5.5 kg/d	7.9 kg/d
Dissolved Oxygen	Minimum	1	5.0 mg/l	1.9 mg/l
Fecal Coliform	7 Day average	3	2000 cfu	2666.67 cfu
Ammonia	30 Day average	10	1.5 mg/l	4.7 mg/l
Ammonia	30 Day average Load	9	0.68 kg/l	1.62 kg/l
Ammonia	7 Day average	9	2.3 mg/l	7.23 mg/l
Ammonia	7 Day average Load	8	1.0 kg/l	2.34 kg/l
pH	Minimum	3	6.5	6.3

TSS	30 Day average	5	12 mg/l	15.45 mg/l
TSS	30 Day average Load	4	5.5 kg/d	7.878 kg/d
TSS	7 Day average	8	18 kg/d	25.9375 kg/d
TSS	7 Day average Load	10	8.2 mg/l	11.656 mg/l

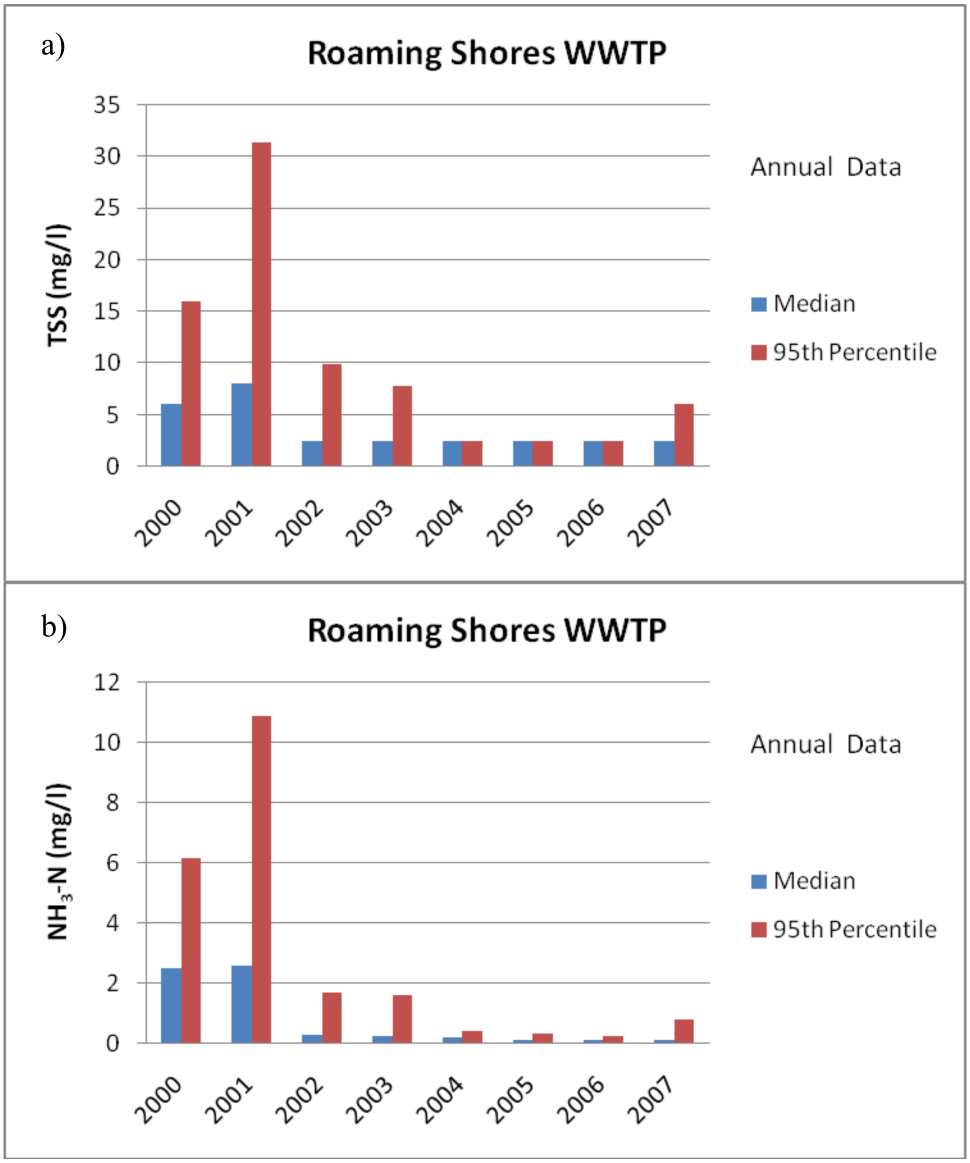

Figure 6. Annual median and 95th percentile effluent concentrations for (a) total suspended solids, and (b) ammonia nitrogen reported by the Roaming Shores WWTP, 2000-2007.

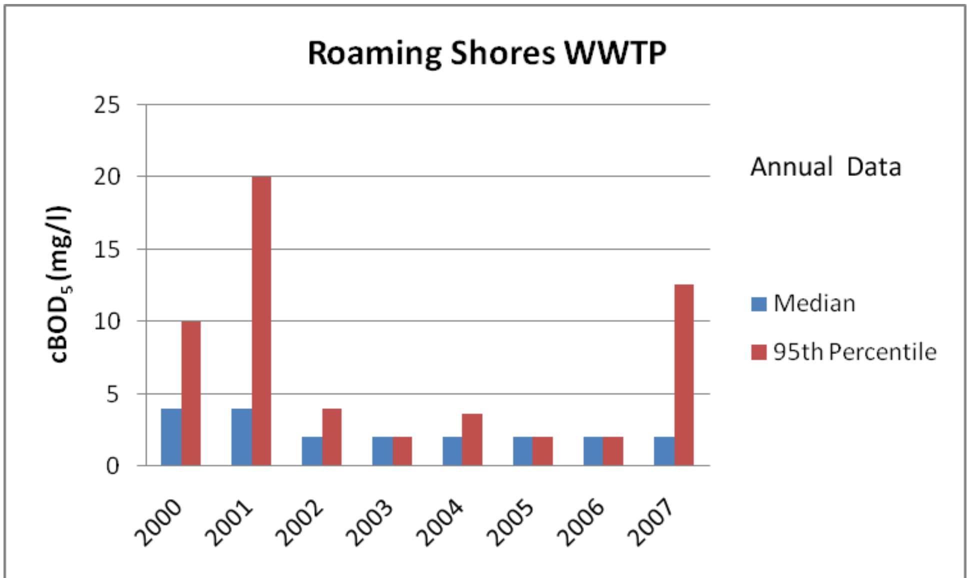

Figure 7. Annual median and 95th percentile effluent concentrations for 5-day biochemical oxygen demand reported by the Roaming Shores WWTP, 2000-2007.

Snyder Ditch – Village of Orwell WWTP (3PB00041)

The Village of Orwell WWTP was originally constructed in 1968 and most recently updated in 2004. The current design flow is 0.52 mgd. Effluent flow averaged approximately 0.27 mgd during 2007and 0.37 mgd in 2008. The plant consists of an influent flow meter, a pump station, an Orbal System oxidation ditch, clarifiers, tertiary rapid sand filters, ultraviolet disinfection and post aeration. Ninety-fifth percentile effluent concentrations of TSS and cBOD5 have trended downward since 2000. There were three violations for ammonia in 2008. All of the other violations occurred prior to August 2005.

Table 6. Effluent statistics for the Village of Orwell WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration
$cBOD_5$	30 Day average	1	25 mg/l	25.4175 mg/l
$cBOD_5$	30 Day Maximum	1	6.6	6.923 mg/l
$cBOD_5$	7 day average	2	15 mg/l	21.3 mg/l
Chlorine Residual	Maximum Conc.	5	0.038 mg/l	1.622 mg/l
Dissolved Oxygen	Minimum[2]	22	5.0 mg/l	4.663636 mg/l
Fecal Coliform	30 Day average	5	1,000 cfu/100 ml	2167 cfu/100 ml
Fecal Coliform	Maximum[1]	12	2,000 cfu/100 ml	3330 cfu/100 ml
NH_3-N	30 Day average	16	2.3 mg/l	5.287 mg/l
NH_3-N	7 Day average	34	3.5 mg/l	6.725 mg/l
NH_3-N	7 Day Maximum Conc.	24	3.4 mg/l	5.999 mg/l

TSS	30 Day average	12	20 mg/l	69.738 mg/l
TSS	7 Day average	21	30 mg/l	137.86 mg/l

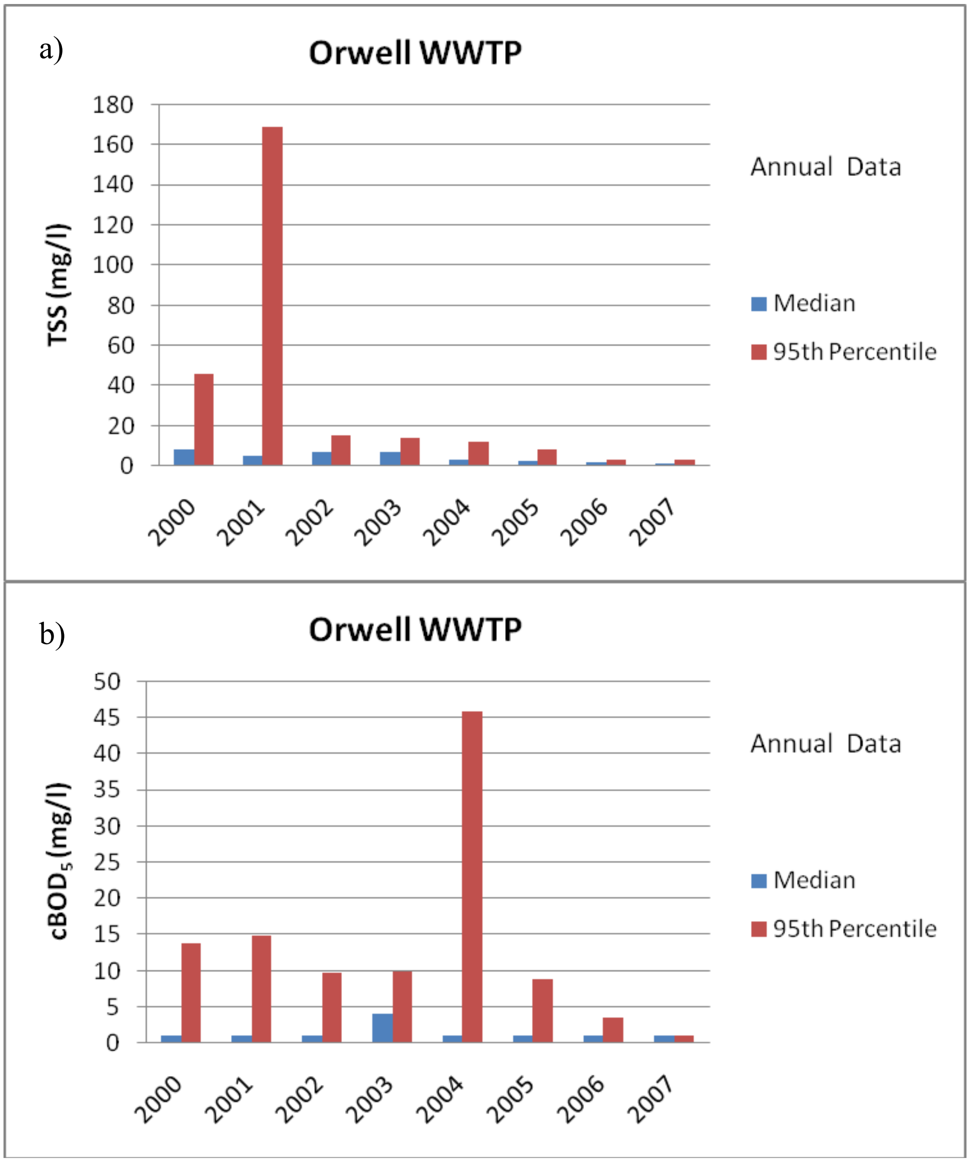

Figure 8. Annual median and 95th percentile effluent concentrations for (a) total suspended solids, and (b) 5-day biochemical oxygen demand reported by the Orwell WWTP, 2000-2007.

Unnamed Tributary to South Branch of Phelps Creek – Middlefield Original Cheese Co-op (3IH00076)

The Middlefield Original Cheese Co-op wastewater treatment works was originally constructed in 1994. The design flow originally was 10,350 gpd however this amount was exceeded regularly. The facility has requested an increase to 25,000 gpd. Effluent flow averaged approximately 5,000 gpd during 2007. The plant consists of a trash trap, aeration tanks, flow equalization, clarifier, sludge holding tank, dosing tank, surface sand filters, UV tank, aerobic digester, and a constructed wetland. The plant discharges to an unnamed tributary to the South Branch of Phelps Creek.

The Middlefield Original Cheese Coop treatment system was designed for a BOD load that was greatly underestimated. The improper design and operation allowed unauthorized bypasses of the plant during 2000 killing the wetland plants and creating violations from the release of pollutants particularly TSS. During 2002 the plant was operated at greater than the designed flow. The facility has had continual operational problems and enforcement actions were initiated in 2007.

Table 7. Effluent statistics for the Middlefield Original Cheese Co-op.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration (mg/l)
$cBOD_5$	30 Day average	2	10.0 mg/l	19.5 mg/l
$cBOD_5$	30 Day average Load	2	0.51 kg/d	0.58 kg/d
$cBOD_5$	7 Day average	2	15 mg/d	19.5 mg/d
TSS	30 Day average	20	12 mg/l	71.15 mg/l
TSS	30 Day average Load	15	0.61 kg/d	2.51 kg/d
TSS	7 Day average	19	18 mg/d	74.12 mg/l
TSS	7 Day average Load	13	0.92 kg/d	2.78kg/d

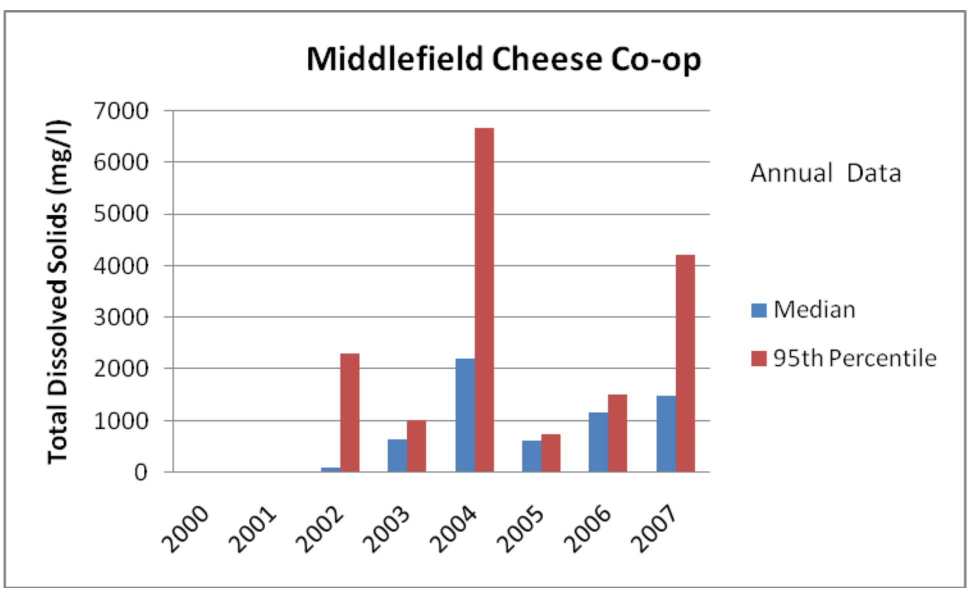

Figure 9. Annual median effluent concentrations for total dissolved solids reported by the Middlefield Original Cheese Co-op, 2000-2007.

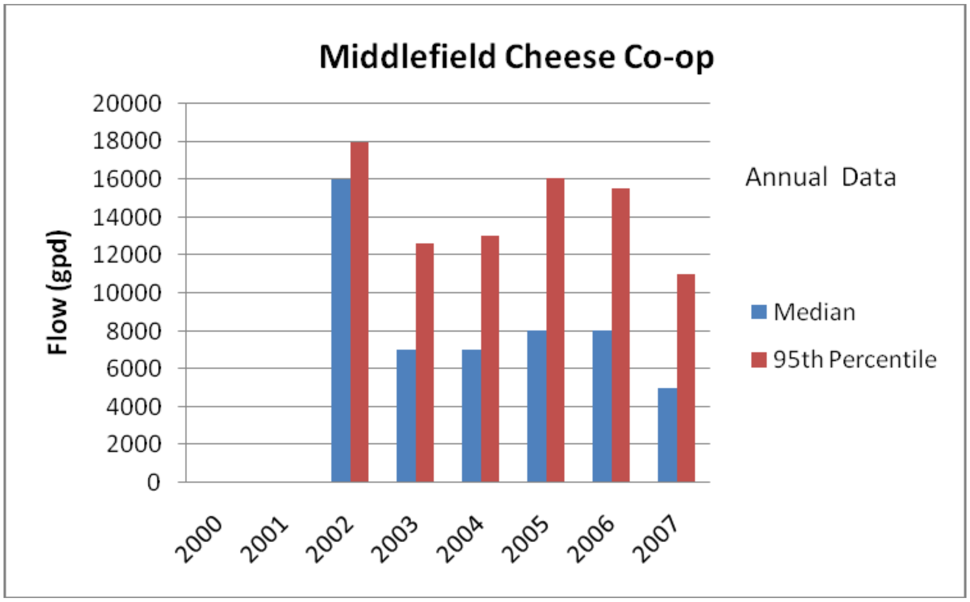

Figure 10. Annual median and 95th percentile flows (gallons per day) reported by the Middlefield Original Cheese Co-op, 2000-2007.

Grand River – River Pines Campground (3PR00135)

The River Pines Campground is operating under a permit that became effective on March 15, 2006. The plant discharges to RM 0.11 of an unnamed tributary to the Grand River (confluence at RM 94.81) with a current design flow of 25,000 gpd. Effluent flow averaged approximately 8300 gpd during 2007. The plant consists of a trash tank, bar screen, extended aeration, final settling, sand filtration, chlorination, de-chlorination, and a sub-surface sand filter. The violations are distributed throughout the time period of 2000-20007. The facility had consistent exceedences of residual chlorine and fecal coliform. All of the violations for dissolved oxygen occurred in or prior to 2003. This facility ceased operation in November 2007. The WWTP has the potential to resume operation, however the intentions for the future of this plant are not known.

Table 8. Effluent statistics for the River Pines Campground WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance
$cBOD_5$	30 Day average	5	8.0 mg/l	18.5 mg/l
$cBOD_5$	7 day average	3	12.0 mg/l	24.5 mg/l
Chlorine Residual	Maximum Conc.	123	0.038 mg/l	0.127 mg/l
Dissolved Oxygen	Minimum[3]	12	6.0 mg/l	4.6 mg/l
Fecal Coliform	30 Day average	21	1,000 cfu/100 ml	18,031 cfu/100 ml
Fecal Coliform	Maximum[1]	18	2,000 cfu/100 ml	20,764 cfu/100 ml
NH_3-N (winter)	30 Day average	5	3.5 mg/l	5.81 mg/l
NH_3-N (winter)	Maximum[1]	3	5.3 mg/l	22.83 mg/l

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NH_3-N (summer)	30 Day average	5	1.5 mg/l	15.29 mg/l
NH_3-N (summer)	Maximum[1]	5	2.2 mg/l	4.15 mg/l
pH	Minimum	10	6.5 (S.U.)	6.3
TSS	30 Day average	11	8 mg/l	21.9 mg/l
TSS	Maximum[1]	2	12 mg/l	77.2 mg/l

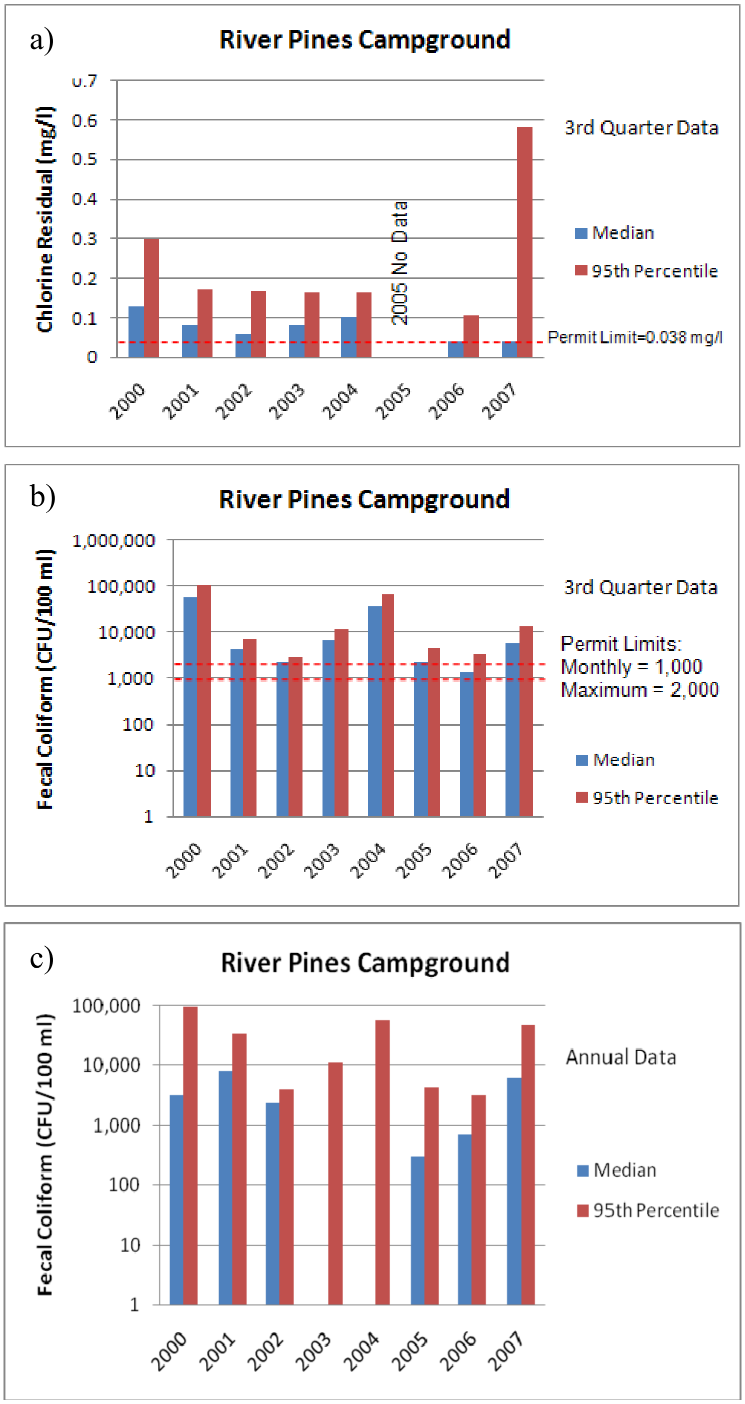

Figure 11. Third quarter median and 95th percentile effluent concentrations for a) residual chlorine, and b) fecal coliform counts. c) Annual median and 95th percentile effluent fecal coliform counts reported by the River Pines Campground, 2000-2007.

Unnamed Tributary to Grand River – Nelsons Ledges Estates WWTP (3PV00009)
The Nelson Ledges Estates WWTP permit became effective on August 1, 2005. The current design flow is 0.03 mgd. Effluent flow averaged approximately 0.0187 mgd during 2007. The plant consists of an influent flow meter, a pump station, an Orbal System oxidation ditch, clarifiers, tertiary rapid sand filters, ultraviolet disinfection and post aeration. The following table shows the violations from 2000 through 2008. This facility averaged 22 violations per year with no strong trends. It discharges to an unnamed tributary to the Grand River (RM 94.81) at approximately RM 1.85.

Table 9. Effluent statistics for the Nelsons Ledges Estates WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration
$cBOD_5$	30 Day average	9	10.0 mg/l	14.5 mg/l
$cBOD_5$	7 day average	15	12.0 mg/l	30.0 mg/l
Chlorine Residual	Maximum Conc.	12	0.038 mg/l	0.139 mg/l
Dissolved Oxygen	Minimum[4]	20	5.0 mg/l	3.8 mg/l
Fecal Coliform	30 Day average	8	1,000 cfu/100 ml	3,620 cfu/100 ml
Fecal Coliform	Maximum[1]	8	2,000 cfu/100 ml	3,620 cfu/100 ml
NH_3-N (winter)	30 Day average	8	4.0 mg/l	7.7 mg/l
NH_3-N (winter)	Maximum[1]	11	6.0 mg/l	13.0 mg/l
NH_3-N (summer)	30 Day average	5	2.0 mg/l	10.3 mg/l
NH_3-N (summer)	Maximum[1]	6	3.0 mg/l	14.4 mg/l
pH	Maximum	2	9.0 (S.U.)	9.4 (S.U.)
TSS	30 Day average	27	12 mg/l	36.0 mg/l
TSS	Maximum[1]	46	18 mg/l	75.2 mg/l

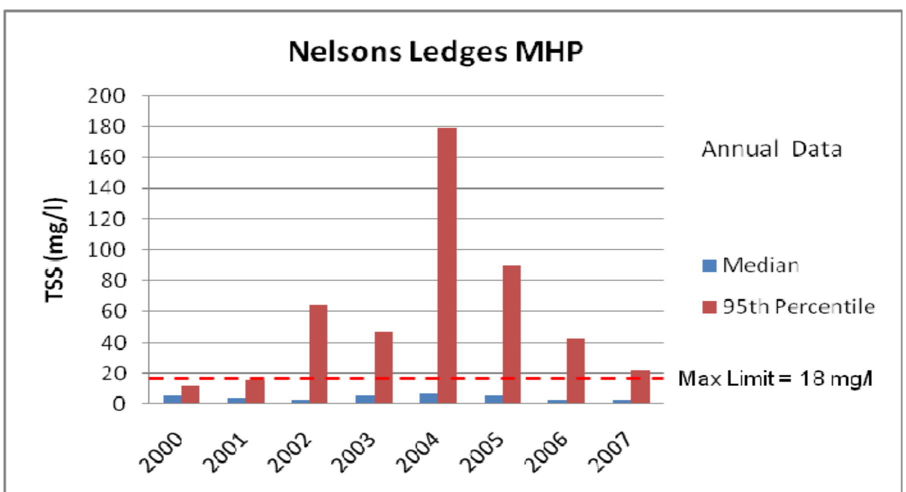

Figure 12. Annual median and 95th percentile effluent concentrations of total suspended solids reported by the Nelson Ledges Estates, 2000-2007.

[4] 7 day average in previous permits.

Tributary to Dead Branch – Southington Estates MHP (3PV00066)

The Southington Estates MHP is operating under an NPDES permit that became effective in April 2007. The current design flow is 30,000 gpd. Effluent flow averaged 14,000 gpd in 2007 and 15,000 gpd in 2008. Current treatment processes consist of flow equalization, extended aeration activated sludge, final settling, slow surface sand filtration, and UV disinfection. Approximately 70% of the facility's effluent violations occurred between 2000 and 2002. Improvements to the facility since that time, including the installation of the equalization basin, have significantly reduced the violations (Figure 13).

Table 10. Effluent statistics for the Southington Estates MHP WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration
$cBOD_5$	30 Day average	5	10.0 mg/l	15.8 mg/l
$cBOD_5$	30 Day average (max)	3	1.1 kg/d	1.589 kg/d
$cBOD_5$	1 Day average	4	15 mg/l	24.5 mg/l
$cBOD_5$	1 Day average (max)	1	1.704 kg/d	2.0439 kg/d
$cBOD_5$	7 day average	11	15 mg/l	21.727 mg/l
$cBOD_5$	7 day average (max)	3	1.7 kg/d	3.8964 kg/d
Dissolved Oxygen	Minimum	19	5.0 mg/l	3.9 mg/l
Fecal Coliform	30 Day average	6	1,000 cfu/100 ml	2,223 cfu/100 ml
Fecal Coliform	Maximum[1]	2	2,000 cfu/100 ml	30,000 cfu/100 ml
NH_3-N (winter)	30 Day average	8	4.0 mg/l	12.9 mg/l
NH_3-N (winter)	30 Day (max)	7	0.45 kg/d	0.94 kg/d
NH_3-N (summer)	30 Day average	5	1.5 mg/l	3.6 mg/l
NH_3-N (summer)	30 Day (max)	3	0.17 kg/d	0.28 kg/d
NH_3-N	1 Day average	3	2.25 mg/l	2.99 mg/l
NH_3-N	1 Day average (max)	1	0.26 mg/l	0.369 mg/l
NH_3-N	7 day average	5	6.0 mg/l	14.424 mg/l
NH_3-N	7 day average (max)	1	0.68 kg/d	1.74 kg/d
TSS	30 Day average	10	12 mg/l	22.9 mg/l
TSS	30 Day (max)	3	1.4 mg/l	4.54 mg/l
TSS	1 Day average	2	18 mg/l	27.5 mg/l
TSS	7 day average	12	18 mg/l	56.67 mg/l
TSS	7 day average (max)	9	2.045 kg/d	7.079 kg/d

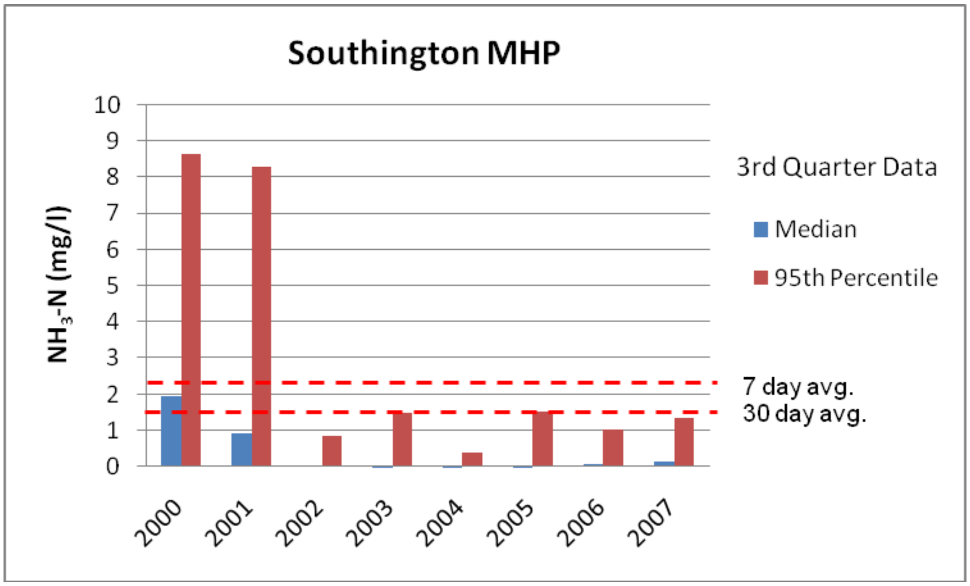

Figure 13. Third quarter median and 95th percentile effluent concentrations of ammonia nitrogen reported by the Southington Mobile Home Park, 2000-2007.

Grand River – Parkman WWTP (3PG00160)

The Geauga County Parkman Municipal Wastewater Treatment Plant first discharged in December, 2004. Design flow is 200,000 gallons per day (gpd), and the recent annual average flow is 9,000 gpd. The plant consists of a vacuum collection system, manual bar screen and automatic screen, Parshall flume, grease trap, distribution chamber, flow equalization, activated sludge aeration tanks, clarifiers, sand filters, UV disinfection, post aeration, and a V-notch weir flow measurement. Alum is used for phosphorus removal. Gravity discharge line flows to the Route 88 bridge below the dam for Shangri-La Lake, at river mile 97.8.

All of the violations at the Parkman WWTP occurred from September 2008 to December 2008.

Table 11. Effluent statistics for the Parkman WWTP.

Parameter	Limit Category	Violations Since 2000	Permit Limit	Average Exceedance Concentration
Total Phosphorus	30 Day Maximum	3	1.0 mg/l	4.06 mg/l
Total Phosphorus	7 day Maximum	8	1.5 mg/l	4.65 mg/l
pH	Minimum	2	6.5 S.U.	6.355 S.U.

Surface Water Quality

Grand River Mainstem

Water quality in the Grand River mainstem is largely a function of land use and surficial geology. Wetlands and livestock agriculture are the most influential land uses, and lacustrine clays are the geological component. The combined influence of these factors is clearly evident in longitudinal plots of chemical oxygen demand, suspended sediment, dissolved oxygen and nitrogen to phosphorus ratios (Figure 14). The increasing trend in chemical oxygen demand and suspended sediment along the mainstem respectively track organic compounds emanating from the wetlands, and the transition from coarse till deposits to fine-grained lacustrine deposits. Obviously, the juxtaposition of lacustrine deposits and wetlands is no coincidence. The trend of decreasing nitrogen to phosphorus ratios toward nitrogen limitation in the lower mainstem likely reflects phosphorus being carried by the suspended sediment, but may also reflect utilization of nitrogen by the microbial community acting on the organic compounds.

Undue influence on water quality by direct anthropogenic sources, either as point sources or localized nonpoint sources (e.g., on-site sewage systems, livestock) was not apparent.

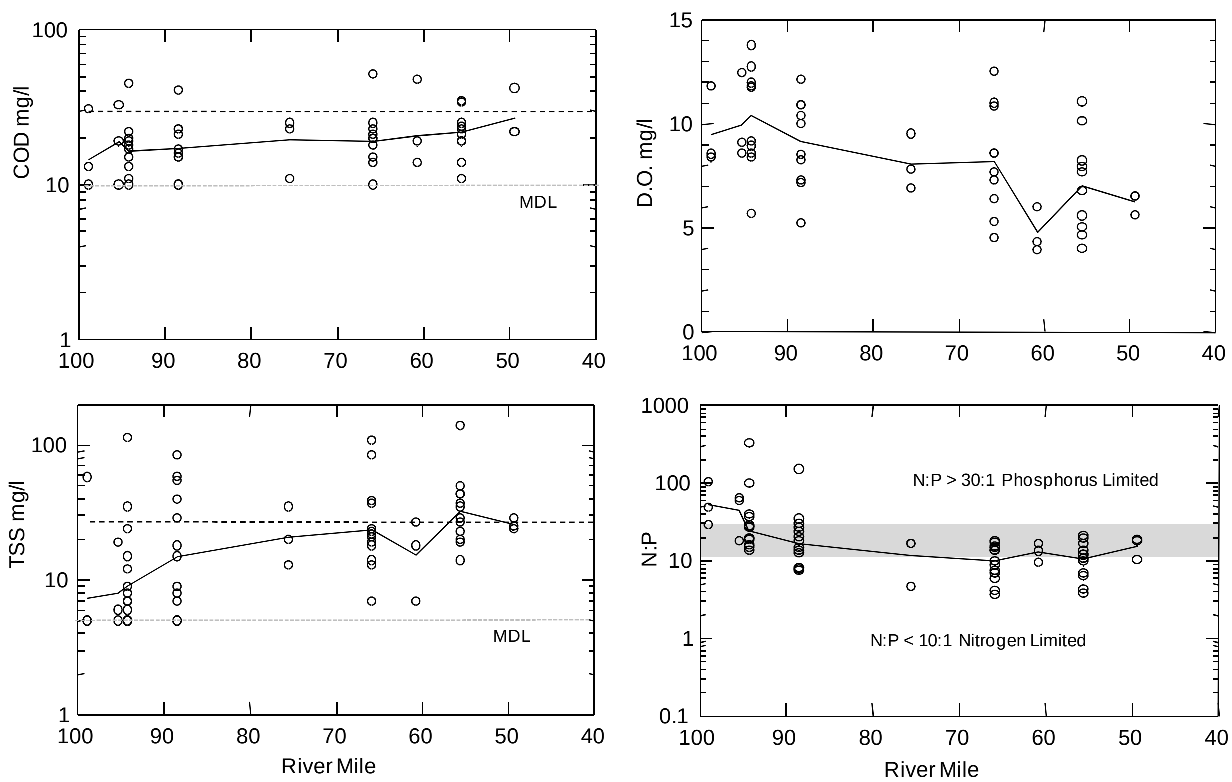

Figure 14. Concentrations of COD, D.O. and TSS, and nitrogen to phosphorus ratios observed in water quality samples collected from the Grand River mainstem, 2007, plotted by river mile from the confluence with Lake Erie. Dashed lines in the COD and TSS plots denote the upper limit of concentrations typical of unpolluted waters, and method detection limits (MDL). The shaded region in the N:P plot bounds the region were systems are generally co-limited by nitrogen and phosphorus.

Concentrations of ammonia-nitrogen, total Kjeldahl nitrogen, and total dissolved solids, key indicators of organic enrichment and point source pollution, were present at background levels, and showed little or no longitudinal variation (Figure 15). Additionally, phosphorus concentrations, though increasing down the run of the mainstem as previously noted, were below levels associated with excessive enrichment.

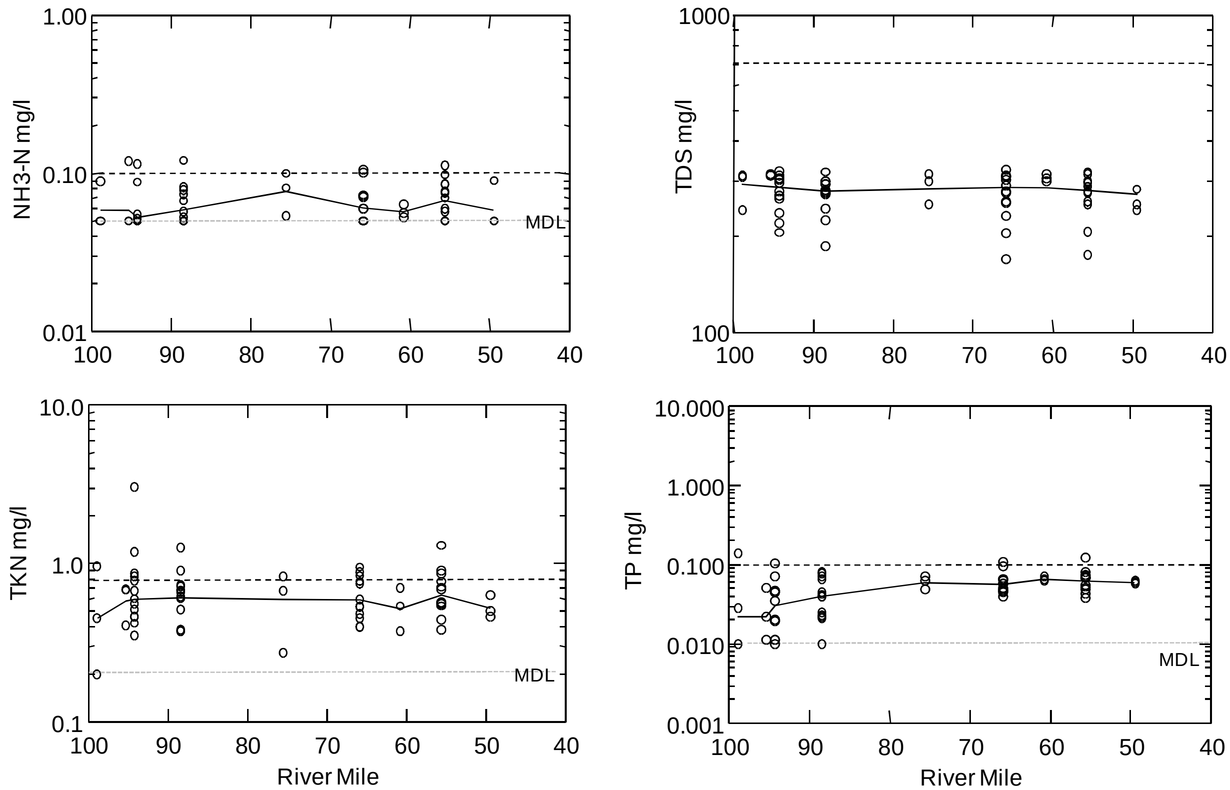

Figure 15. Concentrations of NH3-N, TDS, TKN, and TP observed in water quality samples collected from the Grand River mainstem, 2007, plotted by river mile from the confluence with Lake Erie. Dashed lines denote the upper limit of concentrations typical of unpolluted waters and method detection limits (MDL).

Tributaries

Localized impacts to water quality from anthropogenic sources, principally from organic enrichment, were noted in tributaries to the Grand River. The sources of enrichment were primarily on-site sewerage, livestock, and, in the case of Whetstone Creek, an unknown source. The organic enrichment was most apparent in Deacon Creek, Whetstone Creek, Three Brothers Creek, North Branch Phelps Creek, and Garden Creek, as noted by consistently high concentrations of total Kjeldahl nitrogen (TKN) co-occurring with elevated concentrations of ammonia-nitrogen (Figure 16). Livestock were the source to Garden Creek, on-site sewerage to the others. Other streams where concentrations of both TKN and ammonia-nitrogen (NH3-N) were elevated included Dead Branch, Center Creek, South Branch Phelps Creek, and Crooked Creek. On-site sewerage was clearly the source to Center Creek, and livestock were the source to Crooked Creek. The sources to Dead Branch and South Branch Phelps Creek were unknown; however, both streams were intermittent and influenced by wetlands, suggesting a natural source.

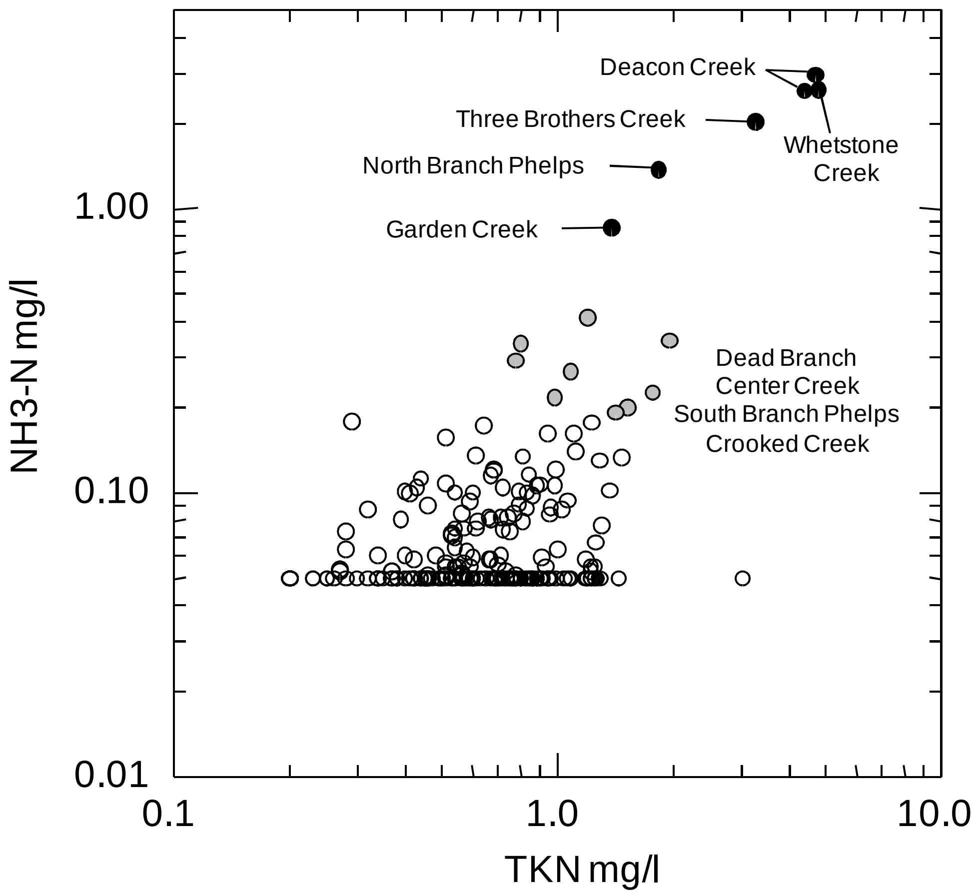

Figure 16. Concentrations of total Kjeldahl nitrogen (TKN) and ammonia-nitrogen (NH3-N) in water quality samples collected from the upper Grand River basin, 2007. Points falling outside one standard deviation of the sample mean are shaded gray, those exceeding two standard deviations are filled black.

Anomalously high conductivity readings were noted for Whetstone Creek and Lebanon Creek, concurrently with high nitrate-nitrogen, phosphorus, and elevated TKN values. Follow-up monitoring in 2008 failed to reproduce similar values, suggesting that illicit dumping may have been the source.

Stratified by hydrologic units, HUC 04110004 010, containing Dead Branch, Deacon Creek and Center Creek, had the highest TKN and NH3-N concentrations. Water quality in Center Creek was affected by home sewage treatment systems. Dead Branch was clearly influenced by wetlands, as was Deacon Creek to a lesser extent. Unit 04110004 030, with Whetstone and Lebanon Creek, had the highest nitrate and phosphorus concentrations owing to single high values as alluded to in the previous paragraph. More generally, water quality was a function of land use, and units 04110004 010 and 04110004 030 having higher levels of developed land compared to units 04110004 020 and 04110004 040, tended to have higher concentrations of enrichment indicators (Figure 17).

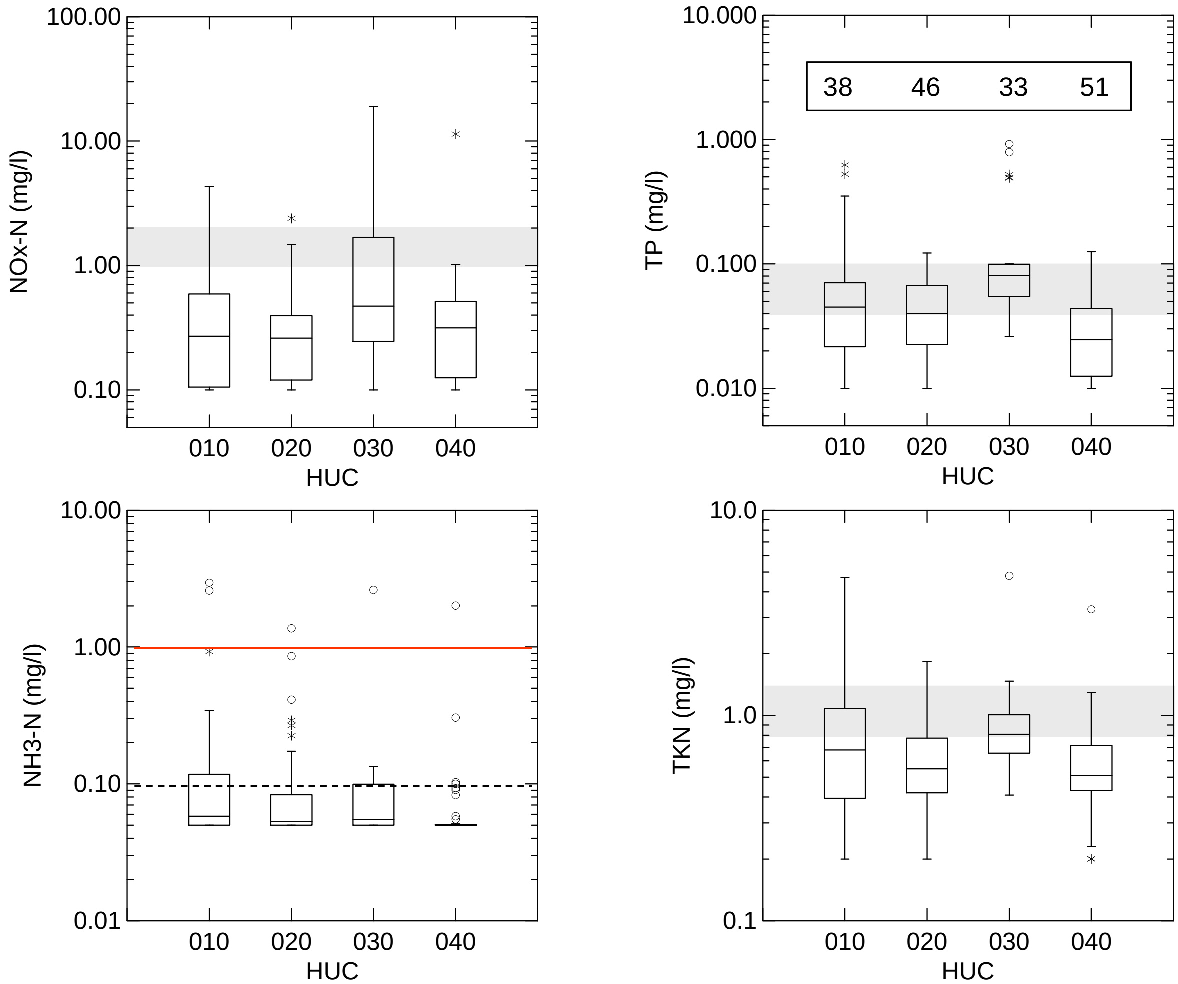

Figure 17. Distributions of nitrox-nitrogen, total phosphorus, ammonia-nitrogen and total Kjeldahl nitrogen in water quality samples from the upper Grand River basin, 2007, stratified by 11-digit hydrologic unit. Percent forest cover for the respective units is shown in the inset box in the phosphorus plot. The shaded region in the NOx, TP and TKN plots show the respective upper ranges of concentrations typical of unpolluted waters. The red line in the ammonia plot show the concentration where chronic toxicity to a broad range of organisms is likely, and the dashed line shows the threshold where toxicity to highly sensitive species is likely.

Table 12. Chemical water quality criteria exceedences in the upper Grand River watershed, 2007.

Assessment Unit / *HUC14* / Location - River Mile (Station ID)	**Date**	**Dissolved Oxygen (mg/l)**	**pH (S.U.)**	**Total Dissolved Solids (mg/l)**	**NH_3-N (mg/l)**
04110004010010					
Grand River @ Hobart Rd. – 94.27 (G01K09)	4/24/2007		9.42[a]		
04110004010020					
Dead Br. @ Old State Rd. - 7.86 (300170)	7/9/2007	3.18[b]			
	8/13/2007	4.56[b]			
Dead Br. @ Geauga Easterly Rd. – 5.05 (300169)	6/4/2007	4.28[c]			
	8/13/2007	4.55[b]			
04110004010050					
Deacon Creek @ Hyde-Shaffer Rd – 5.31 (300176)	6/4/2007	4.86[b]			
	7/9/2007	4.17[b]			2.59[d]
Deacon Creek @ Hyde-Oakfield Rd – 1.38 (300175)	7/9/2007				2.95[d]
04110004010060					
Coffee Creek @ Combs Rd. – 0.23 (G01K17)	6/4/2007	1.57[c]			
	8/13/2007		5.54[a]		
04110004020					
04110004020010					
Garden Creek @ Girdle Rd – 2.31 (300183)	7/11/2007	4.40[b]			
04110004020020					
N. Br. Phelps Ck @ Huntley Rd – 0.94 (300189)	7/11/2007	2.40[c]			
	8/15/2007	3.29[c]			
S. Br. Phelps Ck @ US 322 – 0.58 (300192)	7/11/2007	4.96[b]			
Phelps Creek @ Windsor Rd. Ext. – 1.23 (G01K06)	8/9/2007	4.96[b]			
04110004020030					
Grand River @ US 322 - 65.88 (G01W06)	8/9/2007	4.56[b]			
Grand River @ Montgomery Rd. – 60.95 (G01K07)	7/11/2007	3.94[c]			
	8/15/2007	4.35[b]			
04110004020050					
Grand River @ US 6 – 55.62 (G01K08)	7/11/2007	4.03[b]			
	8/9/2007	4.67[b]			
04110004020060					
Crooked Creek @ Callahan Rd. – 6.70 (300182)	7/11/2007	1.85[c]			
Crooked Creek @ Callender Rd. – 1.62 (G01K01)	7/11/2007	2.71[c]			
Mud Creek @ Higley Rd. – 3.78 (300188)	7/11/2007	4.82[b]			
Mud Creek @ Wilderness Rd – 0.20 (300187)	8/15/2007	4.38[b]			
04110004030					
04110004030010					
Lebanon Creek @ Institute Rd. – 1.93 (300198)	7/16/2007			2,030[e]	
Snyder Ditch @ Moore Rd. - 0.60 (300199)	6/21/2007	4.52[b]			
Whetstone Creek @ SR 46 – 2.00 (300200)	7/16/2007	4.65[b]			2.61[d]
Rock Creek @ Dodgeville Rd. – 9.64 (G01W02)	6/21/2007	4.62[b]			
	7/16/2007	3.78[c]			

Assessment Unit / *HUC14* / Location - River Mile (Station ID)	**Date**	**Dissolved Oxygen (mg/l)**	**pH (S.U.)**	**Total Dissolved Solids (mg/l)**	**NH_3-N (mg/l)**
04110004030010-continued					
Rock Creek @ Dodgeville Rd. – 9.64 (G01W02)					
	8/9/2007	2.09[c]			
Rock Creek @ SR 45 – 1.23 (G01K03)	4/24/2007		9.47[a]		
	7/30/2007		9.69[a]		
Rock Creek @ Union Cemetery – 0.95 (G01W05)	4/24/2007		9.53[a]		
	7/16/2007				0.72[d]
04110004040					
04110004040010					
Three Brothers Creek @ Stumpville Rd. – 6.68 (300203)	7/16/2007	3.07[c]			
04110004040020					
Trumbull Creek @ Dawsey Rd. – 9.03 (300205)	6/21/2007	4.31[b]			
Grand River @ Camp Beaumont – 45.10 (G02K52)	7/16/2007	4.77[b]			
	8/9/2007	4.49[b]			

[a]Value is not within the OMZA range of 6.5 – 9.0 S.U. for pH.
[b]Concentration is less than the OMZM of 4.0 mg/l.
[c]Concentration is less than the OMZA of 5.0 mg/l.
[d]Concentration exceeds the OMZA for NH3-N based on ambient pH and Temperature (OAC 3745-1-07 Table 7-5).
[e]Concentration exceeds the OMZA of 1,500 mg/l.

Recreational Use Assessment

Proposed criteria used to determine whether rivers and streams in the upper Grand River basin were suitable for recreational uses are based upon the presence or absence of *Escherichia coli*. *E. coli* bacteria are microscopic organisms that are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour, 1977), but there is currently no simple way to differentiate between human and animal sources of bacteria in surface waters, although methodologies for this type of analysis are becoming available. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

Pathogenic organisms are typically present in the environment in such small amounts that it is impractical to monitor them directly. Fecal coliform bacteria, including *E. coli*, by themselves are usually not pathogenic. However, some strains of *E. coli* can be toxic and cause serious illness, especially those emanating from cattle raised on a grain diet. Although not necessarily agents of disease, fecal coliform bacteria and *E. coli* may indicate the presence of pathogenic organisms that enter the environment through the same pathway that carries the bacteria (e.g., failing on-site sewage systems, combined sewer overflows). For example, associations have been documented between the proximity of wastewater outfalls, fecal bacteria counts, and gastrointestinal illness at swimming beaches (Cabelli et al. 1982, Wade et al. 2006). These studies failed to use controls, however, calling into question the causal mechanism of the illness. The near real-time counts used in the Wade et al. (2006) study showed increasing concentrations of fecal bacteria during the course of the day, suggesting that the bathers themselves were the source of contamination, and therefore the disease vector. Another important caveat exists with this assumption; *E. coli* is found in soils (Fujioka et al. 1999), and can persist in sediments for several weeks (Solo-Gabriele 2000), thereby obfuscating both source identification and association with potential pathogens.

Designations of recreational uses for water bodies in the Grand River watershed are listed in OAC Rule 3745-1-10. All water bodies with designated recreational uses in the Grand River watershed are designated for Primary Contact Recreation, which "...are waters that, during the recreation season, are suitable for full-body contact recreation such as ... swimming, canoeing, and SCUBA diving with minimal threat to public health as a result of water quality" [OAC 3745-1-07 (B)(4)(b)]. There are no known designated bathing waters within the areas assessed for the Grand River watershed in 2007. Draft (as of June, 2009) bacteria standards for the Primary Contact Recreation Use are stratified into three classes - Class A for waters frequently visited for recreational purposes, Class B for streams that are occasionally visited, and Class C streams which are small, infrequently visited, and maintained for drainage. Standards based on *E. coli* for each class are as follows:

Class A – geometric mean of 2 or more samples during the recreation season (1 May through 31 October) shall not exceed 126 colonies/100ml, or a maximum of 298 colonies/100ml;

Class B – geometric mean of 2 or more samples during the recreation season (1 May through 31 October) shall not exceed 161 colonies/100ml, or a maximum of 523 colonies/100ml;

Class C – geometric mean of 2 or more samples during the recreation season (1 May through 31 October) shall not exceed 206 colonies/100ml, or a maximum of 940 colonies/100ml;

Assessments based upon the proposed bacteria criteria are listed in Table 13. The ubiquity of high bacteria counts clearly suggests that the bacteria indicators are not serving exclusively as surrogates for pathogens of human origin. *E. coli* counts followed a log-normal distribution (Kolmogorov-Smirnov one sample test, P=0.7596; Figure 18), suggesting an origin from diffuse sources such as livestock and wildlife. Presumably the distributions would be strongly skewed if the high counts were generally associated with defined point sources or local aggregations of unsewered homes. Given these caveats, other direct and indirect indicators of organic enrichment were used to suggest the sources most likely contributing to sites identified in non-attainment (Table 13). These other indicator were ammonia-nitrogen, total Kjeldahl nitrogen, total dissolved solids, field notes, census tract data (for densities of unsewered residential units), land use data (for pastured land/livestock densities), and the location of sludge or manure application fields. Where these additional indicators failed to point to an identifiable source, the source is listed as unknown.

The specific waterbodies where high *E. coli* counts were associated with indicators of organic enrichment (Figure 19) were Deacon Creek, Center Creek, North Branch Phelps Creek, Three Brothers Creek, Garden Creek, Crooked Creek, Lebanon Creek and Whetstone Creek. Where anecdotal evidence pointed to contamination from human origins, the sources appeared to be unsewered homes affecting Center Creek and the North Branch Phelps Creek, and the elevated fecal counts in Whetstone Creek and Lebanon Creek were associated with high TDS and nitrates, as well as ammonia and Kjeldahl nitrogen, suggesting a slug of untreated nitrogenous wastes, possibly from a spill or illegal dumping.

Livestock were clearly the source of bacteria found in Garden Creek and Crooked Creek, as the samples were essentially collected in cow pastures. Livestock were the suspected source for other waterbodies with pastures in close proximity upstream from the sampling location.

For sites with high bacteria counts, but lacking both corroborating water quality data (i.e., elevated NH3-N, TKN, TDS) and any anecdotal evidence pointing to a likely source, attainment is considered ambiguous, and the sources are listed as unknown in the Table 13. The bacteria counts in those cases may be from ubiquitous background contamination.

Table 13. Recreational use assessments based on *E. coli* bacteria counts from water quality samples collected in the upper Grand River watershed in 2007.

RM	STORET	GEOMEAN	N	Class	Attainment	Sources
Grand River						
98.95	200631	1170	2	B	Non	Unknown
95.38	G01S07	600	2	B	Non	Unknown
94.27	G01K09	442	6	A	Non	Unknown
88.50	G01K20	971	6	A	Non	Unknown
75.58	G01K18	161	2	A	Non	Unknown
65.88	G01W06	283	6	A	Non	Unknown
60.80	G01K07	335	2	A	Non	Unknown
55.62	G01K08	325	6	A	Non	Unknown
49.45	G02K54	100	2	A	Full	
Bronson Creek						
1.52	300201	1200	1	B	Non	Livestock
0.82	G02K50	230	1	B	Full	
Trumbull Creek						
9.03	300205	790	1	B	Non	Unknown
6.23	300204	42	2	B	Full	
2.05	G02K51	462	6	B	Non	Unknown

Table 13. Continued.

RM	STORET	GEOMEAN	N	Class	Attainment	Sources
Spring Creek						
5.02	300202	364	2	B	Non	Livestock
2.76	300207	416	2	B	Non	Livestock
Three Brothers Creek						
6.68	300203	516	2	B	Non	Unknown
1.99	300208	310	1	B	Full	
Crooked Creek						
6.70	300182	43	2	B	Full	
3.51	300181	159	2	B	Full	
1.62	G01K01	2228	2	B	Non	Livestock
Mud Creek						
3.78	300188	2147	2	B	Non	Unknown
Mill Creek						
4.94	300186	260	1	B	Full	
2.30	300185	284	2	B	Non	Unknown
Garden Creek						
2.31	300183	474	2	B	Non	Livestock
Baughman Creek						
3.30	G02S06	1470	2	B	Non	Livestock
Center Creek						
6.25	300174	1396	2	B	Non	On-site Sewerage
Mud Run						
4.05	300172	600	2	B	Non	Unknown
Dead Branch						
7.86	300170	611	2	B	Non	Unknown
4.10	300169	77	2	B	Full	

Table 13. Continued.

RM	STORET	GEOMEAN	N	Class	Attainment	Sources
Deacon Creek						
5.31	300176	102	2	B	Full	
1.38	300175	6099	2	B	Non	Livestock
Trib. To Mill @ RM 3.79						
0.13	300191	60	1	B	Full	
Trib. To Crooked @ RM 6.5						
0.29	300194	72	2	B	Full	
Rock Creek						
9.64	G01W02	168	6	B	Non	Unknown
1.23	G01K03	92	6	B	Full	
Whetstone Creek						
2.00	300200	212	2	B	Non	Spill?
Lebanon Creek						
1.93	300198	297	2	B	Non	Spill? or WWTP
Snyder Ditch						
0.60	300199	701	2	B	Non	Unknown
Hoskins Creek						
4.88	300184	1386	2	B	Non	Livestock
2.01	G01K19	498	2	B	Non	Livestock
Indian Creek						
1.30	200624	559	2	B	Non	Unknown
Trib. To Hoskins @ RM 2.45						
1.15	300197	8200	1	B	Non	Unknown
Phelps Creek						
4.90	300190	72	2	A	Full	
1.23	G01K06	451	5	B	Non	Unknown

Table 13. Continued.

RM	STORET	GEOMEAN	N	Class	Attainment	Sources
North Branch Phelps Creek						
1.10	300189	420	2	B	Non	On-site Sewerage
South Branch Phelps Creek						
5.20	300193	160	1	B	Full	
0.58	300192	88	2	B	Full	
Swine Creek						
10.40	300178	317	2	B	Non	Unknown
8.18	G01K16	630	6	B	Non	Unknown
1.72	200628	3429	2	B	Non	Livestock
Andrews Creek						
3.62	300179	1777	2	B	Non	Livestock
Plum Creek						
1.48	300180	693	2	B	Non	Livestock*

*The source is more likely from livestock than the ubiquitous background contamination based on anecdotal evidence.

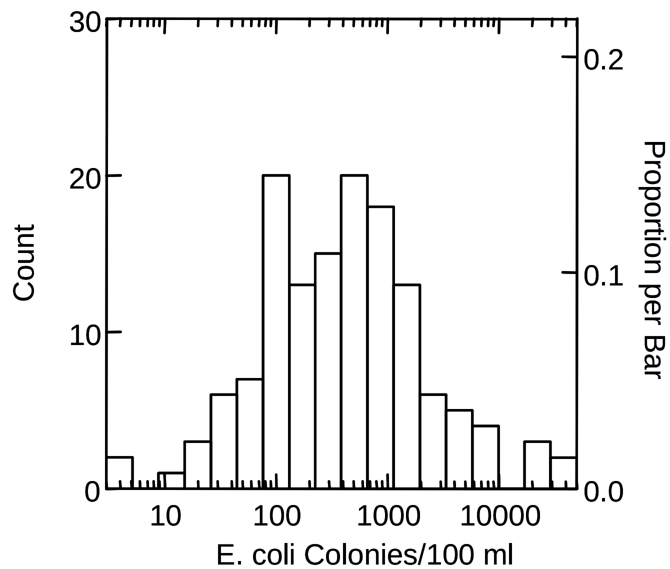

Figure 18. Frequency distribution of *E. coli* counts in water quality samples collected from the upper Grand River study area, 2007. The distribution is log-normal.

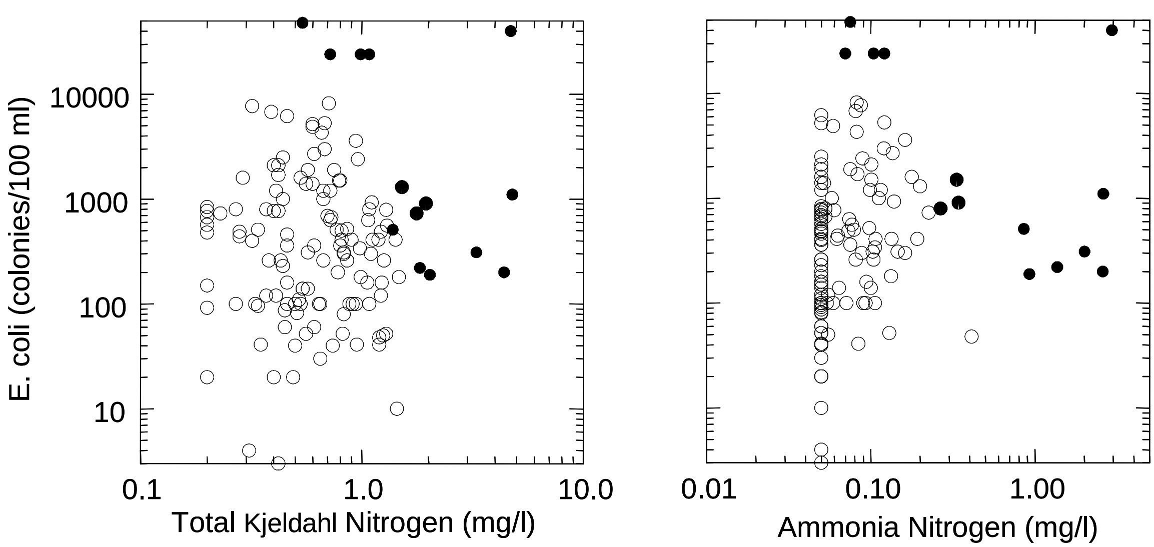

Figure 19. *E. coli* counts in relation to total Kjeldahl nitrogen and ammonia nitrogen. Solid fill indicates sites having elevated concentrations of one or more organic enrichment indicators in addition to high bacteria counts.

Sediment Quality

Sediments were sampled once at four locations in the upper Grand River basin during 2007. Results for organic compounds, including legacy priority organics and pesticides, were all less than the laboratory detection limits. Similarly, concentrations of trace and heavy metals were at background levels typical of unpolluted streams (Table 14). Exceptions were for slightly elevated concentrations of arsenic and zinc. Based on effects levels suggested by MacDonald et al. (2000), NOAA (1999), and OMOE (1993), sediment quality is not likely to be limiting to aquatic life in the upper Grand River basin.

Table 14. Sediment chemistry results for sites sampled in the Grand River basin, 2007. All results are reported in units of mg/kg.

Parameter	Grand River Wood-Curtis Rd RM 88.5 G01K20	Grand River US 322 RM 65.88 G01W06	Rock Cr. Union Cemetery RM 0.95 G01W05	Baughman Creek Fenton Road RM 3.29 G02S06
Aluminum	4510	5180	7040	5060
Arsenic*	3.52	6.05[a]	22.60[b]	10.80 [a]
Barium	31.100	37.400	51.000	44.800
Cadmium*	0.095	0.151	0.299	0.441
Calcium	1270	1650	2190	4370
Chromium*	11	20	11	34
Copper*	6.5	10.0	17.5	13.0
Iron	10200	12800	36500	12000
Lead*	7.03	10.20	19.40	14.70
Magnesium	1310	1810	2150	1410
Manganese	225	524	530	441
Mercury*	0.025	0.028	0.036	0.070
Nickel	15	27	20	46
Potassium	756	1320	892	2300
Selenium	0.76	1.32	0.73	2.30
Sodium	1890	3310	1820	5740
Strontium	11	20	11	34
Zinc*	53.0	50.2	184.0 [a]	82.4

*Parameters for which toxicologically and empirically-based effects levels have been established.

[a] Exceeds Threshold Effects Level from MacDonald et al. (2000)

[b] Exceeds Probable Effects Level from MacDonald et al. (2000)

Physical Habitat for Aquatic Life

Overview

The physical habitat quality of streams in the upper Grand River basin is largely influenced by topography, drainage area, and the juxtaposition of glacial till and lacustrine deposits. Essentially this creates three distinct stream types: lowland streams, upland headwaters, and the non-wadeable Grand River mainstem.

Where the topography is flat, and the substrates are composed primarily of lacustrine silts and clays, habitat quality is generally poor and not conducive to stream faunas typical of the ecoregion (Figure 20). Headwater streams matching this description are found in the lowlands of the southeastern quarter of the catchment in hydrologic units 010 and 030. Baughman, Deacon and Center Creeks have all been historically modified to enhance drainage (Table 15). Baughman showed evidence of recent channelization downstream from Fenton Road. Given that it has sand substrates and flow augmented by groundwater, it appears to quickly reform meanders; hence the apparent perceived need for continued maintenance. The others are not actively maintained, other than near road crossings, and appear to lack the energy to significantly re-form channel features.

The western side of the catchment (hydrologic units 020, 040, and the western half of 010) has high relief, and sediments composed of coarse-grained glacial till and sandstone bedrock. Prior to entering the low-lands adjacent to the Grand River mainstem, the headwaters on the western side tend to have high gradients, and possess the energy to form well-developed channels through the coarse substrates. Where these streams enter the lowlands, stream gradient drops and substrates become fine-grained, though sandier than streams on the southeastern side of the catchment. Typically, the faunas in these headwaters are not limited by habitat quality. The combination of a high gradient, coarse-grained reach running into a low gradient, fine-grained reach makes these streams suitable for northern brook and American brook lamprey (Figure 21). Adult lamprey utilize the coarse substrate in the high gradient reach as spawning habitat, and the ammocoetes reside buried in depositional sediments, especially in the low gradient reaches. The upper Grand River drainage is the only drainage in Ohio where these two species co-occur in the same stream.

On the northeastern side of the catchment, Three Brothers, Whetstone and Lebanon Creeks have the drainage area, gradient, and substrates to form stream channels with features typical of headwater streams. Rock Creek is a lowland stream that is impounded between RMs 2.8 and 8.0 to form Lake Roaming Rock. Rock Creek was intermittently flow starved downstream from the impoundment during the summer of 2007. Upstream from the impoundment, the creek is typical of wading streams between Dodgeville and Windsor Roads, thereafter becoming a channelized ditch with no potential to support a WWH fauna.

The Grand River mainstem downstream from West Farmington flows through a glacial lake-bed and consequently has low gradient, and fine sediment. However, because the catchment is highly dendritic, drainage area downstream from West Farmington increases rapidly, providing sufficient energy to create meanders, and sort sediments such that substrates in the thalweg are generally sand and gravel. Furthermore, because farms in the catchment tend to be small and isolated from the immediate riparian area, and because most of the headwaters are reasonably intact, the channel is not overwhelmed with silt and clay. Lastly, the wooded riparian zone supplies a generous quantity of large woody debris to the river, which, in-turn, creates variation in current velocity that further helps sort sediments.

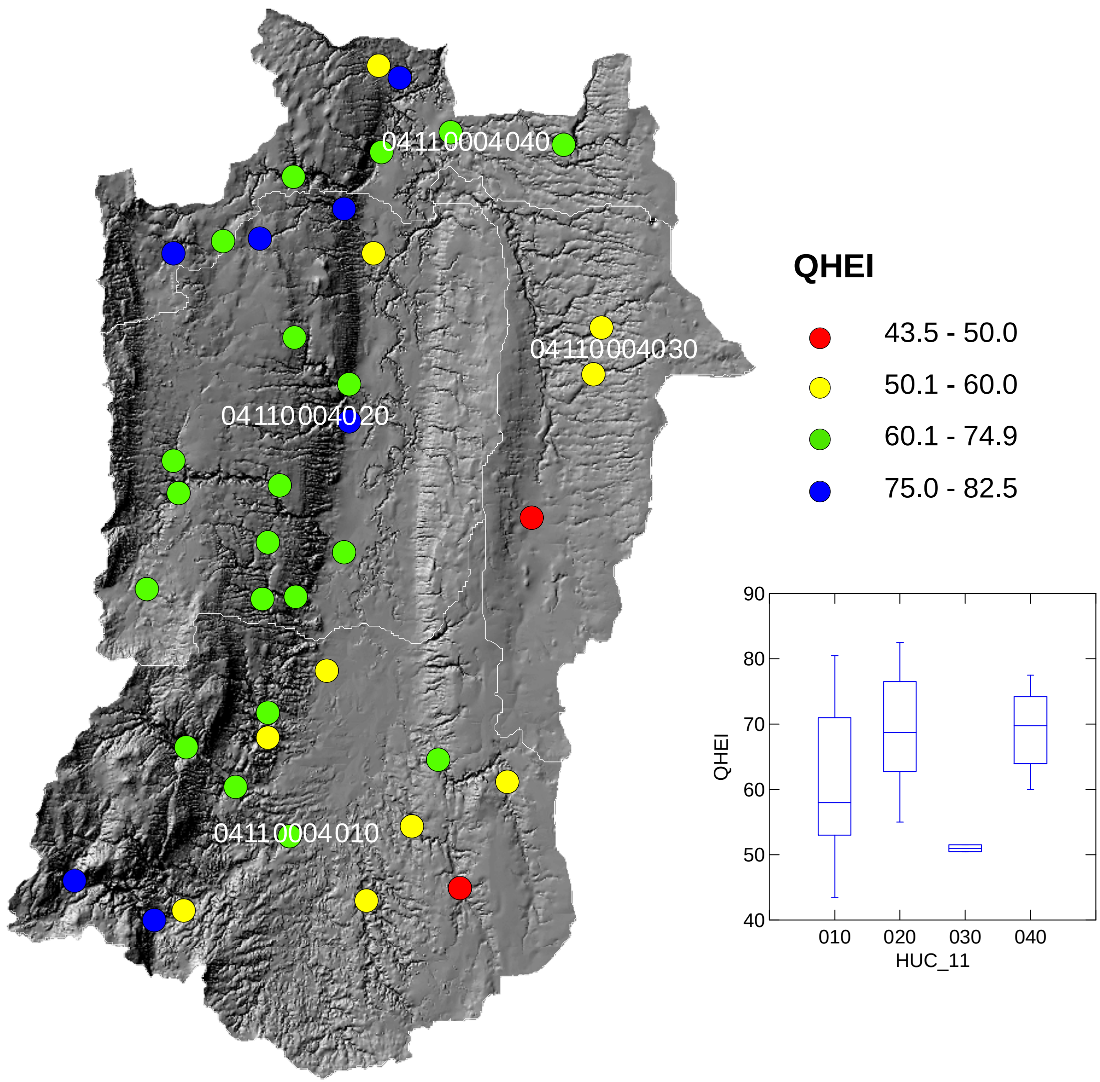

Figure 20. Qualitative Habitat Evaluation Index (QHEI) scores for sites sampled in the upper Grand River basin, 2007, in relation to physical relief. The scores are grouped by quality ranges range from excellent (blue) to poor (red). The inset panel shows the distribution of QHEI scores by 11-digit hydrologic unit.

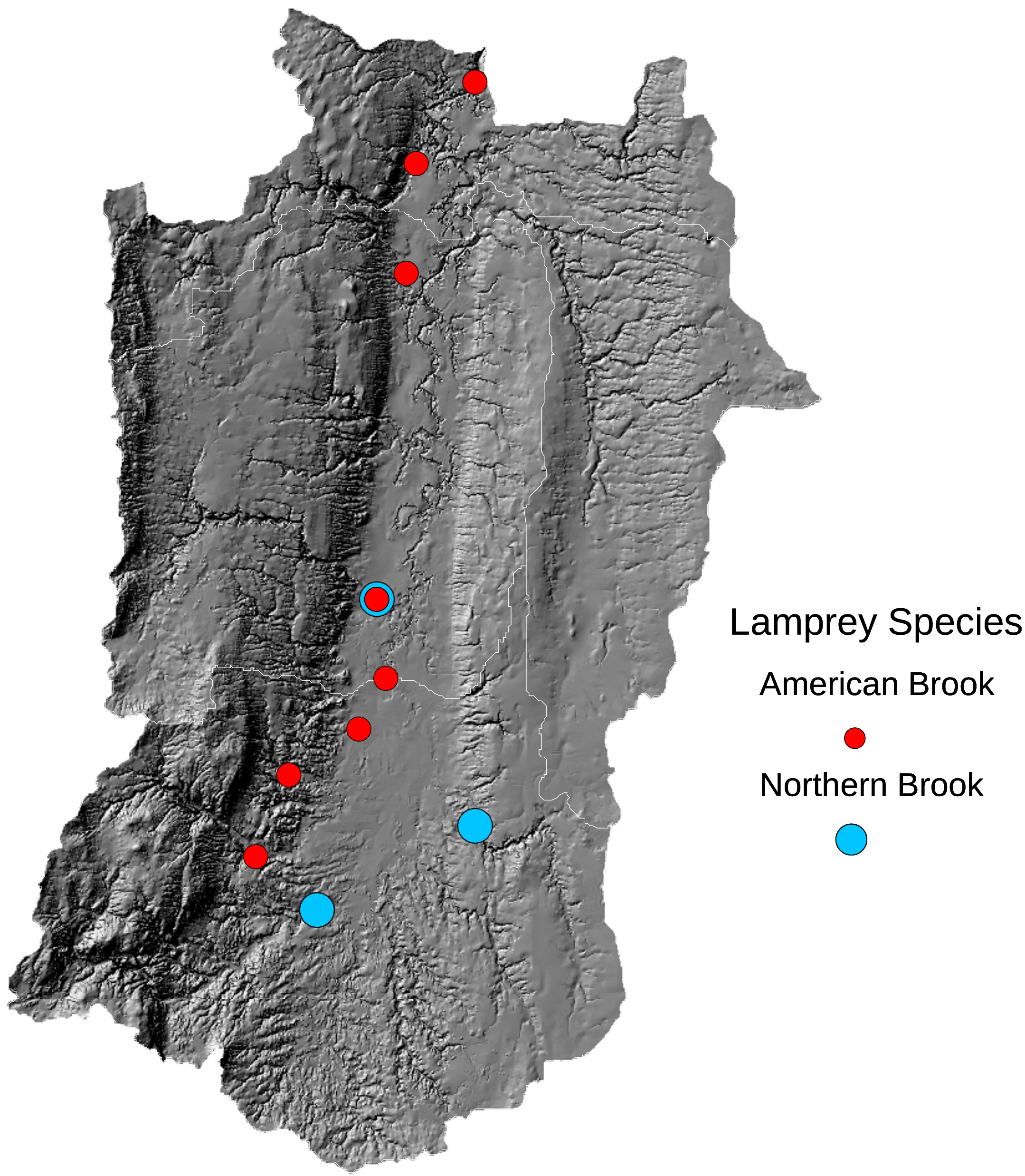

Figure 21. Locations where American and least brook lampreys were collected during the 2007 survey in relation to physical relief.

Table 15. QHEI Attributes for the upper Grand 2007.

Key QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes – High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes – Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(03-001) Grand River																																		
Year: 2007																																		
99.0	**75.0**	22.22	■			■	■	■	■	■	■	■	8						0													0	0.11	0.11
95.4	**80.5**	30.30	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
94.3	**58.0**	21.28	■				■			■	■	■	5				♦		1					●				●				2	0.33	0.67
88.5	**71.0**	3.61	■			■	■	■		■	■	■	7						0					●				●				2	0.13	0.38
75.6	**58.0**	1.84	■				■	■		■	■	■	6		♦				1	●	●			●				●				4	0.29	0.86
63.3	**60.0**	1.01	■				■	■		■	■		5						0				●	●				●			●	4	0.17	0.83
55.6	**59.0**	1.01	■				■	■		■	■		5						0					●				●			●	3	0.17	0.67
48.6	**64.5**	1.08	■	■			■	■		■	■	■	7						0					●				●		●		3	0.13	0.50
42.4	**59.0**	0.82	■				■	■		■	■		5						0					●				●			●	3	0.17	0.67
(03-012) Bronson Creek																																		
Year: 2007																																		
1.5	**60.0**	62.50	■			■	■		■	■	■	■	7				♦		1					●								1	0.25	0.38
0.8	**77.5**	37.04	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
(03-013) Trumbull Creek																																		
Year: 2007																																		
6.2	**69.0**	45.45	■			■	■	■	■	■	■	■	8						0													0	0.11	0.11
2.0	**70.5**	10.64	■	■		■	■	■		■	■		7						0		●		●					●	●	●		5	0.13	0.75
(03-014) Spring Creek																																		
Year: 2007																																		
5.1	**76.0**	12.50	■	■		■	■	■		■	■	■	8						0									●	●	●		3	0.11	0.44
2.8	**61.5**	19.23	■	■				■		■		■	5			♦	♦	♦	3					●				●		●		3	0.67	1.17
(03-015) Three Brothers Creek																																		
Year: 2007																																		
6.7	**66.5**	19.23	■	■		■	■	■		■	■		7			♦			1	●								●			●	3	0.25	0.63
2.0	**72.5**	14.08	■	■		■	■	■		■	■	■	8						0					●				●				2	0.11	0.33
(03-017) Crooked Creek																																		
Year: 2007																																		
6.7	**80.0**	43.48	■	■		■	■	■			■	■	7						0		●							●	●			3	0.13	0.50
3.5	**82.5**	52.63	■	■		■	■	■	■	■	■	■	9						0				●							●		2	0.10	0.30
1.6	**55.0**	6.94						■		■	■		3			♦			1	●	●			●				●	●		●	6	0.50	2.00

Key
QHEI
Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes – High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes – Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(03-019) Mill Creek (Grand R. RM 75.17)																																		
Year: 2007																																		
4.9	**69.0**	52.63	■	■			■	■		■	■	■	7						0		•			•				•	•	•		5	0.13	0.75
2.3	**68.5**	125.0	■	■		■	■	■	■	■	■	■	9						0		•											1	0.10	0.20
(03-020) Garden Creek																																		
Year: 2007																																		
2.3	**62.0**	55.56	■	■	■		■	■		■	■	■	8				♦		1					•				•				2	0.22	0.44
(03-022) Baughman Creek																																		
Year: 2007																																		
3.3	**67.5**	7.35	■	■			■	■			■		5			♦			1	•	•			•				•	•	•		6	0.33	1.33
(03-023) Center Creek																																		
Year: 2007																																		
6.3	**43.5**	11.11					■					■	2			♦	♦	♦	3	•	•		•	•				•	•	•		7	1.33	3.67
3.0	**56.0**	11.76	■				■	■		■	■		5			♦	♦		2	•	•		•	•				•	•	•		7	0.50	1.67
(03-024) Mud Run																																		
Year: 2007																																		
4.1	**53.0**	13.33	■				■			■	■		4				♦		1		•		•	•				•	•		•	6	0.40	1.60
(03-046) Deacon Creek																																		
Year: 2007																																		
1.4	**53.0**	7.81		■				■			■	■	4			♦			1	•	•		•	•				•	•			6	0.40	1.60
(03-130) Rock Creek																																		
Year: 2007																																		
9.6	**61.5**	2.90	■	■		■	■	■			■		6						0				•	•				•	•	•		5	0.14	0.86
1.2	**50.5**	16.39	■			■	■						3				♦	♦	2		•			•	•			•	•		•	6	0.75	2.25
0.9	**68.5**	16.39	■	■		■	■	■		■	■	■	8						0						•			•				2	0.11	0.33
(03-133) Whetstone Creek																																		
Year: 2007																																		
2.0	**51.5**	40.00	■				■				■		3		♦		♦		2		•			•				•	•		•	5	0.75	2.00
(03-134) Lebanon Creek																																		
Year: 2007																																		
1.9	**50.5**	33.33	■	■				■				■	4			♦	♦	♦	3					•				•	•			3	0.80	1.40
(03-138) Snyder Ditch (Rock Creek)																																		
Year: 2007																																		
0.6	**50.0**	2.56						■			■		2						0	•	•		•	•	•			•	•	•		8	0.33	3.00

Table 15 Continued.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes, *High Influence*: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	*Moderate Influence*: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(03-140) Hoskins Creek																																		
Year: 2007																																		
4.9	63.5	90.91	■			■	■	■	■	■	■	■	8				♦		1													0	0.22	0.22
2.0	62.0	52.63	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
(03-141) Indian Creek																																		
Year: 2007																																		
3.9	79.5	66.67	■	■		■	■	■		■	■	■	8						0									●				1	0.11	0.22
(03-150) Phelps Creek																																		
Year: 2007																																		
5.1	73.5	43.48	■		■	■	■	■	■	■	■	■	9						0													0	0.10	0.10
1.2	65.0	2.76	■	■			■	■		■	■		6						0				●	●				●		●		4	0.14	0.71
(03-151) North Branch Phelps Creek																																		
Year: 2007																																		
0.9	66.5	29.41	■	■		■	■	■		■	■	■	8			♦			1				●	●				●				3	0.22	0.56
(03-152) South Branch Phelps Creek																																		
Year: 2007																																		
5.2	69.5	16.67	■	■	■	■	■	■		■	■	■	9						0				●					●				2	0.10	0.30
0.5	73.5	24.39	■	■		■	■	■		■	■	■	8						0									●				1	0.11	0.22
(03-160) Swine Creek																																		
Year: 2007																																		
10.4	71.0	45.45	■	■		■	■	■	■	■	■	■	9						0										●	●		2	0.10	0.30
8.2	72.5	8.18	■	■		■	■	■			■		6						0									●	●	●		3	0.14	0.57
1.7	54.5	2.47						■		■	■		3			♦			1	●	●			●				●	●	●		6	0.50	2.00
(03-162) Andrews Creek																																		
Year: 2007																																		
3.6	68.0	14.08	■	■		■	■	■			■		6						0		●			●				●	●	●		5	0.14	0.86
(03-163) Plum Creek																																		
Year: 2007																																		
1.5	53.0	37.04	■				■	■		■	■		5		♦				1		●			●				●	●	●		5	0.33	1.17

Key QHEI Components

Anthropogenic Habitat Impacts

Habitat impacts to streams in the upper Grand River basin, apart from historic wetland drainage, tend to be localized, and related to either non-systemic channelization and stream relocation, impoundment, and loss of riparian forest through pasturing, silviculture and single-lot housing developments. Collectively, these stressors raise stream temperatures and reduce stream flow. And in the case of unrestricted livestock access, mobilize sediment and organically enrich the stream. Figure 22 shows stream temperatures recorded over the same date range by automated data loggers at three locations in the upper Grand River watershed in relation to land cover. The location noted Spring 2 is downstream from an impoundment (seen as light blue) and a livestock pasture (seen as beige). The location Spring 1 is upstream from the impoundment, and the creek immediately upstream from the sampling location has a wooded riparian area. The Crooked Creek location is downstream from a large woodlot. Specific locations where these types of habitat impacts acted to limit fish communities are listed in Table 16.

Several of the headwaters entering the Grand River from the west are coldwater streams, notably Trumbull Creek and Crooked Creek. Of the two, Crooked Creek has the potential to be fully restored to its maximum potential for supporting a cold water fauna, including the native brook trout.

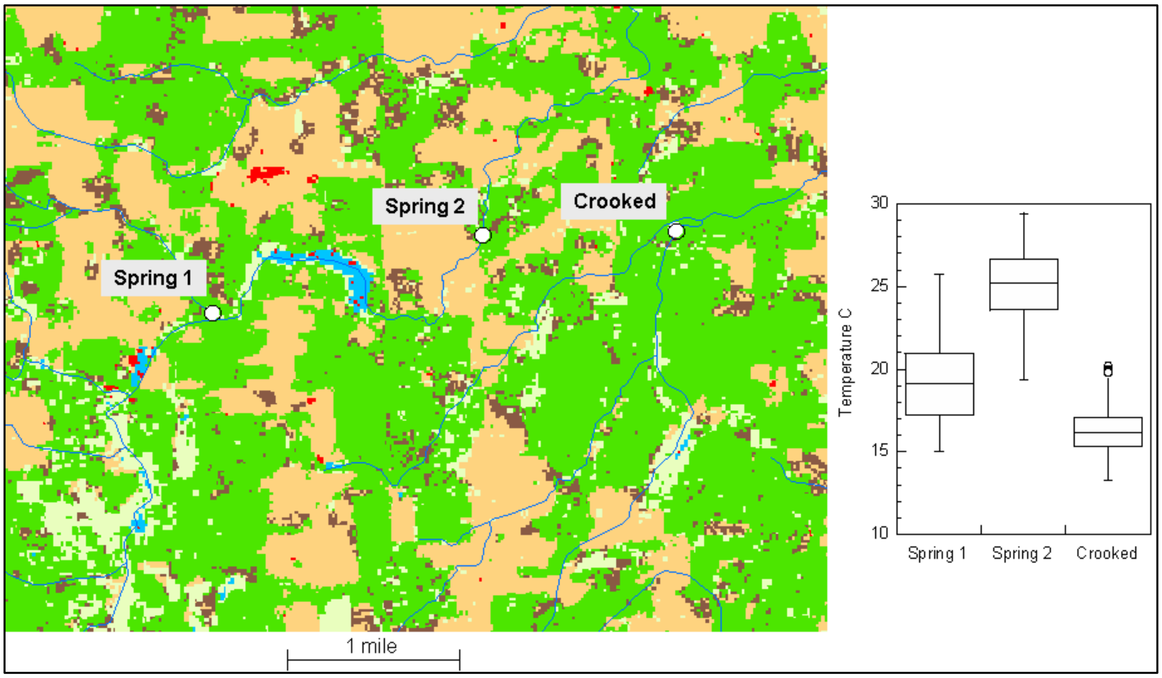

Figure 22. Land cover estimated from 1994 Landsat imagery for a portion of the headwater drainage network in the northwestern corner of the upper Grand River basin. Callahan Road joins the downstream site on Spring Creek (Spring 2) and the Crooked Creek site. State Routes 528 and 534 form the western and eastern boundaries. Green is forest cover, beige is pasture and row crop, red shows buildings and road surfaces, light green shows wetlands, brown is late-successional field/early-successional forest, and blue is open water.

Table 16. Locations in the upper Grand River watershed where habitat alteration appeared to limit fish communities.

River or Stream	Location	Habitat Impacts
Grand River	RM 98.95, Upstream from US 422	Flow starved by upstream impoundment.
Grand River	RM 94.27, Hobart Road	Recent bridge construction altered channel features, denuded habitat.
South Branch Phelps	RM 5.16, Peters Road	Flow starved relative to the drainage area, little riparian canopy in upstream network based on aerial photos.
Mill Creek	RM 4.94, Wiswell Road	Flow starved by upstream impoundment.
Hoskins Creek	RM 4.88, Upstream from SR 534	Stream relocation and channelization upstream from US 6.
Crooked Creek	RM 1.63, Upstream from Callender Road	Channelization upstream from Windsor-Mechanicsville Road; unrestricted livestock access upstream from Callender Road.
The following sites had marginal fish communities, and underperformed relative to less impacted sites located either upstream or downstream.		
Spring Creek	RM 2.76, Callahan Road	Riparian removal, unrestricted livestock access, historic channelization
Bronson Creek	RM 1.52, Windsor-Mechanicsville Rd.	Riparian removal
Rock Creek	RM 1.23, at SR 45 (Main St in Village of Rock Creek)	Flow starved from Lake Roaming Rock
North Branch Phelps	RM 0.94, Huntley Road	Construction of impoundment immediately upstream from Huntley Road.

Biological Communities - Fish

Headwaters

The quality of fish communities in the headwaters of the upper Grand River watershed is strongly tied to habitat quality. Excluding two outliers, substrate quality and drainage area account for almost three-quarters of the variation in headwater IBI scores (Table 17). The strength of substrate quality as an explanatory variable is directly related to the sharp differences in substrate size and origin imparted by the glacial and lacustrine history of the basin. With one exception, Plum Creek, samples from streams with poor substrate quality, as noted by substrate scores less than 10 on the QHEI, did not achieve the WWH biocriterion for headwaters (Figure 23). These streams (Dead Branch, Deacon Creek and Mud Run) are located in the southeastern quarter of hydrologic unit 010, and were obviously ditched to drain wetlands. Dead Branch was not sampled because the silt and clay substrates were so thick as to render electrofishing unsafe. In general, these streams lack the potential to support fish faunas consistent with expectations derived for regionally typical streams. Center Creek was also historically channelized to promote drainage, and has substrates scores less than 10; however, the site at Corey Hunt Road (RM 3.0) possessed a sufficient number of warmwater attributes to suggest that the fish community was limited beyond what can be explained by habitat quality. Whetstone Creek, located in hydrologic unit 030, was also a wetland stream with little potential to support a typical WWH fauna. However, Whetstone Creek was unique in that is was impounded by beaver dams, and supported an abundance of pumpkinseed sunfish and golden shiners - exactly what one would expect of a beaver dam pool. Sites with exceptionally high biologic index scores included Crooked Creek at Higley Road (RM 3.5), Indian Creek at Montgomery Rd (RM 3.9) and the Grand River downstream from the lower crossing of US 422 (RM 95.4).

Seven headwater sites scattered throughout the watershed had fish communities that appeared impaired beyond what can be explained exclusively by natural limitations. Those sites are noted in Figure 23 as having substrate scores greater than 10. Five of the seven cases were impaired, as noted in Table 16, by localized habitat alteration, or sequelae associated with watershed modifications. Organic enrichment from livestock may have contributed to the impairment noted for Crooked Creek at Callender Road (RM 1.63) given that abundance of omnivorous fishes was elevated and low dissolved oxygen concentrations were noted during the survey. Lebanon Creek lacked pools greater than 40 cm deep, as bedrock was the dominant substrate. It also appeared to be transitional between headwaters and primary headwaters, given the presence of two-lined salamanders. However, sustained flow was evidenced by rainbow darters and a total of 10 fish species. Pollution, as a stressor acting beyond the natural limitations of shallow bedrock, is suggested by low relative numbers in the sample across species, and the low total number of species found.

Table 17. Results of the regression of headwater IBI scores on substrate scores and drainage area.

Adjusted squared multiple R: 0.7271

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P
CONSTANT	-6.3081	5.1593	0.0000	.	-1.2227	0.2310
SUBSTRATE	2.4324	0.2702	0.8656	0.9225	9.0034	0.0000
LOGDRAIN	15.8578	3.2381	0.4708	0.9225	4.8972	0.0000

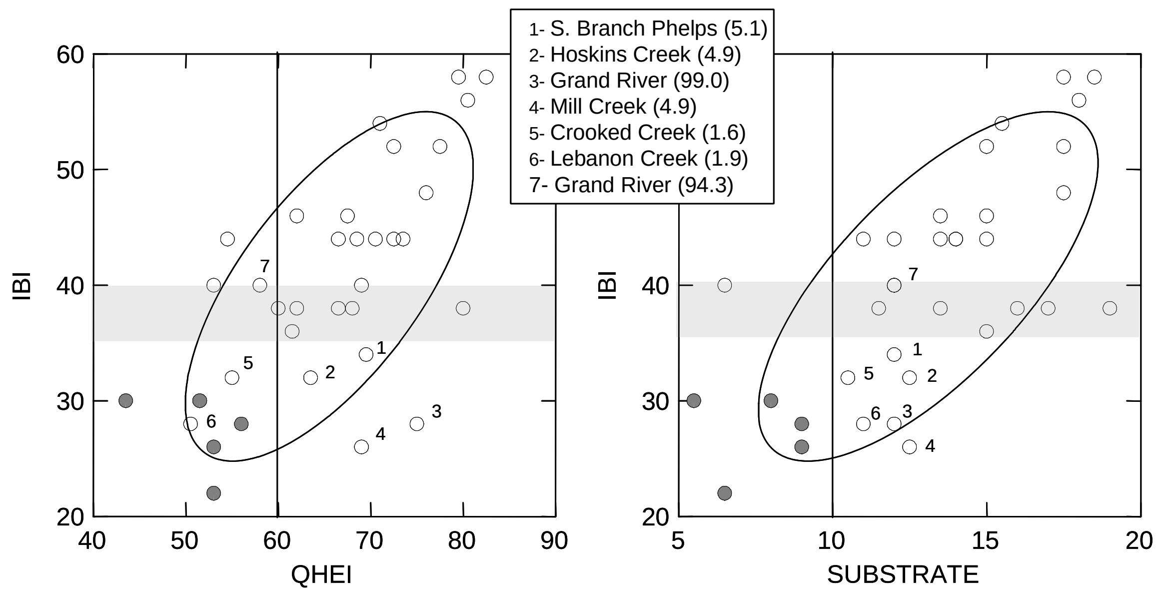

Figure 23. Scatter plots of IBI scores on QHEI scores (left panel) and substrate scores (right panel) for headwater sites sampled in the upper Grand River basin, 2007. The solid points show sites that have primarily silt and clay substrates, and are naturally limited. The vertical lines through the plots demarcate scores where biological potential is generally not limited by habitat quality. The gray horizontal box in both plots shows the lower boundary of the WWH biocriterion for headwaters (literally, the gray area between meeting and not meeting the biocriterion). Sites that have the potential to meet the biocriterion are noted (with river miles). Note that site 7, the Grand River at RM 94.3 (Hobart Road), is designated EWH (Biocriterion = 50). In 1995, the QHEI scored 71, and the IBI 50.

Three of the seven impaired headwater sites were limited by low stream flows. Two of those sites, the Grand River at RM 99.0 (US 422) and Mill Creek at RM 4.9 (Wiswell Road) were flow starved due to impoundments located upstream. The South Branch of Phelps at RM 5.1 (Peters Road) similarly had low and intermittent flows, but aerial photos reveal no upstream impoundment.

The fish community in the Grand River at RM 94.3 (Hobart Road) was impaired due to loss of habitat. The habitat at that location in 1995 had greater pool depth, a narrower channel and more variation in current velocities than 2007. In 2007, the habitat was denuded to bedrock, the channel was wider, and flow speeds were slow and moderate. No proximate cause was readily apparent, but bridge replacement at Hobart Road may have destabilized the channel morphology.

The reach of Hoskins Creek sampled between SR 534 and US 6 possesses natural habitat, albeit primarily bedrock. However, upstream from US 6, the creek appears to have been historically re-routed to follow US 6 as a ditch for approximately one-half mile. Because the stream is bedrock, and not likely to score well naturally, it has limited capacity to absorb stress.

Rock Creek

Fish communities were evaluated at four sites on Rock Creek, two upstream from Lake Roaming Rock, and two bracketing the Village of Rock Creek WWTP (Figure 24). The fish community sampled downstream from the WWTP met standards for WWH. Upstream from the WWTP, fish were limited by lack of flow, and did not meet the standard for WWH. Upstream from Lake Roaming Rock, at RM 9.6 (Dodgeville Road) and at RM 0.6 (Moore Road) of Snyder Ditch (a.k.a Rock Creek), fish communities met standards for WWH and Modified Warmwater Habitat (MWH), respectively.

The Grand River Mainstem

Fish Communities were sampled at nine locations along the Grand River mainstem. As previously discussed, two headwater sites in the vicinity of Parkman did not meet applicable standards (Figure 25). Fish communities met standards for WWH from West Farmington (RM 88.5) downstream to Footville Richmond Road (RM 48.6). Northern brook lamprey ammocoetes and sand darters were found in the Grand River near West Farmington. Downstream from Footville Richmond Road, starting at RM 44.5, the Grand River is designated Exceptional Warmwater Habitat (EWH). The fish community sampled at RM 42.4 (Schweitzer Road) did not meet EWH; however, the reach sampled did not have a riffle, and therefore is expected to be handicapped. Functionally, the fish community at the site represents one of the closest approximations Ohio has to an intact, lowland, large river fish fauna. No other river in Ohio has native, naturally reproducing populations of muskellunge, northern pike and walleye occurring together. Preservation of the bottomland forests and wetlands is essential for maintaining these populations.

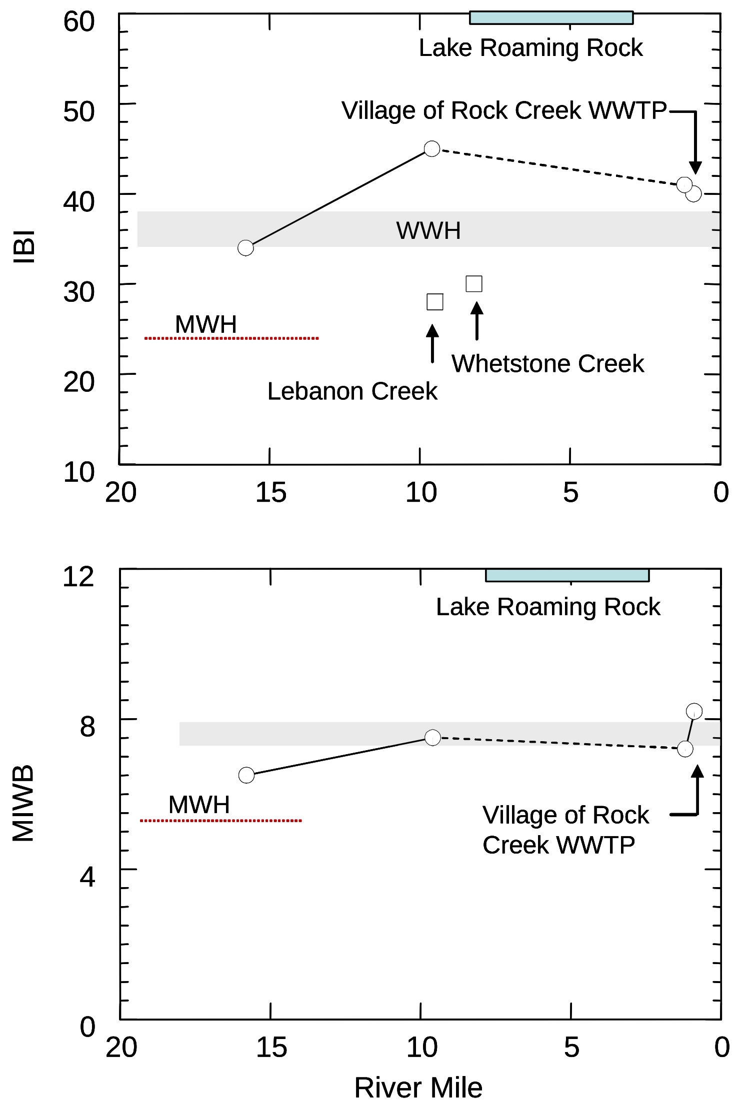

Figure 24. Longitudinal plot of IBI scores (top panel) and MIWb scores (lower panel) for sites sampled on Rock Creek in relation to the Village of Rock Creek WWTP and Lake Roaming Rock. The shaded area in each plot shows the minimum range of acceptable scores for WWH. The redline in each plot shows the minimum standard for Modified Warmwater Habitat.

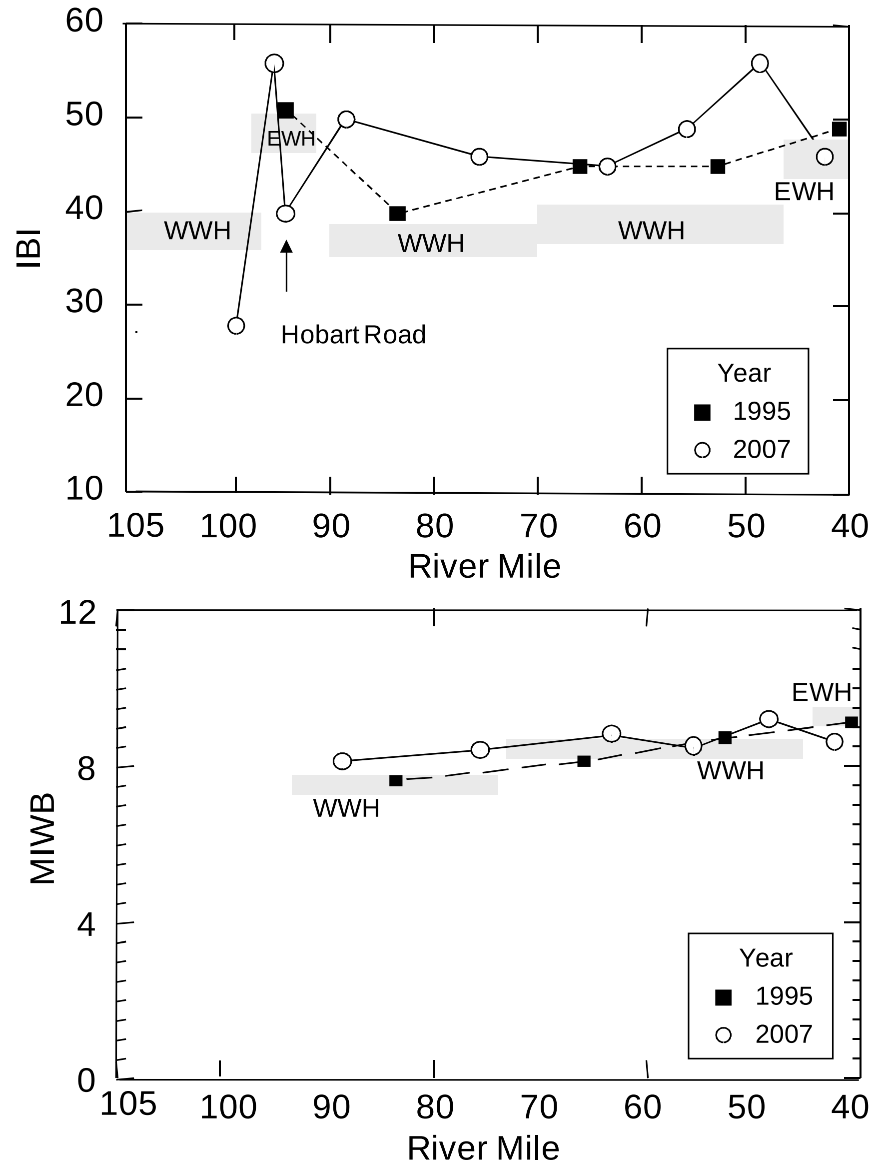

Figure 25. Longitudinal plots of IBI (top panel) and MIWB (lower panel) scores for sites sampled on the Grand River Mainstem, 2007 and 1995. Shaded areas in each plot show the range of minimally acceptable index scores.

Table 18. Fish community attributes for study sites in the upper Grand River basin, 2007. Narrative ratings are as follows: E, excellent; VG, very good; G, good; MG, marginally good; F, fair; P, poor; PHW, primary headwater habitat (fish not sampled); DNS, did not sample-wetland, or access denied (note by asterisk for the latter). QHEI is the Qualitative Habitat Evaluation Index, IBI is the Index of Biotic Integrity, MIWb is the Modified Index of Well-being.

STORET	RM	Cumulative Species	Mean Species	Relative Number	Relative Weight	Drain Area	QHEI	IBI	MIWb[a]	Narrative
Hydrologic Unit 04110004010										
03-001	Grand River - unverified WWH/CWH recommended									
200631	98.95	7	7.0	690.0	0.0	6.8	75.0	28[*]		F
			EWH							
G01S07	95.38	21	21.0	1065.0	0.0	14.1	80.5	56		E
			WWH							
G01K09	94.27	12	12.0	275.4	0.0	15.2	58.0	40		G
G01K20	88.50	26	22.5	373.4	3.6	32.1	71.0	50	8.0	E/G
03-022	Baughman Creek - EWH									
G02S06	3.30	18	18.0	1046.0	11.4	15.5	67.5	46[ns]		VG
03-023	Center Creek - unverified WWH - recommended									
300174	6.25	10	10.0	282.0	0.0	6.4	43.5	30[*]		F
G01K13	3.03	15	15.0	404.0	0.0	11.6	56.0	28[*]		F
03-024	Mud Run - unverified WWH - wetland stream									
300172	4.05	11	11.0	768.0	0.0	8.5	53.0	22[*]		P
03-025	Dead Branch - unverified WWH - wetland stream									
300170	7.86					0.0	0.0	0		DNS[†]
300169	4.10					0.0	0.0	0		DNS[†]
03-046	Deacon Creek - unverified WWH - wetland stream									
300176	5.31					0.0	0.0	0		DNS[†]
300175	1.38	9	9.0	176.0	0.0	9.3	53.0	26[*]		P
03-160	Swine Creek - WWH/CWH recommended									
300178	10.40	15	15.0	964.0	0.0	6.5	71.0	54		E
G01K16	8.18	18	18.0	552.0	0.0	11.8	72.5	52		E
				WWH						
200628	1.72	17	17.0	514.0	0.0	18.0	54.5	44		G

Table 18. Continued.

STORET	RM	Cumulative Species	Mean Species	Relative Number	Relative Weight	Drain Area	QHEI	IBI	MIWb[a]	Narrative
Hydrologic Unit 04110004010										
03-162	Andrews Creek - unverified WWH - recommended									
300179	3.62	16	16.0	1758.0	0.0	6.0	68.0	38		G
03-163	Plum Creek - unverified WWH/CWH recommended									
300180	1.48	11	11.0	276.0	0.0	1.3	53.0	40		G

Table 18. Continued.

STORET	RM	Cumulative Species	Mean Species	Relative Number	Relative Weight	Drain Area	QHEI	IBI	MIWb[a]	Narrative
Hydrologic Unit 04110004020										
03-001	Grand River - WWH									
300209	75.58	31	25.5	277.5	17.0	126.2	58.0	46	8.4	VG/G
G01W06	65.88	25	21.0	364.0	67.9	212.0	60.0	45	8.8	VG/G
G01K07	60.80					0.0	0.0	0		DNS
G01K08	55.62	23	19.0	252.0	58.0	251.0	59.0	49	8.4	VG/MG
03-017	Crooked Creek - EWH/CWH recommended									
300182	6.70	14	14.0	800.0	0.0	3.2	80.0	38		G
300181	3.51	17	17.0	1068.0	0.0	6.9	82.5	58		E
		EWH/WWH recommended								
G01K01	1.62	18	18.0	820.0	0.0	9.3	55.0	32[*]		F
03-018	Mud Creek - unverified WWH									
300188	3.78					0.0	0.0	0		DNS[†]
03-019	Mill Creek - EWH									
300186	4.94	8	8.0	806.0	0.0	2.8	69.0	26[*]		P
		EWH/CWH recommended								
300185	2.30	10	10.0	884.0	0.0	8.9	68.5	44		G
03-020	Garden Creek -- unverified WWH - recommended									
300183	2.31	4	4.0	2256.0	0.0	1.0	62.0	38		G
03-048	Trib to Mill @ RM 3.79									
300191	0.13					0.0	0.0	0		PHW
03-049	Trib to Crooked @ RM 6.50									
300194	0.29					0.0	0.0	0		PHW
03-140	Hoskins Creek - EWH/CWH recommended									
300184	4.88	10	10.0	549.3	0.0	5.7	63.5	32[*]		F
G01K19	2.01	11	11.0	1502.0	0.0	13.5	62.0	46		VG

Table 18. Continued.

STORET	RM	Cumulative Species	Mean Species	Relative Number	Relative Weight	Drain Area	QHEI	IBI	MIWb[a]	Narrative
Hydrologic Unit	*04110004020*									
03-141	Indian Creek - EWH/CWH recommended									
200624	1.30	19	19.0	838.0	0.0	1.8	79.5	58		E
03-143	Trib to Hoskins @ RM 0.4									
300196	1.40					7.2	0.0	0		DNS[†]
03-144	Trib to Hoskins @ RM 2.45									
300197	1.15					2.0	0.0	0		PHW
03-150	Phelps Creek - EWH/CWH recommended									
300190	4.90	21	17.0	775.3	6.5	23.5	73.5	36[ns]	7.4[ns]	MG
		EWH/WWH recommended								
G01K06	1.23	26	20.0	375.0	4.5	25.8	65.0	45	7.7[ns]	G/MG
03-151	North Branch Phelps Creek - unverified WWH - recommended									
300189	1.10	13	13.0	555.0	0.0	6.3	66.5	38		G
03-152	South Branch Phelps Creek - unverified WWH - recommended									
300193	5.20	11	11.0	603.0	0.0	4.7	69.5	34[ns]		MG
300192	0.58	14	14.0	1234.0	0.0	11.8	73.5	44		G

Table 18. Continued.

STORET	RM	Cumulative Species	Mean Species	Relative Number	Relative Weight	Drain Area	QHEI	IBI	MIWb[a]	Narrative
Hydrologic Unit 04110004030										
03-130	Rock Creek - WWH									
G01W02	9.64	20	17.0	220.4	9.6	52.0	61.5	45	7.4*	G/F
G01K03	1.23	25	19.0	548.3	2.5	70.0	50.5	41	7.2*	G/F
G01W05	0.95	24	19.5	402.0	21.5	70.0	68.5	40	8.2	G
03-138	Snyder Ditch - undesignated/MWH recommended									
300199	0.60	18	14.0	205.5	9.2	29.0	50.0	34[ns]	6.4*	MG/F
03-133	Whetstone Creek - unverified WWH - recommended									
300200	2.00	11	11.0	891.0	0.0	5.9	51.5	30*		F
03-134	Lebanon Creek - unverified WWH - recommended									
300198	1.93	10	10.0	146.0	0.0	4.0	50.5	28*		F

Table 18. Continued.

STORET	RM	Cumulative Species	Mean Species	Relative Number	Relative Weight	Drain Area	QHEI	IBI	MIWb[a]	Narrative
Hydrologic Unit 04110004040										
03-001	Grand River - WWH									
G02K54	49.45	23	23.0	510.0	49.0	323.0	64.5	56	9.2	E/VG
G02W16	45.90	26	20.0	298.0	58.7	417.0	59.0	46	8.6	VG/MG
03-012	Bronson Creek - unverified WWH - recommended									
300201	1.52	15	15.0	482.0	0.0	5.2	60.0	38		G
G02K50	0.82	15	15.0	738.0	0.0	7.5	77.5	52		E
03-013	Trumbull Creek									
300205	9.03					0.0	0.0	0		PHW
		EWH/CWH recommended								
300204	6.23	15	15.0	1032.0	0.0	13.1	69.0	40		G
G02K51	2.05	20	20.0	274.0	0.0	19.6	70.5	44		G
03-014	Spring Creek - unverified WWH - recommended									
300202	5.02	14	14.0	849.4	0.0	1.9	76.0	48		VG
300207	2.76	11	11.0	603.0	0.0	6.5	61.5	36 [s]		MG
03-015	Three Brothers Creek - unverified WWH - recommended									
300203	6.68	15	15.0	1066.0	0.0	5.8	66.5	44		G
300208	1.99	16	16.0	673.9	0.0	8.4	72.5	44		G

Ecoregion Biocriteria: Erie-Ontario Lake Plain

Site Type	IBI WWH	IBI EWH	IBI MWH[b]	MIwb WWH	MIwb EWH	MIwb MWH[b]
Headwaters	40	50	24	NA	NA	NA
Wading	38	50	24	7.9	9.4	5.6
Boat	40	48	24	8.7	9.6	5.7

a - MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi².
b - Modified Warmwater Habitat.
ns - Nonsignificant departure from biocriteria (≤4 IBI units or ≤0.5 MIwb units).
* - Indicates significant departure from applicable biocriteria (>4 IBI units or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.
† - did not sample.

Macroinvertebrate Community

Macroinvertebrate communities were evaluated at 57 stations in upper Grand River study area (Table 19). The community performance was evaluated as exceptional at 18 stations, very good at four, good at 15, marginally good at two, fair at 13, and poor at five stations. Two of these stations were on streams with primary headwater habitat (PHWH) characteristics. The station with the highest total mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa richness (EPT) was on Crooked Creek at Higley Road (RM 3.51) with 31 taxa. The station with the highest number of total sensitive taxa was on Phelps Creek at Wiswell Ring Road (RM 4.90) with 41 taxa. Twenty-one uncommonly collected sensitive taxa (excluding the freshwater mussels) were found in this study area (Table 20). In addition to these, the state listed Threatened species *Cambarus robustus* (Cavespring Crayfish) was collected at seven sites and the Species of Concern *Orconectes propinquus* (Great Lakes Crayfish) was found at 49 sites in the study area. Huehner et al. (2005) reported finding populations of 19 species of freshwater mussels (Unionidae) in the upper Grand River mainstem, including one state Threatened species and four state Species of Concern. Fourteen of these species were collected from the Grand River mainstem during this study either as live individuals or fresh-dead shells (Table 21). In total, this study found three state Threatened species and five state Species of Concern in the upper Grand River basin. The stonefly *Pteronarcys biloba* (Knobbed Salmonfly) was found in Ohio for the first time (from Indian Creek RM 1.30) and represents a western range extension for the species. This study area had an unusually high number of uncommonly collected sensitive taxa and state listed species, which is an indication of the exceptional resource quality in the upper Grand River basin.

Grand River

The three most upstream stations sampled on the Grand River (RMs 98.95, 95.38, 94.27) were located in an upland area with relatively high gradient and substrates composed of bedrock and glacial till. Macroinvertebrate communities collected from these stations were performing at an exceptional level with high diversity of EPT (20-24) and sensitive taxa (24-36) (Table 19, Figure 26). The most upstream station (RM 98.95) had 11 taxa of cold water macroinvertebrates, which was the highest number in the study. The remainder of the Grand River stations were located in a lowland area with low gradient and substrates composed primarily of smaller sized particles and woody debris (glacial Grand River Lake lacustrine deposits). Macroinvertebrate communities at these stations were performing at good to exceptional levels, with generally lower diversity of EPT (9-23) and sensitive taxa (14-31). Fourteen species of freshwater mussels were collected at these lowland stations with the most diverse populations found at Wood Curtis Road (RM 88.50), US 322 (RM 65.88), upstream Footville Richmond Road (RM 49.45), and Camp Beaumont (RM 45.90) (Table 21). Five species of freshwater mussels reported by Huehner et al. (2005) were not found in this study. These species, for the most part, were uncommonly collected by Huehner et al. (2005). *Simpsonaias ambigua* and *Toxolasma parvus* are small species and easy to overlook. *Anodontoides ferussacianus* is a headwater species. *Utterbackia imbecillis* is adapted to ponds and areas of streams with pond-like conditions, which are common habitats in parts of the upper Grand River mainstem, but not targeted for sampling in this survey. Macroinvertebrate sampling in the upper Grand River in 1995 found similar results (Figure 26).

Rock Creek

The macroinvertebrate community sampled upstream from Lake Roaming Rock at Dodgeville Road (RM 9.64) was evaluated as exceptional with high EPT (25) and marginally high sensitive taxa (25) diversity (Table 19, Figure 27). Downstream from Lake Roaming Rock, diversity of EPT (13, 14) and sensitive taxa (16, 15) declined into the good range. The stream water surface was completely covered by floating mats of filamentous algae at these sites at the time of artificial substrate placement (11 July). This nuisance algal growth may be due to a combination of nutrient enrichment and limited flow from the reservoir. The algal mats were washed downstream by a high water event prior to the artificial substrate retrieval (29 August). The discharge from the Village of Rock Creek WWTP at RM 1.05 did not affect the ICI score or diversity of EPT and sensitive taxa in the qualitative sample. However, mild impacts from the WWTP included thick silt deposits observed at the downstream station and the macroinvertebrate community had greater abundance of flatworms (pollution facultative taxa often associated with enrichment effects) and an overall increase in organism density (705 orgs./sq.ft. at RM 1.23 compared to 1162 at RM 0.95). The EPT and sensitive taxa diversity was similar in 1987 downstream from the reservoir, prior to the construction of the Village of Rock Creek WWTP (Figure 27).

Tributaries

Macroinvertebrate communities evaluated in the upper Grand River tributaries can be grouped, to a large part, based on the physical habitat, shaped by the typography of the landscape, they flow through. Macroinvertebrate communities that were not meeting their designated or recommended Aquatic Life Use expectations, due to more or less natural low gradient landscapes that were formed by the glacial Grand River Lake or other former wetland areas, included Dead Branch, Tributary to Dead Branch (@ RM 6.20), Mud Run, Deacon Creek, and Tributary to Hoskins Creek (@ RM 0.40).

Headwater stream stations that were limited by low to interstitial flow included Mill Creek RM 4.94; Whetstone Creek RM 2.00; Three Brothers Creek RMs 6.68, 1.99; Trumbull Creek RM 9.03; and Bronson Creek RM 1.52. Macroinvertebrate communities evaluated at these stations had lower than expected EPT (3-7) and sensitive taxa (3-11) diversity, due to the loss of surface flow as the result of the water table dropping below the level of the riffle habitats.

Stream stations that appeared to have anthropogenic impacts included Center Creek at SR 45 (RM 6.25) which had a macroinvertebrate community evaluated as high fair with EPT (9) and sensitive taxa (14) diversities just below WWH expectations. The riffle habitat was devoid of sensitive EPT and had an unusually high abundance of flatworms (facultative taxa often associated with enrichment effects). Unusually high siltation and algal growths were observed at this station. A possible source of pollutants was the Paradise Lake mobile home park. The macroinvertebrate community evaluated in Lebanon Creek at Institute Road (RM 1.93) was not meeting WWH expectations with low EPT (6) and sensitive taxa (6) diversities and the riffle habitat devoid of sensitive EPT. Organism densities were unusually low in all habitats. Unusually high TDS (2,030 mg/l), chloride (980 mg/l), and NO_2+NO_3 (19 mg/l) on 16 July were evidence of periodic slugs of brine pollution, possibly from road application or gas/oil drilling operations. The nearby Whetstone Creek (RM 2.00) also had high TDS (1,100, 1,290 mg/l) and chloride (375, 585 mg/l) on 21 June and 16 July, respectively.

Many of the streams on the western part of the basin flow through high gradient channels that in places have cut down to sandstone bedrock and receive significant groundwater. These streams generally have high EPT (19-31) and sensitive taxa (23-41) diversity, presence of cold water taxa (4-9), and uncommonly collected sensitive taxa (1-9). Stream stations that fell into this category were Swine Creek RMs 10.15, 8.18; Mill Creek RM 2.30; Phelps Creek RM 4.90, Hoskins Creek 2.01; Indian Creek RM 1.30; Cooked Creek RM 3.51; and Trumbull Creek RM 6.23. The two upstream most Grand River stations (RMs 98.95, 95.38) would also fall into this category. These stations have high numbers of uncommon fauna components and should receive the highest level of resource protection.

Other stations with four or more cold water macroinvertebrate taxa, and therefore would qualify for the CWH Aquatic Live Use, were Plum Creek RM 1.48, Hoskins Creek RM 4.88, Tributary to Hoskins Creek (@ RM 2.45) RM 1.15, Mud Creek RM 3.78, and Bronson Creek RM 0.82. The stream stations Tributary to Hoskins Creek (@ RM 2.45) RM 1.15, Tributary to Crooked Creek (@ RM 6.50) RM 0.29, and Mud Creek RM 3.78 had characteristics of PHWH streams and may best be classified thus.

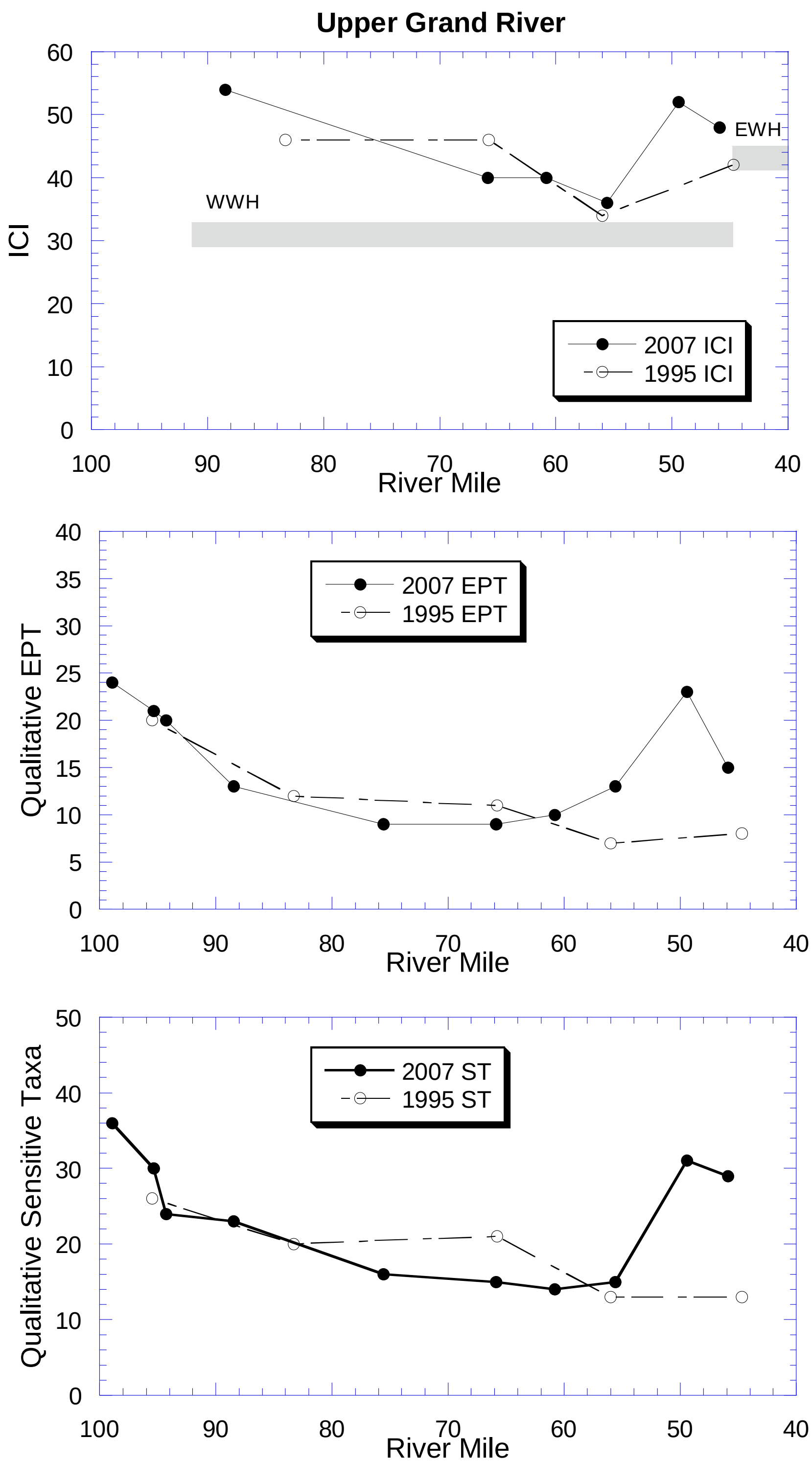

Figure 26. Longitudinal trend of the Invertebrate Community Index (ICI), number of EPT taxa (EPT) in the qualitative sample, and number of sensitive taxa (ST) in the qualitative sample in the upper Grand River, 1995-2007.

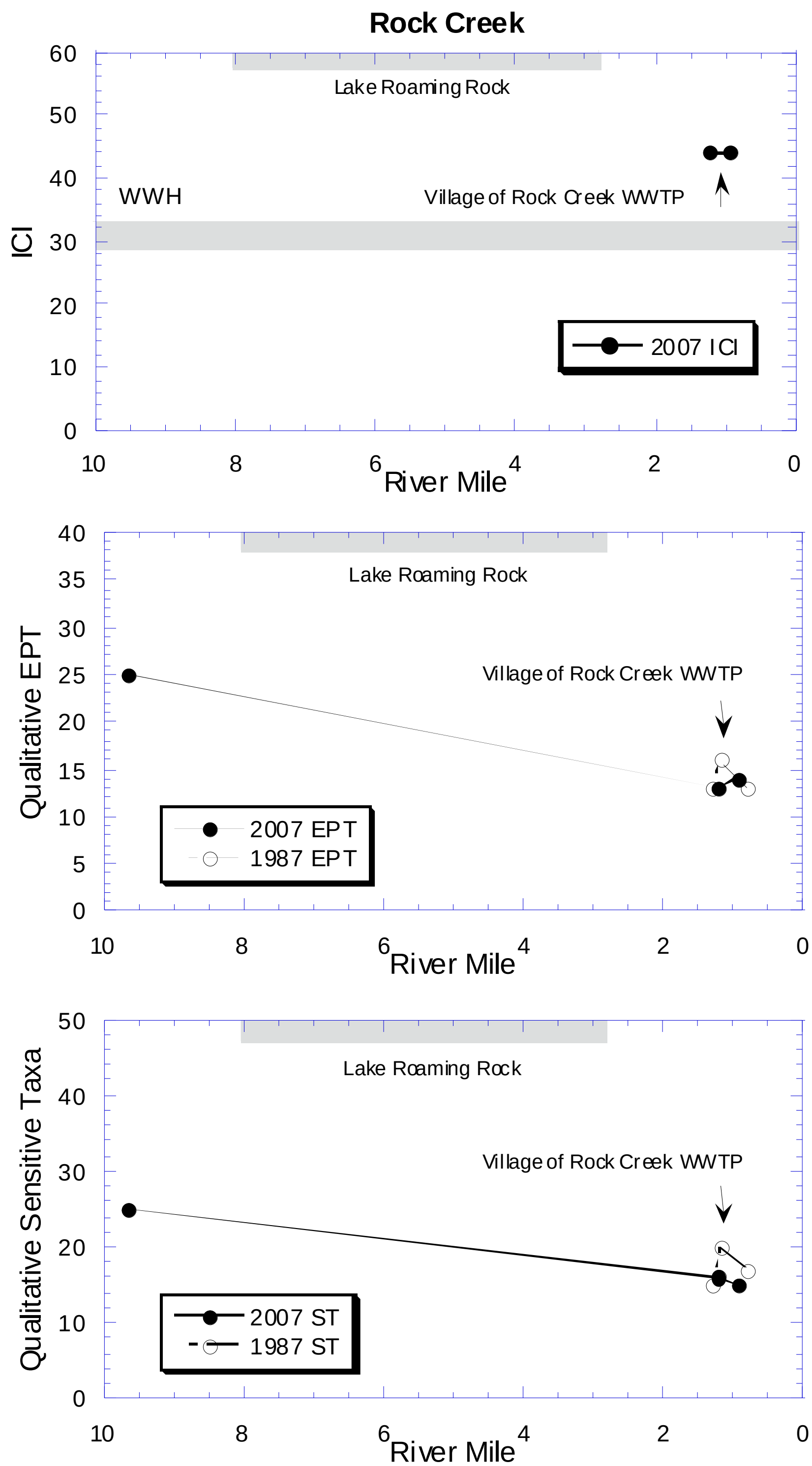

Figure 27. Longitudinal trend of the Invertebrate Community Index (ICI), number of EPT taxa (EPT) in the qualitative sample, and number of sensitive taxa (ST) in the qualitative sample in Rock Creek, 1987-2007.

Table 19. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Upper Grand River study area, July to October, 2007.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Grand River (03-001)										
98.95	7.0	-	67	24	36	M	11	Hydropsychid caddisflies (MI), baetid mayflies (MI), *Leuctra* stoneflies (I)	-	Exceptional
95.38	14.2	-	60	21	30	M	2	Baetid mayflies (F,I), hydropsychid caddisflies (MI,F), midges (MI)	-	Exceptional
94.27	17.2	-	57	20	24	M	1	Hydropsychid caddisflies (F,MI), midges (MI), baetid mayflies (F,I)	-	Exceptional
88.5	32.1	-	52	13 / 15	23 / 34	L-M / 372	0	Hydropsychid caddisflies (F), midges (F,MI), baetid mayflies (F)	54	
75.58	126	-	43	9	16	L	0	Caddisflies (MI,F), midges (MI), baetid mayflies (F,MI)	-	Marg. Good
65.88	210	-	41	9 / 12	15 / 21	L / 254	0	Hydropsychid caddisflies (F), baetid mayflies (F,I), riffle beetles (MI)	40	
60.80	222	-	32	10 / 13	14 / 18	L-M / 361	0	Caddisflies (F,MI), baetid mayflies (F), midges (F,MI)	40	
55.62	251	15	43	13 / 16	15 / 21	L-M / 280	0	Hydropsychid caddisflies (F), midges (MI), baetid mayflies (F,MI)	36	
49.45	361	-	64	23 / 24	31 / 36	L-M / 1291	0	Hydropsychid caddisflies (F,MI), midges (MI,MT), riffle beetles (F)	52	
45.90	382	-	60	15 / 18	29 / 32	L-M / 625	0	Hydropsychid caddisflies (F), midges (MI,F), baetid mayflies (F,I)	48	

Table 19. Continued.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Dead Branch (03-025)										
7.86	4.8	9	31	3	2	H	0	Water boatmen (F), snails (VT,T)	-	Poor
4.10	15.1	-	38	5	2	M	0	Water boatmen (F), scuds (F)	-	Low Fair
Tributary to Dead Branch (@ RM 6.20) (03-050)										
0.40		-	37	5	5	L-M	0	Midges (MT,F,T), water boatmen (F), snails (T,F)	-	Fair
Mud Run (03-024)										
4.05	8.5	-	29	6	5	L-M	0	Water boatmen (F), mayflies (MI,F)	-	Fair
Center Creek (03-023)										
6.25	6.4	-	54	9	14	L-M	0	Hydropsychid caddisflies (F), flatworms (F), midges (MI,F)	-	Fair
3.03		-	68	18	19	M	0	Hydropsychid caddisflies (F), midges (F), mayflies (F)	-	Good
Baughman Creek (03-022)										
3.30	15.5	-	65	19 / 21	25 / 34	M / 1154	3	Hydropsychid caddisflies (F, MI), baetid mayflies (F,I), midges (MI)	58	
Deacon Creek (03-046)										
5.31	5.2	9	23	1	0	M	0	Water boatmen (F)	-	Poor
1.38	9.3	9	17	2	4	L-M	0	Water boatmen (F)	-	Poor

Table 19. Continued.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Swine Creek (03-160)										
10.15		-	48	22	24	M	7	Hydropsychid caddisflies (MI), midges (F,MI)	-	Exceptional
8.18	11.8	-	60	23	30	M	5	Hydropsychid caddisflies (MI), baetid mayflies (F,I), midges (MI,F)	-	Exceptional
1.72	18.0	-	58	17	21	L-M	0	Hydropsychid caddisflies (F), midges (MI,F), baetid mayflies (F)	-	Good
Plum Creek (03-163)										
1.48	1.3	-	39	4	14	L-M	6	Hydropsychid caddisflies (F), midges (MI)	-	Fair
Andrews Creek (03-162)										
3.62	6.0	-	55	16	21	L-F	1	Midges (MI), hydropsychid caddisflies (F), baetid mayflies (F)	-	Good
Mill Creek (03-019)										
4.94	2.8	9	21	3	4	L-M	0	Red midges (F)	-	Poor
2.30	9.0	-	44	19	23	M	4	Caddisflies (MI,F), baetid mayflies (I,F), midges (MI)	-	Very Good
Tributary to Mill Creek (@RM 3.79) (03-048)										
0.13	3.5	9	48	13	16	L-M	2	Caddisflies (MI,F), heptageniid mayflies (F), flatworms (F)	-	Good
Garden Creek (03-020)										
2.31	1.2	9	37	13	16	L	2	Caddisflies (MI,F), midges (F)	-	Good

Table 19. Continued.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Phelps Creek (03-150)										
4.90	23.5	-	70	29	41	M-H	3	Caddisflies (MI,F), mayflies (MI,F,I), midges (MI,F)	-	Exceptional
1.23	25.7	-	55	19 / 25	25 / 37	L-M	2	Hydropsychid caddisflies (F), baetid mayflies (F,I), midges (F,MI)	60	
North Branch Phelps Creek (03-151)										
1.10	6.3	-	62	24	32	L-M	2	Caddisflies (F,MI)	-	Exceptional
South Branch Phelps Creek (03-152)										
0.58	11.8	-	47	15	20	L-M	1	Caddisflies (F,MI), water penny beetles (MI), flatworms (F)	-	Good
Hoskins Creek (03-140)										
4.88	5.7	-	54	16	25	L	4	Caddisflies (F,MI), midges (MI), water penny beetles (MI)	-	Good
2.01	13.5	-	74	30	36	M-H	5	Caddisflies (MI,F), mayflies (F,I), midges (F,MI,MT)	-	Exceptional
Tributary to Hoskins Creek (@RM 2.45) (03-144)										
1.15	2.0	-	30	11	12	L	4	Caddisflies (MI,F), *Nigronia* fishflies (F), alderflies (F)	-	Marg. Good
Indian Creek (03-141)										
1.30	3.9	-	55	28	35	L-M	8	Caddisflies (MI,I,F), mayflies (MI,I), midges (MI)	-	Exceptional
Tributary to Hoskins Creek (@RM 0.40) (03-143)										
1.40	7.2	-	58	10	9	L-M	0	Scuds (F), hydropsychid caddisflies (F)	-	Fair

Table 19. Conintued.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Crooked Creek (03-017)										
6.70	3.2	-	38	15	17	L	1	*Nigronia* fishflies (F), *Polycentropus* caddisflies (MI)	-	Good
3.51	8.2	-	62	31	38	L-M	9	Caddisflies (MI,F), midges (MI,I,F), baetid mayflies (F,I)	-	Exceptional
1.62	9.3	-	52	12	17	M	0	Hydropsychid caddisflies (F), baetid mayflies (F)	-	Good
Tributary to Crooked Creek (@RM 6.50) (03-049)										
0.29	1.9	-	28	8	12	L	3	*Nigronia* fishflies (F), burrowing mayflies (MI)	-	Fair
Mud Creek (03-018)										
3.78	1.7	-	46	13	23	L	4	Hydropsychid caddisflies (F), midges (MI)	-	Good
Rock Creek (03-130)										
9.64	52.0	-	66	25	25	L-M	0	Caddisflies (F,MI), midges (F,MI,MT), baetid mayflies (I,F)	-	Exceptional
1.23	70	-	45	13 / 14	16 / 20	M / 705	0	Caddisflies (F,MI), baetid mayflies (F,I)	44	
0.95	70	-	49	14 / 15	15 / 20	M-H / 1163	0	Hydropsychid caddisflies (F), midges (MI,F), riffle beetles (F)	44	
Snyder Ditch (Rock Creek) (03-138)										
0.60	29.0	-	47	10 / 12	7 / 16	L	0	Hydropsychid caddisflies (F), midges (F,MT)	46	

Table 19. Continued.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Whetstone Creek (03-133)										
2.00	4.0	9	29	6	6	L	0	Heptageniid mayflies (F), midges (T,F), crayfish (F)	-	Fair
Lebanon Creek (03-134)										
1.93	4.2	-	38	6	6	L	2	Hydropsychid caddisflies (F)	-	Fair
Three Brothers Creek (03-015)										
6.68	5.8	9	30	7	11	L	1	Midges (F,T,MI), heptageniid mayflies (F)	-	Fair
1.99	17.4	9	32	7	10	L	1	Red midges (T,MT,MI), crayfish (F), heptageniid mayflies (F)	-	Fair
Trumbull Creek (03-013)										
9.03	2.7	-	19	4	3	L	0	Blackflies (F)	-	Poor
6.23	13.1	-	57	30	32	M	5	Caddisflies (MI,F), baetid mayflies (F,MI,I), midges (MI,F)	-	Exceptional
2.05	19.6	12	45	21 / 24	23 / 36	L / 420	1	Hydropsychid caddisflies (F), midges (MI), baetid mayflies (I,F)	48	
Spring Creek (03-014)										
5.02	5.9	-	50	18	24	L-M	3	Caddisflies (F,MI), midges (MI), mayflies (I,F)	-	Very Good
2.76	6.5	-	63	13	20	M	0	Caddisflies (F,MI), midges (MI,F,MT), mayflies (F,MI)	-	Good

Table 19. Continued.

River Mile	Drain Area (mi^2)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Bronson Creek (03-012)										
1.52	5.2	9	29	5	9	L	1	Midges (MI,F,MT)	-	Fair
0.82	7.6	-	43	8	18	L-M	5	Caddisflies (F,MI), midges (MI,F)	-	Fair

Data Codes: 2=Dam Pool, 5=3 HD Only, 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 15=Current >0.0 fps but <0.3 fps.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
CW: Coolwater/Coldwater.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant
[a] ICI values in parentheses are invalidated due to insufficient current speed over the artificial substrates. The station evaluation is based on the qualitative sample narrative evaluation.

Table 20. Uncommon, sensitive macroinvertebrate taxa collected during the 2007 survey of the upper Grand River basin. State listed species: **T**=Threatened, **SC**-Species of Concern.

Taxa	**Collection Location by River Mile**
Mayflies	
Acentrella turbida	Grand R. 95.38, 94.27; Swine Cr. 10.15; Hoskins Cr. 2.01; Crooked Cr. 3.51; Trumbell Cr. 6.23
Acerpenna macdunnoughi	Baughman Cr. 3.30; Phelps Cr. 4.90; N. Br. Phelps Cr. 1.10; Hoskins Cr. 2.01; Indian Cr. 1.30; Trumbull Cr. 6.23, 2.05; Spring Cr. 5.02; Bronson Cr. 0.82
Epeorus sp.	Crooked Cr. 3.51
Maccaffertium ithaca (**SC**)	Grand R. 98.95; Trumbull Cr. 6.23
Maccaffertium modestum	Crooked Cr. 3.51; Spring Cr. 5.02
Dragonfly	
Boyeria grafiana	Grand R. 98.95; Phelps Cr. 4.90; Indian Cr. 1.30; Trib. to Crooked Cr. (@ RM 6.50) 0.29; Bronson Cr. 0.82
Stoneflies	
Pteronarcys biloba	Indian Cr. 1.30
Acroneuria carolinensis	Grand R. 98.95; Mill Cr. 2.30; Hoskins Cr. 2.01; Trib. to Hoskins Cr. (@ RM 2.45) 1.15; Indian Cr. 1.30; Crooked Cr. 6.70, 3.51; Mud Cr. 3.78
Agnetina capitata	Swine Cr. 10.15
Neoperla clymene complex	Andrews Cr. 3.62
Paragnetina media	Crooked Cr. 3.51
Caddisflies	
Dolophilodes distinctus	Swine Cr. 10.15; Hoskins Cr. 4.88; Indian Cr. 1.30; Crooked Cr. 3.51
Psychomyia flavida	Indian Cr. 1.30; Crooked Cr. 3.51; Trumbull Cr. 6.23
Glossosoma sp.	Grand R. 98.95; Swine Cr. 10.15, 8.18; Hoskins Cr. 2.01; Indian Cr. 1.30; Crooked Cr. 3.51; Trumbull Cr. 6.23; Spring Cr. 5.02
Leucotrichia pictipes	Grand R. 95.38
Goera stylata	Mud Cr. 3.78
Psilotreta indecisa (**T**)	Indian Cr. 1.30
Molanna sp.	N. Br. Phelps Cr. 1.10
Midges	
Pagastia orthogonia	Grand R. 98.95
Nanocladius (P.) downesi	N. Br. Phelps Cr. 1.10; Indian Cr. 1.30; Mud Cr. 3.78
Sublettea coffmani	Phelps Cr. 4.90; Crooked Cr. 3.51; Trumbull Cr. 2.05

Table 21. Freshwater mussels (Unionidae) collected live by Huehner et al. (2005) and live or fresh-dead by the Ohio EPA (in 2007) from the upper Grand River. State listed species: **T**=Threatened, **SC**=Species of Concern.

Species	**Huehner et al.**	**Grand River stations by river mile**						
		88.50	**75.58**	**65.88**	**60.80**	**55.62**	**49.45**	**45.90**
Actinonaias ligamentina	X			X				X
Amblema plicata	X							X
Anodontoides ferussacianus	X							
Elliptio dilatata	X							X
Fusconaia flava	X	X		X				X
Lampsilis cardium	X	X					X	
Lampsilis radiata luteola	X	X		X			X	
Lasmigona compressa (**SC**)	X						X	
Lasmigona costata	X							X
Ligumia recta (**T**)	X							X
Obovaria subrotunda	X	X						X
Pleurobema sintoxia (**SC**)	X							X
Ptychobranchus fasciolaris (**SC**)	X							X
Pyganodon grandis	X	X	X	X				
Simpsonaias ambigua (**SC**)	X							
Strophitus undulatus	X	X						X
Toxolasma parvus	X							
Utterbackia imbecillis	X							
Villosa iris	X							
Total species per station:		6	1	4	0	0	3	10

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